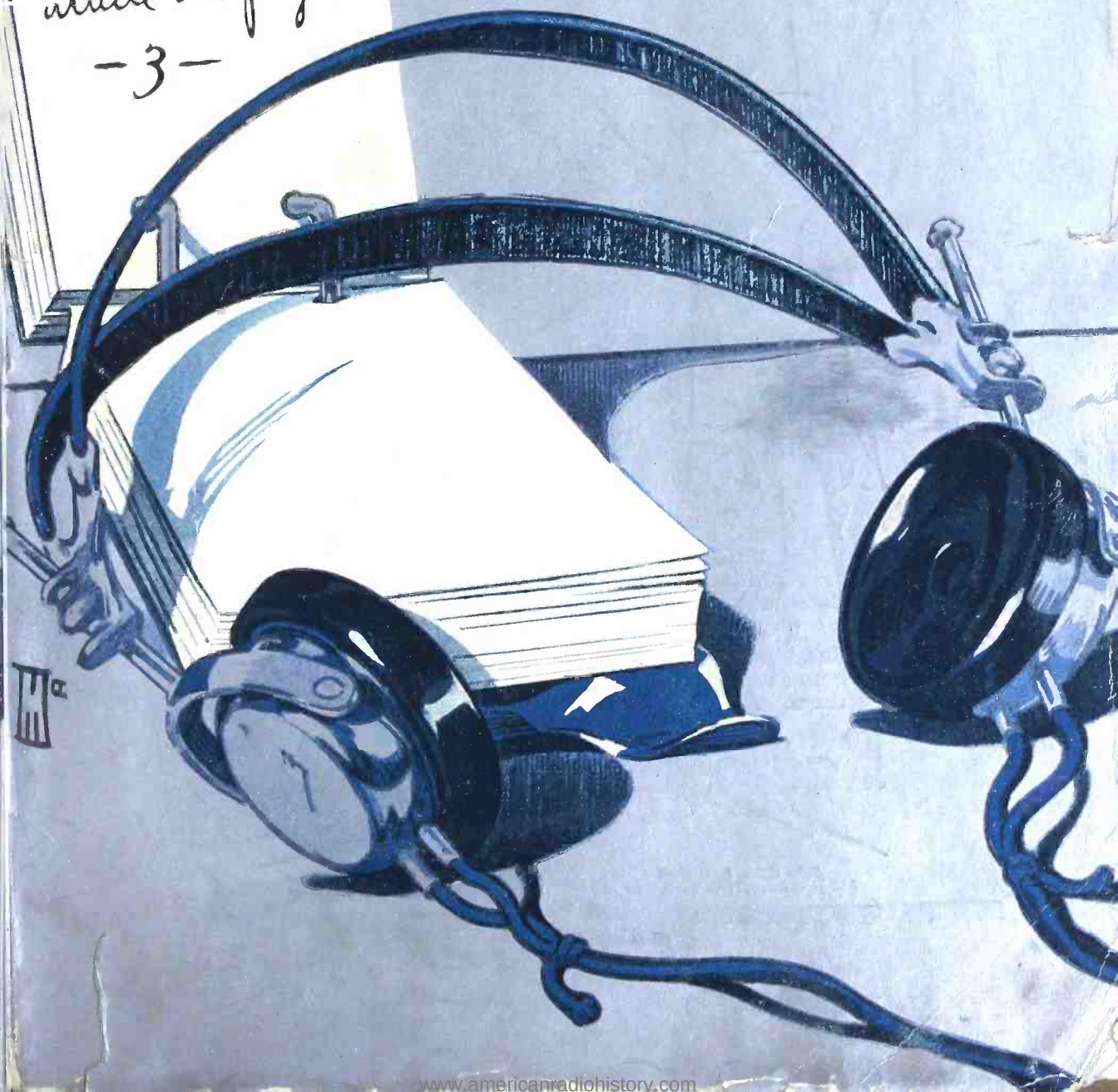
Popular Radio

JANUARY
1923

15¢

Read
Sir Oliver Lodge's
article on page
-3-



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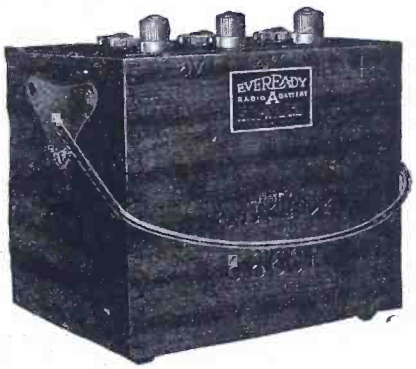

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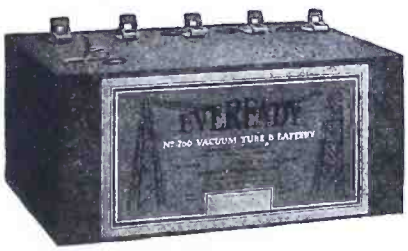

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POPULAR RADIO

EDITED *by* KENDALL BANNING

CONTENTS *for* JANUARY, 1923

(Cover design by Frank B. Masters)

VOLUME III NUMBER 1

DEPARTMENTS

VOLUME III JANUARY, 1923 NUMBER 1

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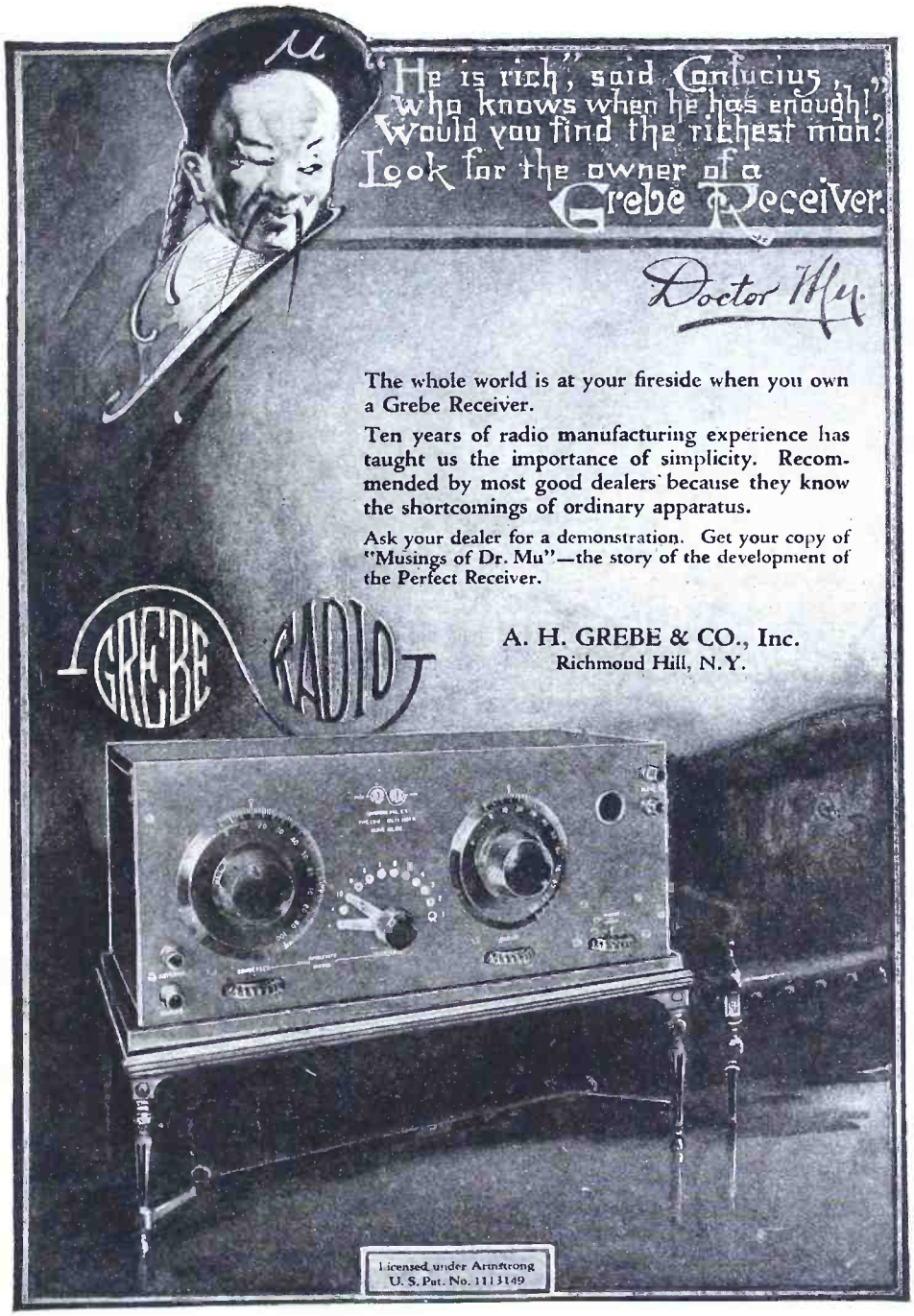
E. E. FREE, Ph.D., *Contributing Editor* LAURENCE M. COCKADAY, R.E., *Technical Editor*



A PAGE WITH THE EDITOR

ANOTHER POPULAR RADIO article has stirred up a tempest in a teapot—or, to be exact, in a kettle. When Houdini wrote his now famous article, "Ghosts that Talk—by Radio" (published in our October issue), he told how certain fake spiritualist mediums had been using inductive radio for years in performing tricks credited to spiritualistic phenomena. He mentioned, among other devices, a "talking kettle," invented by David P. Abbott. In conformity to the ethics of his profession, Houdini did *not* reveal the secret of the kettle.

* * *

THE Editor must take upon himself the full responsibility of explaining the *modus operandi* of the kettle in the form of diagrams and footnotes prepared in the sanctum—and it was just this specific detail that stirred up the unexpected tempest. Following the storm, we are glad to report that Houdini has been entirely exonerated, even if the purposes to which the talking kettle have been applied is still a live topic of discussion.

* * *

IN the meantime, however, POPULAR RADIO'S explanation of how inductive radio is used for performing such tricks is technically correct, as every radio expert knows.

* * *

"I HAVE read all kinds of radio magazines," confesses Frank J. Sloane, of Toronto, Can., "but none can compare with POPULAR RADIO." The immediate cause of this reader's enthusiasm is a hook-up which appeared in our May issue, with which Mr. Sloane experimented. Among the many stations he picked up with it were WNAS, WOH, KYW, WHD, WHAM, WGL, WWI, KSD, WJZ, WGI, WHAS, WOB, 2XE, CJGG and CKAC, covering a territory from Manitoba to Kentucky, from Massachusetts to Iowa, and including a score of States!

If you see it in POPULAR RADIO, *it's so!*

* * *

HERE'S an idea that is worth recording; it comes from Edward J. McDonald of Alton, Pa.:

"POPULAR RADIO is the best radio magazine on the market. I am binding the last few issues in book form for reference; it makes a fine hand-book on radio. Please keep your magazine at its present dimensions."

We will—only we *must* add more pages!

* * *

THAT (happily) rare bird who delights in "writing to the papers" but who hides his shrinking soul behind letters that bear neither name nor address, is advised to save his efforts so far as POPULAR RADIO is concerned. We carefully file all anonymous contributions where they belong—in the scrap basket.

* * *

AN army sergeant in Grove City, Pennsylvania, recently addressed a letter to "*the* radio magazine." Naturally, it was properly delivered to POPULAR RADIO.

* * *

STILL another scientist of international fame has been added to the rapidly enlarging list of distinguished contributors to this magazine. The newest POPULAR RADIO author is Prof. J. A. Fleming, F. R. S., known throughout the world as the inventor of the "Fleming valve"—the first vacuum tube ever used in radio.

"There's a reason" why the foremost scientists of the world select this magazine as the medium of expression—and that reason is so apparent that the Editor will modestly refrain from comment.

* * *

So popular is our department, "What Readers Ask," that our Technical Editor is literally deluged with inquiries from radio fans throughout the country. Indeed, the success of his department, gratifying as it is, is causing real embarrassment to him, as it is impossible for him to answer his letters as fast as they pour in. At last reports he was eleven weeks behind in his correspondence and sinking fast!

* * *

To meet the situation POPULAR RADIO, in justice to its subscribers, must hereafter restrict this special service to those fans whose names appear on its *subscription list.*

To those who are *not* subscribers a nominal charge of 50 cents will be made for each inquiry, to cover the cost of this service.

Beginning December 15th, accordingly, all inquiries of a technical nature addressed to our Technical Editor should be accompanied either by 50 cents service fee or by a subscription for a year—unless, of course, the correspondent is already a subscriber.

* * *

IN our October number the Editor asked advice as to whether or not he should enlarge the magazine in order to permit its readers to profit from the rich supply of new and timely editorial material that is piling in upon us.

The response was an impressive "Yes." Eighty percent of the replies were, in effect:

"*We want more* POPULAR RADIO!"

* * *

THE Editor gracefully yields to this expression of opinion. Beginning with our next number—February—POPULAR RADIO will be substantially enlarged, although the price will be advanced only a nickel.

But our readers will get a larger and better magazine for 20 cents than they are now getting for 15 cents.

Kendall Banning

Editor, POPULAR RADIO

From a photograph made for POPULAR RADIO

THE EVIDENCE OF EXPERTS

Into this scrapbook have been collected photographic copies of over a hundred letters from the country's foremost radio experts, dealers and manufacturers, endorsing POPULAR RADIO'S *campaign to establish broadcasting upon the high plane that it must attain as a public utility. This book has been delivered personally into the hands of the Secretary of Commerce by Paul Godley (at the left) as evidence that the radio interests are not only ready for action but are demanding it.*

DO YOU WANT

BETTER BROADCASTING?

Will *YOU* Mr. Radio Fan, Mr. Dealer and Mr. Manufacturer, Help Get It? POPULAR RADIO Here Points Out the First Step for You to Take.

THE average fan's interest in radio is determined by the quality of the broadcast programs he hears. If he enjoys the entertainment, that enjoyment is reflected in the radio apparatus made and sold throughout the country.

Thus the problem of maintaining broadcast programs of the highest possible plane of interest becomes the most vital problem confronting the radio industry; indeed, the very existence of thousands of makers and sellers of radio equipment is hanging upon it *this month.*

Several months ago POPULAR RADIO began an investigation of the fundamental cause of the decline of public interest in radio. The cause was evident from the first; it was a general lowering of the standards of the programs —for reasons quite outside of the control of the broadcasting stations.

To assist actively in the establishment of high-grade programs, and to prove what could be done by actual demonstration, POPULAR RADIO initiated the following important projects:

The broadcasting of a series of outdoor concerts by the New York Philharmonic Orchestra last summer, through WJZ;

The broadcasting of side-line reports of the big football games in New York last fall, through WJZ;

The broadcasting of a series of indoor educational concerts by the New York Philharmonic Orchestra during the present season, through WEAF;

The installation of wiring in Cooper Union, New York, for the purpose of broadcasting lectures, concerts, conventions and other features of importance and value;

The broadcasting of a series of indoor concerts during the present season, 1922-23, by the City Symphony Orchestra of New York, through WJZ.

That these projects have stimulated interest in radio has been shown by the corresponding betterment in local radio trade. But, more im-

—if you can afford to pay more—you will still prefer CROSLEY efficiency

From the most humble home to the elaborate drawing room, Crosley Instruments are preferred. Regardless of the many higher priced instruments on the market, the man who knows—even if he can afford to pay more—will choose Crosley.

There is no secret in this. Crosley instruments are the acme of efficiency and simplicity and their construction is based on sound fundamental principles. Numerous tests by disinterested parties all over the country will bear us out in this statement. Your dealer should be able to furnish you with Crosley Apparatus. If not, send us his name and order direct.

If you are a Jobber or Dealer and do not already handle Crosley Instruments, you will be wise to satisfy the demand that our national advertising has created.

CROSLEY
BETTER·COST LESS
RADIO

Complete sets from $25 up, all kinds of parts and experimental units.
Write for Catalog

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116 Alfred Street, Cincinnati, Ohio

CROSLEY RECEIVER MODEL X. A four-tube outfit the same as shown in the above scene. It consists of tuner, one stage of Tuned Radio Frequency Amplification (the feature that has made this set so popular) Detector and two stages of Audio Frequency Amplification in a beautiful mahogany cabinet. It will bring in distant stations loud and clear. With this set, listeners in Florida have heard Winnipeg, San Francisco and Honolulu. Price, without phones, batteries or tubes, $55.00.

portant than merely offering temporary stimulant to the industry is the problem of establishing these high-grade programs upon an enduring and sound economic foundation—of insuring the best possible entertainment for the longest period of time, with the least possible interference, and at a proper cost that should be paid by the proper interests.

The first step in the attainment of this object is to establish the proper legal authority in Washington for dealing with the present emergency.

In the opinion of those who best know the situation, the establishment of the necessary governmental authority may best be attained by passing the pending radio bill (known as H. R. 11964), proposed by Congressman White of Maine on June 9, 1922. Since that date the bill has lain dormant, largely because the law makers felt uncertain whether or not the radio interests were ready to push it.

In order to gauge the present temper of the radio industry toward the need of immediate action, POPULAR RADIO sent to a thousand leading dealers and manufacturers of radio apparatus a letter accompanied by a galley proof of an editorial that was published (in part) in our December number. That editorial outlined a constructive project for meeting the present situation.

The response to this letter was electric. It gives impressive proof that the industry is ready for action. It gives convincing evidence that the time has come to push House Bill 11964 *and to get it passed,* either in its present form or with such changes as may be decided upon when it comes up for consideration at the hearings.

The passage of this bill, consequently, directly concerns not merely every radio dealer. It concerns *every radio fan in the country.*

In proof of this attitude of the industry, POPULAR RADIO has selected the first hundred letters that came in from the more important dealers and manufacturers, made photographic reproductions of them, mounted them in an album and sent the album down to our lawmakers in Washington, as tangible evidence that the time for action has come. And to insure its attention by the proper officials, the evidence has been sent in the custody of a fan who needs no introduction, either to the radio amateurs or to the authorities in Washington —Paul Godley.

The readers of POPULAR RADIO—the fans, the novices, the amateurs, the dealers, the manufacturers—can render no more useful service at this time than to urge upon their Congressmen and upon their Senators to have this bill brought up for consideration at the present session of Congress.

POPULAR RADIO does not believe that the radio bill is perfect in its present form. It believes that certain changes are desirable. In all probability these changes will be made when the bill is under consideration. And the only way to bring these points to an issue is to *urge action now.*

The bill, originally drawn at the suggestion of Secretary Hoover, has been endorsed, at a conference in Washington last spring, by a thoroughly representative body of men, representing the foremost radio amateurs, scientists, engineers and manufacturers. It provides for the establishment of an agency (the Department of Commerce) that shall be charged with the responsibility of getting radio on the right track and of keeping it there. By way of guiding this agency, a committee of twelve men is also provided for, each of these men to be chosen from one of the departments of the government and six from among radio engineers of standing. Amateur station owners are taken care of through the allotment of all waves between 150 and 275 meters to their use under certain proper circumstances. The Secretary of Commerce is given power to stipulate what wavelengths are to be used for the various classes of radio services; to say how these services shall be conducted; to stipulate the nature of broadcasting programs, and to specify the time of operation of broadcasting stations, and the power to be used; to penalize station owners who do not play the game; and to make changes in regulations as they become necessary.

In brief, the bill establishes the necessary authority for handling the situation that now confronts the radio interests; it does not, however, affect the government radio stations. The President assigns the wavelengths for them.

Unless this bill is acted upon during the present session, it cannot be acted upon for another year—in which case the radio fan cannot profit from it until 1924.

This magazine believes that action on this bill —action that will result in its passage in either its present form or with such revisions as may be decided upon—is of immediate importance to the radio interests. The last radio legislation was passed by Congress in 1912, and is inadequate to meet present day conditions.

POPULAR RADIO, accordingly, advises each of its readers to send both to his Congressman and to his Senator, some such letter, telegram or postal as this:

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

And as every day counts, POPULAR RADIO advises its readers to send this brief message *today!*

Send this message to your Congressman and to your Senator at Washington. Do it *now!*

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

(SIGNED) *John Doe*

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The Reproducer Supreme

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

R-2 Magnavox Radio with 18-inch horn: this instrument is intended for those who wish the utmost in amplifying power; for large audiences, dance halls, etc. $85.00

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Magnavox products may be had of good dealers everywhere. Illustrated booklet on request.

IT was in 1913 that the Magnavox electro-dynamic receiver made its first public demonstration, when telephone communication was held by means of it between Denver and New York—a revolutionary advance.

The rise in radio broadcasting found Magnavox apparatus already fully developed to make possible the reproduction of wireless music and speech in ample volume and marvelous clearness.

The facilities and experience back of each piece of equipment bearing the Magnavox trade mark are unrivaled anywhere in the world.

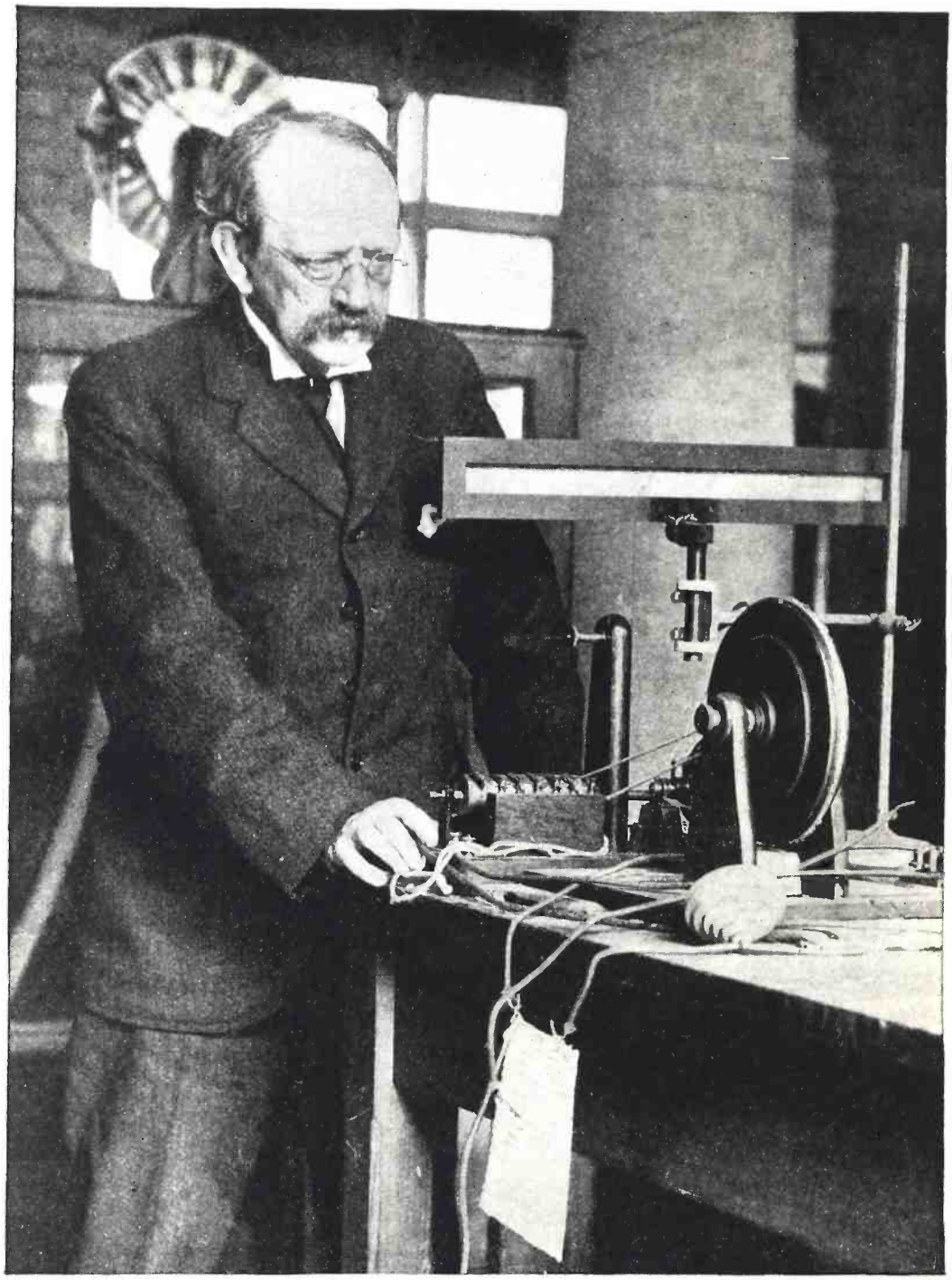
THE MAGNAVOX COMPANY

Home Office and Factory: Oakland, California
New York Office: 370 Seventh Avenue

Radio—the Greatest Potential Educational Force in History

"All thinking men must realize that in the broadcasting service we have a potentiality, particularly for education and culture, the like of which the world has never known in its history. We must find a practical way to utilize this great potentiality for the maximum good to all of our people."

MAJOR GENERAL, UNITED STATES ARMY



From a photograph made for POPULAR RADIO by the Special Press, London

HE PROVED THAT THE ELECTRON REALLY EXISTED

Not until the distinguished English physicist, Sir J. J. Thompson, demonstrated by actual experiment that the electron was not merely a theoretical but an actual physical body was the "electron theory" finally accepted by the world of science. He is here shown in his laboratory at Cambridge, explaining the phenomena of electricity and magnetism in terms of the theory which his research work validated.

Popular Radio

VOLUME III JANUARY, 1923 NUMBER 1

What Bends Radio Waves?

"Ground Conduction," answers Dr. Elihu Thomson. "The Heaviside Layer," believes Sir Oliver Lodge— for reasons which he specifies in this article.

THE ARGUMENT IN A NUTSHELL:

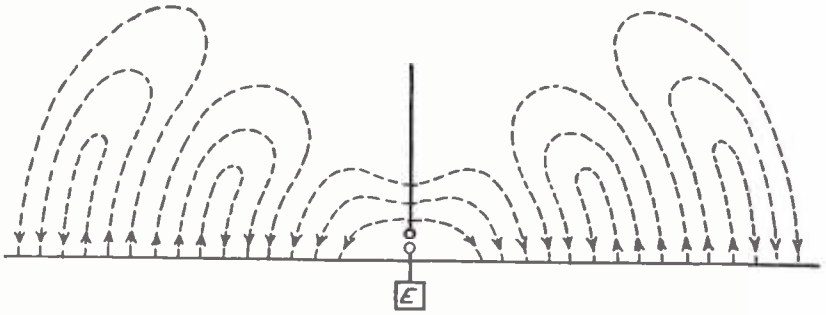
Until radio signals were transmitted across the ocean in 1896 scientists believed that radio energy followed the laws of wave motion and traveled in straight lines. Following that disturbing event, however, scientists were required to offer another explanation of radio phenomena. So they evolved the "Heaviside layer" theory, which presupposes a conducting layer of gas that envelops the earth and that bends the radio waves around the earth's surface. This explanation was generally accepted until Dr. Elihu Thomson, the distinguished American scientist, rejected the Heaviside layer theory (see POPULAR RADIO for December, 1922) and submitted instead the theory that radio waves are conducted across the ocean by earth-conduction. In the following article the foremost English authority on ether answers Dr. Thomson and makes a vigorous defense of the generally accepted layer hypothesis.—EDITOR.

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

IN the early days of Hertz waves, 1888 to 1894, when we were engaged in demonstrating the reality of electrical oscillations in the ether (that is in free space) we avoided earth transmission as being unfair and deceptive, suggesting the conclusion that the disturbance was being transmitted by the conducting power of the earth rather than by the insulating power of the ether.

Thus, for instance, if a Hertz oscillator or a discharging Leyden jar was attached to the gas pipes of a building it was easy enough to get disturbances in neighboring buildings and to light the gas at a distant jet by turning it on and bringing a finger or piece of metal near it. But it was possible also and more interesting to get sparks in unexpected places, as for instance between gas and water taps which happened to be near each other in a basement, when the discharge circuit of a condenser was completely insulated in a room above—which is indeed a modification of the experiment that Joseph Henry conducted at Washington, D. C., long ago, though at that date he did not know the meaning of it.

So long, therefore, as we were experimenting with wireless waves mainly for theoretical and, so to speak, optical purposes, verifying Clerk Maxwell's theory



HOW RADIO WAVES RADIATE FROM A GROUNDED OSCILLATOR
Notice that the transmitted waves are half-waves only; in scientific terms they are "dichotomized."

of light—reflecting, refracting, and polarizing the waves by suitable apparatus, and seeing how far and by what means they could enter closed spaces—it was natural and proper to have the main oscillator insulated from the earth and avoid anything that could be suspected in the direction of earth conduction.

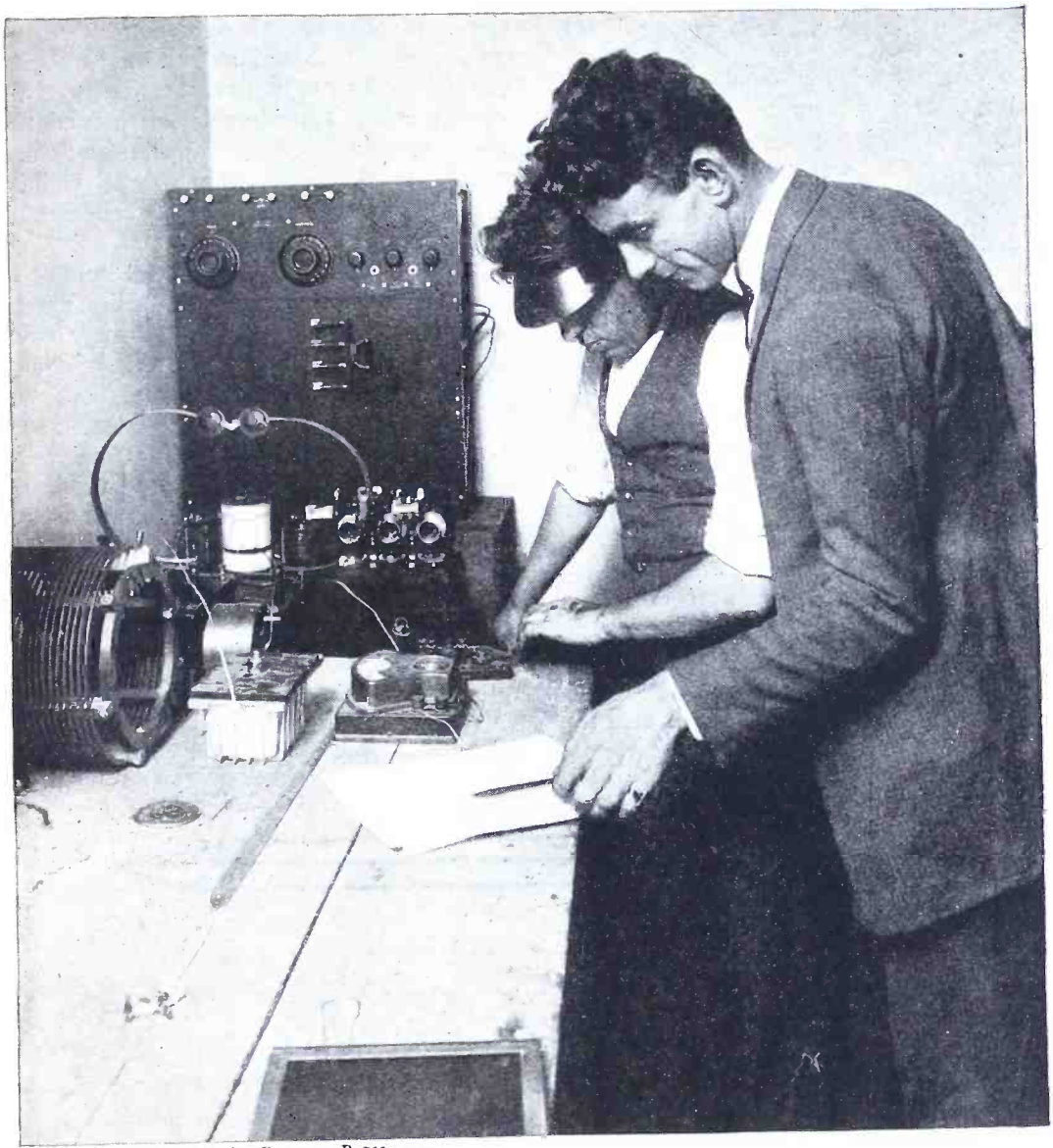
But when Marconi, in 1896 and onwards, applied these waves to practical telegraphy, his object was to get the signals at a distance, no matter by what means they went. He therefore naturally and properly employed earth conduction for all it was worth, making a good earth-connection at both sending and receiving stations, so that the earth became part of the oscillator. Thus began the Marconi aerial and ground system, which, as we all know, is very effective for long-distance work.

We were all fully aware that the effect of this system would be to dichotomize the waves or cut them in half (which had been depicted diagrammatically by Heinrich Hertz) and to assist them to run along the surface of the ground so far as it was conducting. It was natural, therefore, to expect and to get better results over sea than over land.

So also if we wanted to get signals from a coherer inside a closed metallic chamber, we found we could do it by allowing some metallic conductor to enter that chamber, provided it was insulated from the chamber at its place of entry. The entry of a gas pipe, for instance, into a metal coated room, had the virtual effect of turning the room inside out and of thus eliminating its screening property; though, without such introduced conductor, a metallic enclosure was a complete shield against ether waves. But we found that the merest chink, or even a bad joint in the metal coating of a chamber, allowed some of the waves to penetrate; though a round hole was not equally effective, unless a bit of gutta-percha-covered wire was put through the hole to act as a sort of speaking tube or conveyer of the waves into the interior.

We also suspected that any stray conductors, like wire fences or buried mineral lodes or any other conducting material, would help to transmit the waves. And Dr. Alexander Muirhead applied to a cable company for permission to make connection with the outer metallic sheathing of a cable, in order to see whether the signals could not thus be transmitted with greater ease. But the dislike of any responsible cable company to the idea of high voltages applied to any part of their cable prevented this experiment, and good earth connection was found sufficient without it.

That metallic conductors conveyed the waves was, however, well known, and I first obtained evidence of the existence of such waves along wires, by reflecting them so as to get nodes and loops, early in 1888 and even before the publication of Hertz's great discovery of their ready transmission by free space.



From a photograph made for POPULAR RADIO

Experiments with the Hertz oscillator—shown above—prove that radio waves can be transmitted without using a ground.

How far earth conduction assisted, or would be likely to assist, the transmission of waves between a completely insulated transmitter to a completely insulated receiver became an open question, and at Messrs. Muirhead's works many experiments were made. What we found was that the avoidance of earth connection assisted the definiteness and purity of the waves, prolonging the oscillations and rendering very accurate tuning possible. We found, indeed, that earth connection spoilt the tuning by damping the waves, and we therefore preferred to use an aerial system consisting of two insulated capacity areas, one, called the antenna, elevated as high as practicable, and the other suspended at a fair height above the earth.[1] We found, indeed, that the

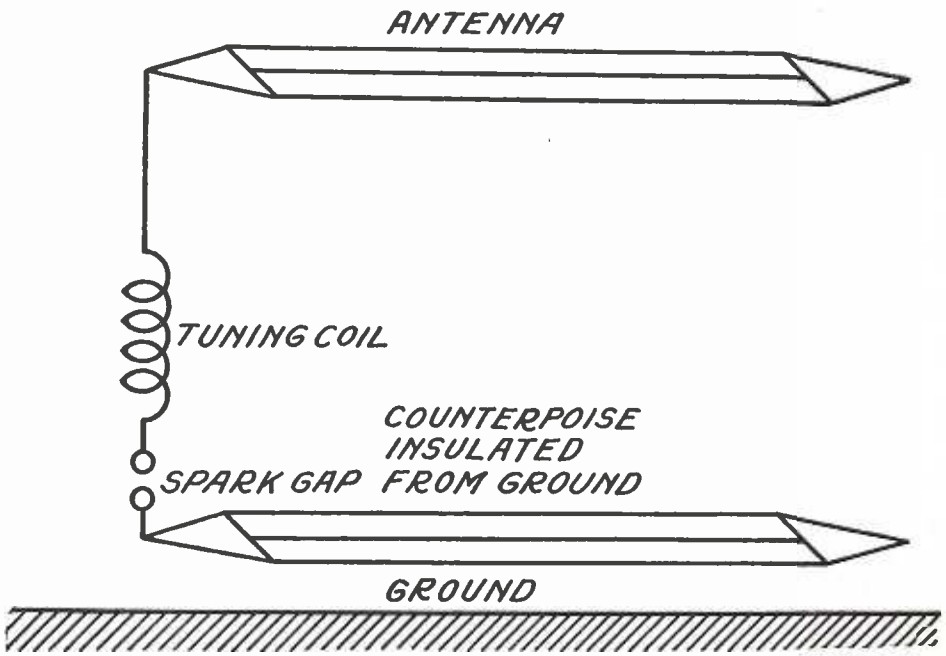
[1] *Known in America as a "counterpoise antenna."*

best position for the lower capacity area or counterpoise was at such a height that the capacity of the whole was a minimum. If the counterpoise were put higher, it was brought too near the antenna. If it was put lower, it was brought too near the ground. We found a position at which the tuning was sharpest, and a record of these experiments was published by the Royal Society at a later date when they were fairly complete.[1]

It was found, however, that for practical purposes the use of the earth as a ground was simpler in practice, and in some positions was inevitable; as, for instance, on board ship, where the sheathing of the ship made a perfect ground, and no other grounding was necessary. It was found also that the counterpoise or balancing capacity was always rather a nuisance and an expense, and that even if it was constructed it was best buried out of the way. It was found also that the extra damping, though in itself to a certain extent objectionable, was not so deleterious as might have been expected when a coil of considerable self-induction was employed, since the inductance of the circuit by prolonging the waves could partly overpower the damping effect of the ground.

