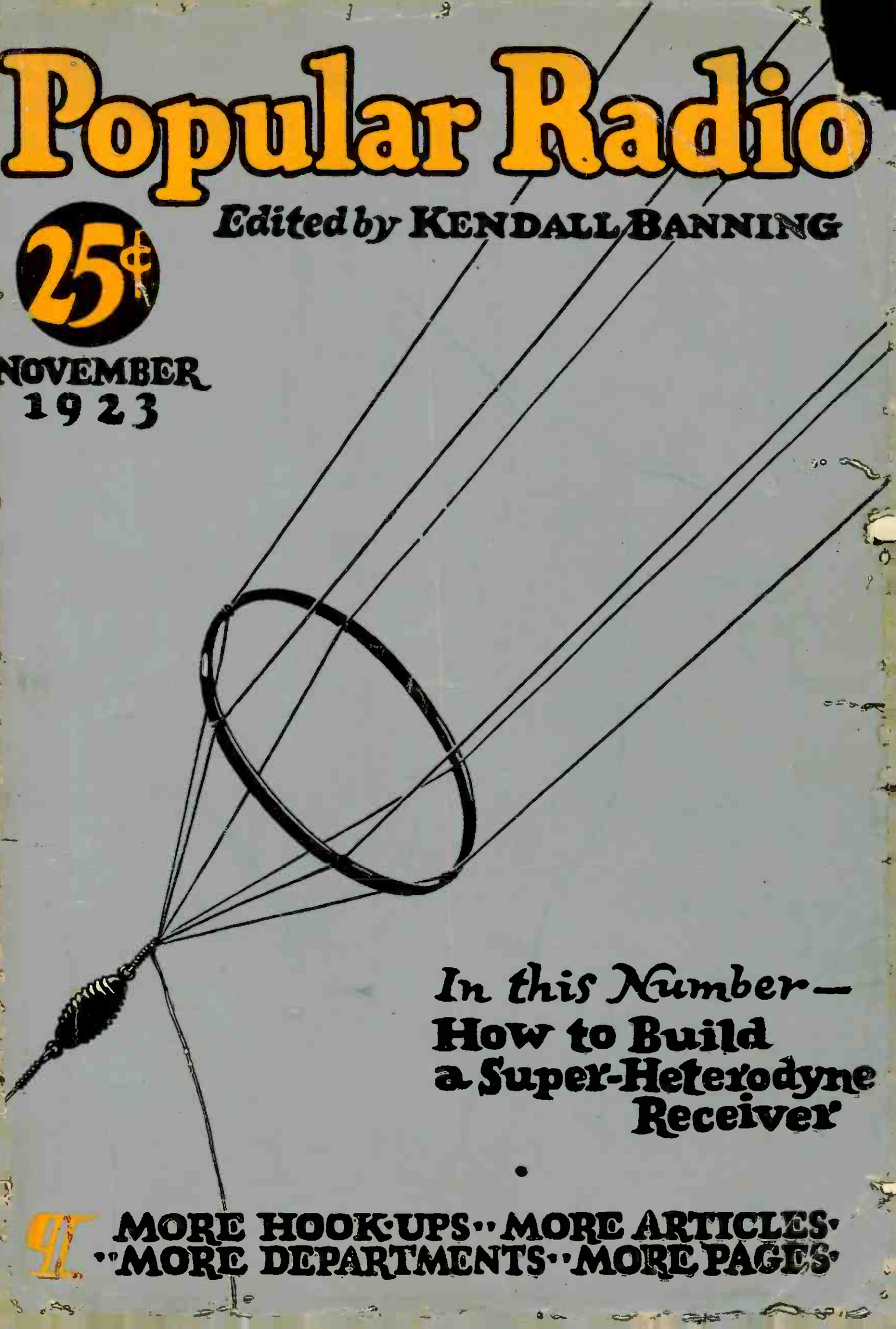
Popular Radio

Edited by KENDALL BANNING

25¢

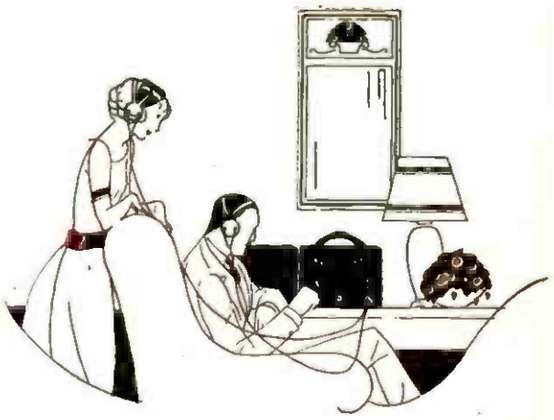
NOVEMBER
1923



In this Number—
How to Build a Super-Heterodyne Receiver

MORE HOOK-UPS · MORE ARTICLES · MORE DEPARTMENTS · MORE PAGES

Radiotron
UV-199
For detection or amplification
$6.50



Radiotron UV-199

A Small Tube That's a Big Performer

The new UV-199 is proving a mighty popular member of the Radiotron family, particularly for portable sets.

Only three-and-a-half inches high. And drawing so small an amperage that it will work on flashlight batteries. It has been called the "tube with nine lives." Battery economy, long life and sensitivity are the big points of Radiotron UV-199. And if by accident it should be operated at too high a temperature, instead of burning out like other tubes, it becomes inoperative and can be brought back to normal operation all over again by disconnecting the "B" battery and lighting the filament for twenty minutes.

For quiet operation—great ruggedness—uniform operation Radiotron UV-199 is unsurpassed. Each new Radiotron has marked a big step in radio advancement. The RCA mark is the foundation of radio growth—and your protection when you buy. Ask for Radiotrons—and look for the mark.

This symbol of quality is your protection

Radio Corporation of America

Sales Dept., Suite 2067: 233 Broadway, New York

District Sales Offices:
10 South LaSalle St., Chicago, Ill. 433 California St., San Francisco, Cal.

Radiotrons

Brandes

His first taste of music!

The truly modern young person gets his first taste of music by Radio—and a Brandes. Catchy melodies and charming bed-time stories come to him clearly through a Brandes *Matched Tone* Headset.

Mother lets him wear only a Brandes because it's so much lighter in weight and won't catch in his curls. And she knows that his little ears will be trained to true harmony by the *Matched Tone* qualities of Brandes.

NEW PRICES
Superior
$6.00
Navy Type
$8.00

C. BRANDES, Inc. **237 Lafayette Street, New York City**

Matched Tone

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

Radio Headsets

POPULAR RADIO

EDITED *by* KENDALL BANNING

CONTENTS *for* NOVEMBER, 1923

(Cover design by Frank B. Masters)

VOLUME IV NUMBER 5

VOLUME IV NOVEMBER, 1923 NUMBER 5

Published monthly by Popular Radio, Inc., 9 East 40th Street, New York, N. Y., telephone number Vanderbilt 9985; H. B. Emerson, President; Paul O. Batch, Secretary; F. C. Hemberger, Treasurer. Price, 25 cents a copy; subscription $2.00 a year (prior to Dec. 15, 1923) in the U. S., Canada and all countries within the domestic postal zone; after Dec. 15, $3.00 a year; elsewhere $3.50 a year, payable in advance. The International News Company, Ltd., No. 5 Bream's Bldg., London, E. C. 4, sole distributors in England. Entered as second class matter April 7, 1922, at the Post Office at New York, N. Y., under the act of March 3, 1879. Printed in U. S. A.

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

PAGES WITH THE EDITOR

EVERY regular subscriber will find enclosed in his copy of this the November number a green Subscription Order slip that represents a cash value of $3.00—*provided* that he uses it on or before December 15th, when the new subscription rate goes into effect. The green slip is issued to our subscribers in order to give them the privilege of extending their subscriptions for two years longer at the present low rate.

* * *

AFTER sizing up this November issue, now in your hands, the Editor hopes that you will be so pleased with what POPULAR RADIO promises for the future, that you will wish to take advantage of the special offer of two years for $3.00.

* * *

HERE is a double-barreled compliment that comes from the professor of English at Indiana University, who comments not only upon the technical excellence of our articles but also upon the style in which they are presented:

* * *

"I happened to pick up the first issue on a newsstand. I became a subscriber and have not missed a copy since.

"I particularly enjoy the articles on how to make instruments and sets. Your directions are more explicit than I find in other magazines, and your recent practice of stipulating the exact make of instrument used is very helpful. I have on several occasions read elsewhere articles covering the same subject matter as articles in POPULAR RADIO. Without exception I have found your treatment clearer and more to the point. I am a professor of English and I know when an article is well written.

* * *

"I USED to buy all the radio magazines that came out. Perhaps the best I can say of yours is that I am constantly buying fewer and fewer of the others."

—PROF. HENRY THEW STEPHENSON

* * *

OUT in Anthony, Kansas, there lives an ardent radio fan, Leroy Hughbanks, who has for several years carried on his experiments despite what would be to most of us an unsurmountable obstacle—total blindness. "People scarcely realize what radio means to the sightless" he bravely comments to the Editor. "The sightless men in particular have not yet realized what they can do in radio."

NOT only does friend Hughbanks keep up with the development of radio but he builds successfully the sets that are described in this magazine—which will give pause to some of our less handicapped readers who sometimes blame the instructions rather than their own oversight when their set does not work properly at the first trial. Mr. Hughbanks writes:

"LET me once again express to you my great appreciation of that dear old magazine POPULAR RADIO. It is beyond doubt the finest journal on the subject I have found, regardless of price. I have but one criticism; it is by far too small. Make it larger and charge it up to us! We will be glad to pay more for the magazine if you wish to make it bigger and better."

* * *

WE take pleasure in carrying out this reader's suggestion. Beginning with this issue POPULAR RADIO is enlarged by about 56 pages, and the price is 25 cents.

* * *

FROM 'way down east—specifically from Waterville, Maine—comes this gratifying tribute from an ardent reader:

"I am more than pleased with POPULAR RADIO; its pages are filled with information that is priceless to the wide-awake radio amateur. It brings to me the latest news and articles by the best authors who are working to elevate radio in the minds of the general public—and POPULAR RADIO is accomplishing this task with excellent success.

* * *

"To be able to give a concise description of a new circuit or a new piece of apparatus without involving many technicalities, is not a very easy undertaking, but POPULAR RADIO seems to have no great difficulty in doing so."

—D. GILBERT LIBBEY

* * *

CONTRARY to general belief, Brother Libbey, to write and to edit and to illustrate an article so that it will be concise and clear and logical and simple is one of the Editor's most difficult tasks.

* * *

SOMETIMES, when a last-minute rush forces the Editor to send a timely article to the printer without the usual care in preparation, he is prompted to quote the postscript that a famous author once wrote at the bottom of a letter: "Please excuse the length of this message; I hadn't time to make it short."

* * *

WHEN POPULAR RADIO defined its purpose to keep its editorial pages entirely clean and uninfluenced by the business office it merely put into words a policy which the magazine has strictly observed from its very first number. In the protection of its readers no other policy is possible.

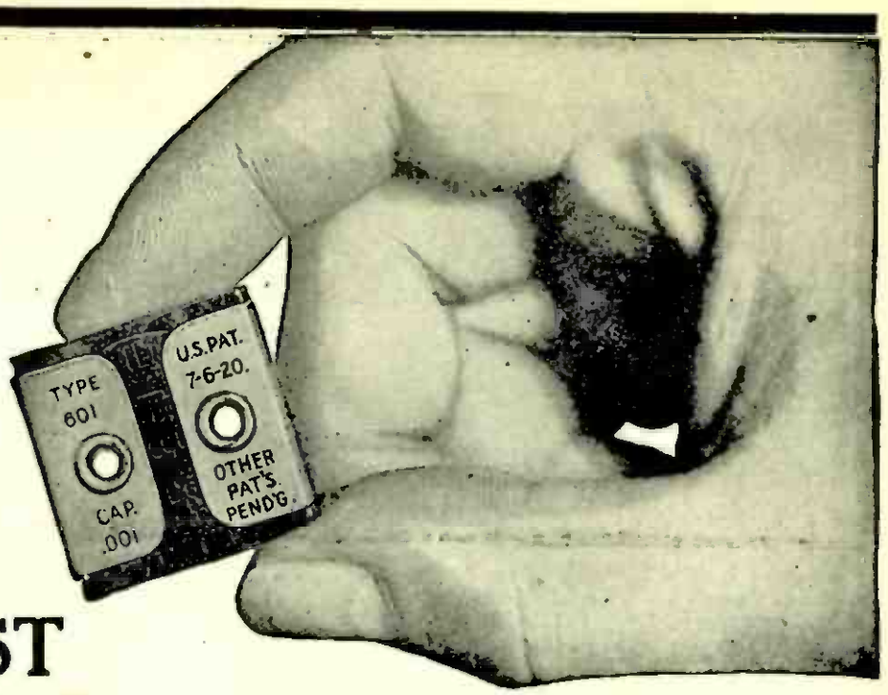
* * *

NOT a single article or statement or picture has yet appeared in this magazine that has been published as the result of pressure from advertisers or prospective advertisers. Nor has any article or statement or picture been held out for a similar reason.

* * *

THE Editor cannot state too clearly or too emphatically the simple fact that *"The editorial pages of* POPULAR RADIO *are not for sale."*

(Continued on page 8)



The BIGGEST LITTLE THING *in radio*

Here is the Dubilier Micadon, Type 601, full size. It is the standard fixed condenser of radio—adopted by nearly all the leading manufacturers of sets and accessories and by discriminating amateurs *because it is permanent-in-capacity.*

Made in many styles and capacities for any circuit.

Price 35 cents up.

Look for a Micadon in your set.

Here is a list of well-known manufacturers who are regular customers of ours and who endorse Micadons:

Adams-Morgan Co.
F. A. D. Andrea, Inc.
Bissell Engineering Co.
Bristol Co.
Central Radio Laboratories
Clapp Eastham Co.
Crosley Mfg. Co.
Cutting & Washington Radio Corp.
De Forest Radio Tel. & Tel. Co.
Durham & Co.
Eagle Radio Co.
Freed-Eisemann Radio Corp.
Garod Corporation
Independent Wireless Tel. Co.
Michigan Radio Corp.
Midwest Radio Co.
R. Mitchell & Co.
Murad Laboratory, Inc.
National Airphone Co.
O & T Electric Corp.
Operadio Corp.
Pfanstiehl Radio Serv. Co.
Q.R.S. Music Roll Co.
Radio Distributing Co.
Sec-Tron Radio Co.
Signal Electric Co.
Sleeper Radio Corp.
Telephone Maintenance Co.
J. S. Timmons
Ware Radio Corporation
Western Coil & Electric Co.
Westinghouse Elec. & Mfg. Co.
Whiteland Mfg. Co.
Wireless Improvement Co.

Dubilier Duratran (Radio Frequency Transformer)

DUBILIER CONDENSER AND RADIO CORPORATION
48-50 West Fourth Street
New York

Dubilier Variadon (Variable Mica Condenser)

Dubilier Ducon Socket-plug

DUBILIER DEVICES

PAGES WITH THE EDITOR

(Continued from page 6)

PERHAPS because this policy is so unusual, it has been difficult for an occasional reader to accept or to appreciate its significance. To be specific, two readers—Mr. R. F. Downs of Medford, Wisconsin and Mr. Brenthal G. Worden of Rensselaer, N. Y.—have questioned the sincerity of this magazine in publishing a description of the Haynes DX Receiver (in the September number) and in the same issue publishing an advertisement of the Haynes-Griffin Radio Service in which the "Haynes Coupler" was listed for sale.

* * *

THE Editor welcomes the opportunity of again defining the policy of POPULAR RADIO by quoting from his reply to Mr. Downs:

"I cannot reiterate too clearly or too emphatically the fact that no influence from the business office of this magazine has ever had the slightest effect upon our editorial policy nor will it have as long as I am Editor of this magazine.

* * *

"THE article written by our Technical Editor, descriptive of the Haynes circuit, is *bona fide* and was accepted solely on its merits. It describes a set which has found favor among radio fans and has proven remarkably efficient. Mr. Haynes has no patent on this set or on any part of the set. The article was written, accepted and scheduled without any consideration whatever concerning the advertising.

"Mr. Haynes is in no better position than any dealer or manufacturer to profit from the publication of this article—except insofar as the circuit bears his name as the inventor of it.

* * *

"THE fact that Mr. Haynes has adapted for use in his set a standard type of variocoupler, gives him no advantages that any amateur or any dealer cannot enjoy; how to adapt this standard type of variocoupler was described in detail in the article; you could make the adjustment yourself.

* * *

"FOR your information I may state that I shall continue to edit this magazine entirely regardless of the advertising pages and I shall neither insert nor omit any article or any item or any picture as the result of influence from our business office."

* * *

CAN any policy be more clean-cut or more sane? Or can it be expressed more clearly?

* * *

RIGHT on the heels of this correspondence, however, comes many letters from readers who not merely endorse POPULAR RADIO'S policy but offer sincere congratulations. From Washington, D. C., for example, comes this word of cheer—from a reader who knows POPULAR RADIO long and well:

"I AM very much interested in your *Pages with the Editor*. They read well and convincingly. Apparently yours is one of the few magazines in the world with a conscience as highly developed as you can maintain it. I rather imagine it was a good thing to put the October argument in, in view of the publication in that number of 'How to Build the Haynes DX Receiver' and the simultaneous advertising of the parts. I rather imagine that it will help others to see that you don't intend to keep out excellent hook-ups or improvements merely because they happen to be advertised either in your own publication or elsewhere, but will publish them if you think it is in the interests of your audience.

"Such an attitude is surely, to use your words 'entirely free from the taint of commercialism.'"

—TROY RODLUN

* * *

WITH this number POPULAR RADIO inaugurates a feature for which the Editor has been preparing for months; it is, in effect, an inter-continental radio news department. Everything of importance that happens in radio throughout the world—all the significant discoveries that are announced, all the researches that are being carried on by scientists and experimenters—will be reviewed briefly by our own technical staff. The essence of it all will appear each month in the new department, *In the World's Laboratories*—starting on page 410 of this issue.

* * *

RADIO has already become an inter-continental interest; it is only a matter of time when listeners in the United States will be tuning in on the European broadcast stations, not as a carefully prepared experiment, but as a daily commonplace. Developments in England, France or Germany will soon be as important to us as are the changes on our own continent.

* * *

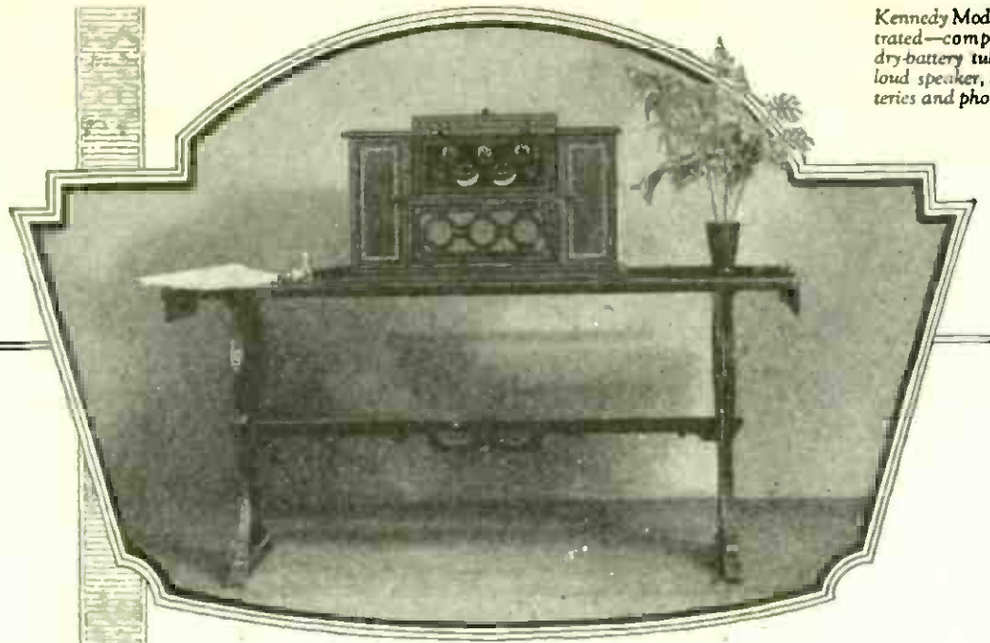
IN anticipation of this development POPULAR RADIO now has a special agent in Europe. The Editor is now beginning to give our readers the up-to-the-minute radio news of the *world*—real news, obtained directly and authoritatively from the laboratories where the work is going on.

* * *

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

Kendall Banning

Editor, POPULAR RADIO



Kennedy Model X—illustrated—complete with 3 dry-battery tubes, built-in loud speaker, all dry batteries and phones, $285.00

Radio Refined and Simplified

The New Radio Unit

Simplicity is apparent—anyone can use it with complete success. No switches—only two dials. Responds to all broadcasting wave-lengths on any type or size antenna. Highly polished Formica control panel. Gold-plated metal trimmings on front, including dials.

All Kennedy Radio Receiving Sets are regenerative—Licensed under Armstrong U. S. Patent No. 1,113,149.

THERE is an air of elegance and *refinement* in the new Kennedy Furniture Model radio sets that truly makes them "The Royalty of Radio." They are designed to harmonize perfectly with artistic furniture and home surroundings. In designing the radio units incorporated in each of these sets the Kennedy Engineering Staff has scored a notable achievement in obtaining high selectivity (avoidance of interference) and long distance reception with the utmost simplicity of operation. Only one dial is required for tuning, and a second dial to control the sound volume.

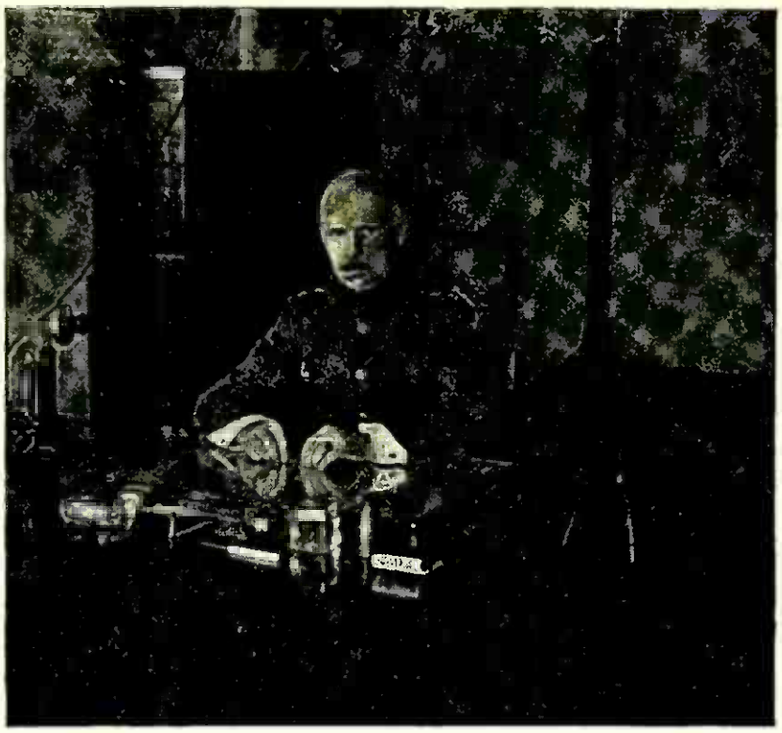
Each of these new models is complete and self-contained, with internal space for all dry batteries. A built-in loud speaker assures ample volume with remarkable clarity and fidelity of reproduction.

See a Kennedy dealer for demonstration or write us direct for descriptive literature on the new Furniture Model sets.

THE COLIN B. KENNEDY COMPANY
SAINT LOUIS SAN FRANCISCO

KENNEDY

The Royalty of Radio



To the Editors of Popular Radio:

"I congratulate you on the excellent standing of Popular Radio. *You have done wonders with it, and I cannot afford to miss a single number."*

George O. Squier

Major General, United States Army

From a photograph made for POPULAR RADIO

He Transmitted Speech by Radio Twenty-three Years Ago

Dr. Reginald A. Fessenden, one of the world's foremost scientists, is not only among the very earliest and most successful experimenters with wireless, but has more radio inventions to his credit than anyone else.

Popular Radio

VOLUME IV NOVEMBER, 1923 NUMBER 5

How Ether Waves Really Move

The Development of the "Gliding Wave" Theory

Sir Oliver Lodge, Dr. Elihu Thomson and Major-General George O. Squier have discussed in POPULAR RADIO the movement of ether waves around the earth according to the theory of the Heaviside Layer and the alternative theory of Gliding Waves. In this authoritative article the originator of the Gliding Wave theory explains his own views of the matter.

By REGINALD A. FESSENDEN, Ph.D.

THE sliding wave theory appears to have been somewhat misunderstood both by its advocates and its opponents. The nature of this misunderstanding and how it arose will be better appreciated if we consider the general state of the art at the time the sliding wave theory first appeared, in the Proceedings of the American Institute of Electrical Engineers, November 22, 1899[1].

Joseph Henry, who was the founder of wireless telegraphy, had discovered electromagnetic induction and invented the induction coil[2]. He had also made the fundamental discovery that the discharge of a condenser was under certain conditions oscillatory, or, as he puts it, consists "of a principal discharge in one direction and then several reflex actions backward and forward, each more feeble than the preceding until equilibrium is attained." Henry was not only the first to produce high-frequency electric oscillations, he was the first to detect them at a distance, using what was later known as the magnetic detector. The high-frequency oscillations were generated in the upper floor of a building and transmitted to the cellar, where they were received by a receiving coil and utilized to shake out the magnetism from a magnetized needle[3].

Edison, Elihu Thomson and Houston made many experiments on these transmitted waves, and reports of their experiments will be found in Edison's papers in the technical journals of that

Reprinted from the November, 1922, POPULAR RADIO

DIAGRAM OF THE HEAVISIDE LAYER THEORY

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

DIAGRAM OF THE GLIDING WAVE THEORY

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

period and in the paper by Houston and Thomson in *The Journal of the Franklin Institute* for April, 1876[4]. Between 1870 and 1888 von Bezold, Fitzgerald and Hertz had cleared up to a very considerable extent the nature of the phenomena observed, and Hertz's work had shown that the experimenters were dealing with true electrical waves.

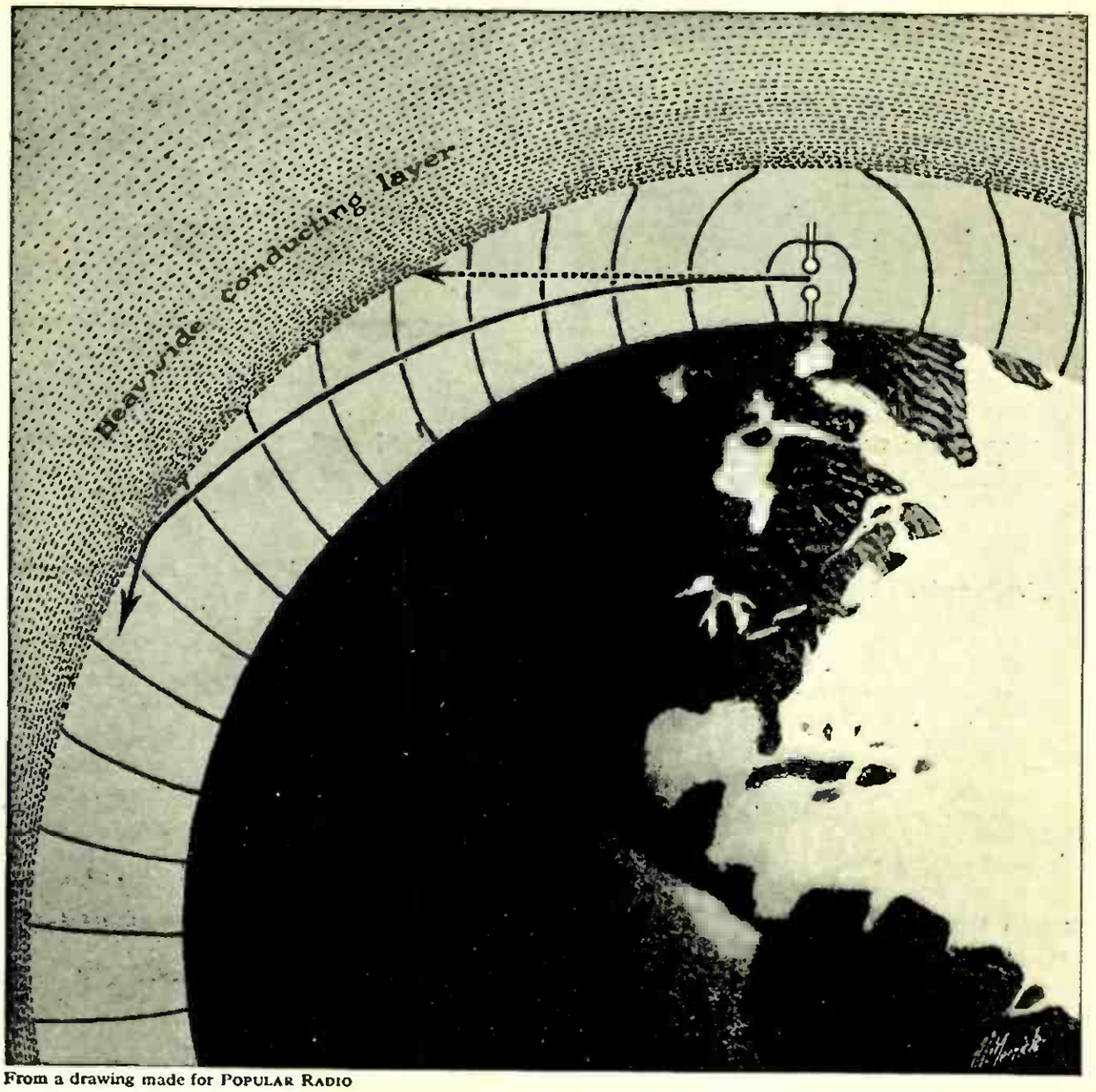
Dolbear[5] and Edison had been using vertical grounded antennas for telegraphing wirelessly, though the effects they obtained appear to be mainly electrostatic and only partially true wave transmission.

Crookes in the *Fortnightly Review* for February, 1892, proposed that resonant tuned circuits should be used to select out messages from different stations. Lodge[6] and Popoff[7] had used these waves for signalling, and Popoff, who had used a vertical grounded antenna, coherer and tapper back, pointed out that the apparatus might "be adapted to the transmission of signals to a distance."

Tesla[8], who had been doing a great deal of work in high-frequency oscillations, in 1892 proposed a system for transmitting signals wirelessly using the vertical antennas of Dolbear and tuned transformer circuits at the sending and receiving ends.

Edison, in 1884, discovered and invented the hot-cathode vacuum tube[9], and used it for rectifying high-frequency currents. De Forest's great invention, which consisted of the introduction of a third electrode between the other two, was made about 1907.

Marconi, who had worked under Righi's instructions, had, with the keen eye for commercial opportunity possessed by his race, realized that there was a market for such a telegraphic system, even if working over only short distances, and in July, 1896, gave a demonstration to the English Post Office at Salisbury Plain and succeeded in increasing the range from its previous figure of a half mile obtained by other experimenters to a distance of two miles, using parabolic reflectors and the coherer. In the same year Captain



From a drawing made for POPULAR RADIO

DIAGRAM OF DR. FESSENDEN'S THEORY

Instead of moving in straight lines outward from the source, as shown by the dotted line, the waves really move in a curve like that shown by the solid line. But this curve tends to bend away from the earth's surface and reflection from the Heaviside Layer is necessary to bring it back again.

Jackson (now Admiral) of the British Navy found that considerably greater distance could be obtained by using the Dolbear-Edison-Tesla arrangement of vertical antennas and tuned sending and receiving transformers at both transmitting and receiving ends.

Such was the state of the art in 1899. Henry had discovered the method of producing high-frequency oscillations and of detecting them at a distance, utilizing his other inventions, the induction coil and the magnetic detector, for this purpose. Dolbear had invented the vertical antenna. Edison had invented the hot-cathode vacuum tube detector. Tesla had invented the tuned sending transformer and tuned receiving transformer, connecting to the vertical antennas. Marconi, Samuels and Isaacs had undertaken the commercial exploitation of the field. De Forest was about to begin the work which resulted in his invention of the audion.

But even then the nature of the phenomena involved were not clearly understood. Possibly influenced to some extent by patent reasons there was a strong effort made to show that there was something radically new and strange in the systems which were being commercially exploited. It was stated by a number of authorities that the phenomena were *not* due to high-frequency alternating currents, but that some peculiar "whip-crack" was necessary in the ether. A few quotations will illustrate this point[10].

Professor Cross stated that "alternating currents in the vertical wire will not produce Hertzian waves in the ether, as such waves are produced only by the disruptive discharge. Probably a crude mechanical illustration would be the case of a whip-lash—motions of some kind would be produced, but they would be of a quite different character." Fleming stated that "although in the third claim the patent speaks of employing rapidly recurring or alternating electric impulses, unless some form of a condenser is discharged to cross the spark gap there cannot be any production of Hertzian waves—the disruptive discharge is the one essential condition for the production of Hertzian waves."

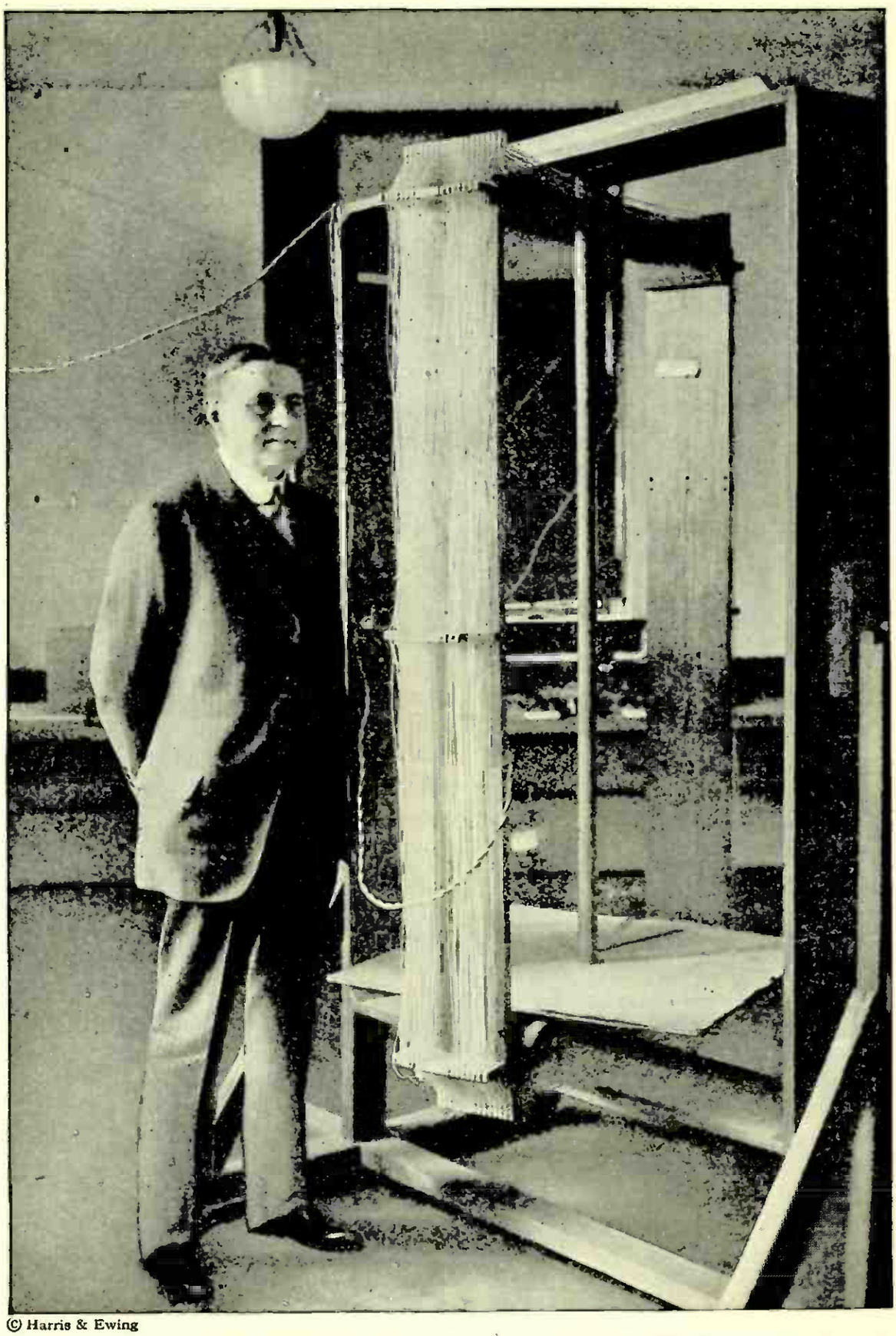
Marconi stated that "the difference between Hertzian oscillations and ordinary alternating currents is most certainly *not one of degree.* An analogy may be found in the case of a sound wave in air. The swinging of a bell in a church steeple to and fro will produce no wave, and further, no sound, but if the rim of the bell is struck soundly with a hammer, it effects the air with sufficient suddenness. Hence it appears absolutely clear to me that there is no Hertzian wave telegraphy without the essential feature for producing Hertzian waves, which is the Hertzian spark."

The writer had been lecturing and experimenting on the production and detection of Hertzian waves for a number of years[11], and was convinced that there was no essential distinction between the Henry high-frequency oscillations and Hertzian waves. With the object of demonstrating this a considerable number of experiments were made in 1899, with the assistance of one of the writer's former students, Dr. Kintner, and the results published in the American Institute paper above referred to, that is of November 22, 1899, in which the sliding wave theory referred to by Professor Elihu Thomson[12] was fully explained and illustrated.

It will be seen that this paper on the sliding wave theory was written for a specific purpose, i. e., to show that there was no mysterious "whip-crack of the ether" involved in wireless telegraphy, but merely the well-known high-frequency currents, and though it led to important developments, for instance, the wave chute, the use of the magnetic component of the wave, the loop antenna, the pelorus or wireless compass, continuous wave generation, the wireless telephone and the heterodyne, it was never intended as a presentation of the complete theory.

This has resulted in the theory being misunderstood to some extent. Professor Thomson has supposed, it would appear from his article, that the waves are *entirely* guided by the surface of the conductor and follow the earth around. Eckersley[13], on the other hand, states that the transmission of the half waves is not influenced *at all* by the conductor but "the energy is propagated in straight lines."

The correct theory lies between these two opinions. The original mathematical investigation made by the writer in 1900 shows that the sliding waves are guided by the earth's surface to a quite considerable extent near the origin, but that the effect rapidly falls off. The amount of the bending is expressed by a series formula, the first term of which is an angle equal to half the angle between a tangent to the source and a straight line



HOW UNCLE SAM STUDIES ATMOSPHERIC DISTURBANCES WITH A LOOP AERIAL

Dr. L. W. Austin of the Bureau of Standards, with the apparatus used for investigating the effects of the ionized clouds described in this article.

joining the surface of the conductor at a distance of a quarter wavelength from the source, and the source. The effect of this series falls off very rapidly with the distance. For transatlantic distances it is negligible, but for the distances dealt with in my original paper it is quite appreciable.

The reception of waves across the Atlantic cannot, therefore, be due to guiding of the sliding waves by the conductor and must be due to some conducting layer in the upper portion of the earth's atmosphere.

Writers on the subject of the Heaviside Layer seem to assume that this layer is more or less hypothetical and are apparently not aware that it was investigated fully prior to 1907.

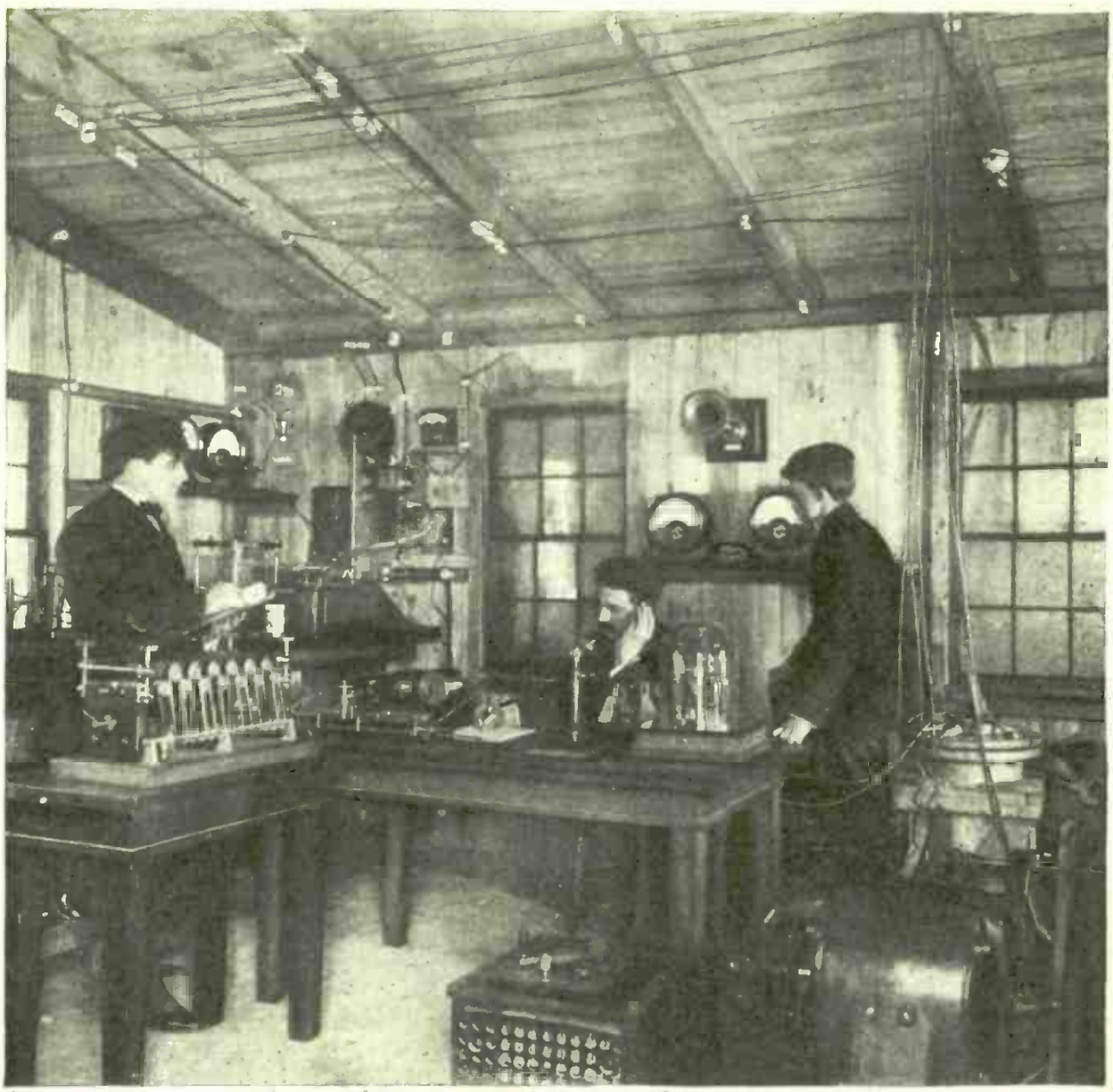
The investigation was begun by the writer in 1900 at Cobb Point, Maryland[14], where two masts were erected one mile apart and by means of hot wire barreters and ring receivers, the exact method of transmission of the waves was experimentally determined[15]. By means of ladders placed at varying distances from the antennas the course of the waves in the air was fully mapped out up to distances of several hundred yards from and to the antennas, and by burying the receivers at different depths in the ground and immersing them to different depths in the sea water, the rate of decay below the surface and the strength of the currents flowing in the surface were accurately determined. The results appeared in papers published by the writer some twenty years ago, where, for example, the figure is given that with a certain amount of salt in the sea water and with a certain wavelength the strength of the high-frequency currents falls off to the fraction 1/e of its former value at a depth of 18 inches. Figures are also given of change intensity in going up and down sloping ground. Later, in 1906, while operating across the Atlantic between Brant Park in Massachusetts and Machrihanish in Scotland extensive measurements were made on the efficiency of transmission of different wavelengths at different hours during the day and night. A curve showing the results was published in 1906[16] and again in 1908[14].

The first point determined, as will be seen from these articles, was that the failure in transmission during daylight was not, as Dr. Fleming had stated and attempted to show mathematically[17], due to absorption in the neighborhood of the sending station. This was determined by measuring accurately and simultaneously the difference in intensity between the daytime and nighttime reception of signals at six different stations at distances of 200 yards, 30 miles, 170 miles, 270 miles, 400 miles and 3,000 miles from the sending station. It was found that there was no difference in the daytime and nighttime transmission for nearby stations, and that the difference increased rapidly with the distance.

A second point determined was the efficiency of different wavelengths for transmission during daytime and nighttime. From the curves given in the papers referred to it will be seen that the absorption increased slightly as the wavelength increased, up to a frequency of 70,000 and then fell off with extreme rapidity. It was for this reason that long wavelength was adopted by the writer for transatlantic working in January, 1906. Up to this time short waves had been used in the attempts to work across the Atlantic, under the impression that they gave a sharper "whip-crack," but as the result of these experiments and the publication of these curves it became generally known that long waves should be used for successful operation.

The third result was the determination of the height of the conducting layer. This is given in section 10 of the article of May 18, 1906[16], as follows:

"The height above the earth at which marked absorption begins to take place may be roughly estimated as about 300



From a photograph in the collection of Dr. R. A. Fessenden

DR. FESSENDEN'S BROADCASTING EXPERIMENTS SEVENTEEN YEARS AGO

As far back as November, 1906, this station was in operation at Brant Rock, Mass. Gramophone music was broadcast from the machine shown in the left corner. This historic picture shows three of Dr. Fessenden's assistants (left to right), Mr. Stein, Mr. Mansbendal and Mr. Guy Hill.

miles at nighttime and 100 miles during daytime."

It will be noticed that the height of this reflecting layer as determined in 1906 from transatlantic wireless experiments agrees almost exactly with the height at which aurora are formed, as determined ten years later by trigonometrical photographic measurements.

The fourth point determined was that the Heaviside Layer was not a smooth surface but was broken up into clouds of ionized air, *"ionephs,"* as the writer has termed them. To quote from the paper referred to, "these masses of ionized air are not continuous but somewhat resemble clouds."

The fifth point determined was the size of these clouds, which is given in the article referred to as varying in diameter from 150 feet to two miles and more.

The sixth result was the discovery of aeolotropic absorption or the variation in intensity in different directions on different nights.

The seventh point referred to in the paper is the discovery of diffraction effects.

The eighth result was the discovery of a relation between the efficiency of transatlantic transmission on different nights and the curves of variation in the earth's magnetism. The two sets of curves were found to be substantially identical in character.

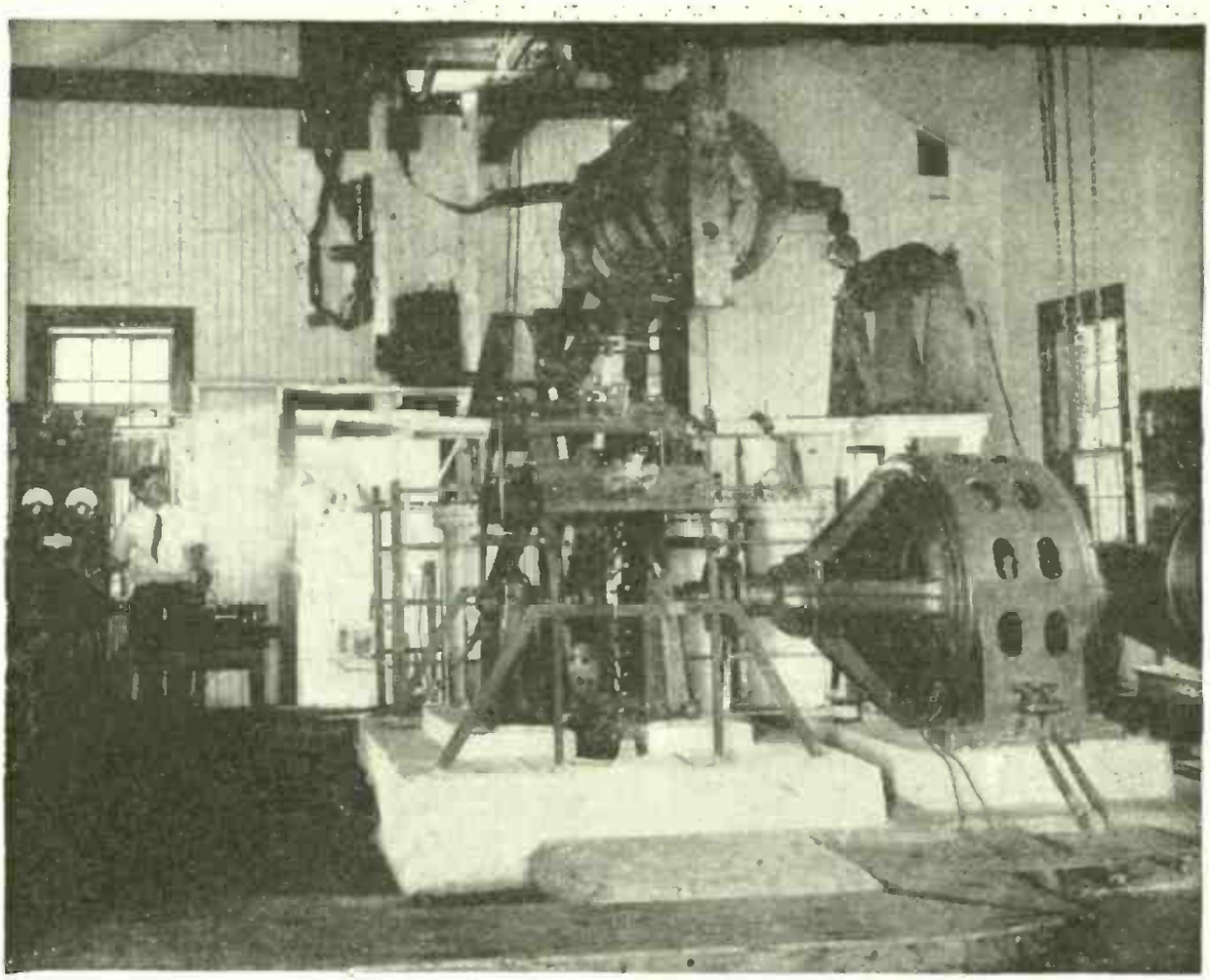
The ninth point was the discovery of what were called "echo signals." To quote from the article: "On certain nights there appeared to be indications at the Boston station that a double set of impulses were being received, one about a fifth of a second later than the other. It is too early yet to make any definite statement in regard to the matter, but there is some reason for thinking that the second set of signals arrived at the station after going the longer way round. To take an actual numerical example, the strength of signals received at Boston from Machrihanish on the night of January 30 was 480 times that of audibility. If the second set of signals went around the other way, their intensities, according to the square law, would be as 1 is to 70. Hence signals that had gone the other way round would have an intensity of 480 divided by 70, or 7 times audibility. As a matter of fact, the second set of signals, which we may call the echo signals, were really nearly twice as strong. This, of course, might be taken as an argument against their having come that way, but I am not disposed to consider it as a conclusive one. If, however, they did come round the other way, it is evident that the rate of absorption must become uniform after a certain distance."

Though the statement was severely commented upon at the time (May 18, 1906), the existence of these echo signals has since been confirmed. In the January, 1922, issue of the "Monthly Notices of the Royal Astronomical Society," from the Greenwich, Poulka, Uccle and Edinburgh Observatories, Professor Sampson gives curves of "the error in wireless time signals which demonstrate the curious fact that each observatory is liable to be in error by 0.2 second, and that the error frequently persists for some weeks in the same direction. The cause is obscure; lateral refraction due to dissymmetry in the distribution of atmospheric pressure is examined, but is insufficient to explain the whole anomaly."

It will be seen that a quite considerable amount of experimental work had been done on the Heaviside Layer as far back as May, 1906, and it is hoped that someone else may take up work along the lines indicated. Some additional information will be found in a paper on the pelorus published in 1919[18].

Dr. Elihu Thomson and Sir Oliver Lodge have referred to the "scepticism" concerning Marconi's first attempt to transmit wireless signals across the ocean to Newfoundland. This is really a commercial and not a scientific matter.

The reference is, of course, to the disclosures of fact which appeared in the *London Electrician* for November 22, 1907[19]; to the fact that three dots were used as a signal letter; the fact that the receiver used (a carbon-mercury coherer) can be made to give a succession of three dots followed by a period of silence by adjusting the electrodes to the right distance; the fact that no one was allowed to listen in to the signals except Marconi and a single assistant who had no knowledge of electric circuits; the fact that the experiments were abruptly discontinued in spite of the very generous offer of the cable companies to waive their monopoly so far as experimental work was concerned and not only to permit but to assist Mr. Marconi in making any further tests; the fact that we now



From a photograph in the collection of Dr. R. A. Fessenden

MEASURING THE HEIGHT OF THE HEAVISIDE LAYER

By means of this elaborate transmitter Dr. Fessenden carried on experiments in 1906. The operator, Guy Hill, has since become known to radio fans everywhere as Captain Hill, for several years associated with Major General George O. Squier.

know that with the short wavelength used and with the single, kite-supported wire at the receiving end, the small amount of power and no amplification, no signals could possibly have been received over that distance with that apparatus; the fact that even with the much more highly powered stations subsequently built at Cape Cod it was found necessary to first send the Roosevelt message by cable from the Holland House, New York, and then, after it had been sent out from the Cape Cod station wirelessly, to send a second cable message by the Duxbury cable directing the release of the message cabled from the Holland House; the circumstances connected with the Glace Bay tests as discussed in *The London Electrician* of the date referred to, and the fact that a considerable amount of cable stock had been sold shortly prior to the announcement of the Newfoundland tests. These facts have undoubtedly influenced public opinion to scepticism. But this is a matter on which everyone must form his own opinion, and those who may be inclined to pass harsh judgment should remember that the standard of commercial ethics is not quite the same as that of abstract science.

To conclude, I think that perhaps the most striking evidence of the reality of the Heaviside Layer is the close agreement of the results of the tests made to determine the height of this layer (as given in the paper in *The Electrical Review* for May 18, 1906, cited above)

with the determinations of the height of the aurora borealis made in 1920. The fact that these two heights agree almost exactly is pretty conclusive evidence of the existence of such a layer. At first sight the aeolotropic transmission referred to in the paper of May 11, 1906, cited above, might be considered as equally conclusive evidence, but it will be seen from the paper of 1919 in *The Electrician* (also cited) that such a deviation would still exist even though there were no Heaviside Layer.

---

[1]Reginald A. Fessenden, "The Possibilities of Wireless Telegraphy." (A discussion). Trans. *Amer. Inst. Elec. Engs.*, volume 16, mail edition pages 635-642, regular edition pages 607-614 (1899).

[2]Joseph Henry, "On the Production of Currents and Sparks of Electricity from Magnetism." *Amer. Jour. Science.*, volume 22 (appendix), pages 403-408 (1832).

[3]"The Scientific Writings of Joseph Henry," 1832-1848. The Smithsonian Institution, Washington, D. C. Henry's important papers on electromagnetic induction are reprinted in "The Discovery of Induced Electric Currents," edited by J. S. Ames, volume 1, 107 pages, The American Book Company, New York, 1900.

[4]Edwin J. Houston and Elihu Thomson, "The Alleged Etheric Force. Test Experiments as to its Identity with Induced Electricity." *Jour. Franklin Inst.*, volume 101, pages 270-274 (April, 1876).

[5]U. S. Patent No. 350,299, issued October 5, 1886.

[6]Sir Oliver Lodge, "The Work of Hertz." *Proc. Royal Institution* (London), volume 14, page 321, June 1, 1894.

[7]Popoff, *Jour. Russian Phys. Chem. Soc.*, April 25, 1895.

[8]Nikola Tesla, "Experiments with Alternate Currents of High Potential and Frequency." *Jour. Institution Elec. Engs.* (London), volume 21, pages 51-163 (1892).

[9]U. S. Patent No. 307,031, issued October 21, 1884. See also Edwin J. Houston, "Notes on Phenomena in Incandescent Lamps," *Trans. Amer. Inst. Elec. Engs.*, volume 1, first paper, 8 pages, October, 1884.

[10]Court reports in Marconi *vs.* De Forest, Southern District of New York. Proceedings Electrical Congress at St. Louis; Discussions *Inst. of Elect. Eng.* (England) and "Principles of Electric Wave Telegraphy."

[11]Purdue University catalogue for 1892-93. Thesis, Bennet and Bradshaw, Western University of Pennsylvania, 1895.

[12]POPULAR RADIO, volume 2, pages 231-235, (December, 1922). See also Elihu Thomson, "A Short Story in Wireless," *The Electrician* (London), volume 89, page 148 (August 11, 1922).

[13]T. H. Eckersley, "A Short Story in Wireless" (letter to the editor). *The Electrician* (London), volume 89, pages 242-243 (September 1, 1922).

[14]Where speech was first transmitted wirelessly, December, 1900. See Reginald A. Fessenden, "Wireless Telephony." *Trans. Amer. Inst. Elec. Engs.* volume 27, pages 553-629 (1909).