The efficiency of the ground connection, however, might vary in different localities. Some soils constitute a very bad conductor, others a good one. And wherever sea-water is available there is no question but that it is desirable to use it. For whether earth conduction assisted every kind of wave, even from insulated aerials, there was no doubt that it would assist when the earth was made part of the oscillating system. The only objection to it was that it was indefinite and might have a high damping resistance. Even now it would be well to use a counterpoise for any experiments involving really precise tuning. But for ordinary purposes all that was necessary

[1] *See Proc. Roy. Soc., vol. 82, p. 227. 1908-9.*



NO GROUND IS NEEDED IN THIS TRANSMITTING SYSTEM

Every experienced amateur will recognize this oscillating system that includes, in addition to the antenna, a "counterpoise" between it and the earth. It permits exceptionally sharp tuning by cutting down the effective resistance of the circuit to a low value.

was to get sufficient tuning and to reach the greatest distance possible.

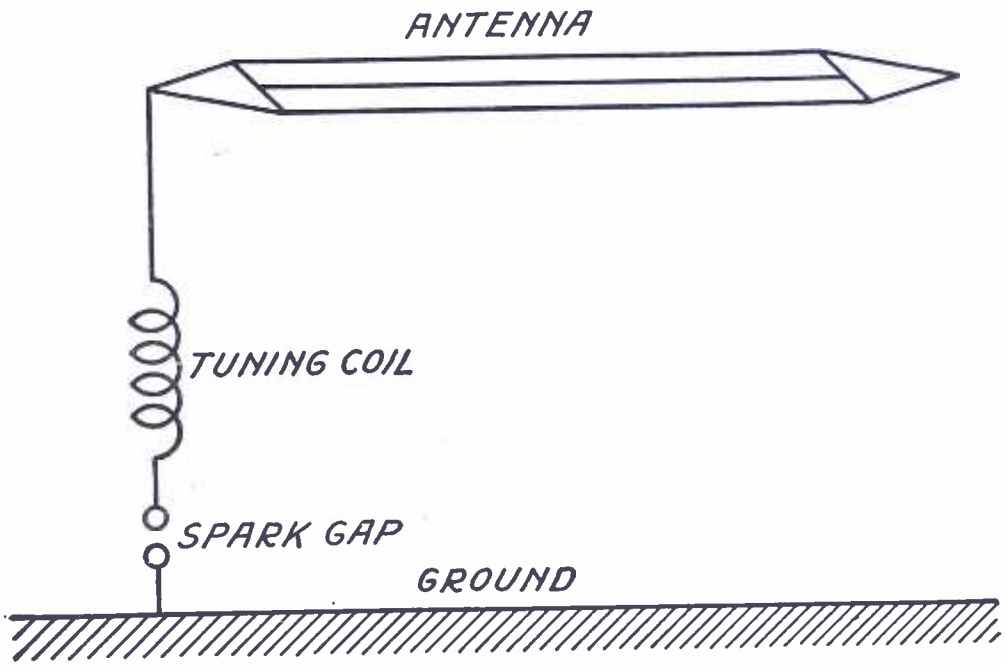
The whole subject is summarized in Professor Fleming's treatise on *The Principles of Electrical Wave Telegraphy and Telephony*, Chapter VIII, in the second edition; probably in the first edition also. And the experiments of Zenneck on different kinds of earth—that is, on the effective different kinds of soil—is there quoted and elaborated, with a citation also of further experiments by Brylinski on page 743. The usual diagram of the dichotomized Hertzian waves is given on page 408 in Fleming's Chapter V, Section 11, where the earth is considered as a perfect conductor acting as a mirror to the upper capacity area, and as if the lower area were an equal distance below the surface. A similar discussion will be found in Prof. Pierce's *Principles of Wireless Telegraphy*, Chapter XV.

How far such a condition really obtains in practice must depend on the efficiency of the ground available; and the distortion which the waves inevitably undergo by traveling over poor conducting soil must be learned from the experiments of Zenneck and others above referred to.[1]

But in the November issue of this magazine Dr. Elihu Thomson claims that this earth transmission is the really effective way in which the waves are conveyed to great distances and are by this means enabled to go round the curvature of the earth and reach even the Antipodes. So he concludes that any upper conducting layer in the higher parts of the atmosphere is unnecessary to explain the transmission, and that the existence of such a reflecting layer has become a superstition.

It is difficult to decide this by experiment, for we cannot get away from the upper regions of the atmosphere and determine how effective the sea alone would

[1] *See, for instance, page 736 in Section 14 of Fleming, Chapter VIII.*



BUT THIS MARCONI SYSTEM USES THE EARTH AS PART OF THE OSCILLATOR.

Why is it, then—if transmission depends upon earth conduction—that radio signals are so much stronger at night time than during the daytime?

From a photograph made for POPULAR RADIO

In this ungrounded receiver the earth plays no part in the reception of radio signals transmitted by the Hertz oscillator.

be without what has been called "the Heaviside layer" in the atmosphere. But it is plain that there must be a best conducting layer in the air, since the density of the air varies as you ascend from its ordinary value down to an absolute vacuum, and it is known that during the exhaustion of vacuum tubes, when the pressure is a few millimetres of mercury, the residual air does conduct to a degree almost comparable with the conducting power of water. It is further plain that if ether waves are confined between two strata, both fairly conducting, one above and one below, they will be kept from escaping in all directions and will spread out in only two dimensions, thus surely economizing their power.

It may be argued that the conducting layer in the upper air is too gradual to

give sharp reflection—that is to say that the thickness of this layer is greater than any probable wavelength, and hence that the waves might succeed in penetrating it. I doubt that this is the contention. I believe that the contention of Dr. Elihu Thomson is rather that the layer is likely to be too irregular, too corrugated and uneven, to act as anything like a reasonably good mirror, even for long waves.

I should suppose that in the daytime, when the air is subject to all manner of vertical currents from the heat of the sun, such corrugations might very well occur, but that during the night, even if there were a wind below, the upper regions of the air with their high kinetic viscosity might be trusted to preserve a fairly even surface. And anyhow the demonstration by Marconi's large-scale experiments of the conspicuous influence of sunlight in spoiling transmission is not readily explicable unless the atmosphere has something to do with it. If transmission depends only on earth conduction—as Dr. Elihu Thomson seems to think—one would expect signals to be as good in the daytime as they are during the night.

Hence, on the whole, I think facts point to a real influence of the upper atmosphere on transmission; whether the part played by the atmosphere can be dissected out from the part played by the earth or sea may have to be settled by the mathematicians. And further, from different points of view, the opinions of high authorities in America and elsewhere may have to be ascertained before the question can be considered settled. I do not suppose that Dr. Elihu Thomson considers that he has settled the question, but rather that he has raised it in a more acute form and has reopened it in all its bearings for further discussion throughout the scientific world.

I have indicated sufficiently that I have nothing dogmatic to say about it, but I am impressed:

a. With the fact that a conducting layer in the upper air is inevitable.
b. That such a layer, if effective, would be a great assistance in very long-distance transmission.
c. That, without it, the deleterious influence of sunlight seems rather inexplicable.

Finally, Dr. Elihu Thomson writes as if there had been, in the past, undue scepticism concerning Marconi's great achievement of first getting wireless signals across the Atlantic. I know of no undue or improper scepticism about it. A hope was expressed by myself among others, in a congratulatory letter to the press, that further experience would confirm the result (as it conspicuously has), but caution in accepting a newspaper report of a remarkable achievement is not unprecedented, and hasty, enthusiastic congratulation on the strength of such reports has not always been justified.

Photo made for POPULAR RADIO

How the Navy Radio Experts Are Reducing "Interference"

No radio fan needs to be reminded of the days when the Navy's radio signals pretty much monopolized the ether. How this condition is being overcome—to the relief of the amateur—is told by Commander S. C. Hooper in POPULAR RADIO *for February.*

From a photograph made for POPULAR RADIO

RADIO ENTERS THE DOCTOR'S LABORATORY

Among the distinguished members of the medical profession who are experimenting with the application of radio to the study of the human being is the author of this article, Dr. Henry Smith Williams. Incidentally, he is the author of more than forty books on scientific subjects.

Photographing Our Emotions —by Radio

How Some of the Scientific Apparatus Developed by Radio Is Being Applied for Measuring the Physical Reactions of Thought

By HENRY SMITH WILLIAMS, M.D., LL.D.

WE read in the newspapers the other day about the girl who was entertained with a radio concert while a surgeon was operating on her with the use of a local anesthesia. The incident was sufficiently picturesque to catch the eyes of the reporters; and it suggests unexploited possibilities of radio-receiving in hospitals and other institutions, for diversional and even perhaps curative effects. But of course the case recorded had only incidental connection with medicine considered as a therapeutic art.

Another report, however, tells of a radio experiment that brings the new art a little more directly in coalition with the art of healing, a radio entertainment was given at the Central Islip Hospital for the Insane, near New York, under direction of Mr. Charles Isaacson; on which occa-

sion about 3,000 patients listened to the opera "Cavelleria Rusticana," with explanatory comment, broadcast from the station WJZ at Newark, fifty miles away.

Mr. Isaacson, as is well known, has long been an enthusiastic advocate of the value of music in "ministering to the mind diseased," and his efforts to put his theories into practice have met with notable success. Hitherto he has been dependent upon musical performers who were present in the flesh at the institution, or upon phonograph records; now he has shown that radio may serve the purpose equally well, with the added advantage that one set of performers may entertain simultaneously an indefinite number of institution audiences.

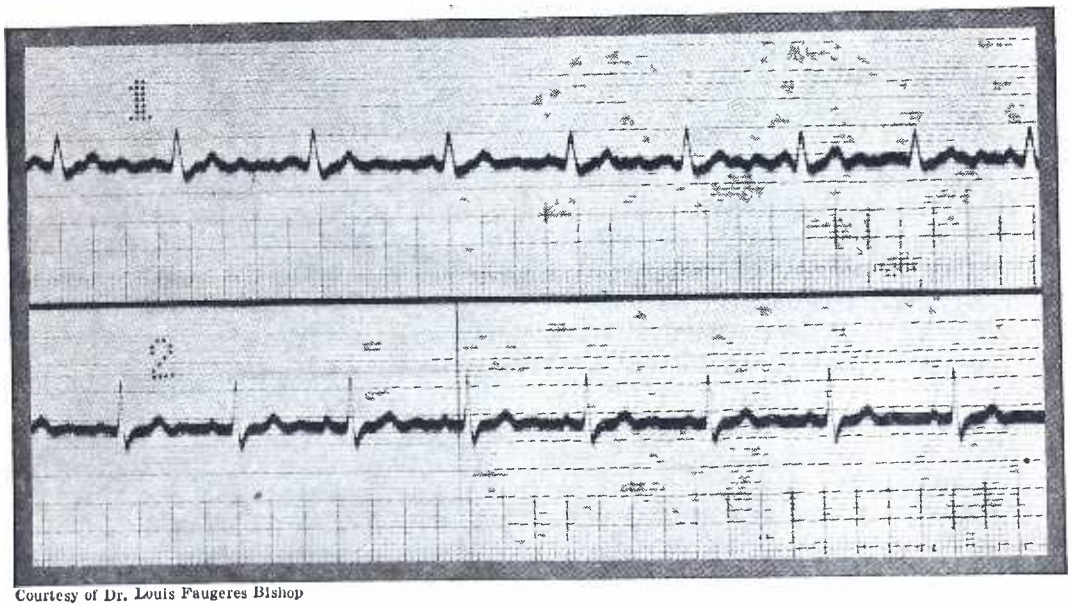
The time is probably not distant when every public institution will be provided with radiophone receivers; and it is more than likely that in many places special programs, on isolated wavelengths, will be broadcast for the edification and mental benefit of institution residents. Even the prisons will probably be included in this program.

The therapeutic possibilities of radio thus utilized are by no means to be dismissed as trivial. Nothing revolutionary is to be expected in individual cases; but the aggregate betterment in mental outlook and what may be called "psychic morale," cannot fail to be consequential.

A more direct and tangible utilization of the radio principle, as regards individual patients, is that suggested by the experiments of Major-General Squier, in which the sound of the heart beat has been transmitted to a distance and magnified there by the use of triode amplifiers.*

This furnishes an interesting demonstration of the possibility of transmitting and magnifying sounds; something practical will doubtless come of it ultimately. But for the moment it does not directly aid the diagnostician, inasmuch as the heart sounds are adequately audible to the unaided ear, while the variations in

*See POPULAR RADIO for June, 1922.



Courtesy of Dr. Louis Faugeres Bishop

AN ELECTRIC PORTRAIT OF ANXIETY

The upper "electrocardiogram" shows the cardiac current during a period when the patient experienced anxiety for the safety of her jewels, left in the dressing room. The lower electrocardiogram shows the heart current of the same patient a few minutes later, after mental equanimity had been restored. This is part of one electrocardiographic record excerpted from the series of more than 4,000 consecutive cases recorded by Dr. Bennett Bishop, who can usually detect any change in a patient's emotional state by observation of the shadow of the "string galvanometer."

muscular activity which produce the sounds may be studied with other types of apparatus already in hand, notably the electrocardiograph. General Squier's experiment has special interest, however, as representing perhaps the first attempt to utilize the sensitive mechanism of the radio apparatus in the study of a physiological function. The application was made to the heart for obvious reasons; but it may be taken for granted that the activities of other organs will presently be brought within range of observation from the new coign of vantage afforded by the necromantic electron tube. The nearest-to-hand possibility appears to be the investigation of the electrical manifestations associated with the functioning of the nervous system. It is this aspect of the problem toward which my own projected investigations are directed.

It has long been known that the living body is a generator of electricity. To prove this, nothing more is necessary than to place a sensitive galvanometer in a loop of wire and bring the ends of the wire in contact with surfaces of the body —for example, holding a wire in each hand. This completes the circuit; the body acts as a battery, causing a current to flow through the wire, deflecting the galvanometer.

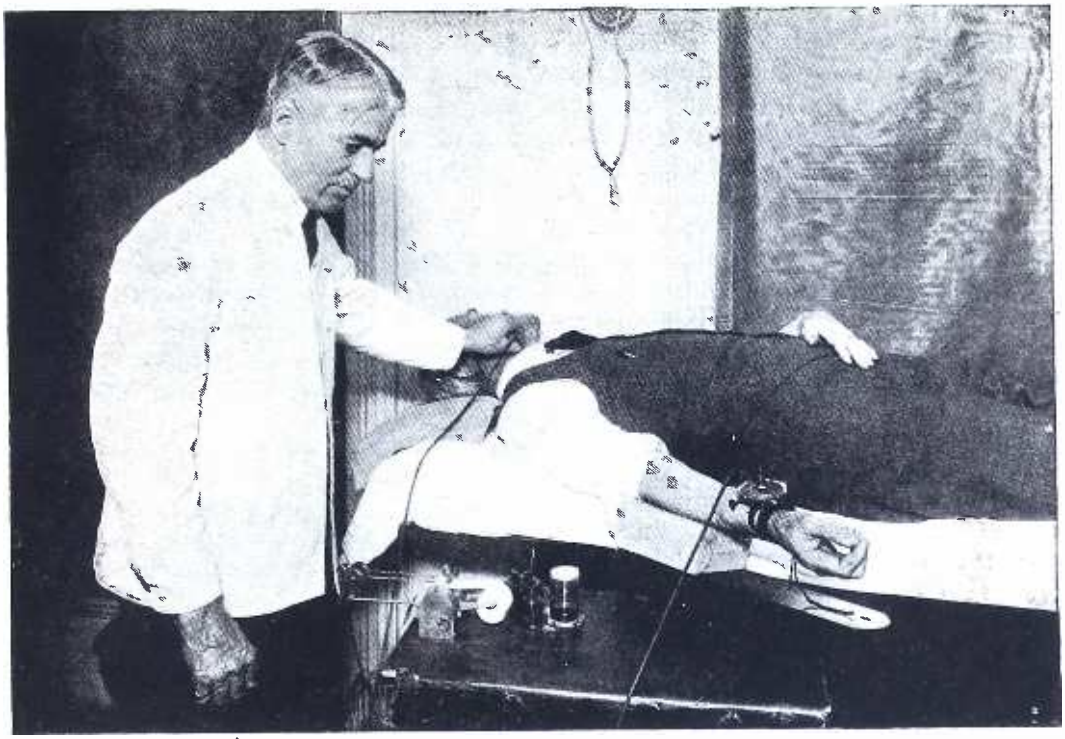
Interesting tests have been made with this simple apparatus in the endeavor to determine whether the amount of current that flows through the wire is modified by changing mental or emotional states of the person under observation. Such changes have been noted (they are, indeed, easily demonstrable), but competent observers have expressed the opinion that the modification is due chiefly to increase or decrease of moisture of the skin, caused by perspiration. It is common knowledge that emotional conditions affect the cutaneous circulation—as is evidenced, for instance, in the phenomenon of blushing. A greater or less amount of perspiration exudes from the pores concomitantly; and of course a moist skin offers less resistance than a dry one to the passage of an electric current.

So the galvanometer experiments, which at one time seemed so promising, led to no very definite conclusions as regards fluctuations in the development of electricity in the human battery. It seemed necessary to find a more delicate instrument for testing electrical currents before real progress could be made.

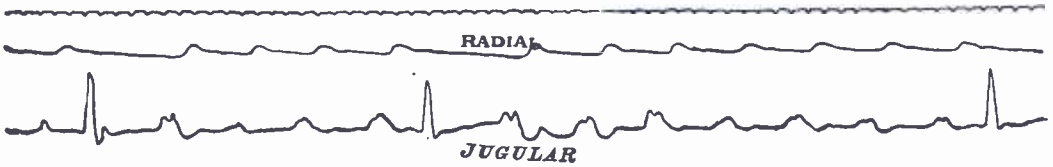
Such an instrument is found in the electrocardiograph. This is a large and rather cumbersome piece of machinery, occupying a stand or table several feet in length; to casual inspection it suggests power rather than delicacy of operation. Yet its really essential part is a little filament of glass, of spider-web proportions, upon which a thin layer of gold has been deposited by electrolysis. The thread of gold thus devised is sometimes called a string galvanometer. It is stretched crosswise in the space between the poles of a relatively huge electromagnet; its ends are connected with wires through which an electric current might pass. The other ends of the wires, when the apparatus is in operation, are connected with electrodes designed to be placed in contact with surfaces of the human body.

Gold, as is well known, is a non-magnetic metal, but it is an excellent conductor of electricity. It is equally well known that when an electric current passes along a conducting wire, there is developed round the wire a magnetic field that comes to grips, so to speak, with any other magnetic field that may invade the same territory.

It follows that the magnetic energy of the electromagnet does not affect the gold thread when not electrified; though it would instantly rupture a thread of similar size made of steel or other magnetic metal. But when a feeble electric current passes along the thread of gold, there is instant mutual attraction between its field and that of the magnet, with the result that the thread is pulled vigorously in one direction or the other according



From a photograph made for POPULAR RADIO



RECORDING IN GRAPHIC FORM THE REACTIONS OF THOUGHT

This apparatus, known as a "polygraph," records mental actions as reflected in the mechanical action of the heart, transmitting through the blood to the wrist and neck of the patient. Compare this record with the electrical record of the electrocardiograph on page 11.

to the direction of flow of the current it carries.

Any deflection of the thread is therefore tangible evidence of the passing of an electric current; and the amount of deflection measures the relative strength of the current. If the wires joined to the end of the thread are put in circuit with the human body, we shall know whether electricity is generated or stored in the body, and whether the current fluctuates.

This could not be determined by direct observation of the little gilded-string galvanometer, to be sure, inasmuch as the tug of the magnet will deflect it to only an infinitesimal degree. But there is an arc light at the other end of the table on which the magnet rests, and this throws a concentrated beam through the chamber in which the little gold thread is strung, and casts a shadow of the thread on a disc several feet away. This shadow, of course, reveals the movements of the thread in greatly magnified proportions.

Across the disc that carries the perpendicular shadow is a little horizontal slit which is in effect the eye-piece of a camera in which a photographic film is automatically unrolled, so that it passes across the slit and is everywhere affected by the light except where the shadow of

the little gold thread shields it. This shadow, projected through the hair-like slit, becomes a mere point that moves back and forth as the galvanometer thread oscillates, and thus records a zigzag line on the strip of celluloid.

This zigzag line is the record of the varying strength of the electric current that passed through the little gold wire. It tells, therefore, of fluctuations in output of the current generated in the human body. Specifically, as the apparatus is actually used in medical practice, the record has to do with currents of electricity being generated by action of the heart.

The patient whose heart is thus allowed to make a photographic diagram of its own action sits in an arm chair at a little distance from the apparatus, with an electrode attached to each wrist and to his left leg just below the knee. The metal electrodes are in direct contact with the skin, and a cloth saturated with salt water is wrapped about each wrist to insure better contact. All three electrodes are not in circuit at the same time, of course. It is obvious that there are three possible combinations: (1), between right arm and left arm; (2), between right arm and left leg; and (3) between left arm and left leg.

Three pairs of insulated wires lead from the patient's arms and leg to an apparatus beside the electromagnet, through the operation of which the operator, by turning a knob, can establish any desired one of the three possible circuits.

There must, of course, be a difference of potential between the different pairs of electrodes, else no current would flow. This difference in potential, as recorded by the shadow on the actual cardiogram, is measured in millivolts, or thousandths of a volt. The balance of potentials changes from moment to moment in cyclic manner, in response to the rhythmical activities of the heart; it is these changes, of course, that are recorded as zigzag tracings on the photographic film in unison with the fluctuations of current in the gilded thread that casts the shadow.

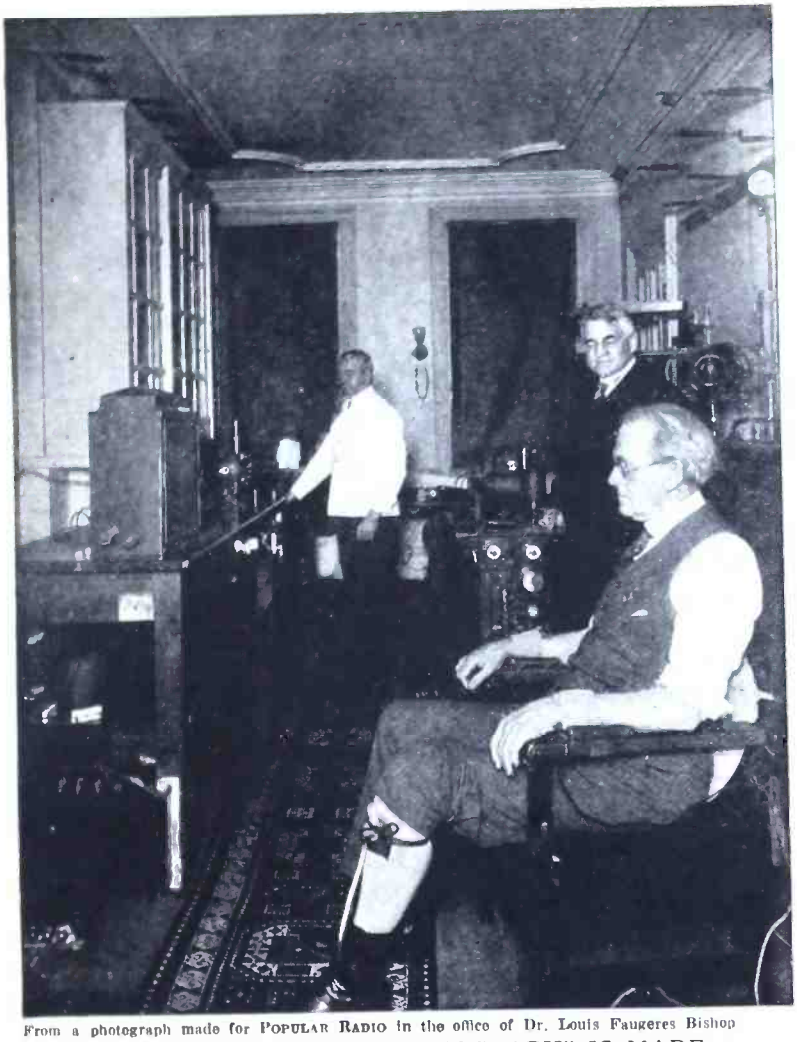
Between arm and arm the difference of potential is usually relatively slight, and between right arm and left leg there is usually somewhat less conspicuous variation than between left arm and left leg. Minor oscillations have significance and interest only for the heart specialist. It may be noted, however, that no fewer than thirty possible departures from the normal are listed, for all of which the heart specialist must keep an open eye in analyzing the electrocardiogram, although only a few departures will probably be found in the case of any individual record.

The particular item which concerns us most in the present connection is that which notes a "movement line due to nervousness or restlessness." This clearly suggests that an emotional state may modify the electrical current generated by the heart's action.

There is not the slightest question that such a supposition is valid. To illustrate the point, observe this electrocardiogram (Figure 1); it shows two quite different series of oscillations. When the first zigzag line was being registered, the operator, Mr. Bishop, watching the shadow of the gold thread on the disc, realized that something was wrong. He interrupted the action of the apparatus to interrogate the patient. She replied that she was solicitous about the safety of her jewels, which she had left in her purse in the dressing-room. She had heard steps in the hall, and feared that the person who had gone toward the dressing-room might purloin the jewels!

That explained the anomaly. The jewels were sent for, the session was resumed, and the shadow now oscillated normally, producing the second and quite different series of lines shown by this electrocardiogram.

Such modification of currents from the cardiac generator are frequently observed by the expert who operates the electrocardiograph. The origin of the modification may be physical discomfort, or (as



From a photograph made for POPULAR RADIO in the office of Dr. Louis Faugeres Bishop

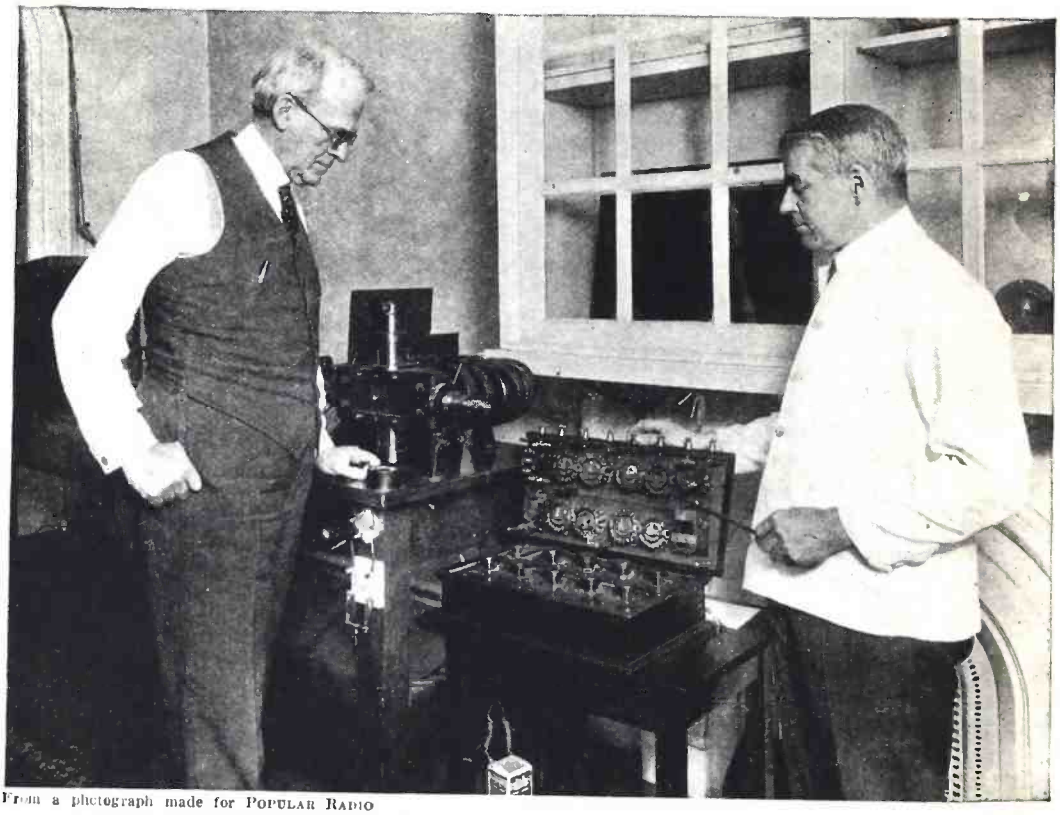
HOW AN "ELECTROCARDIOGRAPH" IS MADE

The experimenter is in the position occupied by a patient during the taking of an electrocardiogram. Electrodes are adjusted to the wrists and left leg to complete the three alternative circuits. The electromagnet in front of the operator shows the location of the "gilded-string galvanometer," the shadow of which is thrown on the white disc beyond by a beam of an arc light. Six-volt storage batteries, like those used in the radio receiver, are used to operate the apparatus.

in the case just recorded), a purely mental departure. It is possible to produce modifications by an effort of will, in case of a patient of good powers of mental concentration.

At first blush, this might seem to imply that in such case measurement has been made of modifications of electrical current directly associated with mental processes—the equivalent of brain activities. But a moment's reflection shows that such an inference is not justified. All marked mental and emotional changes are reflected more or less in modifications of cardiac action; and it is the modification of heart action that directly changes the electrical potentials. It is reasonable enough to assume that there are electrical phenomena directly associated with the changing brain activities; but if existent they have not hitherto been differentiated from the changes demonstrably due to modified heart action.

The essential point, however, is that



From a photograph made for POPULAR RADIO

HOW THE "ELECTROCARDIOGRAPH" WORKS

By adjusting the resistances of the electromagnet, the current is stabilized and extraneous currents are shut off, thus regulating the voltage of the cardiac currents.

electrical currents generated in the human body are registered graphically by the electrocardiograph. It remains to inquire whether the apparatus, as usually employed or in any modification, can be made to differentiate more accurately between electric currents originating in different parts of the body—leading up, of course, to the really salient question as to whether we can gain any clues to direct modification in the electrical output of the brain mechanism itself in association with modified mental states.

This is a problem which I have discussed with Dr. Louis Faugeres Bishop, the New York heart specialist, and his brother, Dr. Bennett Bishop, and for which we are trying to find a tangible answer. Dr. Bennett Bishop has taken electrocardiograms of more than four thousand consecutive cases in recent years, supplemented in many cases with notes that throw interesting side-lights on the problem of electrical response to brain activities. But, as already suggested, these records cannot by themselves furnish unequivocal testimony, for the electrical current in evidence must be assumed to be always chiefly of cardiac origin.

It is a fair presumption that currents developed in other organs would be far feebler than those developed by action of the enormously powerful heart muscles.

On the other hand, it is a valid assumption that there must be an electrical accompaniment of the action of all bodily tissues; since, according to modern theory, all chemical action is essentially electrical action. Every organ of the body must be in effect an electrical battery. And no one who had thought much on the subject is likely to doubt that electricity plays a larger role in the living

organism than has usually been ascribed to it.

Many radio workers, including some not without knowledge of physiology, have been astonished to learn that the human body has appreciable electrical "capacity," and that its store of energy cannot be disregarded when dealing with the sensitive radio receiver. Every radio expert knows that the operation of a delicately adjusted regenerative circuit may be radically modified by approaching the hand to the apparatus. Many novices have amused themselves by "playing tunes" on oscillating tubes by light manipulation with the fingers.

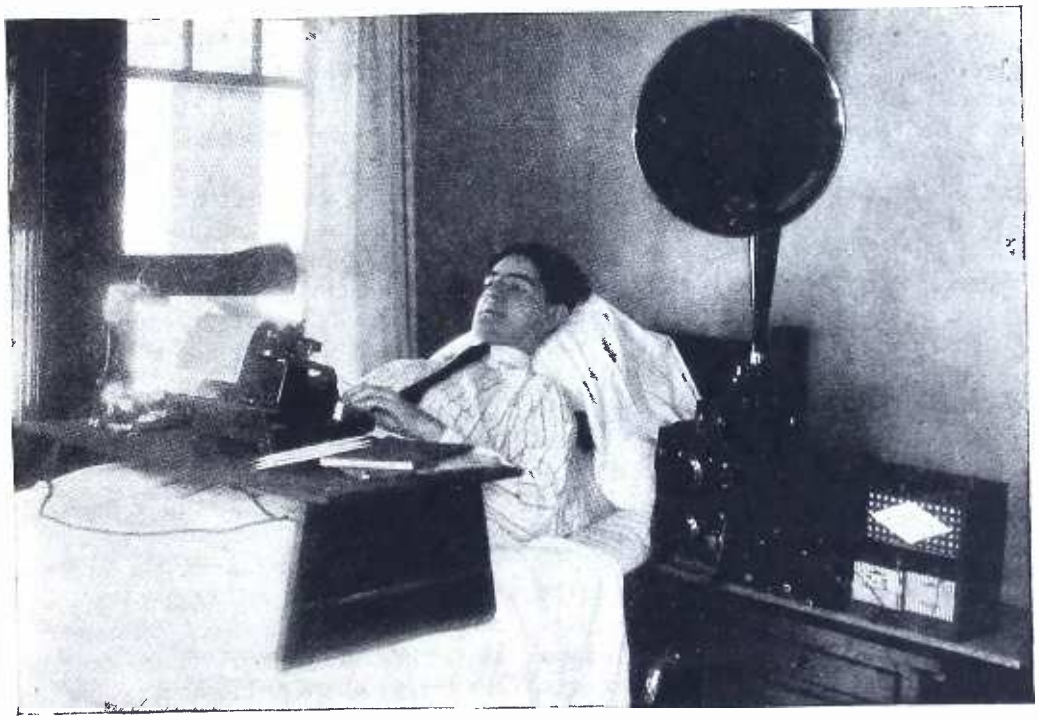
Incidentally, it may be noted that the tube thus heterodyned may send its messages out along the receiving antenna, which now becomes a transmitting antenna as well, to the exasperation of other operators of receivers in the neighborhood.

Obviously, then, the human body is a condenser of not insignificant capacitance.

We must recall, however, that electricity thus stored in the body is not all, of necessity, generated in the bodily tissues. The charge may come from without. When, on a cold day, you scuff your feet along the carpet and then light a gas jet with a spark from your finger, or "draw" visible sparks from the steam radiator or water faucet, you have obviously generated by surface friction the charge for which your skin acts as condenser.

We are almost constantly charging our bodily surfaces by frictional contact with various objects, but we are even more incessantly developing electricity from within. Our bodies are, in effect, living radio apparatuses—having inductance and capacity, with local sources of electrical supply.

It has been shown that the body may act as an aerial on occasion, when connected with an ordinary radio receiver. Why, it may be asked, may it not act as



A. J. DeLong

WHAT EFFECT WILL BROADCAST PROGRAMS HAVE ON INVALIDS?

The mental attitude of a patient is an important factor in his treatment. That radio may influence it "suggests unexplored possibilities in hospitals and other institutions, for diversional and even perhaps curative effects," states Dr. Williams.

an aerial when it is not so connected?

The question has implications that are rather startling. It seems to suggest the possibility of direct transfer of energy from one person to another through ethereal channels hitherto unrecognized—or at least not recognized by those of us to whom the evidence for the existence of what is called telepathy, as hitherto presented, is altogether unconvincing.

May it not be that there is some form of energy radiated from the human body during the chemical action in the brain accompanying the process of thought, that there is more than "mere words" exchanged between two persons in conversation. This may be some form of radiant energy.

And after all there is no reason why one should find the suggestion disconcerting. It might rather be said to be, reasoning from analogy, in line with what one should *a priori* expect. For there is no question at all that certain lower organisms are provided with radio apparatuses, operated by their vital tissues. I refer to the numberless instances in which animals appear to exercise a "sixth sense," to the bewilderment of human observers; and, more specifically, to the fact, as chronicled by Professor Jacques Loeb, that a butterfly may come directly to its mate, obviously under some guiding influence, when the mate is securely shut up in a cigar box by an open window in a room.

If that observation is not accepted as conclusive evidence, it is necessary only to point to the case of the fire-fly and the glow-worm. These insects develop radio currents of high frequency, for the electromagnetic waves they send out are visible light waves. And such waves, be it recalled, are universally admitted by physicists, since the time of Clark Maxwell, to be one in kind with the longer oscillations that we now call radio waves.

It is not mere fantasy, then, but a matter of established and even familiar fact, to say that certain lower organisms carry with them radio-transmitting apparatuses, operated by the vital activities of their own tissues.

Therefore it is not fantastic to suggest that human organisms also may retain this function in modified form. It is not fantastic—but neither is it an assumption to be accepted as proved by mere reasoning from analogy. The vital question is: Can we secure tangible evidence of the existence of such a capacity?

That is the ultimate issue that lies back of the problem which Dr. Bishop and I are preparing to investigate.

My own interest in the matter was stimulated by certain observations in connection with the use of the high-frequency current (the same current that generates radio waves) in the treatment of patients in my office; and by theoretical consideration and practical observation of the electron tube, or triode, which is admittedly a new instrument of precision of unexampled delicacy.

Until recently electricity has played a minor role in practical medicine. It is destined, I believe, to become an agent of the utmost significance. And the transition will be effected, I strongly suspect, through studies connected with apparatus made available by the radio engineer. For no available apparatus except the triode has the qualities of sensitive response and amplifying power that are indispensable for the effective investigations of electrical currents of such tenuousness as those which we must assume are associated with the operation of individual bodily organs, and in particular with the functioning of that organ of organs, the brain.

An implement which, in recently developed circuits, has proved capable of dealing with currents of the order of magnitude of the millionth of a microampere (the *trillionth* of an ampere!), may conceivably reveal to us secrets of the energy-phase of biochemical phenomena not less important than the physical secrets of histology and pathology revealed by that other wonder-working instrument, the microscope.

The School Teacher Who Harnessed a Darning Needle

MAKERS OF MODERN MIRACLES—NO. 2

The True Story of Joseph Henry, Long an Obscure Scientist, Who Laid the Foundation for Radio with Experiments on Which the Modern World of Electricity Largely Rests

By THOMAS COMMERFORD MARTIN

IF it were not for a common metal darning needle, laboriously wrapped about with a wire insulated by bits of silk picked from a waste bag as far back as 1827 by an obscure school teacher, it is not only possible but probable that radio, as we know it today, would be a phenomenon yet to be discovered.

The world has a habit of praising a man who blows away the last veil of obscurity surrounding some scientific fact —and of forgetting the pioneers who blazed the trail in the years that went before. Everyone knows Marconi and Tesla; De Forest's name is a byword in thousands of homes; the "Armstrong Circuit" is spoken of as we have become accustomed to speak of the Pullman car. But who knows Joseph Henry and his early experiments with the darning needle?

It is too much to say, perhaps, that Joseph Henry and his darning needle started the wireless ball rolling, yet his efforts have a peculiar significance in studying two later luminaries of the radio world—Hertz and Maxwell.

The modern radio fan is apt to think that electric wires are grown with insulation on them and must be "skinned" if they are to be used bare. It is hard for him to think that insulation had to be invented. Yet it was this simple invention, and methods which now seem as simple, that helped Henry to discover the nature of the oscillatory spark discharge essential in wireless.

Henry spent his youth in the public library at Albany, N. Y., where he surreptitiously read the popular fiction of his day. His most ardent desire was to become an actor; for some time he was sharing in the amateur theatrical performances of his neighborhood. Then a series of popular lectures on scientific subjects attracted his attention and his interest in the theater waned.

It was at the famous old Albany

Academy that Henry did the earlier part of that experimental work which he continued with brilliancy at Princeton, and which made him the worthy peer of Faraday as the contemporary discoverer of the principles of electro-magnetism, upon which all the modern electrical arts and industries are based. There was much in common between the two men and they became friends. The Englishman had no mathematics; the American became a mathematical professor; with unlike methods of approach they were both passionate devotees of physical research in novel fields with results fruitful for the benefit of mankind.

The wonder is that Henry ever found time to do the monumental work that placed him so conspicuously in the Hall of Fame. The Albany Academy, once dubbed a "college in disguise," began its courses lowdown when the young professor took hold in 1826. He had to teach seven hours a day; half that time he drudged with a large class of boys in the elements of arithmetic. Some of his classes met at 6 o'clock in the morning. It is marvelous that Henry found any time at all for the researches and experiments that made him a commanding figure in science. The room he used as a laboratory was only at his disposal during vacation; moreover, his financial resources were utterly inadequate. His contemporary, Faraday, on the other hand, enjoyed all the resources of the Royal Institution in London. Just what the spare cash of inpecunious Henry was may be inferred from the fact his professional salary was only $83 a month.

In his room at the Albany Academy Henry strung up a fifth of a mile of wire. Here he developed the electro-magnet, which paved the way for inventions more directly connected with radio. He shares the honor of inventing the magnet with Sturgeon and with Michael Faraday, who made experiments which ran more or less parallel with his own.

By carefully wrapping his wire in silk and winding it around an iron core, Henry developed electro-magnets which performed unusual feats when they were energized by a primary battery that contained only 2/5ths of a square foot of zinc surface and that required only a half-pint of diluted sulphuric acid for its submersion.

He had been making magnets for five years and earning only $250 a quarter when he wrote in *Stillman's American Journal of Science* for January, 1831:

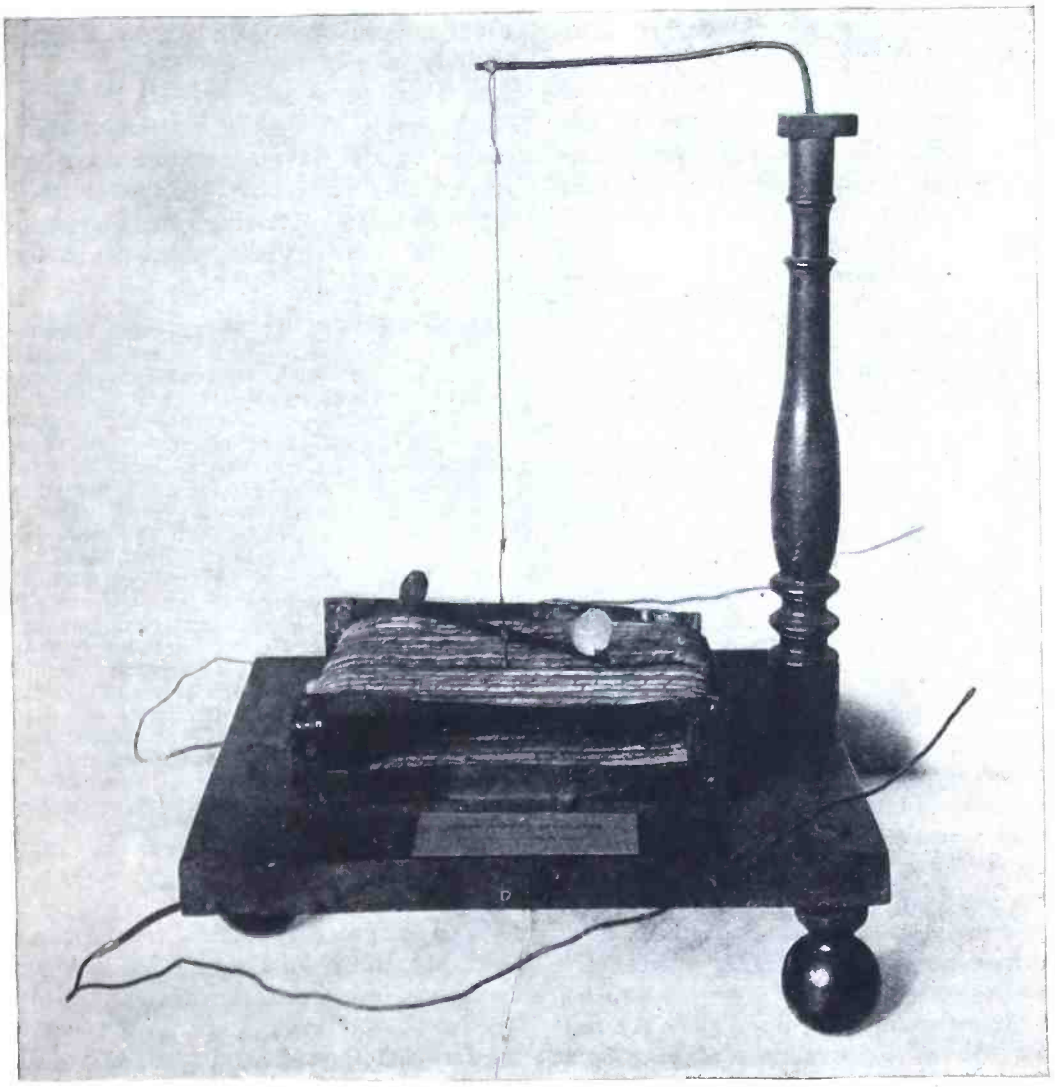
"Our new magnet weighs 21 pounds and lifts more than 35 times its own weight. It is probably, therefore, the most powerful magnet ever constructed."

By winding several insulated layers of wire around his iron core he produced at least a hundred times more magnetism than had Sturgeon with a similar battery and a single layer of wire on an electro-magnet of equal size and weight. A short time later, Henry made an improved type of magnet for Yale University; it weighed 82½ pounds and lifted 2,300. Later he made a magnet for Princeton University which lifted 3,000 pounds. By suddenly reversing the current through it he astonished his pupils by causing the magnet to drop its armature and seize it again before it had fallen beyond the sphere of attraction, thus demonstrating the principle which is employed in every stroke of the neutral relay of the quadruple telegraph of today.

Soon Henry found a way to make the armature of a magnet tap a bell at a distance of nearly half a mile, developing the principle which made possible the Morse telegraph.

He refused to take out a patent for his device, although he had the fundamentals of the electric telegraph in actual operation, "because he did not think it consistent with his position as a scientist." For this reason, the patent office, the "graveyard of buried hopes," has no record of his early work.

Ten years later, Samuel F. B. Morse patented the first telegraph and secured a money grant from Congress with which



THE FIRST GALVANOMETER EVER MADE

Its inventor built it merely to demonstrate a scientific truth; neither this device nor its companion, the electromagnet, were thought to have any commercial value. Yet the withdrawal today of the property developed from these "toys" would paralyze all civilization.

to complete his experiments. To quote this modest Henry himself:

"The principles I had developed were applied to render Morse's instruments effective at a distance."

The discovery of the "extra spark" led Henry directly into the realm of radio. In his own words, "A wire coiled into a helix gives a more intense spark than the same wire uncoiled, and a ribbon of copper coiled into a flat spiral gives a more intense spark than any other arrangement yet tried." Such a flat spiral is used today in the oscillation transformer of radio stations.

Henry was first to note and record the oscillatory nature of the discharge from a Leyden jar, or (as we call it now) a "condenser." He knew the condenser to be a storehouse for electrical energy, the charges of electricity attracting and holding each other on the two conducting plates of metal which are separated by glass, air or other insulation.

His darning needle, which had served as a galvanometer, he placed inside a coil of wire through which he caused the stored energy of the condenser to flow. The needle was magnetized each time—but not in the same manner. He noted that sometimes the point would be the north pole and at other times the south pole. This simple truth he discovered by hanging the needle up by a fine thread and letting it swing like a compass needle.

"The phenomena require us to admit," Henry wrote in 1842, "the existence of a principal discharge in one direction and then several reflex actions backward and forward, each more feeble than the preceding, until equilibrium is obtained."

He had discovered radio frequency.

There could be no radio communication today without this fundamental principle. Even in those early days, Henry saw the principle clearly. He realized that there was tension on the plates of the condensers which drew the unlike charges of electricity together and he understood that at the first discharge more of the charges rushed from one side than were needed to neutralize the condenser and that consequently some of the charges had to rush back and forth thousands of times in an instant until the condenser plates were neutralized.

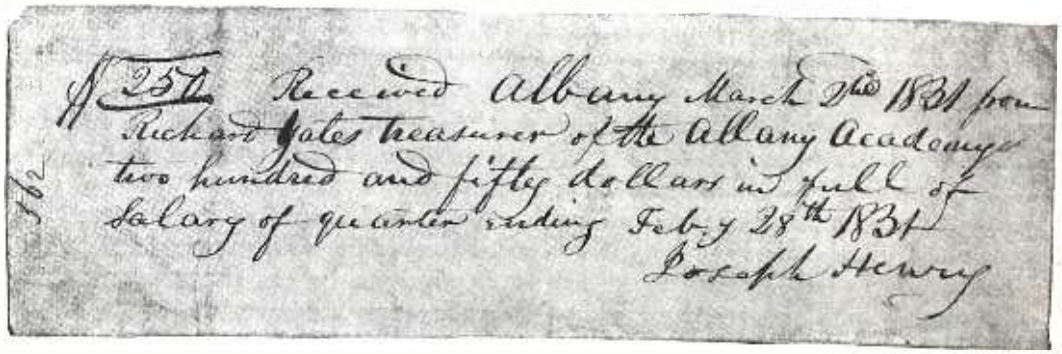
Henry went about developing the next essential of radio almost at once. He found that an electrical current could exert a peculiar influence at a distance entirely without the use of wires. This was what is now so commonly known as "induction"—the same property which causes a radio wave to produce a current in a distant antenna and so make itself heard in a radio receiving set. His statement is a recognized landmark in the history of science:

> "In extending the researches, a remarkable result was obtained in regard to the distance at which induction effects are produced by a very small quantity of electricity.
>
> "A single spark from the prime conductor of a machine of about an inch long thrown on to the end of a circuit of wire in an upper room produced an induction sufficiently powerful to magnetize needles in a parallel circuit of iron in the cellar beneath, at the perpendicular distance of 30 feet, with two floors and ceilings, each 14 inches thick, intervening.
>
> "The author is disposed to adopt the hypothesis of an electrical plenum (ether) and from the foregoing experiment it would appear that a single spark is sufficient to disturb perceptibly the electricity of space throughout at least a cube of 400,000 feet capacity; and when it is considered that the magnetism of the needle is the result of the difference of two actions, it may be further inferred that the diffusion of motion in this case is almost comparable with that of a spark from a flint and steel in the case of light."

"Comparable it is indeed," is the comment of Sir Oliver Lodge, "for now we know it to be the selfsame process."

Henry's bed-rock experiments were used as the foundation of radio.

Lodge's experiments in resonance phe-



THE REWARDS OF GENIUS

At the very height of his career, when Henry was making experiments of the most far-reaching value to mankind—experiments that mark the beginning of modern radio—he was earning but $19.23 a week, or about as much as a competent office boy gets today. (The original paper is owned by T. C. Martin).

THE FATHER OF ALL ELECTROMAGNETS

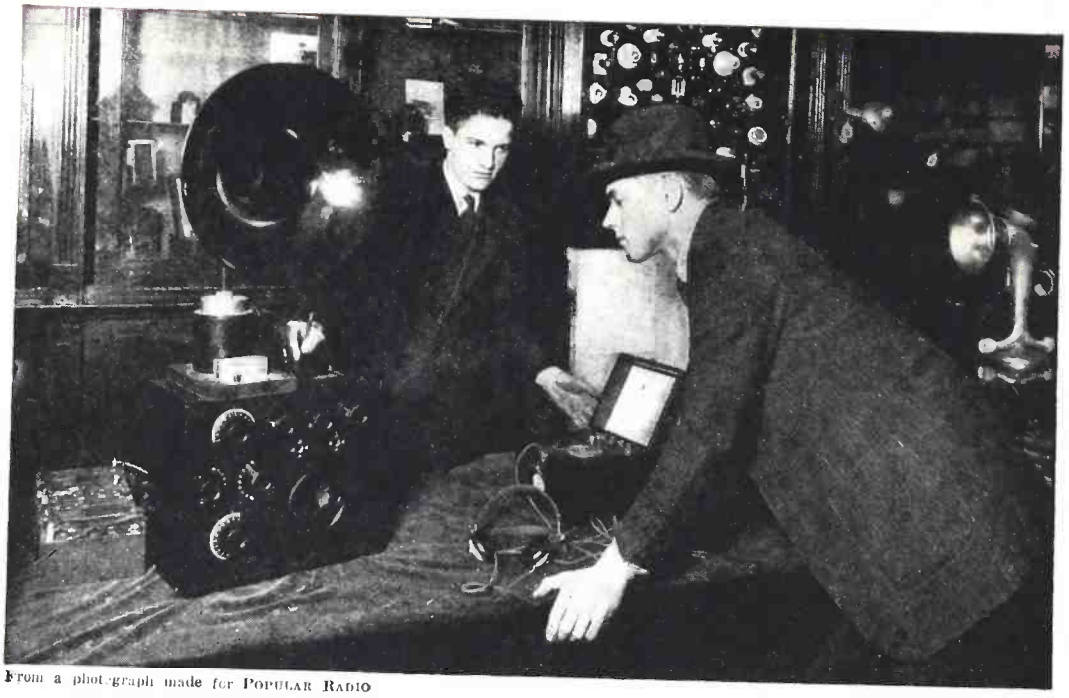
This famous relic—now preserved at Princeton University—was the first instrument made to generate a current of electricity in a coil of wire. These coils were wound by hand by the inventor, Joseph Henry.

nomena developed the wave theory. He found that by using two Leyden jars or condensers of the same size and by employing similar lengths of wire to connect the plates, a discharge from one would produce a sympathetic discharge from the other. He discovered the process now known as "tuning." This first receiving set was crudely tuned to resonance quite as modern radio sets are tuned with condensers and other helping devices.

Henry's work was taken up by Heinrich Hertz, a professor at Carlsruhe, in 1886. By studying Henry's "extra spark" and the nature of discharges from condensers, he was able to resonate the waves given off and to cause interference between waves, thereby proving conclusively that such waves existed. In his honor, they are called "Hertzian waves," and are the same electrical disturbances which make modern radio possible.

All inventors connected with radio now give Henry a good share of credit for the work they are able to do; he is now universally acknowledged as a pioneer in the new science.

Henry lived long enough to be hailed as a genius and a prophet. The boy who was once apprenticed to a silversmith became a professor at Princeton University and was later placed in charge of the Smithsonian Institution. And in recognition of his achievements the unit of inductance has since been named the "henry."



From a photograph made for POPULAR RADIO

Should he spend $20—or $300? Should he choose a crystal set—or a tube set? Should he buy headphones—or a loudspeaker? What facilities has he for putting up an antenna—and what kind of antenna should he have? This article tells the first-time buyer how to settle these problems himself.

WHAT KIND OF RECEIVING SET

Should I Buy?

Pointed Questions That Every Layman Is Asked When He Starts Out to Select His Equipment, Questions That He Must Decide Before He Makes His Purchase, Here Answered by

EDGAR H. FELIX

THE uninformed layman who selects and purchases instruments for his radio receiver is about as likely to make a wise choice as a Hindu poet attempting to outfit an Arctic expedition.

He is offered the choice of an extensive line of apparatus, each piece of which seems to have certain specified technical merits. Only a few of the instruments are essential, although many others are highly desirable, if the buyer can afford them; but he does not always know this, and after a few minutes of demonstration is lost in a maze of indecision.

Despite the diversity of radio equipment on sale, only a little knowledge is required to make a sensible and economical purchase with due regard to the buyer's financial limitations. The important point is to know exactly what is wanted in the way of results and to watch for defects in construction which are obvious if they are pointed out.

The answer to the layman's general question, "What kind of set should I buy?" may best be answered by a consideration of what he wants his set to do —the service he expects from it

1

"How Loud a Signal Do You Want?"

This is usually the first question to be decided. If the buyer can pay the price he can receive music from a broadcast station more than a thousand miles distant and make it audible for a block or two from his house. On the other hand, a salesman may state truthfully that a certain station can be heard at a certain distance with a particular set, yet that signal may be so weak that it will be drowned out by the ticking of a watch.

The question of signal strength is not hard to settle. It is determined by four factors:

The distance from the transmitting station;
The size of the antenna;
The type of detector used;
The amount of amplification to which the detected signal is subjected.

If the buyer is content to lounge comfortably in a chair with a pair of earphones on his head and is satisfied if but one or two persons may listen in at a time, signal strength of the order obtained on a crystal set or vacuum tube detector set will be sufficient.

But if he wants to dance to radiophone music, or if he wants to make concerts audible to as many persons as he can accommodate in a room, or if the buyer is bothered by the prospect of wearing a receiver on his head for several hours each evening, instruments will be needed which produce much greater signal energy. This must be sufficient to operate a loud-speaking horn, and except for short distances an amplifier is necessary. Provided money enough is spent, a signal can be amplified to practically any degree of strength.

Of course, the distance from the transmitting station is a fixed quantity.

The type of receiver essential to obtain signals of sufficient loudness for head telephones and the type for operating loud-speakers for various distances from the transmitting station can be determined after reading further points discussed in this article.

2

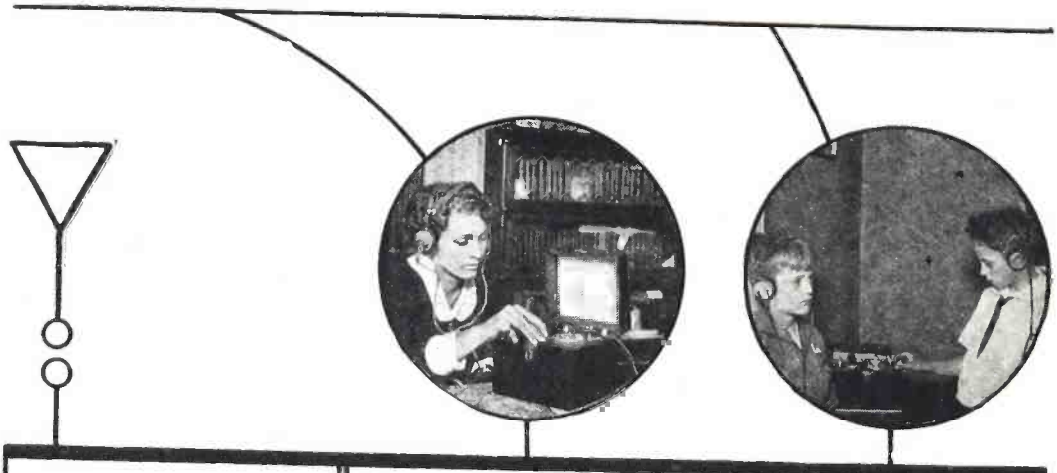
"What Size of Antenna Can You Use?"

The size and design of the antenna partly determine the amount of energy which is collected to actuate the receiver, just as the distance from the transmitter determines the amount of energy available.

In general, the longer the antenna the greater the energy received. For receiving purposes many wires are not essential; a single wire is practically as effective as four parallel wires of equal length, and it is easier and simpler to erect. A one-hundred-foot antenna may be considered an average length. In some cases, by increasing the length of a fifty-foot antenna to two hundred feet the signal strength is increased to the same degree as by one stage of amplification. Hence the longer it is practical to make an antenna up to two hundred feet, the louder the signal obtained.

The natural wavelength of an antenna —that is, the wavelength to which it responds without the addition of tuning apparatus—is roughly proportional to its length. For the reception of broadcast music on a wavelength of 360 meters, a one-hundred-foot antenna may be connected directly to the receiving apparatus. A longer antenna requires an artificial means of shortening its natural period or wavelength. This is accomplished by means of a variable condenser inserted in the ground connection or lead-in. With such a condenser, the concerts broadcasted on 360 meters can be heard on antennas of two hundred feet or longer.

When the lead-in to the receiving set is taken from one end of a single-wire antenna, greater energy is received from stations in the direction from which the lead-in is taken. The single-wire antenna may thus be considered as an arrow, with its head or point at the end where the



TYPE OF SET	(A) CRYSTAL SET	(B) SINGLE TUBE SET
DISTANCE RANGE	10 TO 30 MILES	30 TO 75 MILES
COST TO INSTALL	$20.00 TO $30.00	$45.00 TO $60.00

The five receiving sets pictured on these two pages will serve your purpose—provided you

lead-in is taken. This directional effect is marked and should be taken advantage of by pointing the aerial so that maximum energy is received from the most desirable broadcast station.

Signals received on indoor ærials usually require considerable amplification: *First,* because the indoor antenna is limited in size; *secondly,* because some of the energy is absorbed by steel girders or other metal parts of the building in which they are located. For these reasons, outdoor antennas are recommended.

Indoor antennas are of two types, loop and flat top.

The loop antenna consists of a number of turns of wire mounted on a frame (usually one to three feet square), so arranged that the loop may be rotated on a horizontal axis. A loop has strong directional characteristics, hence interference from stations in directions other than that at which a desired station is located may be reduced or eliminated. But the loop antenna collects so little energy that many stages of amplification are necessary to make a signal of strength equal to that obtainable from a long single-wire outdoor antenna—and amplifiers are costly.

An indoor flat-top antenna consists of one or more wires stretched through the greatest available length.

If an indoor antenna is long enough and located high enough in a building, it may approach the efficiency of an outdoor antenna of equal length, provided the absorption from the steel framework of the building is not too great.

3

"What Detector Will You Choose?"

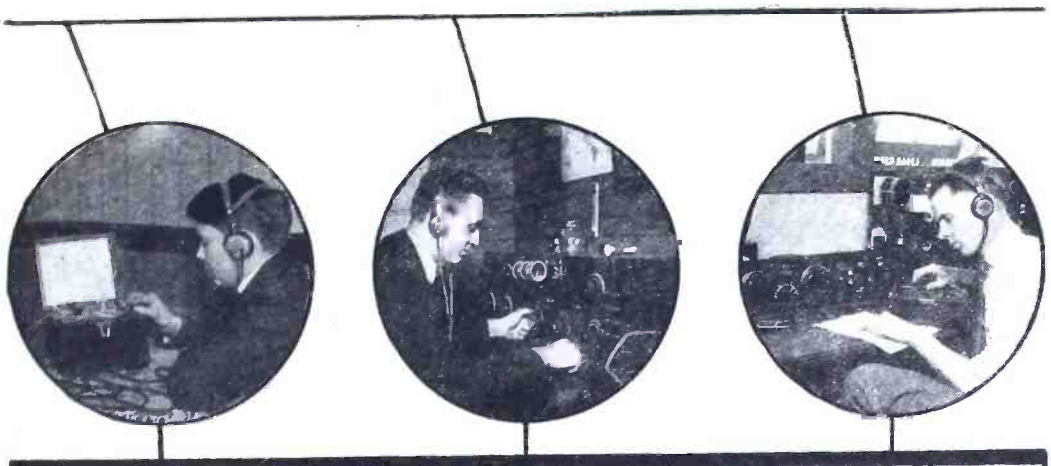
Receiving sets may be classified thus:

Those that employ crystal detectors;

Those that employ a vacuum tube as detector;

Those that employ a vacuum tube detector with a regenerative circuit.

The crystal detector is the least expensive type. For short-distance work, it gives a satisfactory signal in the telephones. The vacuum tube detector is more



(C) SINGLE TUBE REGENERATIVE SET	(D) REGENERATIVE SET WITH SINGLE-STAGE AMPLIFIER	(E) REGENERATIVE SET WITH TWO-STAGE AMPLIFIER
75 TO 200 MILES	200 TO 500 MILES	500 TO 1500 MILES
$60.00 TO $80.00	$80.00 TO $100.00	$125.00 TO $175.00

are content to use headphones that will permit only one or two persons to listen in at a time.

expensive but it is a much more stable device and gives a signal approximately twice as loud as a crystal detector.

The vacuum tube detector employed with a receiving set that uses a regenerative circuit is still more sensitive, although it requires greater skill in adjustment. The degree of regeneration is determined by the adjustment of the tickler or regeneration control. If too great a degree of regeneration is employed the quality of the received music will be distorted, and if a still greater degree is used the music will be entirely destroyed. But a set in this condition (it is then acting as an oscillator or transmitter) is capable of receiving C. W. (continuous wave) telegraph signals, which require ability to read the Continental code for interpretation.

One stage of amplification makes a faint signal comfortably audible in the receivers. A second stage makes such a signal loud enough to hear all over an average room. Hence, if the antenna does not pick up enough energy to give a comfortably loud signal, an amplifier solves the difficulty. Also, if a signal is received sufficiently loud so as to be heard easily with receivers, and it is desired to have it audible throughout a room, an additional step of amplification is necessary.

4

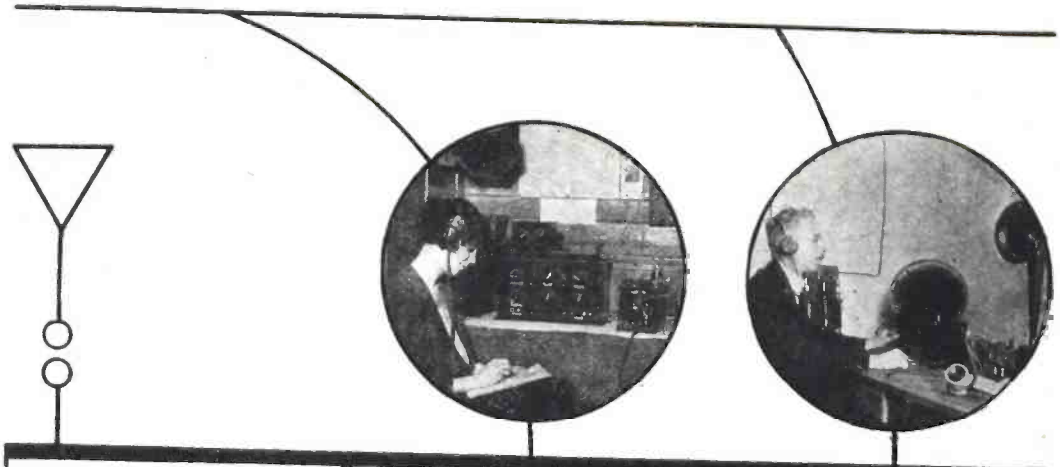
"How Far Are You from a Station?"

Assuming that the antenna is of average length, say one hundred feet, the buyer can then decide just what is necessary for him to purchase to receive broadcast programs from a transmitting station located at a given distance.

For distances up to twenty-five miles, using head telephone receivers, a crystal detector and simple tuner are sufficient.

A vacuum tube detector instead of a crystal detector permits the use of four or five telephone receivers at the same time.

A vacuum tube detector with a receiver of the regenerative type makes a signal loud enough to be audible through a small room, when projected through an amplifying horn. The addition of a one-



TYPE OF SET	(F) TUBE SET WITH SINGLE-STAGE AMPLIFIER	(G) REGENERATIVE SET WITH SINGLE-STAGE AMPLIFIER
DISTANCE RANGE	10 TO 30 MILES	30 TO 200 MILES
COST TO INSTALL	$65.00 TO $80.00	$85.00 TO $100.00

The five sets pictured on these two facing pages are provided with loudspeakers—which will

stage amplifier to this equipment produces a signal audible through a room.

For distances up to fifty miles, a vacuum tube detector is essential to a clearly audible signal. A regenerative circuit increases the range of reception up to 200 miles. A regenerative receiver and one-stage of amplification increases the range for reception from broadcast stations up to 500 miles, and a second stage of amplification brings the range up to 1,000 miles.

In each of these cases an additional stage of amplification brings the signal to sufficient audibility to be heard throughout a room of average size when the signal is projected through a loud-speaking horn. However, it is not advisable to use more than three stages of audio frequency amplification.

5

"Will Interference Trouble You?"

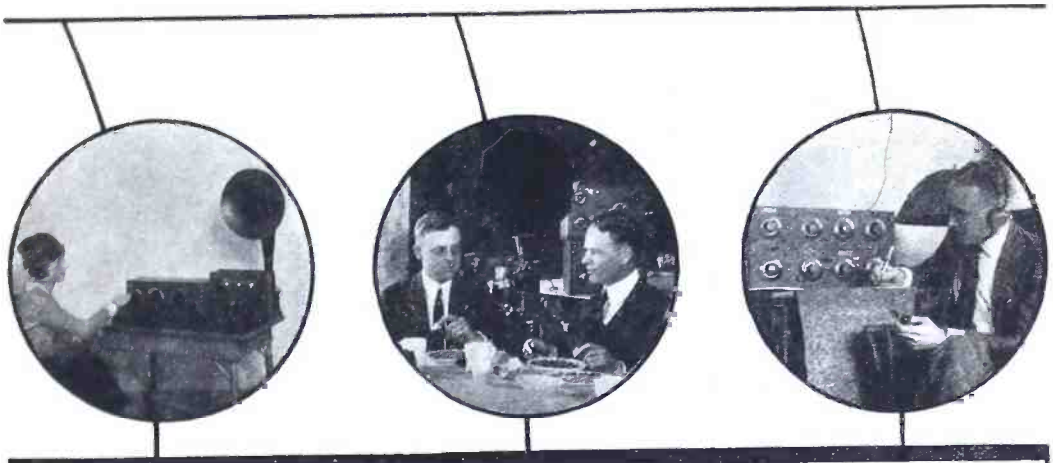
The next point to be decided by the buyer is the selectivity required of his receiving set.

The selective quality of a receiving set is determined by the circuit employed. In general, there are two types: Single-circuit receivers, in which the energy is delivered to the detector direct from the antenna circuit; and two-circuit receivers, in which the antenna is coupled to a secondary circuit tuned to the same wavelength as the antenna circuit, the detector taking its energy from this secondary circuit.

A single-circuit receiver is simple to operate. There is only one adjustment to be made to vary the wavelength to which the receiver responds. But it is not always possible to eliminate a spark station with a single-circuit receiver.

Some two-circuit receivers have been designed, which combine the selectivity of the two-circuit receiver with the simplicity of adjustment of the single-circuit receiver. In such sets, the coupling between the primary and secondary circuit is fixed and the tuning of both primary and secondary circuits is effected simultaneously by a single control knob.

More complicated circuits, such as used by the amateur relay stations, have four



(H) REGENERATIVE SET WITH TWO-STAGE AMPLIFIER	(I) TWO-STAGE RADIO-FREQUENCY SET WITH TWO-STAGE AUDIO-AMPLIFIER	(J) THREE-STAGE RADIO-FREQUENCY SET WITH TWO-STAGE AUDIO-AMPLIFIER
200 TO 500 MILES	500 TO 1000 MILES	1000 TO 1500 MILES
$175.00 TO $250.00	$200.00 TO $275.00	$275.00 TO $300.00

fill a room or an auditorium with sound. No headphones are needed with this equipment.

controls for tuning. One controls the wavelength of the antenna or primary circuit; the second controls the coupling between the primary and secondary circuit; the third controls the wavelength of the secondary circuit; and the fourth the amount of regeneration.

These circuits require skilful adjustment, but with a set so designed interference can usually be eliminated by trying various degrees of coupling and then retuning the primary and secondary and tickler controls.

6

"What Apparatus Can You Afford?"

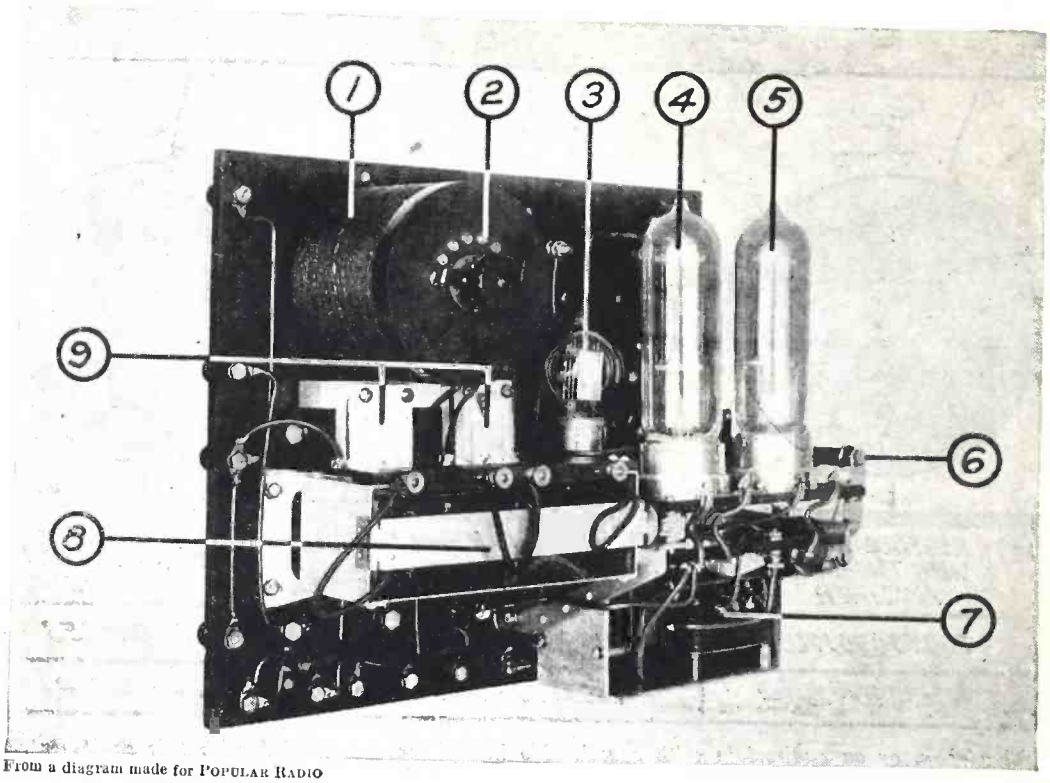
In selecting receiving equipment, a buyer unversed in the radio art is more or less dependent upon the reputation of the dealer who sells and the manufacturer who builds the apparatus selected.