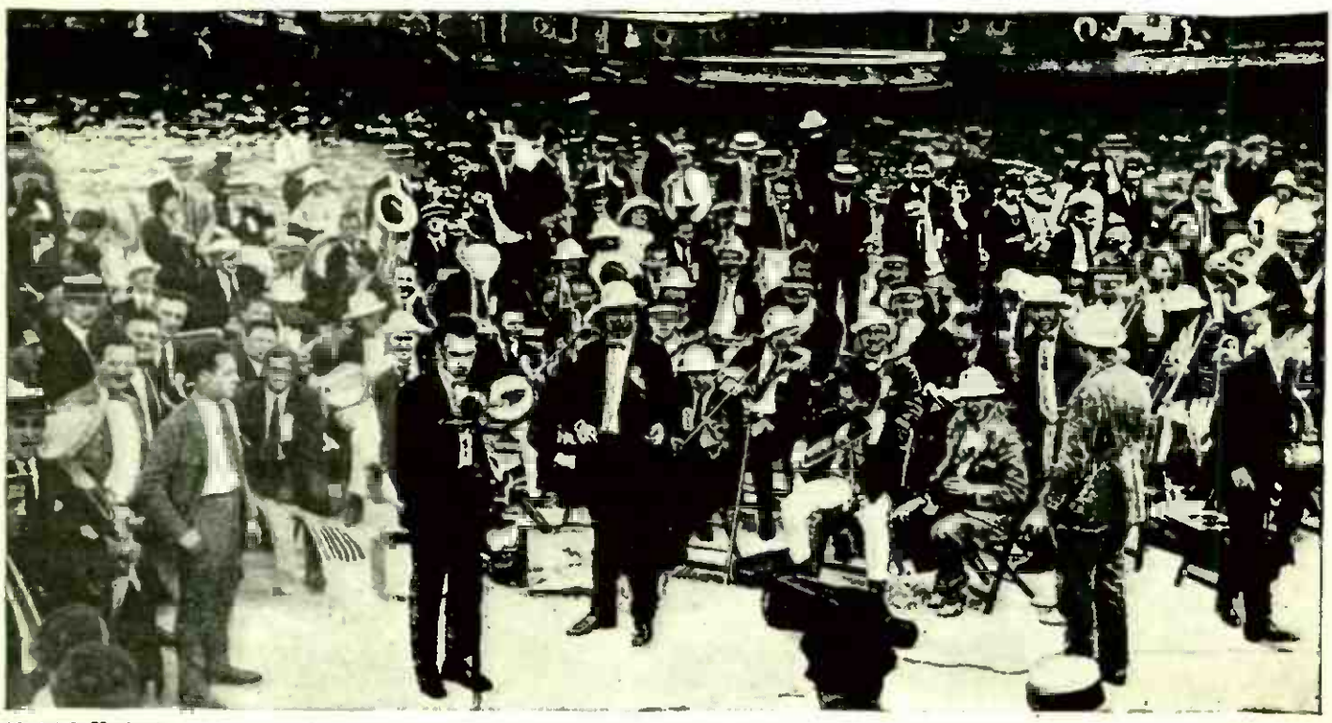
[15]A. Frederick Collins, "Fessenden's Work in Wireless Telegraphy." *Electrical World*, volume 42, pages 474-476 (September 19, 1903).

[16]Reginald A. Fessenden, "Wireless Telegraphy," *Electrical Review* (London), volume 58, pages 744-746 (May 11, 1906) and 788-789 (May 18, 1906).

[17]J. A. Fleming, "Principles of Electric Wave Telegraphy," pages 617 and 618.

[18]Reginald A. Fessenden, "The Fessenden Pelorus (Wireless Compass); a Caution as to Its Use." *The Electrician* (London), volume 83, pages 719-721 (December 19, 1919).

[19]Reginald A. Fessenden, "A Regular Wireless Telegraph Service Between America and Europe." *The Electrician* (London), volume 60, pages 200-203 (November 22, 1907).



Kadel & Herbert

BROADCASTING A CONCERT FROM A LINER'S DOCK

In the foreground may be seen the microphone that transmitted the jazz of Paul Whiteman's orchestra just before the sailing of the steamship LEVIATHAN *from New York. The innovation made a hit with the radio fans.*

From a photograph made for POPULAR RADIO

THE HEAD OF UNCLE SAM'S DETECTIVES

Although officially known as chief of the Bureau of Investigation of the Department of Justice in Washington, the author of this article, William J. Burns, is perhaps more widely known because of his career as a sleuth in many important criminal cases.

Radio Puts on Gum Shoes

The applications of radio to police work are limitless. How the Department of Justice, in co-operation with the police departments, is preparing to create a nation-wide radio net for locating and catching criminals is here told by—

WILLIAM J. BURNS

A YOUNG man in a certain city recently called on a large dealer in radio equipment and selected a high-priced receiving set. He claimed to be representing a public school. He took the set away, saying that the money for it "would be brought in later."

When the dealer found that he had been deceived he placed the case in the hands of the Burns Detective Agency. This agency's operators decided to give the case what we call "absent treatment."

That night there went out from a local broadcasting station, a message, somewhat as follows:

"Wanted: A youth, about 18 years old, 5 feet 7 inches tall, weight about 135 pounds, light hair and eyes, affable, small scar on cheek. He is wanted for procuring illegally a radio receiving set (fully described). A reward of $50 will be paid for information leading to his arrest."

It happened, as was expected, that at the time the youth was entertaining a group of friends with the outfit which thus poured into their ears the account of his misdoing. They recognized him at once, but with quick wit he warded off embarrassment by saying:

"It's only a chum of mine pulling off what he thinks is a good joke."

But on the next day the youth's mother went to the dealer's store and paid in full for the outfit.

The case, though a minor one, shows how the radio may be used in subtle way for detecting crime. In truth, I believe it will prove to be our single best medium for pursuing criminals in many kinds of difficult cases. It will thus rank among the best of crime preventives.

That is the thought that we, who plan to nationalize this new instrument of crime detection, have of the radio as an arm of law and order.

It is to be a first feature in the operation of the National Bureau of Identification and Information hereafter to be carried on by the Bureau of Investigation, U. S. Department of Justice.

The new bureau is to be taken over rather than set up. For nearly twenty-five years it has been operated in Washington, D. C., by the National Association of Chiefs of Police. To it have come copies of identification material collected by the police of large cities—material that consists of photographs, fingerprints, Bertillon measurements and records of individual offenders of the more or less professional class of criminals. It now has on file probably a million items of information relating to several hundred thousand criminals. New items reach it now at the rate of perhaps 40,000 a month.

Through it large police departments and detective agencies exchange data that are of mutual value. Its biggest service has been in making identifications.

Although of much value, this bureau has not been adequate to the need for a national clearing house on crime for various reasons.

One reason is, that because of its semi-private nature, there are facilities which it could not use to the fullest extent. There is the radio, for instance, but this can be used with fullest effect only through some form of broadcasting service.

In order that it be able to make use of such a service as well as many other things now beyond its range, the Department of Justice has agreed to take over the activities of the bureau and hereafter operate it. This move is in furtherance also of a policy laid down, upon his taking office, by Attorney General Daugherty with reference to the Department of Justice's investigating bureau. It was to make this bureau an all-round agency for public service, especially in the prevention of all crime. Through it we have tried to bring all the crime detecting agencies of the country into a form of co-operation that will enable them to work as a single unit in protecting the public from the criminal, and in detecting crime.

This aim will be greatly advanced by the National Bureau of Identification and Information, for under government operation the bureau will be of service to peace officers of all kinds, the rural county sheriff as well as the big city chief of police, the village constable as well as the large private-detective agency. In fact, we hope to get them all to supply it with as well as to draw upon it for information.

We expect also to make it an all-round storehouse as well as clearing house for crime data. There will be a statistical office—the first of national scope, to collect regularly numerical data, such as used to be gathered periodically by the Census Bureau; however, the data will be more up to date and more inclusive. There also will be a library where we expect to keep on

From a photograph made for POPULAR RADIO

The Radio Detective Who Unfathomed the Famous "Nauen Buzz"

During the early days of the World War the incredibly rapid and undecipherable radio signals between the most powerful broadcasting station in Germany and the station of the "Telefunken Company" at Sayville, Long Island, N. Y., aroused the attention of the U. S. officials. But it was a radio amateur, Charles E. Apgar of Westfield, N. J., who finally found the solution by means of amplifiers that recorded these signals on wax phonograph cylinders. By this means the messages were de-coded—and the Long Island station was promptly seized. This picture shows Mr. Apgar operating the same apparatus which he used on that historic occasion.

AS THE PICTURE WAS SENT—

The Jenkins apparatus for transmitting and receiving pictures by radio (as described in POPULAR RADIO *for April, 1923), is already being used for sending motion pictures in the same way.*

—AND AS IT WAS RECEIVED

The device, in effect, "draws pictures with pencils of refracted light." Note the steel engraving-like quality of the received portrait.

file every book, report or other published item of material having to do with crime. We hope to make it so complete that even any general student of crime may go there and get full and accurate information having to do with all phases of the subject.

But the big function of the Bureau of Identification and Information will be the quick dispatch of information respecting crime and the pursuit of criminals. In that purpose radio will be used on a national scale, and it will thus be made available to all peace officers. In many cases it will greatly expedite pursuit and speed up interchange of information to a degree beyond what is now possible through any other medium of communication.

A serious crime, let us say, is committed in Massachusetts or Texas. The offender drops seemingly, as the reporters often say, "out of existence." With the bureau in full operation and the government's radio facilities at its command, all space may cry out for his apprehension. No matter how fast or how far he may go, the radio will dog his footsteps—it, indeed, may pour into his own ears an inescapable harbinger of discovery.

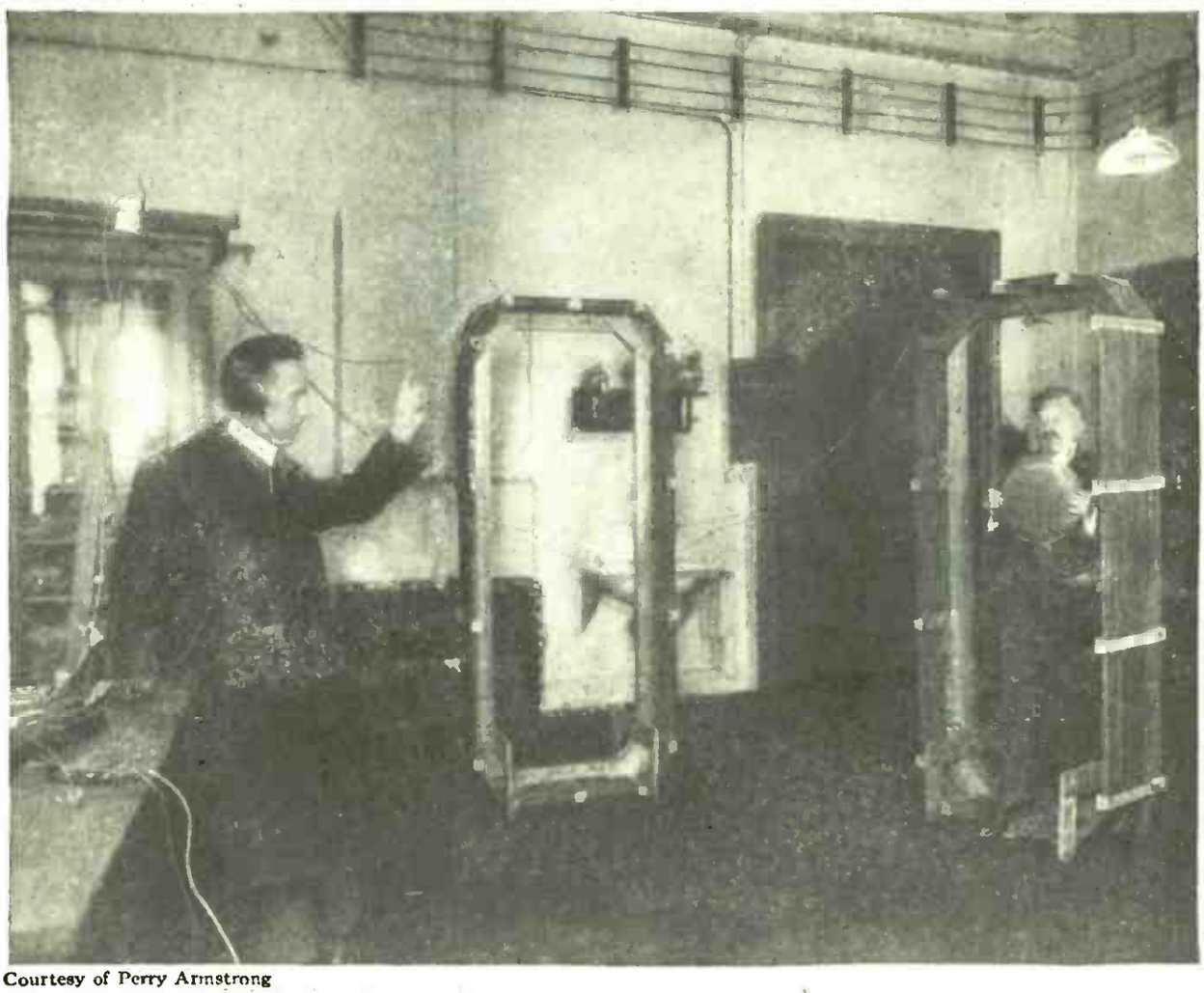
For a flash by radio from an officer of the law anywhere in the country may rally against the fugitive every pursuing agency in the country, and do it almost instantaneously.

In many cases the radio will be able to send forth much more than general descriptions of the fugitive. If he happens, for example, to be recorded in the official archives of crime, his finger-prints and even his photograph may be broadcast, by a single operation, throughout the country.

In that case the officers of the law at the scene of the crime would need only to file a simple telegram to Washington, saying, for instance, no more than the following:

"We want No. 1162. Broadcast."

A clerk in the Washington bureau,



Courtesy of Perry Armstrong

HOW RADIO WAVES TRAP THIEVES OF COPPER

Coils of wire, concealed behind the casings of the doorways of an Austrian factory and connected with similar coils at the door of the watchman, tuned to resonance by the use of inductance and capacity in variable units, permits the detection of a piece of copper as small as four square inches.

with nothing but the number as guide, could turn to a file and get all information needed for broadcasting full data regarding the criminal to all parts of the country.

The information will include fingerprints and photographs and histories of every important criminal arrested anywhere in the country.

It is now possible to transmit fingerprints by either telegraph or radio. Among the several recently invented methods of doing this is a process recently devised by Hakon Jörgenson of the University of Denmark. It consists of a system for reducing fingerprints to numerical formulas. By means of it a fingerprint at one place may be sent to another place in some such formula as the following:

"$14 \times 6 - 5 - 8 \times 10 - 142 \times 152$."

With such formulas at hand, the expert can construct the essential parts of the print. Hitherto, fingerprints could be transmitted from one place to another only by mail or in person. This often caused serious delays in carrying on investigations. A suspect would be arrested, say, in San Francisco. The only way to determine positively whether he was the person wanted would be by comparing his fingerprints with ones on file, say, in New York. Thus a week or more would elapse before duplicates could be transmitted from the one place to the other.

Courtesy *The Tribune*, N. Y.

A POLICE PORTRAIT TRANSMITTED BY RADIO OR WIRE

With the aid of the geometric chart shown on the page facing, portraits are broadcast by the Italian Home Office in Rome; a special staff of men are employed for sending and receiving not only portraits but fingerprints.

In international cases there often is several weeks' delay. Now, however, a fingerprint may be transmitted by radio or telegraph in an hour's time. Indeed, by means of radio it may be broadcast to all the ends of the earth.

The same may soon be done, also, with photographs—thanks to the invention made by C. Francis Jenkins of Washington, D. C.* By means of the Jenkins machine the actual portrait may be transmitted. This will vastly expedite identifications when the system is applied to police methods, as it will insure quick and wide distribution to the means by which fugitives may be recognized at sight.

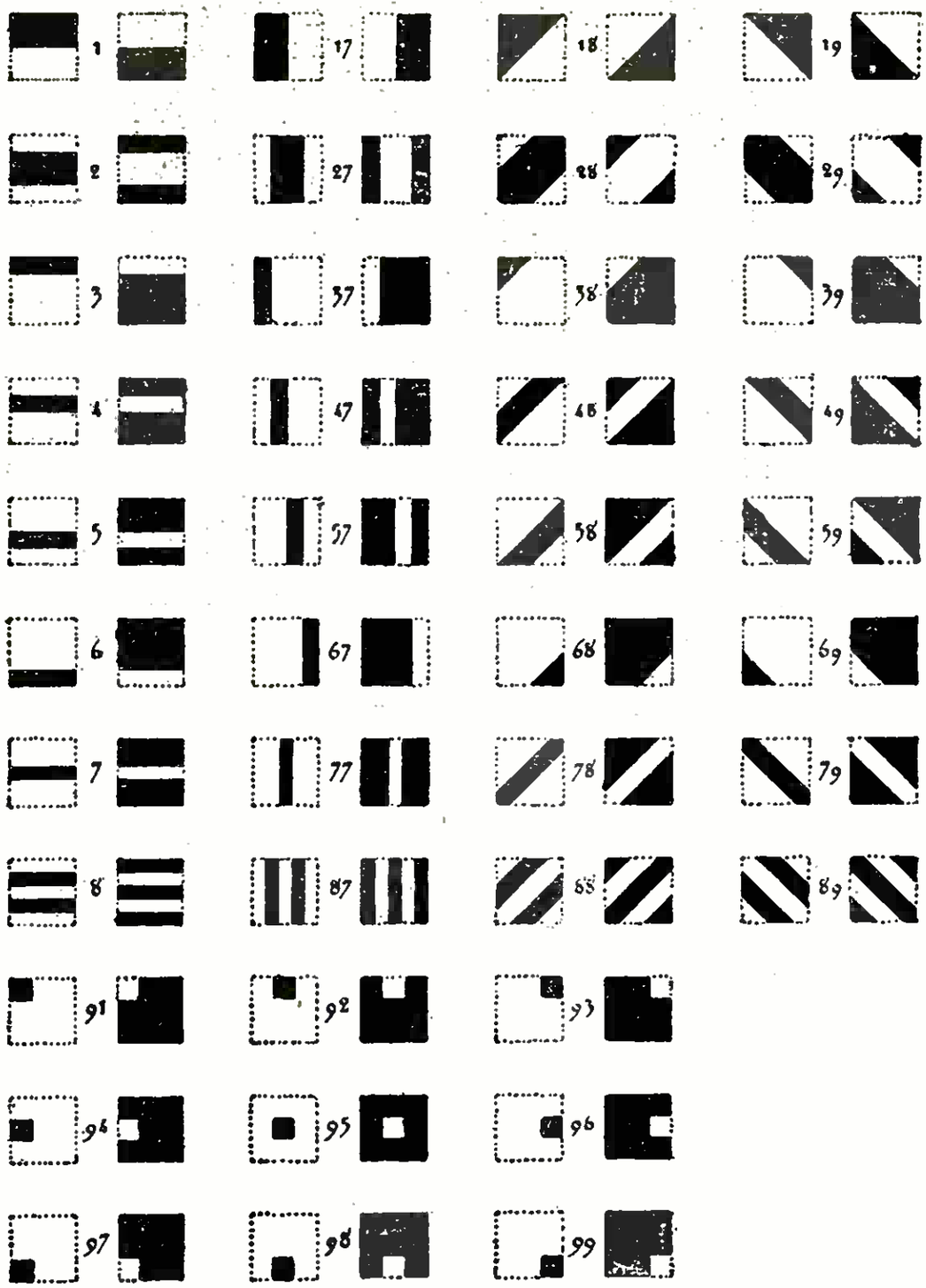
By means of radio photography it may be possible, for example, to have posters containing a photograph of a fugitive on display in every locality of the country within a few hours after a crime is committed.

The essence of strategy in fighting crime, as in war, is speed. As a famous general once put it, success depends on "getting there furstest with the mostest men." The essence of crime prevention is certainty of apprehension and punishment—but the criminal must be caught before he can be punished.

Both prevention and apprehension will be aided by the radio, once it is applied in the full, as by no other system or device yet invented.

One may telephone or telegraph by one operation in a single direction only. Despite the vast network of wires that now stretch over the country there are

*See POPULAR RADIO for April, 1923.



THIS CODE CHART IS THE BASIS OF THE "ELLERO SYSTEM"

By means of these shaded squares, designated by numbers, a picture may be literally dissected into units similar to the units of a halftone screen, and re-assembled by numbers transmitted by wire or radio. This system was invented by an Italian code expert, Commendatore Ellero.

many spaces only sparsely touched or not at all by them. The police of New York and Philadelphia, for instance, may "burn" the wires in making a joint pursuit of a fugitive while the criminal drops into some isolated community between those cities and lets the winds of pursuit blow harmlessly by. With the radio every locality wherein the criminal possibly could take refuge would be reached at the same time with calls for his arrest.

This is now being demonstrated locally by several city police departments, notably those of Chicago and Detroit. In the first city, I am informed, the scout cars of detectives are equipped with receiving sets through which the operators can be reached from headquarters at any time, and be kept informed with developments as they work.

In both cities the radio is being used with particular success in the matter of automobile thievery. Every day names and numbers and descriptions of stolen cars are broadcast into all surrounding country, with the result that thousands of eyes are put on the watch for these cars.

Incidentally, it should be possible, through the radio to reduce to *nil* automobile thievery, which as a rule depends for success on quick get-aways over open roads. With officers and garages and the great number of amateur radio fans, whose aid could be secured quickly, kept informed along the highways of escape, it should become well-nigh impossible for a thief to make his escape with a stolen automobile.

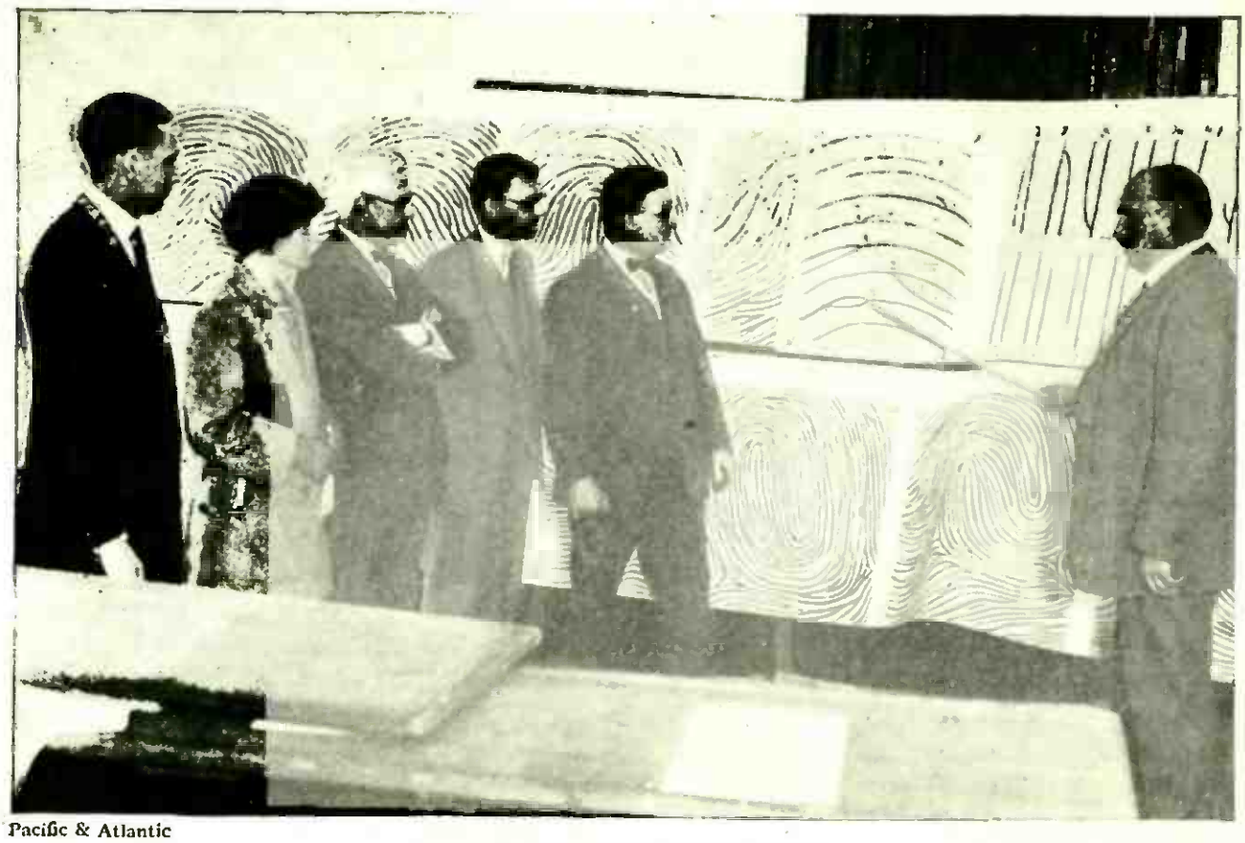
The automobile as a means for the quick pursuit of criminals is offset to a great degree by the fact that it can be used almost as well by fugitives themselves. Indeed the criminal, I have no doubt, will learn to make use of the radio, not only in making escapes but also in accomplishing crimes.

This latter is made difficult by the

From a photograph made for POPULAR RADIO

WHERE THE RECORDS OF LAW-BREAKERS ARE KEPT

Into these files of the National Bureau of Identification and Information at Washington pour monthly about 40,000 items of information about criminals. Radio will play an increasingly important part in both collecting and disseminating this data for police uses.



Pacific & Atlantic

FINGER PRINTS BY RADIO

Hakon Jorgenson, sub-director of the Copenhagen police and inventor of a finger-print classification system that permits the transmission of these identification marks by radio, is demonstrating his invention to the New York police experts. The plan is based upon numbers for curves, valleys and whorls.

fact that track of stations can be kept, but it will be relatively easy for the fugitive to carry his own receiving set and by means of it keep reasonably well informed as to what is done *via* radio by those in pursuit of him. But again, as illustrated by the case of the youth who stole the receiving set, this very fact may be turned upon and used against the fugitive. In truth, the "psychological" possibilities along this line are limitless.

These lines of development will cause the radio to serve as a great crime preventive. The very knowledge that radio is available for full use in pursuit, that it can reach him no matter where he may go, should have and must eventually have a restraining influence upon the criminal.

And it is the prevention of crime which is the prime aim of every conscientious peace officer. And it is crime prevention that we hope for most through the work of the Bureau of Identification and Information and its chief arm, the radio.

It will give us something we have long needed and under our system of government cannot have except by voluntary action—a central establishment through which all crime-pursuing agencies may work together, particularly in the matter of crime prevention.

In European countries all policing activities generally are directed by national bureaus or departments. That is probably why several of them already have gone further than we have done with the radio as a policing agency. In France it has been in general use for some time, and it has been successful.

Among the more striking examples of the use of radio in detecting crime may be included the following report from Mr. Armstrong Perry, who has been

Keystone

IN THE BROADCASTING ROOM AT POLICE HEADQUARTERS

New York City owns one of the most efficient radio stations in the country, WLAW; the uses of it, however, have not begun to be realized. Receiving apparatus has been installed at headquarters of each of the five boroughs.

touring Europe and picking up items of interest for the readers of POPULAR RADIO. He writes as follows concerning the illustration published on page 351:

By the guilty expression on the face of Hofrat Dr. Max Reithoffer as he steps through a suppositious doorway with a theoretically stolen plate of copper and by the reproving attitude of Ingenieur Emil Wolf, his assistant, it is easy to see that the apparatus shown in this picture is the latest thing in radio thief-catchers.

Morals in Austria were not much after the war. Theft and pilferage became almost as common as in the United States, where they drove to the wall several of the leading insurance companies that guaranteed policyholders against such risks. Dr. Reithoffer, at the head of the government technical institute's radio department, was besought by numerous manufacturers, tradesmen and building contractors to devise some means for detecting pieces of copper that were being carried away from the premises where they belonged by workmen who did thieving as a side-line. He responded by inventing the system shown in the picture.

It is simple, now that the problems involved have been solved. Any doorway used by departing workmen is supplied with a coil such as that through which Dr. Reithoffer is seen stepping. The wires are concealed behind the casing, of course. From this coil wires lead to a similar one at the door of the watchman or detective who may be near or several hundred yards away. The two coils are tuned to resonance by the use of inductance and capacity in variable units. So delicately is the apparatus adjusted that four square inches of copper concealed in the pocket of a light-fingered workman will disturb the balance and signal the watchman, who, thus warned, loses no time in apprehending the guilty one. The large plate carried by the inventor was used only because it would show up well in the photograph; it is several times the size of the smallest plate to which the apparatus will respond.

One of the difficulties encountered in perfecting the device was that it persisted in sounding alarms for watches, pocket knives and other metal articles that the workers had

a perfect right to own and carry. Adjustment had to be made so that it would signal: "watch and knife plus stolen copper."

The photograph was taken at *Das Elektrotechnische Institut der K.K. Technischen Hochschule* in Vienna, where Dr. Reithoffer has been a professor for twenty years. He prefers not to give fuller details at present as he has no attachment for signalling to Vienna when ambitious imitators try to get away with valuable ideas pilfered from others.

In this country radio can be used with fullest efficiency only when main reliance is placed on the facilities possessed by the Federal Government. The big broadcasting stations of the army and navy may thus be utilized to serve all the peace officers of the country, and in so doing will bring all of them into closer working harmony. This also will be voluntary, thus giving us the benefits without the risks attaching to a national department of police.

We hope also to develop the idea internationally. The bureau we are to operate will be at least the nucleus of an international clearing house on crime—something which (as recently pointed out by Sir Basil Thomson, late of Scotland Yard) is a vital need. This will be facilitated by radio, and especially by the numerous stations abroad already owned and operated by our government.

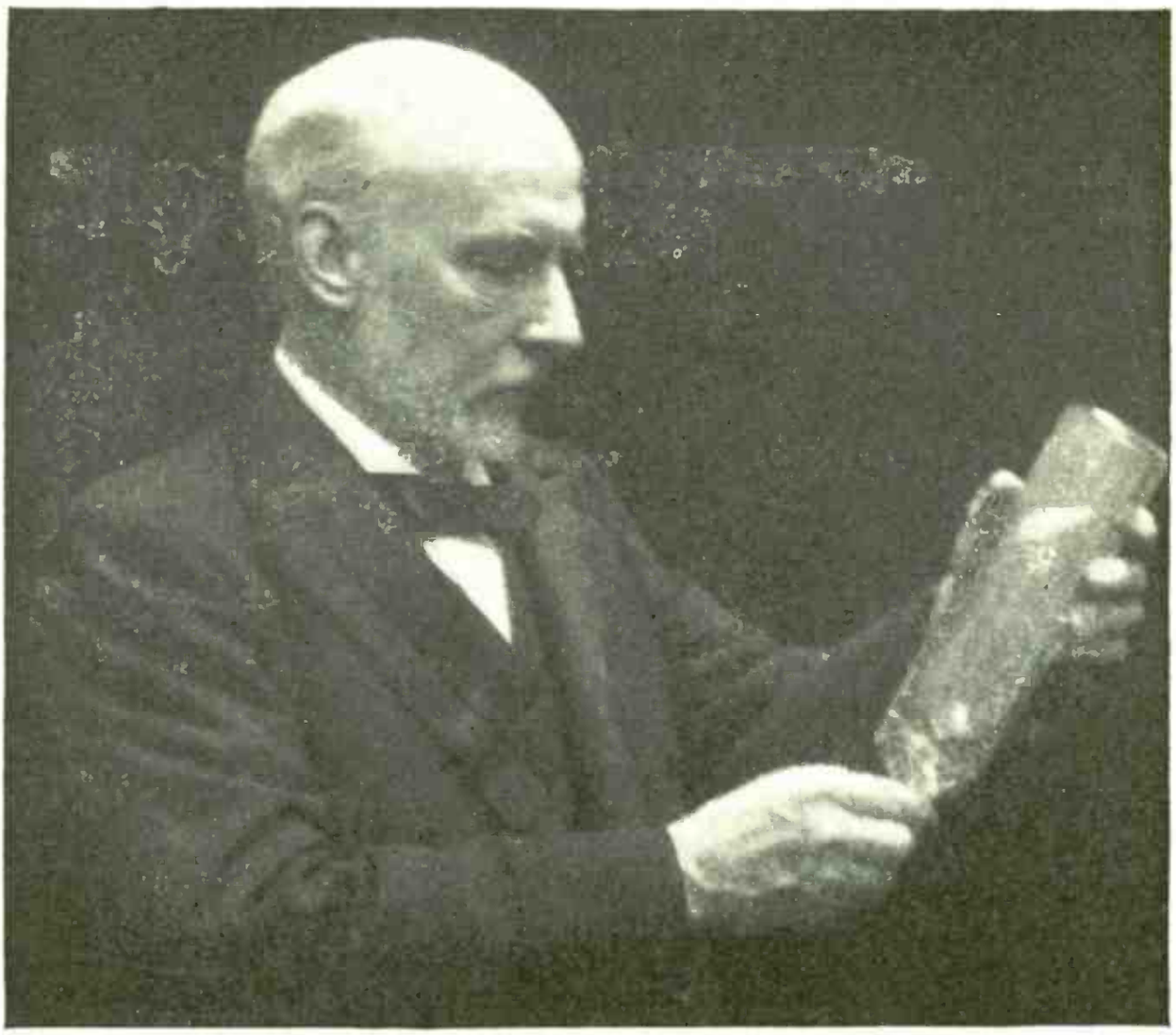
Many details bearing upon our plans are yet to be worked out. But I see no obstacle in the way of solving them.

When they are fully applied a tremendous force will have been brought to bear against the world of crime. Already, I understand, more than a million and a half amateur radio fans operate receiving sets in this country. In certain situations they can be of inestimable service in fighting crime. This can be done through the aid they can give in distributing information quickly and widely and also in keeping eyes out for fugitives from justice.

Photonews

AN AERIAL IN YOUR WINDOW SHADE

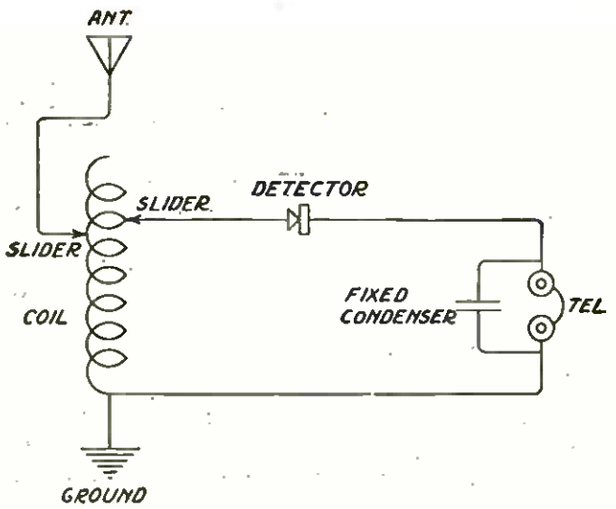
Wires running around just an ordinary roller window shade is the novel device worked out by W. H. Bullock of New York. "Tuning is accomplished by pulling the shade up or down" is the report that accompanies the picture.



From a photograph by Hoppé, London

The Inventor of the Superfreeze

THE manufacture of vacuum tubes for radio use owes much to Sir James Dewar, Ph.D., LL.D., F.R.S., F.I.C., F.R.C.S., who was a pioneer investigator of the properties and uses of liquid air. By a series of new methods and devices which he invented Sir James succeeded in liquefying not only air but hydrogen, oxygen and several other gases. These novel liquids, never before seen by man, were intensely cold. Some of them reached temperatures as low as 450 degrees below zero, Fahrenheit. In order to keep these liquids and use them in experimental work it was necessary to invent a new kind of cold-proof container, and Sir James produced the double-walled vacuum flask, now familiar as the household thermos bottle. This conquest of extreme cold, so that it can be used in the laboratory as easily as any other reagent, has been an important item in the production of the nearly perfect vacuum which is necessary in some kinds of radio vacuum tubes, as was described in POPULAR RADIO for October, 1922.



THE CONDUCTIVELY-COUPLED CRYSTAL CIRCUIT

Cost of parts: Not more than $10.00.
Selectivity: Fairly good.
Operation: Very simple. Only two controls are used; a primary and a secondary slider.
Ease of construction: No technical knowledge necessary.
Approximate range: 15 miles.
Outstanding features: This circuit is especially suitable for the beginner who wants to start out by building the simplest set that will give him clear reception of local signals at the smallest cost.

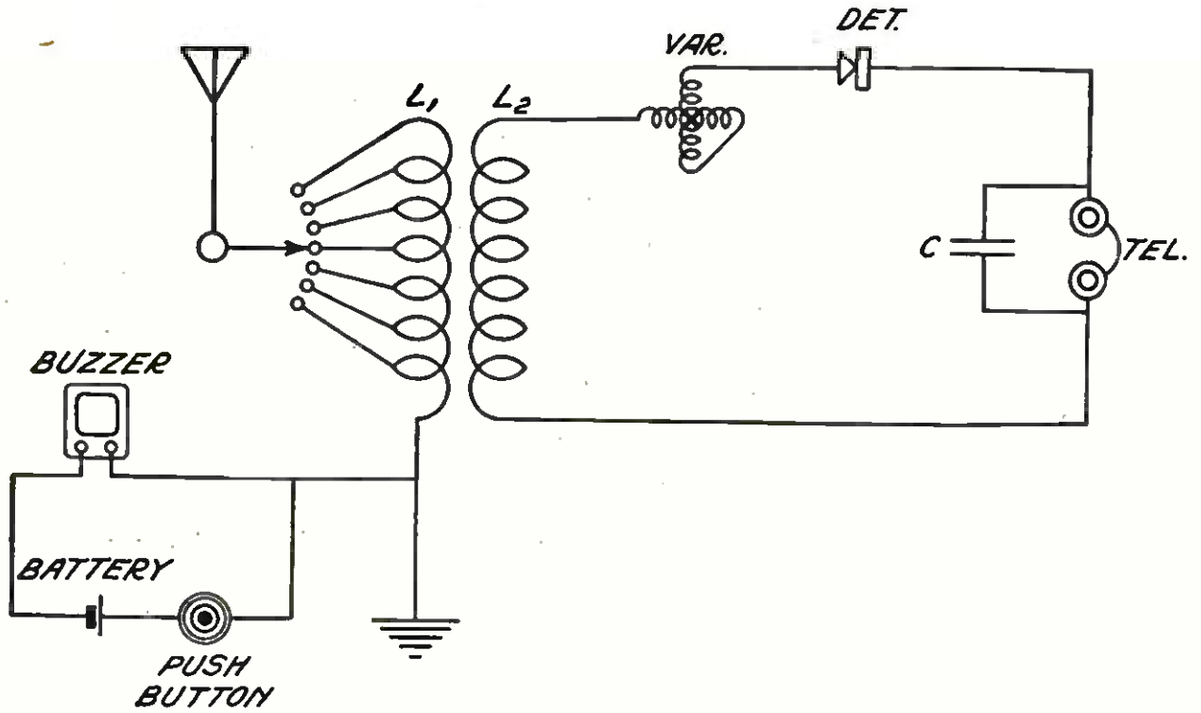
The 100 BEST HOOK-UPS

INSTALLMENT NO. 1

A carefully compiled list of the most efficient receiving sets and the approximate costs, range and peculiarities of each; selected for the practical guidance of the radio novice

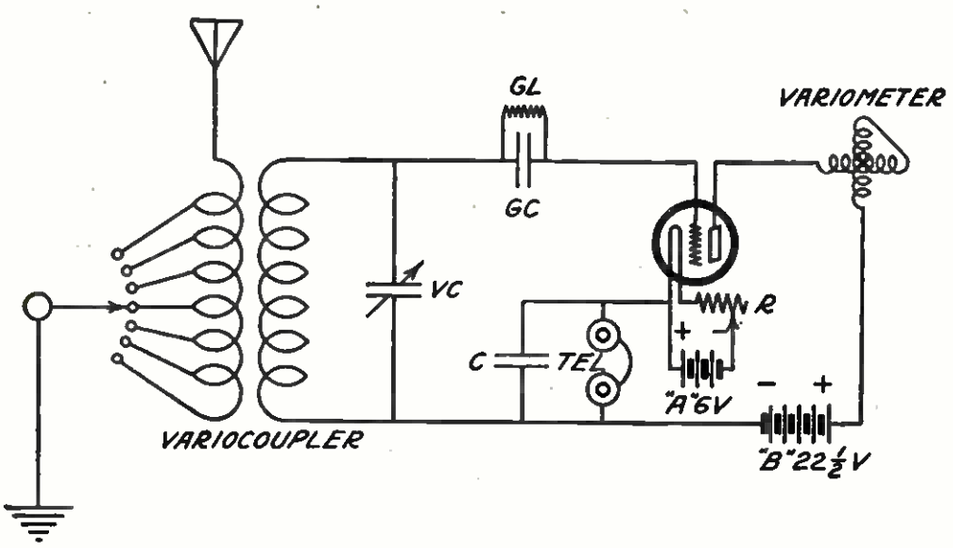
IN choosing these circuits, careful consideration has been given to the various uses to which the apparatus may be put. The circuits have been rated under six different classifications which, it is believed, will enable the radio fan to pick out the one that is most suitable for his own particular needs. One hundred picked and tested radio receiving circuits, each one of which is best for its own particular field of usefulness, will be included in this hook-up series for the special benefit of the man who is undecided as to just what he wants. In his selection he will be influenced by (1) *the cost* of the parts; (2) *the selectivity* of the set—particularly if the experimenter is near numerous stations; (3) *the ease of operation;* (4) *the ease of construction;* (5) *the approximate range,* and (6) *the outstanding features* of the set.

The approximate ranges here given are yearly averages on actual records made with receiving sets throughout the country. During the summer the actual ranges may fall to 50 percent of the value given, while in the winter, under the best of conditions, the actual ranges have been known to exceed the values given by as much as 500 percent.



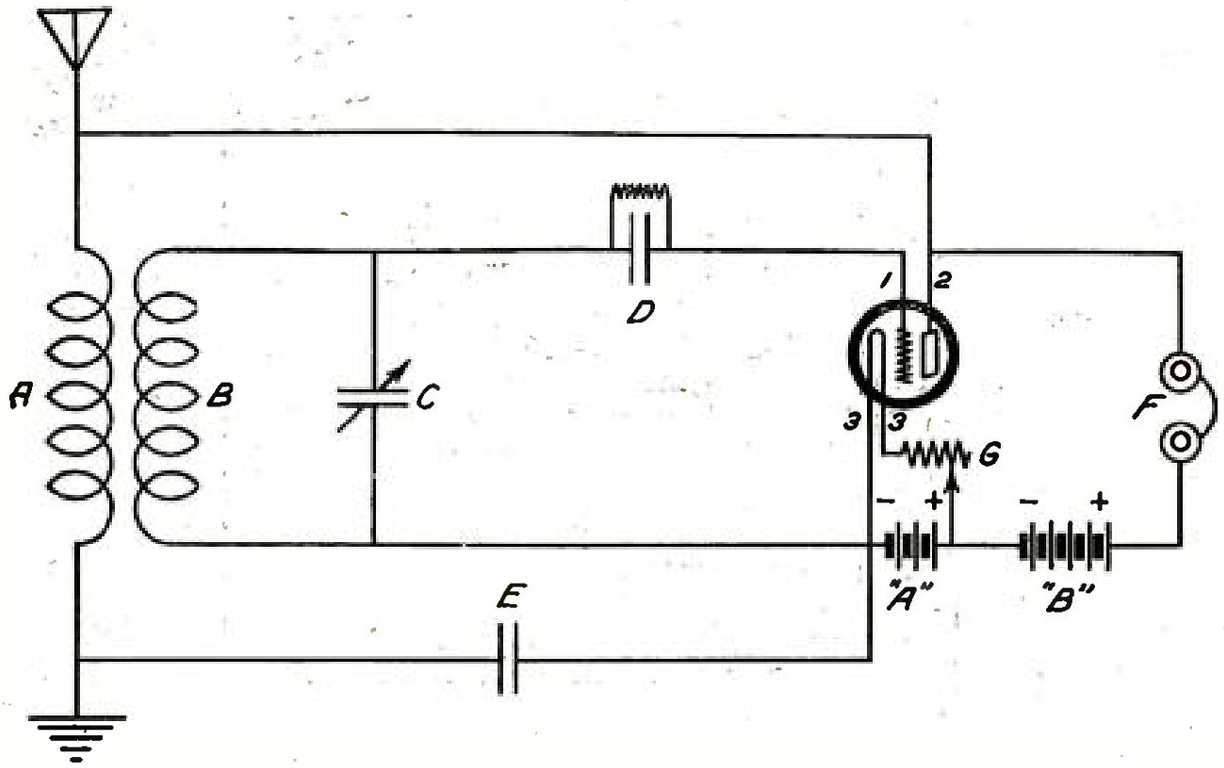
THE INDUCTIVELY-TUNED CRYSTAL CIRCUIT

Cost of parts: Not more than $15.00.
Selectivity: Good.
Operation: Fairly simple. The antenna circuit is tuned by a tapped switch, the secondary by a variometer and the coupling is varied by rotating the secondary coil of the variocoupler.
Ease of construction: Easy to build.
Approximate range: 15 miles.
Outstanding features: The set is sharp to tune on account of the loose coupling that can be employed, and it has a test buzzer which is a great help in setting the crystal in adjustment.



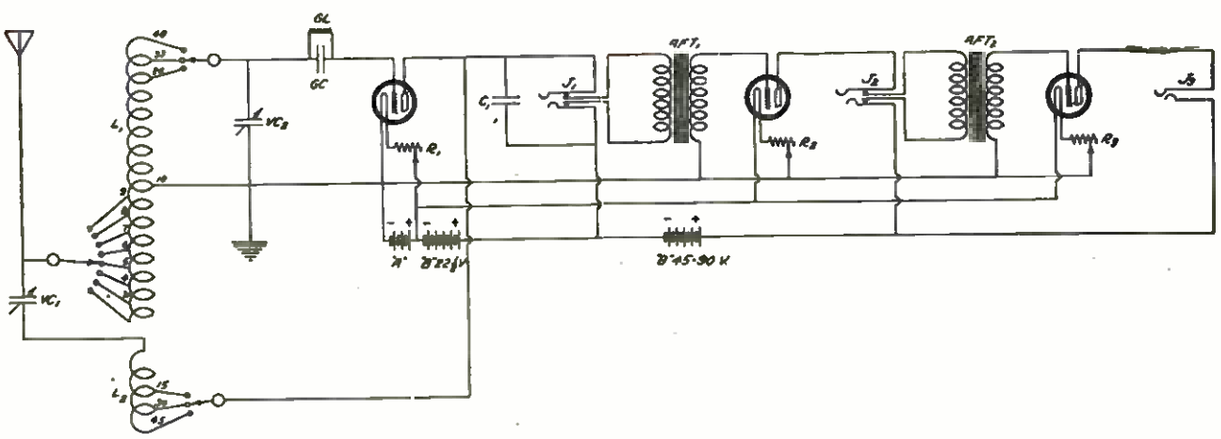
THE COMBINATION TUNED-PLATE, ULTRA-AUDION CIRCUIT

Cost of parts: Not more than $25.00. (Note: The cost of tubes and batteries is considered "extra," and is not included in the costs given in these descriptions).
Selectivity: Excellent.
Operation: Requires considerable skill which can be acquired in a couple of months of experimenting with the tuning.
Ease of construction: Just an ordinary acquaintance with tools, but some electrical ability in wiring up the circuit is necessary.
Approximate range: 500 miles.
Outstanding features: Exceptionally suitable for DX amateur work on CW. Tuning is very sharp and easy when it is learned correctly.



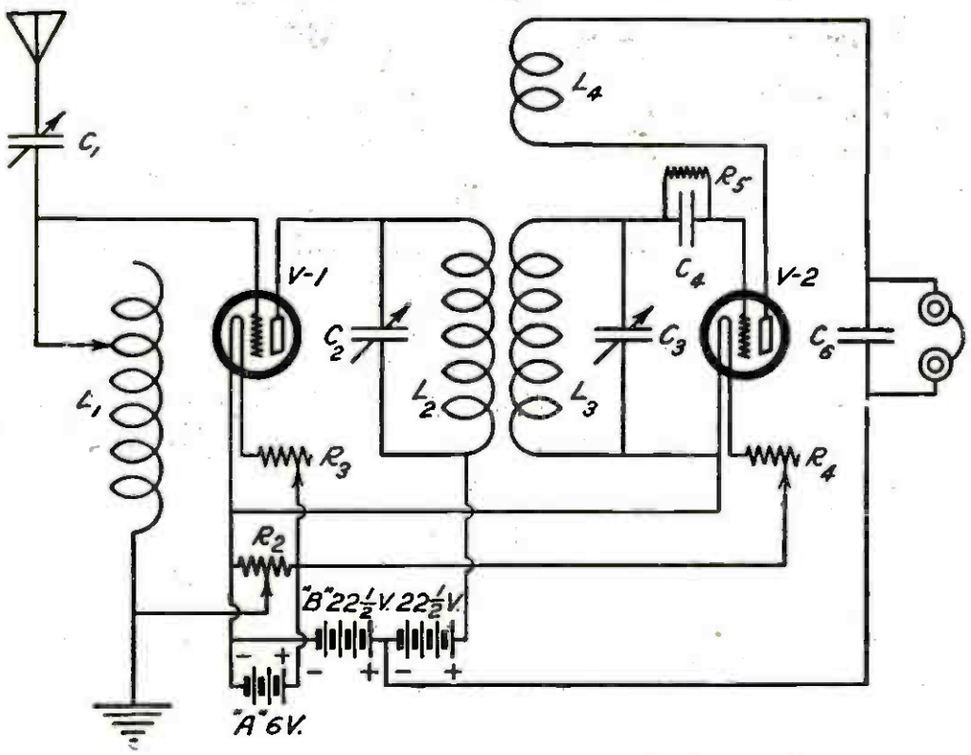
THE MAN-DAY SINGLE-CONTROL REGENERATIVE CIRCUIT

Cost of parts: Not more than $12.00.
Selectivity: Excellent.
Operation: Very easy. Only one control for wavelength. Regeneration is adjusted with the filament rheostat.
Ease of construction: Simple.
Approximate range: 500 miles.
Outstanding features: This is the simplest regenerative circuit to tune. It is very selective and costs but little.



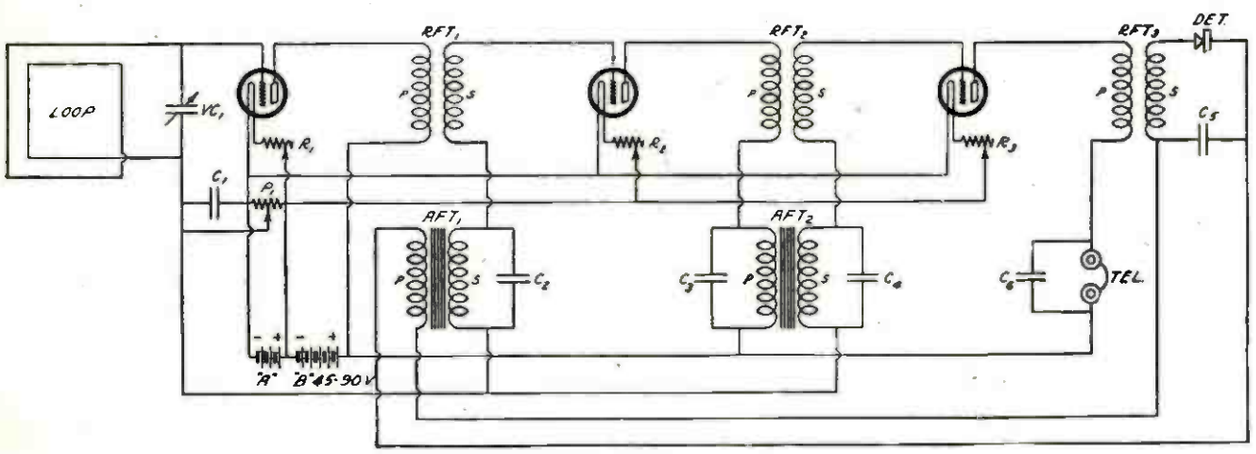
THE REINARTZ CIRCUIT, WITH 2 STAGES OF AUDIO AMPLIFICATION

Cost of parts: Not more than $35.00.
Selectivity: Excellent on amateur wavelengths, very good on broadcasting wavelengths.
Operation: Easy when mastered; about a month's practice should suffice to become well enough acquainted with the peculiarities of the tuning.
Ease of construction: Simple.
Approximate range: 1,500 miles.
Outstanding features: It is noted for its DX amateur reception and its low cost.



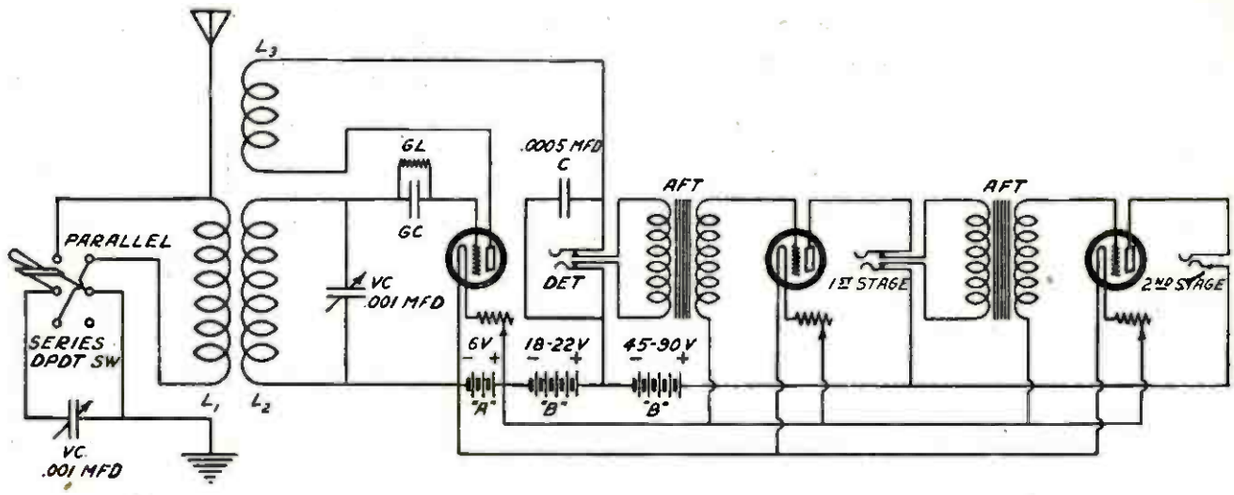
TUNED RADIO-FREQUENCY AND REGENERATIVE-DETECTOR CIRCUIT

Cost of parts: Not more than $28.00.
Selectivity: Good.
Operation: Rather complicated for a beginner.
Ease of construction: Easy.
Approximate range: 500 miles.
Outstanding features: May be used with short indoor antenna. It may be made from a single-circuit, honeycomb set to stop re-radiation, and may be used to give the builder a good idea of radio-frequency amplification before he tries out the more complicated circuits.



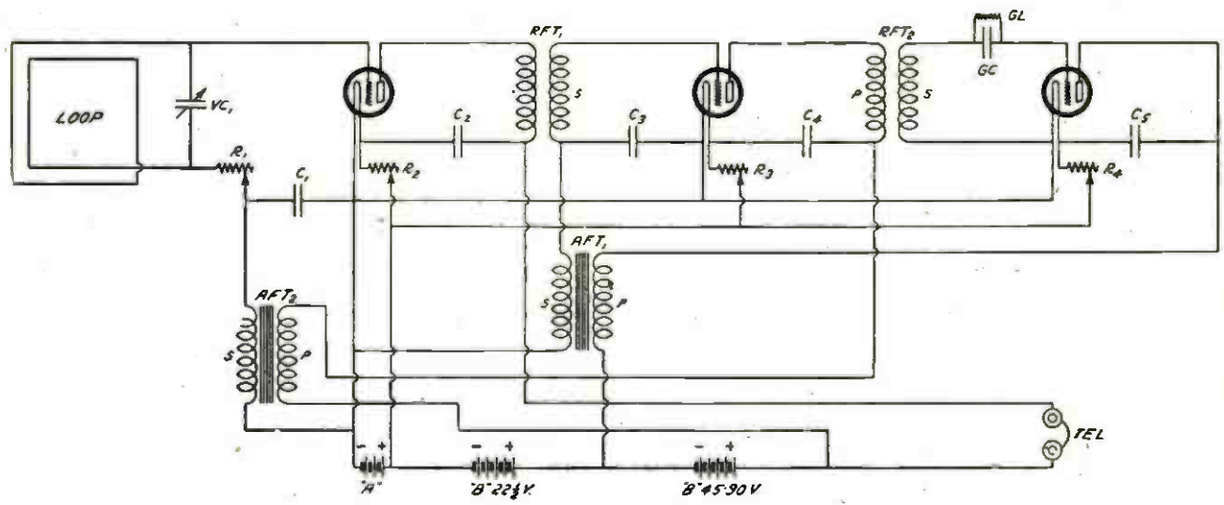
THE SQUIRE REFLEX CIRCUIT

Cost of parts: Not more than $50.00.
Selectivity: Excellent.
Operation: Very simple. One control for wavelength and one control for regeneration; the only other adjustment that must be made is the setting of the crystal detector.
Ease of construction: More or less complicated. There are a number of precautions that must be taken to get the circuit to operate at highest efficiency.
Approximate range: 500 miles (with the loop antenna).
Outstanding features: No outdoor antenna is needed for DX reception. Simplicity of tuning.



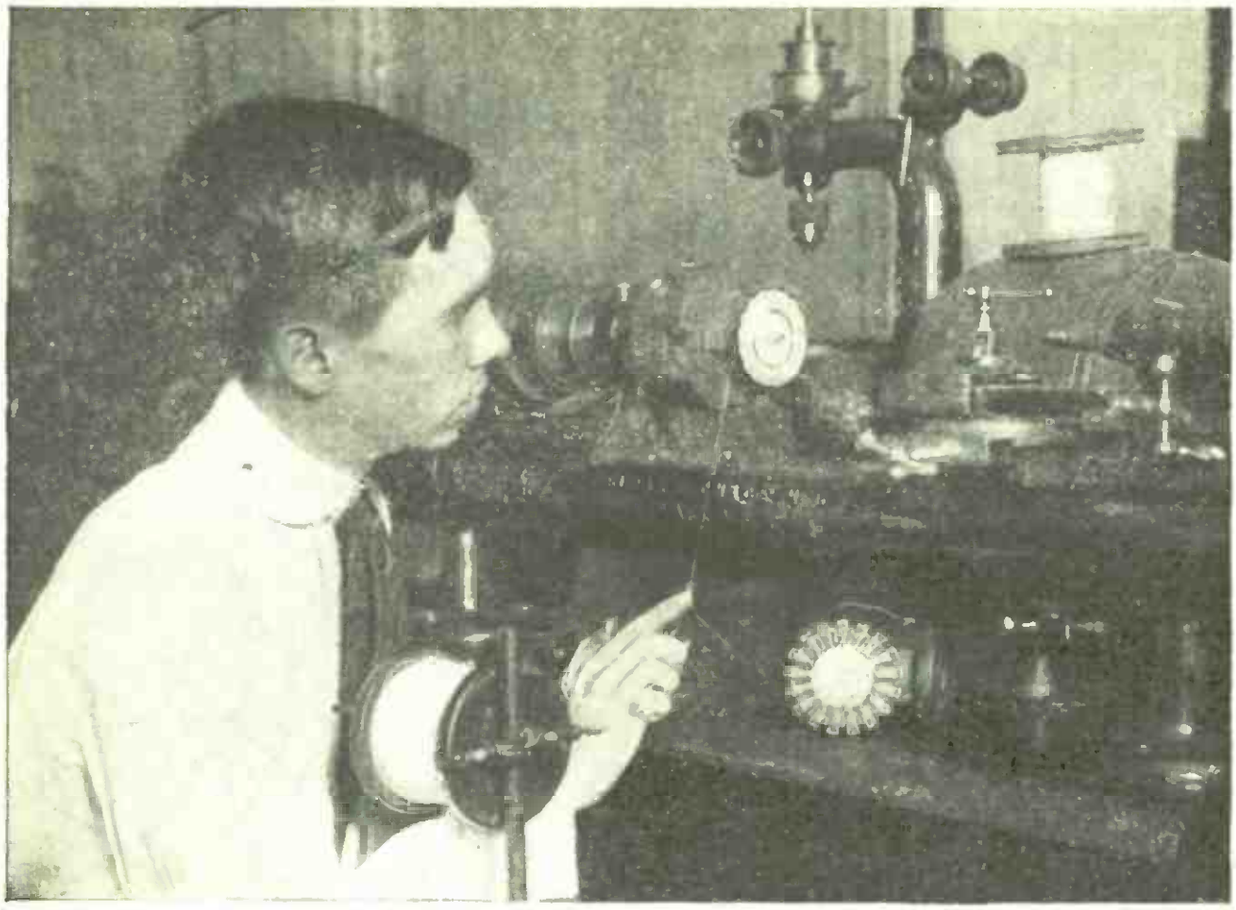
TRIPLE-COIL, HONEYCOMB REGENERATIVE CIRCUIT WITH TWO STAGES OF AMPLIFICATION

Cost of parts: Not more than $35.00.
Selectivity: Good.
Operation: Rather complicated.
Ease of construction: Not hard to make.
Approximate range: 1,000 miles on the low broadcasting and amateur wavelengths and 3,000 miles on the extreme high wavelengths.
Outstanding features: It may be made to cover all wavelengths by interchanging coils. The coils may be plugged into sockets at will, thus making the set into a high or low wave receptor which is regenerative.



THE GRIMES REFLEX CIRCUIT

Cost of parts: Not more than $40.00.
Selectivity: Excellent.
Operation: Extremely simple. Only one control for wavelength needed and one control for regeneration.
Ease of construction: This is a quite complicated circuit to follow out and to get in operation. There are a number of details that will give the beginner trouble when he first tries to make this set, but they can be overcome.
Approximate range: 500 miles (with loop antenna).
Outstanding features: No outdoor antenna is needed for DX reception. Simplicity of tuning. No crystal detector to bother with. The audio-frequency amplification is fed back to the next preceding tube in each stage.



Kadel & Herbert

WINDING A SPIDERWEB COIL

For calculating the inductance for the various shaped coils, used in radio for reception, there are numerous formulas which are applicable to only one of the types or shapes of coils.

HOW TO CALCULATE

The Inductance of Your Coils

No. 6 of a series written especially for POPULAR RADIO

For this kind of mathematical foretelling of the electrical characteristics of coils, a number of standard formulas have been developed, but for a given type of coil a given formula must be used, if accuracy is to be attained. Some interesting formulas and helpful information on how to use them are brought out in this article.

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

THE expression given by Maxwell for the inductance of any compactly wound coil whose diameter is considerably greater than its width, is the following:

$$L = 4\pi n^2 r \left(\text{Log}_e \frac{8r}{R} - 2 \right)$$

Where r = the mean radius of the coil, n = the number of turns of wire, R = the geometric mean distance of the points in the section of its winding. R = one-quarter of the width and depth of the wound channel, added together.*

In applying this formula it is neces-

*This is sufficiently accurate for ordinary purposes. Thus, suppose the width was half an inch and the depth a quarter of an inch, the value of R would be a quarter of three-quarters, or three-sixteenths of an inch.

sary to remember that the numerator of the fraction inside the brackets, whose natural logarithm is to be taken, must be decidedly bigger than the denominator—at least ten times greater—otherwise the 2 cannot be subtracted from it without causing error or even absurdity. For $\log_e 10 = 2.3$, and the balance is dangerously small, even then. It is necessary, therefore, that the radius r be itself at least double or treble the greatest sectional dimension, for then the margin is adequate and the formula applicable.

A much more elaborate expression to cover any case, is given by Maxwell, and simpler ones have now been invented and may be cited in due course.

Meanwhile we may examine the above expression to see when it is a maximum for a given length of wire. It is plain that the length of wire wound on the coil will be the number of turns multiplied by the average length of a turn, namely $2\pi r$; or $l = 2\pi n r$. So the expression is:

$$L = 2 n l \left(\log \frac{8r}{R} - 2\right)$$

Having decided on the *shape* of the section or channel for the winding (say square), it is plain that R varies with its linear dimensions, and that therefore, n varies as R^2. It also varies inversely as r, for a given length of wire. Putting these things together, it follows that L is a maximum when

$$\log \frac{8r}{R} = 3\frac{1}{2}$$

and that accordingly the maximum value of L is 3 n l, which is the same as $6\pi n^2 r$.

We will return to this extremely simple expression for maximum inductance, $L = 3 n l$, shortly. If T is the thickness of the covered wire, and b is the side of the square in which it is wound, it is obvious that

$$n T^2 = b^2$$

Hence the maximum self-inductance is

$$L = \frac{6\pi r b^4}{T^4}$$

But the condition

$$\log \frac{8r}{R} = 3\frac{1}{2}$$

gives us

$$\frac{8r}{R} = e^{3\frac{1}{2}} = \sqrt{e^7} = \sqrt{(1096 \cdot 6)} = 33 \cdot 11$$

Or

$$\frac{r}{R} = 4.14$$

Whence, for a square section,

$$r = 4.14 \times \cdot 45 b$$
$$= 1 \cdot 863 b$$

The outside diameter is

$$2r + b = 4 \cdot 726 b$$

The inside diameter is

$$2r - b = 2 \cdot 726 b;$$

so that

$$D = 1 \cdot 734 d.$$

Now since $r = 1 \cdot 863 b$,
the maximum L may be written

$$\frac{6\pi \times 1 \cdot 863 \times b^5}{T^4}$$
$$= \frac{35 \cdot 1 b^5}{T^4}$$

The Preceding Articles of This Series by Sir Oliver Lodge—

1. How to Get the Greatest Efficiency out of Your Radio Circuits ..... *March*, 1923
2. How to Get the Maximum Inductance in Your Coils ..... *May*, 1923
3. The Ratio in Size Between Your Antenna and Your Coil ..... *July*, 1923
4. Helpful Formulas for Designing Your Coil ..... *September*, 1923
5. Practical Hints for Coil Calculation ..... *October*, 1923

Kadel & Herbert

WINDING AN ORDINARY SOLENOID COIL ON A LATHE

This is the most used type of coil in this country, for reception below 600 meters. The wire is usually wound on a composition tube and the turns run in a single layer, each turn lying beside the preceding turn.

or, using n_1 to express the number of turns per unit breadth,

$$L_m = 35 \cdot 1 n_1^4 b^5 *$$

Given the inductance required, and also the thickness of covered wire to be used, this determines b the size of the groove which is to be filled with wire.

$$b = \tfrac{1}{2} \sqrt[5]{L T^4}.$$

We know that the mean radius of the bobbin is $r = 1.863\,b$, so the external diameter of the bobbin is $\frac{14}{3}$ b, while the internal diameter is $\frac{8}{3}$ b.

(More exactly, of course, the fifth root of 35·1 is not 2 but 2·04.)

Example:

Let the inductance required be 1,600 meters, and the thickness of covered wire half a millimeter. Then

$$L T^4 = \frac{1{,}600{,}000}{16} = 10^5$$

So approximately we get for breadth and depth of section, $b = \frac{10}{2 \cdot 40} = 4.9$ millimeters.

For external diameter D = 23 millimeters.

For internal diameter d = 13 millimeters.

For mean radius $r = 1.863\,b = 9.13$ millimeters.

For number of turns

$$n = \frac{b^2}{T^2} = 96$$

For length of wire

$$l = 2 \pi n r = 5{,}520 \text{ millimeters}$$
$$= 5\tfrac{1}{2} \text{ meters}$$

*Only simple arithmetic is needed to convert this into the formula previously given: $66 \cdot 6\ L = D^5 T^4$.

If we check this by reckoning back to the inductance as 3 n l, an expression as obtained a few paragraphs above, we shall find it about right. This extremely simple expression, 3 n l, for maximum inductance, when the proper conditions are satisfied, is perhaps not of much use for predetermination, but it is handy for checking. It is worth considering, moreover, whether its simplicity does not make it useful even for the beginning of predetermination; and this we will do in another article.

If we need to know the inductance, or the resistance, or any other feature, of a coil extremely accurately we must determine it by direct experiment. Its estimated value can only be a first approximation, unless excessive precautions are taken and an elaborate calculation made.

But it may be asked, "Is no notice to be taken of the thickness of the uncovered wire—the conductor itself?" We always seem to attend to the thickness of the covered wire instead of to the bare copper. Well, there is a small correction to represent the concentration of the current in the core of the wire sheath. It takes the form of a small addition to the inductance, and Maxwell's complete expression for a ring-shaped compactly wound coil of large diameter is not merely what is quoted above, but has an additional term, so that it may be re-written thus:

$$L = 4\pi n^2 r \left\{ \log_e \frac{8r}{R} - 2 + \frac{1}{n}\left(\log_e \frac{T}{t} + \cdot 12 \right) \right\}$$

where $\frac{T}{t}$ means the ratio of the thicknesses of the covered to the bare wire.

The fact that the logarithm of this ratio has to be divided by the number of turns, before using it as a correction inside the bracket, shows that it is but a small correction, even when the covering of the wire *is* thick.

We will only attend to it for a coil shaped so as to give maximum inductance, and in that case the formula becomes

$$L = 3\,n\,l + 2\,l\left(\log_e \frac{T}{t} + \cdot 12 \right)$$

Or practically

$$\frac{L}{l} = 3\,n + \log\left(\frac{T}{t}\right)^2$$

So for a coil of many turns the correction is small, but it always tends in the direction of increase.

Taking an extreme case, in which the covering is so thick that T = 10 t, then for a coil of 100 turns the factor with which to multiply l is not 300 but 305, when the correction is applied

Coils of Other Shapes

For the calculation of the inductance of coils in general several formulas have been elaborated by the mathematicians. Some of these are appropriate for one shape, some for another.

For compact coils, of which the dimensions of the wound channel are small compared with the diameter of the whole coil, the fundamental formula of Clerk Maxwell is probably the best. But for elongated or spread out coils—those in the shape of a long cylinder, for instance—a quite different formula is more serviceable. The Maxwellian one would then be unwieldy, and in its simple form altogether inapplicable.

For elongated or cylindrical coils an expression was worked out by Cohen.*

It applies to a single-layer coil whose length is not less than four times its diameter, and runs thus:

$$L = 4\pi^2 n_1^2 r^2 \left(\frac{2r^2 + b^2}{\sqrt{(4r^2 + b^2)}} - \frac{8r}{3\pi} \right)$$

where b is the length of the helix (i.e., the breadth of the coil), r its radius, and n, the number of turns per unit length.

Neglecting r^4/b^4, that is, taking the ratio r : b as moderately small, this can be simplified down to the following very handy formula, with n_1 b replaced

*See the *Bulletin of the Bureau of Standards, U. S. A.*, Volume 4, page 385. for 1907-8.
*See also The Appendix to Professor Pierce's "Principles of Wireless Telegraphy," page 341.

Bureau of Standards

A U. S. STANDARD OF INDUCTANCE

This is one of the standard inductance coils, used by the Bureau of Standards at Washington, D. C., for actual inductance measurements of other coils. The standards are matched up with other coils of unknown inductance in a bridge-circuit and their inductance is thus determined.

by n the total number of turns of wire,

$$L = \frac{4\pi^2 n^2 r^2}{b}\left(1 - \frac{8}{3\pi}\cdot\frac{r}{b}\right)$$

Or in other words,

$$L = \frac{\text{square of total length of wire}}{\text{length of coil}}\left(1 - \frac{8}{3\pi}\cdot\frac{r}{b}\right)$$

where the correction factor in brackets is of less and less importance as the helix is longer and narrower.

Example: Take a coil 1 meter long, wound with covered wire 1 millimeter thick, the diameter of the coil being 20 centimeters, so that $\frac{r}{b} = \frac{1}{10}$. The number of turns will be 1,000, and the total length of wire 20,000 π centimeters. So

$$L = \frac{(\text{Length of wire})^2}{\text{length of coil}}\left(1 - \frac{8}{3\pi}\frac{r}{b}\right)$$

$$= \frac{4 \times 10^8 \pi^2}{100}\left(1 - \frac{8}{30\pi}\right)$$

$= 36.6 \times 10^6$ centimeters $= 366$ kilometers.

If the coil is only fairly long, and the ratio of its radius to its length be called x, then a few additional correcting terms, due to Dr. A. Russell, can be added, so that it becomes:

$$L = \frac{\text{square of total length of wire}}{\text{length of coil}}\left(1 - \frac{8x}{3\pi} + \tfrac{1}{2}x^2 - \tfrac{1}{4}x^4\right)$$

All expressions for L inevitably involve the square of the number of turns and the linear dimensions of the coil, so that the answer comes out as a length. All the rest of the formula consists of ratios of similar quantities, that is to say, of mere numbers. All such formulas, provided there is no error, will give the right order of magnitude for the inductance; on the assumption, of course, that the core is air, and not iron. But there will usually be some corrections to apply if accuracy is wanted. More accurate formulas are given in Eccles' Handbook to Wireless; but usually the accurate value is best obtained by experiment.

Disc Coil

The value of L for a disc coil of large aperture can be reckoned from Maxwell's formula.

Or we may re-write it in terms of external and internal diameter of the disc coil thus:

$$L = \pi n^2 (D+d)\left\{\log_e\left(16\frac{D+d}{D-d}\right) - 2\right\}$$

Let us apply this to a disc spiral of external diameter 6 inches and internal diameter 2 inches.

$$L = 8\pi n^2 (\log_e 32 - 2) \text{ inches}$$

Or if there are 10 turns in the spiral,

$$L = 2{,}500 \times 1{\cdot}466 = 3{,}700 \text{ inches}$$

or about 100 yards.

It is remarkable how nearly the simple expression 3 n l happens to agree with this. But it won't apply at all to the case of a long cylindrical coil or solenoid. It would give a result much too big for such a coil; though it is nearly right for a disc.

A long coil may be convenient for sliding contact purposes, but it does not give maximum induction. A disc coil on the other hand is not usually so far away; and indeed a properly shaped coil can be built up of disc coils.

The close addition of one disc coil to another similar one will practically quadruple the inductance, and therefore double the wavelength to be dealt with. A third coil will approximately treble the wavelength, the antenna or condenser capacity remaining the same.

Kadel & Herbert

A group of Arapahoe Indians from Wyoming, camping in New York while on their way to England, get their introduction to radio.

From a photograph made for POPULAR RADIO

THE ORIGINATOR OF THE FAMOUS SHORT-WAVE RECEIVER

Paul F. Godley, one of the most capable radio experts in the world, demonstrates a new method for picking up radio signals.

Receiving Without Antennas

How to use the ordinary regenerative set efficiently and economically without an outside antenna, without expensive radio-frequency amplifiers and without a complicated circuit

By PAUL GODLEY

THERE is an increasing desire on the part of radio folks and would-be fans to receive without using an antenna. The usual excuse is that someone in the household is in fear of the effects of lightning when any overhead conductors run to the home.

Fears such as these are groundless. There is no more danger from an antenna than from electric light and telephone service, which have running to them overhead conductors elevated to practically the same extent that an antenna needs to be elevated. The mystery which is wrapped up in radio seems to carry with it, for many, some of this unfounded fear. Thus it is we find experimenters, writers, and manufacturers trying to cater to this demand.

Circuits of one sort or another have been devised which enable broadcast reception without the use of an antenna. Mainly these have been comprised of multi-stage amplifiers of the radio-frequency type; so far as the writer knows, no general attempts have been

made to take advantage of the inherent sensitivity of regenerative circuits in conjunction with "antenna-less" outfits.

In passing, two interesting facts might be observed. (1) The cheapest and most effective form of radio amplification which has ever been devised for use in conjunction with an antenna-less radio receiver may be constructed at a cost of a few dollars. In effect it will equal or surpass three stages of the best radio-frequency amplification which the writer has ever seen. It is comprised of an average-sized antenna and a good earth connection.

(2) As compared to hazards involved by telephone and electric light connection due to lightning or other cause, the lightning hazard of an antenna is, at least, small.

Multi-stage radio-frequency units depend as a rule for excitation upon the energy collected by a loop antenna consisting of a few turns of wire on a square frame, two feet or so on a side, and almost invariably the circuits call for a ground connection. Upon trying circuits of this sort, it is immediately learned by the experimenter that if the ground connection is left off the strength of the received signal is materially weakened. From this it must be assumed that all of the energy which excites the outfit does not come to it through the loop antenna; that the ground connection in itself is in some manner acting as an antenna; that currents are being generated in the earth and fed up to the receiver through the ground connection.

It takes but a moment for even the uninitiated experimenter to prove to his own satisfaction that the currents generated in the loop antenna, such as that described briefly above, are small indeed as compared to those generated in an overhead antenna of average dimensions. In other words, the difference of potential which exists between the points A, and B, in the antenna circuit of Figure 1-A are quite large as compared to those differences in potential existing between points A, and B, in Figure 1-B. The ratio of those potentials will run somewhere in the neighborhood of one hundred to one. If the ground connection is run directly to

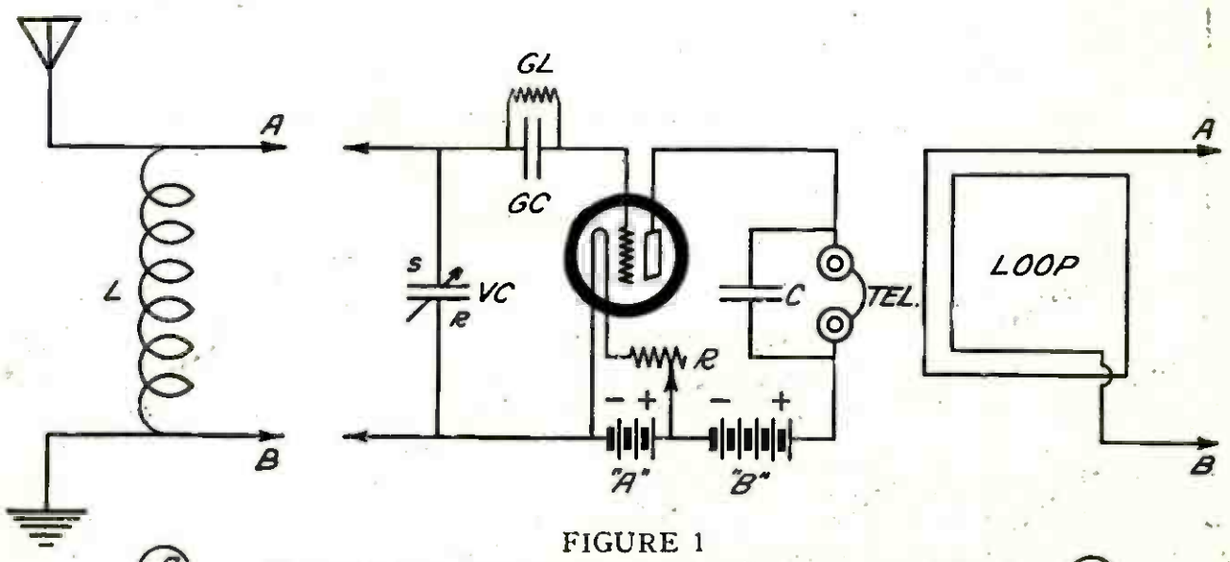


FIGURE 1

The potentials developed across the terminals A and B of coil L (shown at "A" in connection with an outdoor antenna) are of enormously greater amplitudes than those developed across A and B of the loop antenna (shown at "B"). If either of these two pick-up systems were used with the vacuum-tube detector circuit (shown in the middle of the diagram), scheme "A" would therefore be immeasurably better.

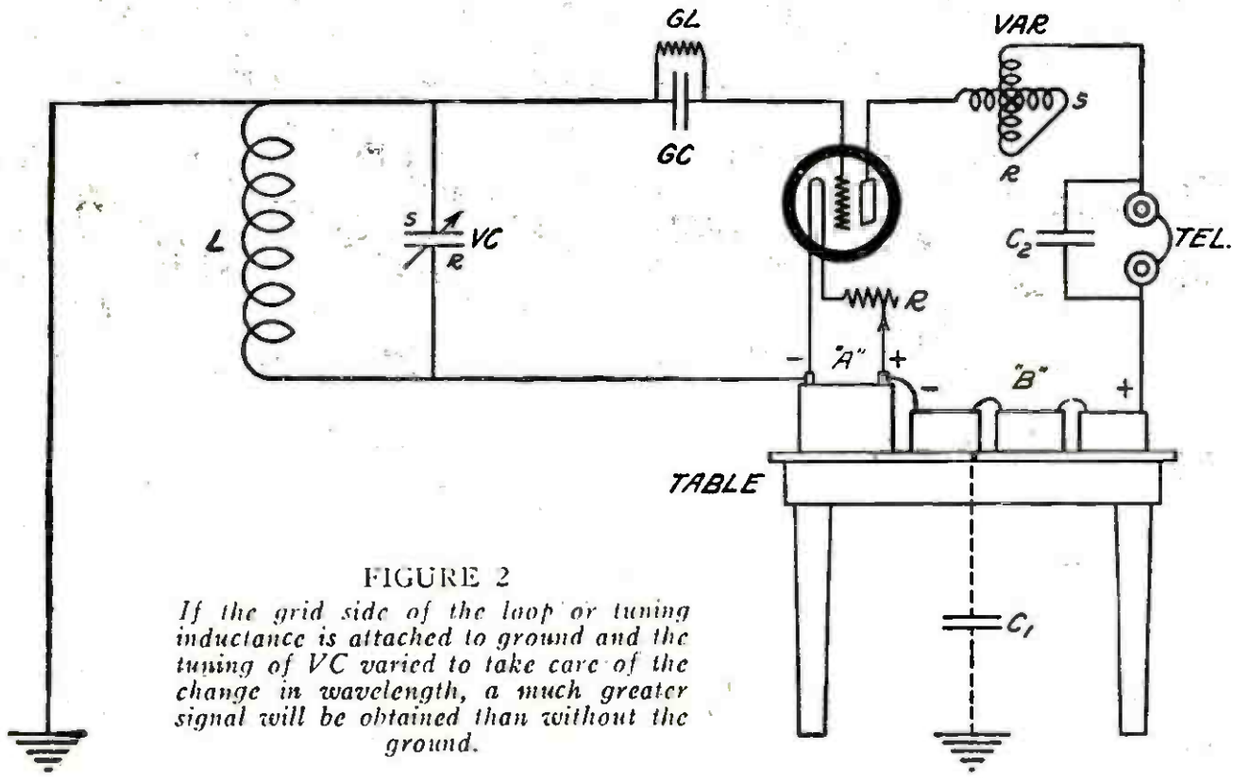


FIGURE 2

If the grid side of the loop or tuning inductance is attached to ground and the tuning of VC varied to take care of the change in wavelength, a much greater signal will be obtained than without the ground.

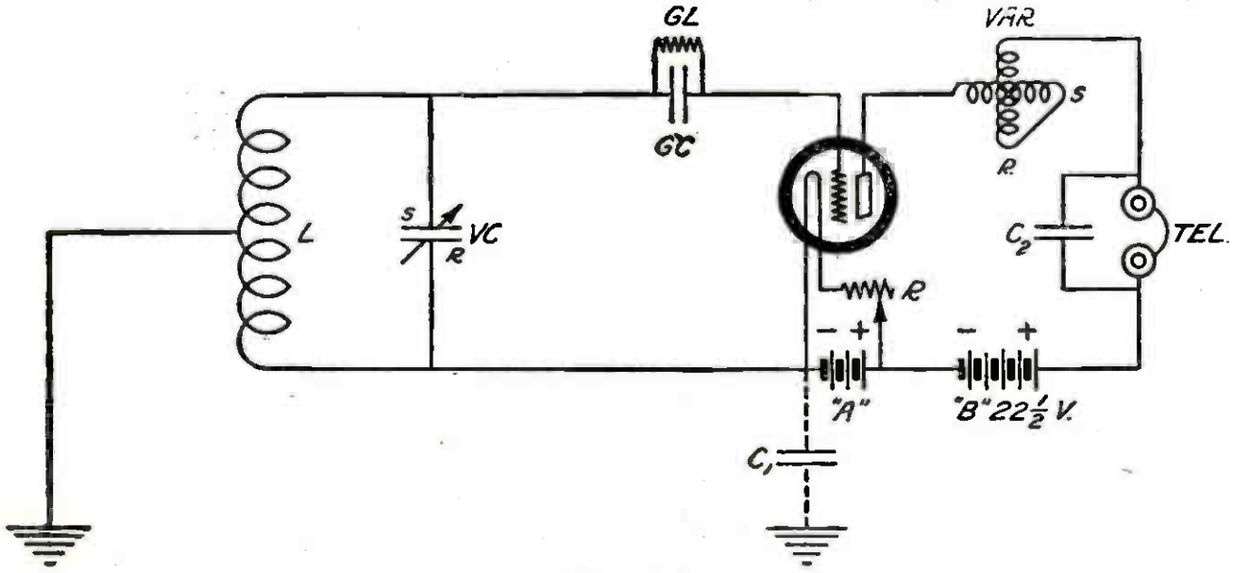


FIGURE 3

A still greater signal may be obtained by this method of grounding in which the ground is taken off somewhere in the middle of the loop or tuning inductance.

the grid of the vacuum tube (as shown in Figure 2) and if proper compensation is made in the tuning element of Figure 2 so as to allow for the change in wavelength which results, surprisingly large values of signal will be fed into the outfit as compared to those fed into it by the loop alone. The ratio of the signal potentials picked up on the average ground connection, as compared to those picked up by the average antenna, is about twenty to one in favor of the antenna. This ratio will vary a great deal, however, depending upon the type of ground connection. Where the ground connection is a long one, the energy picked up will be *greater;* if the ground connection is a

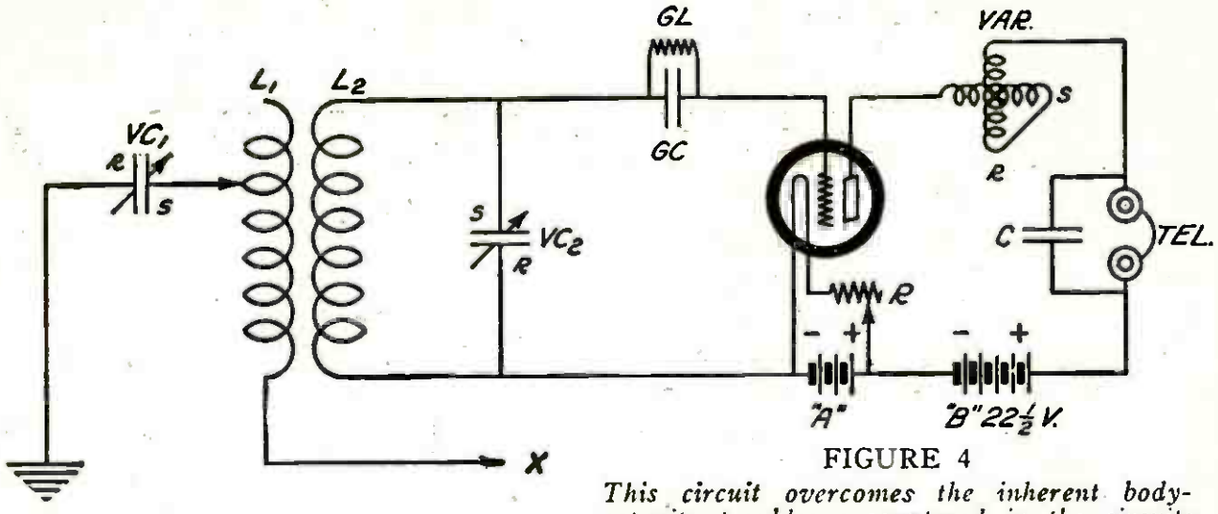


FIGURE 4

This circuit overcomes the inherent body-capacity troubles encountered in the circuits of Figures 2 and 3.

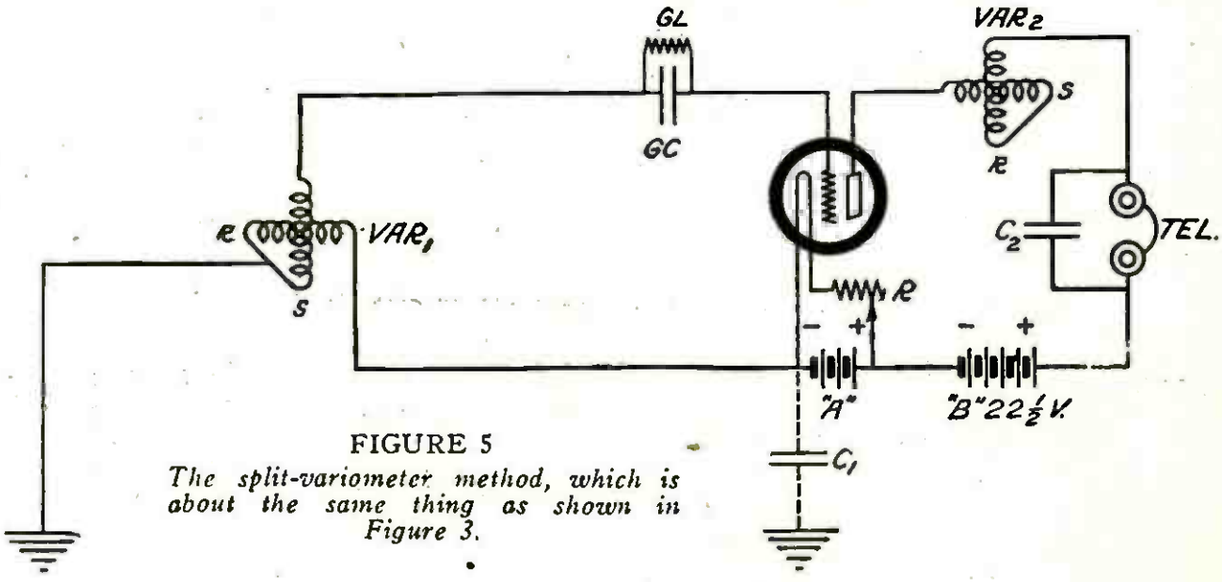


FIGURE 5

The split-variometer method, which is about the same thing as shown in Figure 3.

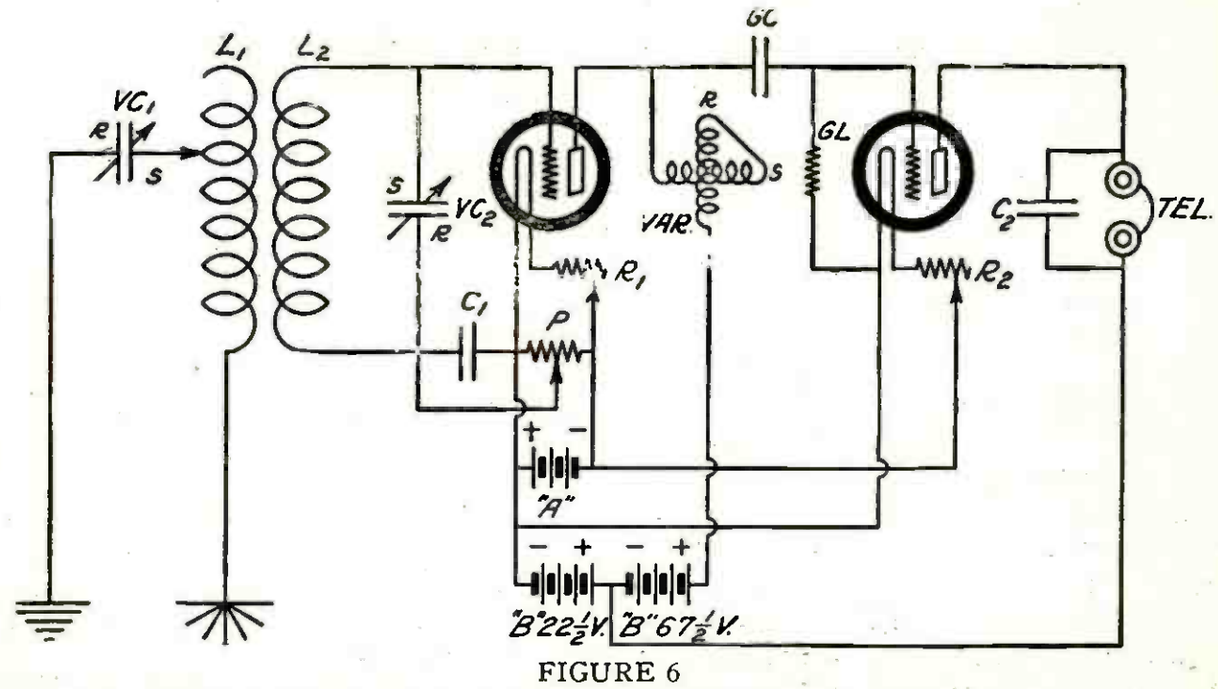


FIGURE 6

One stage of tuned, regenerative, radio-frequency amplification added to Figure 4.

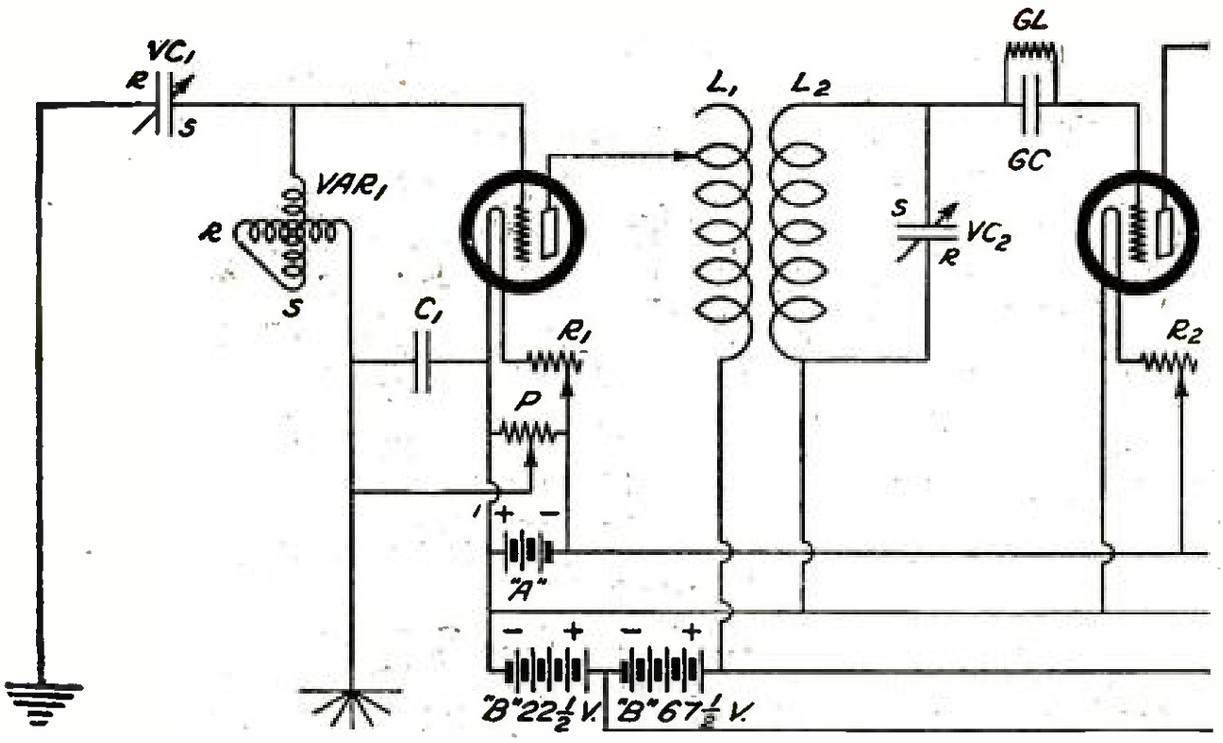


FIGURE 7

The best circuit arrangement of all to use. This is a standard three-circuit regenerative receiver, with the tuned ground circuit, one stage of radio-frequency amplification and two stages of audio-frequency amplification.

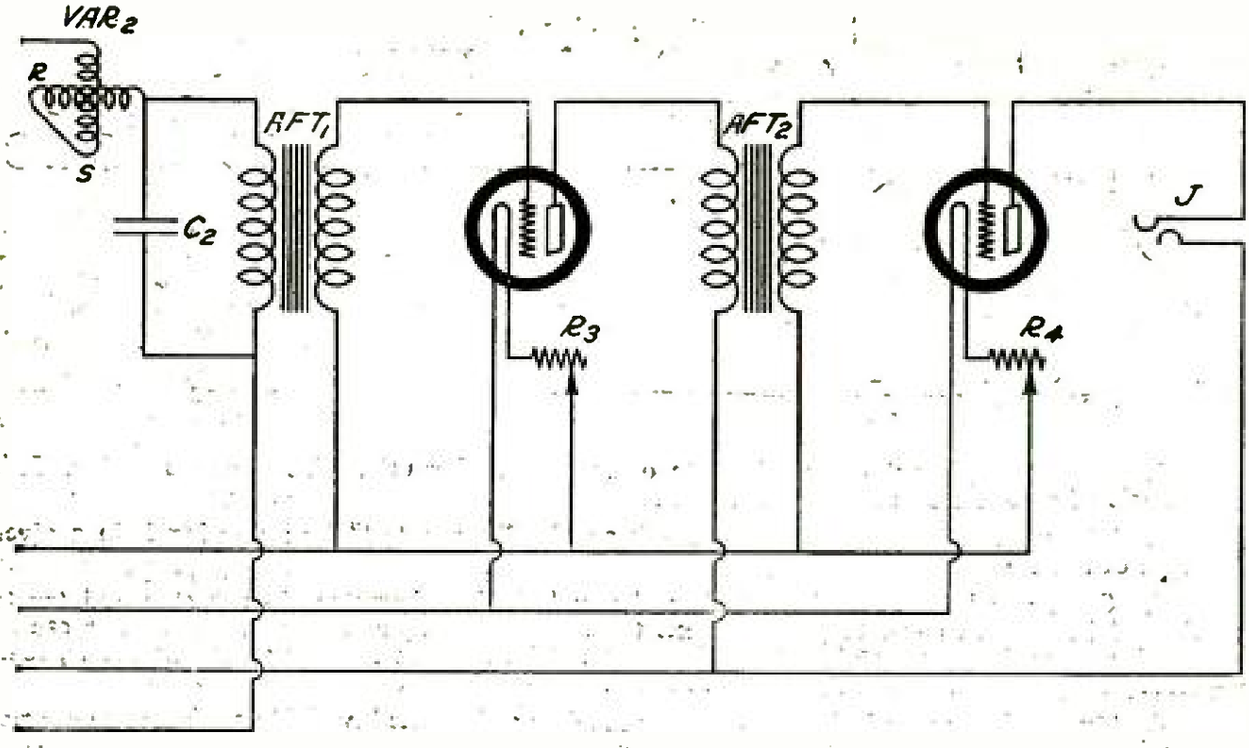
short one, it will be *less*. In the average home, however, this ratio of approximately twenty to one will hold true.

Connecting the ground to the grid of the vacuum tube is *not* desirable, however, for the reason that the size of the capacity C-1, is large. (This capacity C-1, is formed by the receiver and its battery which go to make up one plate of a condenser, and the ground which forms the other plate. The insulating material, air, or whatever it may be, between the receiver and the earth, forms the dielectric. Its value will, of course, vary, depending upon the location of the receiver with respect to the earth.)

A better method of connection is that shown in Figure 3, where a tap is taken out of the center of the grid inductance and grounded. This, however, has not completely eliminated the difficulty of the shunt capacity; furthermore, both the methods of Figure 2 and Figure 3 place the filament circuit of the receiver at a potential considerably above earth potential, which results in serious difficulties as soon as one attempts to tune the outfit, as the operator's body in approaching the receiver will alter the value of the capacity C-1, in either case, with the usual baffling result.

The circuit shown in Figure 4 overcomes these difficulties and results in the same signal strength. Figure 4 is easily arranged in conjunction with any standard three-circuit receiver and may be set up without any great amount of difficulty when using a single-circuit receiver (merely by supplying and coupling an extra inductance L-1).

Figure 5 indicates a method of utilizing the earth pick-up where the receiver is comprised of two variometers, one in the grid circuit and one in the plate circuit. In this case, the earth is connected to the mid-point of the grid variometer. On account of this connection and that shown in Figure 3, circuits of this type have been classed as "split circuits," although reference to Figure 3 will indicate that there is noth-



ing particularly novel about the arrangement.

Figure 6 shows the circuit of Figure 4 except that the vacuum tube coupled directly to the pick-up connection (ground) acts as a tuned regenerative, radio-frequency amplifier. Difficulty will be had with this circuit due to its persistent tendency toward oscillation unless some method is used to control the oscillations. A potentiometer may be connected as shown in Figure 6 so as to throw *positive* potentials upon the grid of the radio amplifier. Or resistance may be placed in the grid circuit of the radio-frequency amplifier tube, but, this broadens the tuning to a marked degree unless the circuits are on the verge of oscillation at all times, and is, for this reason, undesirable. It is far better to use the potentiometer method shown or to regulate the amount of potential fed to the plate circuit of the radio-frequency tube.

Figure 7 is perhaps the best circuit of all; in this a single stage of tuned-radio-frequency amplification is employed. Here a standard three-circuit, regenerative receiver is connected with the radio-frequency amplifier as shown. The variable coupling between the output circuit of the radio-frequency amplifier and the input circuit of the detector in the regenerative receiver will provide complete control over the tendency toward oscillation in the radio-frequency circuit. Tuning the pick-up circuit may best be accomplished by utilization of a variable condenser as shown, or by the substitution of a variometer for the inductance L, in this circuit.

Using the combination shown, it is usually possible, either in the city or the country, to pick up signal strength of sufficient order to operate a loud-speaker satisfactorily from a two-stage amplifier at distances of twenty-five or thirty miles from the broadcasting stations. This is particularly true when the tuned-radio-frequency unit is used.

Those who are in the habit of carrying radio receivers to remote places will find it easy indeed by substituting a wire fence for the ground connection, to pick up distant stations. Railway tracks, exposed water lines, wires thrown into the bed of a brook or small stream, and other similar connections have been used with remarkable success in just this way.

HINTS FOR
Learning the Code

By EDWARD R. LEIGHT

1. Do not let your thoughts divert to other things. Form the habit of concentrating. It is the basis of all success in learning the code.

2. WHEN you memorize the code, make it an "intelligence test" by mastering it in a given length of time.

3. ONCE you have learned the code and you "miss" a character, do not stop and try to think of it. It will come to you the next time. If the group is a word, the character can be filled in; otherwise you have lost the entire group. The habit of holding on to characters, temporarily forgotten, retards the progress in speed.

4. THE beginner who insists on counting the dots and dashes invariably confuses one character with another, particularly when trying to copy speed.

5. Go over the characters in your mind in between times; not by so many dots and dashes but by the sound. For instance Y is—dah-dit-dah-dah.

6. EACH code character is a musical sound. Memorize it in that way. If you must begin by counting the dots and dashes, do so. But save time and acquire speed by reverting to the sound method as soon as possible.

7. Do not attempt to put a character down before it has been completed. Read ahead and write at least one or two characters behind the key.

8. IN copying well behind the key there is ample time to determine doubtful characters before you come to them, to space the groups or words properly and to make a neat copy.

9. THE habit of writing two or more characters behind the sender comes from retaining groups or words in the mind; that is, by having someone send press, word at a time, which must not be written down but connected in the mind and called off as completed. Begin with short words, sent slowly, and increase in length and gradually in speed.

10. THE habit of trying to guess the words and attempting to write them down before they have been completed is a bad one. In many instances the word turns out to be other than that expected and the result is that you become disconcerted and lose the rest of the message.

11. MAKE the characters legible. I's and E's, T's and L's and K's and H's, for instance, should not resemble each other. Dot the I's and J's, cross the T's and distinguish M's, N's and U's from each other.

12. WHEN you send, round out the characters properly. Make the dashes of equal length, the dots in proportion, and evenly and equally spaced.

13. DON'T try to send fast at first. Learn to form the characters correctly; then send slowly and work up in speed as you grow in proficiency.

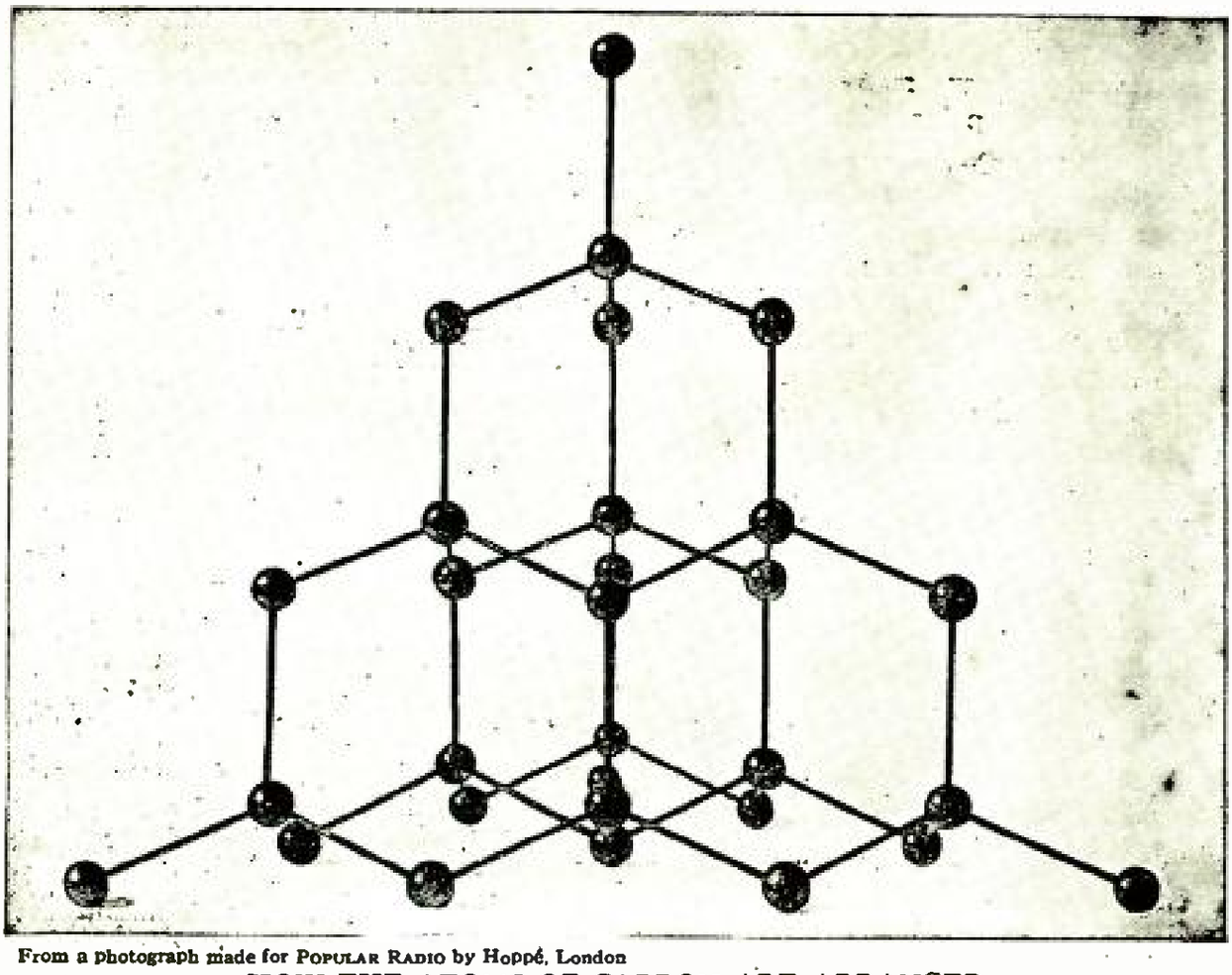
14. AVOID jerky sending. This is generally the result of holding the muscles stiff. Let the forearm rest on the table; let the muscles relax and put the movement in the wrist. This rests the arm and makes it easier to form the characters correctly.

15. To send fast is one thing; to send fast correctly is another. Become known for having a good "fist" by first practicing slowly and carefully.

16. THE habit of letting the fingers come in contact with the metal of the key while sending is a bad one. It will eventually result in a shock.

17. WHEN you make an error in transmission make two interrogation marks, instead of a series of dots, and then begin the word anew.

18. SEPARATE the heading of the message from its body by a break or double dash; likewise the body and signature.



From a photograph made for POPULAR RADIO by Hoppé, London

HOW THE ATOMS OF CARBON ARE ARRANGED INSIDE OF A CRYSTAL OF DIAMOND

As they would look if they were magnified several million times. The model was made by Sir William H. Bragg.

The Crystal Houses that Atoms Build

By WALDEMAR KAEMPFFERT

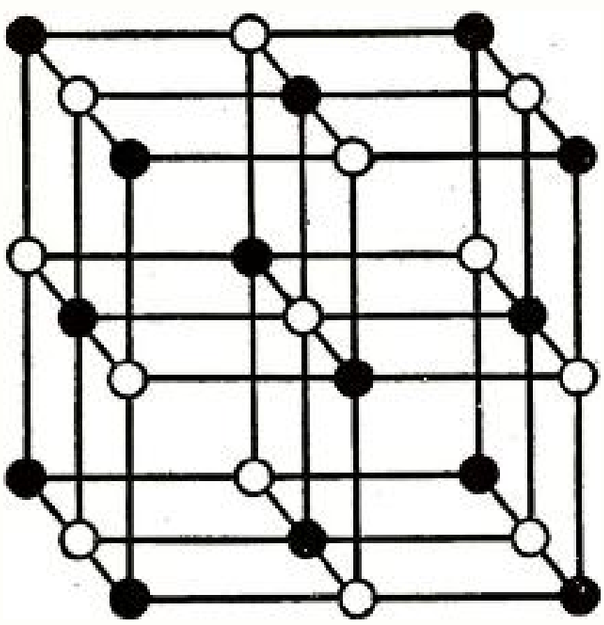
PICK up a brick. How heavy, how solid and substantial it seems. Look at the heavens above you—at the distant moon, at the still more distant stars. How empty seems the sky for all the myriad twinkling suns and planets in that vast black canopy. Yet the brick in your hand is relatively no more solid than the immense expanse above you. If you could but magnify it to the dimensions of the solar system the atoms of the brick would be millions of miles apart.

Any solid, a chair, a table, the flesh of your body is emptier than it seems—an aggregation of countless atoms, but atoms separated from one another by distances that are comparatively as awe-inspiring as those that greet the astronomer's eye. Hundreds of comets have swept through space without colliding with planets or suns, and a comet far smaller than an atom might theoretically swim through a seemingly dense brick just as readily.

Medieval churchmen were given to

speculating how many angels could stand on the point of a needle. The modern conception of a solid's spaciousness of structure is not to be classed with similar idle vaporings. It would take a million million million atoms to fill the head of a pin, but the positions of atoms in many substances are as definitely known as those of the blocks of stone and of the steel beams and girders that compose the Woolworth Building. Physicists and chemists used to *guess* at the internal arrangement of atoms in an element or its compounds. Now they *know* how they are grouped because they have actually seen the groupings.

Two brilliant, painstaking, thorough scientists discovered a method of making the infinitely small atom tell the story of the part that it plays in chemical architecture. They have worked in such harmony that the one can hardly be mentioned alone. This follows not only because they are father and son, but because they have experimented together, reasoned together and written together about their investigations. Bragg is their name. Professor Sir William H. Bragg is the father; Professor W. L. Bragg is the son. Talk to the son about atoms and he will refer you to his father; talk about them to Sir William, and he will refer you to his son. When the Nobel prize for physics was awarded a few years ago it was divided between them. There are two Braggs in the flesh, but scientists generally speak of the work of "Bragg" when they discuss atoms and their architectural arrangement in matter.



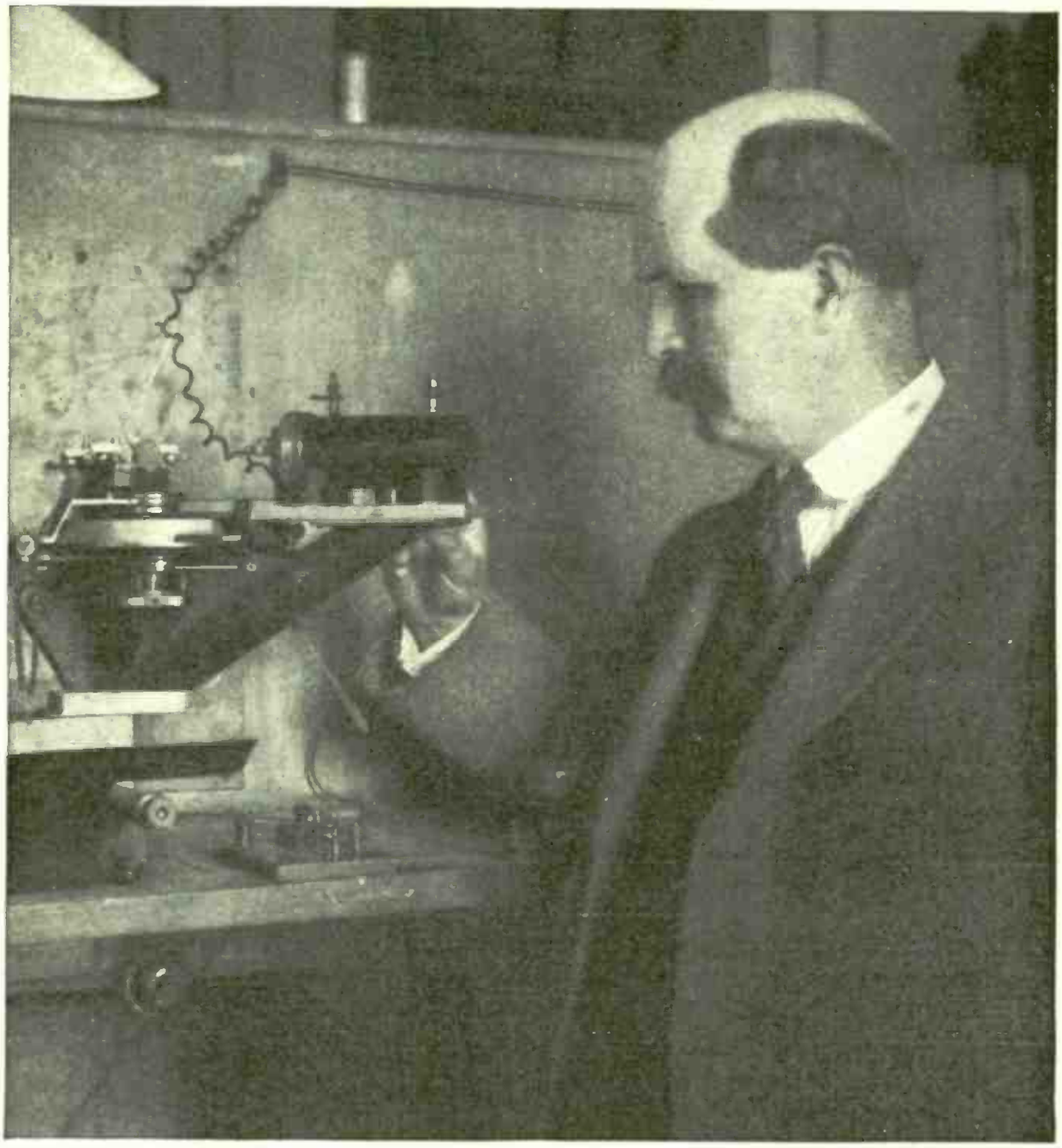
THE SKELETON OF COMMON SALT

The black spots represent atoms of sodium and the white spots atoms of chlorine, as they are arranged inside a crystal of sodium chloride which is the chemist's name for common salt.

These extraordinary Braggs, like generations of scientists that preceded them, were struck by the amazing and obvious uniformity of crystal structure. Always crystals of the same composition are alike so far as the angles formed by corresponding faces are concerned. Diamonds may differ in size, but not in these angles. And so sugar, common table salt, and hundreds of other crystals, invariably present the same angular uniformity. It was evident long ago that a crystal must be built somewhat like a skyscraper and that some unit-pattern or floor-plan must be repeated over and over again.

Now it happens that most of the solids that we know are crystalline in nature. Hence the man who can make a crystal reveal the secret of its structure so that we can draw a plan of it as we can of a house, must go far toward answering such age-old questions: What is matter? Why is iron iron and gold gold? Why is an element what it is and not something else? What holds a lump of matter together? Why is it different from a liquid or a gas? Why doesn't it fly apart?