However, certain mechanical defects that are easily detected if the buyer is forewarned should decide him against an instrument possessing them, despite any claims made by the salesman for its electrical efficiency.

In a well-made set, the control knobs work smoothly and easily and with uniform resistance throughout the scale. The dials run true and do not scrape the panel at any point. There is no play in the bearings of the instruments; they cannot be pulled in and out. The lettering is etched in and not merely painted on the surface of the panel. The panel is usually made of one of the synthetic-resinous compounds. The vacuum tubes are accessible and mounted on non-vibrating supports. All wiring is secured firmly in place, soldered at each connection and binding post. All the units in the cabinet are firmly attached to the panel and are readily inspected.

After this beginning and the first enjoyment of listening in, the layman may, and usually will, delve further into the mechanism of receiving sets. He is no longer a tyro.

The "distance range" specified on the charts that accompany this article are conservative approximations, and are intended only for a general guide.



From a diagram made for POPULAR RADIO

A Compact 100-Watt Transmitter

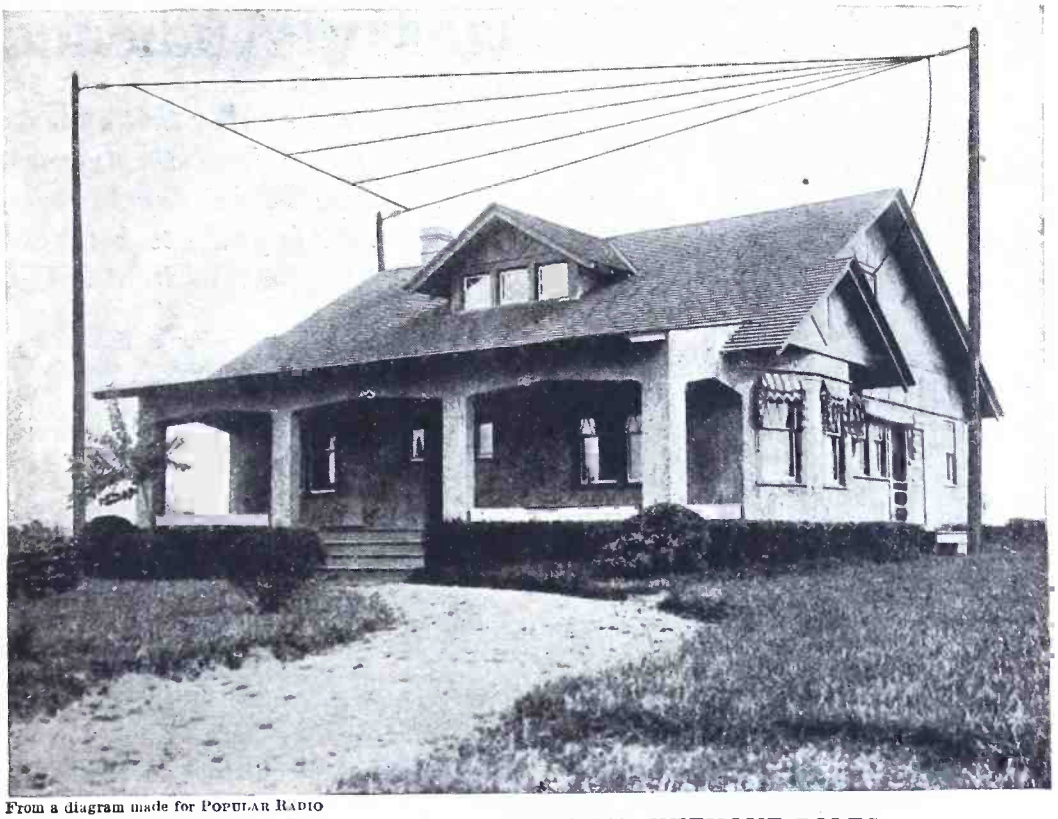
A NEW transmitter developed for the Signal Corps of the United States Army contains many points that will be of interest to the progressive amateur who builds his own apparatus; among them are its compactness and efficiency combined with ease of operation and simplicity.

The illustration on this page shows the inductance coil (1) which is wound with insulated wire and is remarkably small, considering the power that is used. The wavelength switch (which is shown at 2) is variable, so that eight different wavelengths may be used. The transmitting wavelength may be changed by turning the knob controlling the switch.

Three is a 5-watt vacuum tube used for speech amplification. The voice currents generated by speaking into the microphone are increased in strength by passing through the modulation transformer and the small-power vacuum tube. The amplified voice currents are then passed on to the large 50-watt vacuum tube modulator (4), which in turn is used to modulate the input to the oscillating 50-watt vacuum tube (5). In this way the voice currents are impressed on the high-frequency carrier-currents which upon being transferred to an antenna, cause Hertzian waves to be radiated, carrying the voice frequency along with them.

The grid leak (6) for the oscillator tube is mounted beside the tube. The compact assembly containing the modulation transformer, and the low-frequency and high-frequency choke coils is shown at 7. The small compartment for holding the batteries for keeping the grid of the modulator tube sufficiently negative is shown at 8. The two condensers used in the ground and grid circuits, are shown at 9, mounted under the coil. The plate and antenna meters for this set are mounted on the front of the panel.

The circuit used is an adaptation of the well-known Colpit's circuit, using Heising's constant current modulation scheme.



From a diagram made for POPULAR RADIO

THIS AERIAL COSTS ABOUT $11.00—WITHOUT POLES

Usually the wires are attached to trees or buildings, in which case there is no cost for antenna supports. The wire costs about $9.00 and the three insulators about 50 cents each.

An Inexpensive Antenna *for* All-Around Use

NO. 4; THE FAN TYPE

By DAVID LAY

THE fan-type of antenna may be used for either transmitting or receiving. It is rigid in construction and therefore especially suitable for use where the location is swept by strong winds, as there are no heavy spreaders used in its construction.

This type of antenna is less directional than the ordinary flat-topped antenna and for this reason is suitable for long-distance work in all directions of the compass.

The wider the fan is made, the less directional will be the reception or transmission. With a fan of 90 degrees the efficiency will be found practically equal in all directions from the station.

The support for the antenna consists of three masts (or other elevated structures) as shown in the above diagram. One of these masts is located at the lead-in end and the other two masts support the far end; these latter two supports are connected by a wire, to which is attached the ends of the three middle wires. The wires are all joined together and soldered at the lead-in end.

Only three insulators are necessary and no guy wires are used.

This type of antenna is simply constructed; it is efficient and at the same time economical in cost.

My Audience

"The main thing that appeals my release from the tyranny held me in bondage twenty no tailor is going to help put and not how I

IT was at a broadcasting station near New York that I recently saw the Professor. He had been a feature for years on various Lyceum circuits. I had crossed his trail in the Middle West and the Far West and in the little towns of Northern New York State, where lectures are featured every season. He was a veteran of many summer campaigns which had physically finished more brilliant speakers, who were unable to stand the combined discouragements of hard travel and bad cooking which the entertainer must face on the road. The Professor had been broadcasting his most popular story. I have no doubt that it went well among the army of listeners who generally

IT'S a little hard for me, this radio game, after so many years of the platform. I can't get over the idea that my audience is sitting somewhere, looking at me, just behind that disc into which I am talking. Consequently I go through the same motions that I have fallen into the habit of using on the platform. I gesticulate and smile at the customary time, and bow and scrape just as if those people were sitting out in front. That's the power of habit. Maybe I'll get over it as I continue this broadcasting. But the main thing that appeals to me among the possibilities of radio is my release from the tyranny of the dress suit.

This is all a defiance of the things that have held me enslaved. I am wearing my baggiest trousers and I did not shave this evening purposely. Just before I left home this evening, for instance, I opened the closet in which hangs my dress suit, and I laughed my harshest laugh.

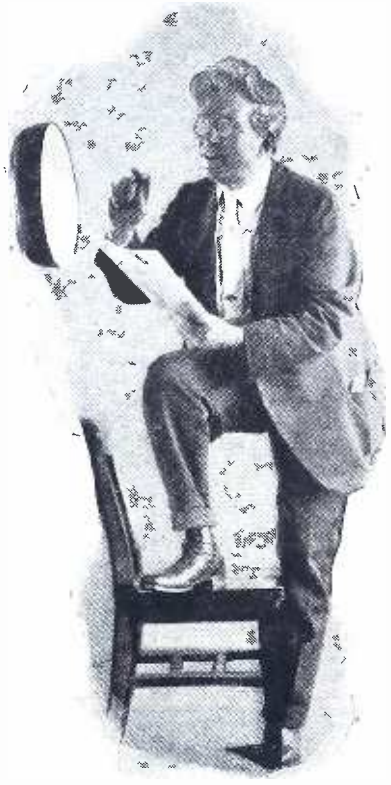
That dress suit has held me in bondage for twenty years. Every day during my career on the lyceum platform, I have trembled lest I should find myself unable to climb into those tyrannizing clothes in time for the evening program. You have no idea how important evening clothes are in such matters. At least they had become so with me. I found that a good appearance on the platform meant about thirty-five percent of my value. It was not flattering to my vanity to have to admit that the tailor and the shirt-maker could claim all the credit for my lyceum success, but I knew it to be true and I stared the facts honestly in the face and made a clothes horse of myself for the benefit of my income.

The clothes value ran higher in other lyceum cases. I know of men who are getting much larger contracts than I was ever able to demand, whose appearance

Beyond *the* Disc

to me in radio broadcasting is of the dress suit. That suit has years. On the radio circuit me across. It's what I say look that counts."

tuned their receivers to get the programs from this particular station. The Professor's shoes were not shined and the trousers of his business suit were bagged at the knees. His face might have been closer shaved, his hair might have been more neatly brushed. Altogether, he presented a marked contrast to the man's usual dapper appearance on the lecture platform, where I first knew him. And then I realized this: that the radio is changing the type of our popular performers. Appearance, gesture, stage presence, clothes no longer count and here is the first-hand account of how this change is taking place in a man who has long been a famous lecturer—and who, for obvious reasons, prefers to remain anonymous.—ARTHUR CHAPMAN



accounts for at least seventy-five percent of their success. By appearance, I mean when they are dressed as if headed for a box at the Metropolitan Opera House. People who hear such men speak are not able to remember anything particularly wise or witty that has been said, but they do recall that the speaker had a nice face or flashing teeth, or—most common of all—that he made a commanding figure in a dress suit. Such men are going to have a hard time of it when it comes to entertaining by radio.

I've had no end of struggles on account of the dress suits I've had to carry along. It has been a nightmare getting my dress shirts laundered, for one thing. If it was impossible to get any laundry, such a calamity always happened in a town so small that the merchants never carried dress shirts and consequently I could not get a new one. Getting my suit pressed was another bugbear. Many a time I have arrived in town half an hour before my time to appear on the program, and have dashed to my hotel, changed into my dress outfit, and rushed to the lyceum hall or tent just as the chairman was telling his last funny story in his effort to hold the impatient crowd.

Some of my traveling has been from town to town by auto. My wife has accompanied me on such trips and she has suffered for me and with me on account of the dress suit nuisance. Except for her aid I should have gone under long ago.

Sometimes, when bad roads have made automobile progress slow, the approach of the lecture hour has found us at an alarming distance from the platform, and gas given out or the machine stalled in the mud. We had a small sedan, and in it we covered part of Missouri and most of Iowa in the hottest summer known. Our car was specially equipped with

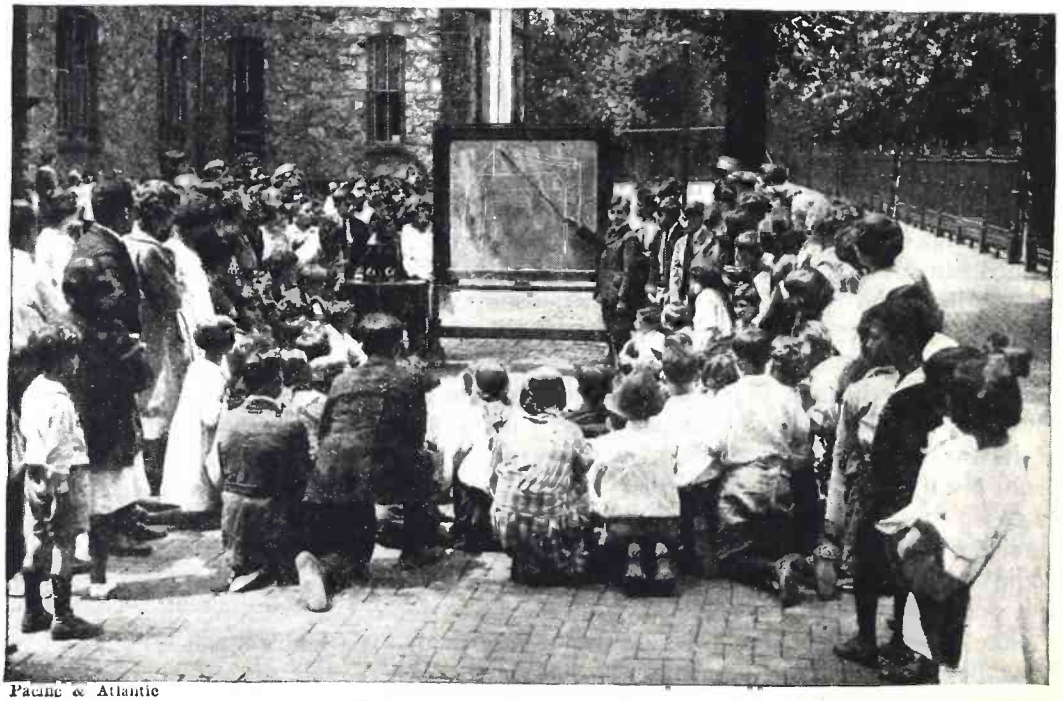
beds not unlike those in a Pullman, which made us independent of hotels. But I was not independent of that dress suit—not at all!

One evening we were racing for the little town where I was to fill my next engagement. I had shaved hurriedly while eating a sandwich and swallowing a cup of coffee from the meal which my wife had provided, gypsy fashion, at the roadside. But we were ten miles from town and I could not wait to change into that dress suit. We piled our cooking kit into the car and my wife took the wheel and stepped most decisively on the gas, while I climbed into the back of the sedan and lowered the curtains and proceeded to make the required change of clothing.

Getting into one's clothes in an upper berth of a Pullman on the crookedest railroad in the world is simple in comparison with changing into a dress suit in a small sedan while hitting it up on a rough country road to the limit of speed. I was thrown against the roof and against the sides of the car. One of these bumps cost me a slight cut on the cheekbone, which court plaster fixed, but alas! there was a sanguinary mark on my dress shirt. Nothing remained but to drag out another shirt and change into it. The change was effected just as we drove up to the lyceum tent. As I stepped out of that car, it required all my years of experience in control of my facial muscles to dissemble the thoughts that were crowding upon me in connection with the dress suit as an institution.

That's why I have seized upon the opportunities presented by the radio program. To be able to reach one's audience without a care for the formalities of dress—to be as natural and at ease in one's clothes as a Joaquin Miller—it's no small thing.

On the radio circuit no tailor is going to help put you across. It's what you say, and not how you look when you're saying it, that counts.



Pacific & Atlantic

THE WORLD'S YOUNGEST RADIO "EXPERT"

Philadelphia is not so slow, after all; it can at least point with pride to its eleven-year-old citizen, William N. Allen, who has held an amateur radio license for two years. Here William is shown giving a practical talk on radio to his schoolmates.

¶ *Sooner or later every true radio amateur develops a desire for a topnotch long-distance receiving set—a set that he can build at reasonable cost and that will enable him to tune out all interference. This article tells him just how to do it.*

How *to* Build a Real "DX" Regenerative Receiver

By LAURENCE M. COCKADAY, R. E.

IN these radio days of interference on both the amateur and broadcast wavelengths a man must have a receiver that will distinguish between minute differences in wavelength if he expects to tune in one station without experiencing jamming from other stations. If he be a real honest-to-goodness telegraphic amateur, engaged in transcontinental relay work, he must be able to tune out all the other amateurs within range in order to copy a distant message from a fellow relay man situated on the other side of the continent; at the same time he must attain this selectivity of tuning without a multiplicity of tuning controls and also without a great loss of sensitivity.

The same condition holds true for his younger brother, the broadcast listener, for both of them are amateurs in different stages of development. The broadcast man soon gets tired listening to the nearby broadcasting station; he wants to reach out and hear the stations at the other end of the country.

With most of the simple single-circuit sets now on the market this is almost an impossibility. How can we tune that distant signal through the amateur transmitting station in the next block or how can we get that speech from Pittsburgh

"DX" is the amateur slogan for "Long Distance."

with a receiving set that will not tune sharply, when the local broadcasting station is blazing away with a jazz orchestra on almost the same wavelength? What are the requirements for a receiver that will do this thing?

First, the receiver must be finely selective and capable of distinguishing changes in wavelength of two or three meters.

Second, the set must also be ultra-sensitive to pick up and amplify even the weakest impulses.

Third, the set should also be easily and quickly tuned, especially for amateur relay work.

If the set has not these three qualities we might as well junk it. On the other hand, a receiver that has these three characteristics was actually developed by the writer during the late war and has been used and further developed at experimental station 2XK ever since that time. A description of it should prove of interest to the amateur who wishes to listen to "distance."

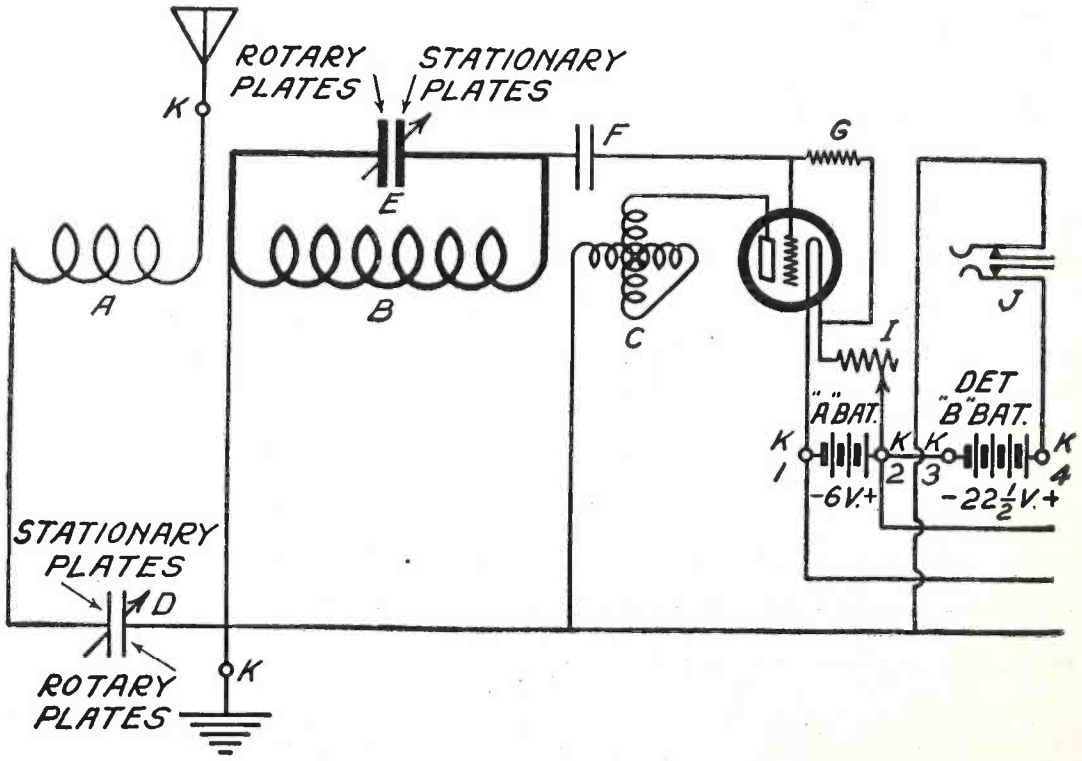
The circuit used in this set is of the triple circuit type, with an antenna circuit that responds to a large band of wavelengths at the same time (untuned). The secondary circuit is very selective, with a low decrement, and really constitutes a wavemeter which can be tuned to any definite wavelength between 180 and 550 meters. The plate circuit is coupled back to the secondary circuit in three ways:

First, by means of capacity feed-back (the old ultra-audion circuit of De Forest), in which one side of the secondary inductance is attached immediately to the plate circuit.

Second, the stator of a variometer is used as a permanent inductive feed-back.

Third, the rotor and the stator of this same variometer, which is in series with the plate circuit, are used to tune the plate circuit.

This multiple feed-back method insures stability, and allows regeneration to be easily controlled over the entire wavelength range of the set.



The coupling between the primary and secondary circuits is rather tight and fixed, eliminating the coupling control. This also allows the secondary circuit to be calibrated to wavelength; this calibration holds true, within a few per cent, for any antenna to which the set may be connected.

As the vacuum tube is a potentially operated device, this tight coupling, combined with the high ratio of secondary turns to primary turns, provides a relatively high grid voltage which results in a strong signal.

The set is completely shielded in a novel way, which prevents the troublesome effects commonly experienced from "body-capacity." This is accomplished in the set by placing the side of the instruments which face the panel at ground potential; thus the stator of the variometer is grounded and the rotor plates which are attached to the shaft of the tuning condenser are also grounded; so also is the rotor section of the so-called "vernier condenser." This is made possible by the peculiar hook-up used; the plate circuit is at ground potential, the grid and filament circuits at correspondingly higher negative potentials above ground, according to the "B" battery used.

Two stages of audio frequency amplification are included in the set and the cores of the transformers are placed at right angles to prevent magnetic coupling; the cores are also grounded. This entirely prevents any tendency toward "howling."

The electrical circuit diagram 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 a receiver may easily determine how to mount the instruments in the correct places and connect them properly in the electrical circuit. The same designating letters are used in the text and the list of parts below. The list of parts includes the exact instruments used in the set from which these specifications were made up; however, there are many other reliable makes of instruments which may be used in the set with excellent results. If other instruments than the ones listed are used it will only necessitate the use of different spacing of the holes drilled in the panel and shelf for mounting them.

A—Primary winding, consisting of 18 turns of No. 18 S.C.C. copper wire;

B—Secondary winding, consisting of 55 turns of No. 18 D.C.C. copper wire, or this coil may be wound with Liztendracht cable, which consists of 48 No. 38 copper wires, each wire convered with enamel insulation and all the wires bunched together and covered with a silk covering (A and B are wound on a composition tube, the dimensions of which are shown in Figure 3);

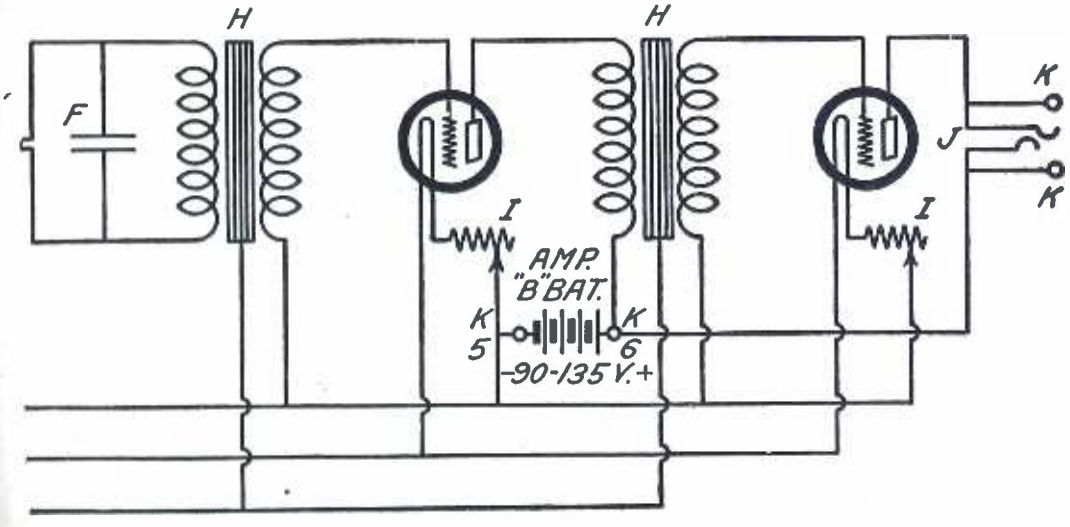


FIGURE 1

This diagram illustrates all the connections for all of the instruments required by this DX set, as well as the connections for the binding posts and batteries.

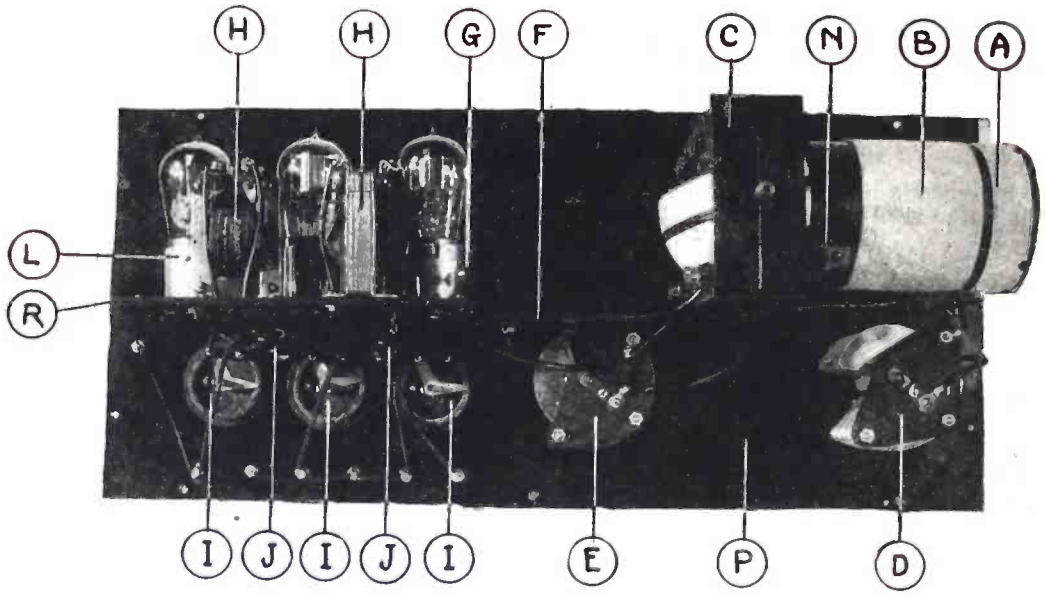


FIGURE 2

The rear view of the panel, showing the arrangement of the instruments. The various lettered parts are described in the text of the article.

C—Tuska moulded variometer;
A1, B1, C1—Tuska knobs and dials;
D—Signal variable condenser .001 mfd.;
E—Signal variable condenser .0005 mfd.;
F—Mica fixed condensers, .0003 mfd. (constructed as described in the article on page 124 of the October issue of POPULAR RADIO);
G—2 megohm tubular grid leak;
H—Paragon amplifying transformers;
I—Fada rheostats;
J—Pacent jacks;
K—Binding posts;
L—Aluminum socket spinnings;
M—Variometer supports, brass (shown in detail in Figure 3a);
N—Brass brackets for fastening the composition tube to variometer (see Figure 3a);
O—Fada rheostat knobs;
P—Composition panel;
Q—Phosphor bronze mounting for grid leak (see Figure 3a);
R—Composition shelf for mounting tubes, amplifying transformers and grid leak (this shelf is mounted on the two jacks, J);
S—Phosphor-bronze contact-fingers for sockets (see Figure 3a);
Connecting wire No. 18 bare copper, varnished cambric tubing for insulation, machine screws, and other miscellaneous items.

How to Construct the Set

After all the instruments for building the receiver are procured, the amateur should set about preparing the panel P (shown in Figures 2, 3, 4 and 5).

First of all the panel should be cut to the correct size (10 by 22 inches); then the edges should be squared up 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 the lower view in Figure 3. The holes outlined here with a double circle should be countersunk so that the flathead machine screws used for fastening the instruments will be flush with the panel. All the rest of the holes in this panel are straight drill holes. Sizes for the diameter of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the size of the screws and shafts of instruments that have to go through the holes.

When the panel is drilled, it may be given a dull finish by rubbing lengthwise with smooth 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, and 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 drilling.

Next, the condenser D should be mounted in the lower left-hand corner by means of two screws fastened through the panel, as shown in Figures 3 and 4. Then the condenser E should be mounted in a similar manner, as shown in Figure 3. The large dials A1 and B1 may be fastened to the shafts of these condensers as shown in Figures 3 and 4. These dials are made fast by means of set screws.

The three rheostats I should be mounted

(two screws to each rheostat) in their proper places (see Figures 2, 3 and 5), and the three knobs and pointers O attached to them.

The ten binding posts K may then be inserted through the panel and fastened tight by means of the nuts on the rear of the panel, as shown in Figures 3, 4 and 5.

The next step is the preparation of the shelf assembly R. This shelf panel should be cut to the correct size (4¾ by 7½ inches), and should then have three square holes cut in it, as shown in Figure 6. These holes may be easily made by boring a hole in each corner of the square and cutting out the sides of the square with a small fretsaw; the squares may then be dressed down evenly with a small file. The eight holes for fastening the four contact fingers for each socket should be drilled and tapped for 4/32 round-head brass machine screws. The three sets of contact fingers S should then be made of phosphor-bronze (as shown in Figure 3a) and fastened to the under side of the shelf, with the square contact surfaces projecting up into the square holes (see S, Figure 3). The three aluminum socket spinnings L should then be screwed to the top side of the shelf as shown in the same figure.

Next, the two spring contacts Q should be made of phosphor-bronze as in Figure 3a, and fastened to the upper side of the shelf by means of two machine screws, as shown at QQ, Figure 3. The grid leak tube G may then be inserted in the two holes in the contacts made for that purpose.

Now mount the two amplifying transformers H with four machine screws to each transformer, making sure that the mounting flanges do not touch or make contact with the screws holding the contact fingers for the sockets.

The two jacks J should then be fastened to the shelf. As the shelf R is to be mounted on the panel P by means of the jacks J, this should be done with care. There are two screws running through the jacks which hold the jack contacts and insulating fillers in place. These two screws should be extracted and replaced, one at a time, by two screws, a half inch longer than the originals. Great care should be exercised in doing this, as the parts of the jack must not be disarranged or they may short-circuit the connections when the set is operated. The jacks are then fastened to the under side of the shelf by means of these longer screws, the extended ends of which are inserted up through the two holes in the shelf for that purpose. A nut is then screwed down over the two screw ends and the jacks held rigidly against the shelf, as shown in Figures 3 and 5.

The whole shelf assembly may then be mounted on the panel P by screwing on the hexagon nuts that form the front portion of the jacks. The correct spacing and position for this shelf will be automatically assured if the jacks are fastened into the two holes drilled for them in the panel P as shown in the layout for this panel in Figure 3.

Further efforts should now be directed

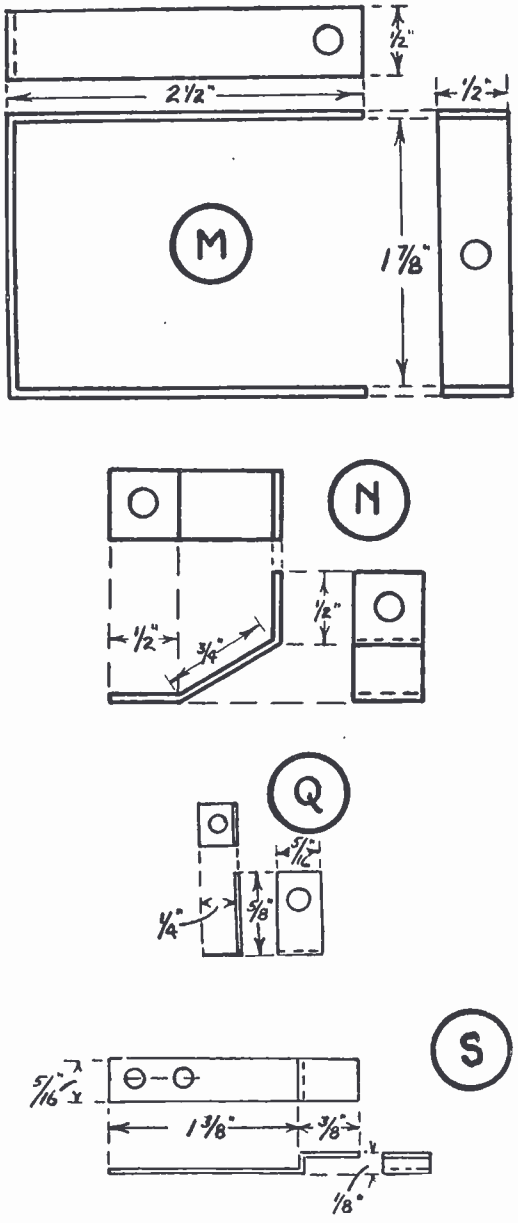


FIGURE 3a

This diagram gives the dimensions of the metal brackets and contacts, and shows the correct shapes for bending. Pieces M and N are of 1/16-inch brass. Pieces Q and S are of springy phosphor-bronze. Two of M are used for mounting the variometer, two of N for the coil tube, two of Q for the grid leak, and twelve of S for the sockets. The sizes of the holes to be drilled are determined by the screws used. The parts should be carefully made and bent or the instruments will not be securely mounted.