While it was apparent that a crystal must be built according to some definite unit-pattern or floor-plan, there were long only shrewd guesses as to what the unit-pattern or floor-plan must be. The trouble was that no microscope could possibly be invented which would magnify the infinitely small atoms and show



From a photograph by Hoppé, London

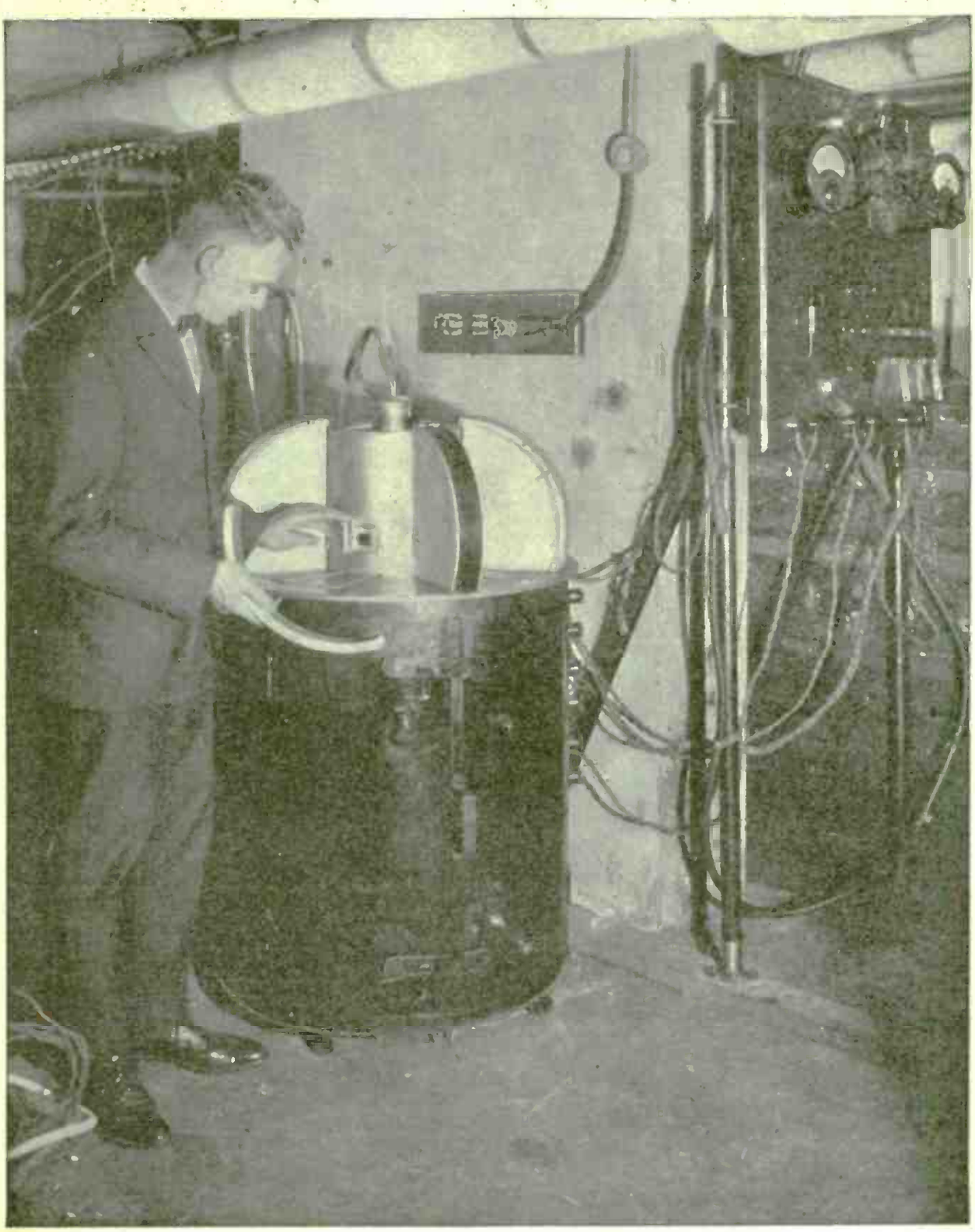
AN EXPLORER IN THE REALMS OF THE ATOM

Sir William H. Bragg (together with his son, Prof. W. L. Bragg) has supplied most of our knowledge of how the atoms inside of crystals are put together. The instrument shown above is the identical X-ray spectrometer with which were made many of Sir William's explorations into the realm of these tiniest of dimensions.

us exactly how they are grouped. Lenses are themselves composed of atoms. To see atoms in a crystal the lenses themselves would have to become granular or atomic.

In 1912, Laue, a Swiss physicist, made this startling suggestion: Turn the X rays on crystals. Two discoveries might be made. In the first place, the true nature of X rays might be revealed, about which there was no unanimity of opinion at that time. In the second place the atomic structure of a given crystal might be disclosed.

To understand why Laue made this suggestion and carried it out himself we must grasp the nature of light and of the many other waves that undulate



General Electric

A NOVEL DEVICE FOR STUDYING ATOMS BY X-RAY PHOTOGRAPHY

An American student of crystals, Dr. A. W. Hull of Schenectady, and the apparatus developed by him for examining how the atoms are arranged inside the fragments of a crystalline powder. Strips of photographic film inside the quarter-round boxes on the top of the apparatus permit the making of four X-ray crystal photographs simultaneously.

through the ether. That energy is transmitted in waves every radio amateur knows. His waves are like light waves, only longer—so long, in fact, that his eyes cannot see them.

When we say that we "see" a light we mean that our eyes have been affected by waves of a certain size and frequency. A musical note may be deep or shrill; it has what we call a certain "pitch." Light has its pitches, too; only we call them "colors" in the vernacular, while the scientist speaks of wavelengths, just as amateurs do in radio parlance. A radio set can be tuned to receive music and speech on a certain wavelength band. When we look at the world around us through a piece of red glass we have tuned in to red; we have excluded all other wavelengths of light. Like any radio set the eye has its limitations so far as this tuning process is concerned. Our visible wavelength band extends from deep red to deep violet. The red waves are the longest which we can see or to which we can tune in, and the violet the shortest. An ordinary camera is a far better receiver of light waves than our eyes. It can photograph the invisible. It can "see" or be attuned to waves that are much shorter than those that lie beyond the violet end of the spectrum—waves that are called ultra-violet.

The only difference between radio waves and light waves is one of wavelength. A radio wave may measure twenty miles from crest to crest when it is sent half around the world by some powerful trans-oceanic station. Visible light waves have an average wavelength of only one fifty-thousandth of an inch. Still shorter are the X rays.

It follows that an ordinary light wave is huge compared with an X-ray wave. That was one reason why scientists were at first not sure whether or not X rays should be classed as light waves. For example, they could not reflect X rays Now we know the reason. Mirrors reflect light because they are very smooth surfaces. A rough surface scarcely reflects light. The smoothest surface that human skill could produce is rougher than sandpaper to the X rays. For this reason X rays cannot be reflected by any smooth man-made surface. But the atoms of crystals (not the actual surfaces) are so much finer than X rays that they can act as reflectors. Knowing this, Laue proposed that they be used as little mirrors. When a crystal of mica was broken and subjected to test a beautiful X-ray reflection was obtained. X rays were thus proved to be a finer kind of light.

At this point the Braggs appeared. Laue had a rather cumbrous apparatus which, however successful it was in enabling him to prove that X rays are light waves, was not simple or effective enough to penetrate deep into the heart of a crystal. That there was a regular arrangement of the atoms was clear, but the exact structure was not readily determined. The Braggs devised a simple instrument which they called an "X-ray spectrometer," and with it they tore aside the veil of mystery and conjecture in which the atoms had so long been shrouded.

They knew that they could never hope to see an atom; there was no way of magnifying it the necessary one hundred million times. But they could make it reflect X rays, and they could note the points of reflection and thus locate the atoms.

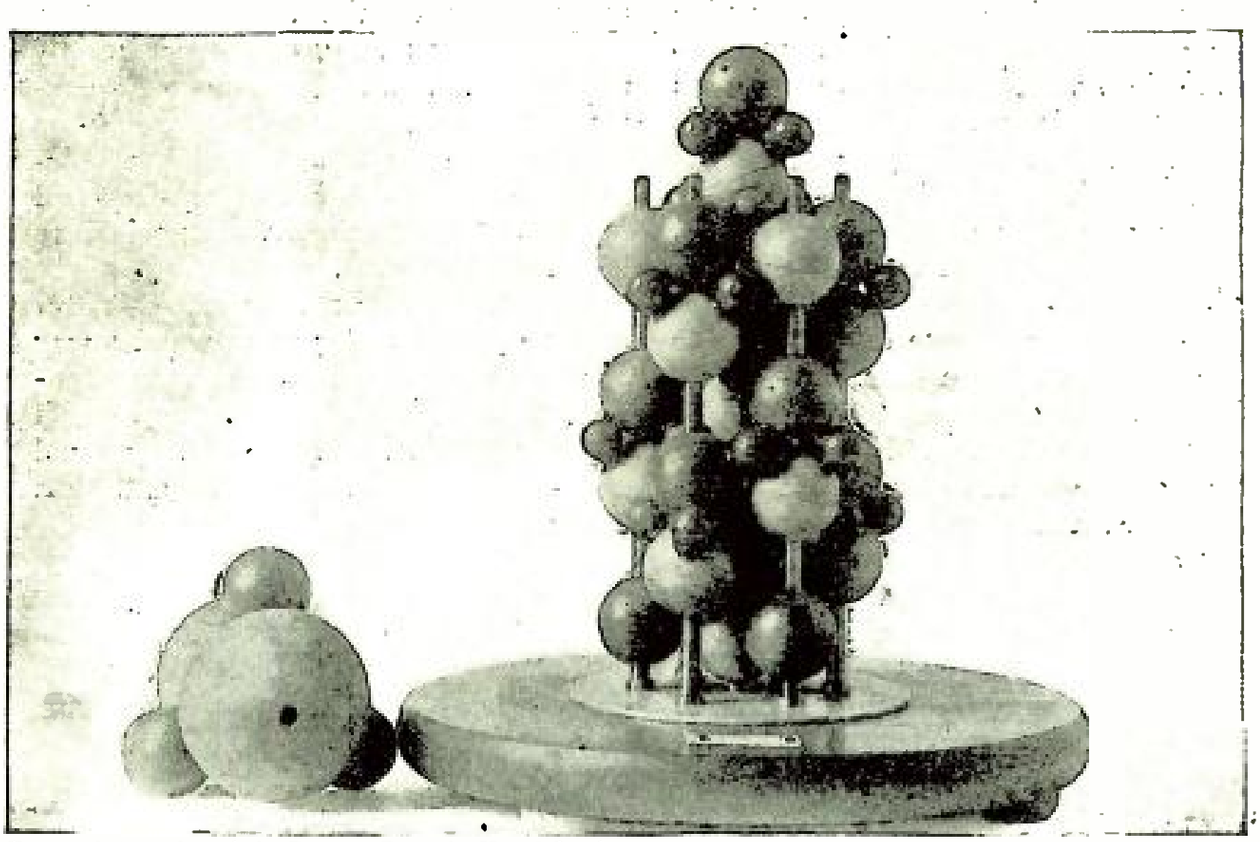
This can be made still clearer if we imagine that we had to study water waves by the action of corks thrown upon the ocean. The corks have no effect whatever on the large waves (the equivalent of ordinary light waves). But if the surface of the water is disturbed only by the smallest perceptible ripples (the equivalent of X rays), they have a very marked effect. As the fine ripples strike a cork they are broken; there are ripple reflections and scatterings. If the corks were invisible a clear-headed, straight-thinking scientist

could form a very good picture of their size and spacing simply by watching the way in which the ripples were broken.

So the Braggs turn the X rays on a crystal and note with their spectrometer the manner in which they are scattered by the invisible atoms. A photograph is taken. To one who knows nothing about light, X rays, wave motion, and atoms, it is meaningless—a blur of lines. To the Braggs and to scientists who have repeated their experiments it is as clear as the blueprint of a complicated machine is to an engineer.

What is it that is so startling? You have seen a field of corn planted in regular rows. Look down one row and you see an almost endless line of stalks. Looks down another, and you see a second line. In whichever direction you look there is this regular, precise array. So the Braggs, in a sense, look down the avenues of a crystal from end to end. They do more than look; they actually measure the intervals between the atoms. Mind you, these atoms are so small that billions of them are clustered in the smallest visible speck of dust. Yet these two indefatigable men have measured the spacings with such accuracy that the error cannot be more than one in one thousand.

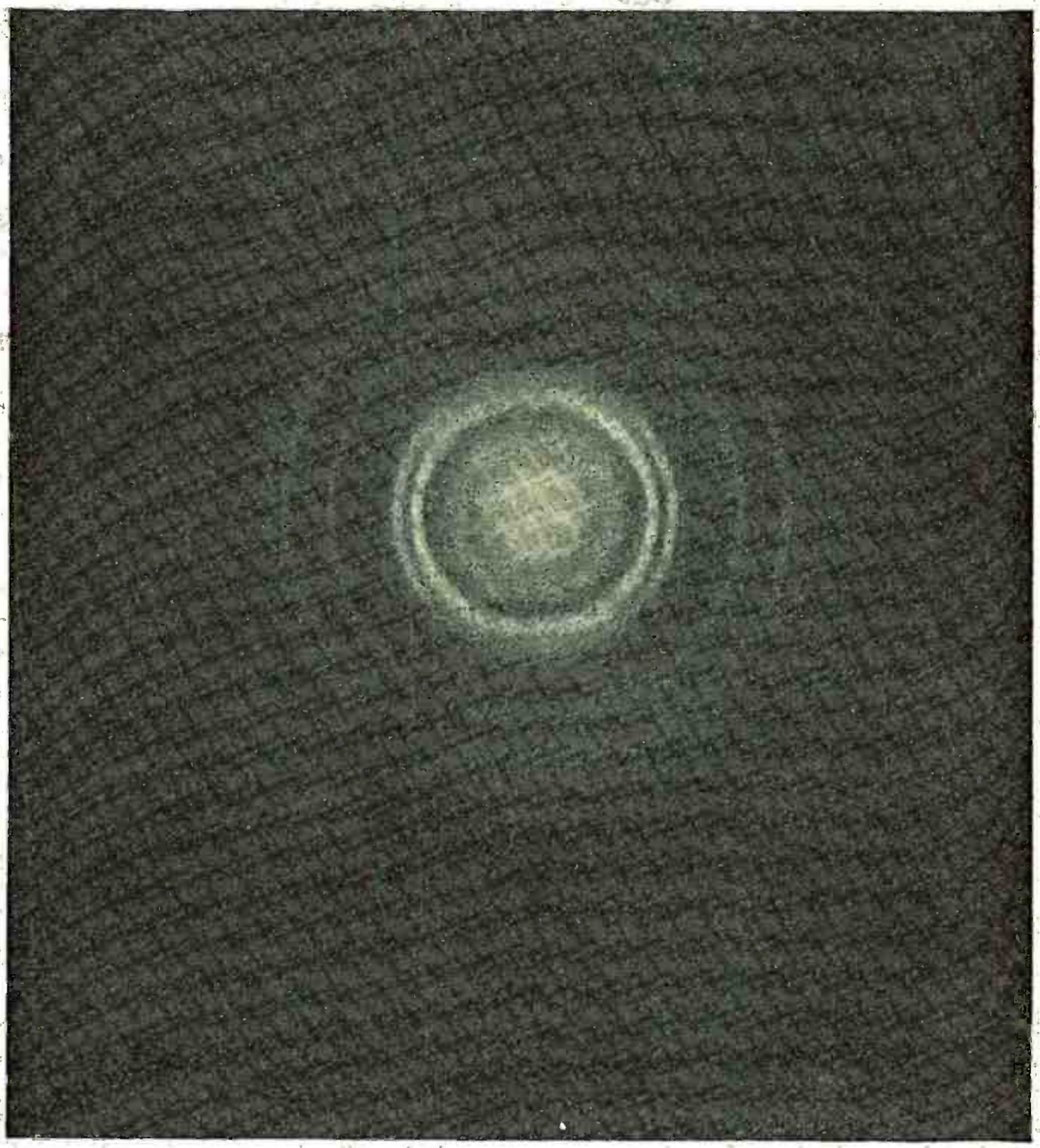
The stalks in a corn field have been regularly planted in two dimensions only—according to the length and breadth of the field. Atoms in a crystal are located in avenues that spread out in three directions. This makes it possible for them to distribute themselves in many very regular ways, but nature seems to content herself with not more than four or five.



From a photograph made for POPULAR RADIO by Hoppé, London

A STILL LIFE STUDY OF ALUMINUM AND OXYGEN ATOMS

How the atoms of aluminum (represented by the large balls at the left) and of oxygen (the small balls) are arranged inside the crystal of a gem ruby. This, like the diamond model reproduced on the first page of this article, is from the collection of crystal models prepared by Sir William H. Bragg.



AN X-RAY PHOTOGRAPH OF A CRYSTAL

This ring pattern was produced by the bending of X-rays on passing through a thin sheet of aluminum. From the relative diameters of the different rings it is possible to calculate the arrangement and distance of separation of the atoms in the tiny invisible crystals of aluminum.

Take the diamond, for example. Each atom has four neighbors regularly disposed about it. A group is formed which has the shape of a tetrahedron. Why is a diamond hard? Because of this very tetrahedron arrangement of its atoms. A diamond is pure carbon. So is graphite. Why is graphite black and greasy to the touch and the diamond brilliantly transparent and hard? Graphite atoms are arranged in hexagonal columns which split with the greatest ease into thin leaves that slide easily on one another. It is this slipperiness of the leaves that makes graphite such a good lubricant. As for the difference between the diamond and graphite in color and brilliancy—that is due to the

internal structure of the atom itself.

Potassium chloride is a familiar chemical compound. As its name indicates, it is composed of potassium and chlorine. The Braggs have shown that in a crystal of potassium chloride each potassium atom is surrounded by six chlorine atoms and each chlorine atom by six potassium atoms. In the ruby the unit consists of a pair of aluminum atoms surrounded symmetrically by three oxygen atoms.

Napthalene is familiar to us in the form of moth balls. Why is it so light? Because the internal structure of the napthalene crystal is so lace-like, so empty.

This study of crystals is not easy. The atoms are arranged in planes behind one another, and the Braggs must distinguish the reflections from one plane from those of others. This is somewhat like trying to pick out the features of a single man who has been photographed with half a dozen other men to make a composite portrait.

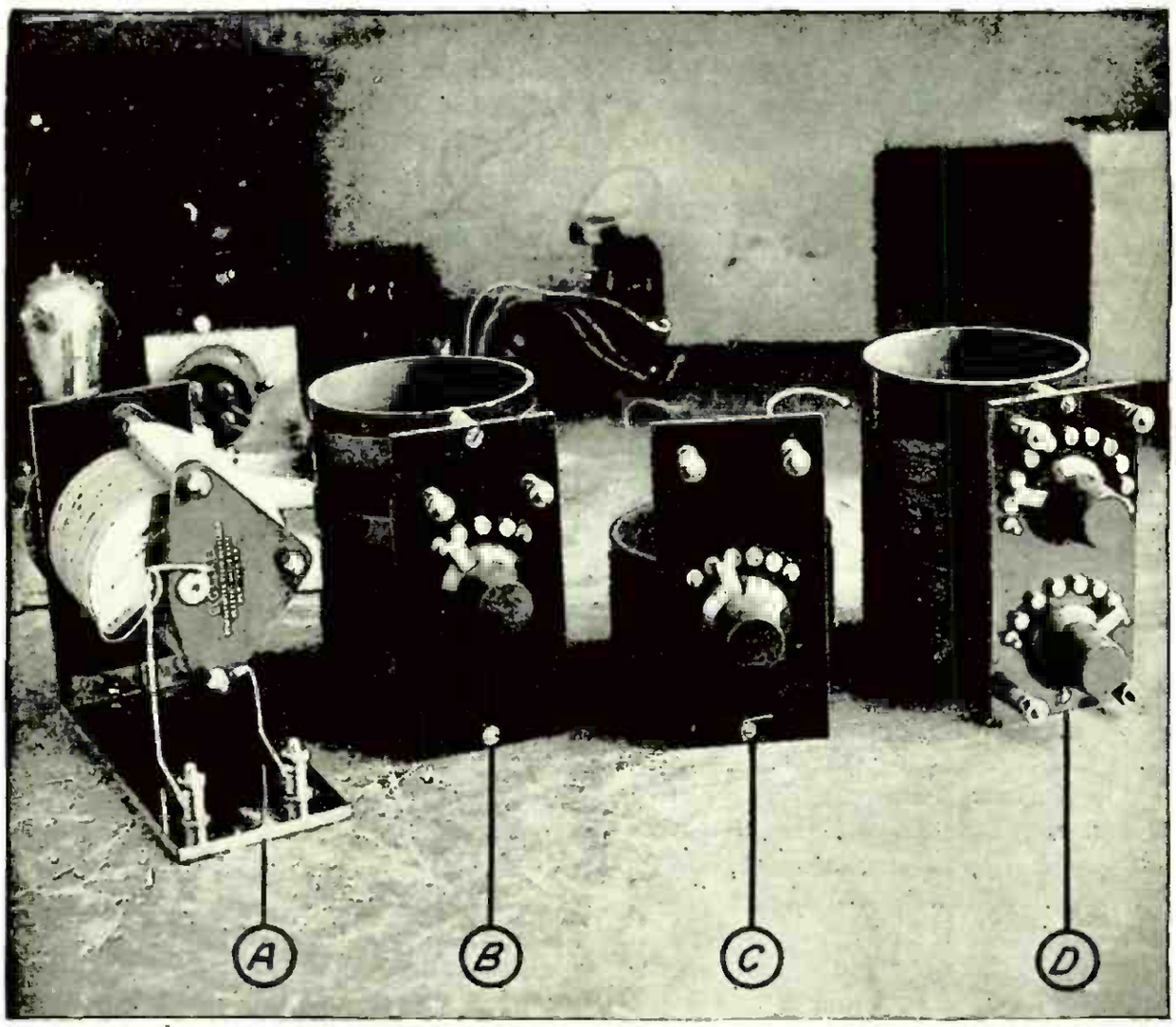
So the Braggs consider crystal after crystal. They plot the location of the atoms. They construct models of the different atomic arrangements that they have studied, and each model is an accurate plan of the crystal whose structure it represents. The crystal proves to be a kind of lattice. Each lattice is known by a special name. There is the simple "cube lattice," the "centered cube lattice," the "face-centered cube lattice," and a few more. The different lattices constitute what may be regarded as styles of crystal architecture. They are identified by the skillful Braggs because nature never displays bad taste in mixing her architectural styles. She may superpose two face-centered lattices to form the characteristic tetrahedron of the diamond, but the tetrahedon structure is always recognizable.

The lattice arrangement of the atoms is not real, like the girders of a building or the wires of a suspension bridge. Only the atoms are real. Probably they are round—bullet-like. What holds them in place? Forces of which we know only too little as yet, but which are the equivalents of very substantial ties and rods. No doubt they are electrical in character. Theoretically, it is possible to hold steel girders together by electromagnetic attraction. In some such manner are the atoms of a crystal held together.

Twenty years ago the atom was "the hypothetical smallest subdivision of matter" as the text-books phrased it. It has ceased to be either hypothetical or the smallest possible particle of matter. It is as real as a rock. It has a definite size, a definite shape, a definite weight and a definite place in a solid body. The Braggs have told us so much about it that it is almost possible to explain why iron is iron and gold is gold. The properties of a substance prove to be due to the peculiar way in which atoms are architecturally grouped. So, the strength and elasticity of metals, their power of conducting electricity and heat can be explained in terms of their structure as it is revealed by the X rays. The Braggs are not concerned with practical or engineering applications of their discoveries, but it is safe to predict that the day is at hand when the hired chemists and physicists of steel works will find the X rays as useful to them in producing a desired alloy as the crucible or the cupola.

How to Increase the Selectivity of Your Receiver

In the next number of POPULAR RADIO*—for December—one of the foremost radio experts in the world, John V. L. Hogan, will tell the amateur and the novice how to reduce interference by sharpening his tuning.*



The following panel-mounted units will be found useful additions to any radio experimenter's equipment; A, .001 mfd. variable condenser, B, variable coupling unit, C, short wave tapped tuning coil, and D, a long wave inductance tapped in tens and units.

Handy Units for the Radio Laboratory

By M. B. SLEEPER

IN laying out a radio set the wise experimenter does not proceed with the construction of a finished outfit—unless he is working from drawings—without first laying out a test circuit on the laboratory bench. Under such circumstances it is not always practical to build complete tuning units, and for that very reason the testing instruments shown in the accompanying photograph are extremely convenient.

At the left is a 43-plate condenser mounted on a vertical panel, to which, in turn, is bolted a base panel secured in position by short lengths of angle brass. Binding posts are arranged in the rear for connections to the test circuit. Three experimental inductances also are shown.

The type shown at the left is divided into three sections that are separated considerably in order to reduce the coupling between them. This coil was employed in tests for a wide wavelength range. The center coil was constructed for a short-wave receiver.

The unit at the right was also made for a long-wave set in which the primary coil was adjusted by means of units and tens switches.

Although the coils were originally built for particular sets, they have come in handy for all kinds of work. Now when an experimental circuit is to be set up it is seldom necessary to wind additional coils. This type of mounting is much easier to handle than plain round coils, the tubes of which must be adjusted by means of loose clips. Moreover, for coupling, they can be moved together or separated.

When fairly tight coupling is required one coil can be set directly on top of the other, either above or below, according to the end of the coil to which coupling is required.

A Home-Made Variometer

—*That Can Be Built at a Cost of 30 Cents*

By DAVID LAY

THE tuning instrument shown in Figure 1 can be made at home with a little care and patience. Inserted directly in a standard aerial, it will cover a range of from 200-600 meters without the use of a condenser.

A disc five inches in diameter is cut out of a piece of "fiber" or cardboard, and the periphery or outer edge is divided into any odd number of parts. Twenty-one divisions are shown in the illustration, but seven, eleven, fifteen, or any other uneven number will serve equally well. Lines should be drawn radially outwards from the center to the marked points, these being afterwards cut out so as to form slots in which the wire is wound.

Before making the slots, however, an inner circle, three inches in diameter, is first drawn, and then cut out to form the "rotor" part of the tuner, the outer annulus or ring forming the stator or stationary part.

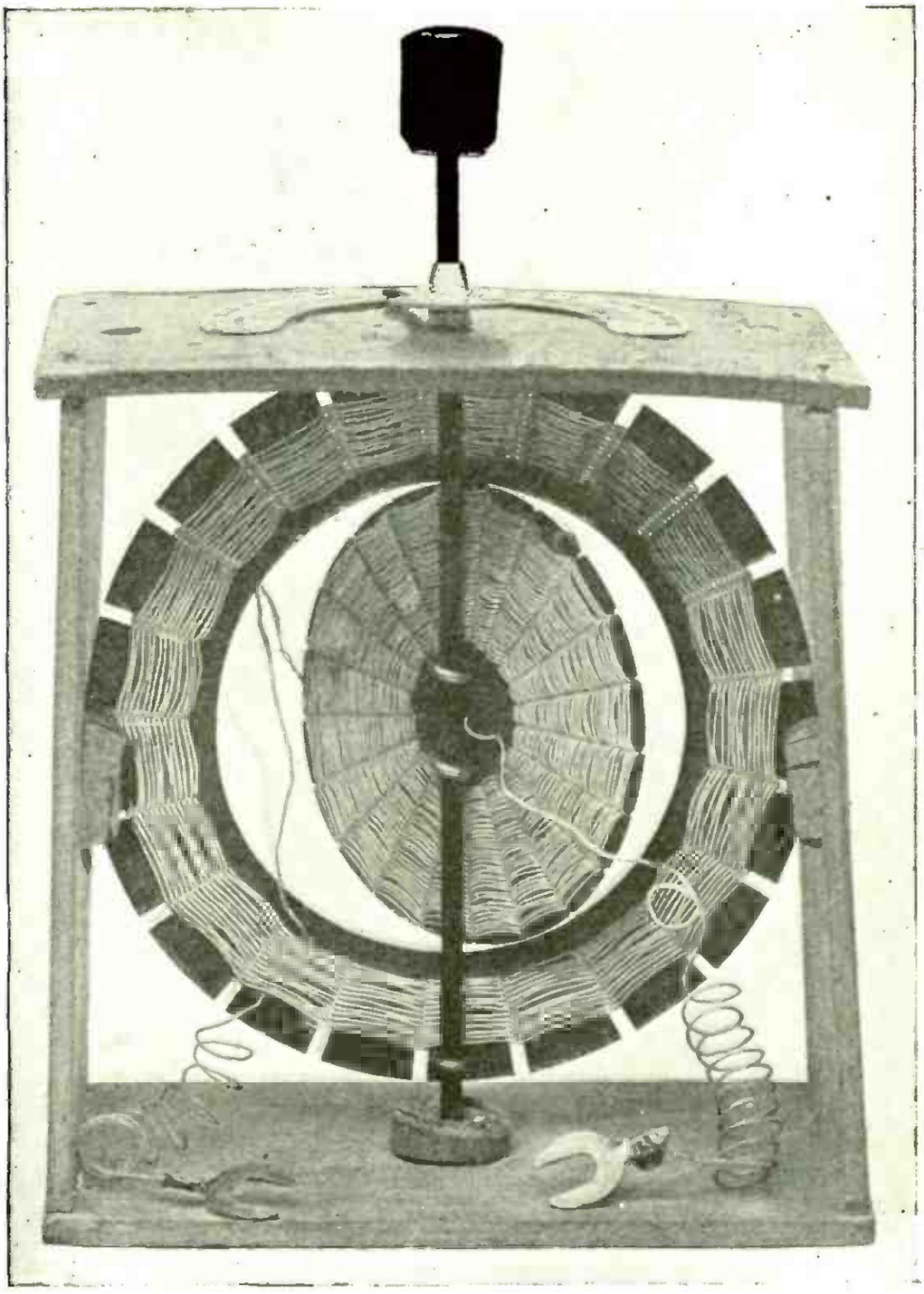
Both parts are then cut out with a sharp knife along the radial lines, the slots in the stator being made somewhat wider than those in the rotor. A core one inch in diameter is left at the center of the rotor, as shown.

The outer ring is wound with 24 turns of No. 28 D.C.C. wire, and 60 turns of the same wire are coiled around the inner disc in the well-known basket weave fashion. The inside end of the stator winding is joined to the outside end of the rotor winding, so that the coils run in sequence, a sufficient length of wire being left to allow of relative movement between the two parts. It is also advisable, when cutting out the inner disc, to take off a shaving of about ⅛ inch. This will give a sufficient clearance to allow the inner disc to be rotated.

The two ends for connection to the antenna and ground terminals of the set are taken from the center of the inner disc and from the outside of the ring respectively, and are preferably fitted with "spade" terminals, as shown. The remaining two terminals of the stator and rotor are connected together.

Small brass eyelets are inserted at the top and bottom of the stator to form bearings for the turning spindle, which is fastened in turn to the center disc or rotor by two center eyelets, as shown. The two central eyelets are somewhat smaller than the others, in order to grip the spindle firmly; or a simple lashing of wire may be found more convenient.

The variometer may be mounted in a casing built up from the parts of an old cigar box, as shown. Two pieces of cork are tacked at each side to se-



THE SPIDERWEB VARIOMETER

Although this instrument was made by an amateur, out of odds and ends of materials, it proved to be a really efficient variometer. It may be used to tune the antenna circuit or the plate circuit of a regenerative receiver. The frame was made out of the wood from an old cigar box.

cure the outer ringcoil and prevent it from turning, whilst a third piece of cork, tacked to the bottom, serves as a friction bearing for the spindle. Finally a turning knob, pointer, and scale are added.

The instrument gives remarkably good results with an ordinary crystal set, and is sufficiently elastic to pick up amateur telephony, broadcasting, and commercial ships traffic.

It will also serve as a variable inductance for tuning the plate circuit of a regenerative vacuum-tube receiver.

From a photograph made for POPULAR RADIO

A "TALKING" FIXED CONDENSER

The author listens to music which is reproduced by a poor condenser in which the plates are so loose that they vibrate in unison with the currents that flow through them.

THE TRUTH ABOUT FIXED CONDENSERS

By RAYMOND FRANCIS YATES, R.E.

IT has been said that "upon trifles the greatest gifts of the Gods often hang." So it is with long distance radio—upon trifles the best DX records often hang.

Not the least among these trifles is the little fixed condenser, which is so sadly ignored and neglected by those in whom the temperature of the DX fever runs highest.

Too many fans make the mistake of believing that a fixed condenser should simply consist of a few sheets of tinfoil, separated by greased paper and stored away in a cigarette box filled with wax. But the wise radio man has grown to respect the little fixed condenser and consequently he attaches the greatest importance to it. But what can possibly be wrong with a fixed condenser? No matter how crudely it is made it will "condense." What more is to be expected? We shall see.

A moment's reflection on the history of the condenser will be interesting. It was on October 11, 1745, that old Dean von Kleist, of the Cathedral of Camin, Germany, made an experiment. It was an important experiment, but von Kleist did not realize it. That he was amazed and mystified, however,

is proven by his letter to Dr. Leberkuhn which follows:

"When a nail or a piece of brass wire is put into a small apothecaries' vial and electrified, remarkable effects follow; but the vial must be *very dry and warm.* I commonly rub it over beforehand with a finger on which I put some powdered chalk. If a little mercury or a few drops of spirits of wine can be put into it the experiment succeeds the better. As soon as this vial and nail are removed fro ı the electrifying glass, or the prime conductor to which it hath been exposed is taken away, it throws out a pencil of flame so long that with this burning machine in my hand I have taken about sixty steps in walking about my room; when it is electrified strongly I can take it into another room, and then fire spirits of wine with it. If while it is electrifying I put my finger or a piece of gold which I hold in my hand, to the nail, I receive a shock which stuns my arms and shoulders."

This was the birth of the Leyden jar. In January, 1746, Peter Van Musschembroeck made the same discovery in the University of Leyden, hence the term "Leyden jar."

The Abbé Mollet in France later played with Leyden jars or condensers, and killed small birds with a discharge in order to entertain the ladies of the French court. Another experimenter tried to emulate him but did not succeed until he struck upon the happy thought of grouping the jars together and in this way obtaining a more powerful discharge.

Like the storage battery, a condenser is called upon to hold electricity. This is a crude comparison, however, as the storage battery does not actually hold electricity but keeps it stored in the form of chemical energy which is released as electrical energy. There is only one true container of electricity; only one device that can be "filled" with it. It is the condenser. Each condenser has a certain capacity to hold electricity. We measure liquids in quarts and the capacity of condensers in microfarads. The term "farad" is taken from the first five letters of the name Faraday, in honor of Michael Faraday. Now, a condenser with a capacity of one farad would be as big as a house, and so it is necessary to measure the capacity of condensers in microfarads. (A microfarad is one-millionth of a farad). Even a condenser of one microfarad capacity is too large for general use in radio measurements. Fixed condensers used in radio-frequency circuits usually extend from .0001 microfarad to .0025 microfarad.

We have probably been told many times that a condenser is made up of two conducting surfaces separated by a dielectric. The word dielectric is one of those high-sounding words used by the electrical expert to denote an electrically non-conducting medium. Therefore, we find dielectrics in condensers consist of paper, glass, oil, air or mica. The two last named substances are by all means the best as we shall later discover.

The capacity of a container depends entirely upon its dimensions. This is partly true of condensers—the larger their surfaces and the greater the number of plates, the higher the capacity will be. There is also two other factors which help to determine the capacity of a condenser. These are the thickness of the dielectric and also what is known as the "dielectric constant." The closer the conducting plates of a condenser, the higher the capacity will be. This means that we must place between them a dielectric as thin as possible and yet with a high insulating strength. A poor dielectric, however, no matter how thin it may be, will not give us an efficient, high-capacity condenser. These requirements make mica the ideal dielectric for fixed condensers, and tinfoil the universally used conducting medium. Mica can be split into sheets with a thickness of only a few thousandths of an inch. This makes it possible to build up a condenser of high electrical capacity, of high insulation strength and small dimensions.

When a condenser is charged (filled), static electrical pressure is stored between the metal sheets. In the case of radio-frequency currents this process

From a photograph made for POPULAR RADIO

THE "SQUEEZE" METHOD OF TUNING

This ingenious fan tunes his set by means of a cheap paper condenser which is connected in series with his single-circuit set. When he wants to listen to one station he holds it loosely, but when he wants to hear another station, he pinches it between his thumb and forefinger. This changes the capacity of the condenser and tunes either station in or out.

takes place with lightning-like rapidity. Like a quart measure, when the condenser becomes filled or charged it runs over and discharges. With a liquid stream of given force, it would require longer to fill a two-quart measure than it would a one-quart measure, and likewise with a given electrical pressure it would take longer to fill a 1-microfarad condenser than it would a ½-microfarad condenser. The same holds true in the case of discharge. One would take twice as long to discharge as the other.

The character of a condenser discharge is oscillatory in nature; that is, it dashes back and forth alternately and dies out. If we place one end of a steel strip in a vice, pull it back and release it it will vibrate, and the amplitude of these vibrations will gradually diminish until the strip is at rest. A condenser discharges in similar fashion. The released currents dash back and forth from one side to the other, charging and discharging and recharging and redischarging the device until it is "empty." The time occupied by the twinkling of an eye is long compared with the time required for the discharging of a small condenser. Small condensers may be charged and discharged millions of times in a single second, larger ones, of course, require more time.

What has all of this to do with the use of fixed condensers in receiving sets? This is the interesting question that we will now consider.

When a condenser is being charged the negative and positive impulses of the charging current exert an actual physical pressure upon the plates of the condenser. This pressure is due to the electrical repulsion and attraction which

tends to tear the conducting medium away from the surface of the dielectric. This is *not* theoretical. It is a known and observed fact which every radio fan may verify for himself if he wishes. The phenomenon is not noticeable when radio-frequency currents pass through a condenser, as the frequency of these currents is so high that the inertia of the tinfoil plates will not allow them to respond to it. In the case of audio-frequency currents, and condensers in audio-frequency circuits, the result is different. These currents are able to cause the plates of a condenser to vibrate, and for this reason condensers that do not have a permanent capacity and that are not built to withstand this action are a constant source of trouble. They develop circuit noises and produce howling that is often laid to other causes. This is especially true, of course, in connection with vacuum-tube circuits. When the plates of a condenser vibrate they affect the capacity of the whole circuit, as this movement causes the capacity of the condenser to fluctuate within comparatively wide limits although the plates may move only a microscopic distance. These small changes are magnified by the vacuum tubes, and many a hectic noisy set can be brought into the pink of condition by using better condensers.

There are a number of experiments that can be made to demonstrate this point. Under certain conditions the writer had heard speech from a broadcasting station reproduced with an ordinary paper condenser. The reproduction was rather faint, to be sure, but nevertheless it was audible. The plates vibrated in exact sympathy with the audio-frequency currents, and if higher amplification had been used, the reproduction could have been heard at a considerable distance from the condenser.

We have all heard of the "condenser microphone" which is used in many of the modern broadcasting stations. Here we have two plates separated by air. The device is really a simple condenser, and the sound waves impinge upon one of the plates causing it to vibrate. This vibration is sufficient to cause variations in the capacity of the device, and in this way the sound is impressed upon the electrical circuit.

If a carelessly constructed paper condenser is placed in a 500-cycle circuit the thing will emit a humming noise that will exactly correspond to this frequency. The loudness will depend upon the strength of the current.

While the writer was editing the radio columns of a New York newspaper one of his readers wrote in and told how he was using a so-called "fixed condenser" to tune with. When the condenser was left undisturbed he could hear WEAF. When he pressed the condenser tightly between his fingers he was able to change the capacity sufficiently to hear WJZ. Being an ingenious sort of a chap, he connected the condenser to a long wire where it was in reach of his easy-chair. Then he sat there and listened to either of the two stations at will; he pinched the condenser or he let it loose!

From our discourse here it is evident that we should use only such condensers as are of permanent capacity.

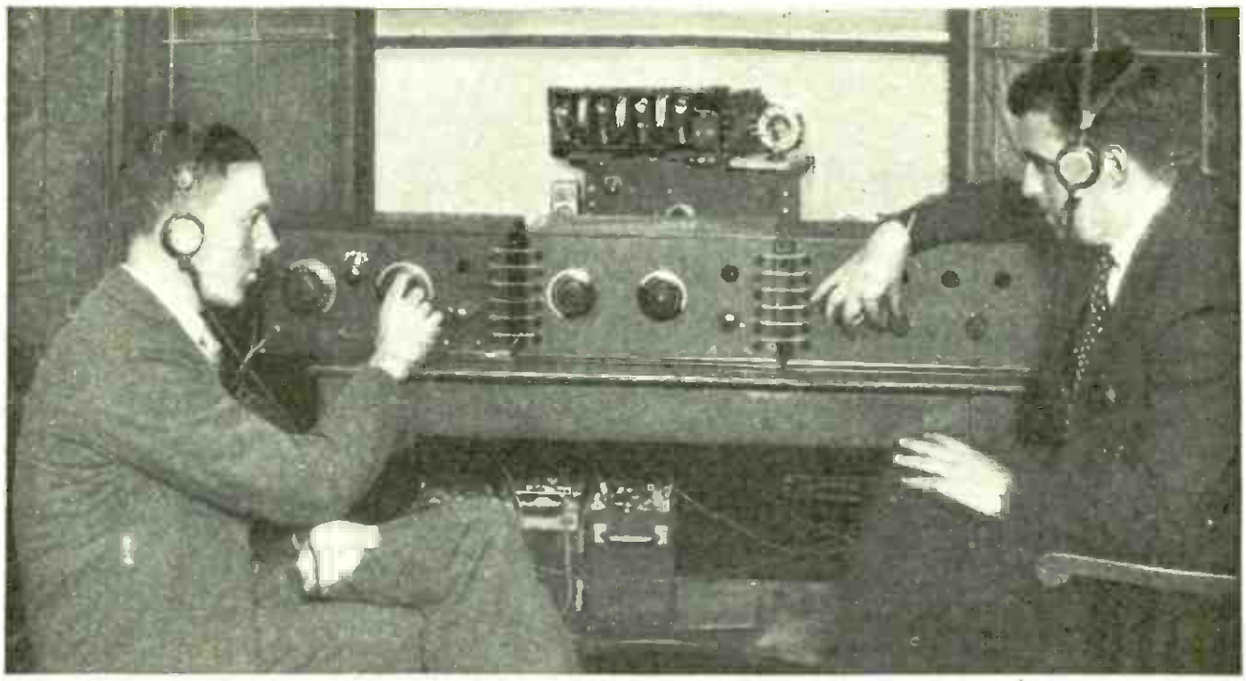
Condensers, like batteries, may be connected together in series or in parallel if we wish to arrive at different capacities. If we had three condensers of .001 mfd. capacity and wished to use them as a single condenser of .003 mfd. capacity, we would simply connect them in parallel. We must always remember then that we add the capacities of the condensers when we connect them in parallel. The following simple formula expresses this:

Capacity .001 + .001 + .001 = .003 mfd.

If the condensers are connected in series the formula becomes:

$$1/c = \frac{1}{.001} + \frac{1}{.001} + \frac{1}{.001}$$

$$1/c = \frac{3}{.001} \text{ or } 3C = .001 \text{ or } C = .00033 \text{ mfd.}$$



From a photograph made for POPULAR RADIO

THE TWO DESIGNERS DEMONSTRATE THEIR EXPERIMENTAL SET

The new receiver consists of three parts in separate cabinets. The tuner at the left is being operated by Mr. Haynes, the builder of the set; the oscillator is in the center and the amplifier at the right is being adjusted by Mr. Cockaday.

HOW TO BUILD THE NEW REGENERATIVE

Super-heterodyne Receiver

PART I

Here is a new and remarkable type of super-heterodyne which is more sensitive, more selective and more simple to tune than any other kind of multi-tube receiver yet developed. The costs of the parts approximate $100, and anyone who can build and operate an ordinary regenerative set can build and operate this one. While the principle of the super-heterodyne receiver is patented, this set is not on the market, and the following description of it is published for research and experimental purposes only.

By LAURENCE M. COCKADAY, R. E.

THE super-heterodyne receiver is the most *sensitive* receiver yet developed. If it is properly designed it is also the most *selective*. Its one drawback, heretofore, has been its *complexity*—complexity of construction and operation. This and the fact that the amateur and broadcast listener cannot afford such a costly piece of apparatus as it has been up to this time has kept the super-heterodyne from gaining the popularity that it justly should have received.

However, the super-heterodyne (or any other type of set) must have the following qualities before it can ever be acclaimed by the multitude as a really popular circuit.

1. *It must be selective.*
2. *It must be sensitive.*
3. *It must be easy to construct.*
4. *It must be inexpensive.*
5. *It must be easy to operate.*
6. *It must be economical from an "A" battery standpoint.*

Although the super-heterodyne meets

the first two points better than any other known type, it has always been termed the "Rolls-Royce" of radio. But, beside being the most selective and sensitive it was also complicated, expensive, and could not be built by any but the most experienced engineers. It has always imposed a heavy strain on the "A" battery on account of the large number of tubes necessary to take advantage of its extraordinary amplifying powers. These factors have kept it, up to the present time, as the "lord of all radio receivers," but unfortunately they have also limited its use to a chosen few who have had the price, the ability and the patience to master its complications.

The authors of this article have long realized the possibilities of this wonderful circuit and they have, during the last six months, devoted much time to research for the purpose of developing a simplified super-heterodyne that is worthy of the name.

Of course, with the new low-filament-consumption vacuum tube such as the C-301-A and the UV-201-A, the set can now be made efficient as far as "A" battery loading is concerned.

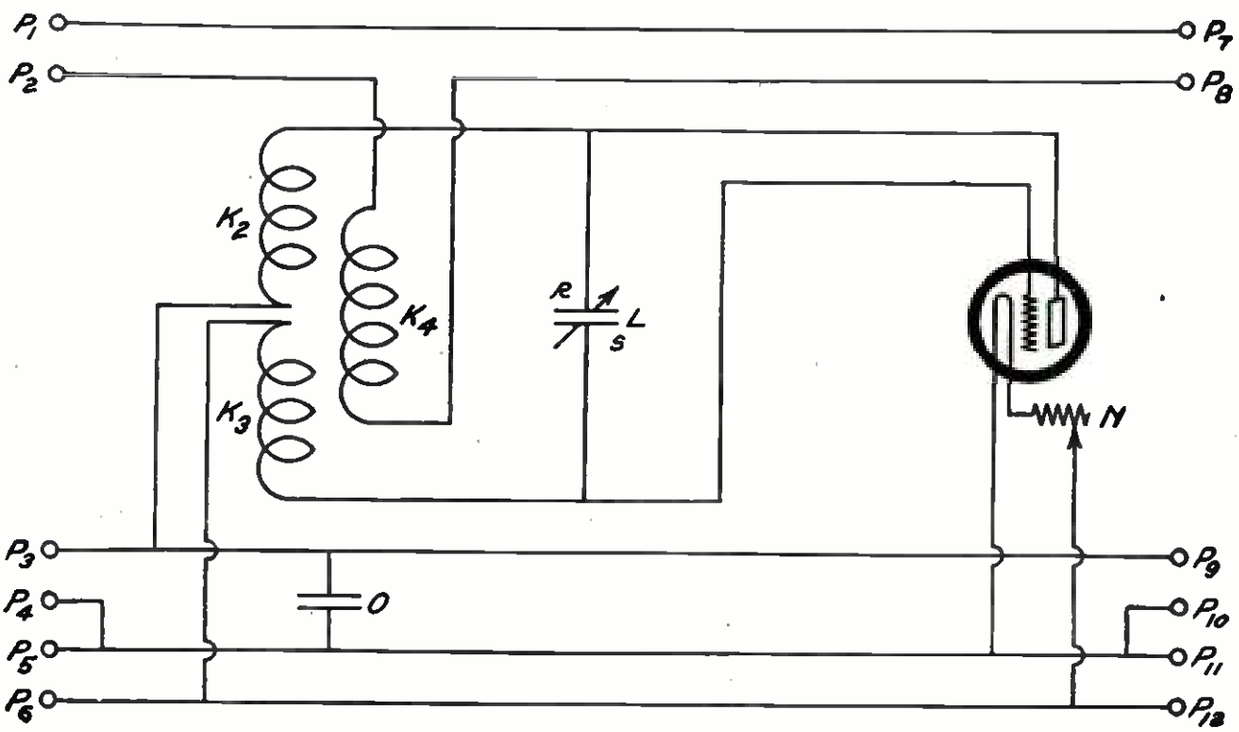
It is now possible to burn four tubes with less filament current than one tube would have taken a year ago.

This fact covers the point raised in the 6th requirement specified at the head of this article.

The circuit as finally evolved (and as will be described in this article) has only two operating controls; for this reason it really *is* simple to operate. (Point No. 5.)

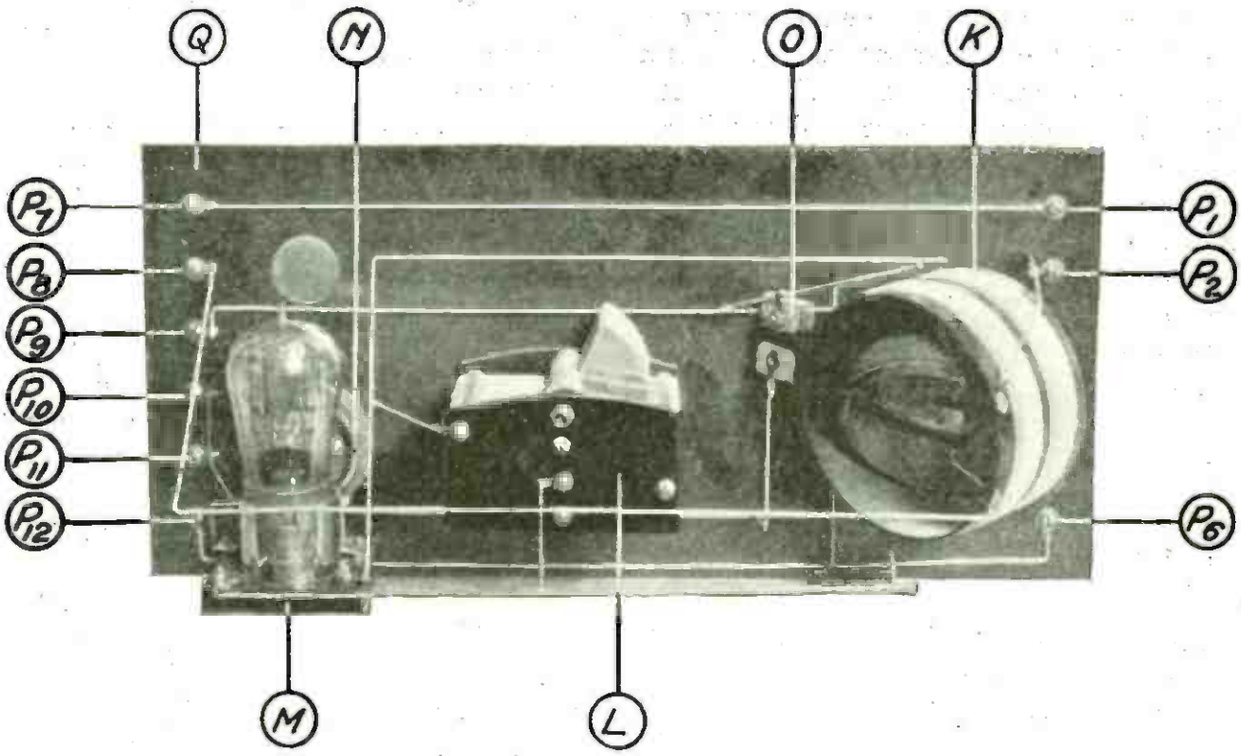
The circuit has been so simplified and the parts used so reduced to essentials, that it is relatively inexpensive. (Point No. 4.)

In its final form the set is really simple to construct. (Point 3.) It can be built in units. This places the super-heterodyne right where it ought to be as the ultimate in radio-reception apparatus but within the reach of anyone who is ordinarily handy with tools and who can afford to experiment with radio at all.



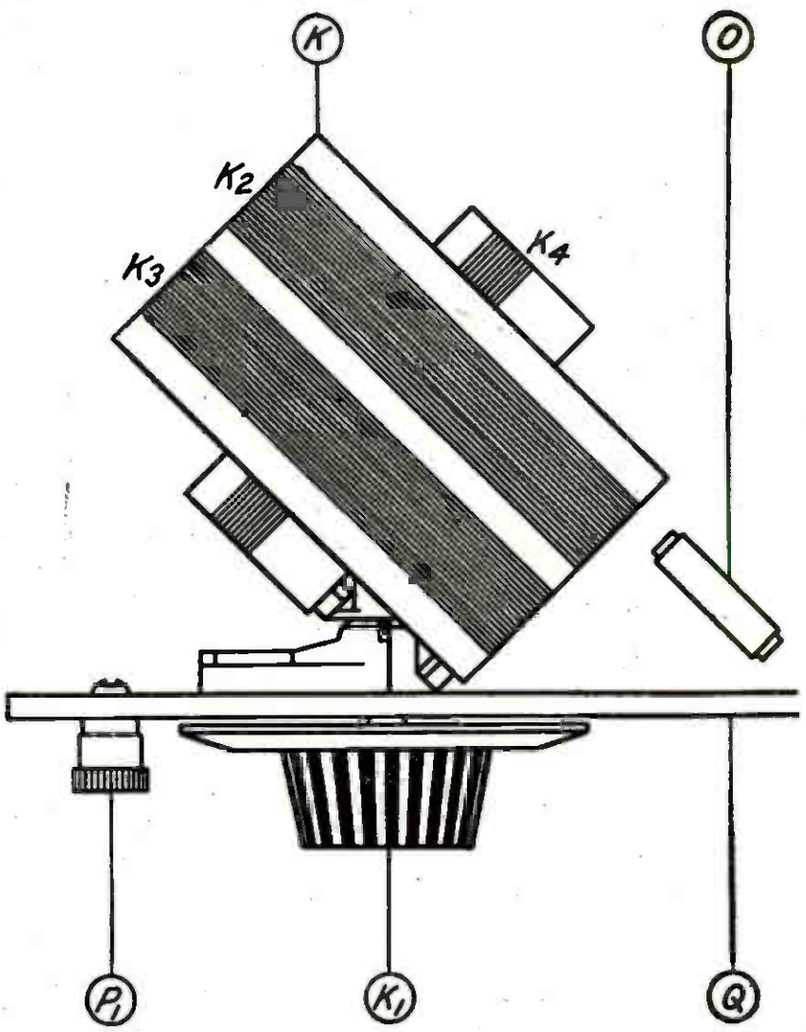
THE EXACT WIRING DIAGRAM FOR THE OSCILLATOR

FIGURE 1: *This diagram shows how to wire up the oscillator panel including the special oscillator coupler, the heterodyne condenser, the tube and the fixed condenser. The binding posts are numbered so that the experimenter will have no trouble in connecting up.*



THE INTERIOR OF THE OSCILLATOR

FIGURE 2: *(Above). The parts are designated by letters which reappear in the text and in the other diagrams and drawings. This actual photograph of the instruments indicates the simplicity of the set and should dispel any fears the prospective experimenter may have that its construction is difficult.*



HOW THE PARTS ARE ASSEMBLED

FIGURE 3: *(At right). The diagram extending across the bottom of these two facing pages is a working drawing of the oscillator; it shows the general arrangement of the parts as they are viewed from above.*

Some of the new features incorporated into the design of the set which make it so suitable for DX reception over wavelengths between 180 and 600 meters are:

The use of the first tube as a *radio-frequency amplifier.*

The use of a heterodyne oscillator *coupled to the plate circuit* of the first tube (instead of to the grid circuit as is usual).

The use of a new type of air-core, radio-frequency transformer which is *sharply tuned to a wavelength of 3,000 meters.**

The use of *regeneration* in the radio-frequency amplifier (which greatly boosts up signal strength without complicating the control).

The *elimination of the variable-tuned circuits* at the input of the radio-frequency amplifier.

The *reduction of the tuning controls to two knobs,* one for the wavelength and one for the heterodyne oscillator.

The successful use of *regeneration* in the first-tube circuit.

The use of the Haynes circuit *for tuning.*

The use of the *new thoriated-filament vacuum tubes throughout* (six tubes).

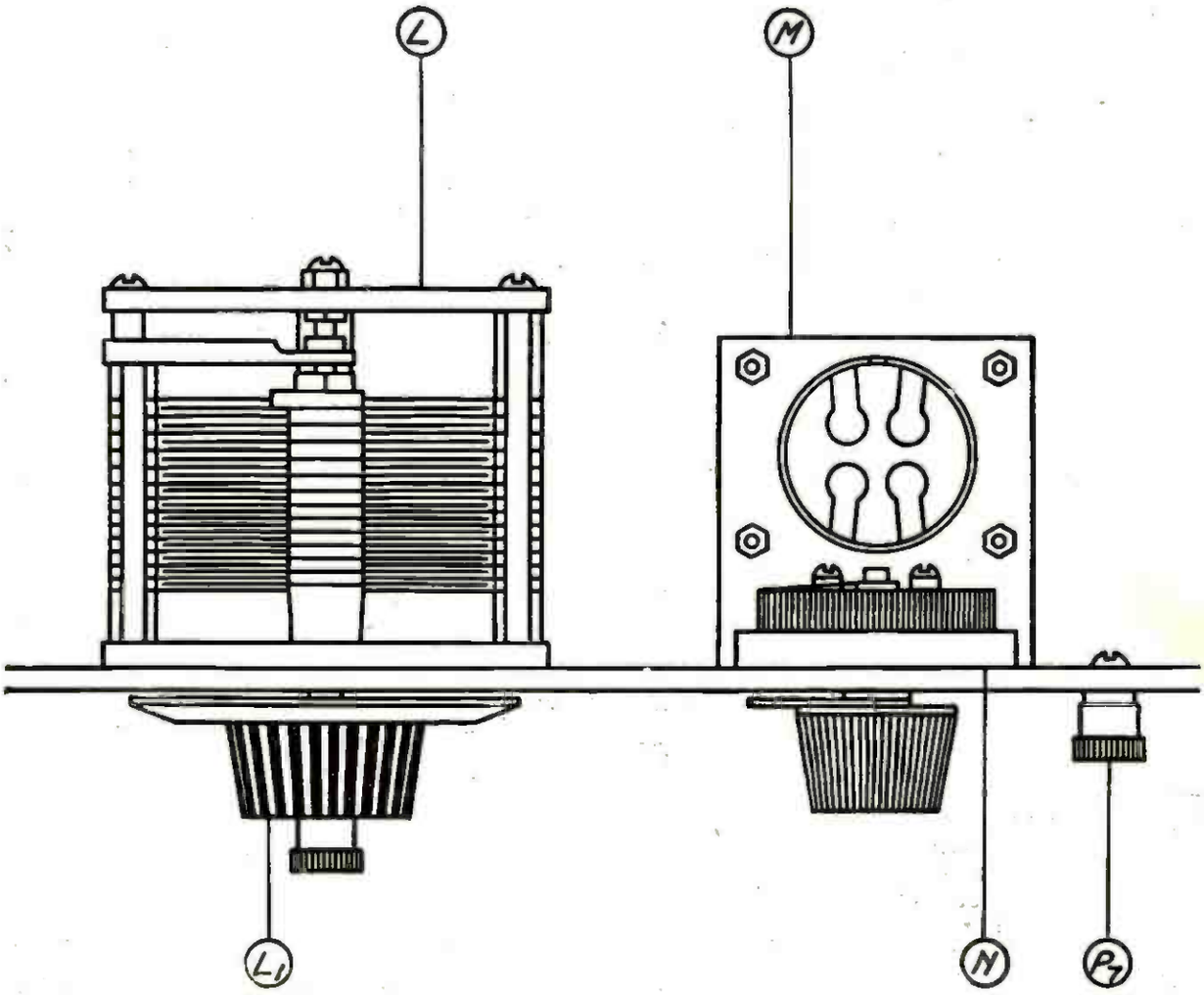
The use of a *new oscillation coupler* for the oscillator.