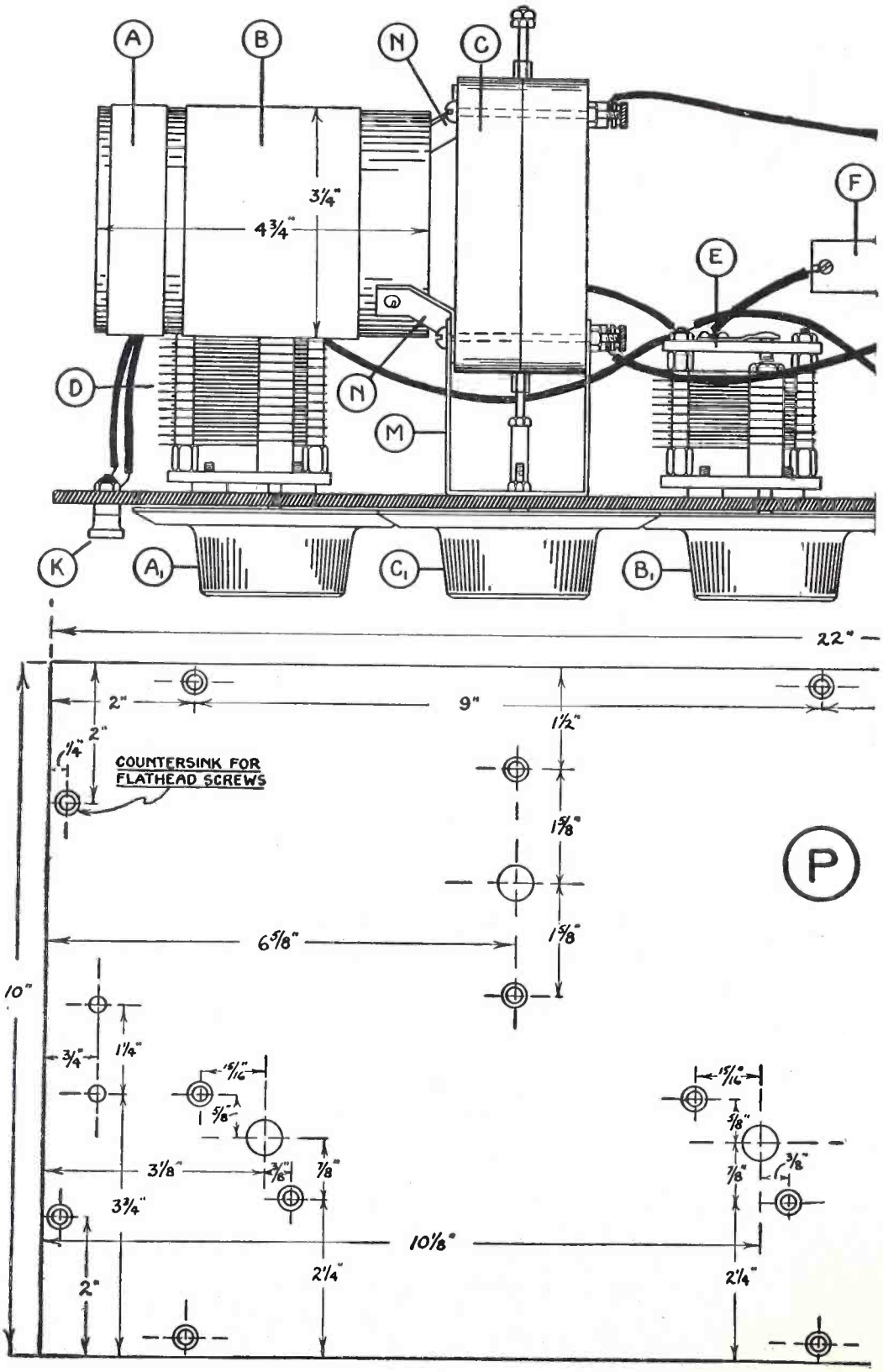
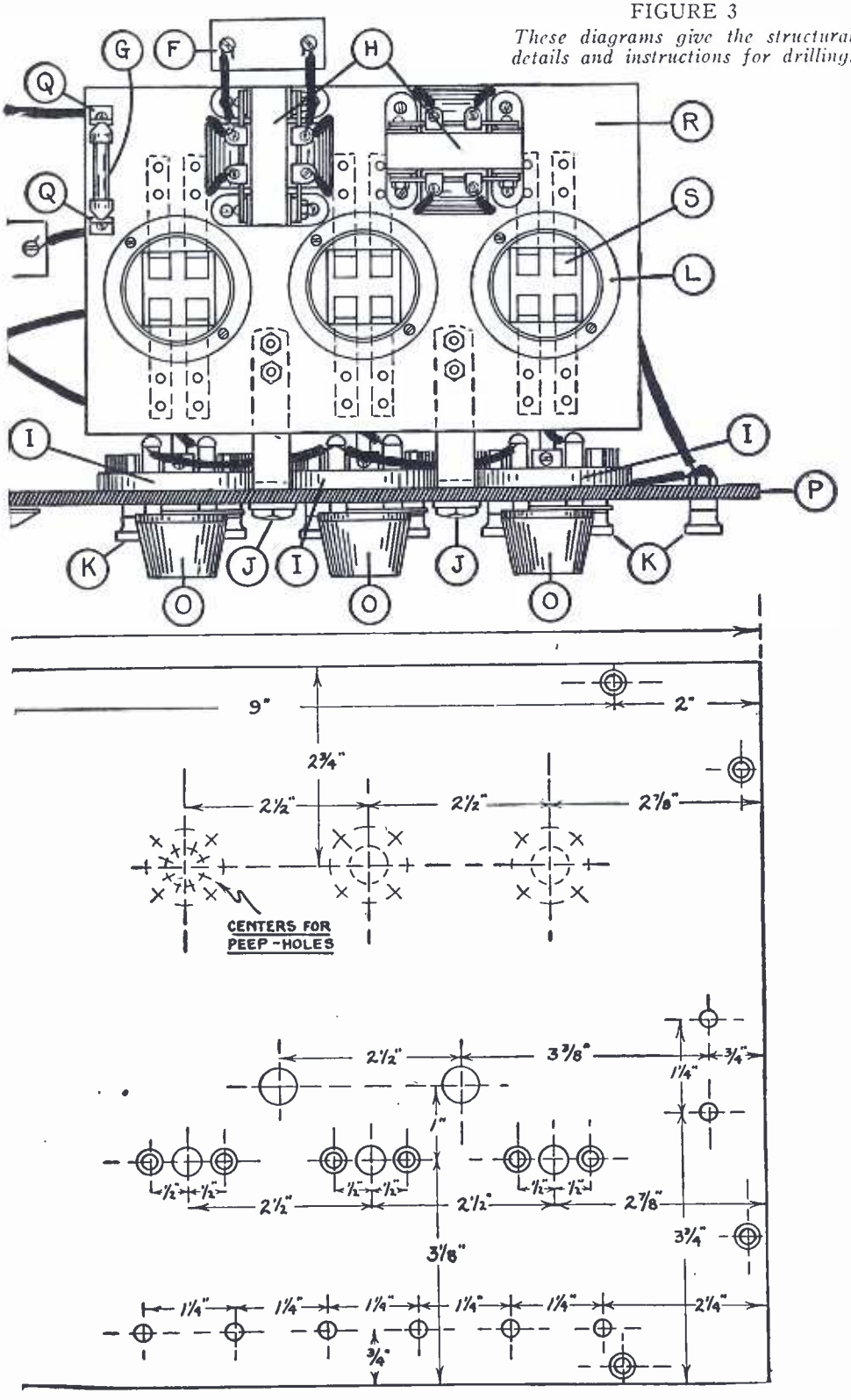


FIGURE 3

These diagrams give the structural details and instructions for drilling.



toward the construction and assembly of the tuner elements consisting of the coils A and B and the variometer C.

Let us start by cutting the insulating tube, which is 3¼ inches outside diameter, to a length of 4¾ inches. Bore a small hole in one end of this tube, one-eighth of an inch from the end, just large enough to pass the No. 18 single cotton-covered copper wire, and thread one end of the wire through the hole, and proceed to wind on the tube the 18 complete turns that constitute the primary coil A. Another hole is then bored at the finish of the winding, and the wire threaded through it, and a six-inch lead brought out through the center of the tube. One-quarter of an inch farther on beyond this last hole, another hole should be made for the start of the secondary winding (coil B). For this coil wind on, in the same spiral direction as the coil A, 55 turns of wire and finish off in the same manner as with coil A. If the "Litz" cable is used for this coil, slightly better results will be obtained in both tuning and signal strength. The results obtained with the ordinary solid copper wire, however, will be almost as good, due to the use of the regenerative circuit, which tends to decrease the resistance of the coils, thus doing away with the losses in the circuit. Now make the brass brackets according to the dimensions as shown at N in Figure 3a. These should be fastened to the tube by means of short machine screws and nuts (see Figures 3 and 4).

We can now set the tube aside for the time being and make the two large brass brackets M for mounting the variometer. These are bent and drilled as shown in Figure 3a. The two long screws that hold the front half of the variometer together are then extracted, the two brackets are placed in the position shown at M in Figures 3 and 4, and the bottom screw is put back and tightened. The bottom rear screw that runs through the variometer is then taken out and the tube with the coils A and B wound on them is placed in the position shown in Figures 3 and 4, and the top front screw and the bottom rear screw of the variometer inserted through the brass brackets, thus fastening the tube securely to the variometer.

The whole tuner assembly may now be mounted on the panel P by means of two screws inserted through the proper holes in the panel, and the two holes in the brass brackets M. The knob C1 may then be tightened on the shaft of the variometer.

The construction work on the set is now completed except for the mica condensers F, which may be purchased. The capacity of each is .0003 mfd. However, if the builder wishes to make them, he may easily do so by following the directions given in the article, "How to Make Your Own Grid Condenser," on page 124 of the October issue of POPULAR RADIO. It is better to use mica-dielectric condensers than paper ones, as their capacity does not vary as much.

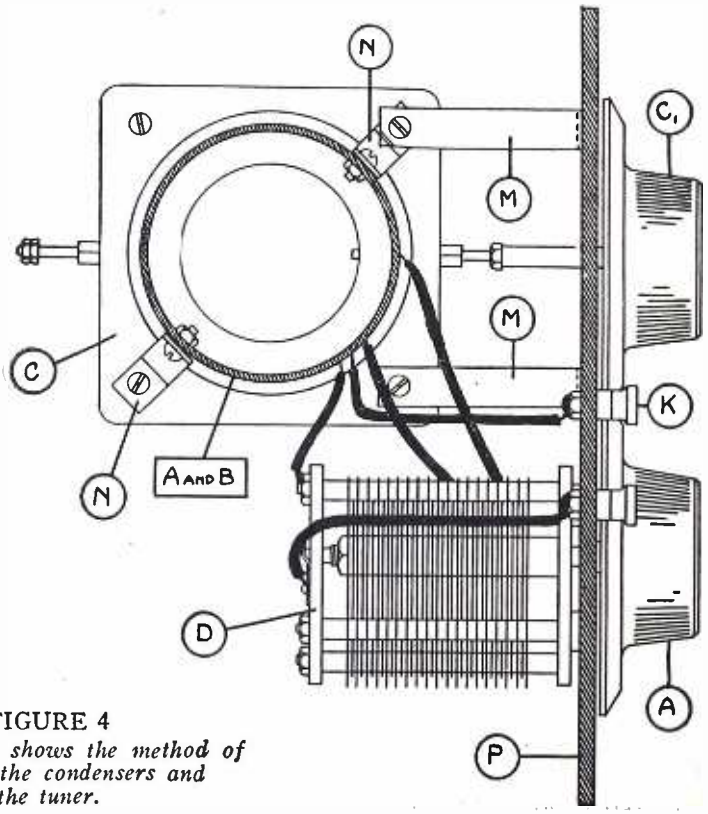


FIGURE 4
This diagram shows the method of mounting the condensers and the tuner.

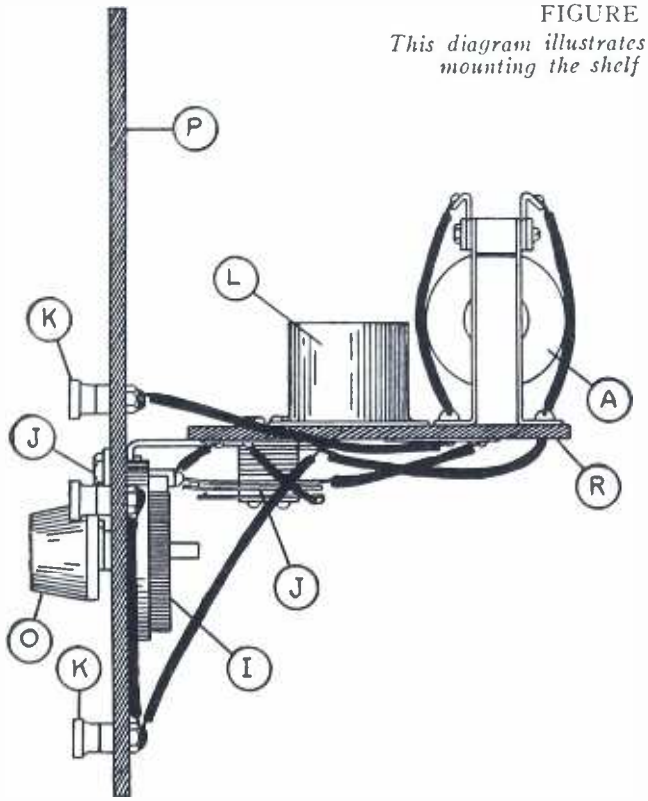


FIGURE 5
This diagram illustrates the method of mounting the shelf of the set.

How to Wire the Set

Before we start to wire it may be well to first consider just what the "wiring" accomplishes or is meant to accomplish in a radio receiver. Many radio fans who make their own sets breathe a sigh of relief when they finally get the instruments mounted.

"All I have to do now," they say, "is to wire it up."

So they get out the diagram and proceed to do just that thing, running all the wires nice and straight, with beautiful square turns and corners, like a lot of lighting cables running underground, up one street and around the corner, bunched together in a fine workmanlike way. When the set is finished the wiring sometimes looks so beautiful that the builder dislikes to put the set into a cabinet; it "looks too pretty."

This is foolishness. Many a set, with this square bus-bar wiring which looks so neat, works poorly, because the wiring does not accomplish the purpose it is supposed to. The wiring is supposed to so harness the different instruments in their proper electrical places that they will all pull together for a given purpose. The wiring of a radio set bears the same relation to the set that the tracings and reins of the harness do to a horse and buggy, or that the steering gear and propelling gear do to an automobile. We must not mix up the reins (which control the horse) with the traces (which transmit the motive power or energy); we must not get the steering gear of the automobile mixed up with the propelling apparatus or the results will be disastrous. Likewise we must keep the control-circuit wiring of a radio set separated from the energy circuits; in other words, the grid leads, which control the vacuum tube circuits, should not be run parallel or close to the filament or plate energy circuits. Keep them as far away as possible.

Another point to remember: If you happened to be walking through a section of town which was not built up as yet, and your destination could be reached much more quickly, and with less expense of energy, by cutting across lots in a "bee-line," you certainly would do so if "the going were good."

Make the "going" good for the electrical currents flowing in your radio set by using bee-line wiring. When you connect two instruments with a wire, do it by the shortest path—unless this would interfere with the rotation of some moving part, or would bring two leads of a control circuit and an energy circuit, respectively, too close to each other.

Do not use too large a size of wire for connections; No. 18 is plenty large enough to handle any of the currents flowing in a receiving set without any dangerous rise in temperature and a corresponding rise in resistance. If larger sized wire than this is used, the capacity between two parallel wires may be high enough to interfere with the proper functioning of a circuit, and the little imaginary condensers thus formed will in reality act as numerous filter circuits in your

set and will filter out and weaken your signals.

Each connecting wire may be covered with varnished-cambric insulated tubing. Solder all connections when you have tested out the set and determined that they are all correct, and thus eliminate chances that the set may become "noisy."

Is there anything else to be said in the way of advice and admonition? If there is it is this: "Think well, before you connect, and check well after you have connected, and you will hear well when the set is finally put in operation."

Start wiring the filament circuits of the three tubes in the set; when this is complete, wire up the condensers and tuning coils A and B, first the antenna circuit and then the secondary circuit; then wire the variometer and the plate circuit of the first tube, including the "B" battery connections, the jack, and the primary winding of the first amplifying transformer. When this is done, commence with the plate and grid circuits of the first stage of amplification, including the primary winding of the second amplifying transformer. This leaves only the grid and plate circuits of the second stage of amplification to be finished and the wiring will be completed. The diagram for connecting the set is shown in Figure 1. If the wiring scheme as outlined above is kept in mind, while referring to the diagram for the correct connections, the job should be a comparatively simple one.

A cabinet for the set may be made of wood (mahogany or oak) according to the dimensions given in Figure 7, but we will not go into details concerning it here.

Operating Data

In connecting this set, the following hints may be of value:

The set may be used with almost any type of antenna with a horizontal length of over 75 feet. This should be connected to the top left-hand binding post shown in the illustration on page 35.

The ground is connected to the lower post at the left.

The negative "A" battery terminal is connected to the first post at the bottom of the set (counting from the left).

The positive terminal of same battery is connected to the second from the left.

The third post is for the negative "B" battery, for the detector plate.

Number four is for the positive "B" battery, for the detector plate.

Number five is for the negative "B" battery for the amplifier plates.

Number six is for the positive "B" battery for the amplifier plates. (Note that two separate "B" batteries are used, one for the detector tube, about 22½ volts, and one for the amplifier tubes 90 to 135 volts).

The two binding posts mounted vertically at the right should be connected in shunt to the last jack, and are used for additional connections for telephones or for a loudspeaker.

To set the receiver into operation insert the plug attached to the telephones into the first jack and light the filament of the first tube to the correct brilliancy by rotating the first left hand small rheostat knob O. This will allow reception with the detector tube, without the use of amplifiers.

If a louder signal is required (such as for operating a loudspeaker), the plug should be inserted in the second jack, and all three knobs O should be adjusted for the proper filament current for the three tubes.

All tuning is done with the three larger dials A1, B1, and C1. The vernier tuning dial A1 should be placed at approximately 75, and the regeneration dial C1 at O, and the

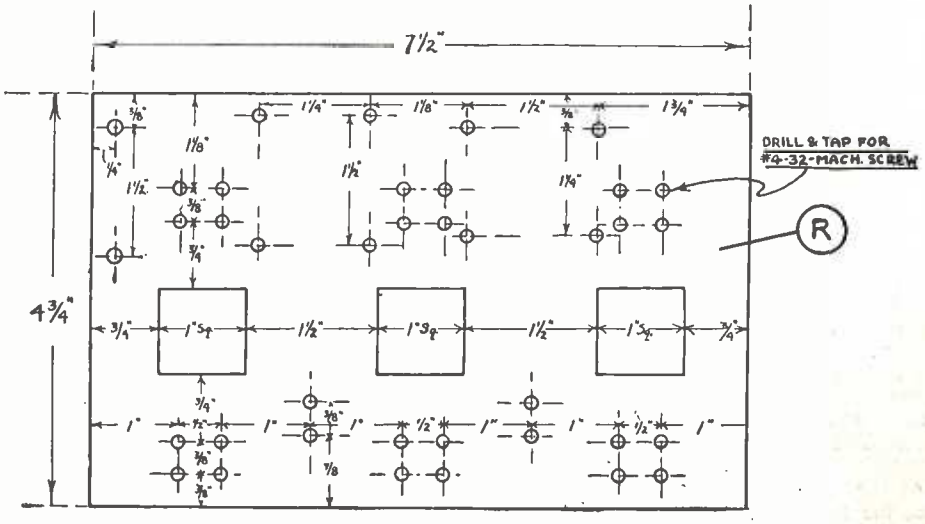


FIGURE 6

This diagram shows the layout for preparing the shelf, with proper spacing for drill holes.

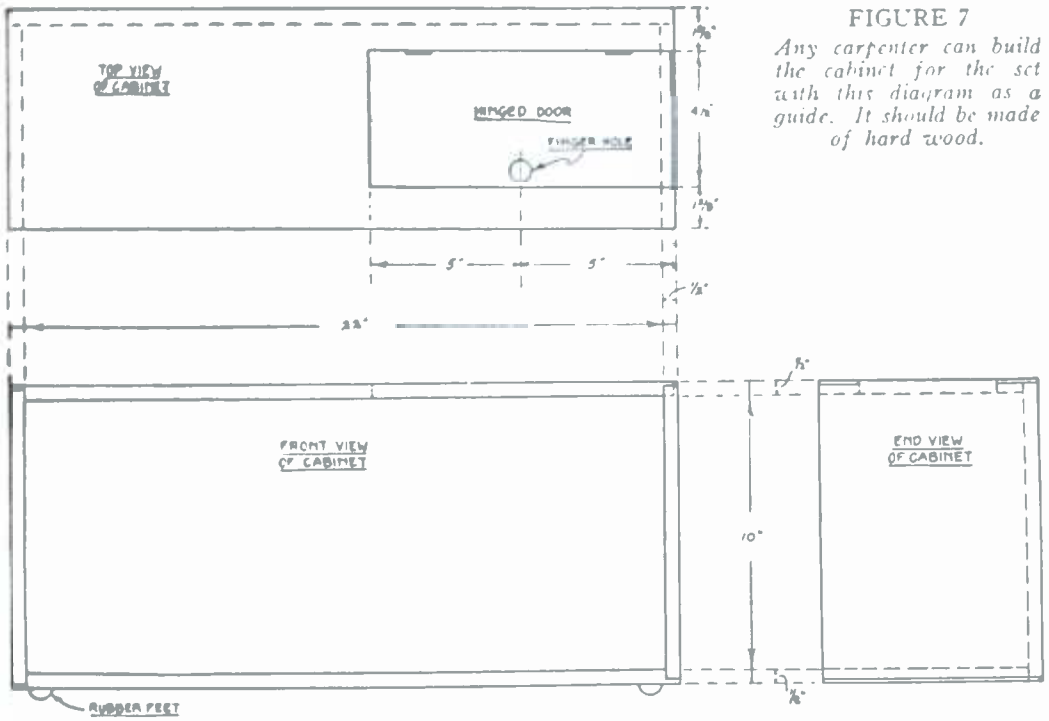


FIGURE 7

Any carpenter can build the cabinet for the set with this diagram as a guide. It should be made of hard wood.

main tuning dial B1 at 0. This will correspond to a wavelength of about 180 meters. If the listener wishes to listen to amateurs he should rotate the dial B1, very slowly, between 0 and 20. This dial should be handled with care or the signals will be passed over, as the tuning is so sensitive that two amateur stations may be tuned in and out in one degree on this scale. Then when a signal is heard, the dial C1 should be slowly rotated until the signal is increased in strength sufficiently without the tube starting to oscillate; it may be turned only so far, for a given wavelength, then a click and a mushy sound will be produced which will blot out voice signals and spark. The final delicate tuning is accomplished by turning the vernier control dial A1 in one or the other direction for the loudest results that can be obtained with clarity.

For broadcasting reception on 360 to 420 meters, the same general rule for tuning holds true, except that the dial B1 must be rotated until somewhere between 35 and 45; the same procedure is gone through as outlined above with the regenerative dial C1. It will be found that the higher the wavelength employed, the more regeneration will be required to bring the set to the oscillating point. Too much regeneration will cause distortion.

For listening to C.W. signals the dial C1 is rotated past the oscillating point, and the dial B1 rotated until the beat note is picked up, when it may be tuned in strong with the vernier.

When this set is constructed properly, and the operator becomes familiar with the method of tuning, amateur and broadcasting stations from all over the country may be tuned in clearly with little or no interference.

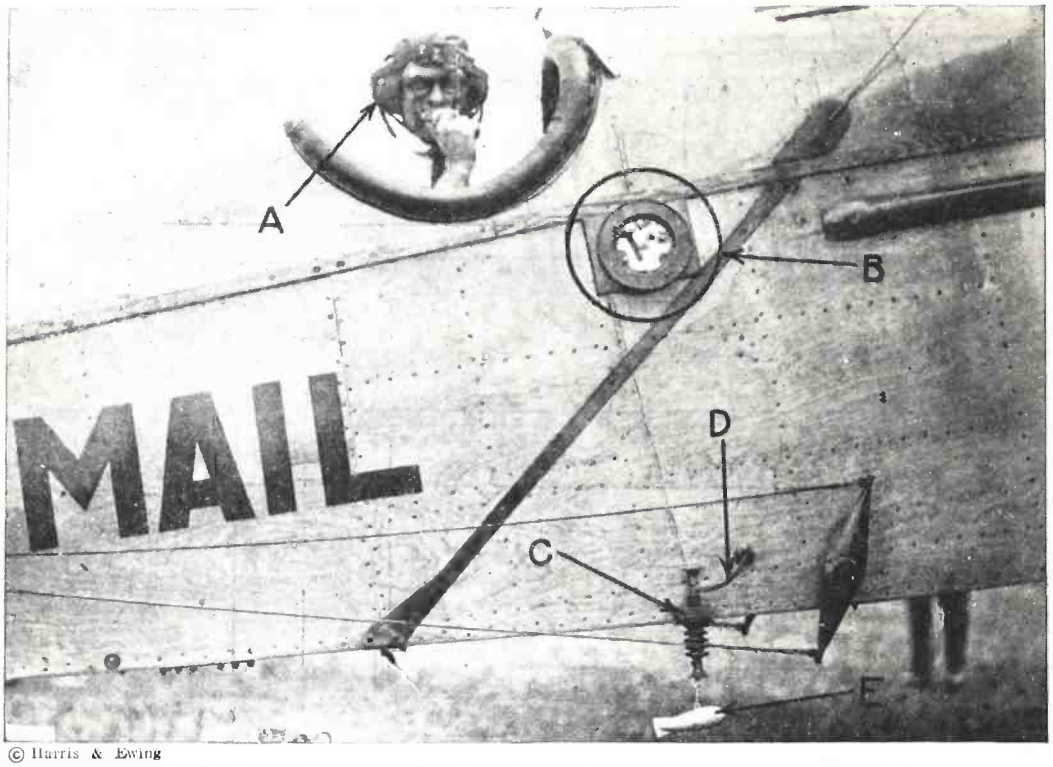
Photo made for POPULAR RADIO

What Educators Think of Radio

TO THE EDITOR OF POPULAR RADIO:

"You may be sure that the Bureau of Education of the Department of the Interior will be glad to co-operate to the extent of its ability in the broadcasting program which you are planning."

L. A. KALBACH
Chief Clerk, Bureau of Education



THE FIVE FEATURES OF THE NEW INSTALLATION

A is the soundproof head-gear which contains the sensitive receivers; B is the automatic reel containing the antenna wire; C is the insulating bushing through which the antenna wire is led out when the plane reaches a suitable height; D is the lead-in-wire to the radio apparatus, and E is the leaden weight which holds the antenna wire taut while flying.

A Mail Plane Guided by Radio

By RICHARD LORD

IF the experiments now being carried on at Bolling Field, Washington, D. C., prove successful, the Air Mail Service of the U. S. Post Office Department may install radio telephone sets on all its planes and start a "night flying" schedule. There are a number of problems that must be solved, however, before such a program can be effective.

In the installation itself, the head-telephones and the mouthpiece have to be soundproof to keep out the roar of the motor; an outfit of this type is shown in the illustration. Also the ignition of the motor (each spark plug and coil is a radio transmitter) must be shielded, to prevent the voice from being drowned out; this is accomplished by running all the ignition wires in metal conduit or metal braided wire.

A suitable antenna system for aerial use had to be devised that would not interfere with the flying controls and which would not be in the way while the plane is making a landing. The type selected consists of a reel (something like a large fish reel) attached to the side of the fuselage, fitted with a handle and ratchet and containing about 300 feet of flexible wire. The wire is led down through an insulating guide bushing and may be unreeled when the plane has reached a suitable height, and re-reeled when the plane reaches a point above its destina-

tion and the operator begins his preparations to descend.

A ground is made by fastening to the metal parts of the plane.

Other problems connected with night flying are: The determination of direction; means of communication between ground stations and planes in flight to warn the flyer against storm centers he might be unknowingly flying into; and a means by which the flyer might advise the nearest route station of trouble with the craft. Radio offers a possible solution to these problems. In each of the fifteen radio stations of the U. S. Post Office, there could be installed a direction finder, by means of which the land stations may advise the flyer of his position and aid him to get back "on the track" if he should be forced off his course by a storm. These sets, furthermore, enable the land station to determine the position of the craft in case of trouble with the machinery, so that the nearest depot could rush mechanics to the scene for repairs.

If the scheme works with anything like the success that is predicted for it, a wide extension of the mail service may be looked for.

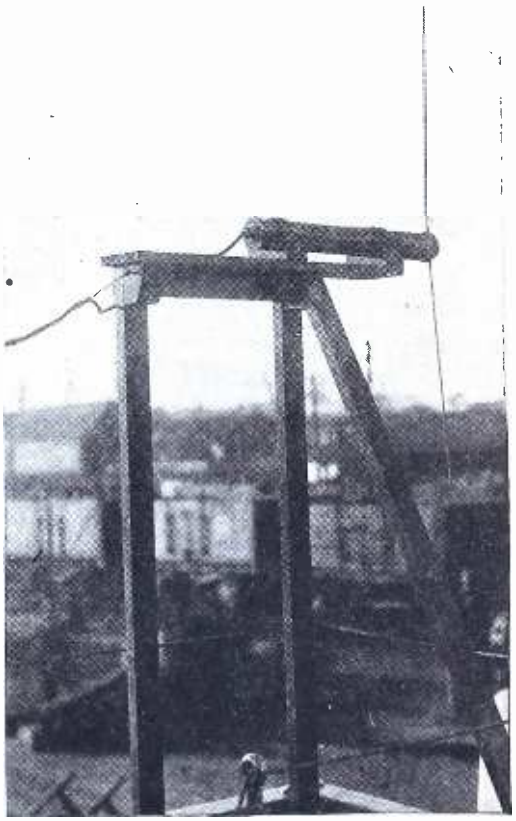
A New Kind of Radio Lighthouse

By STEPHEN LEE

A LIGHTHOUSE that sends out invisible beams, that will probably replace the old time lighthouse and has a greater range, has just been completed on Inchkeith, an island in the Firth of Forth, Scotland. This new lighthouse replaced a smaller experimental one at the same place, after tests between it and the *S.S. Pharos* had been completed.

The "beam" that is sent out by this revolving lighthouse (which, by the way, would never be recognizable as a lighthouse by an old mariner) is a radio wave of very short wavelength, 4.28 meters, which is focused in one direction much in the same way that a beam of light is focused along the road by an automobile headlight.

The lighthouse consists of a steel frame, reminding one of a revolving clothesline hanger, except that there is another series of arms placed near the ground. The wires which form the reflectors are stretched between these two series of arms as shown in the illustration. The receiving antenna and apparatus as used on shipboard are shown in the picture on this page.



From a photograph by P. J. Risdon, London

A NOVEL ANTENNA

The arrangement of the aerial installed on the bridge of a ship. This is the type of antenna that receives the 4.28 meter wave sent out by the radio lighthouse.

The method provisionally adopted for giving bearings to a ship is as follows:

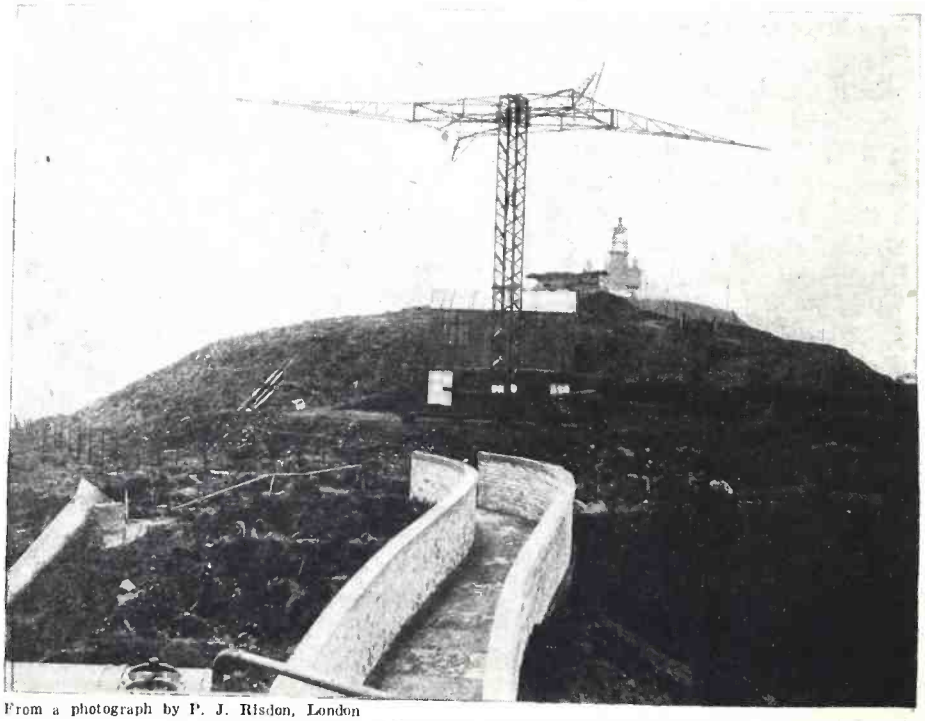
On the base of the revolving lighthouse or reflector are arranged a number of contact segments that cause a short signal to be sent out at every quarter or half point of the compass. The reflector revolves one revolution every two minutes. A distinctive letter is sent out at every two points of the compass. In this way a ship may know at just what particular instant the lighthouse is sending out a ray in a specified direction.

The beam is so directional that at a distance of four miles signals are heard from the reflector for only seven seconds out of each minute; at greater distances this time is reduced. However, the exact time of maximum intensity, indicating the instant when the beam is pointing right at the ship, is hard to determine by ear; accordingly the method used is to listen for the start and finish of the signals, which is easily recognized. The time half way between these two intervals gives with exactitude the moment that the beam is pointing at the ship.

The mariner then consults his chart and determines what direction the letter heard at this instant corresponds with, and thus is enabled to get his bearing.

This system is destined to come into extended use, as any number of ships may get bearings at the same time without waiting their turn, as is the case with the system employed in American waters.

There is one shortcoming in this method, however: there is no way of determining how far distant the ship is from the lighthouse. This shortcoming may be easily overcome by taking observations from two lighthouses in different locations at the same time, by means of two receivers on board ship. The correct position of the ship may then be plotted on a chart, the position being the point where the two lines (indicating the direction of the two beams) meet on the chart.



From a photograph by P. J. Risdon, London

A REVOLVING "RADIO BEAM" PROJECTOR

This unique radio apparatus has taken the place of the old-fashioned lighthouse at Inchkeith, Scotland. No matter what the weather is this new marvel of science gives accurate bearings to the vessels at sea.

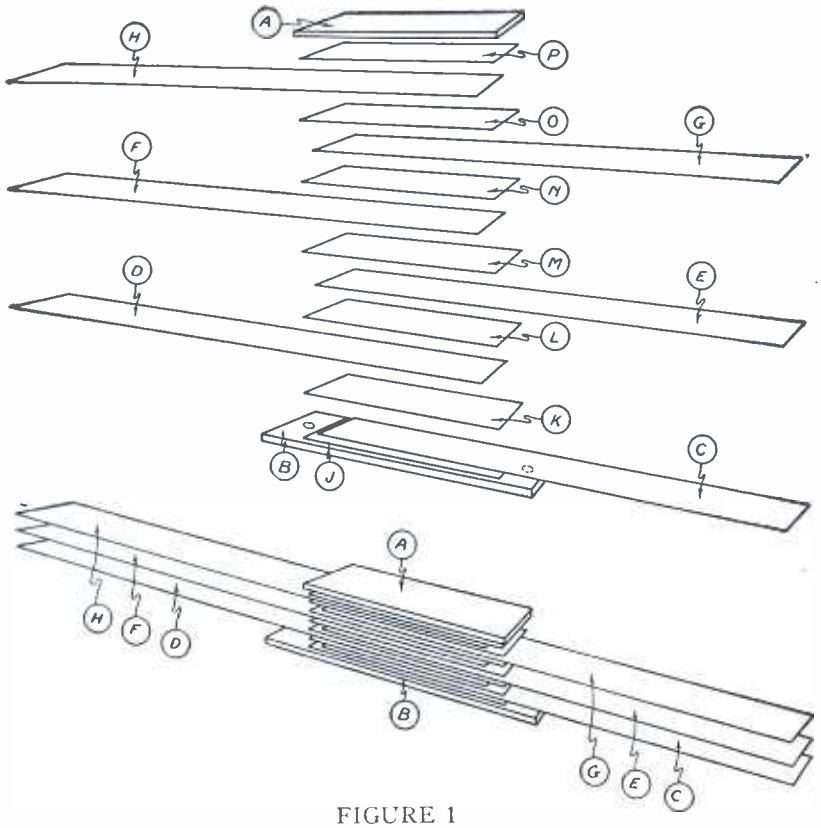


FIGURE 1

The parts of the condenser should be assembled in the order shown on this diagram—reading from top to bottom.

How to Make a TELEPHONE CONDENSER

A Simple Device for Increasing the Efficiency of Your Set—at a Cost of 30 Cents

By WATSON DAVIS

THE interest that Uncle Sam is taking in his large and rapidly growing body of radio enthusiasts is being demonstrated in essentially practical form. Through the Radio Laboratory of the Bureau of Standards he is experimenting with the "one best way" of making the various parts of radio apparatus that the amateur may make at home at trifling expense; indeed, the receiving sets which have already been developed (as well as the various auxiliary parts) have enabled thousands of novices to participate in the broadcasting programs and have stimulated an interest in the radio art that is leading to far-reaching results.

The latest apparatus developed by the Bureau of Standards is a telephone condenser—which any novice may make at home for about 30 cents. It may be attached to the receiving sets previously described in detail in POPULAR RADIO. The effect of the telephone-shunt con-

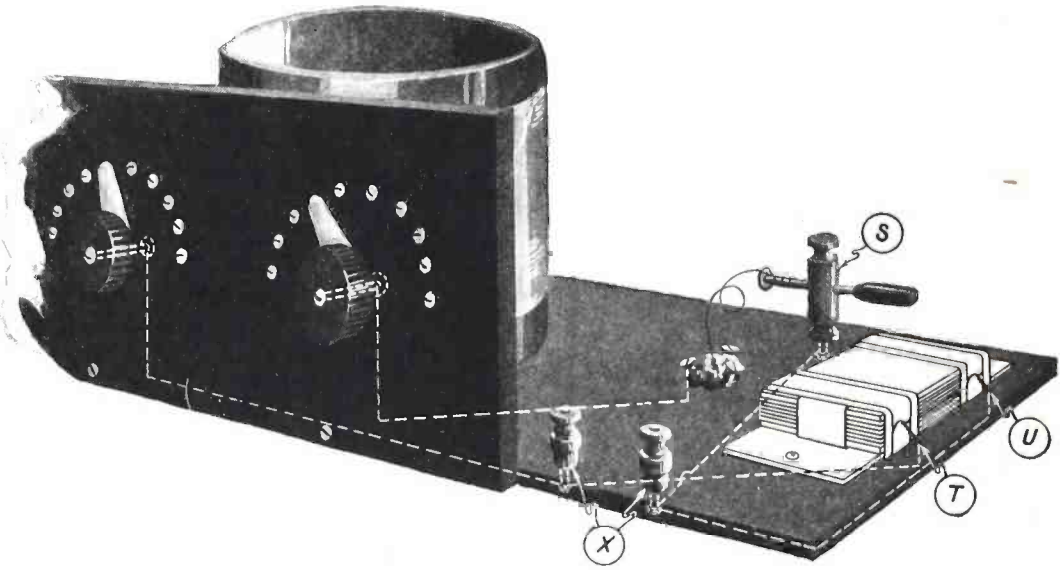


FIGURE 2

The telephone condenser may be connected to the single circuit receiver by connecting the two terminals, U and T, to the two binding posts of the set, marked X in the above diagram. The wiring may be done on the under side of the board, as indicated by the dotted lines, thus both making a neater appearing set in which the wires are out of the way and also keeping the connections from becoming broken.