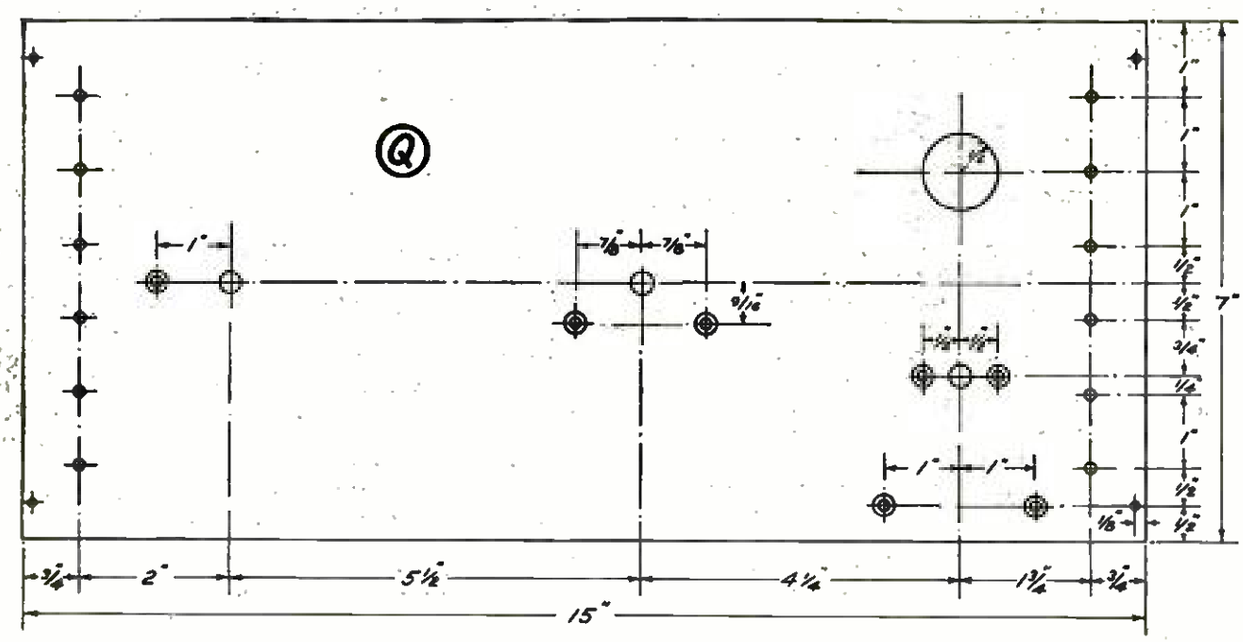
The set is constructed in three parts; the *tuner,* the *oscillator,* and the *radio-frequency amplifier.*

The tuner was described in the September, 1923, issue of POPULAR RADIO.

The oscillator will be described in this article. The radio-frequency amplifier will be described in the December issue of POPULAR RADIO along with a

*The authors wish to thank Mr. McMurdo Silver for the important work that he has contributed toward the perfection of the radio-frequency transformers.





THE DRILLING PLAN FOR THE PANEL

FIGURE 4: *This drawing shows where to drill the holes in the panel for mounting the instruments and attaching the binding posts. The correct spacings are given for the holes. The holes outlined with a double circle should be countersunk.*

full, detailed description of the proper way to set up the complete receiver, and how to adjust and tune it. Although the receiver will bring (in New York City) all the western broadcasting stations and DX amateur transmitters throughout the country, on a loud-speaker, without any audio-frequency amplification, if the builder so desires he may use the two-stage amplifier described in the October issue of POPULAR RADIO. This will produce too much volume on almost any signals for the ordinary home, but there are some folks who like a lot of volume, and this will give it to them.

All of the units described here are mounted in standard-sized cabinets, and the binding posts are arranged so that they may be simply bridged across from one unit to another when the cabinets are arranged side by side. The batteries are connected to the end unit and the other units are fed through the bridging binding posts. This does away with any unsightly, sprawling connections. The general appearance of the complete set (without the audio-frequency amplifier) is shown in the photograph on page 392.

The actual wiring diagram for the oscillator is shown in Figure 1.

The Parts Used in Building the Oscillator

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 here given 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 equally good results.*

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

(K2, K3, and K4)—Haynes-Griffin special oscillator coupler;
K1—knob and dial, 3 inch;
L—Fett and Kimmel Micro-tune variable condenser, .0005 mfd.;
L1—knob and dial, 3 inch;
M—Fada panel mounting socket;
N—filament rheostat, 20-30 ohms;
O—Micadon fixed condenser, .005 mfd.;
P1 to P12—binding posts;
Q—composition panel;
R—cabinet.

How to Construct the Oscillator

After procuring all the instruments and materials for building the set, the amateur should

set about preparing the panel Q, (shown in Figures 2, 3, 4 and 5.

First of all the panel should be cut to the correct size, 7 by 15 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 Figure 4.

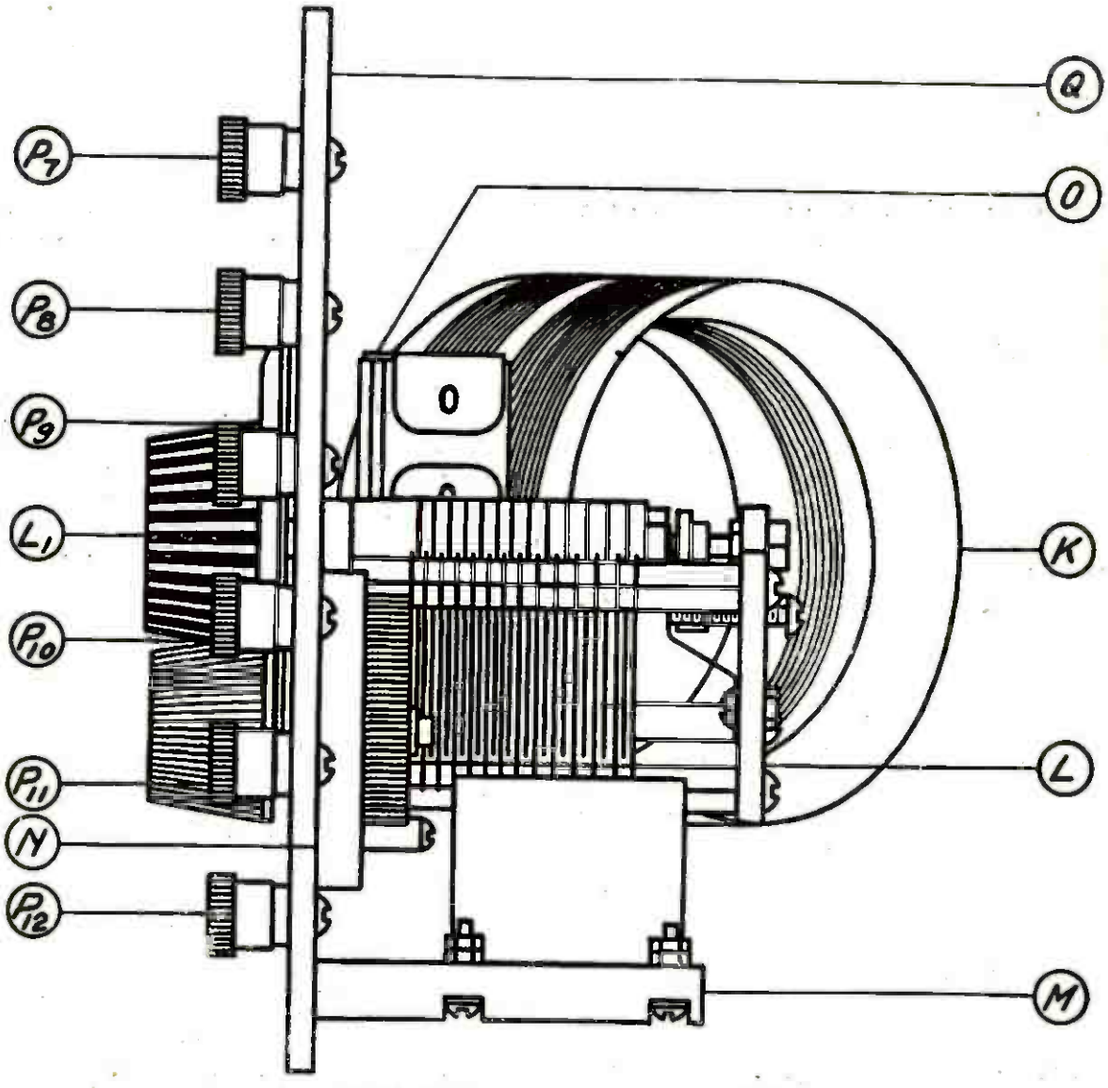
The holes outlined here with a double circle should be countersunk so that the flat-head machine screws used for fastening the instruments will be flush with the panel. All the rest of the holes in this panel are straight drill holes. Sizes for the diameter of these holes have not been given, but the 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 my 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, mount the variable condenser L, by means of two screws inserted through the panel as shown in Figures 2, 3, and 5. The dial L1, should then be fastened to the shaft of the condenser by means of a set-screw.

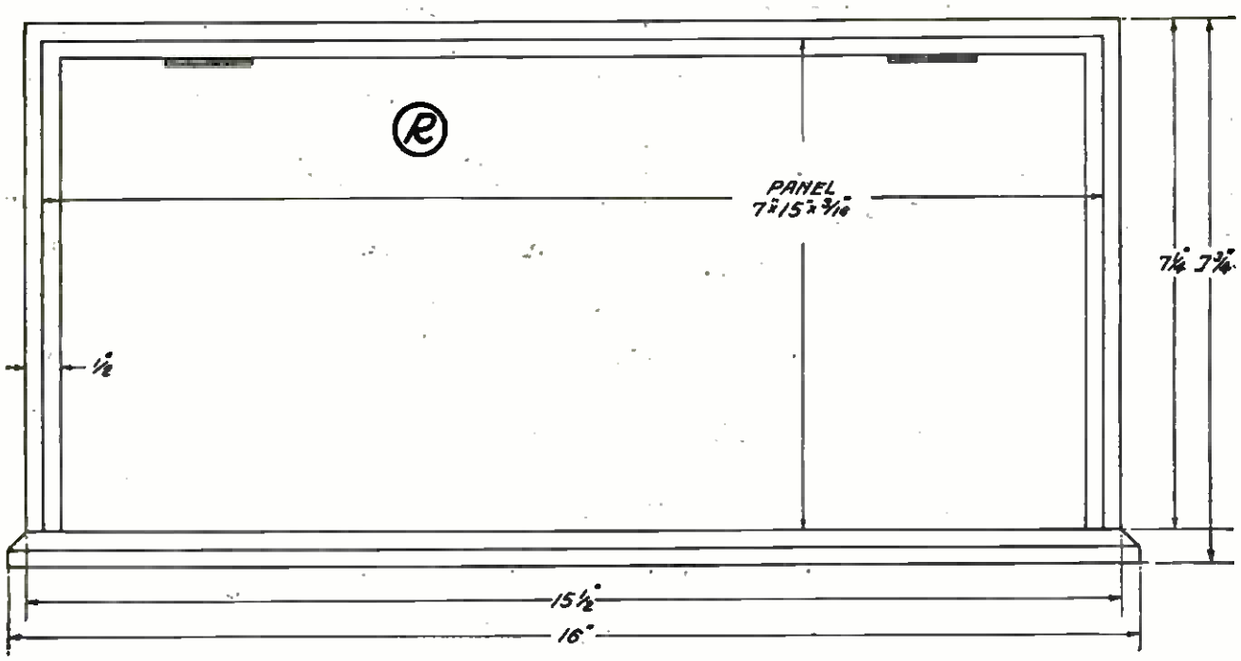
Now, fasten the oscillator coupler K, in its correct place (Figures 2, 3, and 5) by a single screw and attach the knob and dial K1. The three windings of the coupler are designated as K2, K3, and K4, but these designations are for wiring up and will be considered later.

When this is done, mount the socket M, by two screws fastened through the panel, and mount the rheostat N, just above the socket. The arrangement of these two parts is clearly shown in Figures 2, 3, and 5.



THE SIDE VIEW OF THE OSCILLATOR

FIGURE 5: *This mechanical drawing gives the side elevation of the instruments as they should be fastened to the panel. The binding posts are mounted in a vertical line at each end of the panel.*



THE DIMENSIONS FOR THE CABINET

FIGURE 6: *This diagram (which contains the front and side measurements for the hardwood cabinet) may be turned over for construction to the cabinet maker or a cabinet of this size may be obtained from almost any radio supply store.*

The fixed condenser O, can be left until the wiring is done as it is to be supported by the connecting wires and does not need to be mounted on the panel.

Now fasten on the binding posts P, as indicated in Figures 2, 3, and 5 by inserting a screw through the panel for each one. The various binding posts are designated in the diagrams by numbers from 1 to 12 but these are only given for ease of identification in wiring. All the binding posts are exactly alike.

The dimensions for the cabinet are given in Figure 6. This cabinet may be made by anyone who is handy with carpenter tools, or, the drawing in Figure 6 may be turned over to a cabinet maker. It should be made of hardwood finished to suit the owner's taste. However, as the cabinet for this set is a standard size, it may be procured from almost any radio store; merely ask for a cabinet for a 7 by 10-inch panel.

How to Wire the Oscillator

The oscillator should be connected up with bus wire in the following manner:

Run a straight piece of tinned copper bus wire from the binding post marked P1, to the post marked P7, as shown in Figure 1. P1, is the top binding post on the left hand side of the panel (looking from the front). P7, is the top binding post on the right side of the panel (also looking from the front of the panel).

Next, connect binding post P2, with one end of the rotor winding K4, (of the oscillation coupler K,) with a wire and connect the other end of the winding K4, with the binding post P8.

Now run a wire from P3, to P9, and also connect another wire to this piece and run it to the inside end of the stator winding K2, (of the coupler K). From the outside end of the winding K2, run a wire direct to the plate terminal of the socket M.

Then run a wire from binding post P4, direct to P5, and from there over to P11, and on to P10. The condenser should now be connected by two bits of wire between P3, and P5.

When this has been done, run a wire from P11, to one filament terminal of the socket M, and from the other filament terminal connect a wire to the rheostat N. From the other side of the rheostat a wire should be connected direct to P12.

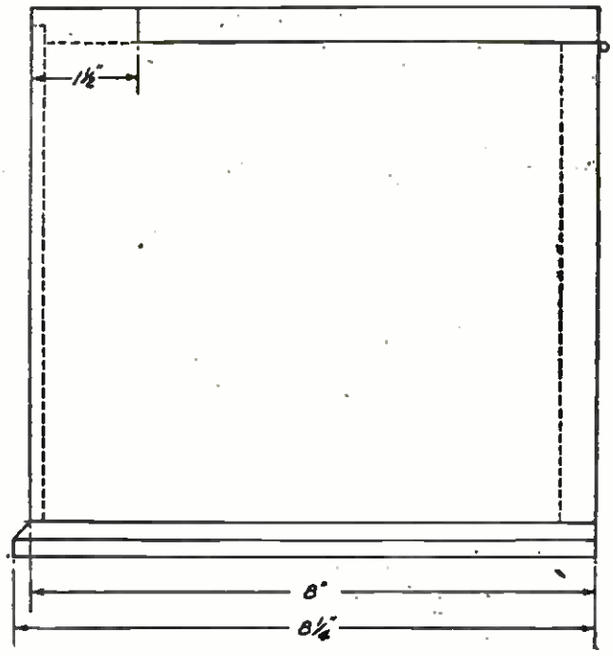
Now, connect binding posts P6, and P12, with a wire, and run a connection from P6, up to the inside end of the winding K3, (of the coupler K). The other end of the winding K3, should be run to the grid terminal of the socket M.

Finally connect the variable condenser L, between the plate and grid leads (from the socket M), being sure that the rotor plates of the condenser are connected to the plate lead and the stator plates of the condenser are connected to the grid lead as indicated in the wiring diagram in Figure 1.

This completes the wiring.

What the Oscillator Does

Almost every radio fan who operates a regenerative set is familiar with the whistle accompanying reception of a radio-broadcast signal when the detector is *oscillating*. We know that this is caused by the incoming radio-frequency current combining with the radio-frequency current generated by the vacuum tube when it is allowed to oscillate. However,



when the wavelength of the oscillating receiving circuit is varied slightly *off* the wavelength of the incoming signal, the whistling note heard in the receivers goes up in pitch. In other words, when the frequency of the local oscillations (generated in the receiver) is identical with the frequency of the signals being received, the whistle is *not* heard. The two sets of oscillations are then in synchronism or in phase with each other.

When the frequency of the local oscillations is varied either up or down, slower or faster than the frequency of the received oscillations, a whistle is heard which starts with a low pitch and gradually increases till it goes way up and up above audibility. The greater the difference in frequency between the local oscillations and the received oscillations, the higher the "beat note" will be. As stated before if we further increase the difference in frequency the note will become inaudible and if it is increased sufficiently a *beat will be produced which will have a radio-frequency wavelength of its own.* The oscillator (or heterodyne as it is more widely known) does this when used for this purpose. It generates an oscillating, radio-frequency current, the frequency of which can be varied at will, so that it will heterodyne or beat with the incoming signals and produce another signal like the incoming signal, only on a higher wavelength!

In this way the incoming signal can be *reproduced* on a higher wavelength, in this case 3,000 meters, at which wavelength, radio-frequency amplification can be carried on with enormously greater efficiency than on the original wavelength!

This is the secret of the super-heterodyne; it permits of super-amplification at a radio-frequency by means of a heterodyne.

In the oscillator, just described, the frequency of the local oscillations is varied by rotating the condenser L, by means of the knob L1.

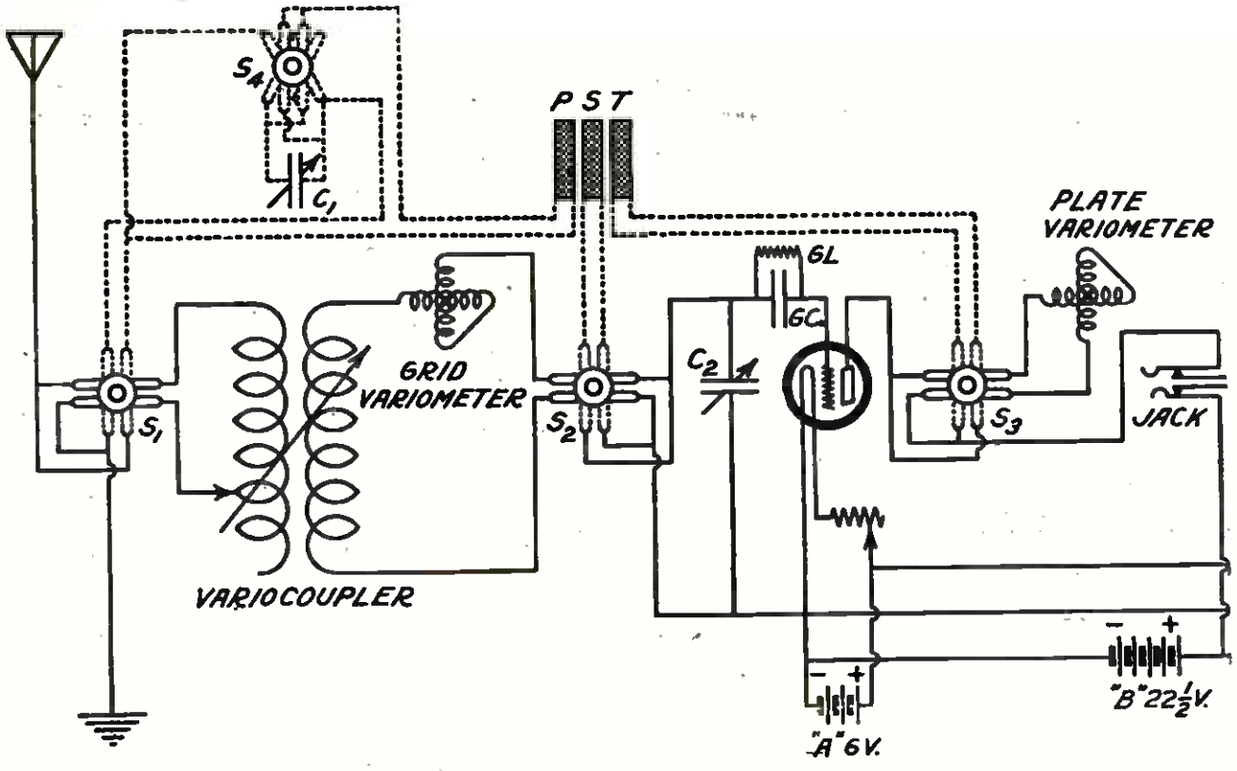
For those who want to own a receiver that will literally reach out to the corners of the earth and pick out a whisper to recreate it into a mighty shout, here is the set to make. Contrary to belief, it really is a simple set to tune.

For those who decide to build it we recommend starting work on the tuner described on page 222 in the September issue. Then build the oscillator described here, and next month in the December issue we will describe the radio-frequency amplifier unit. This will be the complete set, unless you want to use audio-frequency amplification, which really is not necessary unless a terrific signal from a loudspeaker is desired. You may get the information on the audio amplifier from the October issue.

The second part of this article—which will appear in the December number—will also tell all about connecting up and tuning the complete super-heterodyne receiver, and will be accompanied with full operating data.

The "University of the Ether"

THE *wonderful field that radio is opening up in the province of education is so vast that it is not inconceivable that our whole conception of education may be revolutionized. Some vision of what the future holds will be set forth in* POPULAR RADIO *by one of America's most imaginative authors—Percy Mackaye.*



HOW TO BUILD A COMBINATION SHORT AND LONG-WAVE

REGENERATIVE RECEIVER

This set combines the advantages of the three-coil honeycomb tuner for receiving long waves with the advantages of the variocoupler two-variometer regenerative receiver for receiving short waves. The changeover may be made at will by the operator by means of a clever series of simple switches.

By LESTER A. TWIGG

THE modern radio enthusiast wants a receiving outfit with which he can listen in to a large number of distant as well as nearby broadcasting stations. He wants efficiency in his set, which means not only that it must possess sensitiveness, stability and selectivity, but that it must cover a wide range of wavelengths. And he wants all this at the lowest possible cost.

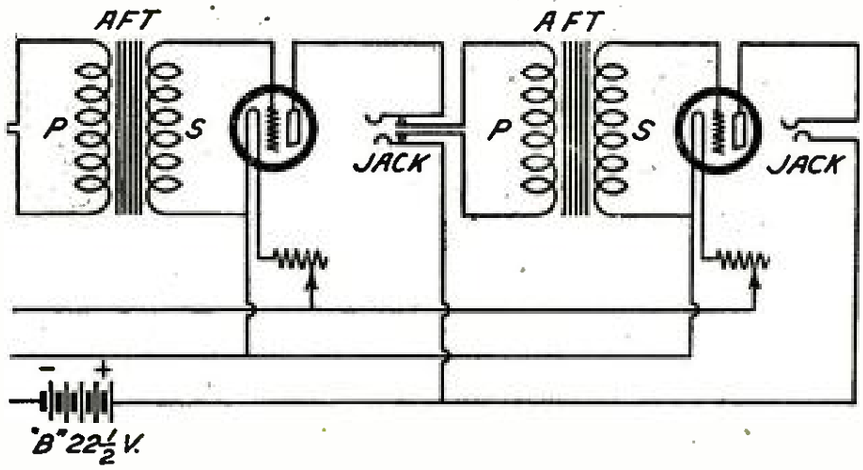
The present-day short-wave receiving sets are designed to give the best results on wavelengths of 200 to 600 meters. While these short-wave sets can be loaded so as to receive messages on longer waves, it is generally conceded that the spiderweb coils, or coils of similar windings, give better results in the reception of long-wave signals. A combination, then, of a short-wave set and a long-wave set is the answer to the demand for efficiency in both short and long-wave reception.

Such a combination, which I shall call an ideal set, can be constructed from standard parts at a cost of about $110, but if the windings are home-made and the cabinet and panel omitted it can be constructed for much less. Properly constructed it will compare favorably with any two-stage set on the market selling for two or three times the cost, and if carefully operated it will give surprising results.

One feature which materially lowers the cost of this set is the elimination of

FIGURE 1

This diagram shows the circuit connections for the two tuning units and the detector and two stages of audio-frequency amplification. When either tuner is in use, the other tuner is entirely disconnected and does not interfere with the proper functioning of the one that is being operated.



the double-pole, double-throw switches, substituting series-parallel switches and taps. Four of these switches, shown in Figure 1 as S1, S2, S3 and S4, can be purchased with the necessary taps for less than four dollars; this is less than some shops charge for a one-panel mounted double-pole, double-throw switch. Another feature which lowers the cost is the compactness of the set. All the apparatus, except the batteries, are contained in a cabinet 21 inches long, 12 inches wide and 10 inches deep. This makes all connections comparatively short and adds efficiency to the outfit.

The arrangement of the parts can best be understood by referring to the diagram, Figure 3. A small shelf is fastened to the panel directly under the rheostats, upon which is fastened the two audio-frequency amplifying transformers and the three tube sockets. By extending the shelf to the back of the cabinet, ample room is provided for adding one or two stages of radio-frequency amplification, which today is a very necessary part of the outfit of a wide-awake experimenter.

The duo-lateral, or spiderweb, coils are mounted on the panel and can easily be changed and adjusted to vary the wavelength and tuning as desired. When radiophone messages, or other messages below the 600-meter wavelength are to be received, the switches are turned horizontally to the short-wave set; when signals above the 600-meter wavelength are to be received the proper coils are selected according to the table accompanying Figure 1, and the switches turned longitudinally to the long-wave set.

The variable condenser, C-1, used in the long-wave set, is controlled by switch S-4, as shown in Figure 2-A, and this condenser is shifted to the different positions as shown in B, C and D of Figure 2. This condenser is of the 43-plate type with a capacity of about .001 microfarad. The variable C-2 is a 23-plate condenser with a capacity of .0005 microfarad.

In constructing a set such as has been described the different parts I used were all of standard make. The material used and the costs of the various items are listed as follows:

1 variocoupler with dial	$ 6.00
2 variometers with dials	12.00
3 porcelain tube sockets	1.65
3 filament rheostats	2.25
2 audio-frequency amplifying transformers	7.00
2 double-circuit phone jacks	1.50
1 open-circuit phone jack	.50
7 binding posts	.35
1 grid condenser (.00025 mfd.)	.30
1 grid leak (2 megohms)	.50

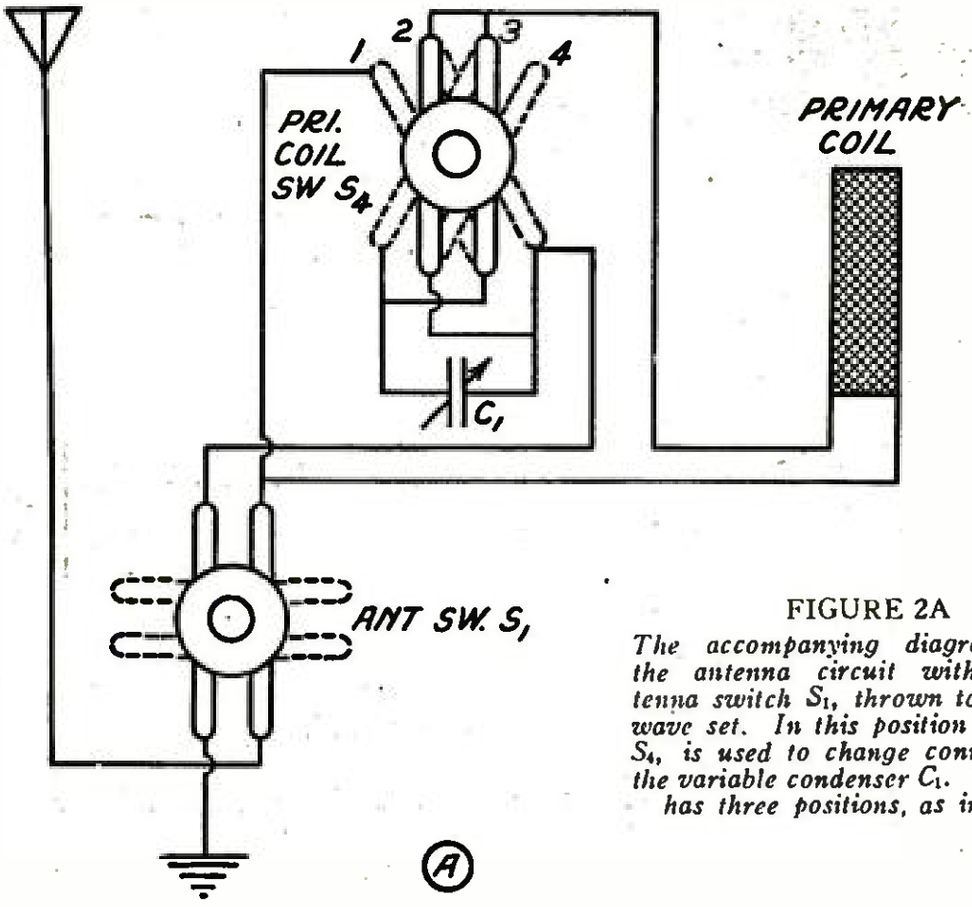
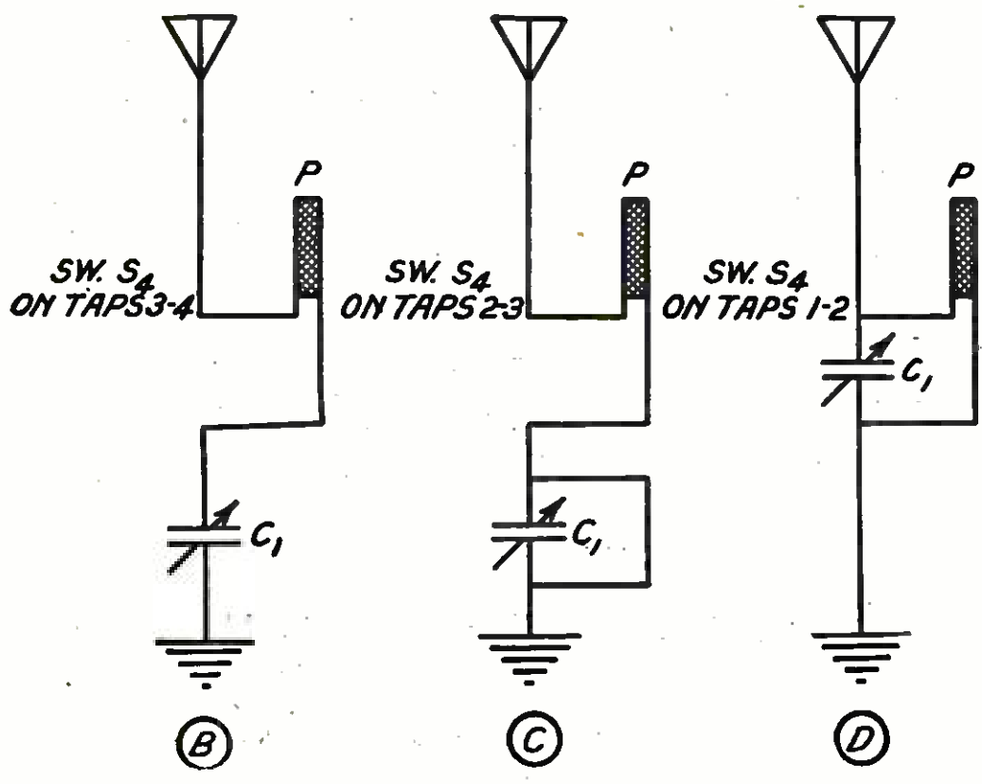


FIGURE 2A

The accompanying diagram shows the antenna circuit with the antenna switch S_1, thrown to the high-wave set. In this position the switch S_4, is used to change connections to the variable condenser C_1. The switch has three positions, as indicated.



FIGURES 2B, 2C AND 2D

In the diagram 2B the switch levers are on 3 and 4 (condenser in series with coil); in the diagram 2C the switch levers are on 2 and 3 (condenser short-circuited) and in the diagram 2D the levers are on 1 and 2 (condenser shunted across the coil). By this means the wavelength of the antenna circuit may be varied over a wide band of wavelengths.

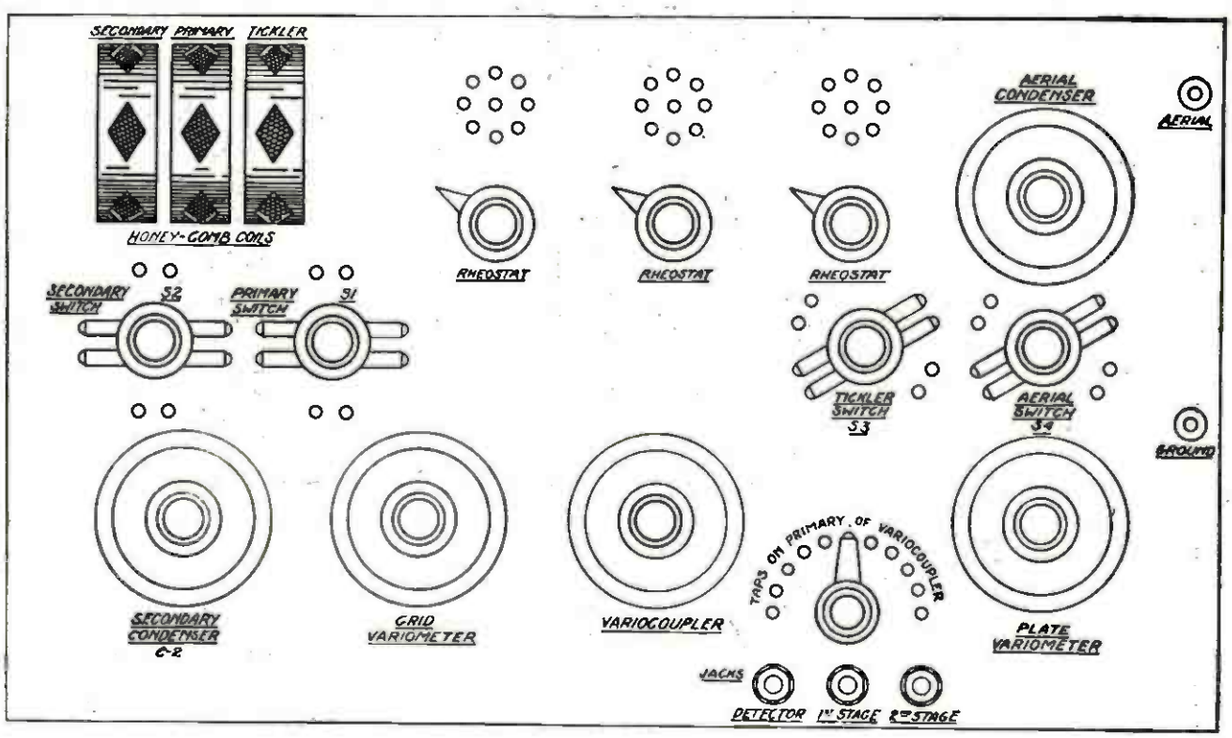


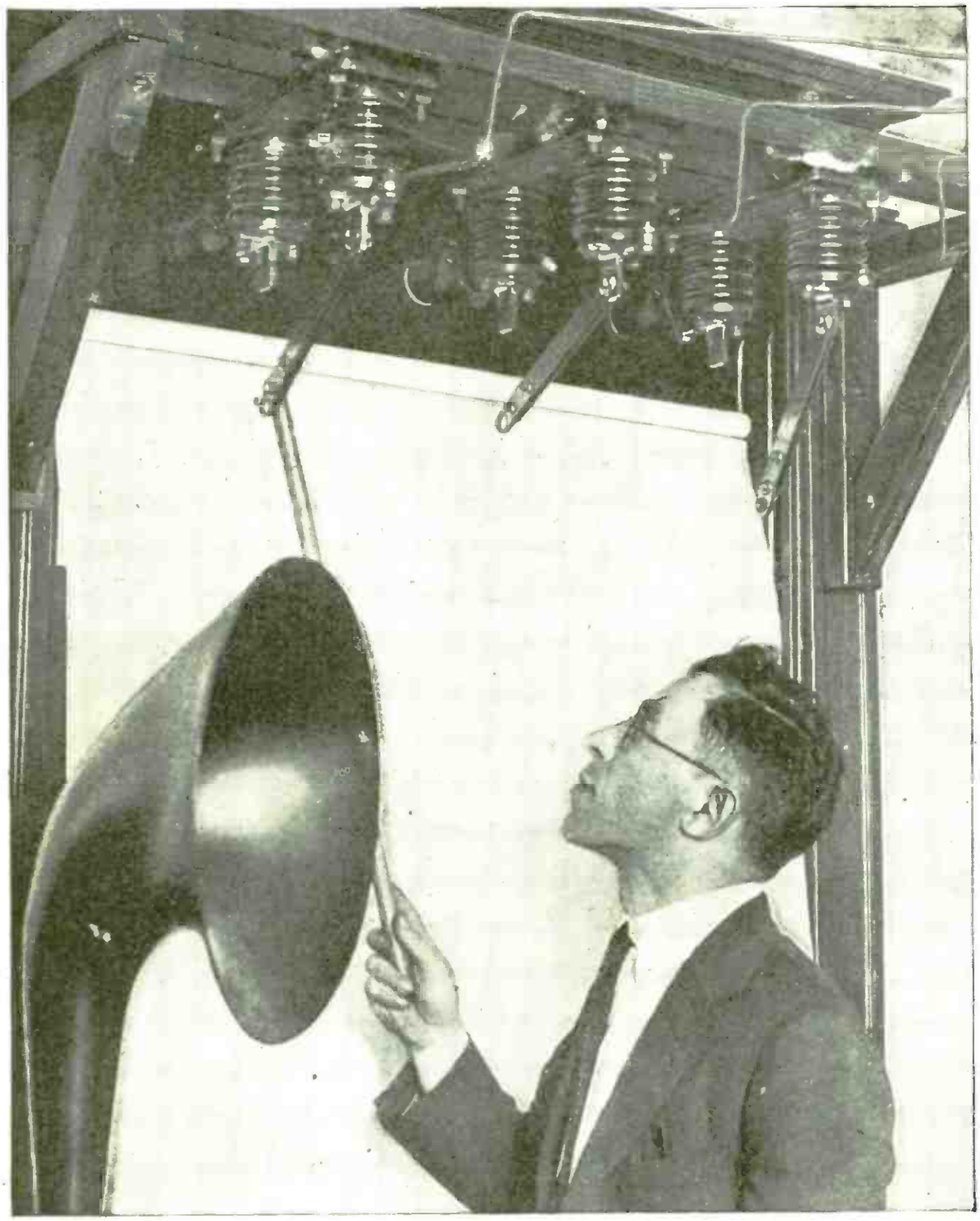
FIGURE 3

A diagram for laying out the instruments on the panel, showing how to put the set into a cabinet.

2 amplifying tubes	12.68
1 detector tube	4.84
2 "B" batteries (22½ volts each)	2.00
1 "A" battery (6 volts, 60 ampere hour capacity)	14.00
1 set head phones (2,000 ohms)	5.00
1 phone plug for jacks	1.00
1 switch lever (1¼ inch radius)	.25
1 100-foot length No. 14 antenna wire	1.00
1 switch (porcelain base S.P.D.T.)	.35
1 piece 50-foot length aluminum wire No. 14, for ground and for wiring outfit	.26
1 cabinet (12 x 21 x 10 inches)	3.25
1 panel (12 x 21 x 3/16 inches)	3.50
1 dozen contact points	.40
ADDITIONAL FOR LONG-WAVE SET	
3 dozen contact points	1.20
4 series-parallel switches	3.16
1 stationary coil mounting	.70
2 pinioned coil mountings	2.20
1 variable condenser (.001 mfd.)	4.00
1 variable condenser (.0005 mfd.)	3.00
1 coil each of the following sizes: L-75, L-100, L-150, L-200, L-250, L-300, L-400, L-500, L-1,000, L-1,250.	15.00
Total cost	$109.84

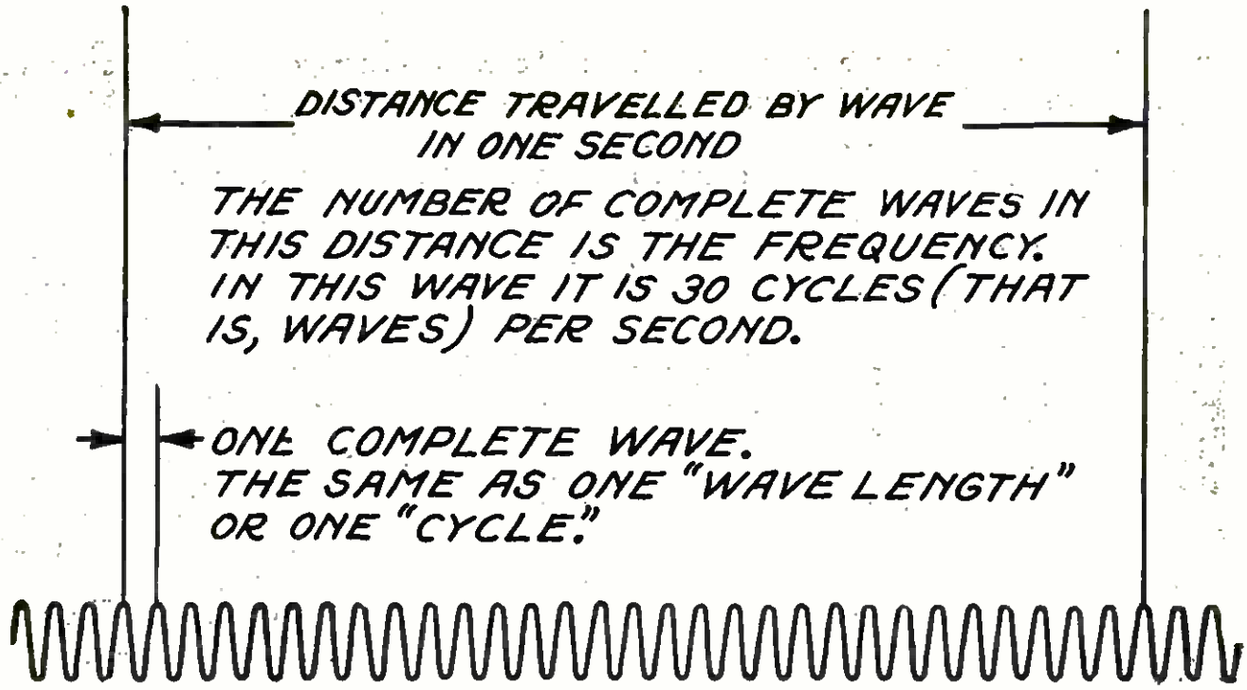
With this set, located in Washington, D. C., I have regularly heard concerts from Pittsburgh, Indianapolis, Detroit, Cleveland, Newark and Schenectady, besides a number of stations within a radius of 300 miles. Any number of telegraph stations, from almost any distance, may be heard on the long-wave set.

Number of Turns in			*Wavelength*
Primary	*Secondary*	*Tickler*	*in Meters*
35	25	35 =	145 — 350
75	50	35 =	305 — 710
150	100	75 =	635 — 1,660
200	150	100 =	845 — 1,970
300	250	150 =	1,420 — 2,850
500	300	200 =	2,550 — 4,250
500	400	200 =	4,200 — 6,300
1,250	1,000	400 =	6,250 — 14,500
1,500	1,250	500 =	13,600 — 21,000



BUYING HOME AMUSEMENT WITH YOUR ELECTRIC LIGHT

This is a part of the system recently installed on Staten Island, one of the boroughs of New York City, by which regular programs of music and other interesting material will be supplied to subscribers over the power lines of the local electric service company. The methods of "wired wireless" as developed by General Squier are used. The insulators shown at the top of this photograph carry the high-tension power-distributing wires to which the radio-frequency currents carrying the broadcast material are supplied. A full description of the apparatus used will appear in an early number of POPULAR RADIO.



This diagram shows clearly the relation between wavelength and frequency for the specific wave pictured at the bottom—in this instance the wave produced by the note of a flute.

HOW TO CONVERT

Wavelengths Into Kilocycles

ARTICLE NO. 1 OF A NEW SERIES

Useful facts about ether waves—condensed for your notebook

By E. E. FREE, Ph D.

WHAT is a kilocycle? Why are radio waves now being measured in this new unit instead of the familiar wavelengths? What is frequency?

Of these question let us take first what frequency is and what is its relation to wavelength.

Any wave whatsoever, a radio wave in the ether, a sound wave in the air, a water ripple on the surface of a pond, consists of a succession of pulses moving along one after another. Most waves have a succession of *regular* crests and troughs like ocean waves or like the electric wave, a picture of which is shown in Figure 1.

The part of the wave between one crest and the next following crest is called one complete wave. Its length —that is the distance between successive wave crests—is one wavelength. This is the familiar radio unit.

The *frequency* is merely the number of such complete waves that pass in one second (or what is the same thing) the number of wavelengths in the distance the wave moves in one second.

Consider the arrival of a moving wave at some fixed point; for example, the arrival of a sound wave at your ear.

The wave appears to your ear as a succession of regularly timed pulses,

one pulse for each wave crest. Each pulse pushes a little against your ear. This sets the drum of the ear to vibrating; inward for each pulse, outward again during each time between pulses. The number of these back-and-forth vibrations of the drum a second is the same as the number of pulses of the wave that arrive a second; it is the same; that is, as the frequency of the wave. The higher this frequency, the shriller the sound seems to your ear.

What you really hear, then, is the frequency, not the wavelength. Frequency, indeed, is always a more characteristic property of waves than length is. Wavelength depends on the *speed* of the wave, and the speed depends not only on the kind of wave but on the medium in which the wave is traveling. Sound waves, for example, move faster in water than they do in air. The wavelength of a sound wave will be greater in water than in air. But its frequency will be the same. It is frequency, not wavelength that is the constant property.

Similarly when you modulate a sound wave onto a radio wave the wavelengths of the two waves do not matter. The sound wave is a slow wave in air. Its single waves are very short. The radio wave on the other hand, is a fast wave in the ether. Its wavelength is relatively very long. The factors that really determine the relation of the two waves, the factors that you need to take account of in modulation calculations, are the respective frequencies of the two waves.

This is one reason why frequencies are coming to be used instead of wavelengths. The use of frequencies makes all kinds of waves comparable directly. Modulation calculations are easier. Interference, harmonics and all other mutual relations of waves are more directly discoverable.

The *kilocycle* is merely a unit of frequency, just as the meter is a unit of wavelength. In electrical terminology a "cycle" means one complete wave, measured, as usual, from one crest to the next following one. (See Figure 1.) The frequency may be expressed, therefore, in cycles. It is the number of cycles a second. An alternating current, for example, may have 60 cycles a second, which means the same as a frequency of 60 cycles.

The kilocycle is merely 1,000 cycles, just as a kilometer is 1,000 meters or a kilowatt is 1,000 watts. To say that a wave has 500 kilocycles a second means that it has 500,000 cycles (that is, complete waves) a second.

To convert frequencies and wavelengths into each other requires knowledge of the speed of the wave. Radio waves move with the speed of light. According to the most accurate experimental determinations this speed (in vacuum) is 186,326 miles a second, or 299,860,000 meters a second. For ordinary calculations radio engineers use a round number of 300,000,000 meters a second.

A wave that has 500 kilocycles (which is the same as 500,000 complete waves) a second, will move in that second 300,000,000 meters. The length of each single wave will be, therefore, 300,000,000 divided by 500,000, or 600 meters. This wave will have a wavelength (in vacuum) of 600 meters.

Here are the rules for conversion:

To convert the wavelength (in meters) into the frequency (in kilocycles) divide it into 300,000.

The reverse rule is the same:

To convert the frequency (in kilocycles) into the wavelength (in meters) divide it into 300,000.

The speed of radio waves in air and in non-conducting materials is nearly the same as in vacuum. These rules hold, therefore, for all ordinary calculations.

By way of comparison, the speed of sound waves in ordinary air is about 1,150 feet a second (350 meters a second), not much over one millionth

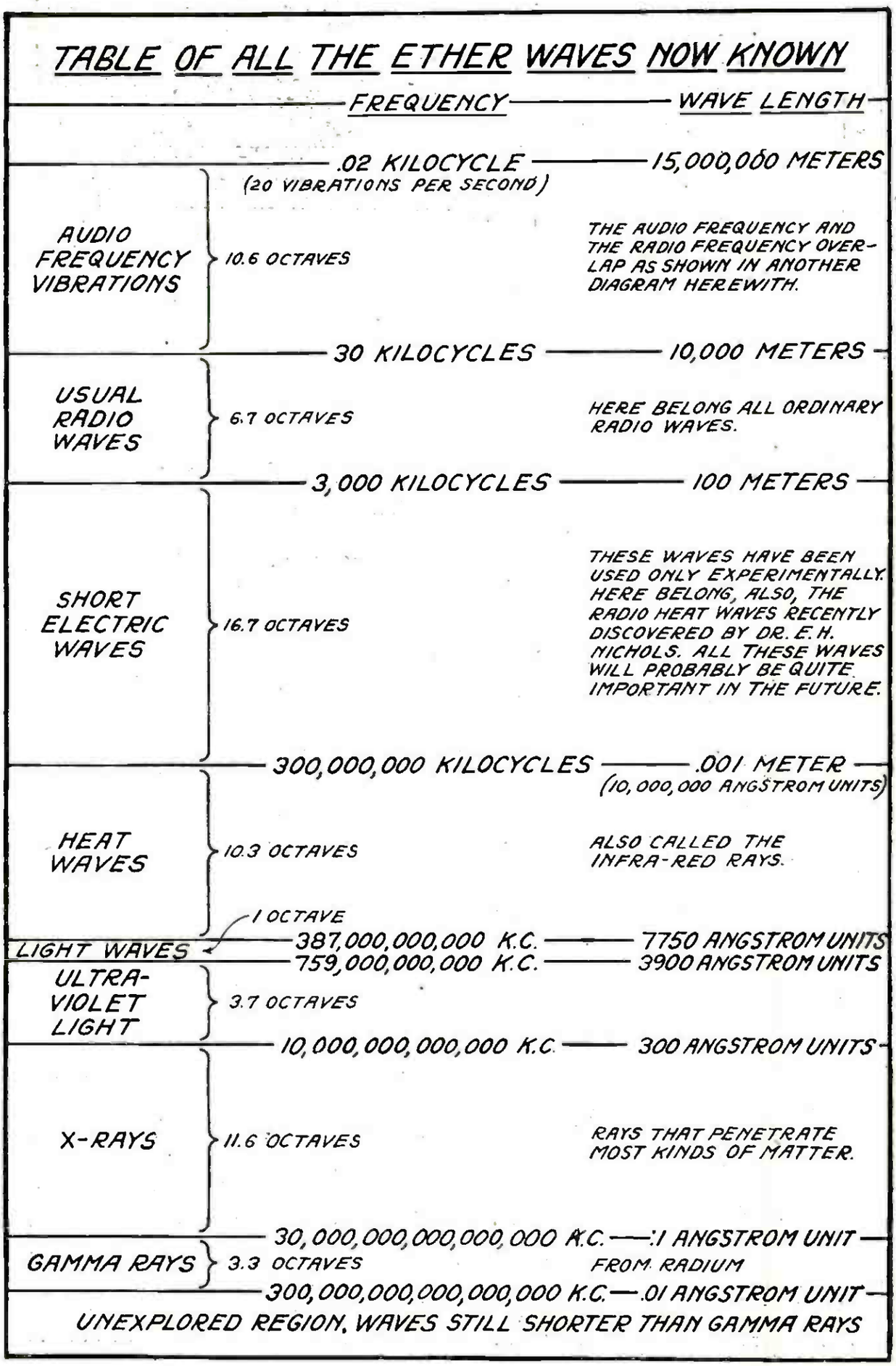
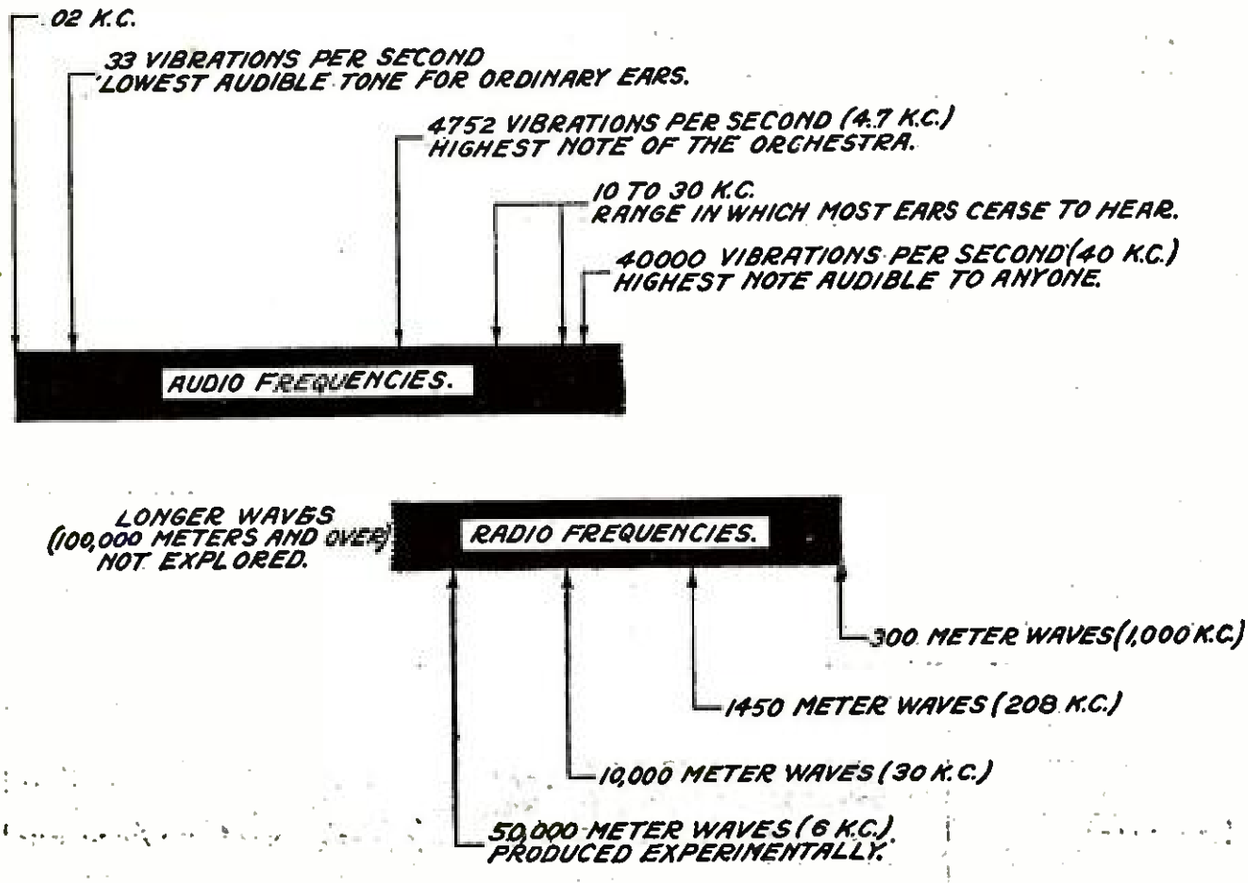


TABLE OF ALL THE ETHER WAVES NOW KNOWN
FREQUENCY
WAVE LENGTH
.02 KILOCYCLE
(20 VIBRATIONS PER SECOND)
15,000,000 METERS
AUDIO FREQUENCY VIBRATIONS
10.6 OCTAVES
THE AUDIO FREQUENCY AND THE RADIO FREQUENCY OVERLAP AS SHOWN IN ANOTHER DIAGRAM HEREWITH.
30 KILOCYCLES
10,000 METERS
USUAL RADIO WAVES
6.7 OCTAVES
HERE BELONG ALL ORDINARY RADIO WAVES.
3,000 KILOCYCLES
100 METERS
SHORT ELECTRIC WAVES
16.7 OCTAVES
THESE WAVES HAVE BEEN USED ONLY EXPERIMENTALLY. HERE BELONG, ALSO, THE RADIO HEAT WAVES RECENTLY DISCOVERED BY DR. E. H. NICHOLS. ALL THESE WAVES WILL PROBABLY BE QUITE IMPORTANT IN THE FUTURE.
300,000,000 KILOCYCLES
.001 METER
(10,000,000 ANGSTROM UNITS)
HEAT WAVES
10.3 OCTAVES
ALSO CALLED THE INFRA-RED RAYS.
1 OCTAVE
LIGHT WAVES
387,000,000,000 K.C.
7750 ANGSTROM UNITS
759,000,000,000 K.C.
3900 ANGSTROM UNITS
ULTRA-VIOLET LIGHT
3.7 OCTAVES
10,000,000,000,000 K.C.
300 ANGSTROM UNITS
X-RAYS
11.6 OCTAVES
RAYS THAT PENETRATE MOST KINDS OF MATTER.
30,000,000,000,000,000 K.C.
.1 ANGSTROM UNIT
GAMMA RAYS
3.3 OCTAVES
FROM RADIUM
300,000,000,000,000,000 K.C.
.01 ANGSTROM UNIT
UNEXPLORED REGION. WAVES STILL SHORTER THAN GAMMA RAYS



RADIO FREQUENCIES THAT WE CAN HEAR

The longer waves of radio overlap into the range of audio frequencies, as is shown in this diagram.

of the speed of radio waves. The speed of sound in water is about 1,500 meters a second. The fastest known speed for sound is in steel; it is about 5,300 meters a second.

Not only radio waves but all kinds of ether waves are designated most conveniently by their frequencies. The table on page 407 gives in form convenient for reference all the ether waves now known with their frequencies and the corresponding wavelengths in vacuum. The term "octave" is borrowed from music. One octave means all the waves between any particular frequency and a frequency twice as great. For example, the first octave of the table includes all the waves between a frequency of 20 cycles a second and a frequency of 40 cycles a second; the second octave is from 40 to 80 octaves a second, and so on.

The entire series of ether waves, from the longest radio waves to the shortest gamma rays, is now known without gaps. There was formerly a gap between the ultra-violet waves and the X rays, but this has been filled by the discovery of some very long X rays lying well within the ultra-violet range. The other former gap, between the heat waves and radio waves, was filled recently by the work of Nichols and Tear (POPULAR RADIO for July, 1923).

The divisions of the waves into radio waves, heat waves and light waves, are made merely for convenience. All the waves belong, really, to one unbroken series. Many of the divisions are overlapped, just as the heat waves overlap the short radio waves and the X rays overlap into the ultra-violet. A similar overlap of the audio frequencies and the radio frequencies is shown in the illustration on this page.