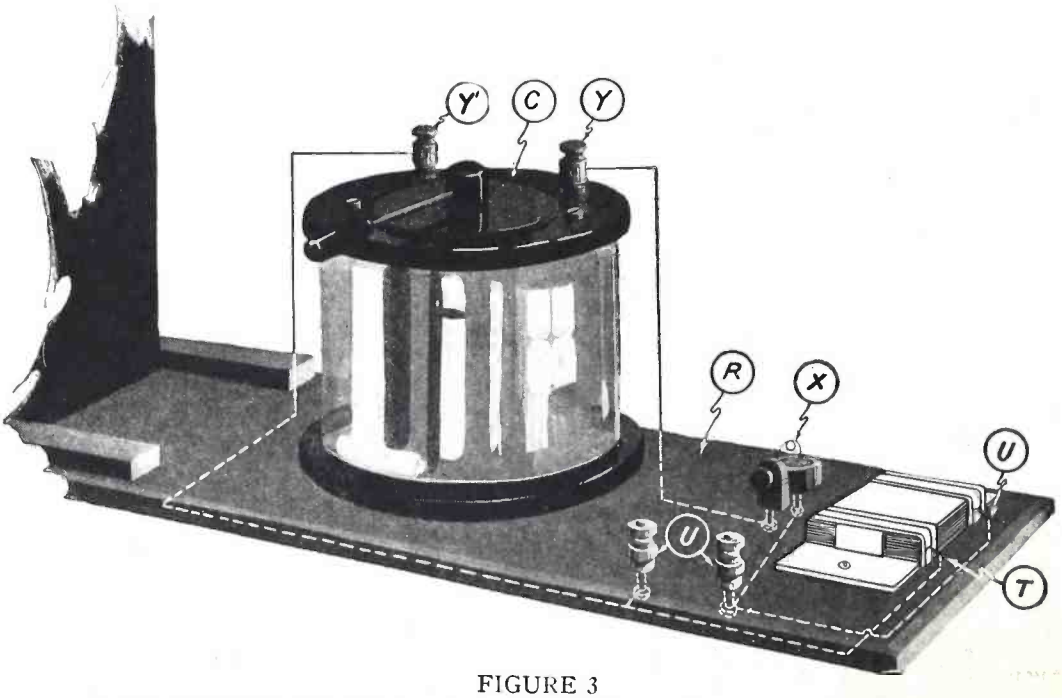


FIGURE 3

In this illustration the two terminals, U and T, are shown connected to the two binding posts marked U on the double circuit receiver. But a telephone condenser may be used with any set, provided it is connected in shunt with the telephone terminals. The effect of such a condenser is to pass the radio frequency impulses around the telephones and to act as an accumulator for the audio frequency voltages.

denser is to increase the intensity of some radio signals to which the receiving set may be tuned. In most cases the use of this condenser has no effect upon the intensity of signals which are received from a radio telephone transmitting station, but will increase the intensity of radio signals which are received from most spark transmitting stations. The telephone-shunt condenser described below has a capacity of approximately 0.0015 microfarad (1500 micromicrofarads).

How to Build the Condenser

The parts used in the construction of the condenser are: a cap piece of heavy pasteboard or wood, A, about 1⅜ by 3 by ⅛ inches, a similar base of pasteboard or wood, B, 1⅜ by 3⅞ by ⅛ inches, six pieces of tin-foil, C, D, E, F, G, H, ⅞ by 7 inches, seven pieces of paraffined paper or mica, J, K, L, M, N, O, P, 1⅛ by 3 inches, one stiff paper clip or its equivalent (for temporary use), about 10 feet of No. 24 bare copper wire, and two round-head wood screws about ½ inch long.

The several steps in the arrangement of these parts are shown in Figures 1, 4 and 5. The layers of paraffined paper and tin-foil are alternated as shown, starting with a sheet of paraffined paper on the Base B. The paper J is placed in the center of B so that there will be a ⅛ inch margin at the sides and 7/16 inch margin at the ends of B. A sheet of tin-foil C is then placed on the paper J so that there will be ⅛ inch of margin of paper uncovered on three sides. The tin-foil C will then extend 4⅛ inches over the right-hand edge of the paper J, or 3 3/16 inches over the right-hand edge of the base B. The paraffined paper K is placed on C directly above J. The tin-foil D is placed on K. The overhanging end of D extends to the left instead of the right as did C. The other three sides of D are ⅛ inch in from the three edges of K. This arrangement of alternate layers is followed until the seven paraffined papers and the six sheets of tin-foil are placed in position. The cap piece A is then placed as shown in Fig. 1.

The condenser now appears as shown in Figure 1, except that the thickness of the condenser is much exaggerated here in order to better show the parts. A paper clip or other form of temporary clamp may be used to hold the parts firmly together. The tin-foil strips, D, F and H, are now bent back over the end of the cap piece A and folded over at an angle of 45 degrees (see line RS, Figure 4) so that the tin-foil may be wrapped evenly around the pieces A and B and secured by several turns of No. 24 bare copper wire. (See Figure 5.) The tin-foil strips C, E, and G (Figure 1) are wrapped in the same manner. The completed condenser appears about as shown in Figure 5, except that

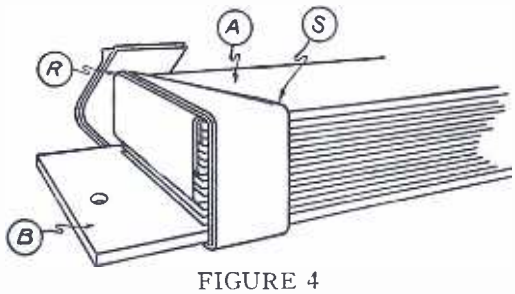


FIGURE 4

How to wrap the tin-foil strips around the ends of the condenser preparatory to securing with the binding wires.

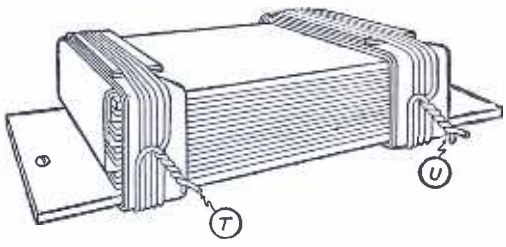


FIGURE 5

How to secure the binding wires which also form the two terminals, U and T, of the condenser.

it is much thinner. The drawing has made the apparatus appear much thicker than it will appear in reality, in order to show the details of construction more clearly.

This telephone-shunt condenser just described may be added to the single-circuit receiving set described in the May issue of POPULAR RADIO or to the two-circuit receiving set described in the July issue. The condenser is placed as shown in either Figure 2 or Figure 3. A somewhat simpler plan is to screw the condenser to the underside of the receiving set baseboard; this saves drilling more holes in the baseboard in order to keep the wiring on the underside. No matter with which receiving set this condenser is used, the two wires T and U (Figures 3 and 2) are connected to the two telephone receiver binding posts marked "Phones."

Fixed condensers may be purchased which will give about the same results as those herein described, but it is more fun and much more instructive to build your own.

The Costs of the Parts

The itemized costs of the telephone shunt condenser are computed as follows:

About 40 square inches of heavy tin-foil	$0.25
2 screws for mounting condenser	.05
2 small pieces of heavy cardboard or thin wood	
Paraffin	
Paper	
Total cost	$0.30

¶ Two notable achievements in the broadcasting of athletic events took place this fall. This article tells how they came about.

Here is POPULAR RADIO'S *press box at the Polo Grounds, New York—from which reports of the big footbal games were broadcast while the plays were still in progress.*

FOOTBALL *by* RADIO

By GEORGE B. CHADWICK

To maintain broadcast programs on such a high level of excellence that they will command the attention of the radio fan is the most immediate problem before the radio industry today.

The interest of the radio fan is centered, not in the receiving set itself, but in *what he will hear on it.*

It is becoming increasingly difficult to induce eminent musicians and lecturers to come to the broadcasting stations. It is becoming correspondingly necessary to tap those auditoriums, lecture halls and athletic fields where entertainment is provided. To tap these points, so that the entertainment may be transmitted to the broadcasting stations, requires land wires. The problem thus resolves itself largely into the problem of obtaining wires.

During the football season just closed this problem was solved in two ways:

First—The American Telephone and Telegraph Company performed the remarkable feat of broadcasting from the New York station, WEAF, side-line reports of football games held in Chicago, thus demonstrating that the technical obstacles can be overcome.

Second—Sideline reports of the football games at the Polo Grounds in New York (broadcast by POPULAR RADIO) were sent out from Westinghouse station WJZ in Newark with the aid of Western Union wires—thus demonstrating that telegraph lines can be used as well as telephone lines.

How these two experiments were successfully made is told in this article.

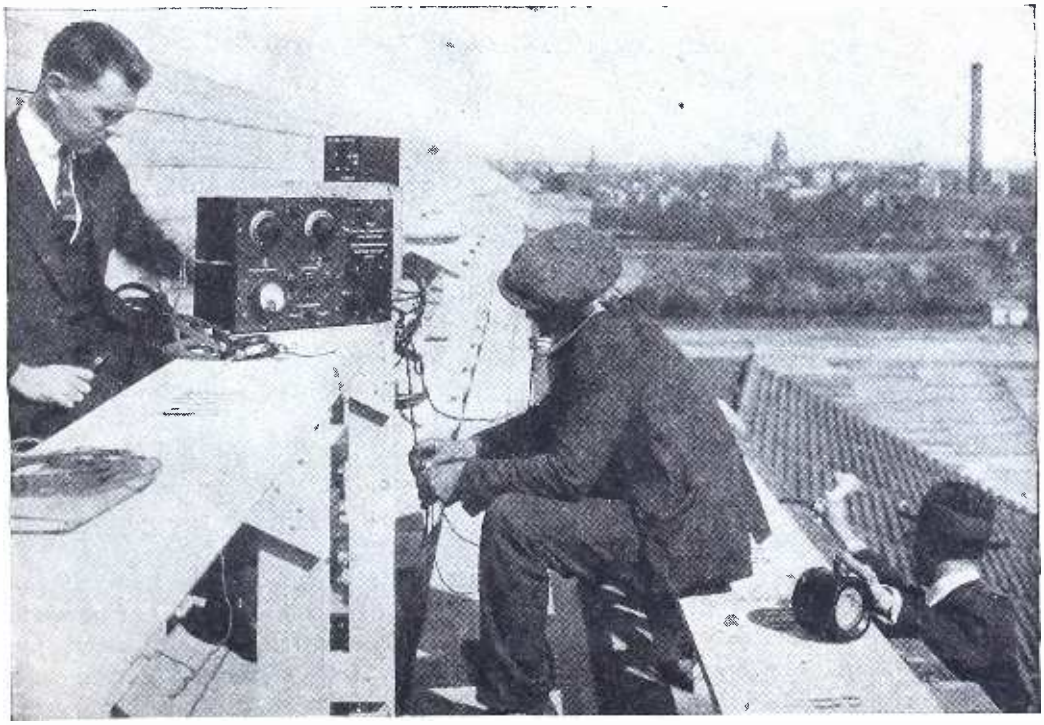
—EDITOR

TIME was when the "old college grad" in a distant city hied himself to a telegraph ticker and waited for the returns of the big football games as they came over the wire, in short colorless messages. There was eagerness in his gaze, perhaps an attempt to catch from the face of the announcer an inkling of what had happened before he read the message aloud. But if the old grad had a touch of the philosophical in his make-up, sometimes there came the deadening thought, "All this took place minutes ago. If I only knew what is happening *now.*"

Today the old grad is—aurally at least—transported to the ball field by radio. He knows when No. 8 is still running down the field with the ball; he can hear the shouts of the grandstands. He knows at the instant when No. 8 is tackled by No. 51 of the opposing team. He hears the rhythmic cadence of organized cheering, the actual music of the bands; in a momentary lull he catches the harsh crackle of a sharp-voiced quarterback. And he hears it all in company with a multitude of people scattered over half a continent.

A few years ago the crowds that attended a mid-season game amounted to a mere thousand or two; only the few big games drew as many as 30,000 to 35,000 people. Today, however, even mid-season games draw as many as 75,000.

There is significance in these two facts: The instant reporting by radio of a great national sport; the multitude of interested people, both those who gather in great crowds to see the games and those who have not been able to attend but who can listen in at home or gathered in a hall or around a curb where there is a loudspeaker. It is the handwriting on the wall; we get a glimpse into the future, of one of



Amrad

HOW THE GAMES IN THE HARVARD STADIUM WERE BROADCAST

The microphone and the voice amplifier were located in a press box on top of the Stadium. Telephone wires connected this apparatus with WGI, four miles distant.

the big things that radio is beginning to do.

No longer are people merely interested in the mechanism of a new device and willing through curiosity to listen to any program that is broadcast. They want entertainment that comes to them direct from the great stadiums, athletic fields, auditoriums and concert halls.

In line with its policy of promoting the broadcasting of events of widespread popular interest, POPULAR RADIO sponsored the broadcasting of the series of four great football games played at the Polo Grounds in New York this fall.

Up in the second tier of the Brush Stadium, in Box 24, located on the south side of the field and almost exactly opposite the 50 yard line, was installed the radio apparatus — the amplifier cabinet with necessary "A" and "B" batteries for the tubes, and two microphones. One microphone picked up the music and cheers on the south side of the field, the other microphone transmitted the voice of the announcer. From this box was run 1000 feet of cable to the north stands to connect with a third microphone, placed in front of the cheering section there at a height of about six feet.

The next essential was a proper land-wire connection with the Westinghouse broadcasting station, WJZ, at Newark. Here the Western Union played its part.

A telegraph circuit was hooked up connecting the amplifier in Box 24 with the terminal board at Harlem River. From this point a pair of regular telegraph wires direct to Newark was used. To make sure of a good connection, and to cut out any extraneous noises, the Western Union had previously checked over their wires; indeed, this had been done before the World Series of baseball games, and the same pair was used for the football contests. The Western Union also conducted tests to make sure that regular traffic going over other nearby wires would not disturb or interfere with the operation of this special circuit, and arranged its traffic during the broadcasting period accordingly. Thus the way was carefully made ready, from a wire standpoint, for the remarkably clear reports that went out through the air to the waiting radio-football fans.

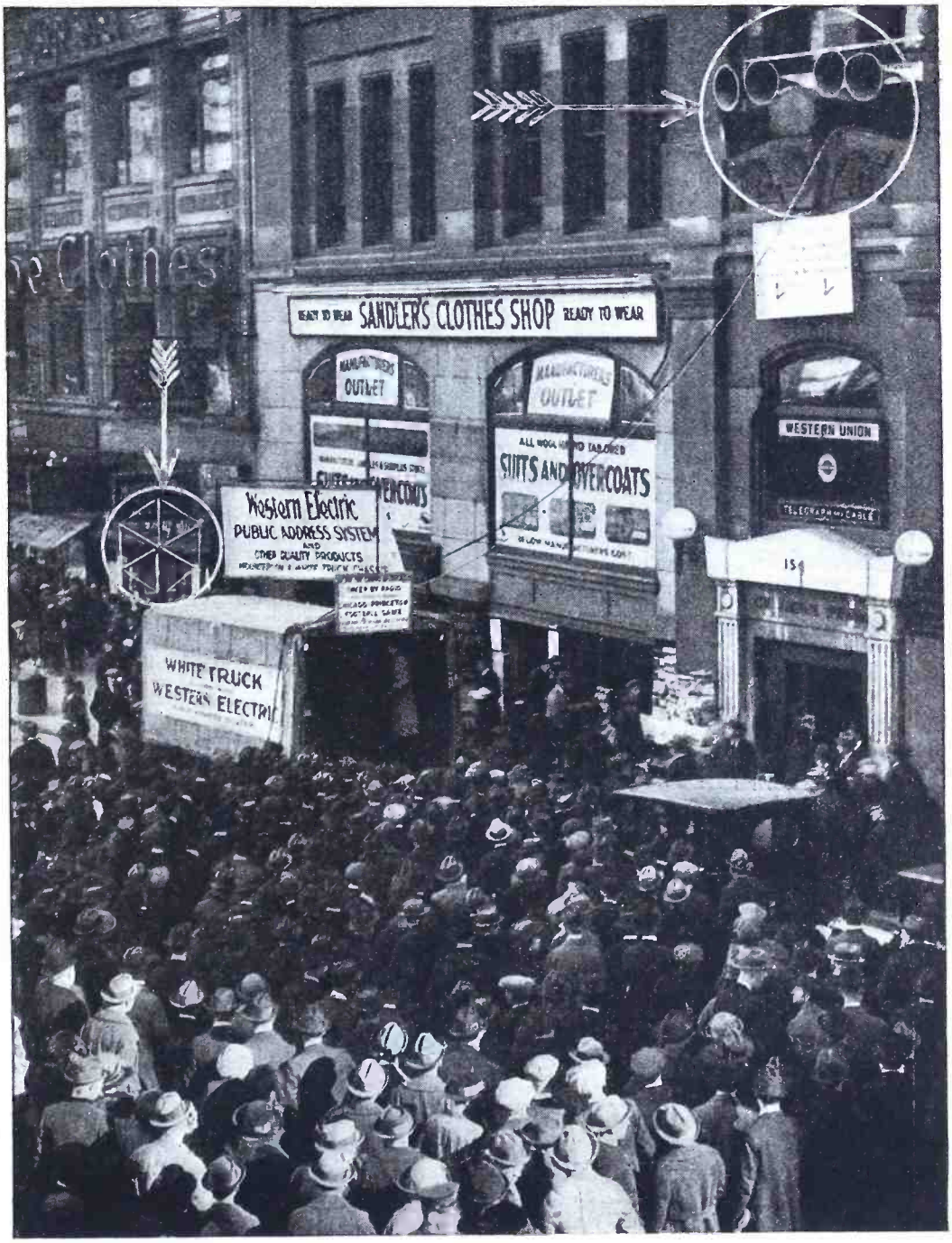
At the field itself, the occupants of Box 24 appeared to the casual observer pretty much like any other upper tier box party. Such an observer might have seen a man talking into what appeared to be an ordinary desk telephone; if he looked closely he might have observed another man, with receivers clamped over his ears, occasionally adjusting switches on a cabinet just above his knees or changing the position of a little square black box near the edge of the concrete rail. But if the observer happened to be a radio fan, he knew that the telephone and the little black box were the microphones, the instruments through which the account and noise of the game started on its way to the ears of listening thousands.

To illustrate the handling of the switches on the amplifying cabinet, let us see what happened during an exciting moment that occurred in one of the games—a drive toward the Dartmouth goal line by the Cornell team. The switch was thrown to one microphone and the announcer, W. S. Flitcraft, an experienced sports editor, was heard reporting:

"Fourth down; there is one yard to go. The ball is on the eight yard line."

Then the switch for the microphone at the south side was thrown and the cheering Cornell crowds were heard crying, "Touchdown! Touchdown!" Again, the switch was adjusted for the north side cheering section and with the change came the sharp cries of the Dartmouth crowds on the defensive, "Hold them! Hold them!"

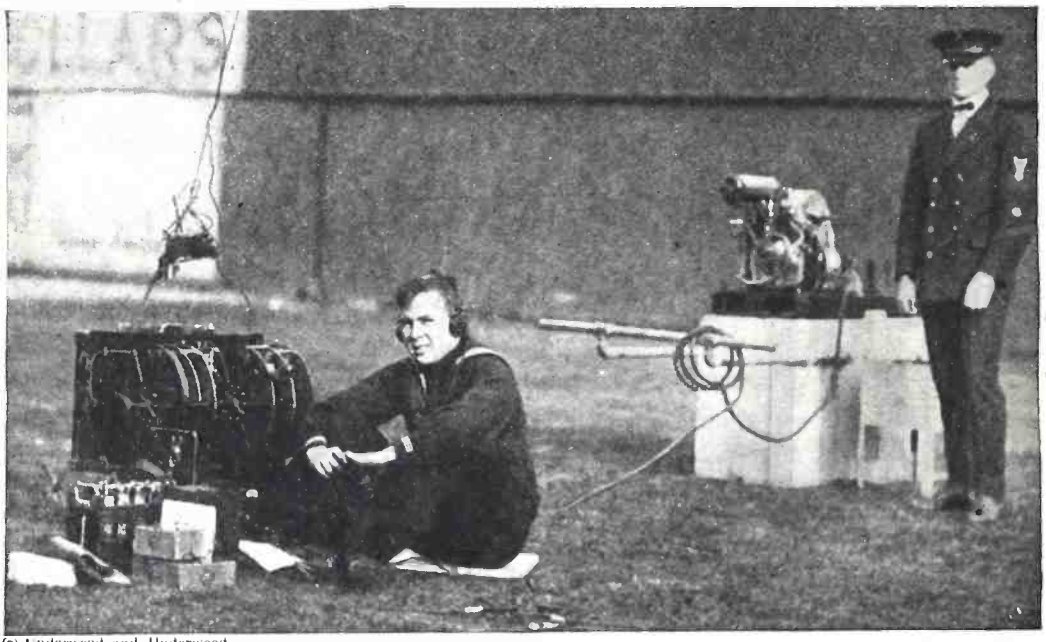
The writer sat in Box 24 at one of



Western Electric

A CITY STREET BECOMES A FOOTBALL GRANDSTAND

By the use of four loudspeakers (shown in the upper circle) the story of the Chicago-Princeton football game was made clearly audible above the noise of traffic to the great throngs that gathered before "The Tribune" Building in New York. The loudspeakers were furnished with energy picked up by a loop antenna (indicated in the lower circle) and a receiving set mounted on the truck, which is shown drawn up alongside the curb. The fact that the voice of the reporter on a football field in Chicago could be heard a thousand miles away in New York augurs a new era in the reporting of athletic contests.



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GOBS BROADCAST THEIR OWN GAMES

When the championship game between the teams of the U.S.S. Maryland and the U.S.S. Delaware was played in New York the sailors themselves set up this field radio sending station, so that their less fortunate mates aboard the ships could hear the story of the game, play by play.

the games and listened in through a pair of head phones during most of the play. At times he forgot the scene in front of him and could almost feel himself miles away, waiting in eager anticipation for the next word from the announcer, the next wild cheer that meant a long run or a cleverly executed forward pass.

The broadcasting of the Chicago-Princeton football game, played at Stagg Field in Chicago and broadcast from the station WEAF in New York, was of special interest because this was the first time that a voice reporting a sporting event had been carried over a long distance telephone wire and broadcast from a station many miles away. In this instance the *Newark Sunday Call* initiated the broadcasting of the game, the American Telephone & Telegraph Company supplied the broadcasting station and the Western Electric Company furnished the special amplifying apparatus which was placed at the athletic field. This special apparatus—amplifier, batteries, microphones—was of course practically the same as that used at the Polo Grounds in New York. However, the apparatus was placed in a booth in the press stand, the door of which was kept closed when the announcer recounted the plays.

But the details of the wire transmission over the telephone lines from Chicago to New York was the most interesting feature in the story of the broadcasting of this game.

Stagg Field was connected up with Morrell Park, a Chicago suburb, by a special telephone line, thence by one of the regular lines to Beaver Dam, thence to Pittsburgh and then New York. At Morrell Park a one way telephone repeater was specially installed, at the other points the regular line repeaters were used.

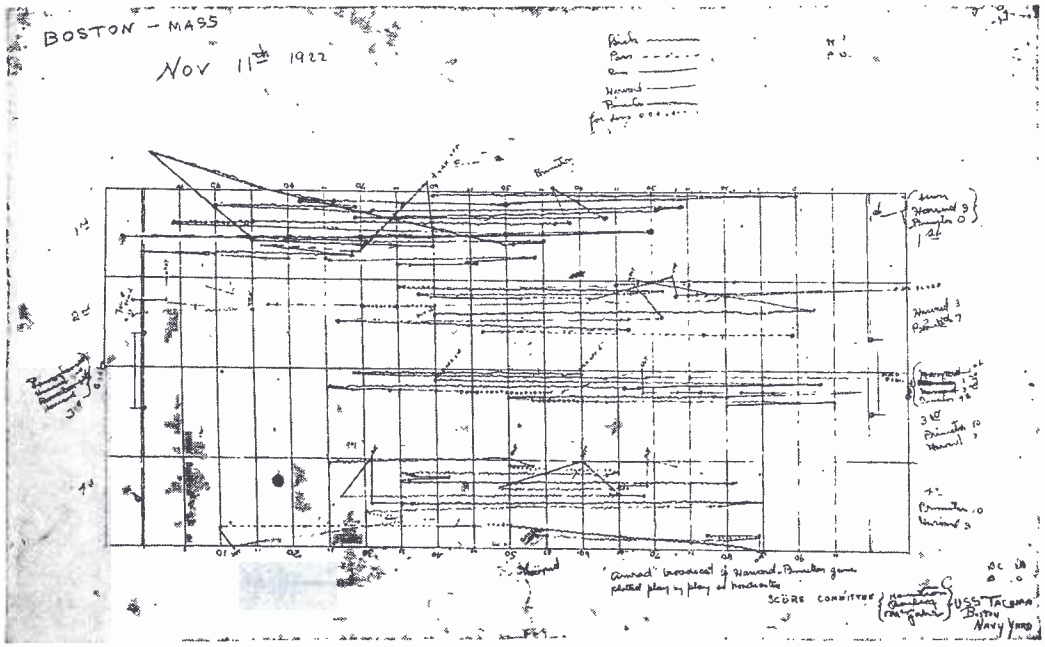
One object that the radio experts are trying to attain is to bring to the listener the sounds of a voice—or any sounds—in natural, lifelike form. The

ordinary telephone does not do this; it is not necessary that it should. But in broadcasting this a vital feature; it is of course vital in music, and a running account of a game is made more enjoyable if it comes in lifelike tones.

The speaking voice consists of a range of pitches over a wide interval of frequencies, roughly of from 100 to 5000 cycles a second; it is also composed of complex sounds. To bring, then, the voice to the listener in lifelike form hundreds of miles over a wire, it was necessary to have a circuit which would transmit with equal facility all the natural frequencies of the human voice.

In the transmission of the game from Chicago to New York the natural distortion of the regular telephone circuit was eliminated by the use of an electric network known as an "equalizer," which is a special type of electric wave filter, the invention of Dr. G. A. Campbell. The equalizer was placed at the first telephone repeater in Morrell Park. By this means all frequencies in the voice transmitted came over in natural strength and clearness, and an interesting experiment in the use of long distance wires to a far-away broadcasting station was successfully accomplished.

But beyond all the mechanics that make possible the bringing of events such as these fall sport classics to scattered millions, there is the element of human interest, exemplified best perhaps by just some little thing that brings to the comprehension in a sudden flash how much, in its developing future, radio can mean to mankind. This element of human interest showed itself in a letter received at Station WJZ from a town in the northern part of Connecticut. Four blind men had eagerly listened each Saturday to the games played at the Polo Grounds. The clear, running account given by the announcer must have been a revelation to these men who were blind, for they "saw" the game much better than if they actually had been there!



Amrad

A FOOTBALL GAME RECORDED BY RADIO

The fact that the sailors aboard the U.S.S. Tacoma were unable to attend the Harvard-Princeton game did not prevent them from following each play. This chart was plotted, during the progress of the game, on information broadcast from WGI.

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

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

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

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

QUESTION: I have an Atwater-Kent variocoupler, a pair of Murdock 2,000 ohm phones, a potentiometer, an audion detector unit, a Tuska socket, and a Radiotron UV-200 tube. Please give me a hook-up for these instruments.

T. J. H.

ANSWER: The diagram appears in Figure 1. The tuning of the antenna and secondary circuits is done by means of the tapped coil and the condenser VC respectively.

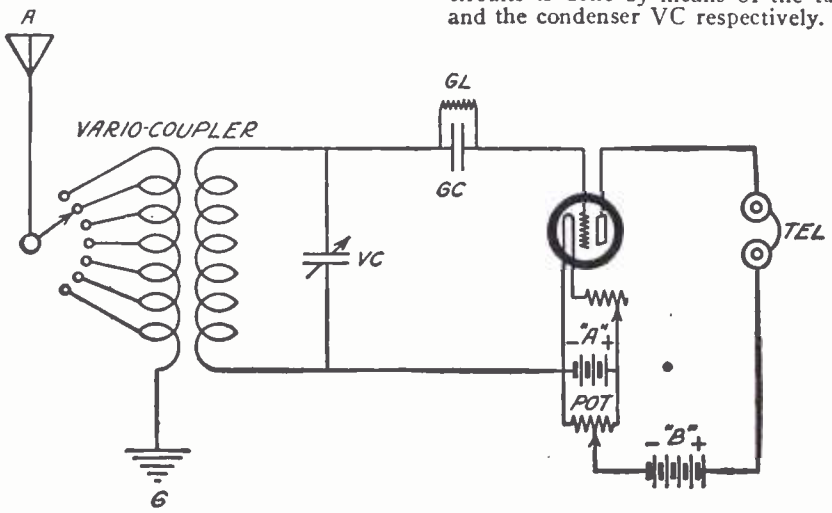


FIGURE 1

A vacuum tube circuit that employs a variocoupler and variable condenser for tuning. A potentiometer is used for adjusting the plate potential of the soft tube.

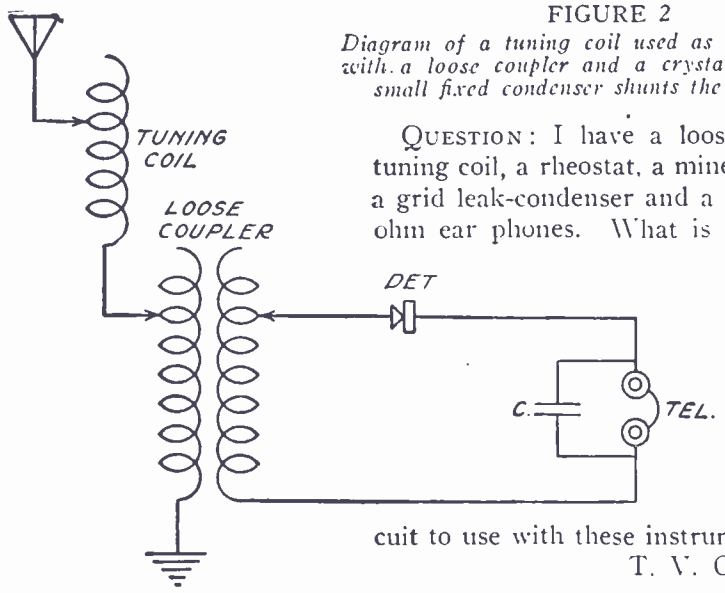


FIGURE 2

Diagram of a tuning coil used as a loading coil with a loose coupler and a crystal detector. A small fixed condenser shunts the telephones.

QUESTION: I have a loose coupler, a tuning coil, a rheostat, a mineral detector, a grid leak-condenser and a pair of 2200 ohm ear phones. What is the best circuit to use with these instruments?

T. V. GALBRAITH

ANSWER: The circuit is shown in Figure 2. The tuning coil is used as a loading coil. The rheostat and the grid leak-condenser are not needed in this set.

* * *

QUESTION: As I had no place to put up an outdoor aerial, I stretched a hundred feet of wire back and forth inside our attic. I have had good results with it. Is there the same danger from lightning as if this wire were outside? Do I need a lightning switch or outside ground with this type of an antenna, or is it unnecessary?

AUBREY H. RUSSELL

ANSWER: Your indoor antenna will be no more of a hazard than the lighting circuits in your home or the buzzer wiring that rings your front doorbell. You do not need a lightning switch.

QUESTION: Will you kindly give me a circuit for using a variometer, a .001 mfd. variable condenser, a .0005 mfd. variable condenser, with an audion detector?

A. J. BERGER

ANSWER: The diagram shown in Figure 3 will be of use to you. You will need a 2 megohm grid leak, a rheostat, and "A" and "B" batteries to complete this set.

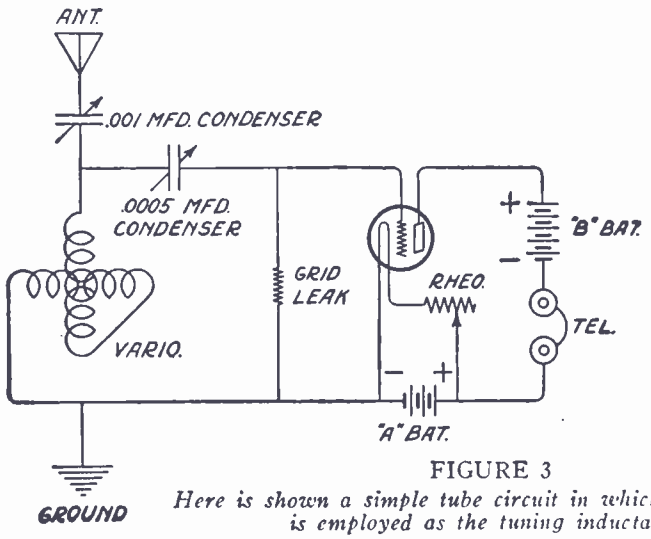


FIGURE 3

Here is shown a simple tube circuit in which a variometer is employed as the tuning inductance.

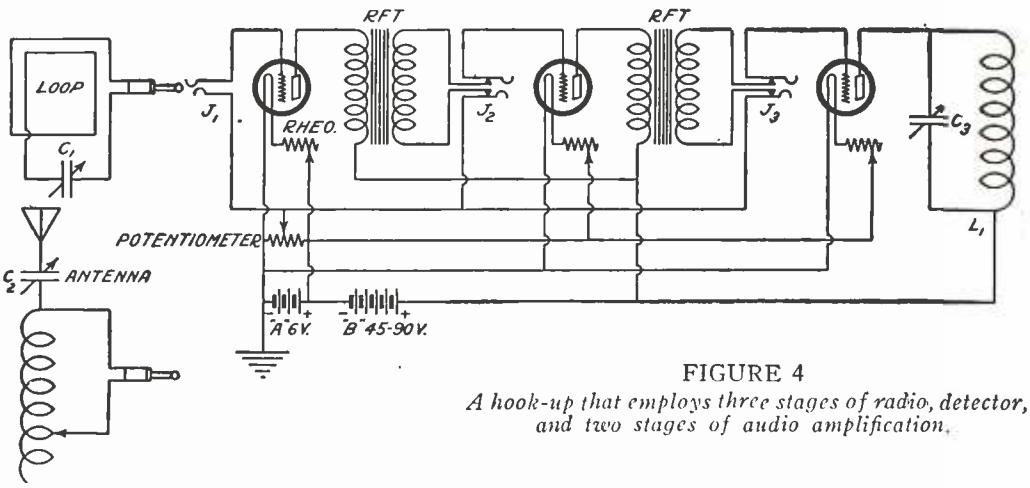


FIGURE 4

A hook-up that employs three stages of radio, detector, and two stages of audio amplification.

QUESTION: I intend to install a receiving set in a building next to a church and would like to use the auditorium of the church for giving radio concerts. Is it feasible to place the magnavox in the church, about thirty feet from the set, and still amplify the sounds enough to be heard by an audience in the auditorium? If this is possible it will easily solve my difficulties.

R. E. MIDDLETON

ANSWER: This will be both feasible and practical. Run two wires over from the building in which the set is installed and connect them to the two proper binding posts of the magnavox. The other ends of these two wires should be connected in the place where the telephones are ordinarily attached to the receiver. Then you may use a separate 6-volt battery for the two battery binding posts of the magnavox in the church. You must, however, tune the set with a pair of head telephones in the other building; when you have the set tuned, switch on the two wires leading to the magnavox.

* * *

QUESTION: Will I be able to hear concerts with a crystal receiving set and a loop antenna? If so, please let me know how a loop can be made.