The ether waves that have been most

studied by scientists are those of light. These differ from the longer and shorter waves only in that they happen to be perceived by the human eye. Physically all the waves are the same. The *color* of light depends upon its frequency, or, what is the same thing, upon its wavelength. The band of color in a rainbow, which scientists call the spectrum, is as follows:

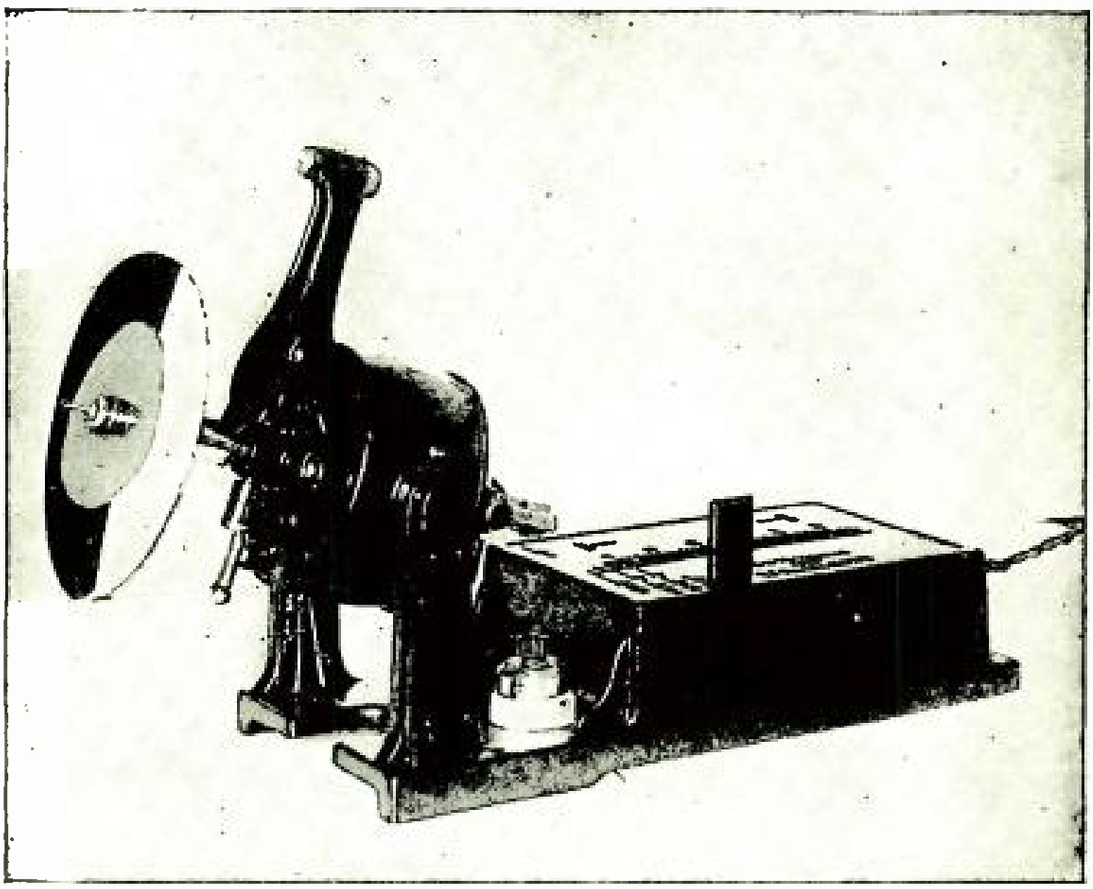
	Angstrom Units
Heat waves (invisible)	longer than 7,750
Red light	7,750 to 6,460
Orange light	6,460 to 5,900
Yellow light	5,900 to 5,600
Green light	5,600 to 4,900
Blue light	4,900 to 4,500
Violet light	4,500 to 3,900
Ultra-violet rays (invisible)	shorter than 3,900

The Angstrom unit used in this table and which is the common unit for the length of light waves, equals one ten-billionth of a meter. It is named after the celebrated Swedish scientist Dr. K. A. Angstrom, who was the first to study and chart the spectrum of sunlight.

Other units of length sometimes used in designating the wavelengths of ether waves, are the following:

1 meter.....equals 1,000 millimeters
1 millimeter....equals 1,000 microns
1 micron.....equals 1,000 double microns
1 double micron equals 10 Angstrom Units

The abbreviation for micron is the Greek letter mu (μ), that for the double micron is ($\mu\mu$); that for the Angstrom Unit is A. U. or sometimes merely A. A double micron is sometimes called a "micro-micron" or a "mille-micron."



Brown Bros.

HOW COLORED LIGHT WAVES ARE MIXED AND JUDGED

One half of the colored rim on the edge of the disk is red, the other half is white. When the disk is rapidly revolved by the attached electric motor the light waves from the two portions of the disk blend in the eye, producing a shade of pink. In the same way the color-blends necessary to produce any desired shade of any color can be worked out in the laboratory. Psychologists also use this same instrument to study the way in which the human eye sees various mixtures of light of different colors.

Einstein May Be Wrong After All

HAS the Einstein Theory been proved right, finally and certainly, by the photographs taken last year in Australia during the eclipse of the sun and recently announced by Dr. Campbell?*

Many scientists would be inclined to answer yes. But Professor William H. Pickering, distinguished student of the moon and of Mars and one of the most famous of American astronomers, is still disposed to be sceptical. In an article in *Popular Astronomy* for June-July, 1923, he reviews the attempts that have been made recently to check Einstein's famous three proofs of his theory, with results not entirely favorable to the completeness and accuracy of the theory itself.

These three proofs, you remember, were the following:

First, the light from a distant star ought to be bent a trifle as it passes close to the edge of the sun. The exact amount of this bending was calculated from the theory, and it was this amount which was confirmed by the Australian photographs.

Second, some of the dark lines across the rainbow band or spectrum of sunlight ought to be displaced a little in position when compared with the corresponding lines in the spectrum of light produced here on earth.

Third, the Einstein Theory explained, according to its advocates, the slight error long known to exist in the annual motion of the orbit of the planet Mercury.

The predicted bending of the light ray from a star appears to have been confirmed with reasonable exactness. This Dr. Pickering admits. The second proof, the displacement of the solar spectrum lines, has not yet been brought to exact test because of the tremendous experimental difficulties involved in work of this sort. The scientists of the Mount Wilson Observatory, who are admittedly the world experts in this field and who have unsurpassed instrumental equipment for it, are not yet willing to announce any result either for Einstein or against him.

The third proof—with reference to the error in the orbit of Mercury—has usually been considered fully favorable to the theory. Indeed it was the ability of the theory to explain this well-known discrepancy that first recommended it to the serious attention of astronomers. But recent recalculations of the motions of this planet are not, Dr. Pickering points out, quite so much on Einstein's side as has been supposed. The Einstein Theory explains the error in the orbit not only sufficiently, but too much. It accounts for more error than exists.

When all known corrections are applied to the figures, including a correction for the polar flattening of the sun, which seems to have been forgotten in

*See POPULAR RADIO for October, pages 284-285.

the first calculations, the error in Mercury's orbit works out, Dr. Pickering writes, as 38.1 seconds of arc. Einstein's equations account for an error of 42.9 seconds: over ten percent more, that is, than exists.

This does not disprove the Einstein Theory, but it does mean, Dr. Pickering implies, that we should go a little slow in accepting it as complete and final. Perhaps some modification of it may prove to be necessary.

Even the proof from the bending of starlight, while it seems undoubtedly to be a *fact,* may not constitute such a real proof of the theory as it has been thought. Dr. Einstein, to be fair to him, never called any of these three things a *proof.* He said merely that they were *consequences* of his theory; that they would be true if it was, and assuming, of course, the usual other theories as to the nature of light and the like. In recent years it has begun to seem as if this last assumption might be a rather unsecure one. We begin to suspect that our usual theories of light are not quite perfect. Some facts about X-rays, for example, do not fit into them very well. We may have to modify these theories, and this may change somewhat our interpretation of the supposed Einstein proof.

All this makes it increasingly desirable to secure accurate information about the second proof, the predicted shift of the spectrum lines. Many scientists are working on this, and early results are probable. It is possible, also, that the eclipse of the sun that is occurring in Southern California while this number of POPULAR RADIO is being written, may yield information of importance. No total eclipse of recent years has been so readily accessible to centers of population and none in the

Brown Brothers

DOES THE EINSTEIN THEORY EXPLAIN ERRORS THAT DO NOT EXIST?

Possibly, thinks Prof. William H. Pickering, the distinguished American astronomer, who questions whether the "proof" with reference to the error in the orbit of Mercury does not prove too much.

International

THE "ELECTRICAL DOG" AND ITS INVENTOR, JOHN HAYS HAMMOND, JR.

This little car, propelled by battery-driven electric motors, contains an arrangement of selenium cells which directs its movement. It follows a light, turning when the light turns, as a dog follows his master.

history of the world has been attacked by such an assemblege of scientists as have gathered in California and Mexico for this one.

Machines That Operate by Light Waves

THE extraordinary property of the metal selenium by which it changes in electrical conductivity whenever light falls on it has been for years an incentive to inventors. Devices employing it have ranged from machines to open window shades when the sun rises in the morning to automatic dogs that will follow you about if you hold up a lamp in front of them. The newest one, of which we read in a recent number of the *Wireless Review* (London), is a device that dims automatically the headlights of your automobile whenever another car approaches yours on the same road.

A selenium cell fixed to the front of your car receives the light rays from the approaching headlights. This changes the resistance of the selenium and actuates a relay which inserts a dimming resistance into your headlight circuit.

So passes a test of road courtesy. When you see the other fellow's lights grow pleasantly dim as you approach, you will not know any more whether it is because he is a member of the fellowship of friendly drivers or whether it is merely because he has money enough to buy a selenium cell.

French Time Signals Are Late

THE report of the British official astronomical observatory at Greenwich indicates that during 1922 the daily time signals sent out by the French radio station at Paris were, on the

average, .04 second later than the British signals. The signals from the Bordeaux station showed an even greater lag, the average discrepancy being .08 second. Both of these figures indicate the final unexplained discrepancy after all known corrections have been applied.

During the year the American signals averaged .03 second behind the British ones, but this is explained by the British authorities as being due to the time required for the wave to cover the long distance separating the two stations. The German signals from Nauen coincided exactly with the British ones.

More interesting, really, than speculation about the possible cause of the lag in the French signals is the fact that this lag was discovered at all. Such precision in the comparing of times between two distant stations would have been absolutely unobtainable before the development of radio. This is only one of the many ways, as pointed out by General Ferrié in his article in POPULAR RADIO for October, in which radio is proving of assistance to other sciences.

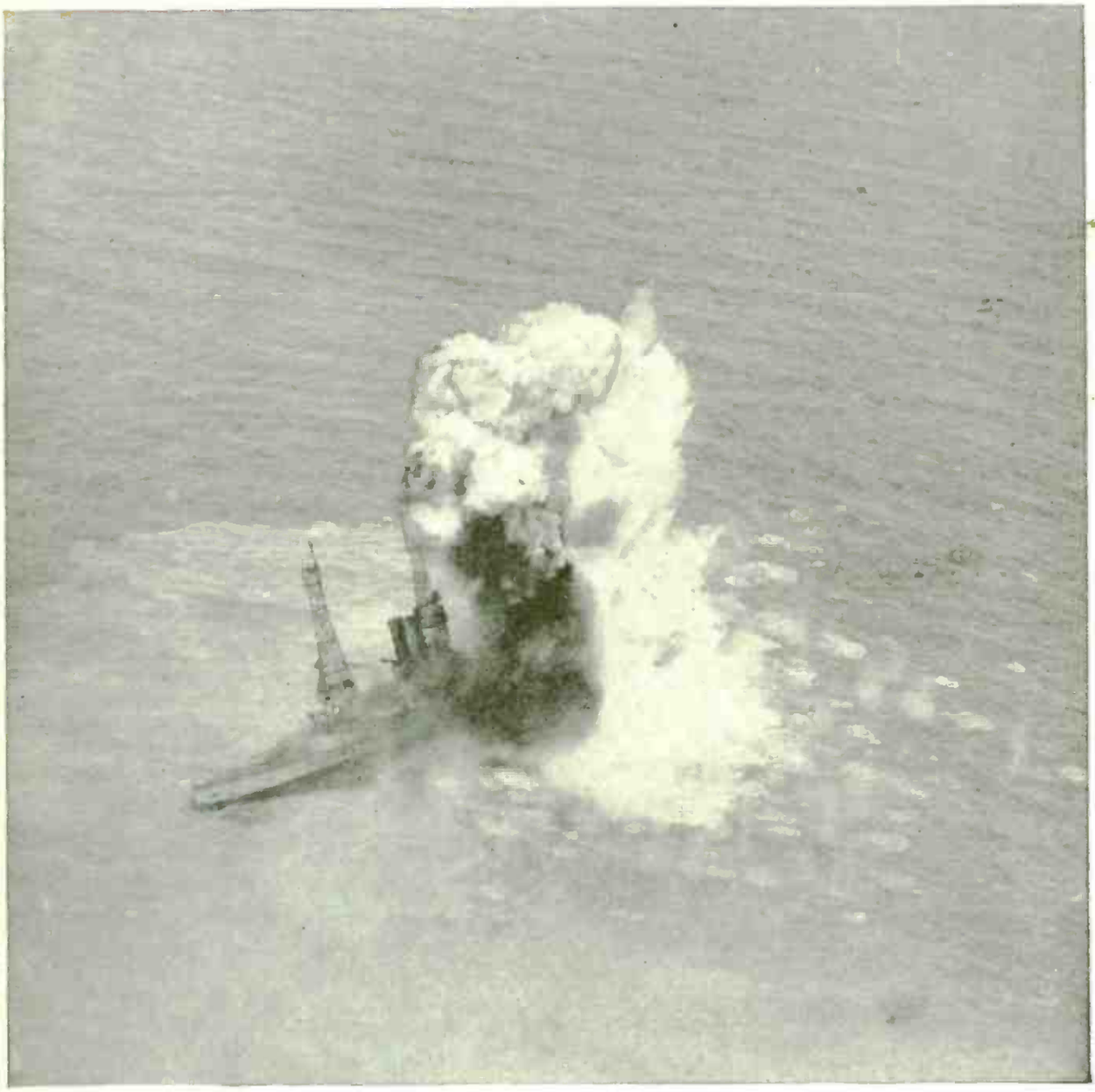
The Future of the Airplane Controlled by Radio

WILL one of the gifts of radio to the world be a mail route encircling the globe in a score or two of hours; moving, that is, as fast as the sun itself? Will we ship freight to Europe overnight? Will the thousand or so men who are necessary to man and operate an ocean liner be replaced by three or four radio operators bending over their keys somewhere in a seaport city?

None of these things is impossible if we are to share the enthusiasm of the

A MAIL CARRIER OF THE FUTURE

A radio-controlled airship recently exhibited in London and said to be capable of making long flights without either passengers or pilot.



U. S. Army Air Service

RADIO-CONTROLLED SHIPS MAY BE DESTROYED BY RADIO-CONTROLLED AIRCRAFT.

In trials by the United States Navy, the battleship Iowa, *with no one on board, was steered and controlled by radio while aircraft attacked the moving ship with full-sized bombs, simulating the conditions of actual warfare.*

scientists and engineers who gathered recently at the jubilee meeting of the French Society of Civil Engineers to hear and discuss the paper of M. Percheron on the possibilities of the pilotless, radio-directed airplane. In the presence of General Ferrié, the head of the French radio service, of M. Soreau, the expert on commercial aviation, and of many other distinguished members of the Society, M. Percheron described some of the French experiments, military and otherwise, in which automatic devices controlled the flight of planes; some of them carrying pilots who acted merely as observers and never found it necessary to touch the controls, others entirely without human passengers and dependent for their control altogether upon the radio signals sent out from ground stations.

The fact that such devices were developed in the latter days of the war by most of the allied nations is common

knowledge, but they have been thought of in the main as having military value rather than as being useful in time of peace. But it is evident, M. Percheron said, that a perfected man-less plane will make available for ordinary use the higher regions of the atmosphere where the air is thinner and the speed attainable by a plane is correspondingly greater. Mail planes cannot now fly at these great elevations because of the discomfort to the pilot. If there is no pilot this limit disappears.

That our own aviation authorities are not unmindful of these possibilities is evidenced by a recent statement made by General Mitchell, of the Air Service, U. S. A., in the course of an interview predicting that airplanes could probably rise without great difficulty to 55,000 feet above the earth, nearly four miles above the present record. At such a height, the general said, planes might be flown to Europe in a few hours. Automatic machinery in the plane would send out radio signals at regular intervals. These signals, picked up by properly placed direction-finders on shore would enable the operators here to keep in constant touch with the position of the plane and to send out from time to time the necessary control signals to direct its flight.

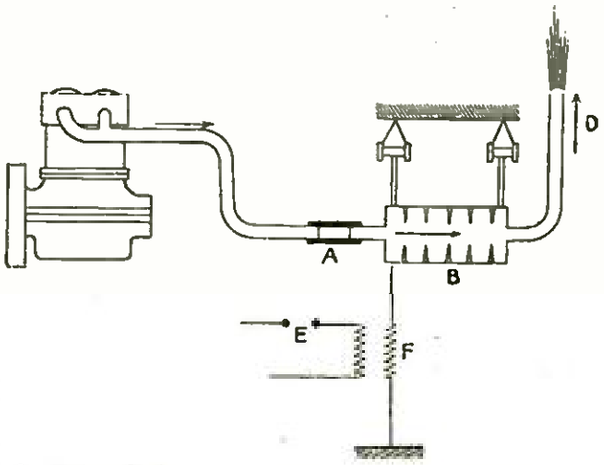
All this is wonderful enough, but a suggestion may be added. If radio movies prove possible, as it now seems almost certain that they will, such a machine placed in the plane would enable the operator at home actually to see out from the plane at all times and to control its flight visually, just as a living pilot would do. Think of the possibilities for military observation during war, of exploration over unknown country, of stay-at-home travel! One could actually send an eye out anywhere in the world to look at things and to report instant by instant whatever was visible from where it happened to be. The traditional magic carpet, gives place to the radio eye.

Exhaust Gases Used as an Antenna

ACCORDING to a note in *La Nature* (Paris) Mr. A. M. Low has patented a novel and surprising method of doing away with metallic antennas, either for reception or transmission. He uses the exhaust gases of his automobile or of any other internal combustion engine. These gases, of course, are discharged from the engine in a highly ionized condition so that they form a conducting cloud extending some distance into the air, just as a cloud of smoke or steam rises some feet above a smoke-stack. If an alternating potential is communicated to such a cloud a wave will be propagated from it much as from a metallic antenna.

The arrangement of the apparatus is shown in the accompanying illustration. The muffler is insulated from the body of the engine and is connected to the exhaust line by means of an insulating coupling. The radio signal wave is fed into the muffler, the internal points serving for the more perfect communication of the impulses to the ionized gas.

The invention is expected to have its main use in airplane radio where it may result, experts believe, in doing away with the trailing wire and other forms of metallic antenna.

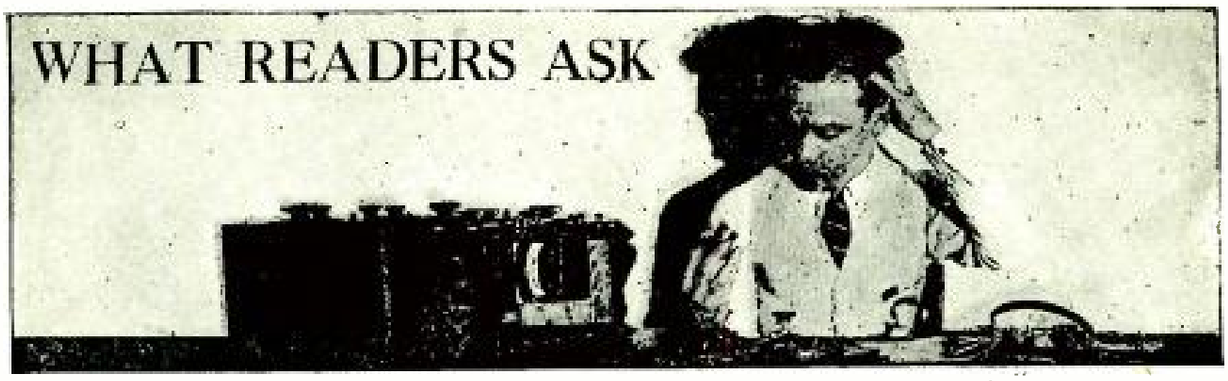


La Nature, Paris

THE EXHAUST-GAS ANTENNA

B, is the muffler, insulated from the engine by a non-conducting suspension and by the insulating coupling A. Radio impulses enter the muffler by way of F, and are communicated to the exhaust, D.

WHAT READERS ASK



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

THE flood of inquiries that has poured in upon the Service Bureau 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 co-operate 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 Service Bureau 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. No inquiries can be answered personally or by telephone.*

QUESTION: Can spider-web coils be substituted for honeycomb coils in a triple-coil honeycomb circuit?

BREWSTER JENKINS

ANSWER: Yes. These two types are often employed interchangeably in the same circuit using a primary coil, a secondary coil, and a tickler coil.

* * *

QUESTION: What is the average plate current of an ordinary six-volt detector tube? I get a reading of only about ¾ to 1½ milliamperes, and I was given to understand that the tube should have a much greater plate current.

A. MILLER-ROBERTS

ANSWER: In order to work on the proper part of the curve (of grid voltage plotted against plate current) to obtain detection, the tube's plate current will be small. The values you have given are representative of the values ordinarily found. However, if the tube were used as an amplifier the plate current may be raised to several times that value.

QUESTION: Why is it that when I change wavelength on my one-tube, crystal-detector reflex receiver, I also have to change the adjustment of the crystal detector? If I do not, the set oscillates. Why is this?

ORVILLE F. ROGERS

ANSWER: If you tune the set to any given wavelength and then lift the crystal adjustment spring off the crystal you will immediately hear the set commence to oscillate. When you adjust the crystal for that wavelength you also are adjusting the resistance of the secondary circuit of the radio-frequency transformer to a certain critical value that stops the set from oscillating. It is really a transfer of effective resistance from the crystal circuit through to the grid circuit of the first tube that controls regeneration in this type of receiver.

When you change wavelength, however, you need a *different* resistance in the crystal circuit to keep the radio-frequency circuit stable, and so you have to readjust the crystal until you have obtained this value to get the best results.

QUESTION: What is the best test for deciding what kind of horn to buy for a loudspeaker? Sometimes the dealers do not have a set going and one has to take their word for it that the type they offer is as good as they say. Can you tell me of any precautions or hints that might help me to pick out a good one?

REYNOLD FENNER

ANSWER: The best test of a loudspeaker is to listen to it in operation. However, you may be helped by the following suggestions:

1. Try tapping the horn with the finger; if it rings with a high tinny note it will reproduce with a twangy sound and will probably rattle on some of the higher tones. It should give off a dull, low thud, if it is to operate satisfactorily.
2. Composition fibre horns are usually less resonant than thin metallic horns.
3. The better type of energizing unit has a moving element that is not in tortion when no signals are being received. That is, they are usually not affected by the magnetic pull of the magnets when signals are not passing through the coils.
4. The base of the instrument should be solid and heavy.
5. The horn should have as few sharp curves or corners as possible.
6. If you take the horn off and sing the musical scale into it with as near equal intensity as you can, each note should be of approximately the same strength and no particular note should stand out above the rest.

QUESTION: Is there any difference between the operating principle of the Fleming valve and the new diode tube?

J. C. D.

ANSWER: They both work on the same principle as an electron-discharge valve. The last mentioned tube is a recent development of the Fleming valve. They may both be used as a detector but neither of them will operate as an amplifier.

* * *

QUESTION: Please let me have a diagram of the triple-coil honeycomb outfit for one tube. I was told that this is a good regenerative circuit for a beginner to start with. I want to build it myself.

ALAN BRENT

ANSWER: You will find the hook-up in Figure 1. The instruments necessary to include in the circuit are the following:

L1—honeycomb or duolateral coil, L-35 or L-50;
L2—honeycomb or duolateral coil, L-50;
L3—honeycomb or duolateral coil, L-75;
VC1—variable condenser, .001 mfd.;
VC2—variable condenser (vernier), .0005 mfd.;
GL—grid leak, 1 or 2 megohms;
GC—grid condenser, .0005 mfd.;
C—mica fixed condenser, .0005 mfd.;
R—filament rheostat.

If a dry-cell tube is used, the filament rheostat should be suitable for the tube; ask the dealer. If a regular 6-volt detector tube is used, use a 6-ohm rheostat.

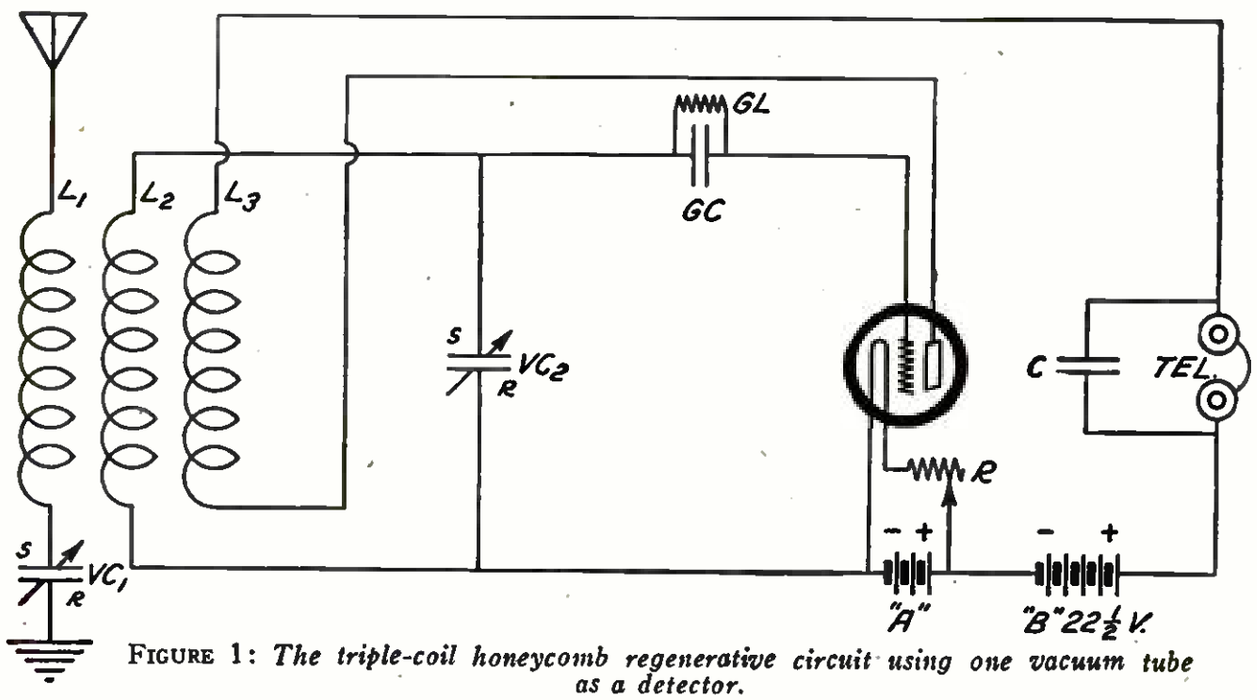


FIGURE 1: *The triple-coil honeycomb regenerative circuit using one vacuum tube as a detector.*

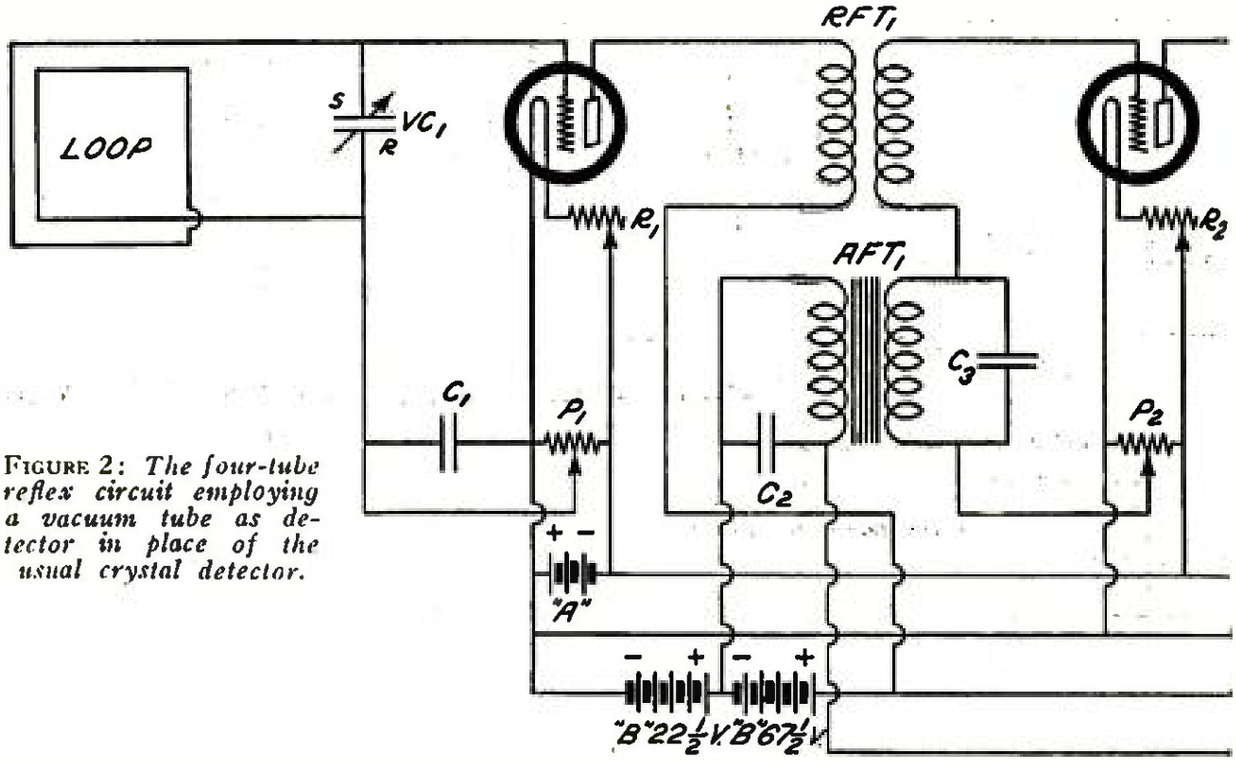


FIGURE 2: *The four-tube reflex circuit employing a vacuum tube as detector in place of the usual crystal detector.*

QUESTION: In the July issue of POPULAR RADIO you printed a circuit (Figure 4, page 78) showing three stages of radio, two stages of audio-frequency amplification, and a crystal detector, with three vacuum tubes. This reflex circuit works fine on a loop antenna, but I don't like the bother of "setting" the crystal detector in adjustment all the time. Will you please show me how to add a vacuum-tube detector in place of the crystal? I have tried it but have had no success, so I thought I had better come to headquarters and get the correct information. ROWLAND BATES

ANSWER: The four-tube reflex circuit shown in the diagram in Figure 2 gives you the information that you require. Exactly the same parts are used that were contained in the old crystal circuit, except for the vacuum tube, which replaces the crystal, and a grid leak GL, of 2 megohms resistance, a grid condenser GC, of .00025 mfd. capacity, and an additional rheostat. Four C-301-A tubes or UV-201-A tubes, or DV-6-A tubes may be used with good results.

* * *

QUESTION: Is a power amplifier much different from an audio-frequency amplifier? JACK ROCHE

ANSWER: Both of the types of amplifiers known by the popular names you mention are really audio-frequency amplifiers. The power amplifier is an audio-frequency amplifier that uses larger tubes than ordinarily used in the regular audio-frequency amplifiers attached to a radio receiving set. This means that it is necessary to employ higher plate voltages and also a "C" battery to keep the grids of the tubes at the correct free potential for proper operation.

Some types of power amplifiers use two tubes for each stage. These are connected "back-to-back" with a special split-winding transformer so that the cores of the transformers are not saturated when no signal is being received.

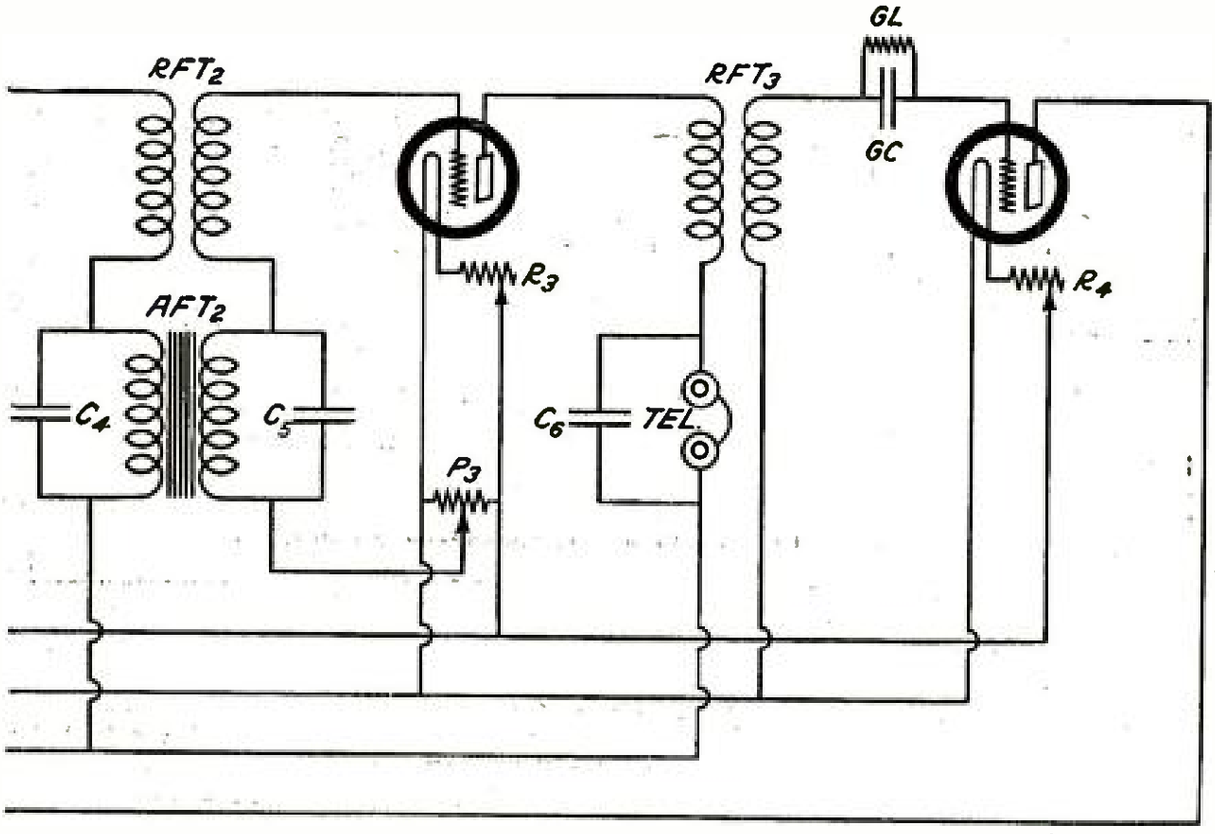
* * *

QUESTION: I want to use the electric light lines for an antenna as I cannot put up an outdoor installation. What kind of a device or instrument is used for connecting to the electric lamp sockets? Do they work well?

S. N. SMITH

ANSWER: The part you must ask the dealer for is an electric light adapter. There are a number of these devices on the market with various trade names, but the dealer will understand if you ask him for an adapter to use the electric light circuit for an antenna.

These devices do not work with the same efficiency in all locations. In some houses they will not work at all. However, it is worth trying if you can not put up any other kind of antenna.



QUESTION: What sized motor generator should I buy to operate two 250-watt G. E. transmitting tubes, one as an oscillator and one as a modulator with a 50-watt speech amplifier?

R. M. H.

ANSWER: You will need a one-kw. machine at least.

* * *

QUESTION: Which is the best for local reception, a crystal set or a vacuum-tube set?

THOS. J. GREGG

ANSWER: They both have their advantages and disadvantages. The crystal is the simplest and the cheapest but it will not bring in the signals as loud as the vacuum-tube set. Although the vacuum-tube set *is* more expensive, it will be found to be more reliable and the detector action is permanent; there is no adjustment of the vacuum tube to sensitivity as in the case of the crystal and it is not knocked out of adjustment. For all around use the vacuum-tube set furnishes the more reliable and efficient service.

* * *

QUESTION: Will it be feasible to use a gas pipe as a ground for my receiver? I will have to run a wire about fifteen feet if I use a water pipe.

JAMES CULBERT

ANSWER: The gas pipe will not be good. Use the water pipe even if you have to run fifty feet to get to it.

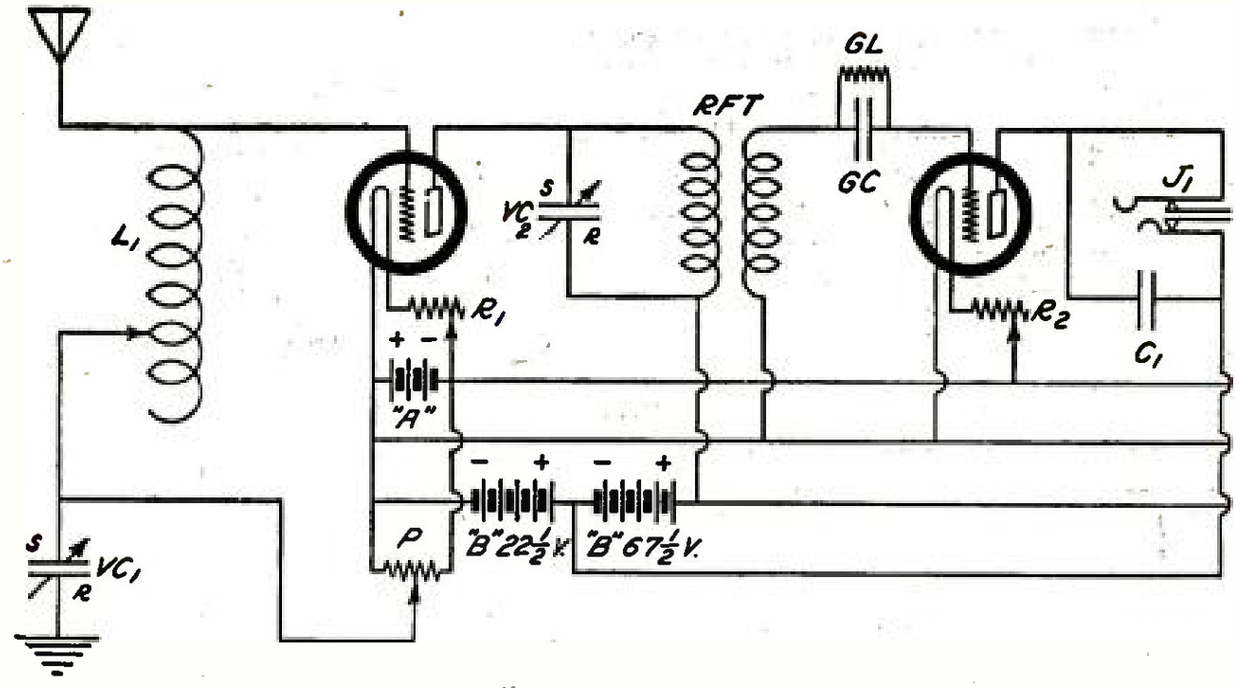
* * *

QUESTION: What is the best way to control the regeneration in an ordinary ultra-audion circuit? Should I use a variable grid condenser or would a variable bypass condenser across the telephones and "B" batteries be better? Or should I use both? I know that the filament rheostat plays an important part in the proper control of this simple circuit but I want to get your views on the subject.

RAYMOND NILES

ANSWER: With a fixed condenser in the grid circuit and a variable condenser used in the plate circuit as a bypass across the telephones, you should get the best results. Varying the grid condenser will also do the same thing but when the grid condenser is varied to a rather high capacity, the tuning may become broadened and at the same time the regenerative control will become "sticky;" that is, it will burst into oscillation and you will have to reduce the capacity of the condenser to a low value and work up again. The variable plate bypass condenser is much the better of the two.

The filament need only be set at approximately the right value and all the control work done with the variable.



QUESTION: Will you kindly give me a hook-up for connecting the following apparatus in a circuit for one stage of tuned radio-frequency amplification, detector and two stages of audio-frequency amplification? The parts are:

1 Variable inductance.....(L1)
2 General Radio variable condensers, .001 mfd.....(VC1 and VC2)
3 UV-201-A vacuum tubes (amplifiers);
1 UV-200 Vacuum tube (detector);
1 Framingham potentiometer....(P)
1 R. M. C. radio-frequency transformer .....(RFT)
1 Dubilier combination grid condenser and leak.....(GC and GL)
3 Amsco filament rheostats, 20 ohms .....(R1, R3 and R4)
1 Amsco filament rheostat, 6 ohms .....(R2)
2 Cardwell amplifying transformers .....(AFT1 and AFT2)

Are there any other parts I will need?

JOSEPH D. HADDON

ANSWER: The circuit is given in Figure 3. You will also need a mica fixed condenser, C1, of .0005 mfd. capacity for shunting the primary of the transformer AFT1, and two double-circuit and one single-circuit jacks, J1 and J2, and J3, respectively.

The antenna tuning is accomplished by varying the inductance of L1, and the capacity of VC1.

The radio-frequency transformer is tuned by the variable condenser VC2. This really tunes only the plate circuit of the first tube but the two coils of the transformer RFT, are so closely coupled that this really forces the tuned signals into the secondary winding. The circuit is a good one.

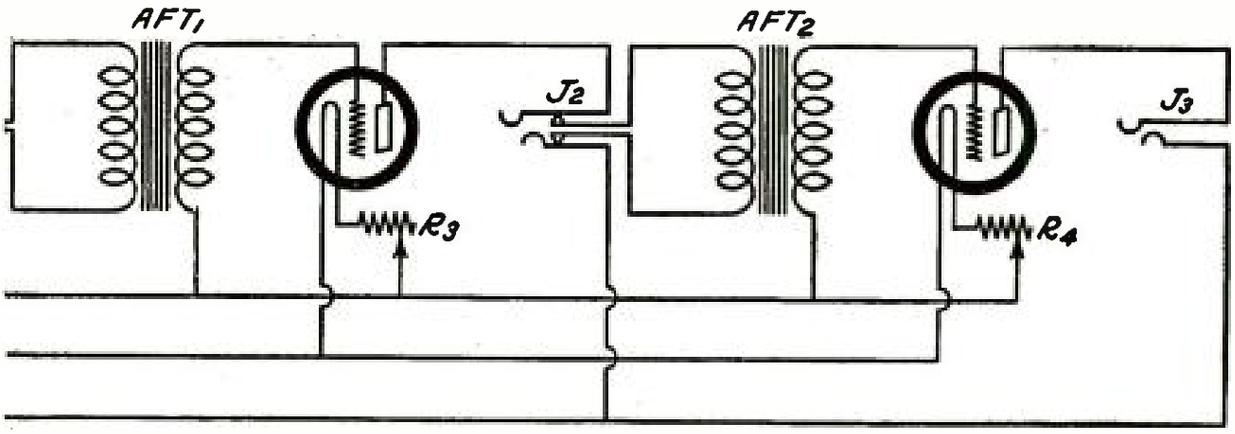
* * *

QUESTION: From which will I get the most sensitivity, a straight regenerative circuit using only one tube, or a non-regenerative circuit using one stage of radio-frequency amplification and a detector, with two tubes? What are the outstanding features of both methods, and which of the two would be the easiest to operate from the standpoint of the layman who does not know the delicate tricks of tuning?

D. FALSTER HOFFMAN

ANSWER: This is a matter of opinion which has not yet been satisfactorily settled. There are so many different radio-frequency systems, and they all have their advantages and disadvantages when considered from various viewpoints, that it is hard to rate radio-frequency amplification under any one set standard. Regeneration, however, is, without doubt, the most efficient method of combining radio-frequency amplification and detection in one tube. It has the disadvantage (in the hands of an inexperienced operator) of sending out interfering waves, if the set is too closely coupled with the antenna circuit, or, if not controlled properly, it may not be brought up to the most efficient operating point. The more recent re-

FIGURE 3: *One stage of tuned radio-frequency amplification, detector and two stages of audio-frequency amplification. This is a real reliable distance getter.*



generative circuits that employ looser coupling and simpler regenerative control go a long way to overcome these difficulties while at the same time retaining all the good advantages of the older circuit arrangements, and in some cases they produce even better results.

Radio-frequency amplification, however, although more tubes are used and although it is harder to tune, has its own advantages, especially the newer types of inductively tuned radio-frequency circuits employing compensating condensers which keep the circuits from falling into oscillation by preventing any feedback of high-frequency energy through the capacity of the tubes themselves. These newer circuits are extremely favorable to long-distance reception on a loop antenna, and the signal-static ratio on such a receiver is considerably increased.

For a given number of tubes, the regenerative method is undoubtedly the peer, but where unlimited radio-frequency amplification is necessary, there is no other way out but to use cascade radio-frequency amplification at the wavelength of transmission, or by some method similar to the super-heterodyne in which the signal is changed to a lower frequency and then amplified with greater efficiency than is now possible at the higher frequencies.

* * *

QUESTION: I am located among the tall buildings of a large city, and am only one half mile from the largest broadcasting station in this section of the country. When this station is working I am, at present, unable to hear anything else. And yet I am using the regular regenerative circuit with a variocoupler and two variometers, which, I was given to understand would tune out anything.

At any rate I am unable to do it, so will you kindly let me know of some circuit, reflex, neutrodyne, Flewelling, four-circuit, or anything, which should enable me to get some of the other local stations, at least.

I can hear the other stations with my present set, but they are "in the background and always overpowered by the station first spoken of.

Would the four-circuit tuner be the right thing to use? The circuit appeals to me.

HARRY Z. MENDEL

ANSWER: The four-circuit tuner will do the work you require. This is because of the extremely low decrement of the circuits used and the loose coupling employed. Be sure to use coils which are wound on composition tubing of good quality and be sure that there is no shellac or any other kind of insulating paint used on the windings; otherwise even this circuit will tune too broadly.

* * *

QUESTION: How many volts should be used on the plates of the C-301-A tubes when they are used as amplifiers?

S. BENNINGTON

ANSWER: Not more than 90 volts, unless "C" batteries are used. You may use up to 120 volts if you use a "C" battery of 9 volts on the grids of the amplifiers.

* * *

QUESTION: What capacity of condenser is used in the secondary circuit of the Haynes type receiver? I want to get a Cardwell condenser for this set and I do not know what size to ask for.

ALLEN AIRES

ANSWER: The correct capacity is .00025 mfd.

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

Radio Renders Heroic Service to Humanity

No more impressive evidence of the inestimable value of radio in the hour of emergency for summoning aid when moments were priceless and in broadcasting warnings when those warnings saved human life, can be offered than in the earthquake calamity in Japan early in September. A part of this service is told here:

The calamity which practically wiped out Tokyo and Yokohama and broke the Pacific cable, gave radio another opportunity to demonstrate to the world its value in international communication, especially in emergencies when land lines and cables fail. Without the single radio communication link left at Iwaki the world might have been without details of the Japanese disaster for as long as a week. Bits of news and imperative information would have been put through by cable, but radio is said by Secretary Hoover to have literally saved the day in bringing in relief as well as in carrying out the news.

To be sure, the first brief message of the disaster came to the Japanese Ambassador at Washington by cable from Nagasaki *via* London—out of the back door of the East, as it were, and over cables estimated 15,000 miles long. The commercial cable from Japan to Bonin Island (reported submerged) and thence to Guam, was put out of service by the earthquake, so that messages were routed east by way of Manila, Shanghai and Nagasaki, or west by way of London.

It remained for radio to carry most of the official dispatches and news reports across the Pacific to North America, and radio, aided by the remaining cable connection of Nagasaki handled a tremendous amount of traffic. The Japanese government station at Iwaki, or Tomioka, stepped into the breach and the world now knows of the excellent service rendered by the Japanese operator who stood a long watch alone. His call and messages on the disaster were picked up by the Radio Corporation's station at Bolinas, California, and were relayed to all points in the United States. Iwaki, which is about 144 miles from the stricken cities, for some time had no means of communication inland; at the suggestion of the Japanese Ambassador at Washington, however, a courier service was established to Tokyo and a regular schedule was put in operation. A statement that "communication was open to Tokyo" by the State Department, led some to believe that line wire communication between the station and Tokyo was established, yet no wires had been re-established. Since the advent of radio, it seems that a new word must be substituted for "communication" when referring to roads and other lines of transportation.

Radio was the means of getting the first authentic account of the disaster to the new world on September 4, when the master of the *S. S. President Jefferson* radioed to his Shanghai office from the port of Yokohama direct. The American Consul put the message on the cable for Secretary Hughes in Washington, where facts relating the unsafe condition of the harbor at Yokohama were immediately broadcast by the Naval Hydrographic Office, so that all ships might be warned of the hidden dangers there owing to the absence of lights.

The U. S. Naval forces in Japanese waters also rendered official emergency service by radio. The American Asiatic fleet was at Yokohama and the Destroyer *Borie* was stationed at Nagasaki as a radio relay ship. Messages from the American flagship were picked up by the *Borie*, relayed to the Naval radio station at Cavite and thence to the Naval station at San Francisco. Government west-bound messages were sent from Washington *via* the Annapolis radio station or commercial land lines to San Francisco, where they were relayed *via* Honolulu, Guam and Cavite to the *Borie*

and thence to the American fleet off Yokohama. The *U. S. S. Sacramento* was stationed at Woosung, China, to relay radio messages. The naval service delivered official dispatches to Yokohama within twenty-four hours.

Many radio experts feel that the terrible disaster and the severing of communication out of Japan will aid materially in establishing better radio service between Nippon and the world. The policy of the Japanese government has been to control radio, although American commercial companies have been endeavoring to provide better stations and transmission for some time. It is now hoped that American radio interests will be given the opportunity to establish high-powered stations in Japan.

—Carl H. Butman

The Bureau of Standards to Transmit Radio-Frequency Signals

The Department of Commerce has announced a schedule of standard frequency radio signals to be transmitted by the Bureau of Standards for the months of October, November and December. These signals should be of interest to all transmitting station operators in checking wavemeters and adjusting transmitting and receiving apparatus; their accuracy is better than three-tenths of one percent. The full announcement follows:

Commercial and ship operators should be especially interested in the transmission of October 20. The signals of November 20 cover approximately the same band as those of October 20; the signals of November 5 cover the frequency band used by "Class B" broadcasting stations. The frequencies transmitted on December 5 cover those used by all broadcasting stations as well as some used by amateurs.

Measurements made at the bureau of the frequencies on which broadcasting stations are operated indicate that some stations are not remaining on their assigned frequencies, hence are causing interference with programs from their own as well as other broadcasting stations.

The schedule followed in these transmissions will be slightly different from that followed in the past. All transmissions will be by unmodulated continuous-wave telegraphy and no announcement will be made by voice. This considerably reduces the time of transmitting any one frequency. The signals will in other respects be similar to those transmitted in the past. A complete frequency transmission will include a "general call," a "standard frequency signal" and "announcements." The "general call" will be given at the beginning of the eight-minute period and will continue for about two minutes. This will include a statement of the frequency. The "standard frequency signal" will be a series of very long dashes

International

THE RADIO ENGINEER WHOSE STATION SUMMONED AID TO JAPAN

Mr. Wakamatsu was the radio expert in charge of the Haranomachi branch of the Tomoka radio station that for a few fateful hours was the only link between the devastated areas and the rest of civilization. The remarkable concrete antenna towers, 660 feet high, were designed by the Japanese scientist F. Omori for the express purpose of withstanding earthquake shocks; to his genius is largely due the help that was summoned in time to save countless human lives.

with the call letters WWV intervening. This signal will continue for about four minutes. The "announcements" will be on the same frequency as the "standard frequency signal" just transmitted, and will contain a statement of the measured frequency. An announcement of the next frequency to be transmitted will then be given. There will then be a four-minute interval while the transmitting set is adjusted for the next frequency.

The complete schedule has been so planned that a wavemeter may be accurately calibrated over a range of from 150 to 1,700 kilocycles, if all of the transmissions are received. With sensitive receiving apparatus it should be possible to receive these signals anywhere east of the Mississippi River.

The complete schedule of standard frequency signals to be transmitted follows:

Schedule of Standard Frequency Transmission from WWV

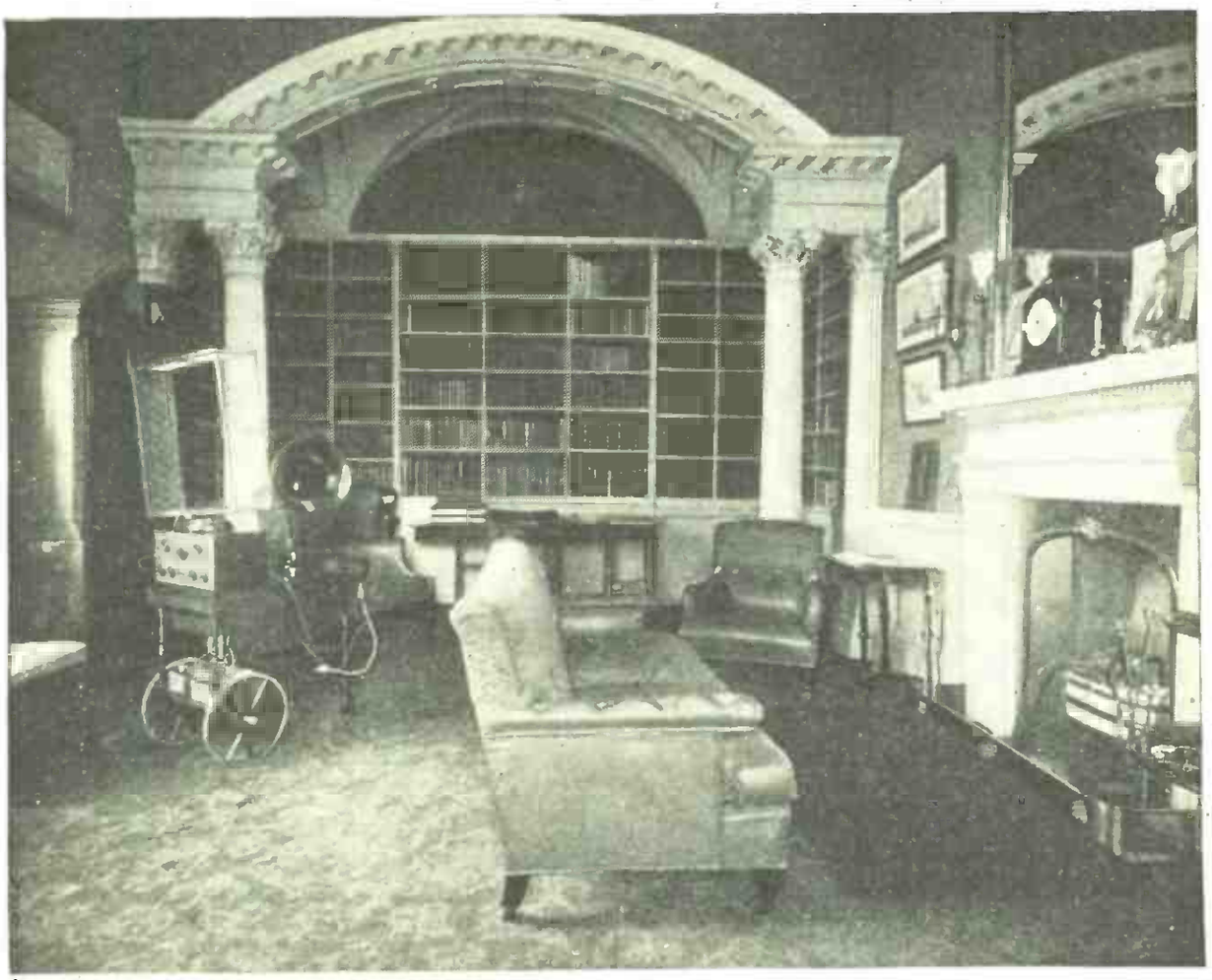
Wavelength in meters is given in parentheses.

Eastern Standard Time	OCT. 20	NOV. 5	NOV. 20	DEC. 5
		Kilocycles		
	166.5	500	150	500
11.00 to 11.08 P.M...	(1800)	(600)	(1999)	(600)
	220	580	190	700
11.12 to 11.20 P.M...	(1363)	(517)	(1578)	(438)
	275	640	240	900
11.24 to 11.32 P.M....	(1090)	(468)	(1249)	(333)
	315	700	290	1100
11.36 to 11.44 P.M...	(952)	(428)	(1034)	(273)
	375	760	360	1300
11.48 to 11.56 P.M...	(800)	(394)	(833)	(231)
	425	833	430	1500
12.00 to 12.08 A.M...	(705)	(360)	(697)	(200)
	500	920	500	1600
12.12 to 12.20 A.M...	(600)	(326)	(600)	(187)
	666	1,000	570	1700
12.24 to 12.32 A.M...	(450)	(300)	(526)	(176)

A Long-distance Watch Tick

AUDIENCES that have been held so spellbound in the theater that they could "hear the ticking of a watch" may have to change a time-worn expression that is being made obsolete by radio. Here is an account of a watch tick that was heard hundreds of miles:

Listeners-in had a new and odd experience recently when they heard the ticking of a



© Vandyck, London

WHERE ROYALTY LISTENS IN

When His Royal Highness, the Duke of York, democratically wants to join the growing army of radio "hams" in England, he merely directs his butler to wheel in his portable radio set—shown above in the duke's sitting room.

Gilliams Service

AN EXTRAORDINARY MECHANICAL CODE WRITER

This machine, invented by Dr. Scherbius, a noted Austrian electrical expert, is capable of 22,000,000,000 code combinations. It may be operated by any typewriter and is capable of writing code messages as they are received by wire or radio and deciphering them automatically.

watch that was held near one of the microphones on the stage of the Municipal Theater in Forest Park, St. Louis, while the operetta *Die Fledermaus* was being broadcast by station KSD. The watch episode was in the second act. Craig Campbell, in the role of Eisenstein, exhibits a lady's watch to a masked woman whom he meets at a gay party. She is his wife, but he does not know it. He playfully counts her pulse while timing the beats with his watch. While doing this Campbell held the watch close to the microphone. Several St. Louisans reported that they distinctly heard the ticking of the watch over their sets and there is no reason to doubt that it was heard at more distant points.