H. STUBBINGTON

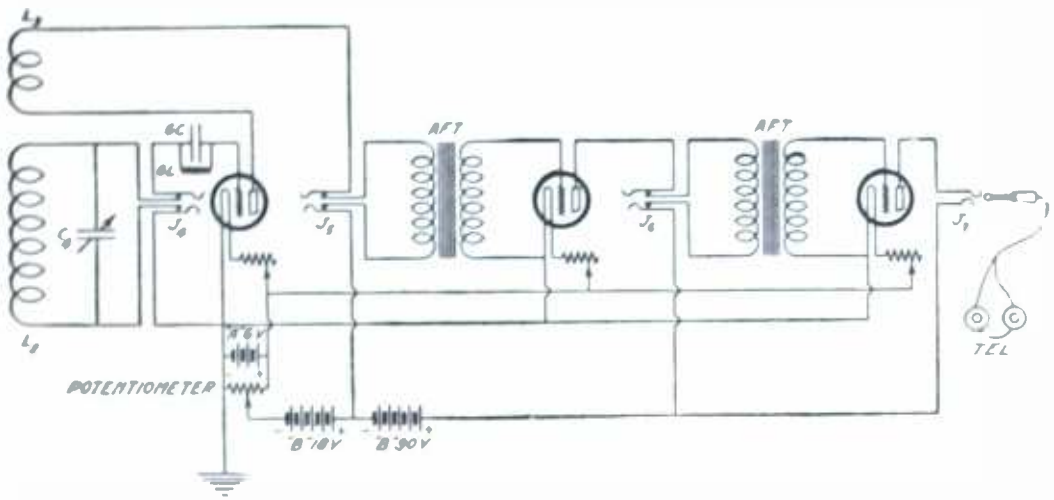
ANSWER: You will not get any results with a loop antenna attached to a crystal receiving set, as the loop antenna delivers a very minute quantity of electrical energy and this is insufficient for operation of a crystal detector. A loop must be used with vacuum tube amplifiers for efficient results.

QUESTION: I would like to get a good hook-up for making a set consisting of three stages of radio frequency amplification, vacuum tube detector, and two stages of audio frequency amplification, using a honeycomb tuner and arranged with jacks so that any stage of radio and any stage of audio amplification may be cut in or out by plugging into the correct jack. I wish to use two potentiometers, one for the radio frequency circuit and the other for the plate circuit of the detector tube; also separate "A" and "B" batteries for the radio and audio frequency amplifiers. I should like to use either an outdoor antenna or a loop with this set. Will you show me how?

J. W. CLARK

ANSWER: Refer to the hook-up shown in Figure 4. Here you will find a diagram that will give you the results you wish to obtain. The materials necessary are the following:

5 hard amplifying vacuum tubes
1 soft detector tube
6 vacuum tube sockets
4 variable condensers, .001 mfd.
1 tapped coil
2 potentiometers, 200 ohms
2 radio frequency transformers
2 audio frequency transformers
1 grid condenser, .0005 mfd.
1 grid leak, 2 megohms
6 rheostats
3 telephone plugs
5 double circuit jacks
2 single circuit jacks
3 honeycomb coils and mounting for same
1 loop antenna
"A" and "B" batteries
Binding posts



QUESTION: Will you please send me a hook up for a tapped coil, a vacuum tube detector, two variable condensers (21 and 43 plate), a fixed condenser, and a pair of 2000 ohm receivers? Is my aerial suitable for this set? It consists of two wires 100 feet long (each wire 50 feet high at one end, and 45 feet at the other) spaced 3 feet apart and made from number 14 bare copper wire. Would it make much difference if I have my ground switch inside the building during the winter?

OTTO STOLTZ

ANSWER: A diagram of a suitable circuit is shown in Figure 5. You will need a grid leak and condenser, shown in the diagram as GL and GC. Your antenna is suitable. The Fire Underwriters require the installation of the lightning switch out of doors; they make no distinction between the summer and winter seasons.

* * *

QUESTION: How do you adjust the "pencil mark" type grid leaks?

E. L.

ANSWER: This type of grid leak may be adjusted in the following manner: to increase the resistance of the grid leak, rub off some of the pencil lines with an eraser; to decrease the resistance, add more lines with the working end of a pencil, or make the lines thicker. This should be done with the set in operation, with the telephones on the ears. Keep adding or withdrawing resistance until the signals are heard loudest, and then leave the grid leak alone.

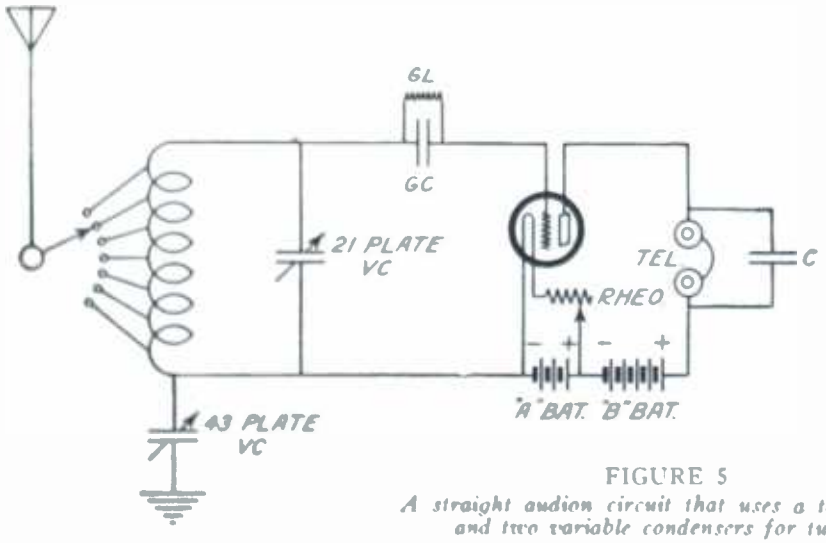
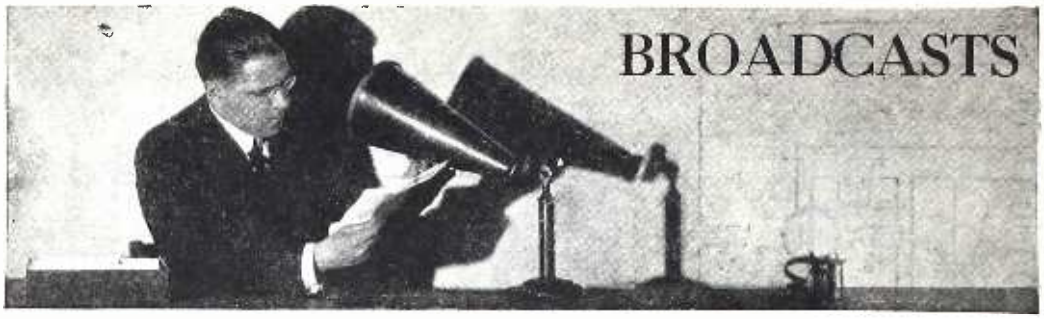


FIGURE 5

A straight audion circuit that uses a tapped coil and two variable condensers for tuning.



BROADCASTS

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

"Reading, 'Riting, 'Rithmetic"—and Radio

The young radio fan who lives in the vicinity of East Ninth street, in New York, does not have to play hookey when he builds his receiving set; he goes to Public School No. 64 instead. The construction of crystal sets is now a part of the school course; each pupil may own the set he builds upon payment of the actual cost of the raw material that he uses.

* * *

Fifty Radiograms an Hour

One of the radio operators on the liner *Majestic* recently sent out, on a four-hour watch, 200 complete messages, ranging from 8 to 65 words each. This is at the rate of one message in a little more than a minute, signatures, O.K.'s and "go-aheads" included.

* * *

Listening to the Sound of Their Money

Dressing up in one's Sunday-go-to-meeting clothes is no longer a requirement of the radio fan who attends church—not even when he attends the most fashionable houses of worship in the country. The latest recruit to the growing list of radio churches is the famous St. Thomas', in the very heart of Fifth avenue's exclusive residential district. The shut-in may now eavesdrop on New York's Four Hundred at prayer meeting by tuning in on WJZ. Every detail of the service may be heard—even to the dropping of the coins in the collection plate!

* * *

News Items in the Air

Sixty-eight newspapers in the United States are now maintaining broadcasting stations. Yet the uses of radio for collecting and disseminating news are only beginning to be developed.

* * *

Receiving Sets as Badges of Distinction

Foreign governments have not shown a consuming interest in the radio amateur; indeed, the American amateur cannot really appreciate his unusual advantages until he knows of the restrictions that are placed upon his fellows in other countries. The latest European country to exact tribute from the amateur is Czechoslovakia, which announces that each radio receiving set must be registered, and taxed—and not everyone will be permitted to own one.

* * *

Radio to Prevent Mine Disasters

The movements of 500 men engaged on construction work on a tunnel located thirty miles from headquarters in the Sierra Madre Mountains, of California, will be directed this winter by means of a radio station in the office of the resident engineer. The installation of a broadcasting station underground augurs the development of radio for controlling the activities of miners and other workmen in shafts, drifts and stopes elsewhere.

* * *

A Radio Clock

The rapid development of radio is proving of assistance to scientists in other fields. A German inventor, Heinrich Scheiferstein, through a study of the manner in which the oscillating currents in radio transmit energy to each other, has developed by the use of an oscillating motor, what he claims to be a noiseless timepiece.

* * *

A Unique Radio Switchboard

The fuel ship *Kamoi* of the Japanese Navy is said to have the most elaborate radio equipment of any vessel afloat. Among its odd features is a radio telephone exchange by means of which the ship's operator can transfer the control of the radio apparatus to any one of several stations. The exchange board resembles a telephone switchboard; a red light shows that the receiver has been taken from a phone hook, and the operator, by throwing a switch, puts the officer in control of both transmitter and receiver.

* * *

Paging Train Passengers by Radio

The first recorded instance of a commercial radiogram reaching a passenger on a morning train recently occurred on the Lackawanna Railroad, when a message received by telegraph

at a station en route after the train had passed was relayed from the railroad broadcast station. Radiophones for two-way communication will soon be considered a regular part of passenger-train equipment.

* * *

An Automatic Fire Alarm—by Radio

A widely-known radio engineer, William Dubilier, has devised an apparatus by means of which fire signals may be broadcast by the operation of an automatic switch when water is set in motion by the opening of any valve in the pipes of the sprinkler system that is installed in buildings. A central listening station administered by the Fire Department may thus be enabled to hear the characteristic calls for each building and so locate the danger. The use of this system might conceivably mean substantial savings in fire loss.

* * *

Electioneering by Radio

During the gubernatorial campaigns just passed many of the candidates resorted to broadcasting—by which means they were enabled to come within the hearing of thousands, where formerly their audiences numbered but hundreds. The widespread interest in radio has established so many receiving sets in American homes that the spellbinder who has access to a powerful broadcasting station can extend the sphere of his influence immeasurably. Indeed, one may well conjecture to what uses a government-owned station might be put by shrewd politicians.

* * *

Radio Puts a Theater Orchestra in the Receiver's Hands

From Iowa comes news of a theater that has dispensed with its orchestra and installed an elaborate receiving set instead. The broadcasting stations of Chicago, Pittsburgh and Denver provide the programs, which are presumably known in advance, so that the musical director may tune in on the selections which best serve the exigencies of the moments on the stage.

* * *

Old Dr. Radio May Cure International Ills

Some idea of the effect which radio is destined to have in welding together the fragments of a broken world may be derived from the recent announcement of a "radio letter" service to London and Germany at the rate of only six cents a word. To what extent the nations will be brought into closer political, business and social contact by the extending use of radio is an interesting theme for speculation.

* * *

Radio for Smoking Out Genius

To discover and exploit local musical talent is the avowed purpose of the Society of Radio Artists and Audiences which has just been organized in Brooklyn. It aims to introduce to the public, through Station WHN, instrumentalists and singers who are capable and who will thus be saved the expense of a debut in recital in a concert hall under private management.

* * *

Fat Folks Made Lean—by Radio

A little girl in Massachusetts recently woke up one morning and saw her mother bending over and waving her arms about with a headphone strapped over her ears. The child was so startled that she called in the neighbors—who discovered that mother was merely going through setting-up exercises that were broadcast from Station WGI at seven o'clock every morning.

* * *

Radio Entertainers as Dictators

When sister studies shorthand at home evenings she need no longer impose upon the members of the family by coaxing them to dictate to her while she takes down practice notes. By merely adjusting the earphones of a receiving set she may get all the practice she wants by transcribing broadcast speeches. The idea originated in Pittsburgh.

* * *

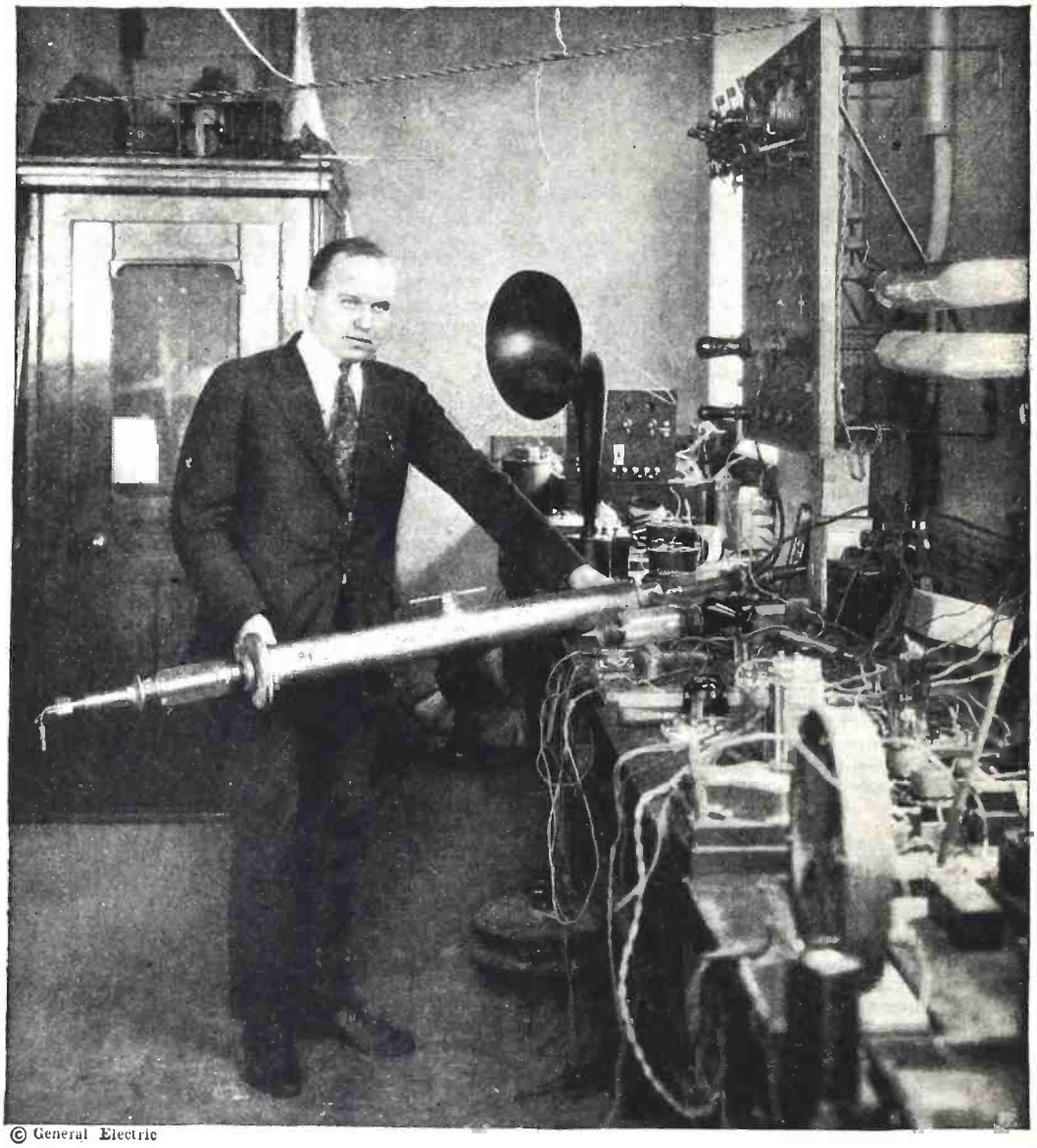
Broadcasting Stations in Every State

Every State in the Union now has one or more broadcasting stations. Wyoming was the last to be represented on the radio map. California leads the States with sixty-six broadcasting stations, Ohio follows with thirty-five and New York is third with thirty.

Sport-Commercial

THE NEW SPEED CHAMPION IN RADIO

Here is Joseph C. Smyth with the silver cup that proclaims him the fastest and most accurate receiver and transmitter of radio signals in this country. He won the "jamming," cipher code and straight press contests.



THE GRANDFATHER OF ALL VACUUM TUBES

No sooner does POPULAR RADIO *introduce its readers to the 100-kilowatt audion built by Dr. W. G. Housekeeper as "the most powerful vacuum tube in the world" when along comes another announcement of a tube that is just ten times as powerful! This latest giant was developed by J. H. Payne, Jr., who made use of the discoveries made by Dr. Irving Langmuir and Dr. A. W. Hull. The father of this new prodigy is shown above, holding his child before the camera man. The power output of this tube is 1,000 kilowatts—sufficient to light forty thousand 25-watt electric incandescent lamps, or enough to light 1,500 average homes. An unusual feature of the tube is its lack of a grid; it is caused to oscillate by means of a system whereby the filament is heated by an alternating current of 10,000 cycles, the magnetic field of which serves to "cut off" the plate current 20,000 times a second and thus sustain oscillations in a circuit tuned to that frequency. Some idea of the significance of this invention may be obtained from the fact that this tube, with all its auxiliary apparatus, occupies a space barely six cubic feet—yet it is five times as powerful as the largest high-frequency alternators now in use. The time is coming when the large power plants now used in transatlantic communication work will be scrapped, and in their place will be a small compact station equipped with one or two of these vacuum tubes.*

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, 9 *East 40th Street, New York City.*

I Pick Up a News Item of World-Interest

OCCASIONALLY the fan confuses the skeptic with a practical demonstration of the superiority of radio over the wire in the dissemination of news—as this adventure from the Middle West relates:

My most thrilling radio experience came shortly after the war, when the country was all excitement over the attempted transatlantic flights by Lieutenants Hawker and Greeley, who, it will be remembered, started to cross the ocean in a common airplane that was equipped only for land flights. They got off their course and were lost.

My grandmother was exceedingly anxious that these two aviators be found. Several times a day she would call up our neighbor, who was the editor of a local newspaper, to find out if the Associated Press had yet reported their rescue. Each time the editor would answer "No." In a few days the press gave them up as dead.

One evening as I sat at my radio set, playing with the 20,000-meter arc-stations, copying a little here and a little there (most of it being in code) a high and clear-pitched arc-station began with a "Q S T." It was the high-powered station at Nova Scotia. I had no trouble getting the signals, as the night was clear and no other station seemed to be working on that particular wavelength. I was not especially interested till I copied the names "Hawker and Greeley."

My heart took a jump. I copied the whole message without error; it was a report of the discovery of the two aviators, unharmed and safe. I ran downstairs and showed the message to my grandmother. She at once went to the telephone and called our editor friend and asked if there was any truth in it. No; the Associated Press had heard nothing of it. Of course, everyone doubted me and my radio message. I went to bed with my whole day ruined.

The next morning the editor called me up and reported that the two men had been found off the coast of Nova Scotia; the press got the news about 2 o'clock in the morning. Yet I had received the message at 10 o'clock the night before!

The local newspaper gave me a big write-up. It should have—for radio had beaten the Associated Press by four hours.

JOHN L. SIEGLE (9DWZ)

I Dig Up a Voice from the Soil

ANY radio fan who has had experience with a pulsating current flowing in a wire, thus producing a magnetic field that induces a similar current in another wire within that field, will know the real explanation of the phenomenon described in the following letter from Sibley, Illinois:

When I had completed my first simple crystal set I spent my first day trying to tune in, but without success. Suddenly it occurred to me that my ground pipe was only a foot under the ground, so I went out and drove a stake about seven feet into the earth, then came back to my apparatus and tried again to pick up signals. This time I heard a low buzz. Soon someone began to talk. I was so excited that I did not listen in on the conversation but ran downstairs to tell my father. He came up to listen, but all was silent again.

An hour later I heard another conversation, and again I went to get my father. He

was talking over the telephone; as I listened to him I realized that what I had heard on my set was merely the telephone conversation. This puzzled me. I started an investigation and found that I was picking up nothing but talk that came over the telephone wires. One end of my antenna was fastened to the telephone pole about a foot below the telephone wire, and the sound had jumped from one wire to the other.

HAROLD ACKERMANN

I Answer a Weird Call for Help

ANY fan would get a thrill out of the adventure of this amateur who lives in Bridgeport, Conn. If this were a play instead of a report of an actual occurrence it would be preceded by the rumble of stage thunder:

I must have been an odd person, I'll admit, for nothing could get me away from my radio outfit. Mac, my best friend, was another of the same crowd—always sticking to the job of twirling a few dials and knobs.

One dismal night I sat idly back in my chair listening to some strait-laced amateur voicing his opinion of the broadcasting conditions. He was amusing and I listened to his wrangling. I was forming my own opinions on that timely subject when some fool with a K.W. spark set opened up, keeping the key down for some time; he was apparently trying to send intelligent phrases but they were completely lost in a jumble. He seemed to be in a hurry, as he cut short some characters and ran others together. Suddenly I heard him distinctly form the call "JR"—*my* call, which was known and used only by Mac!

I strained my ears. The spark still kept on with its ponderous calling. He was calling "JR," of that I was sure. I did not become excited, however, until I heard distinctly and clearly three SOS's and then the signing—HC.

It was Mac, and he was SOS'ing me!

Again I listened. He formed the characters a little more clearly now.

"JR-JR, come over PDQ. Hurry or I will be out of luck for— — — SOS SOS," then the signature, "HC."

I rushed out into the rain, minus a hat and without rubbers or overshoes, to see what was the matter with Mac. He was a good sender and I could not account for the rotten way his fist had worked just a few minutes before. A dozen theories ran through my mind as I splashed from one ankle-deep puddle into another.

Out of breath and soaked to the marrow I finally reached Mac's shack. It was dark. I forced the warped door open and stumbled headlong over a chair and groped around until I found the electric switch.

Mac, wearing only his pajamas and soaked, was standing in that cold shack working the key for all he was worth. When I looked at him, I noticed that his eyes were tightly closed.

I remembered then that Mac was a somnambulist. While dreaming he had walked through a drenching rain to that cold shack just to carry out what was running through his mind. There would be another trip for poor Mac to make before he could get back to the warm house, and I dreaded the necessity of having to awake him, and explain matters. I never saw such a surprised person as Mac, when, with a good deal of strong-arm work, I finally got him quieted down. I stayed with him for the rest of the night, pouring hot lemonade down his throat and keeping him covered.

The next morning when I went home I found that I had left the lightning switch without throwing it, but the lightning had decided to keep away from my antenna. I had also left three tubes on, but luck had been with me—the tubes were still good, except for the fact that the battery was run down.

ELMER J. HUBER, JR.

Radio Is Opening a New World

TO THE EDITOR OF POPULAR RADIO:

"We are convinced that broadcasting has strong cultural value and that it is an effective means for developing an appreciation of good music by large numbers of people who might otherwise not realize what opportunities for refreshment and satisfaction music offers to them.

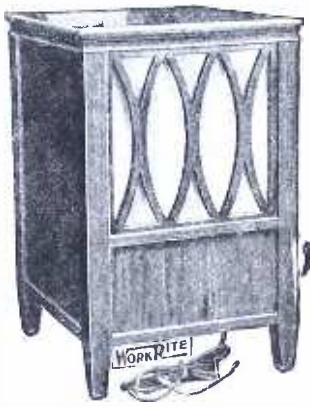
"We know from our experience in Rochester that this broadcasting service is a special boon to invalids who, though confined to bed by sickness, are enabled to hear the music of our concerts by means of receivers easily accessible to their beds.

"Broadcasting, properly conducted and supervised, must wield an undoubted influence for wider and richer culture."

RUSH RHEES, D.D.
President, University of Rochester

WORKRITE

LOUD SPEAKERS OF QUALITY



CONCERTOLA SR.

These Concertolas are very popular with "WorkRite" fans, and when you read about them and compare them with other Loud Speakers on the market you will easily see why.

Except for the phone units, THERE IS NOT THE SLIGHTEST METAL, in either the WorkRite Sr. or Jr. The sound chambers are made from our specially developed material, which reproduces voice or music in a clear, loud tone without the slightest distortion. Why listen to music through a "tin-panny" metal horn that loses all the beautiful tones of the artists, when you can get a WorkRite Concertola that will give you perfect reproduction of concerts?

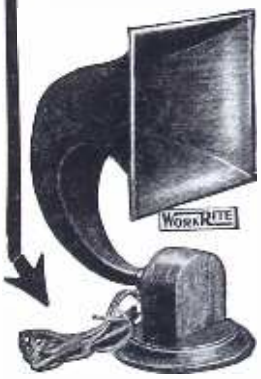
The finish on these instruments is exceptional. The WorkRite Concertola Sr. is built from numerous plies of the finest mahogany, oil rubbed and finished exactly like your piano. It is 10" square by 15" high. Place it on your library table and run wires to your set in any other part of the house.

READ WHAT THIS CONCERTOLA FAN SAYS

"I tried out thoroughly last evening your WorkRite Concertola and am very much pleased with the results. The music and voice from distant stations come in clear and distinct and loud enough to be heard all over the house. THE SQUEALS, HOWLS AND OTHER RACKET I'VE HEARD THROUGH POWER SPEAKERS AND METAL HORNS ARE ENTIRELY ABSENT. The music comes in with a clear, mellow tone and without distortion. Here are the stations I've heard: WJZ, WEM, WGY, WHB, KLZ, WBAP, WHJ, KYW, WHAS, and WOC. The Concertola is the finest loud speaker I have yet heard."

L. A. CRACKEL, 508 N. 5th St., Champaign, Ill.

These Concertolas are designed for use with vacuum tube sets having two-stage amplification. Get one for your set now, so you will have it to enjoy during these winter evenings.



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WorkRite Concertola Sr. with Cord and Phone Unit, $24.00

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CONCERTOLAS

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THE Bel-Canto Loud Speaker *has made good.*

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Hear the Bel-Canto. Hear the loud, clear, undistorted reproduction of this masterful invention. You will agree with the hearty endorsement of that world-famous pianist, Paderewski. He heard the Bel-Canto and wrote us about it: "The clarity and volume of tone and particularly the absence of distortion make the Bel-Canto a remarkable device. You are indeed to be congratulated."

The Bel-Canto is not simply "another" loud speaker. It is a revolutionary instrument in the world of radio music. The Bel-Canto is built on the most perfect acoustic principle known to science—*the human vocal organs.* From the diaphragm of its supersensitive reproducing phone to the hollow, air-tight resounding chamber, this principle is faithfully carried out. The result is an instrument whose perfect reproduction of music and the voice is unequaled by any other loud speaker that we know of—no matter what the price.

The Bel-Canto is handsome in appearance—an addition to the finest home or apartment. The instrument comes complete—ready to plug right into your set. No head phones are necessary. The Bel-Canto includes special reproducing phone, hard rubber plug, and ample cord. The price complete is $30.

Go to your dealer's today and hear this Loud Speaker of loud speakers. You have a real surprise awaiting you.

If your dealer has not yet stocked the Bel-Canto we will send you postpaid the complete Loud Speaker on receipt of price, $30. Or C.O.D. if you prefer.

Guarantee: Each Bel-Canto is thoroughly tested before it leaves our factory. If it doesn't give entire satisfaction we will replace it with a new one, provided the plate on the bottom has not been removed.

Special Offer to Dealers

Send us your name and address and we will ship you C.O.D. one Bel-Canto, giving you the maximum discount from the list price. We want you to introduce the Bel-Canto to *your* trade. One introduction will bring enough enthusiasm on the part of your customers to warrant a reorder. That has been our experience with other dealers. Why don't *you* try it and see? We'll give you your money back if the Bel-Canto doesn't beat out your expectations.

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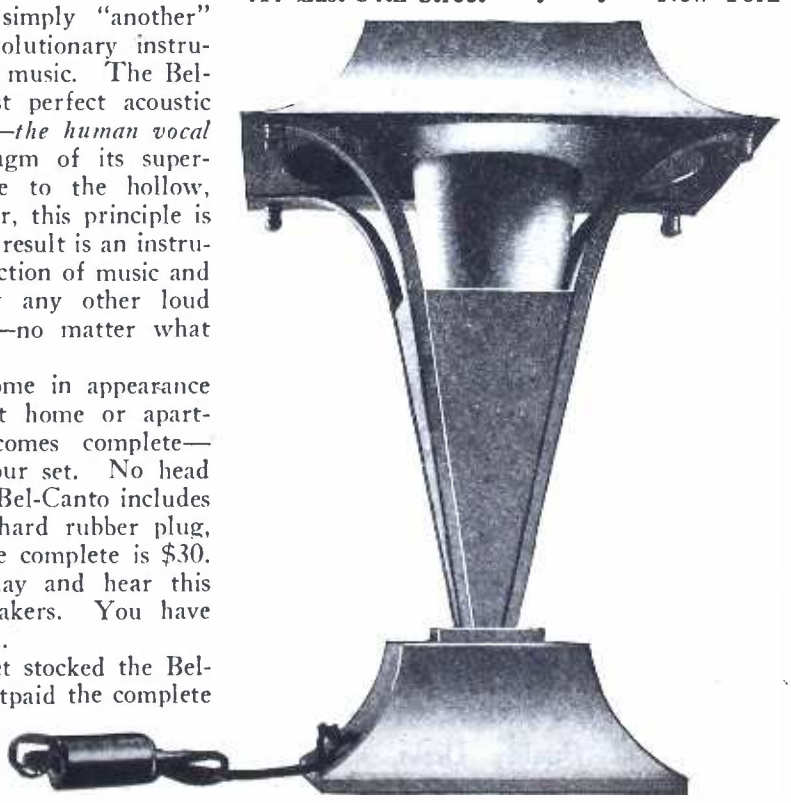
417 East 34th Street : : New York



For the money the Ford is a very good car

You get a place to sit between four wheels that keep going. You don't expect quality-car looks, finish, comfort or smoothness of operation. You get about what you pay for.

It is not otherwise with radio apparatus. There are single circuit receiving sets that sell for less than the Paragon three-circuit receiver. All single circuit receivers will let you listen in, after a fashion, on radio programmes. But you will get mixed messages and general jamming between the numerous broadcasting stations all operating on one narrow wave band.

If you want to get real service, pleasure and satisfaction out of radio, buy a receiving set that is more than a make-shift. Ask some experienced radio amateur what he knows about

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RADIO PRODUCTS

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

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

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

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

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Radio Telephone Transmitters	Amplifier Transformers
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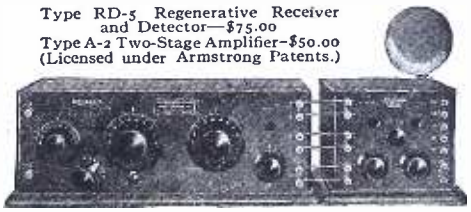

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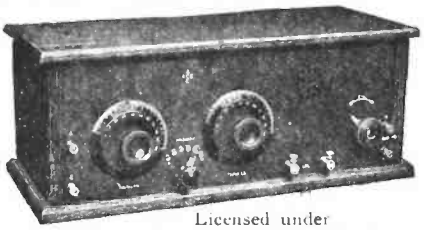

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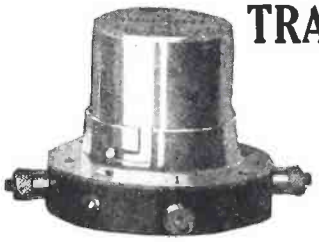

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The type 1 R.F. Transformer, with its range of 200 to 500 meters, gives best results with the present broadcasting wave lengths.

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6.50	Radiotrons UV-201	5.75
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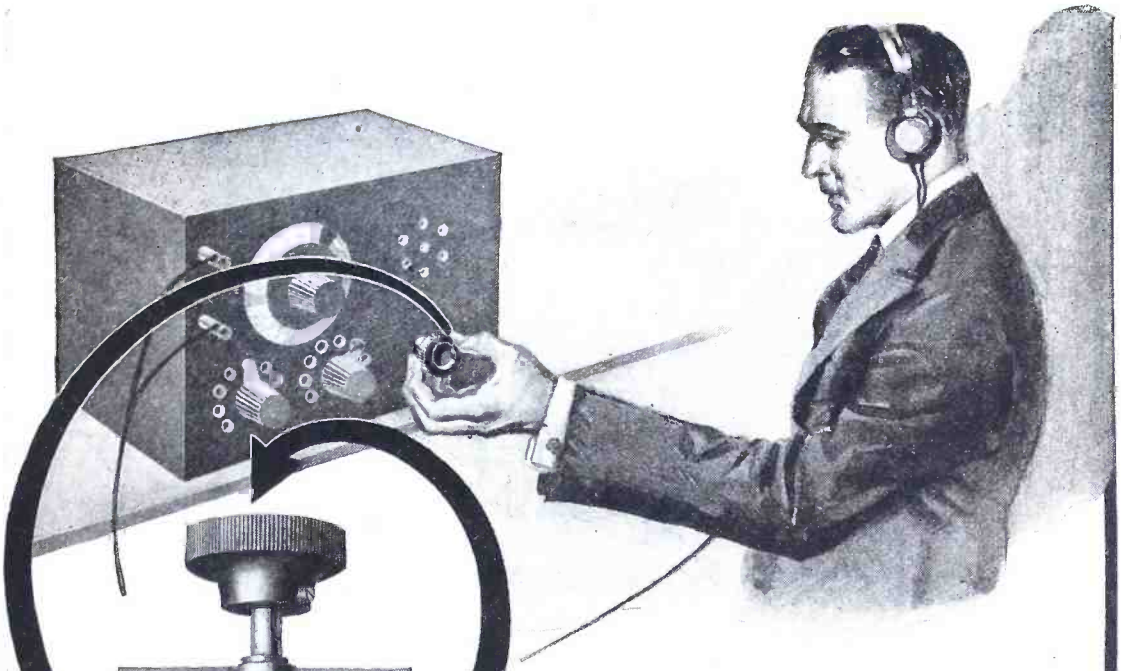

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RESIST-O-METER
TRADE MARK

The Resist-O-Meter illustrated is Type A Filament. Price, $1.80

Your radio receiving set—has it a Resist-O-Meter?

It should have.

The Resist-O-Meter gives you a better outfit by far. You will notice the difference immediately. It is the *ideal* variable resistance.

You need these rugged instruments which provide for an extremely delicate *and continuous* variation in resistance to properly control the current flow from the "A" and "B" batteries of your radio set. Hook up a Resist-O-Meter. You will never go back to the old type.

The Scholes "Resist-O-Meter"—

—is micrometer controlled and *continuously* variable between the extreme ranges of its terminals.

—is non-microphonic.

Possesses the lowest resistance at full compression (practically zero).

—is made in models covering every requirement for radio use.

—is compact and convenient, and takes up very little space in standardized mounting.

The Scholes Radio & Manufacturing Corporation holds the sole license to manufacture this type of current control, under patents granted Mr. F. A. Rojas, Nos. 15478 and 1366945, other patents pending. It is sold only under the trade mark name "Resist-O-Meter." Ask your dealer to supply you.

We manufacture the products listed below:

Resist-O-Meters

Type A—Filament
" B—"B" Battery
" C—Potentiometer
" D—Variable Grid Leak

Test-Rite Condensers in following capacities:

Phone	.001 mfd.	
Grid	.00025 "	
Grid	.0005 "	
Grid Leak	.0005 "	1-meg.

V. T. Sockets
Engraved Binding Posts
Accessories

Write to Mr. C. W. Preston
THE SCHOLES RADIO & MANUFACTURING CORP.
33-36 West 18th Street, New York City

For Your Radio Xmas!

Two New

Popular Radio

Subscriptions

$2.50

Make it a radio Xmas! The most acceptable gift to every radio enthusiast is the gift that costs least and lasts longest—A Year's Subscription to POPULAR RADIO. You may have two yearly subscriptions for a little more than the cost of one. Include $.25 for Canadian postage and $.50 for foreign countries. The subscription rate goes up early in the New Year. Better act right away. *Use the double coupon.*

Coupon Good Until January 21, 1923.

POPULAR RADIO
9 East 40th Street, New York City

Please send POPULAR RADIO for one year to:

NAME .....

ADDRESS .....

CITY ..... STATE .....

And also to this other new subscriber. Here's my cash remittance—(or a check for two-fifty).

NAME .....

ADDRESS .....

CITY ..... STATE .....

To the left is the standard air variable condenser

Below is the Dubilier Variadon as supplied from the factory with graduated scale and knob

The New Variadon—

No thicker than an ordinary dial

THE following are the more remarkable features of the new Dubilier Variadon, the first practical mica variable condenser:

1. It is no thicker than an ordinary dial. Yet it serves the purpose of an air-condenser with several dozen plates.

2. It can be mounted on any convenient part of a receiver case (front or rear of panel).

3. Its adjustment cannot be destroyed by ordinary shocks, falls or vibrations. Hence short-circuits are practically impossible.

4. It makes the vernier unnecessary.

5. It can be used as a grid-leak condenser, so that new tubes or different tubes can be adjusted to suit the receiving set.

Capacity .0004 or .0006 mfd. Retail price $2.50.

Capacity .001 mfd. Retail price $3.50.