—Edward O'Connor

A Radio Net Around the Arctic Circle

SOME idea of what the long arm of radio may mean to the out-of-the-way places of the world which have been deprived in a large measure of the benefits of civilization, may be derived from this brief description of the extending use of wireless into the waste lands of the far north:

A plan has been adopted by the Canadian government by which Dawson City, of Klondike fame, is to be linked with civilization by radio. Stations will be established at Dawson City, Fort Simpson, and Fort McMurray, constituting yet another step in the taming of the far north. Some idea of the distances involved will be had when it is noted that Dawson is only three hundred miles from the Arctic circle. Heretofore the only electric connection that Dawson City has had with the south, has been by telegraph with Ashcroft, British Columbia. The first of the connecting stations, Fort Simpson, is on the Mackenzie River, in the Northwest Territories; the second, and most southerly, is in the province of Alberta, on the Athabasca River. These stations will be installed this summer.

Next year stations will probably be established at Forts Smith, Resolution, Norman, and Aklavik, thus completing the chain of communication in northwestern Canada.

—K. H. Broadus

DON'T skip any articles in this magazine. They have all been carefully chosen to give the reader the proper perspective of the radio art, and to keep him well informed not only of new scientific developments that mean progress, but of new problems and conditions that confront the radio world, and how they are being solved and overcome.

So, just because you do not have as much of an interest in one subject as in another, do not skip. You will really be missing something that will help you to the right viewpoint. If you do not agree with the other fellow on a certain subject, by reading his argument or discussion you will at least be able to understand how he thinks, while at the same time making your own logical conclusions. Some of the ideas may seem too deep for you, just as some of them may seem too simple, but if you study his views, the deep ideas will finally become clear and understandable and the simple ideas will be of interest just because you know they are true.

You really cannot afford to skip a single item!

* * *

IN making the hoops for supporting the wires of a cage antenna it will be found that No. 00 hard-drawn copper wire will be suitable. Bend a piece of this wire into the proper-sized circle and solder the two ends together (flush) with hard solder. Then you can mark off the proper spacings for the wires by notching with a file. The antenna wires should be wrapped around each hoop with a single turn and soldered firmly in place with the same hard solder.

If this is done the cage will be absolutely permanent.

* * *

WHEN you finally *do* go to bed at night, after listening-in all evening (possibly well on into the morning) are you happy but tired and worn out? Well, then, your "A" battery may feel the same way, and it is a good plan to turn on the charger so that the battery may rest and recuperate while you retire and do the same thing. There is nothing like keeping a battery up to full charge to add to its life. A fully charged battery will also be a great help in enabling you to tune in and hold those long distance signals.

* * *

ONE dead "B" battery connected in the plate circuit of a receiving set will make you think that there is a lot of static in the air and at the same time make you believe that the set has "gone wrong." Always test your "B" batteries with a small high-resistance voltmeter.

* * *

KEEP the terminals of the storage battery coated with a thin coat of vaseline and always be sure that no green, gray, or yellow substance is allowed to collect on them. This will corrode the clips or the copper wire which connects the battery with the set and may often cause noises in the set.

THERE is no fault in a receiving set that is as bothersome and which will last as long without the operator finding out how to eliminate it as the existence of "body capacity."

Body capacity in a receiving set causes the wavelength, to which the set is tuned, to vary when the operator's hand is brought near to or taken away from the tuning dials. In such a case, the operator may have tuned in a distant station, and when he takes his hand away from the dial, the signal will have faded out; if he brings his hand near the dial again the signal will come back in again. So much for body capacity; it is a decided nuisance, and takes the pleasure out of DX hunting.

It may be easily avoided, however, by one of two methods of shielding. One method would be to place a copper sheet on the back of the panel, between the panel and the instruments. The sheet should be grounded.

The better way, would be to place the part (the shafts) of the condensers and variable tuning instruments which face the front of the panel or project through the panel into the knob at ground potential, or at ground potential as far as the radio-frequency currents are concerned.

Therefore, in all of the diagrams which will be published in POPULAR RADIO, the proper way to connect the variable-inductive or variable-capacitative instruments will be shown. The rotating coils or rotating plates will be designated as R, and the stationary coils or plates will be shown as S.

The symbol for the variable condenser will therefore be as shown at A, in Figure 1, and the variable inductance (variometer) will be as shown at B.

* * *

Do not leave kinks in your telephone cords, as this will finally allow them to wear through the fine braided wire and result in a loose connection. Make a practice of untwisting the cords each time you put the telephones on your head and the cords will last a much longer time.

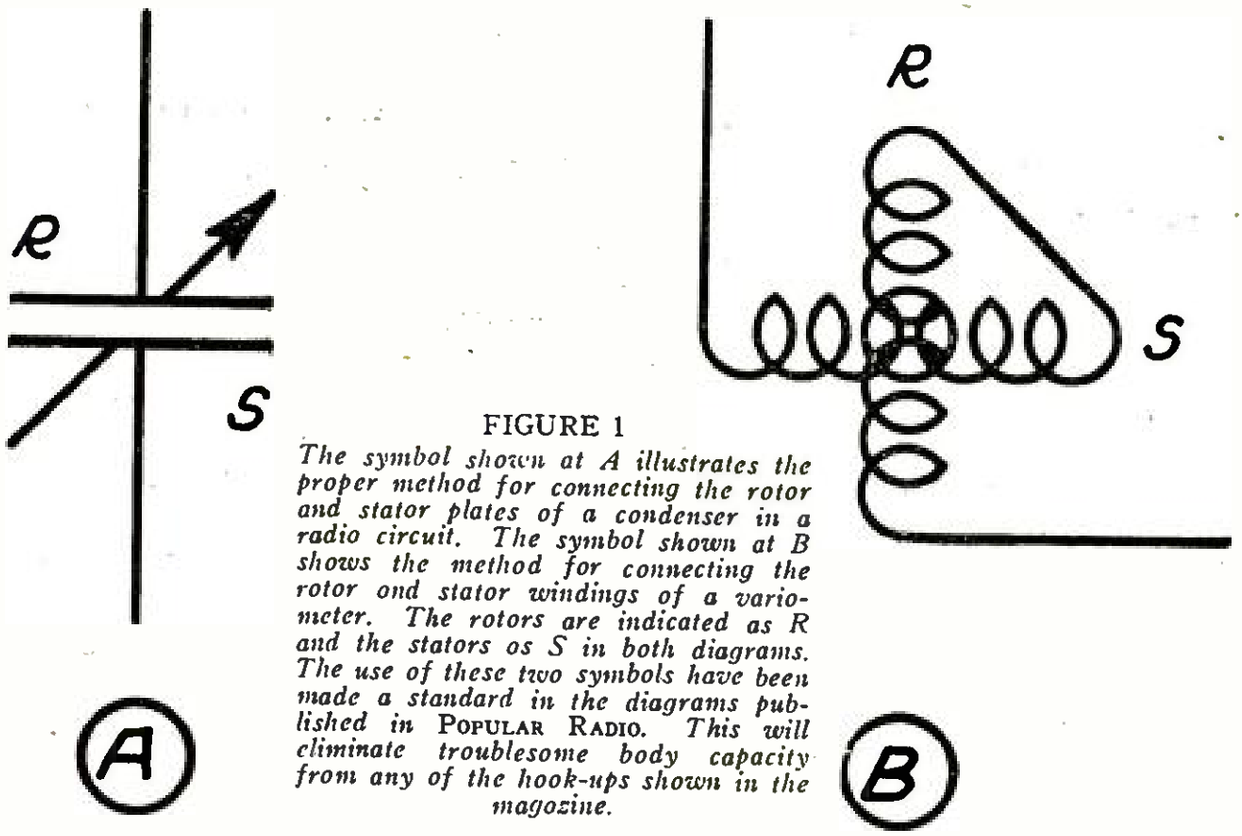


FIGURE 1

The symbol shown at A illustrates the proper method for connecting the rotor and stator plates of a condenser in a radio circuit. The symbol shown at B shows the method for connecting the rotor ond stator windings of a variometer. The rotors are indicated as R and the stators os S in both diagrams. The use of these two symbols have been made a standard in the diagrams published in POPULAR RADIO. *This will climinate troublesome body capacity from any of the hook-ups shown in the magozine.*

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

FIGURE 1: No. 1,458,949. CARRIER RADIO-TELEPHONE SYSTEM. Invented by *Harold W. Nichols,* Maplewood, N. J.

The primary object of this invention is to provide a carrier system which is both efficient and economical. Another object is to provide means whereby a pure modulated wave and energy of the fundamental carrier frequency may be transmitted from a signal station. Other objects will be apparent to those skilled in the art from a reading of the patent, copies of which may be obtained from the Government printing office.

FIGURE 2: No. 1,458,466. ANTENNA SELECTOR SWITCH. Invented by *Alfred Crossley,* Washington, D. C.

The object of this invention is to provide a practical selector switch capable of rapid manipulation to connect various combinations of underground, elevated or loop antenna to the receiving apparatus. Another object is to provide means for insuring perfect electrical contact of the switch elements.

FIGURE 3: No. 1,454,307. RADIO-TELEGRAPHY. Invented by *Adrien L. Anderson,* Palo Alto, Calif.

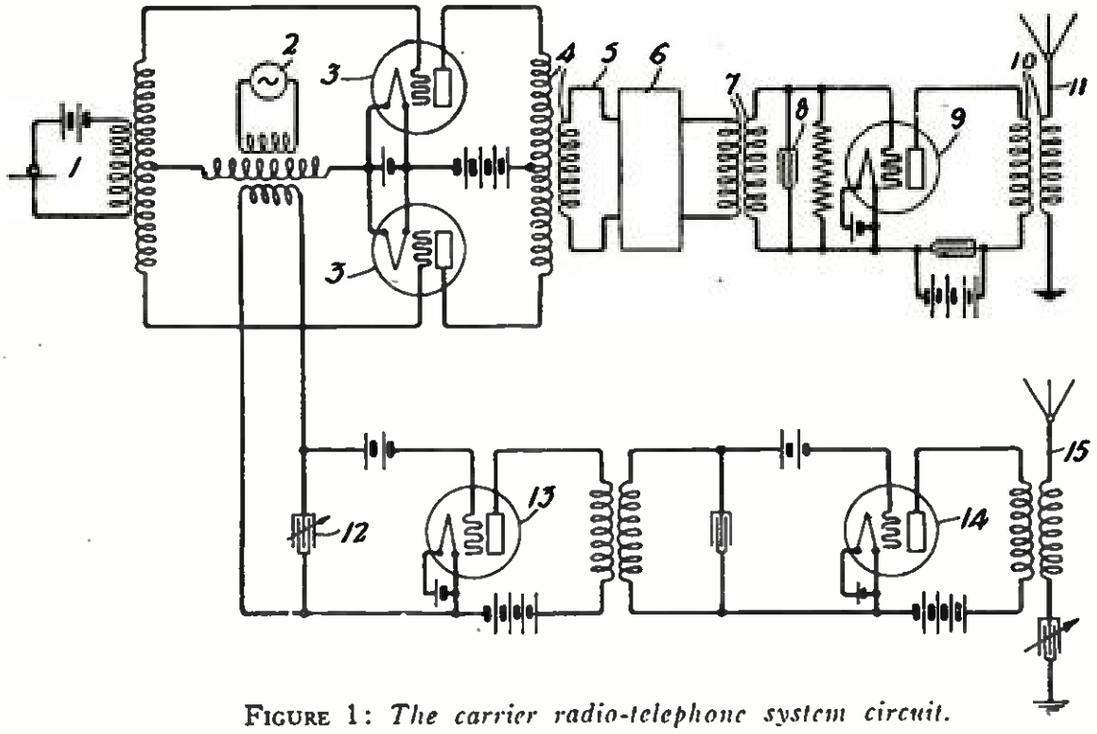
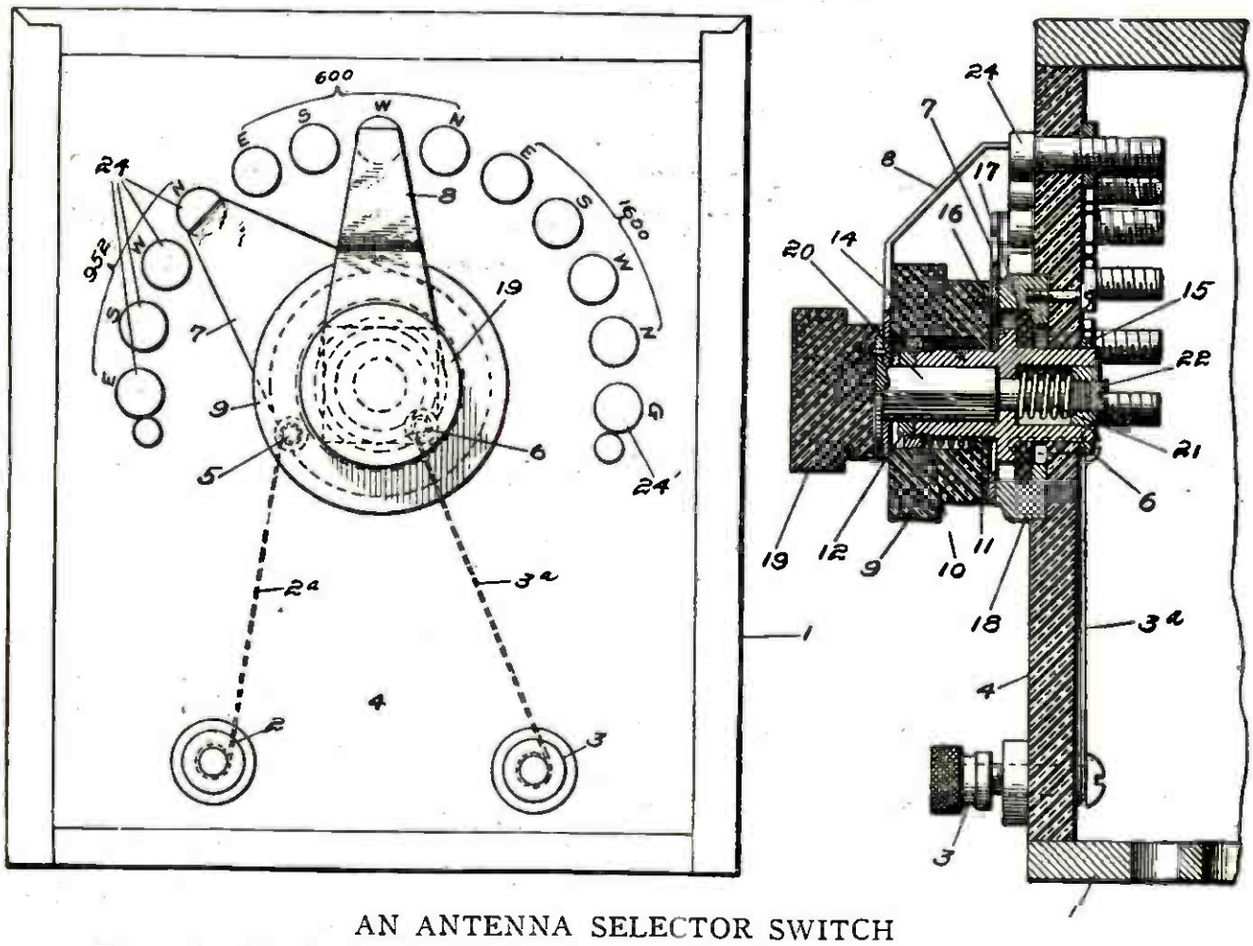
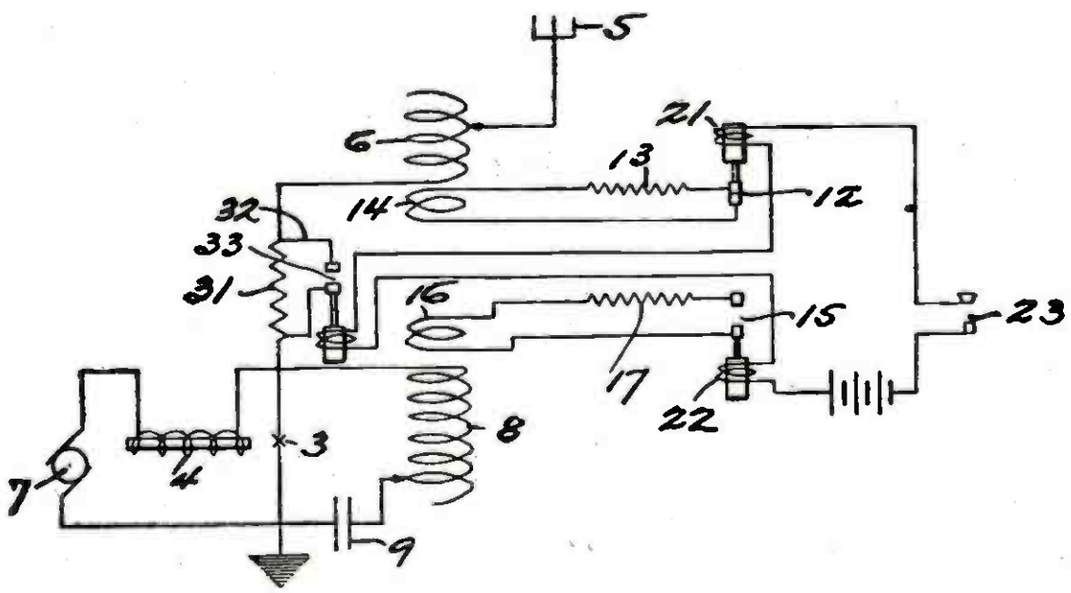


FIGURE 1: *The carrier radio-telephone system circuit.*



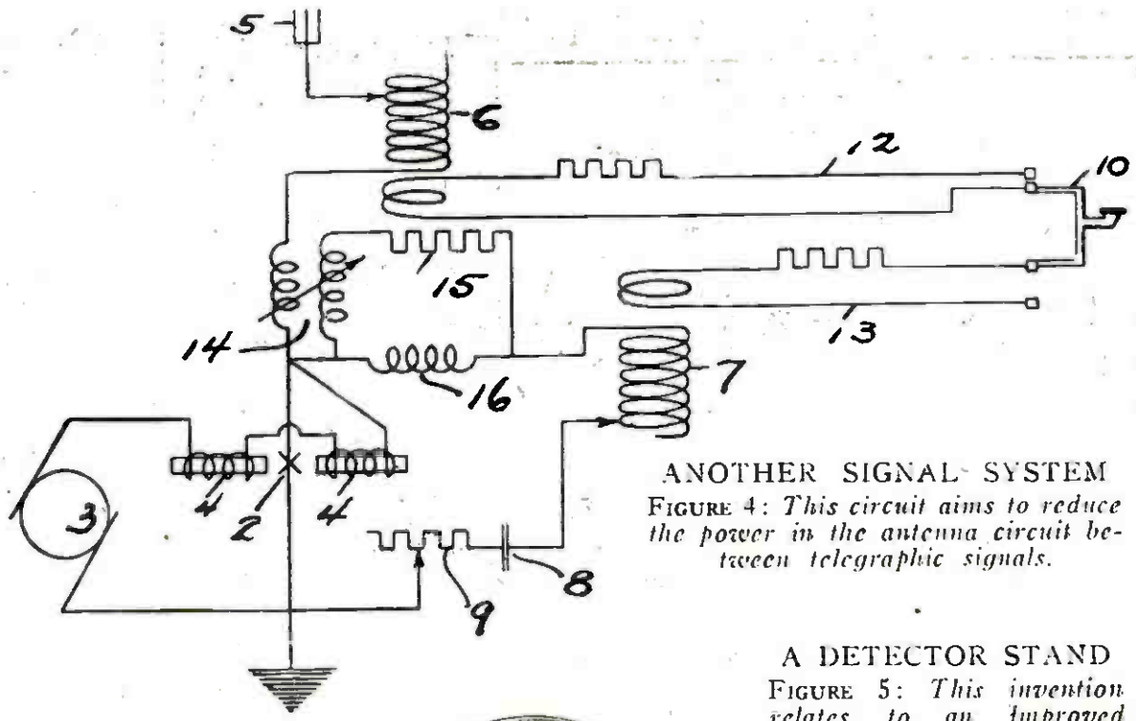
AN ANTENNA SELECTOR SWITCH

FIGURE 2: *The front and side elevations of the selector switch which is designed for automatically changing connections to various antenna systems.*



A RADIO-TELEGRAPHIC SIGNAL SYSTEM

FIGURE 3: *The circuit of the new system for signaling with a single wave. It uses an arc transmitter, with an automatic keying device to produce telegraphic signals without any of the familiar backlash of the old system.*

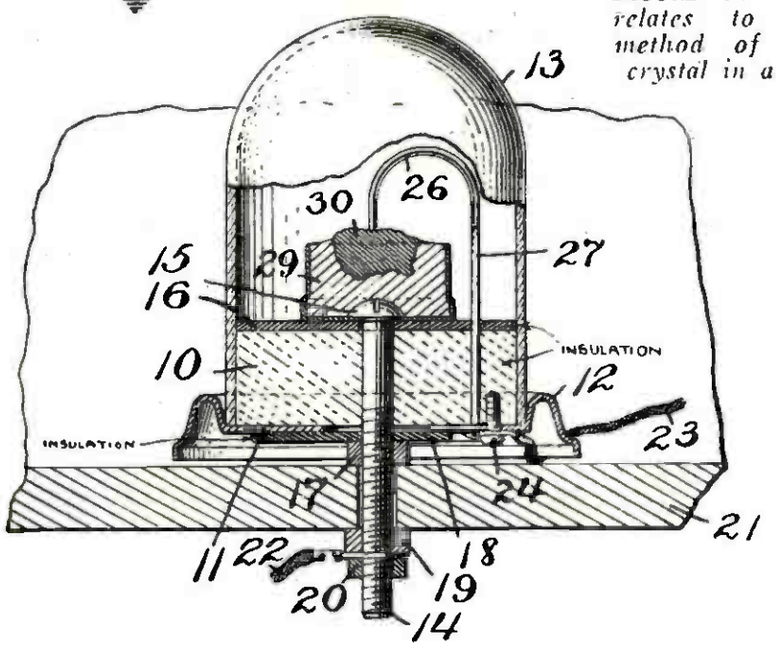


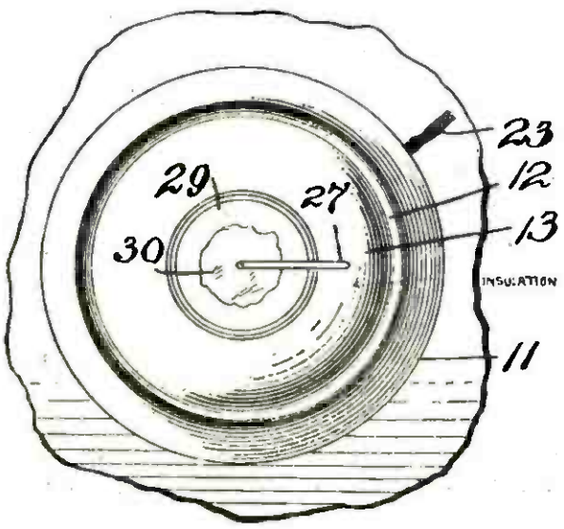
ANOTHER SIGNAL SYSTEM

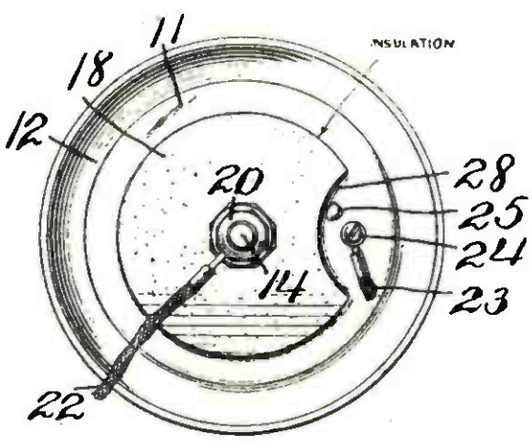
FIGURE 4: *This circuit aims to reduce the power in the antenna circuit between telegraphic signals.*

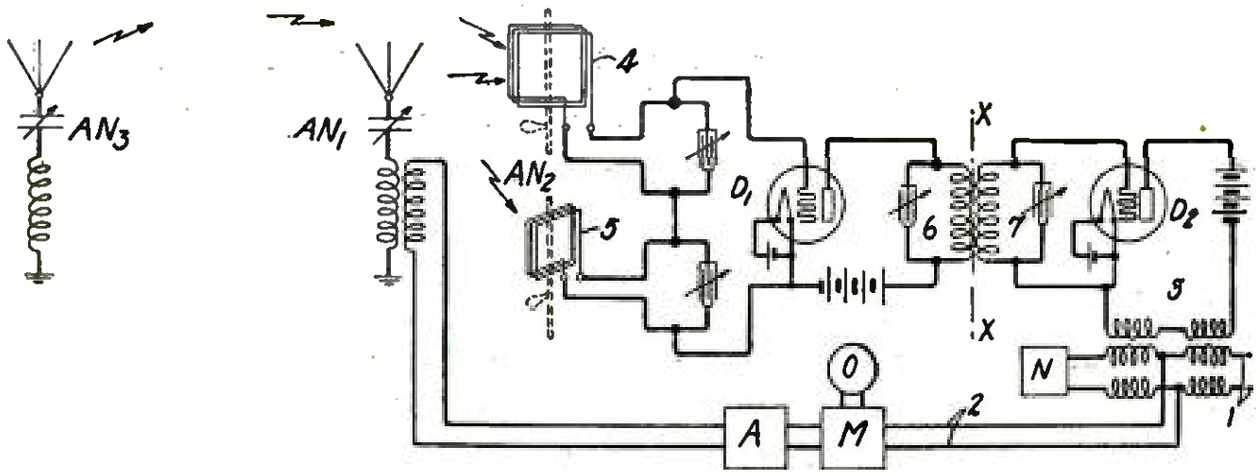
A DETECTOR STAND

FIGURE 5: *This invention relates to an improved method of adjusting the crystal in a receiving set.*









A NEW RECEIVING CIRCUIT

FIGURE 6: *The Mills circuit which includes a means for impressing an auxiliary radio carrier on the detector circuit without impairing reception.*

This invention relates to radio telegraphy and particularly to radio-telegraphy transmission systems. Its object is to provide a single-wave radio signaling system.

FIGURE 4: No. 1,454,630. RADIO TELEGRAPHY. Invented by *Harold F. Elliott,* Palo Alto, Calif.

This invention relates to radio-telegraphy signaling systems and particularly to single-wave signaling systems in which the source of oscillations is connected to the antenna circuit and to a local oscillating circuit, the electric constants of the two circuits being such that the oscillations may be caused to prefer one circuit to the other. Systems of this nature are particularly advantageous in continuous undamped-wave signaling, in which the source of oscillations is an arc or other continuous undamped-wave generator. In systems of this type, the current in the antenna is reduced to relatively low values during the intervals between the dots and dashes of the signal.

It is the object of the invention to reduce the magnitude of the residual current in the antenna during such intervals to smaller values. The invention possesses other advantages, some of which are set forth in the patent.

FIGURE 5: No. 1,454,997. CRYSTAL DETECTOR. Invented by *Gaetano Greco* and *Karl G. Wolff,* Newark, N. J.

This invention relates to an improved crystal detector for radio receiving sets. It is adapted to be placed in position in a set and is easily accessible for adjustment.

FIGURE 6: No. 1,457,447. RADIO RECEIVING CIRCUITS. Invented by *John Mills,* Wyoming, N. J.

This invention relates to radio receiving circuits, particularly to that type employing the principle of successive detection.

The principle object is to provide a means whereby, in an intermediate-frequency receiving circuit, a regulable amount of auxiliary radio carrier-wave may be impressed on the input circuit of the first detector without detriment to reception from the distant station.

Do Ether Waves Cause Gravitation?

SCIENTISTS *are coming to believe in the existence of a new kind of ether wave—the remarkable ultra-X rays. Knowledge of them may solve some fundamental scientific mysteries. The latest developments in this amazing field of research will be told in* POPULAR RADIO *for December.*

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

No Danger of Hypnotic "Spells" Sent Out by Radio

THE instances reported recently in which patients in hospitals and elsewhere have been hypnotized by radio do not involve, say the scientists, any new or startling scientific principle. Once a person has been hypnotized by a certain hypnotist and has become accustomed to the control of that individual the hypnotic trance can be induced later without the personal presence of the hypnotist. A written note, words spoken over the telephone, even a definite message sent by the hypnotist and repeated to the patient by a third person are sufficient to restore the hypnotic control. It is quite natural that words spoken by radio and heard by the patient at a listening apparatus will have the same effect. Such hypnotic messages are effective, of course, only on the patient who has been accustomed to being hypnotized by the particular hypnotist who is sending out the message. There is no danger, the experts assure us, that any kind of "spell" sent out over the radio would affect listeners other than the particular person for whom the message was intended.

* * *

A Bug that Eats Lead Cables

ONE of the most curious troubles encountered by the electrical engineer has turned up in California. The name of it is *Scobicia declivis*. This is not a disease; it is the name of a variety of beetle. With plenty of food available in the fruits and vegetables for which the Golden State is so famous this perverse bug delights to gnaw the lead coatings of telephone cables. He bores little holes through the lead and presently rain water gets in and causes a short circuit. The damage done is so serious that the United States Bureau of Entomology at Washington has been asked to help devise a remedy.

* * *

Snake Doctoring by Radio

IN England recently one of the "uncles" who broadcast talks on snakes (all of the English broadcast talkers seem to be uncles) received next morning a letter from a small boy requesting a diagnosis of a snake, carefully described, which said small boy had captured in the paternal garden. The description showed the snake to be extremely poisonous and a message was broadcast immediately advising the captor to watch his step, or rather to watch the snake.

* * *

What an Electrical Wizard Is Worth to the Country

THE direct money value of Mr. Edison's inventions to the persons who have invested in them has been computed by a writer in the *New York Times* as $15,599,000,000. Even this staggering sum is incomplete for it does not include the much larger indirect values created by the electrical industries based on Mr. Edison's ideas and inventions.

* * *

Can Static Be Used as a Fertilizer?

RECENT careful tests in Iowa reported in the *Chemical News*, confirm the earlier idea that a good deal of nitrate, valuable for fertilizer, is being produced all the time in the air and falls to the earth dissolved in rain and snow. The nitrate is supposed to be formed in the air out of nitrogen gas by means of sparks and other discharges of atmospheric electricity, either the great sparks of lightning or smaller imperceptible ones around dust particles or rain drops. It is these same atmospheric discharges which are believed to be responsible, in part at least, for radio disturbances. Perhaps static may have a very practical use in the world after all if it assists in adding nitrate to the soil.

* * *

Broadcasting a $10,000,000 Lecture

TWICE recently Dr. Russell H. Conwell of Philadelphia has broadcast his lecture "Acres of Diamonds," a lecture familiar to two generations of lyceum and Chautauqua attendants all over the country which has earned for Dr. Conwell more than ten million dollars, nearly all of which he has spent in the cause of popular education.

Education by Radio

IT seems possible that radio broadcasting may prove to be the solution for the vexed question of popularizing the facts and viewpoint of science. A short, interesting scientific talk, received at home over the radio set; will attract many listeners who never could have been persuaded to wade through scientific books or to attend a two-hour lecture at the university. During the past few months the New York Section of the American Chemical Society has been broadcasting short chemical talks once a week over WJZ. WEAF will soon broadcast some of the extension courses of Columbia University. A radio lecture on accountancy was received recently in a New York high school. These mark the beginnings of what must soon be a powerful instrument of national education.

* * *

Scrambling the Program for Outsiders

IN England, where all broadcasting is a monopoly of a single company authorized for this service by the government, there has been patented an ingenious system of preventing unauthorized outsiders from listening-in by means of pirated or "bootleg" sets. This system adds to the carrier wave, in addition to the modulation of the regular program, a mass of confused tones and signals sufficient to obscure the program altogether. Authorized subscribers to the service are then supplied with specially designed filter coils, which may be changed from time to time, and which have the effect of removing the "scrambled" signals.

* * *

Are There Martians for Us to Reach by Radio?

EVER since the announcement of the supposed radio signals from Mars (though these signals turned out to be without any probable connection with that planet) the old scientific problem of the habitability of Mars has been of interest to the radio fan. The newest piece of scientific news about Mars is that it may be, after all, warm enough there for life to exist. It has been claimed that because of the thinness of the Martian atmosphere the surface temperature of that globe must be very low, approaching the intense cold of space. This seems to be a mistake. Dr. W. W. Coblentz of the United States Bureau of Standards has succeeded in measuring the heat reflected from the Martian surface and comes to the conclusion that the mean surface temperature of our sister planet is between 50 and 70 degrees Fahrenheit, about the same as the mean temperature of the earth. The nights, however, are quite cold and the days very warm. This confirms Professor Percival Lowell's idea that the Martian climate is much the same as that of a terrestrial desert.

* * *

Radio Displaces the St. Bernard Dogs

THE Swiss Alpine Club proposes to install at several points on the Alps small radio stations by which lost travelers can summon help from towns far below in the valleys. So the rescue work begun many years ago by the monks of the Monastery of St. Bernard, assisted by their famous trained dogs, yields as does everything else in the modern world to the progress of science.

* * *

A Bishop Finds Old Friends by Radio

THE Bishop of Birmingham, in England, broadcast a talk recently and was surprised to receive many letters from old friends of whom he had altogether lost track and who communicated with him after hearing his voice again through the ether. Radio provides, the Bishop says, a new and unexampled way to extend one's personal touch to thousands of people whom one cannot hope to meet face to face.

* * *

Airplane Travelers Entertained by Radio

A NUMBER of the commercial airplanes used in passenger travel in Europe have been equipped with radio sets by which broadcast concerts may be received during flight. If the greenish tinge of countenance so frequently observable in the inexperienced air passenger as he alights at Paris or at London means anything, entertainment en route must be, we think, the least of one's desires. Yet it is possible that absorption in the remarks of one of the "uncles" of the British Broadcasting Company might be a welcome distraction, removing those disquieting thoughts of how little there is beneath the floor of the cabin.

Keystone

A FAITH-HEALER BY RADIO

Willis Vernon Cole, formerly a healer of the Christian Science Church, has recently issued a code book that covers every human ailment that the author feels capable of treating "metaphysically." Just send him the code word that covers your case—and the healer will do the rest by wire or radio.

The Most Powerful Radio Equipment of Europe

WHILE the United States has been carrying on an intensive campaign in broadcasting and the use of radio by amateurs, France has been hard at work developing its commercial radio business through private enterprise. Today France is reported to have the largest, most efficient and most powerful equipment in Europe.

* * *

Radio Calls Bridal Couple to Sick Bed

A BROADCAST appeal by radio for knowledge of the whereabouts of Mr. and Mrs. George A. Lange, who were known to be on a honeymoon tour of New England, recently resulted in locating the couple in a secluded inn at the town of Lost River, N. H., whence they made their way home at once on receipt of a message that the bridegroom's mother was dangerously ill.

A Gold-Mounted Receiving Set for a Prince

AMONG the countless wedding presents received by the Duke and Duchess of York was a wonderful gold mounted radio receiving set. It is a portable loop receiver, mounted on a mahogany tea wagon, complete in every detail, with loudspeaker and even a charger for the storage battery attached to the shelf beneath.

* * *

Transmitting Sets for Japanese Fishermen

A NEWSPAPER dispatch reports that the chief of the Nagasaki Perfectural Marine Products Bureau of Japan, together with a committee of men interested in marine products, is reported to be investigating the possibilities of installing radiophone outfits on the larger sized fishing boats which have their base at Nagasaki, to enable them to communicate with shore when in difficulties, and to report the catch in time for their owners to realize on it.

General Electric

THE NEW "MAGNETO-MICROPHONE"

A new device, consisting of a moving magnetic coil pivoted between the poles of a permanent magnet which may be firmly anchored to the frame of a piano, has been developed by the engineers at the broadcasting station WGY. The instrument picks up the vibrations directly from the sound-board without any reference to the sound wave in the air. It is this principle that enables it to reproduce electrically all the fine shadings of tone-quality of the concert piano, and to eliminate the hissing and "tinny" sounds that almost always accompany transmission through a carbon microphone. In the picture is shown a studio piano that is equipped with three of these new microphones attached in positions that allow them to pick up the bass, the middle, and the treble ranges with the correct relative volume.

Ask any radio expert

THE first duty of a radio panel is to give satisfactory insulation, as any radio expert will tell you. The wise fan selects his panel with special care and insists on having one that supplies the proper insulation resistance.

Celoron Radio Panels provide satisfactory insulation under all conditions. They have high dielectric strength and great surface and volume resistivity, and do not warp or crack when exposed to moisture.

Cut in standard sizes

For your convenience, Celoron Radio Panels come ready cut in eight standard sizes. Your dealer will hand you the size you want, and you can begin to build your set at once.

Celoron panels are easy to saw, mill, and tap, and will engrave evenly without feathering. Each panel is wrapped separately in glassine paper.

Select from the following standard sizes the panel that suits your needs:

1—6 x 7 x 1/8	5— 7 x 18 x 3/16
2—7 x 9 x 1/8	6— 7 x 21 x 3/16
3—7 x 12 x 1/8	7— 7 x 24 x 3/16
4—7 x 14 x 3/16	8—12 x 18 x 3/16

If your dealer cannot supply you, ask him to order, or write direct to us. Indicate by number the size you need. We also furnish Celoron in full-sized sheets and in tubes, and can cut panels in special sizes if desired.

This booklet free

Write for a copy of our booklet, "Tuning in on a New World," which contains a list of the leading broadcasting stations in the United States and Canada, an explanation of symbols used in radio diagrams, and several efficient radio hook-ups. It will be sent to you free on request.

To radio dealers: Send for special dealer price list showing standard assortments

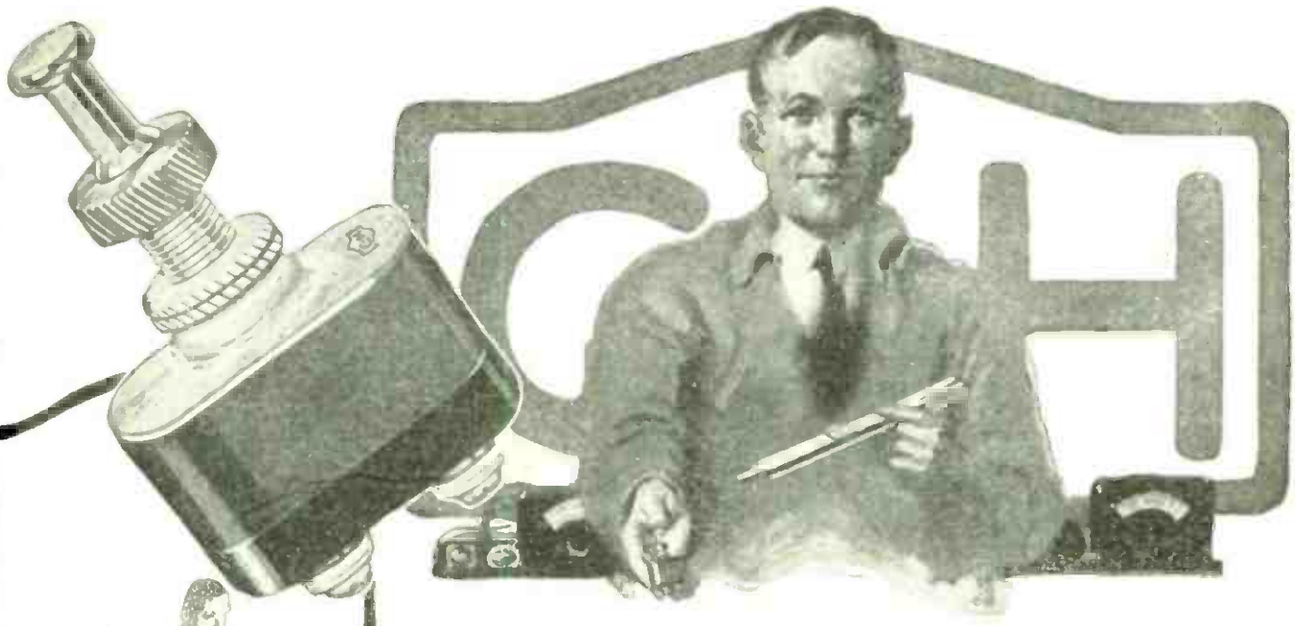
Diamond State Fibre Company

BRIDGEPORT **(near Philadelphia)** **PENNSYLVANIA**

BRANCH FACTORIES AND WAREHOUSES
BOSTON CHICAGO SAN FRANCISCO

Offices in Principal Cities
In Canada: Diamond State Fibre Company of Canada, Limited, 245 Carlaw Ave., Toronto

CONDENSITE
CELORON
STANDARD RADIO PANEL



A Switch by the Master Builder for Your Radio Panel

Beautiful Appearance
Correctly Designed—Easily Installed

In the radio world the name Cutler-Hammer and its symbol the famous C-H trade-mark have become guide posts to quality. In only a few months after their introduction more than a half million radio rheostats with the little mark of approval of the master builders of all electrical control apparatus were purchased.

Now these specialists offer another necessity for your panel, the C-H Radio Switch embodying the same careful design and workmanship to provide more pleasant, convenient reception and protect your expensive equipment at a negligible cost. Its sturdy knife blade mechanism that snaps—not merely slides—is capable of carrying 3 amperes at 110 volts, yet is built with a precision that enables you to use it in your most delicate circuits without any microphonic noises.

It will control your "A" battery to positively indicate whether the tubes are *on* or *off*—your "B" batteries—parts of circuits—condensers—battery charger—practically any demand you may have for current control. It is fully adjustable for panel thickness and can be installed in any set in a few minutes—only a single 7/16" hole is required. Carried by dealers everywhere—if yours has not yet been stocked, send 60c plus 10c carrying charges and you will be supplied direct.

THE CUTLER-HAMMER MFG. CO.
Member Radio Section, Associated Manufacturers of Electrical Supplies
MILWAUKEE · WISCONSIN

Disconnecting a battery lead is one way of shutting off a radio set, but many tubes and batteries have been ruined by putting it back on the wrong post. A C-H Radio Switch costs 75c—if you save only a few dry cells it quickly earns its cost.

What do you do when the phone rings? Just push the C-H Radio Switch button—answer the phone—pull the button and the same program is back on. No turning back rheostats or disturbing your delicate settings when you have C-H convenience.

With the new tubes that operate at a dull red it is easy to forget to turn off the "A" battery—there is nothing to indicate whether the set is ON or OFF. The nickel button of a C-H Radio Switch sticks right out to say "I'm ON—don't forget me!"

C-H

RADIO SWITCH

Every Tube You Buy Should Have the Protection of C-H Control

There Is a Specialized Rheostat by the Master Builder for Every Requirement

The Cutler-Hammer engineers, world-famed specialists in electrical control, provided in their now famous C-H Radio Rheostats a new standard in accuracy of design and quality of workmanship among radio instruments.

Outstanding, was their originality of construction. Built almost entirely of non-warping metal—finished in beautiful satin nickel and ebony black—furnished with adjustable, spring contact fingers, comfortable knobs of genuine Thermoplax, and nickeled pointer, these rheostats were quickly recognized as worthy of the trade-mark they carried.

And as the science progressed and new tubes were introduced the C-H engineers evolved new models anticipating every requirement. Today there are four specialized C-H Rheostats (the 4-ohm vernier, the 4-ohm plain, the 30-ohm and the 125-ohm) to control any tube you desire. Each has been designed for the service it must render, and can only be wired to give the voltage needed for the tube it protects. For satisfaction in radio, demand the mark of the master builder on your control instruments.

THE CUTLER-HAMMER MFG. CO.

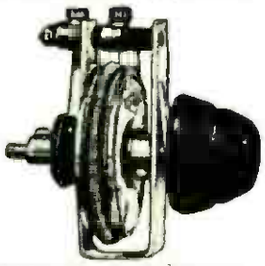
Member Radio Section, Associated Manufacturers of Electrical Supplies

MILWAUKEE, WISCONSIN

One Half Million C-H Radio Rheostats Now in Use

C-H

"Built by Rheostat Builders"



C-H 4-Ohm Radio Rheostat

Perfect control for the one ampere, six-volt tubes, or WD 11 (dry cell) type. With vernier, for detector tube control.

Type 11601-H1 . . . . . $1.50

Plain type for amplifier tube control.

Type 11601-H2 . . . . . $1.00

C-H 30-Ohm Radio Rheostat

Precise control of the one-quarter ampere, six-volt (UV 201-A and C 301-A) tubes or the UV 199 type on 4.5-volt source.

Type 11601-H9 . . . . . $1.50

C-H 125-Ohm Radio Rheostat

For control of the current-saving UV 199 tubes on a current source of six volts. Use your storage cell with the new tubes—it will need recharging only at long intervals.

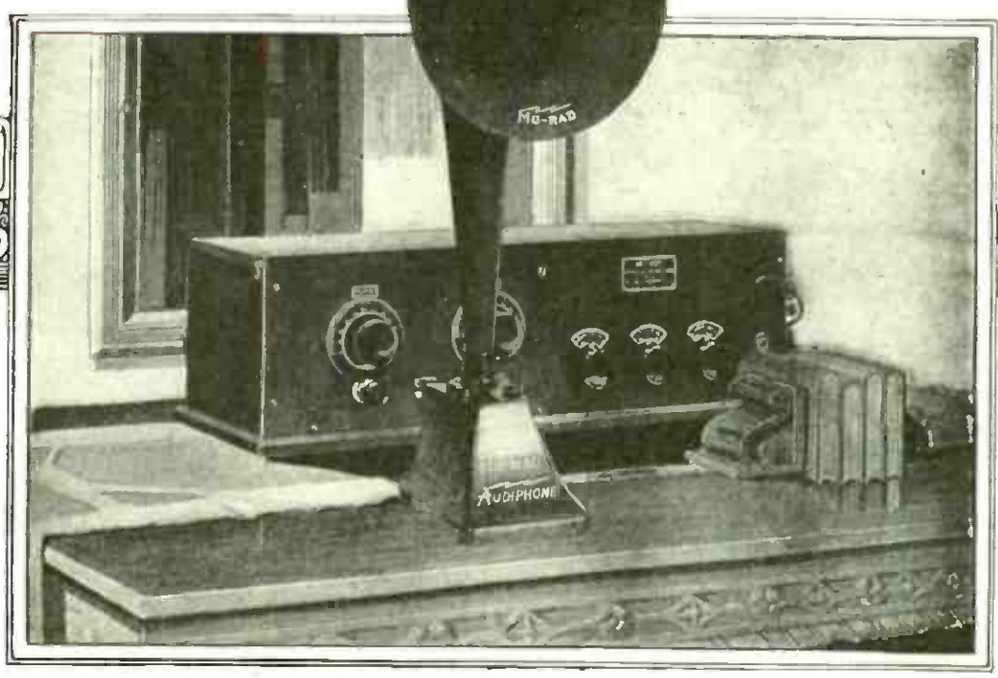
Type 11601-H $1.50

C-H Variable Resistance Unit

Adds to your five-ohm rheostat just the resistance required to control the ¼ amp. 6-volt "A" type tubes or the UV 199 type. Saves the cost of new rheostats and the trouble of redrilling your panel. Fully adjustable for change in battery potential.

Type 11601-H12 . 25c

CUTLER-HAMMER



A New MU-RAD *Accomplishment*

The MU-RAD AUDIPHONE

The super-sensitive mica diaphragm produces sound by the contraction and expansion of an actuating contact, just as the vocal cords produce the voice.

No Extra Battery Connections

PRICE
$25

THE REVOLUTION, wrought in radio reception by the MU-RAD RECEIVER is equalled by this radical improvement of sound amplification. The *MU-RAD AUDIPHONE* aimed for a higher perfection than ever attempted — duplication in electro-mechanical form of the greatest sound producing organ, the human voice. The result of five years' continuous research is a radio reproducer worthy of a finer classification than "loud speaker"; it is *a new radio instrument!*

WRITE FOR LITERATURE AND THE NAME OF THE NEAREST MU-RAD DEALER DEMONSTRATING THE MU-RAD AUDIPHONE

MU-RAD LABORATORIES, INC.

809 FIFTH AVE. ASBURY PARK, NEW JERSEY

Aladdin's Lamp Outdone

IN the fairy stories they asked Aladdin for music and by rubbing his wonderful lamp he produced it for them. No doubt if they had wanted crop and market reports or a bedtime story Aladdin could have produced them also. But these were fairy stories. Whoever thought they would come true?

PARAGON

Reg. U.S. Pat. Off.

RADIO PRODUCTS

Tonight if you sat down with a PARAGON Three-Circuit Receiver you could hear the music of a world-famous orchestra or the marvelous voices of opera singers just as clearly as if you were sitting in the same room with them. You can choose the program you want and enjoy it without interruption.

The name "PARAGON" on radio products means perfection. To listen in with a Paragon set is to experience the full fascination of the world's latest wonder.

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

DEALERS: We believe in the proper distribution of Paragon Radio Products. Our exclusive Distributors are particularly interested in territorially protected dealers, who will concentrate, solicit and serve the consumer in the sale of Paragon Radio Receivers. If interested, write us for details.

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

Illustration shows Type RD-5 Regenerative Receiver and Detector —$60.00

Type A-2 Two-Stage Amplifier—$40.00

(Licensed under Armstrong Patents)

England

Canada

AMPLION

Scotland

Australia

Junior
DeLuxe

Wales

New Zealand

$26.00
List

Ireland

So. Africa

The Uncanny Amplion
A "Human" Loudspeaker

YOU can scarce believe your ears when you first hear the Amplion Loudspeaker.

The clearness, softness and rich tone-quality with which it reproduces voice and music are so real as to be uncanny. You get a new thrill from radio. Delicious "chills" course up-and-down your spine, as they do when you listen to some master of voice or instrument face-to-face.

American Engineers who have tested the Amplion are unanimous in their opinion that for true reproduction and volume it's the best loud speaker yet produced.

The Amplion is not a head receiver fitted with a horn, but the adaption for Radio of an electro-magnetic and acoustic instrument which for thirty years has been successfully used in all parts of the world.

Ask your dealer to let you hear the wonderful "AMPLION" Loudspeaker. Send for illustrated folder.

Patentees Alfred Graham & Co.

SIGNAL ELECTRIC MFG. CO.
Sole United States Distributors Menominee, Michigan

BURNDEPT OF CANADA, LTD.
Canadian Distributors 172 King St., West, Toronto

Norway

India

Sweden

France

Denmark

Italy

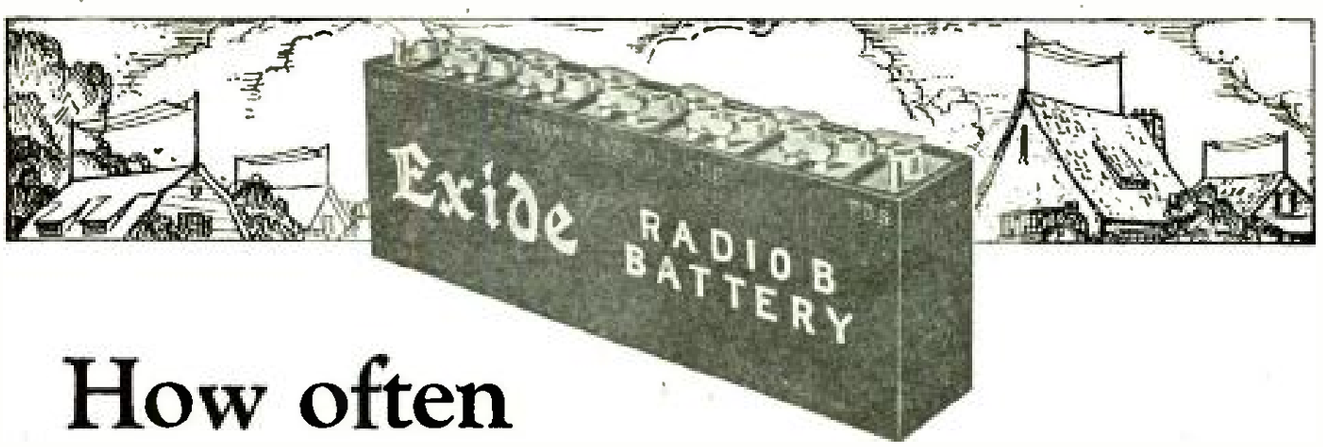
Holland

Spain

The Supremacy of the AMPLION
is the Supremacy
of Actual Performance

Belgium

Japan



How often do you get a new B battery?

THE current from a B battery is relatively small. But it must be always on the job. B batteries that run down quickly are the bane of the radio fan's existence. Your B battery can help you get the most pleasure from radio, or it can be your greatest nuisance. It all depends on the kind of battery you buy.

The wise radio amateur knows it pays to get a good B battery in the first place. And that means an Exide. The new Exide B Battery is built with extra-heavy plates. That is one reason why it lasts so much longer than the ordinary battery. It can be recharged again and again, saving you the annoyance of frequent replacements.

Exide B Batteries give steady, noiseless current. They are strangers to the hissing, frying noises caused by internal discharge. The 12 cells are encased in rubber, with special vents to allow gas to escape when the battery is being recharged. They are designed throughout to prevent electrical leakage.

Exide A Battery for six-volt tubes

Supplies uniform filament current. Is dependable and long-lasting. Comes in four sizes, of 25, 50, 100 and 150 amp. hr. capacities.

Two low-voltage A batteries

If your set operates on low-voltage tubes, it will be worth your while to examine the new Exide two- and four-volt A batteries. They are right in line with the latest developments in radio receiving. The one-cell Exide A Battery will heat the filament of a 1.1 volt .25 ampere tube for 96 hours; the two-cell Exide A Battery will heat the filament of a 3 volt 60 milliampere tube for approximately 200 hours. They are specially adapted to WD-11 and UV-199 vacuum tubes.

The Exide A Battery for six-volt tubes gives full-powered, care-free service. It requires only occasional recharging. Like all Exide Radio Batteries, it is built of the finest materials available, is sturdy and long-lasting.

When you hook up your set with Exide A and B Batteries, you are sure of getting maximum signal strength. You can reproduce broadcast selections in clear bell-like tones.

Wherever reliable storage batteries are required, you will find the Exide doing its work ungrudgingly. It is recognized as the leading storage battery in every field of industry. A majority of all government and commercial wireless plants are equipped with Exide Batteries.

Two- and four-volt A batteries

Consist of one and two cells, respectively, with rated capacities of 24 and 12 ampere hours. The two-volt battery weighs 5 lbs., the four-volt battery 6 lbs.

Don't let inefficient batteries spoil your pleasure in radio. Go to any radio dealer or Exide Service Station and ask for Exide Radio Batteries.

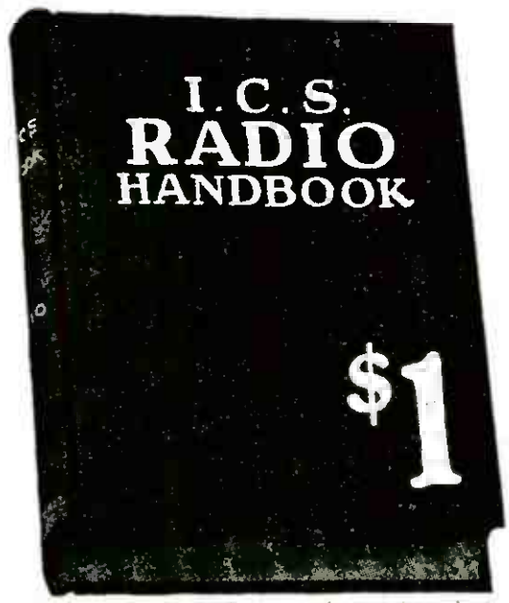
If your dealer can't supply you with free booklets describing the complete Exide line, write direct to us.

Exide
RADIO BATTERIES

THE ELECTRIC STORAGE BATTERY COMPANY, PHILADELPHIA

Oldest and largest manufacturers in the world of storage batteries for every purpose

Service Stations Everywhere — **Branches in Seventeen Cities**



At last! A practical authoritative book on RADIO

514 pages. Price only $1

Compiled by **HARRY F. DART, B.S.E.E.**
Formerly with the Western Electric Co., and U. S. Army Instructor of Radio
Technically edited by **F. H. DOANE**

THE most complete book of its kind ever published. Written, compiled and edited by practical radio experts of national reputation. Packed with concise, sound information useful to every radio fan—from beginner to veteran hard-boiled owl. Hundreds of illustrations and diagrams to make every point clear. Note this *partial* list of contents:

Different types of receiving and sending hook-ups, electrical terms, condensers, oscillating circuits, coupled circuits, induction coils, antenna systems, electric batteries, generators and motors, protective devices, crystal detectors, arc generators, transmitters, filters, wavemeters, radio experiments, International and Morse codes, commercial receiving sets, tables and data, radio transmitting and broadcasting stations (with call letters), Radio License Regulations, etc.

Send $1 to-day and get this 514-page I.C.S. Radio Handbook before you spend another cent on parts. Money back if not satisfied.

TEAR OUT HERE

INTERNATIONAL CORRESPONDENCE SCHOOLS
Box 8250-B, Scranton, Penna.

I enclose One Dollar. Please send me—postpaid—the 514-page I. C. S. Radio Handbook. It is understood that if I am not entirely satisfied I may return this book within five days and you will refund my money.

Name.....

Address.....

Send 50c for this FADA NEUTRODYNE BOOK

It tells in simple language how to construct a Neutrodyne circuit receiver using FADA parts. Nothing is left in doubt. Both four and five tube Neutrodyne wiring diagrams are included. In addition, in the rear of the book there are both four and five tube full size paper panel drilling templates.

This 32-page book and the use of FADA Neutrodyne and standard parts will insure successful Neutrodyne circuit receiver construction.

F. A. D. ANDREA, INC.
1581-D JEROME AVE., N. Y. C.

The special FADA Neutrodyne parts including three Neutroformers, two Neutrodons and the HOW-TO-BUILD-IT book sell for $25.00.

Build your own set *with* Gilfillan Parts

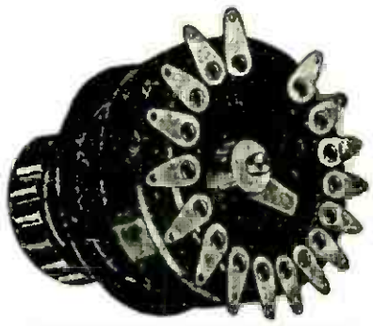
THE work is interesting, instructive and not difficult. Then too, the finished set will give you splendid results—*at low cost*—especially if you have assembled it with *Gilfillan* standard high-quality parts.

Gilfillan Radio Parts are the perfect combination of scientific design, accurate workmanship and best materials; so when you select *"Gilfillan"* you're certain of the inbuilt dependability of that part.