Supplied complete with dial and knob.

Other Famous Dubilier Products

Dubilier Micadons

Micadons are little mica condensers which reduce tube noises. Made in a wide range of capacities. Price 35 cents to $1.50 each, according to capacity.

The Ducon

Screw the Ducon in any lamp socket and thus do away with the antenna. The broadcasting station comes in loud and clear.

Price $1.50.

The Du-tec

A chemical rectifier of which every spot is sensitive. Eliminates tedious and frequent adjustment of "cat whisker." Does not oxidize with age. Price, mounted, 30 cents each.

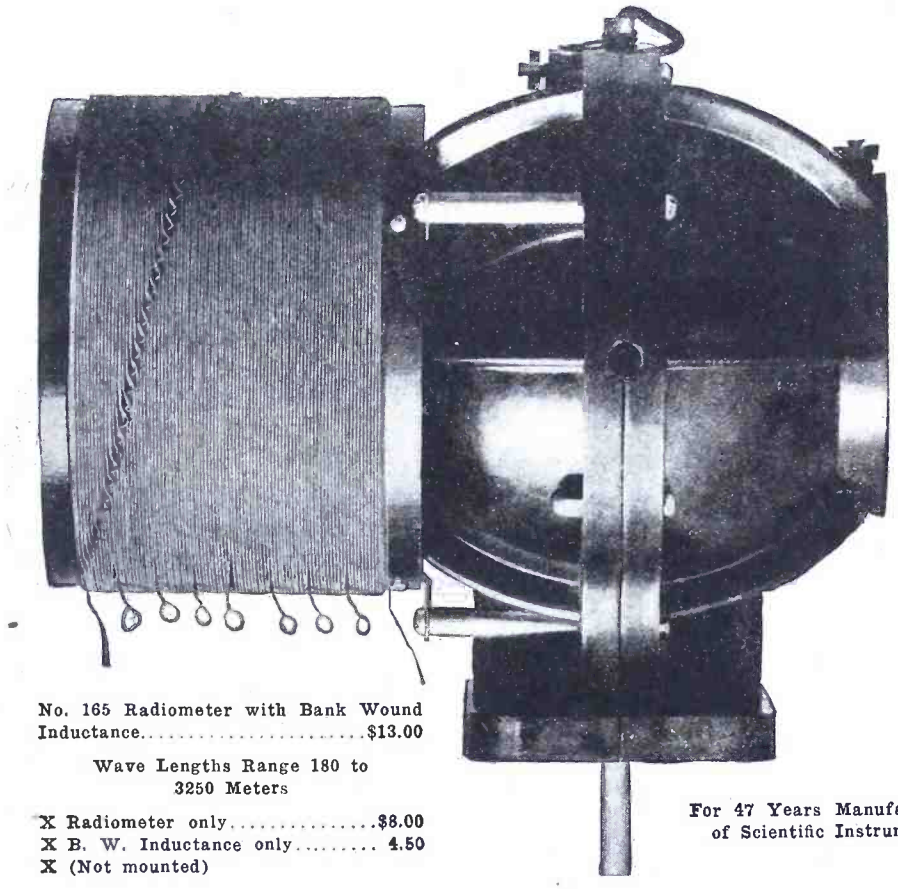
DUBILIER Condenser & Radio Corp.

48-50 West 4th St. N.Y.

DISTRIBUTORS AND BRANCH OFFICES

SAN FRANCISCO, CAL., 709 Mission St. ST. LOUIS, MO., Syndicate Trust Bldg.
WASHINGTON, D. C., Munsey Building CHICAGO, ILL., 33 So. Clinton Street
ATLANTA, GA., Forsyth Building

Distributed in Canada by General Electric Company, Ltd., Toronto



No. 165 Radiometer with Bank Wound Inductance.....$13.00

Wave Lengths Range 180 to 3250 Meters

X Radiometer only.....$8.00
X B. W. Inductance only..... 4.50
X (Not mounted)

For 47 Years Manufacturers of Scientific Instruments

THE PRIDE OF NEW ENGLAND

SE-AR-DE

Clip Coupon for Complete Catalogue of Equipment

Enclose Four Cents for Postage

NAME.....

ADDRESS.....

R. MITHELL & CO.

257 Atlantic Ave., Boston, Mass.

De Forest
D-7
Reflex
Radiophone *

Listen to Half the Continent for 1923!

HERE'S the latest De Forest triumph, the D-7 Reflex Radiophone* Receiver. It's the newest and most sensitive set of them all, with a thousand mile range on a two-foot indoor aerial! That's what you've been waiting for. No outside aerial is needed. The whole set is as you see it here.

Easy to control with its single knob—small, compact, super-efficient—and an ornament to any library table!

Economical to operate, too, because you get five stages of amplification on three tubes, and correspondingly longer life for your storage batteries.

If you want to bring into your home the news, the music, the lectures of half the American Continent—with no trouble—clearly without interfering noises—this is the set for you. And here's one set that is all you ever hoped a receiver could be. Ask your De Forest dealer about D-7 and and other De Forest sets—to-day.

De Forest Radio Tel. & Tel. Co.

Jersey City, N. J.

DE FOREST

*Reg. U. S. Pat. Off.

What is the Finest Receiving Set Made?

To be worthy of this distinction, the set must have three characteristics—

World-wide receiving range—
Reception in all wave lengths—
Reception without distortion.

RadioCraft D-6 Regenerative Radiophone* (by permission of De Forest Radio Tel. & Tel. Co.) will receive even European stations, and of course all those on this continent.

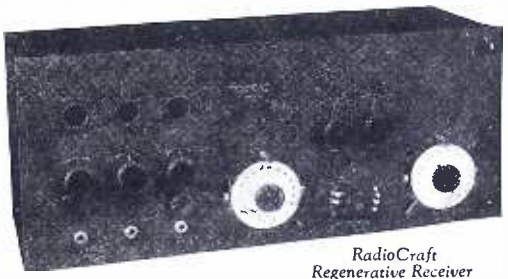
It receives on all amateur, broadcasting, and transatlantic wave lengths.

In clearness and avoidance of distortion, it must be heard to be adequately described.

D-6 uses outside aerial only, and head sets or loud speaker.

It claims to be the finest receiving set now manufactured and any authorized De Forest dealer (who also carries the RadioCraft line) will be glad to prove this to you by actual demonstration.

RadioCraft Regenerative Radiophones*(by permission of De Forest Radio Tel. & Tel. Co.) range from the simplest to the most elaborate.



RadioCraft
Regenerative Receiver
Type D-6

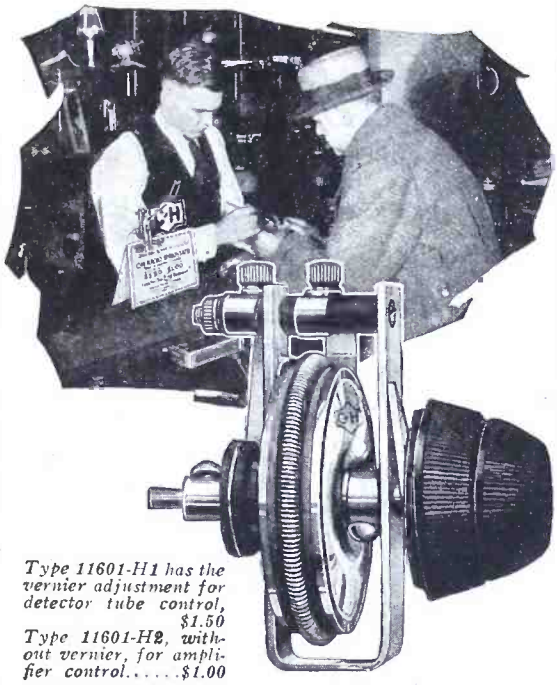
It is unnecessary to add that this entire line of De Luxe radio equipment is most exquisitely finished in every detail.

The RadioCraft Co.

139 Franklin Street, Jersey City, N. J.

RadioCraft

*Reg. U. S. Pat. Off.



Type 11601-H1 has the vernier adjustment for detector tube control, $1.50
Type 11601-H2, without vernier, for amplifier control.....$1.00

Dealers Point with Pride to the C-H Trade-mark

One of the first things any dealer will point out in showing you a genuine Cutler-Hammer Radio Rheostat is the famous C-H trade-mark engraved in the satin-nickel body.

As a practical electrical man, the dealer knows the protection this trade-mark gives the buyer—he knows that "*radio rheostats built by rheostat builders*" means perfection as the result of years of experience, not hasty design to meet a sudden demand.

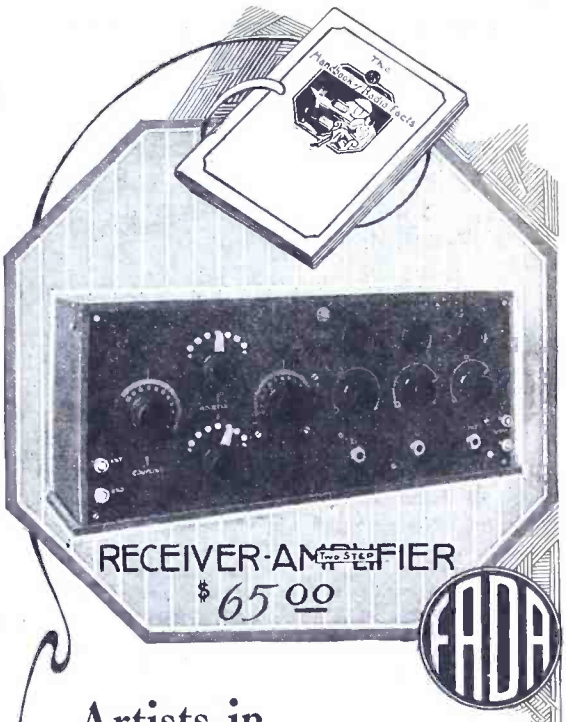
For more than a quarter of a century the engineers of Cutler-Hammer have been the aggressive pioneers in the development of rheostatic control, and their signature of approval—the C-H trade-mark—is known and respected in every industry the world over.

The dealer is proud to show, as representative of his stock, these rheostats of recognized and guaranteed quality, and he recommends them with full confidence, knowing that they were designed by specialists to give you unfailing satisfaction.

THE CUTLER-HAMMER MFG. CO.
MILWAUKEE · WISCONSIN
Over a Quarter Million in Use

C-H RADIO RHEOSTATS
"BUILT BY RHEOSTAT BUILDERS"

"Member, Radio Section, Associated Manufacturers of Electrical Supplies."



Artists in Your Own Home

could not be heard more distinctly than Radio Entertainers with the

Fada Receiver-Amplifier

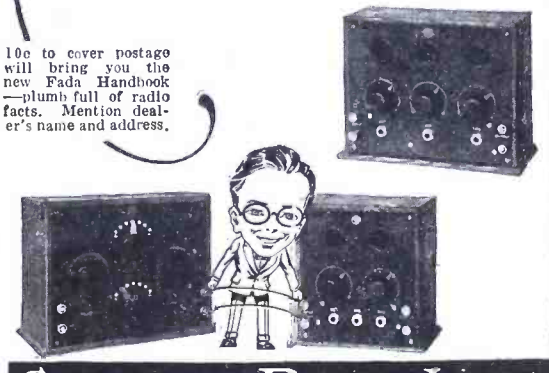
Simplicity of tuning control is an exceptional advantage, and when properly adjusted you enjoy the entire program without giving the instrument further attention.

Tuner can be furnished separate from the Detector and Amplifiers when so desired.

Look for the *Fada* trade-mark when you buy. It's a guarantee of dependable radio equipment.

F. A. D. ANDREA
1581-D Jerome Ave. New York City

10c to cover postage will bring you the new Fada Handbook—plumb full of radio facts. Mention dealer's name and address.



COMPLETE RADIO LINE

Etherphonette

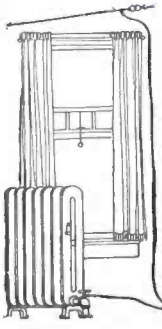
The last word in RADIO

Receiving Set *and* Head Phone *Combined!*

HERE is the most unique "listening in" outfit in the field of Radio. *In the Etherphonette the receiving instrument is built right into the head phone.* No extra equipment is needed. Simply connect to single wire aerial (40 to 75 feet long) inside or outside the home or to lamp socket antenna plug, and ground to radiator, gas or water pipe. Then "tune in."

One shell of the Etherphonette contains a 1500 ohm phone—the other an efficient tuner and concealed crystal detector. Catwhisker, crystal and tuning controlled by outside adjustment knobs. A special eight-foot cord with five foot split ends, and clips for aerial and ground connections, completes the set. Entire Etherphonette is no larger and no heavier than ordinary head phone.

The Etherphonette is not a toy but a practical, scientifically built, radio receiving set. Receives any broadcasting station, sending on 200 to 450 meters, within 18 to 20 miles. An ideal Christmas gift for youngsters or adults.



Price $12.50

If your dealer does not have the Etherphonette in stock order direct from us. We will ship complete Etherphonette parcel post, on receipt of check or money order, or C. O. D., if desired. Money back for your Etherphonette, if within ten days, you are not satisfied.

Order today—be the first in your neighborhood to get the unique Etherphonette.

RADIO APPARATUS CO.
Manufacturers of
"Etherphone" Radio Equipment
40 W. Montcalm St., Detroit, Mich.

BURGESS RADIO BATTERIES

—are recommended by leading manufacturers of radio equipment.
—are specified by radio engineers.
—are designed and built by radio engineers.
—are a guarantee of satisfactory service.
—Ask any radio engineer.

BURGESS No. 6 BATTERIES

Are highly recommended for use in "A" or filament circuits where Westinghouse WD-11 Vacuum Tubes are used.

Burgess Radio Batteries are handled by all progressive jobbers and dealers. Look for the distinctive black and white stripes. If your dealer doesn't handle the Burgess line just address the nearest Burgess office below.

BURGESS BATTERY CO.

Engineers — Dry Batteries — Manufacturers
FLASHLIGHT—RADIO—IGNITION—TELEPHONE

General Sales Office: Harris Trust Bldg., Chicago
Laboratories and Works: Madison, Wisconsin

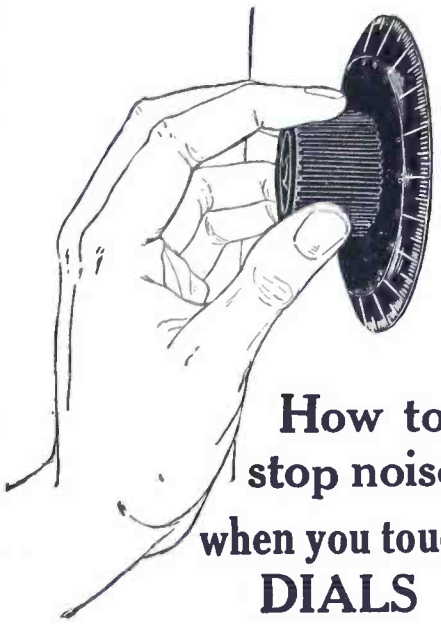
BRANCHES:

NEW YORK	BOSTON	WASHINGTON
ST. PAUL	KANSAS CITY	NEW ORLEANS

In Canada: BURGESS BATTERIES, Ltd.
Winnipeg, Toronto, Montreal

"ASK ANY RADIO ENGINEER"

BURGESS RADIO BATTERIES



How to stop noises when you touch DIALS

Have you ever found, after tuning in a distant broadcasting station, that when you removed your hand from the dial, there is a growling noise which makes it impossible to hear anything else?

This is usually caused by two things—too much current thru your detector tube filament and dials made from compounds which, being comparatively poor insulators, cause body capacity to make proper tuning an impossibility.

If you are positive that the proper amount of current is flowing thru your filament and these distracting noises still persist they can be overcome only by removing the dials at present on your set and replacing them with dials made of RADION.

Tests have proved time and again that RADION is without question the supreme insulating material for Wireless use.

Secure a dial from your dealer today. Take it home and place it on your set and you'll notice the difference immediately. Also have your dealer show you a RADION MAHOGANITE panel—the most beautiful panel made—easy to saw and drill. It is also warp and chip proof.

If your dealer can't supply you, write us direct, giving us his name, and we'll see that your requirements are immediately taken care of.

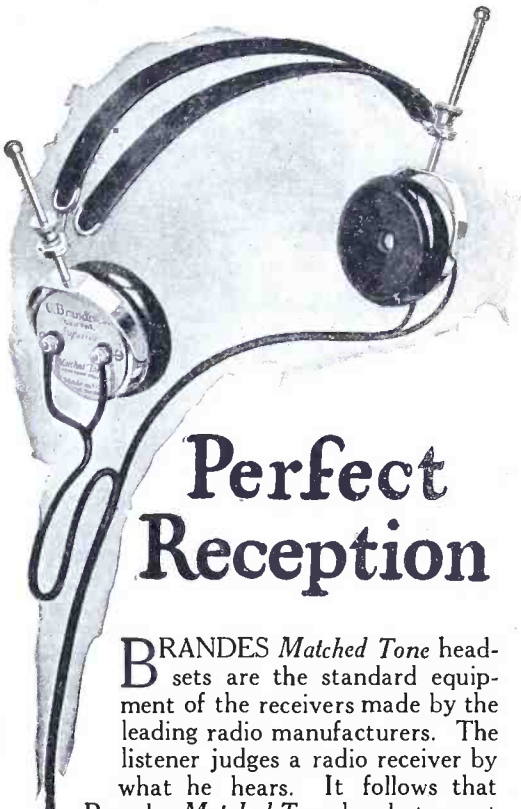
INSIST ON

RADION

Dealers Are Invited to Write for Lists

American Hard Rubber Company

11 Mercer Street **New York**



Perfect Reception

BRANDES *Matched Tone* headsets are the standard equipment of the receivers made by the leading radio manufacturers. The listener judges a radio receiver by what he hears. It follows that Brandes *Matched Tone* headsets must have the qualities that the radio manufacturer demands.

If your receiver is not equipped with Brandes *Matched Tone* headsets, you are not hearing the music perfectly.

Send ten cents in stamps for the "Beginner's Book of Radio." It explains radio in terms that anyone can understand.

Distributors and District Offices:

Munsey Bldg., Washington, D. C.; 709 Mission St., San Francisco, Cal.; 33 South Clinton St., Chicago, Ill.; 76 Pearl Street, Boston, Mass.; 704 Granite Bldg., Pittsburgh, Pa.; 802 Forsyth Bldg., Atlanta, Ga.; 1220 Nicollet Ave., Minneapolis, Minn.; International Electric Company, Wellington, N. Z.

C. Brandes, INC.

Matched Tone Headsets

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

237 Lafayette St., New York

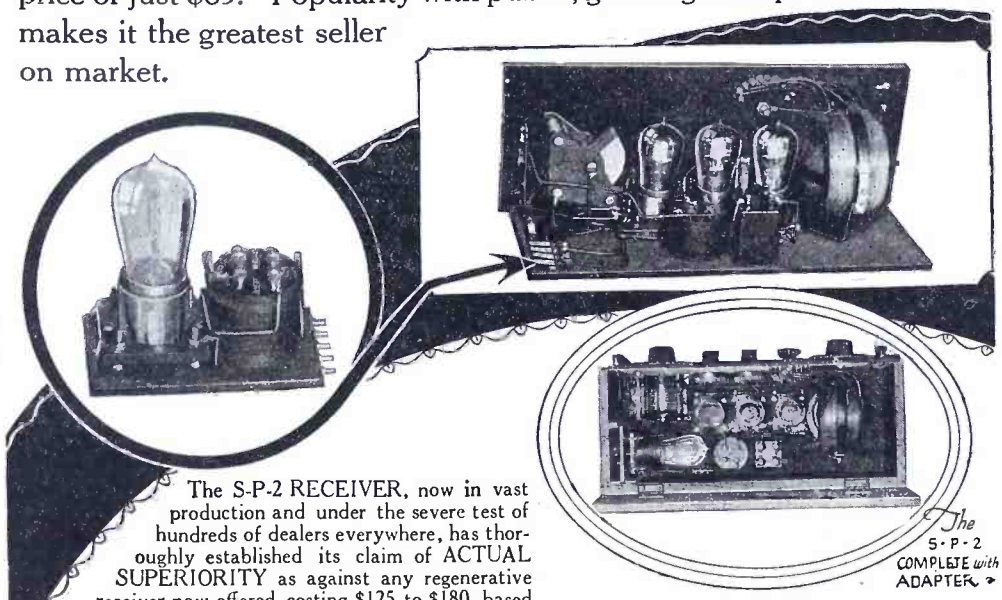
Dept. P. R.

Made in Canada by Canadian Brandes, Ltd., Toronto and distributed by Perkins Electric, Ltd., Montreal

Make This a Radio Christmas

TREMENDOUS DEALER ENTHUSIASM OVER REMARKABLE S-P-2 RECEIVER!

Demonstrated superiority against regenerative receivers, with list price of just $85. Popularity with public, growing in leaps and bounds, makes it the greatest seller on market.



The S-P-2 COMPLETE with ADAPTER

The S-P-2 RECEIVER, now in vast production and under the severe test of hundreds of dealers everywhere, has thoroughly established its claim of ACTUAL SUPERIORITY as against any regenerative receiver now offered costing $125 to $180, based on actual comparisons. THE LIST PRICE OF THE S-P-2 IS BUT $85, WITH AN ADDITIONAL CHARGE OF $15 FOR THE ADAPTER.

The S-P-2 is a complete Receiver of radio-telephone and radio-telegraph signals over a wavelength range of from 180 to 650 meters, using three tubes, viz.: detector, one stage of radio frequency amplification and one stage of audio frequency amplification.

An Adapter representing an additional stage of audio frequency amplification, added to the S-P-2 Receiver AS SIMPLY AS INSERTING A TUBE INTO A SOCKET. Without necessitating the change of a single binding post, wire or batteries or headphones! The S-P-2 Adapter is a basic patent and is thoroughly covered.

Distributors for

Lyradion Sales & Eng. Co.
Sleeper Radio Corp.
Jewett Mfg. Corp.
A. B. C.
Pacent Elec. Co.
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Elec. Prod. Mfg.
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Amer. Radio & Research Corp.
Baldwin Radio
Dubilier

WHOLESALE ONLY

DEALERS:
Write for Catalogue 101A

PITTSBURGH RADIO SUPPLY HOUSE

963 *Liberty Ave. Pittsburgh, Pa.*

BELL TELEPHONE GRANT 3631

American RADIO Exposition

The Official Exposition for American Manufacturers

with the endorsement of the

NATIONAL RADIO CHAMBER *of* COMMERCE

and sanction of the Radio Apparatus Section of the

ASSOCIATED MANUFACTURERS *of* ELECTRICAL SUPPLIES

Grand Central Palace
New York

December 21st to 30th
(Sunday excepted but Christmas Day included)

This first really comprehensive Exposition is to be staged in a manner worthy of a great industry. Leading manufacturers have contracted for space. This opportunity to display Radio products to thousands of buyers during the holiday season is an unusual one. The exposition will be one of New York's big features in connection with National Radio Week.

For further particulars write or wire

AMERICAN RADIO EXPOSITION COMPANY
120 BROADWAY, NEW YORK
TELEPHONE JOHN 0009

PRICES SMASHED

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

Complete Regenerative Vacuum Tube Set
(Knocked down. Approx. range 1000 miles.)

	Our price	Others
Panel 7" x 12"—Bakelite—drilled	$1.75	$2.50
Cabinet of 3 ply wood to fit above panel	1.50	2.50
Two 3" dials @ 35c each	.70	1.40
16 switch points with nut @ 1c each	.16	.48
4 switch stops with nut @ 1c each	.04	.12
8 nickel plated binding posts @ 3c each	.24	.48
2 switch levers @ 25c each	.50	.90
1 filament rheostat. Highest grade	.65	1.10
1 vario-coupler with 7 multiple, 7 single taps	2.25	4.00
1 23 plate variable condenser. Built right	1.95	3.50
1 tube socket—High grade	.45	.85
1 grid condenser and leak	.10	.25
1 phone condenser	.10	.25
1 support for tube socket	.15	.25
12 feet of spaghetti tubing @ 4c per foot	.48	.84
15 feet tinned copper connecting wire	.30	.45
Blueprints showing details to assemble outfit	.10	.25
	$11.42	$20.12

Other articles taken at random from our list are:

Detector tubes—Cunningham—New. NOT rebuilt	$3.95	$5.00
Crystal detector—Enclosed type	.60	1.00
Transformer—Audio frequency	2.95	4.50
Double slide tuner—Knocked down with wound coil	2.50	
Loose coupler—Knocked down with wound coils	3.75	
Loose coupler—Assembled	7.50	12.50
Variometer—Hardwood stators 4¾" square. Assembled	2.45	4.00
Frost Fones 2000 ohms	3.95	5.00
Kelloggs 2400 ohms	8.75	12.00
Western Electric 2200 ohms	9.25	12.00
Two stage amplifier—Knocked down. Cabinet and drilled panel	12.95	23.50
Blueprints giving detail of two stage amplifier	.10	.25
Two step amplifier assembled and wired with cabinet	18.95	35.00
Vacuum tube receiving set with bakelite panel 7 x 12 in. cabinet. Wired	17.95	33.00

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

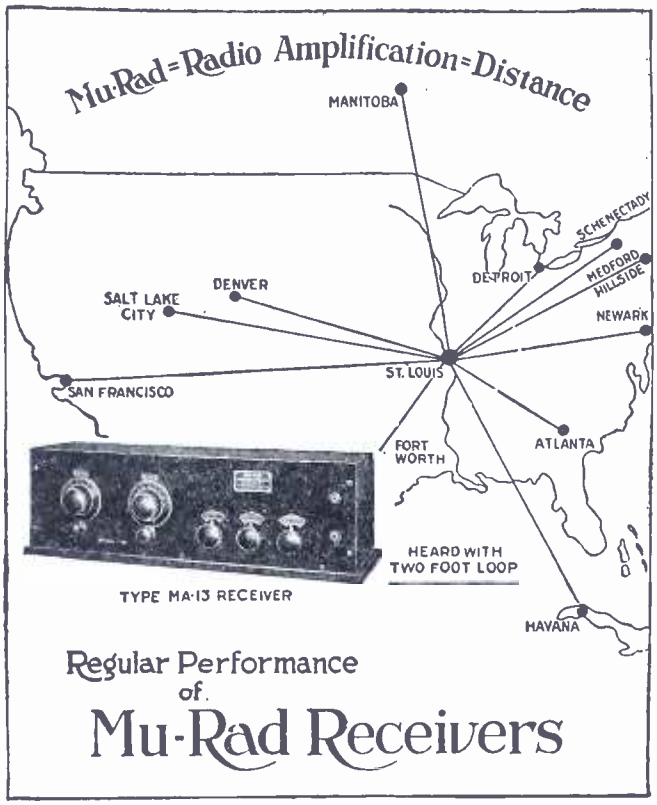
RADIO PARTS MANUFACTURING CO.
17 Park Place **Detroit, Mich.**

Radio Department

Will lease space for a radio sales department in our retail store, Cleveland, Ohio, on percentage-of-sales basis or flat rental.

APPLY

THE STARR PIANO CO.
1225 Huron Road **Cleveland, Ohio**



Regular Performance of Mu-Rad Receivers

INVENTIONS by Mu-Rad engineers are establishing new high standards of radio reception. A Mu-Rad Radio Frequency Receiver with a small loop aerial is more sensitive, more selective, simpler to operate and more compact than any other type of receiving equipment. These are *facts*, determined by impartial tests and comparisons.

Guaranteed for 1000 Miles Reception

We substantiate these claims by a positive, written guarantee on each Mu-Rad Receiver of 1000 miles reception on a loop—another innovation in the marketing of radio receivers.

See These Sets at Your Dealers

Ask him to show you their construction and operation. Note the rigid buss wire connections, the high quality workmanship throughout, the fine finish of the mahogany cabinet, the polished Radion panel, the metal dials, the rugged switch, rheostats, condenser and the simplified control.

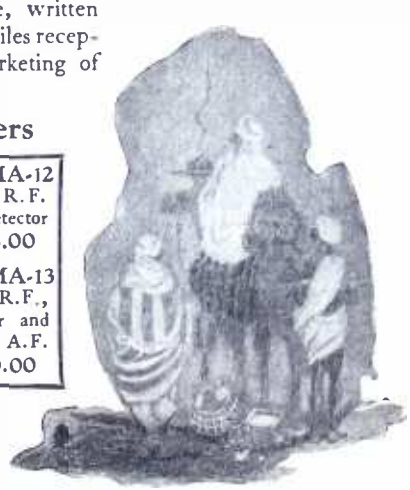
DEALERS: An attractive proposition is open to dealers in good standing.

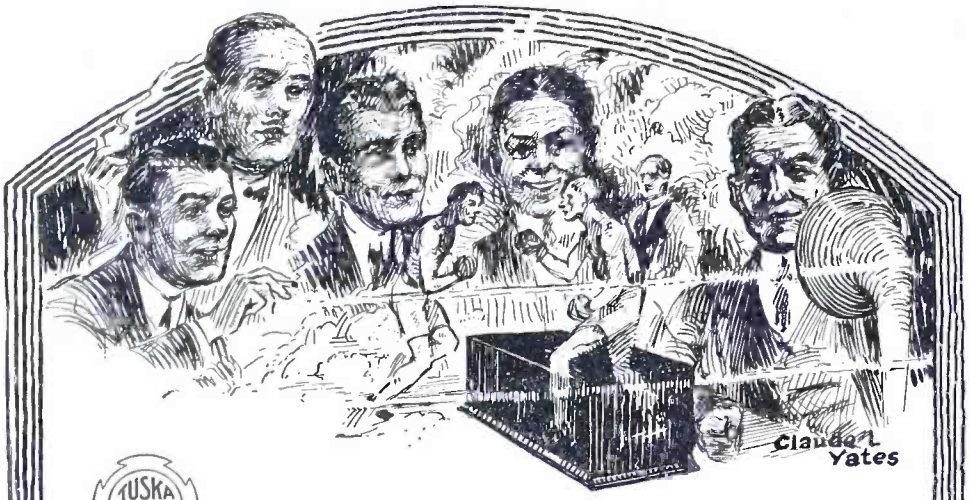
Type MA-12	3 Stage R. F. and Detector $128.00
Type MA-13	3 Stage R. F., Detector and 2 Stages A. F. $160.00

Mu-Rad Laboratories, Inc.
809 Fifth Ave. Asbury Park, N. J.

The New Star in the Radio World

They copied all they could copy,
But they could not copy our mind;
We left them tearing and swearing,
A thousand miles behind.
—Kipling.





Catalog Number Four contains Marvelous article on tuning Receiving Sets. Ten Cents brings it to you

A KNOCKOUT!

Blow by blow 'till the finish! Tuska Quality Radio Apparatus gives you a ringside seat in your favorite Morris chair.

Tuska Radio is supreme in quality, appearance and service.

Ask for Tuska Radio at your dealers today.

The C. D. Tuska Company
43 Bartholomew Ave.
Hartford, Connecticut

TUSKA RADIO

Established 1911

SPECIAL XMAS OFFER

2 Subs FOR $2.50

For a four weeks' period beginning December 15th, we will accept NEW subscriptions to POPULAR RADIO at the special trial rate—two NEW yearly subscriptions for two-fifty ($2.50). To get the full benefit of the Special Xmas Offer, bear in mind that both subscriptions must be NEW. An extra charge of $.25 is necessary to cover the postage cost on each Canadian subscription and $.50 for foreign countries. All subscriptions will be entered for one year beginning with the current issue. A Four Weeks' Offer. Better act right away! Use the double coupon.

(Coupon good until January 15, 1923)

POPULAR RADIO
9 East 40th Street, New York City
Please send POPULAR RADIO for one year to:

NAME.....

ADDRESS.....

CITY.....STATE.....

And also to this other new subscriber. Here's my cash remittance—(or a check for two-fifty).

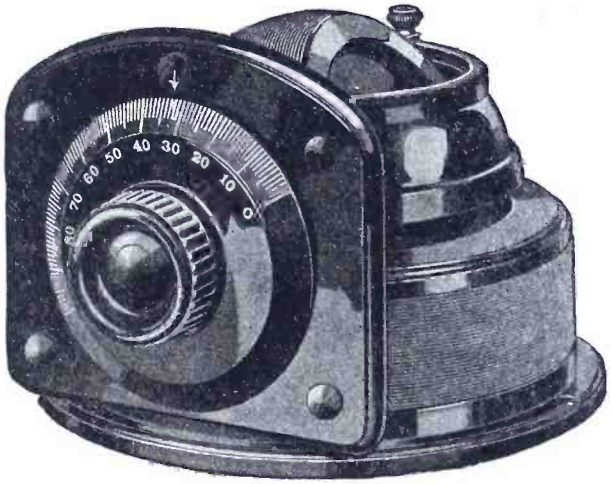
NAME.....

ADDRESS.....

CITY.....STATE.....

ATWATER KENT

COUPLED CIRCUIT TUNER



Price $14.00

¶ *Simplest operation—maximum performance.*

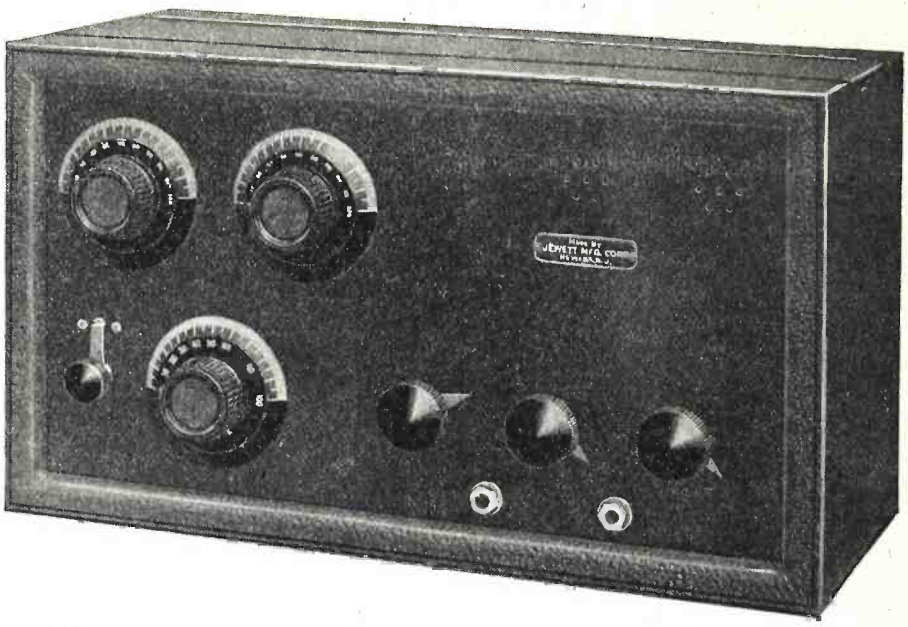
¶ *Takes the place of variometer and coupler.*

¶ *Accomplishes the results with but one adjustment.*

¶ *It is absolutely unaffected by body capacity at dial knob.*

ALL INSULATING PARTS ARE STURDILY MADE OF MOULDED CONDENSITE AND THE WORKMANSHIP THROUGHOUT IS OF THE HIGHEST QUALITY

ATWATER KENT MANUFACTURING COMPANY
4937 STENTON AVE. *Radio Department* PHILADELPHIA, PA.



Jewett Super-Twelve

Self Contained Vacuum Tube Radio Receiver

Designed by Professor J. H. Morecroft of Columbia University, the SUPER-TWELVE is the latest **Radio Creation.**

The Super Twelve Combines:

Selectivity
Good Range
Superb Tone
Marvelous Clearness
High Quality Signal Reproduction

Absolutely Guaranteed free from defects of material, construction or design.

Receiver complete in Mahogany, Walnut or Kodak cabinets, without tubes or batteries, SEVENTY-FIVE DOLLARS f. o. b. factory, shipped packed in Christmas holly boxes if desired.

This is a Radio Christmas. Order early.

JEWETT MANUFACTURING CORPORATION
Newark, N. J.

Teleradio

Products Give Satisfaction

TELERADIO SUPERSENSITIVE PHONES TYPE C, $6.50.

The performance of a pair of phones is what really counts.
Write for our trial offer. Type B, $7.50—Type A, $9.00.

FILAMENT PROTECTOR

List Price 60c.

Here is the cheapest vacuum tube insurance you can buy.

The Teleradio Tube Protector complete sells for 60c and extra fuses for 10c apiece. Not much to pay when you figure that each time you blow out a 10c fuse you save the price of a $5 or $6 tube.

TUBE SOCKET

List Price 60c.

A well-constructed, durable socket. Shell made of drawn aluminum. Hygrade insulated base. Legs not current carrying. Contacts made of phosphor bronze. All parts nickel-plated.

APPROVED LIGHTNING ARRESTOR

List Price $1.00

Approved by National Board of Fire Underwriters.

Electrical No. 5837
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