If your dealer does not handle this superior line, write us for name of nearest dealer, descriptive folder and list.

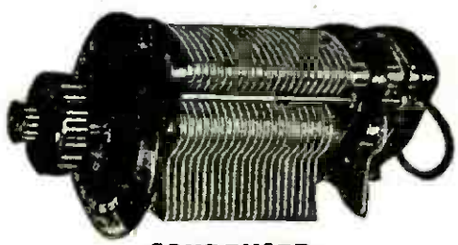
Genuine Gilfillan Radio Parts can always be identified by this trade-mark. Look for it.

Two New Gilfillan Radio Parts



PRIMARY INDUCTANCE SWITCH

15 point. Provided with solder lugs. Moulded brown bakelite black knob and dial.



CONDENSER

With Vernier and pigtail connection. Obtainable in 43 plate, as above, and 23 plate sizes.

Other Gilfillan Parts

Varicouplers (2 sizes)	Tube Sockets
Variometers (2 sizes)	Tube Socket Adapters
Air Condensers (3 sizes)	Detector Amplifier Units
Audio Frequency Transformers	Detector Units
Potentiometers	Vernier Air Condensers
Primary Inductance Switches	Filament Rheostats
Panel Switches	Vernier Rheostats
	Moulded Knobs, etc.

GILFILLAN BROS., INC.

1925 McGee St., Kansas City, Mo.

1815 W. 16th St., Los Angeles, Cal.

225 W. 57th St., New York, N. Y.

Licensees General Bakelite Co.

BROADCASTING

TRANSMITTING delicate electrical currents has been highly developed. Receiving them as sent is vital to your enjoyment.

No matter how efficient your receiving set may be, it rests with the headphones you buy to transform these currents into sound. Beautiful, clear and distinctive tones of music or spoken words cannot be reproduced by inferior headphones.

Twenty-five years of research and painstaking manufacture by the Holtzer-Cabot Electric Co. has produced for you the supersensitive No. 2 Universal Headset.

This light weight, sanitary set reproduces positively and faithfully with an exceptional purity of tone and extreme sensitiveness.

Holtzer-Cabot No. 2 Universal
The supersensitive phone
Holtzer-Cabot No. 4 National
The quality phone at a minimum price
Be sure and send for a copy of our booklet "What you should know about Radio Reception."

THE HOLTZER-CABOT ELECTRIC CO.
125 Amory Street, Boston, Mass.
6161-65 South State Street, Chicago, Ill.
Department B

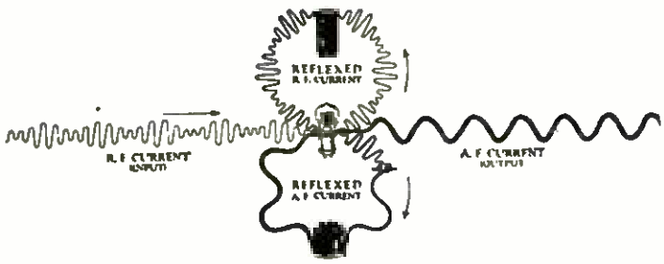
Vacuum Tubes Do Triple Duty
With Erla Synchronizing Transformers

Perfect synchronization of received and reflexed r. f. currents make Erla radio transformers indispensable in reflex work. List, $5

Erla tested capacity condensers are unequaled in rigid, unvarying accuracy, so vital to success in reflex work. Eleven sizes, 35c to $1 ea.

Erla bezels greatly enhance the finest cabinet assembly. Telescoping rim, in bright nickel or dull enamel, fits any ¼" to ¼" panel. List, 20c

Dealers and Jobbers—Erla progress constantly widens avenues of trade. Write for liberal terms and discounts



For the first time, the full efficiency of vacuum tubes is completely utilized and brought under control.

In Erla reflex circuits, tubes do triple duty, providing simultaneous amplification of radio frequency, reflexed radio frequency and reflexed audio frequency currents. Yet, so precise is the manipulation of this complex current flow, that the tremendous gains resulting are achieved without a single drawback.

Not only do Erla reflex circuits demonstrate decisive superiority in range and volume, but they are also unequaled in selectivity, purity of tone, and ease of control. Even the single-tube circuit provides far-flung loud speaker range, while the three-tube circuit surpasses costliest multi-stage units in transcontinental loud speaker reception. And the two-tube circuit is close behind.

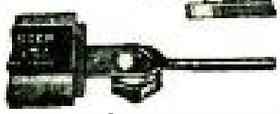
Essential to the operation of these circuits, and the secret of their success, are Erla synchronizing radio and audio transformers. Providing perfect synchronization of received and reflexed currents having the same phase characteristics, they assure tremendously magnified amplification without distortion.

Complete diagrams and descriptions of perfected Erla reflex circuits are set forth in Erla Bulletin No. 14, obtainable gratis from leading radio dealers. Or write us direct, giving your dealer's name.

Electrical Research Laboratories
Dept. R 2515 Michigan Avenue, Chicago

ERLA

Rectified radio frequency and reflexed audio frequency currents are accurately synchronized by Erla audio transformers. List price, $5



Difficult, dangerous use of soldering irons is eliminated by Erla solderless connections, saving time, temper and money. List, 5c ea.

Providing utmost sensitiveness with perfect stability, the Erla fixed crystal rectifier is uniquely adapted for reflex work. List, $1

The New 1924 Model "4-Way" Switch Plug!

Many refinements have been added to make this the best radio plug

—a switch plug which makes it possible to tune in through head set and switch in loud speaker by turning dial. Two head sets can be readily attached, or one head set and loud speaker. Both can be used at same time or either one alone. ***Order yours TODAY.***

$1.50

FOUR WAY CO., 29 Worthington St., Springfield, Mass.

Three Aces!

IN the experience of radio engineers, amateurs and experimenters there is a suggestion which clearly points the way to the battery buyer who desires the most fitting and practical combination of electrical energy, low cost per hour of service, long shelf life and uniformity of discharge.

"ASK ANY RADIO ENGINEER"

These "Three Aces," the famous Burgess "B" —the new *double strength* Radio "A" and our latest product, the Vertical "B" Battery are playing an important part in correct and dependable reception of radio broadcast. Each is

"A Laboratory Product"

Good dealers everywhere recommend and sell Burgess Batteries

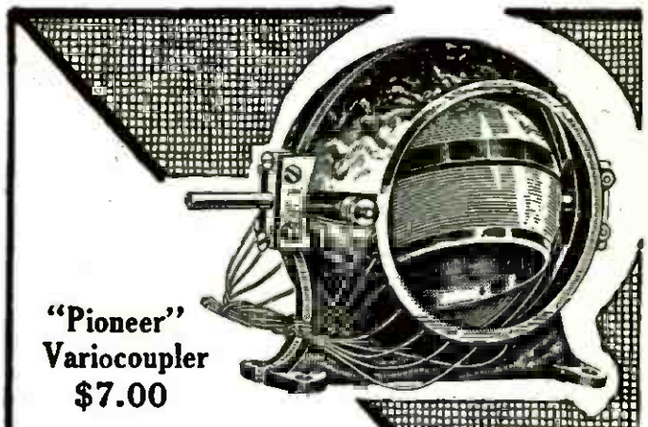
BURGESS BATTERY COMPANY

Engineers—DRY BATTERIES—Manufacturers
Flashlight—Radio—Ignition—Telephone

General Sales Office: **Harris Trust Building, Chicago**
Laboratories and Works: Madison, Wisconsin

Branches: **New York Boston Washington St. Paul Kansas City New Orleans**

In Canada:
General Offices and Works: Niagara Falls, Ontario
Branches: Toronto, Montreal, Winnipeg, St. John



"Pioneer" Variocoupler $7.00

The first impression you get from looking at Pioneer Variocouplers and Variometers is that beyond doubt they are the most beautiful instruments yet devised.

The beautiful Bakelite in a grained mahogany finish has a richness that has never been equalled before.

The heavy copper wire, covered with green silk, gives a contrast that makes the instruments irresistible and adds tremendously to the beauty of any set.

The mechanical parts are no less wonderful. The hardware of heavy bronze—the close-coupled rotor and stator—the positive contacts, all demonstrate the highest mechanical skill and attention to detail.

A special feature is the winding of the variocoupler on the inside of the shell—which is original and exclusive with Pioneer.

Ask your dealer to show you these instruments. If he cannot supply, write us, giving his name and address.

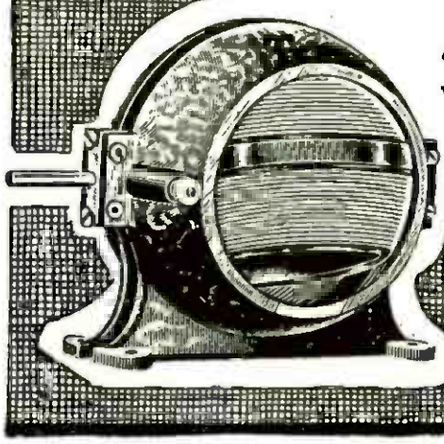
PIONEER RADIO CORPORATION

100 Pioneer Ave. Galesburg, Illinois

BRANCH OFFICES:

European Branch Office:
27-28 Anning Street
London, Eng.
Gaston E. Marbaix
European Manager

New York City.....220 Fulton St.
Chicago, Ill.....33 E. Clinton St.
Kansas City, Mo...208 Baltimore Bldg.
Minneapolis, Minn.705 Plymouth Bldg.
San Francisco.....623 Larkin St.



"Pioneer" Variometer $6.50

The World's Most Popular Battery Charger

Nothing speaks so eloquently of HOMCHARGER satisfaction as the fact that thru sheer merit alone it has become the *standard* by which all other battery chargers are judged. Over 125,000 HOMCHARGERS already in use offer the most convincing proof that it is the most efficient, economical and fool-proof battery charger at any price.

A NEW TRADE-MARK FOR A TRIED AND PROVEN PRODUCT

Its phenomenal success has led to the introduction of many inferior and make-shift imitations. To insure our reputation and protect the buying public against substitution, the Radio De Luxe HOMCHARGER henceforth will be sold under a new Trade-Mark, viz:

GOLD SEAL HOMCHARGER

Retaining the same fundamentally correct operating principle and beautiful appearance of our Radio De Luxe model, it is a step nearer ultimate perfection through adoption of several construction refinements dictated by the policy of Progress.

HOMCHARGER'S 10 POINTS OF SUPERIORITY

1. Simple—Only one moving and wearing part, replaceable after thousands of hours use for $1.00. Will last a lifetime.
2. Efficient—Uses less than one-half the current of any bulb or liquid type rectifier. Will charge any radio or automobile battery for a nickel.
3. Quick—Its high charging rate of 7 amperes eliminates long waiting for battery to become charged. Will charge any "A" or "B" battery over night, or three times as fast as a 2-ampere machine.
4. Clean—No expensive bulbs to break or acids to spill or replace. No acid fumes. Charges without muss, fuss or bother.
5. Dependable—Tungsten contacts insure continuous operation—prevent sticking and stopping.
6. Fool-Proof—Can be operated by anyone. Attach to lamp socket and connect battery either way, it will always charge. High-grade ammeter eliminates guess work.
7. Safe—No danger of shock or fire. Tested and approved by Fire Insurance Underwriters everywhere. Gives tapering charge—will not overheat or injure battery.
8. Beautiful—Mahogany and Gold Finish.
9. Unqualifiedly Guaranteed.
10. Popularly Priced—Retails at $18.50 complete ($22.00 Canada). No extras to buy. Sold by all dealers.

FREE BROADCASTING LIST. Send to-day for Free List of Broadcasting Stations, and Circular Describing the Gold Seal Homcharger.

DEALERS! JOBBERS!

GOLD SEAL HOMCHARGERS will outsell any other radio device this season. "GOLD SEAL Business Builders" illustrates many attractive sales helps and explains how we are prepared to co-operate with the Trade in making this a "HOMCHARGER Year." Send for your copy and Trade Discounts TODAY.

Insist on the GOLD SEAL

LOOK FOR IT

GENUINE GOLD SEAL HOMCHARGER REG. UNQUALIFIEDLY GUARANTEED

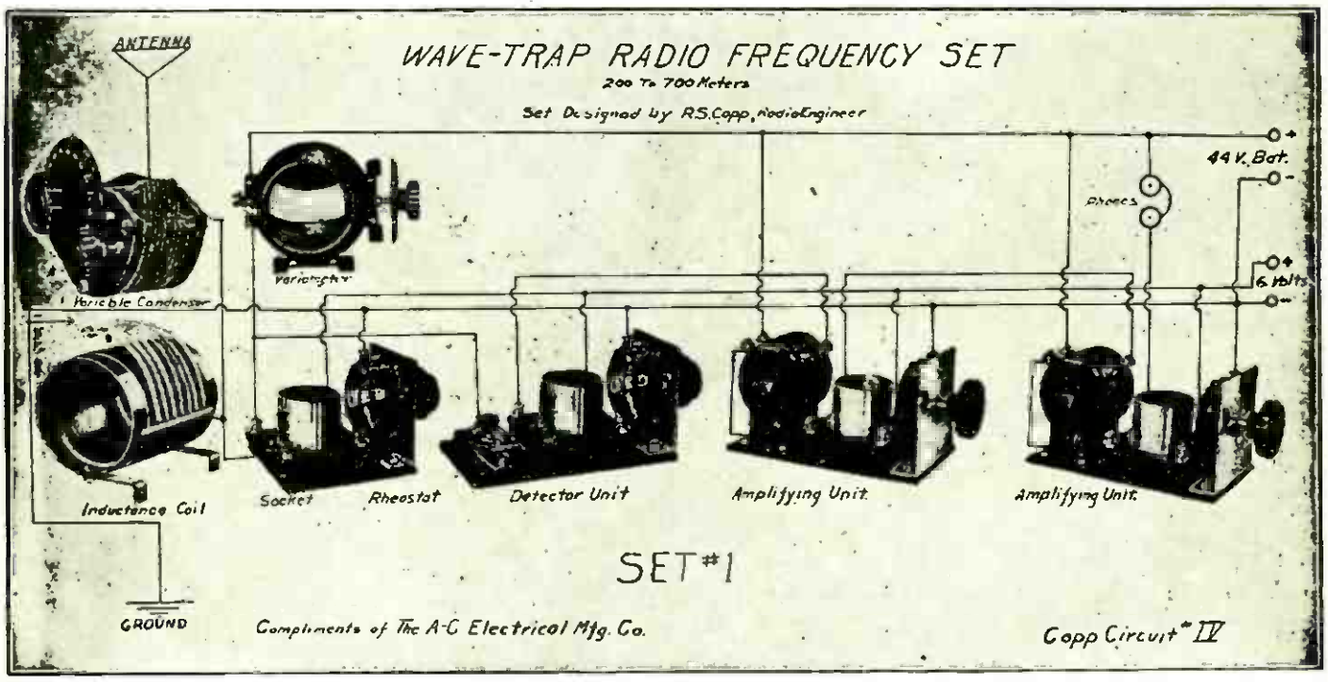
It is your protection against substitution. When buying *order by name* and *verify by the GOLD SEAL*, which appears on the carton as well as the nameplate.

The Automatic Electrical Devices Co., 132 West Third St., Cincinnati, O.

Largest Manufacturers of Vibrating Rectifiers in the World

SAVE $75.00

By building your own set using this wonderful circuit and A-C DAYTON Radio Products



This high class set as shown above would cost $125.00 but we are offering you the opportunity of building this same set at a cost of not over $50.00. All A-C Dayton units are wired and complete, ready for connection in the circuit. This set has one stage of Radio-frequency amplification and two stages of Audio-frequency, producing a set with extreme long range and good signal strength.

A-C Dayton Radio Products represent a complete line of radio parts, and are so designed as to be co-ordinated in any type of radio circuit, producing a beautiful and efficient set at a reasonable price. If your dealer does not have full information on circuits, write us direct or have him send for full description and our latest catalog describing the many uses of our parts and units.

THE A-C ELECTRICAL MFG. CO. **DAYTON, OHIO.**

Makers of Electrical Devices for over 20 years

RADIO FANS

Tune in on station

W E A F (New York)

every Thursday at 8:50 P. M. and listen to a story or article selected from

HEARST'S

INTERNATIONAL

This is one of the most popular weekly features "on the air"

FREE

Write for free copy of Radio Reprint No. 1—it contains a complete Cappy Ricks story by Peter B. Kyne.

Address Radio Editor, 1-A, Hearst's International Magazine, 119 West 40th Street, New York City.

MIRACO GETS 'EM 1500 MILES AWAY

At the low prices shown below you get the efficiency of sets costing three times as much.

These radio frequency receivers—pick up stations over 1,500 miles away under good conditions—everywhere.

Operate either on DRY CELLS or storage battery.

Cabinets of solid mahogany and workmanship the finest throughout. Order direct or send for bulletin.

Two tube outfit, as shown above, for use with headphones only..... $29.50

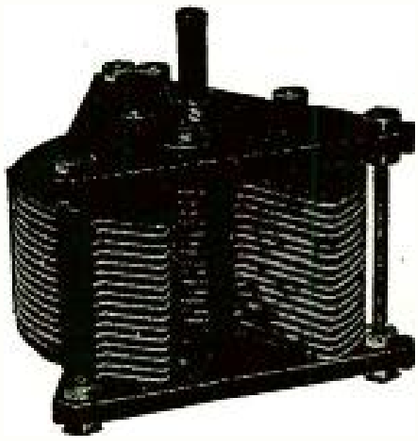
Four tube outfit for loudspeaker or headphones... $54.50

DEALERS—write for proposition quickly—it's a winner. AGENTS

THE MIDWEST RADIO COMPANY

812 Main Street **Cincinnati, Ohio**

Sharpen Your Tuning



A

General Radio Co. Type 247 Variable Air Condenser.

NO operator of a radio receiving set need be told of the advantage of sharp precise tuning. It is not always clear, however, how this may be obtained. After a good tuning coil has been chosen look to the CONDENSER for the answer.

Years before radio became a popular pastime, the General Radio Co. was manufacturing low loss, scientifically designed condensers for use in such discriminating laboratories as those of the Bureau of Standards, Naval Radio, General Electric, Westinghouse, Western Electric and the leading educational institutions of the country. The efforts of these years of research work in our own laboratory have resulted in the design of a condenser incorporating the best features in design and at the same time available at a price substantially lower than other good quality condensers.

Here are some of the important features: Sharp tuning through low loss design using hard rubber properly placed—Heavy brass plates soldered together keeping capacity constant and greatly reducing danger of shortcircuiting—Low zero capacity giving wide wave length range—A CONTINUOUS VERNIER formed by a gear and pinion combination. Only one setting required.

Made in three sizes, 250, 500 and 1000 m.m.f. to fit every circuit. Mounted condensers are fitted with calibrated direct reading capacity dial.

Prices $3.00 to $8.50. Send for Educational Pamphlet, "Quality Condensers" and new RADIO BULLETIN 916U.

GENERAL RADIO CO.

Manufacturers of Electrical and Radio Laboratory Apparatus

MASSACHUSETTS AVENUE AND WINDSOR STREET

CAMBRIDGE, MASSACHUSETTS

The "A" Battery's Power in Your Radio Receiving Set

THIS IS NUMBER TWO OF A SERIES

THE sole purpose of the "A" Battery in your Radio Receiving Set is to furnish current to heat the filaments of the tubes.

And this can be done satisfactorily only by an "A" Battery that supplies an adequate steady current.

Anticipating the popularity of the dry cell tube in Radio, and realizing that it required a Dry Cell capable of standing up under service conditions differing from what dry cells are called upon to meet in other fields, the National Carbon Company developed the Eveready Radio Dry Cell specifically for this new use.

A dry cell gives its maximum service only when designed especially for the work it is intended to perform. There are for dry cells several uses which are so alike that one type of cell serves for all. This is the field covered by the ignition or general purpose dry cell.

The conditions encountered in Radio are different from the conditions grouped together under the term "general purpose." And while the general purpose dry cell performs well as an "A" Battery, it was found possible to produce a Dry Cell "A" Battery capable of delivering more service on Radio loads.

Thirty years of dry cell experience and an immense research organization resulted in the superior Eveready Radio Dry Cell. One of the outstanding features of this special cell is that while it will last much longer when used as an "A" Battery, it is no larger than the standard dry cell.

The increased service life of the Eveready Dry Cell "A" Battery greatly offsets the slight increase in cost; so this battery is not only the best, but it is the most economical you can buy. "The Story of Eveready Dry Cell Radio 'A' Batteries," which tells how to use Dry Cells to the greatest advantage with the various dry cell tubes now available, will be sent to you free on request.

* * * *

The "A" Battery gives power to your Radio Receiving Set. Eveready Batteries—especially made for Radio—serve better, last longer, give better results.

Note: This is number 2 of a series of informative advertisements which will appear in this magazine. They are designed to help users get the most out of their Batteries and their Radio Sets. If you have any battery problem, write to G. C. Furness, Manager Radio Division, National Carbon Company, Inc., 128 Thompson Ave., Long Island City, N. Y.

POWER

for Your Radio Set

Eveready Dry Cell Radio "A" Battery (No. 7111)

Directions and wiring on the jacket tell just how to use this battery with the different dry cell tubes.

This special Radio Cell is also available in two and four cell multiple batteries for receiving sets employing from two to four WD-11 or WD-12 tubes.

Other Radio Batteries

Eveready Storage "A" Batteries—best suited for filament heating of all Radio Tubes not especially designed for dry cells. The quality storage battery with the long life plates, $15 to $20.

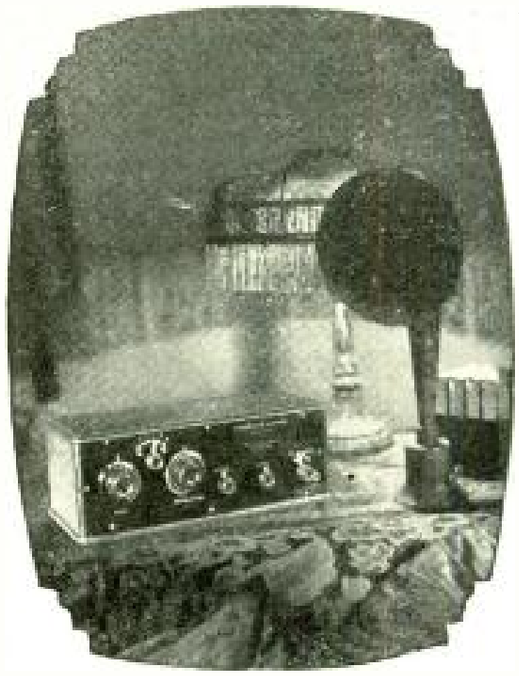
Eveready "B" Batteries—the life of your Radio.

Eveready "Three" Battery—3 cells, 3 purposes.

Manufactured and guaranteed by

NATIONAL CARBON COMPANY, Inc.

EVEREADY
Radio Batteries
—they last longer



The Thrill of Great Distance

For 12 years, Tuska-built radio receivers have been famous for long range reception, and have made records that are unsurpassed.

F. R. Alger of Prince Albert, Saskatchewan, Canada, says, "I am sending a list of 67 stations, a total distance of 78,200 miles away. You will realize that all stations are far removed from us; most of them have to come over 1,600 miles. The Tuska is remarkable for simplicity of tuning. It has been a source of great satisfaction."

You needn't know a thing about radio

Night after night, year after year, a Tuska Radio will bring fine entertainment into your home, at a trifling expense for operating.

You need not depend upon good-natured friends with radio experience to help put a Tuska in your home. Surprise them all by doing it yourself. It is easy to install your own "listening post," and pick up your choice of the wonderful concerts that fill the air.

At pleasure you can tune out any program and tune in another more to your liking. The same Tuska that fills your rooms with clear, unmarred music and distinct speeches will also pick up broadcasting from stations 2,000 or more miles away.

Some of the most experienced radio inventors and engineers in this country designed and built the Tuska. It is right, forever, and needs no tinkering. Have no fear that it will become obsolete. A Tuska set bought today will be serviceable for years to come.

Tuska Popular No. 225

3-bulb Regenerative Receiving Set

Piano finish mahogany cabinet. Amplifier switch. Concealed binding posts. Armstrong circuit, licensed under Patent No. 1,113,149. Price $75, without bulbs, batteries or loud speakers.

Ask for special circular No. 15E, describing this set.

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

The C. D. Tuska Co.

Hartford, Conn.

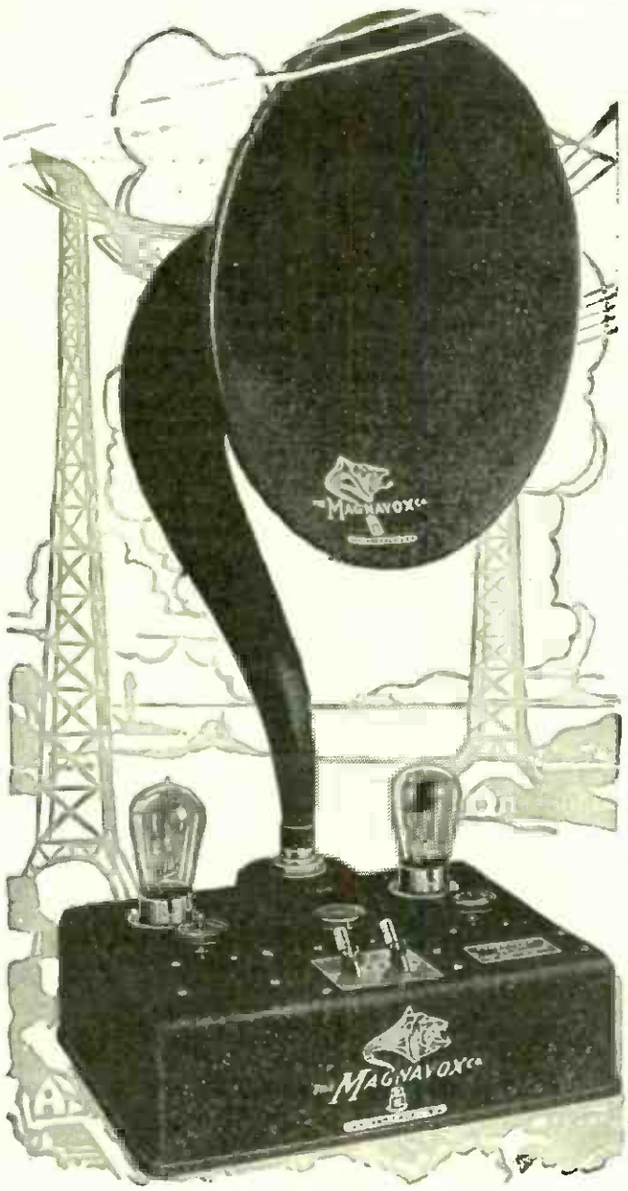
TUSKA RADIO

Magnavox Radio

The Reproducer Supreme

SO simple in operation that any Radio user can obtain perfect results—so sensitive and flexible in scope that the professional will find it fully responsive to every requirement—the new Magnavox Combination Set A1-R or A2-R brings a degree of radio usefulness and enjoyment never before attained.

Every condition in the art of radio reproduction is most successfully met by Magnavox apparatus.



The New Magnavox Combination Sets A2-R [2-stage] and A1-R [1-stage] insure the utmost in convenient, home radio reproduction.

Magnavox Reproducers

R2 with 18-inch curvex horn	$60.00
R3 with 14-inch curvex horn	35.00
M1 with 14-inch curvex horn. Equipped with binding posts and a five foot flexible cord; requires no battery for the field.	35.00

Magnavox Combination Sets

A1-R consisting of electro-dynamic Reproducer with 14-inch curvex horn and 1 stage of amplification	59.00
A2-R consisting of electro-dynamic Reproducer with 14-inch curvex horn and 2 stages of amplification	85.00

Magnavox Power Amplifiers

A1—new 1-stage Power Amplifier	27.50
AC-2-C—2-stage Power Amplifier	55.00
AC-3-C—3-stage Power Amplifier	75.00

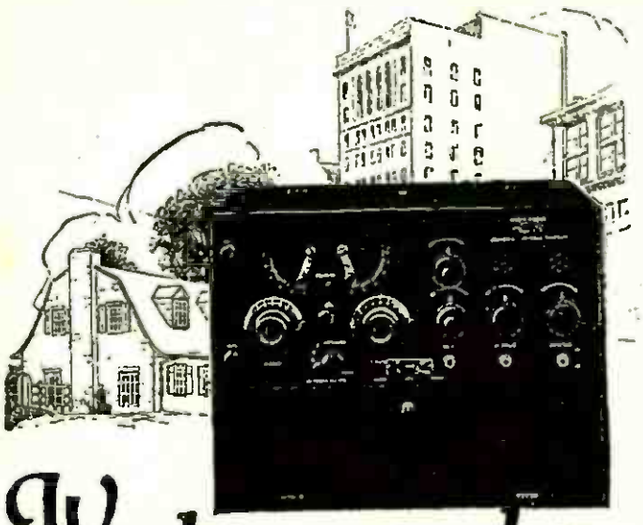
Magnavox Radio Products can be had of good dealers everywhere. 32-page catalog sent on request.

THE MAGNAVOX CO., Oakland, Cal.

New York Office: 370 Seventh Ave.

PERKINS ELECTRIC CO., LTD., MONTREAL, CANADIAN DISTRIBUTORS

11-R



Works everywhere -city or country-

"Local Conditions" do not exist where Moon Satterlee Antennaless Radio is installed. Here is a set which brings distortionless speech and music to you no matter where you live or how severe the local conditions. The Moon is operated by simply grounding to a water pipe or radiator—no antenna, loop or indoor wire is necessary.

Stations within a conservative 1000 mile radius are regularly received with a non-power loud speaker on this set.

It is the ideal set for use in apartments, automobiles, yachts or railroad trains where an antenna is not practical. Extremely sensitive, unusually receptive, yet simple to operate.

Write today for our folder "California or Newark"

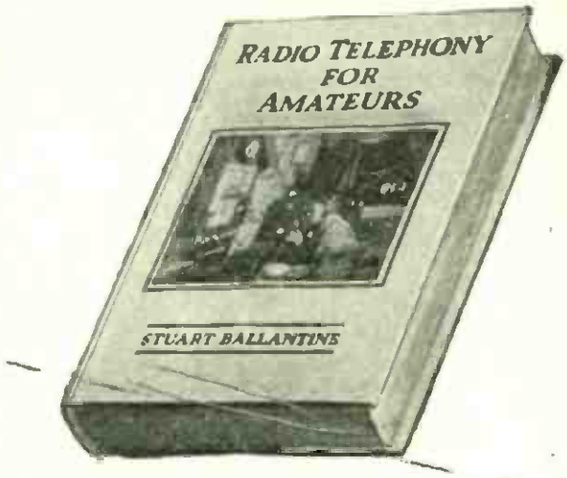
DEALERS:—Ask about our franchise

MOON RADIO CORPORATION

501 Steinway Ave., Long Island City, N. Y.

In Canada: Continental Equipment Co., Ltd., New Birks Bldg., Montreal, Quebec

MOON
Satterlee
antennaless
—RADIO—



This book puts you ahead of the crowd

You know the A B C of radio—now take the next step. Learn how to apply the fundamentals so as to greatly improve your results. Get the latest on scientific reception: build a transmitter. Your difficulties will vanish like magic before the lucidity of Mr. Ballantine's explanations and clean-cut diagrams. Two previous editions of this work bought out by thousands of enthusiastic amateurs. After reading this condensed table on contents, send along the $2—get ahead of the crowd.

Radio fully covered under these headings

PRINCIPLES — elementary theory of radio waves, etc.
TUBES — Audion as detector, amplifier, oscillator.
ANTENNA — various types; grounds and counterpoises.
TRANSMITTERS — circuits, details for building, operating.
SOURCES OF POWER — transformers, rectifiers, filters, batteries.
RECEIVERS—all types, super heterodyne, r. f. amplification.
GENERAL INFORMATION—laws, ethics, societies, etc.

Cloth bound, 296 pages, 153 cuts—the boiled down experience of 15 yrs. Many features not found in other publications.

Third Printing **$2** **POSTPAID**

Tear out coupon—*before you forget*

DAVID McKAY CO.,
S Washington Sq.,
Philadelphia

Enclosed Two Dollars is for the book—Radio Telephony for Amateurs, third printing. Please send postpaid—with the understanding that if not entirely satisfied, I may return the book within five days and have my money returned.

NAME .....

ADDRESS .....

.....

S P 2

1. Unlimited range
2. Perfect reproduction
3. Simplicity of operation
4. Genuine entertainment
5. No large antenna needed
6. Beautiful workmanship
7. Factory guarantee

W.E.A.F.	W.H.A.S.
W.O.R.	W.H.B.
K.D.K.A.	W.D.A.P.
W.F.I.	W.W.J.
W.D.A.R.	W.L.A.G.
W.L.W.	W.O.C.
W.S.B.	K.S.D.
P.W.X.	W.H.A.B.
W.J.A.Z.	K.F.C
K.Y.W.	

THE S. P. 2 Receiver stays sold, minimizes service expenses, unlimited range offering good volume and good distance, absolutely guaranteed. What more can you ask, Mr. Radio Business Man? Your letter head brings our proposition.

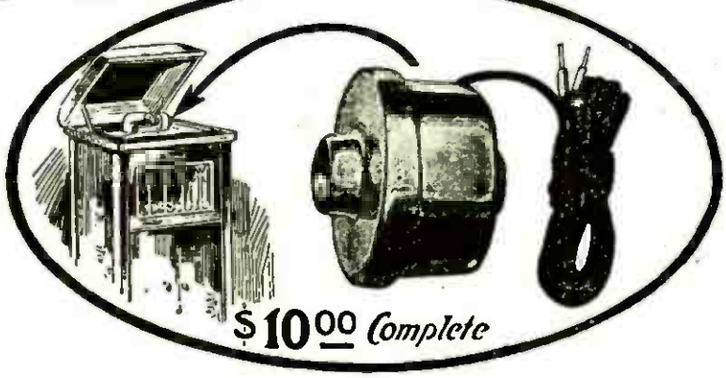
Catalogue 101A:—To "Radio Fans" on receipt of 10 cents

PITTSBURGH RADIO SUPPLY HOUSE

963 Liberty Avenue **Pittsburgh, Pa.**

S P 2

Morrison



Loud Speaker

RADIO SATISFACTION

True enjoyment of Radio begins when you and your family can sit comfortably in your living room and listen to all broadcasting reproduced in Clear, Full Volume. No annoying rattles, no harsh vibrations, no need for constant adjusting and fussing.

Morrison Loud Speaker gives you that kind of Radio satisfaction and pleasure, when attached to either your

PHONOGRAPH OR HORN

Attach the Morrison Loud Speaker to the tone arm of your phonograph—takes only a moment—and you have the benefit of the excellent phonograph sound box. Or attach it to any horn.

A little dial on the back of the Morrison Loud Speaker adjusts the tone from soft, mellow notes, to full-volumed, clear notes.

There is nothing to get out of order. Any one can use this wonderful radio unit with the same perfect results as an expert.

Order from your dealer, or send direct to us if your dealer cannot supply you.

DEALERS
If you are interested in one of the fastest-selling Radio units on the market, write or wire for our proposition—it is interesting.

Satisfaction guaranteed or your money back.

Price complete with 5 foot cord

Nickel Plated Model - - - - - -	$10.00
Gold Plated Model - - - - - -	$15.00

Write for illustrated catalog

MORRISON LABORATORIES, INC.

345 JEFFERSON AVE., EAST, DETROIT, MICH.

Radio Catalogue Free—

Write us a post card—

Address Dept. 38-R

and we will send you free this 52 page catalogue of radio sets and parts. It also contains explanation of radio terms, map and list of broadcasting stations and much radio information, including an explanation of successful hook-ups and circuits.

You will be amazed at the low prices Ward's quote. A complete tube set having a range of 500 miles and more, including tube, head set, batteries, and antenna equipment, as low as $23.50.

This catalogue contains everything for the expert and amateur. Complete sets and every improved part for building sets, all the most up-to-date devices—at the lowest possible prices.

Headquarters for Radio

Montgomery Ward & Co. is headquarters for Radio, selling everything direct by mail without the usual "Radio-profits." Why pay higher prices? Ward quality is the best and the prices will often save you one-third. Everything sold under our Fifty Year Old Guarantee—Your Money Back if You Are Not Satisfied. Write today for your copy of this complete 52-page Radio Book.

Write to our house nearest you. Address Dept. 38-R

Chicago Kansas City St. Paul Portland, Ore. Ft. Worth

Montgomery Ward & Co.

The Oldest Mail Order House is Today the Most Progressive

An Authority Describes The Ideal Radio Receiver

"It seems to us," says the Editor of Radio Broadcast, "that a set having radio and audio frequency amplification, without regeneration, must be possible in such a design that the only adjustment required is the one dial tuning the antenna circuit—the antenna being a loop . . . . To do away with the tinkering—simply to turn one handle to a definite marked point and get the station wanted . . . . that is the kind of a set which will find favor in the future."

Yes, Mr. Editor, you are right. Such a set is already finding favor all over the United States. It is the De Forest D-7-A Reflex Radiophone, and the D-10 Four-Tube Reflex fills the same prescription, with the addition of a Vernier Variable Condenser for precision tuning.

In spite of new fangled circuits, the De Forest Reflexes are snatched up by the radio public faster than we can make them, because of their *simplicity* of installation and operation—the fact that they cost so little to operate—the elimination of the outdoor aerial—and their great selectivity. You can get the station you want, when you want it, without interference.

These features, with a range on indoor loop of from 1,500 to 3,000 miles according to atmospheric conditions, have made people prefer De Forest Reflexes at $125.00 and $150.00 to sets costing four times as much.

Whether you buy complete sets or build your own—

"Rely on De Forest, the Greatest Name in Radio."

D-7-A Reflex Radiophone, $125.00; D-10 4-Tube Reflex Radiophone, (illustrated) $150.00. Prices plus approximately 6% for transportation west of the Rockies. These Reflex sets operate either on wet or dry cells with De Forest wet or dry cell audions.

DE FOREST RADIO TEL. & TEL. CO.
Dept. P. R. 3 **Jersey City, N. J.**

If located west of Pennsylvania, address

DE FOREST RADIO TEL. & TEL. CO.
WESTERN SALES DIVISION
Dept. P. R. 3, 5680-12th St. **Detroit, Mich.**

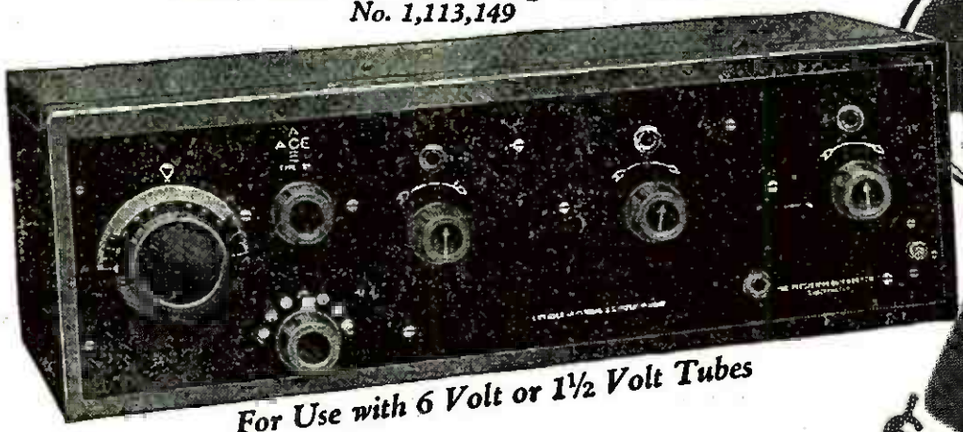
RADIO CATALOGS FREE *Send us your name and address and we will send you the De Forest catalog and price list of sets, audions and parts.*

THE NEW ACE

Three Tube Regenerative Receiver

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

3B



For Use with 6 Volt or 1½ Volt Tubes

ONLY $50

If your dealer cannot supply you, order direct, mentioning his name. Ask for "Simplicity of Radio." Your copy is FREE.

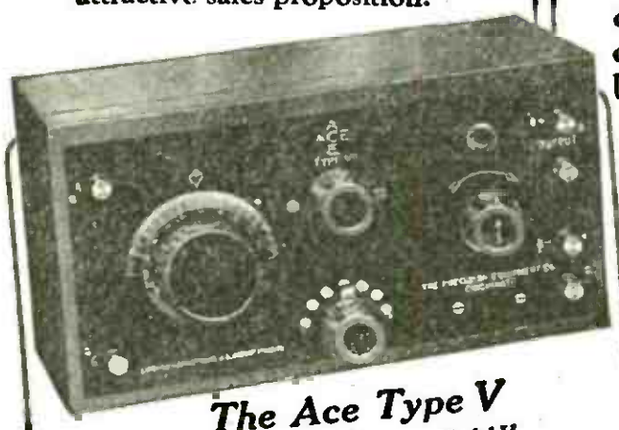
DEALERS:

Write on your letterhead for attractive sales proposition.

This New Ace Type 3B Armstrong Regenerative Radio Receiver combines detector and two stages of Audio frequency amplification. The lowest priced quality receiver ever offered.

When you tune in with this set distant stations come in as though they were only a few miles off. The two stages make the use of a loud speaker possible—this is a desirable feature. Its efficiency has passed every test.

One of the few sets that functions perfectly with all makes of tubes. Has filament switch which eliminates necessity of turning out the rheostats when set is not in use. With this switch you can turn off set and come back later to same concert without retuning. The telephone jack makes it possible to use head phones. When head phone plug is inserted it automatically eliminates loud speaker, but does not affect the filament current. Has genuine mahogany cabinet with beautifully engraved panel.



The Ace Type V

Formerly Called Crosley Model V

The low cost of this set together with its efficiency and simplicity makes the great demand for it increase daily.

A long range receiver. Stations from coast to coast can be heard distinctly. An Ace Two-step Amplifier in connection with this set at $20 makes use of loud speaker practical. Has Crosley Multistat, which permits use of any make tube.

$20

THE PRECISION EQUIPMENT COMPANY

Powel Crosley Jr. PRES.

1116 Vandalia Ave. Cincinnati, Ohio

DESIGNED ESPECIALLY FOR RADIO RECEIVING

We are Manufacturers of Fine Furniture and we sell direct to you with only a small factory profit.

A handsome hardwood hand-rubbed mahogany or golden oak finished Radio Table. Size of top 20 x 34 inches x 31 inches high.

Conceals A & B batteries. Small drawer holds tools and accessories.

PRICE, FREIGHT PAID, East of Mississippi River..... **$18.00**
FREIGHT PAID to Rocky Mt. States.. **20.00**
FREIGHT PAID to Pacific States..... **22.50**

Cash with order. Prompt shipment.

CABINET PRICES REDUCED!

Hardwood, hand-rubbed mahogany finish. Hinged top.

Panel Size	Depth	Price
6 x 7 in.	7 in.	**$2.25**
6 x 10½ in.	7 in.	**2.50**
6 x 14 in.	7 in.	**3.00**
6 x 21 in.	10 in.	**3.75**
7 x 18 in.	10 in.	**3.50**
9 x 14 in.	10 in.	**3.50**
12 x 14 in.	10 in.	**4.00**

POSTPAID, East of Mississippi River.

POSTPAID to Rocky Mt. states, add 25 cents.

POSTPAID to Pacific states, add 50 cents.

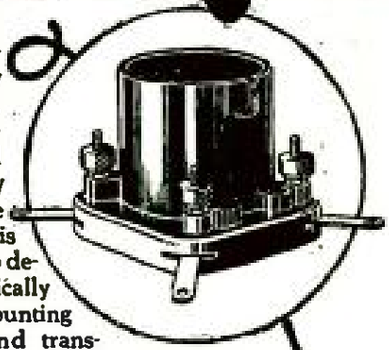
Cash with order. Prompt shipment.

Send for free catalogue of Radio Furniture.

THE SOUTHERN TOY CO.
HICKORY, NORTH CAROLINA

Announcing

E. T. Flewelling Sockets



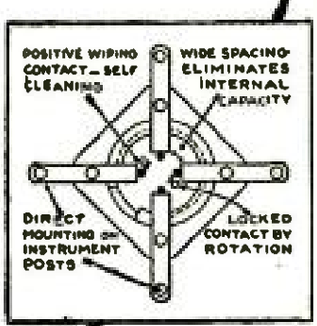
The first unit of a series of parts designed by Mr. E. T. Flewelling, inventor of the 'Flivver Circuit,' which will assemble into a really capable set is the Flewelling Socket. This socket has terminals so designed that they practically assemble the set by mounting on tuner, rheostat and transformers direct.

Internal capacity has been whipped by so spacing a new type of contact terminal that ideal conditions for radio frequency and reflex work are established. Further—good, clean contact against the base part of the tube terminals, with an easily inserted and firmly held tube, results in eliminating doubt as to good electrical contacts.

E. T. Flewelling says:

"Stray or internal capacity effects must be eliminated if we are to secure maximum results."

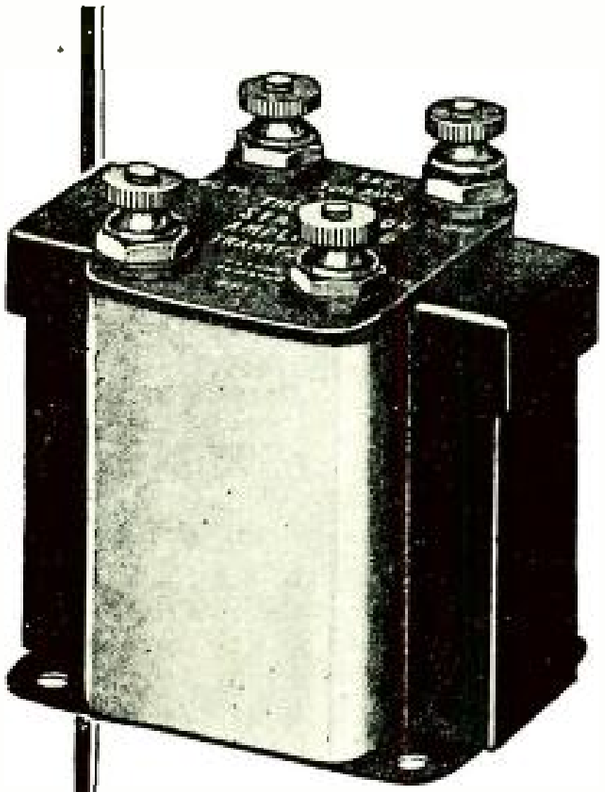
Watch this space in our advertisements for a series of helpful hints that will enable the radio fan to build a better set than has heretofore been deemed possible.



PRICE

Standard tube Socket **$1.00.** At your dealers or, until he is supplied, post paid upon receipt of price.

BUELL MANUFACTURING COMPANY
2979 Cottage Grove Avenue
CHICAGO



The New

THORDARSON

Super Transformer

More than a quarter of a century has been devoted by Thordarson engineers to the design and development of power transformers ranging in size from the smallest bell ringer to the first 1,000,000 volt transformer the world ever saw.

That knowledge and practical experience has been intelligently devoted to devising an Audio Frequency Amplifying Transformer that would produce the greatest volume consistent with *true tone quality.*

Here it is—its specifications and efficiency under all atmospheric conditions and over all audible signals, ranging from 100 to 7,000 cycles have been tested and endorsed by the foremost radio engineers in the United States. Thousands of these new amplifying transformers are daily furnishing the means to greater pleasure and entertainment to discriminating radio amateurs and experimentors.

Developed and manufactured entirely by Thordarson engineers in the Thordarson plant

It is not merely an assembly of bought coils, core iron, etc., as is the case of most audio frequency transformers in the market.

Core is made of .007 highest grade silicon steel, No. 36 gauge, the cross section of which measures ¾ inch—twice that of the usual type transformer. Coil is *square layer wound* of No. 40 wire to fit the square core. The winding process and machinery were designed and developed exclusively by Thordarson.

The basic principle and construction of this new Thordarson product are scientifically, electrically, and mechanically correct. Exhaustive tests and experiments have proved conclusively that:

1. Core losses are reduced to a minimum.
2. Over-saturation of the core is eliminated.
3. When in use the resistance of the plate circuit of one tube and the resistance of the grid circuit in the following tube are balanced to a degree heretofore unequaled.
4. The received energy is increased sufficiently to actuate loud speaking devices without distorting the incoming signal.
5. The volume produced is as great as *pure tone quality reproduction will permit.*

The new Thordarson amplifyer is the choice not only of thousands of amateurs and experimenters, but an increasing number of leading receiving set manufacturers now specify Thordarson Transformers as standard equipment.

Make your own test

Words nor pictures nor specifications alone can do justice nor prove the superiority of Thordarson products. Let your own ears guide you in your comparison.

SOLD AT ALL GOOD DEALERS

PRICE, MOUNTED ONLY

6 to 1 ratio transformer . $4.50
(with Red Label)

3½ to 1 ratio transformer 4.00
(with Blue Label)

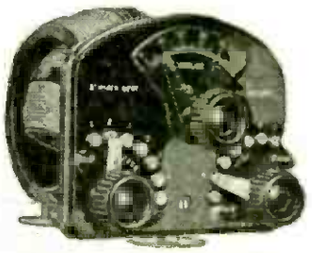
THORDARSON
ELECTRIC MFG. CO

Huron and Kingsbury Streets, Chicago

ATWATER KENT
RADIO EQUIPMENT

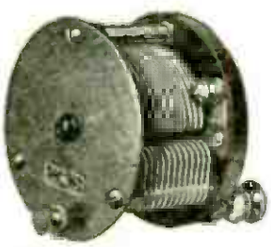
2-Stage Amplifier

Type 11 Tuner



Mounted Variocoupler

Variable Condenser Table Mounting, Front Control



Variable Condenser Panel Mounting

ATWATER KENT Radio equipment is distinctive for the quality of its performance. Parts and Sets embrace a variety sufficiently wide to meet the requirements of every user of radio.

Sets commence with the simplest combination of tuner and detector unit and include the most complete arrangement of units that has been found practical.

Parts include every instrument necessary to the assembling of complete sets.

Every ATWATER KENT Radio Product represents the accumulated experience of more than 25 years in the design and manufacture of scientific electrical equipment.

All insulating parts are made of moulded condensite—they are moisture proof.

Literature describing the entire line of Atwater Kent Radio Sets and Parts sent on request

ATWATER KENT MANUFACTURING COMPANY
4933 STENTON AVENUE, PHILADELPHIA, PA.

Makers of
THE WORLD'S HIGHEST GRADE IGNITION
STARTING AND LIGHTING

Get This First Class Radio License

You Can Earn Big Money With It

THE best paid positions in radio go to the men who hold the Government's First-Class Commerical License. The radio men on every ship, in every land commercial station, in every broadcasting station, must have one of these licenses. Every radio inspector must pass the first-class license examinations. Engineers, mechanics, installation and maintenance experts must all of them own a Government First-Class Commercial License in order to operate a transmitting station. It is every radio man's ambition to get a license, not only because it is the highest mark of honor he can get but because it also opens to him all the wonderful opportunities in this great profession.

Emmett Welch of Peculiar, Mo., is Radio Salesman making $300 per month and expenses, Merle M. Wetzel is inspector in the Engineering Dept. of a Public Service Co., Edwin Forsyth is on his way to Scotland as first-class licensed operator on board ship. Read in the panel of the fine salaries paid in all the wonderful positions open to you as soon as you get the Government First-Class License.

Pick Out the Job You Want and We Will Help You Get It

We have trained hundreds and helped them to splendid paying positions in Radio. You will be interested in knowing exactly what these graduates are doing and in reading the actual letters written by them. Our new Free Book contains scores of these letters, each one a story of success in itself. Send for this book.

Here is a brief list of positions in Radio, and the salaries they pay.

Radio Mechanic, $1,500 to $4,000 a year.
Radio Inspector, $1,800 to $4,500 a year.
Radio Salesman, $2,000 to $10,000 a year.
Radio Engineer, $3,500 a year and up.
Radio Executive, up to $15,000 a year.
Radio Instructor, $200 to $500 a month.
Radio Draftsman, $7 to $15 a day.
First Class Ship Operator, $120 a month, all expenses paid.
Commercial Land Station Operator, $150 a month and up.
Broadcasting Station Operator, $125 to $250 a month.

Win Your Government License This New, Easy Way

The National Radio Institute, America's first and largest Radio School, has devised a remarkable new method that makes it easy for you to win your license. No previous experience in electricity or radio is necessary. Spare time study at home prepares you in an amazingly short time to pass the Government examinations, so you can get one of the fine jobs waiting in this great field. The diploma we give you upon completion of the course, counts for 5 to 10 credits on all government license examinations.

Four Radio Instruments Free

An extraordinary feature of this course is the use of four patented instruments, owned exclusively by us, which give practical training in radio operation, installation and maintenance and repair—all of which you **must** have to become an expert.

Among these instruments is the wonderful Natrometer, said by experts to be the perfect device for teaching the Radio Code. All of these instruments are given free during the course.

Send for Free Radio Book

Thousands of positions are open to Radio Experts. Find out what **your** opportunities are in this fascinating profession. Send for interesting free book, "Your Opportunity in Radio," which gives complete details on plan by which the National Radio Institute quickly qualifies you for a Government Commercial License. If you are sincerely ambitious, send the coupon or a postcard for free book NOW.

NATIONAL RADIO INSTITUTE
Dept. 32L WASHINGTON, D. C.

NATIONAL RADIO INSTITUTE
Dept. 32L WASHINGTON, D. C.

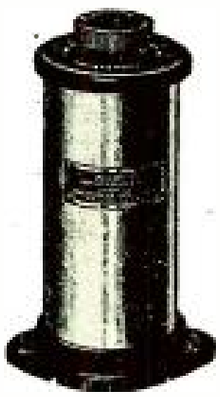
Send me your free book, "Your Opportunity in Radio," with full particulars about the opportunities in radio, and how you will quickly train me in my spare time at home to win a Government First-Class Commercial License. Also tell me how your free Employment Service will help me to a position.

Name.....Age.....

Street.....

City.....State.....

Tells how to get those stations you read about but never hear



BALLANTINE
VARIOTRANSFORMER.
for
Radio Frequency
Amplification
(Patents Pending)

On Sale at All Good Radio Stores
or Postpaid, Price $9.60

CONTENTS

"Radio Frequency Amplification with the Ballantine Variotransformer"

Here's a booklet that will help you get many stations that you've never heard before. Based on research of the Radio Frequency Laboratories, Inc., it gives the latest developments in tuned radio frequency amplification. Furthermore, it tells how to use the *continuously variable* BALLANTINE TRANSFORMER for both amateur and broadcast wavelengths—with amplification *uniformly high.*

Free for the asking, this 25-page booklet is full of facts, helpful information and practical diagrams. Edition is limited—better write for your copy at once.

BOONTON RUBBER MFG. CO.
224 Fanny Road
Boonton, N. J., U.S.A.

Boys have built the radio business

METEORIC, magic, unbelievable—that describes the stupendous growth of the radio business. The demand for sets and parts has increased 60,000 per cent in two years. What has caused this surge of radio interest? The contagious, resistless, energetic enthusiasm of boys.

The lure of radio has caught the imagination of youth. All over the country a vast majority of radio sales are made to boys, or to adults purchasing for boys. To the very limit of his means a boy buys his own equipment, but, lacking funds, he so convinces dad of his desire for radio, and of his knowledge of construction, installation and operation, that dad digs deep and buys the best his pocket affords.

THE AMERICAN BOY
"The Biggest, Brightest, Best Magazine for Boys in All the World"

goes straight to the source of radio sales. Five hundred thousand go-getting sons of well-to-do parents read it regularly from cover to cover. Dyed-in-the-wool radio fans, they turn to its advertising columns for the equipment to supply their radio needs.

Averaging 15½ to 16 years old, their knowledge of radio commands the respect and confidence of their elders; their buying power is large, and their influence on buying decisive. Your advertisement, broadcasted to these up-to-the-minute, radio-saturated boys, will find the greatest market in the world tuned in and listening eagerly.

Start the new year with a message to the army of AMERICAN BOY readers. Copy for January should reach us by November fifteenth.

THE SPRAGUE PUBLISHING COMPANY
(Member A.B.C.)
548 Lafayette Boulevard, Detroit, Mich.

POPULAR RADIO with Your Other Favorites—at Special Club Prices!

Your pick of these leading magazines at reduced rates in combination with a year's subscription to POPULAR RADIO

GLANCE over this big list of magazine bargains that have been arranged for your benefit. Here is your chance to get almost any magazine you want—and by ordering *now* with a year's subscription to POPULAR RADIO you get *both* magazines at special low prices.

If you are already a subscriber to POPULAR RADIO or to any of these other magazines, these special club offers allow you the privilege of renewing or extending your subscription *at a considerable saving of money.*

As you know, the subscription price of POPULAR RADIO will soon advance from $2 to $3 a year. Yet practically all of these magazine combinations are figured at a price for each magazine that is lower than even the present subscription price.

Fill your magazine requirements *now* for the coming year and save money. Simply check the offer you want and mail the coupon below, with your remittance. All subscription prices quoted are for one full year, and may be sent to *one* or to *separate addresses* unless otherwise noted.

But do not delay. These offers are good only until December 15th, 1923. After that date POPULAR RADIO advances in price and these prices will be withdrawn. Safeguard yourself *now* against POPULAR RADIO's raise in price, and in addition get these other magazines at special bargain club rates!

McCall's **Popular Radio** $3.00 Reg. For..... **$2.40**	**Modern Priscilla** **Popular Radio** $4.00 Reg. For..... **$3.25**
Youth's Companion (52 issues) **Popular Radio** $4.50 Reg. For..... **$3.75**	**Scientific American** **Popular Radio** $6.00 Reg. For..... **$5.25**
American Magazine **Woman's Home Companion** (both to one address) **Popular Radio** $6.00 Reg. For..... **$5.00**	**Pictorial Review** **Modern Priscilla** **Popular Radio** $5.50 Reg. For..... **$4.50**

Or You Can Make Up Your Own Club of POPULAR RADIO With:

American Boy	$4.00 reg., for...	$3.75
American Magazine	4.50 reg., for...	4.25
Asia	5.50 reg., for...	4.75
Boy's Life	4.00 reg., for...	3.50
Century	7.00 reg., for...	5.75
Christian Herald (52 issues)	4.00 reg., for...	3.15
Collier's (52 issues)	4.50 reg., for...	3.75
Country Life	7.00 reg., for...	6.25
Delineator	4.00 reg., for...	3.25
Designer	3.50 reg., for...	2.85
House & Garden	5.50 reg., for...	4.75
Judge (52 issues)	7.00 reg., for...	6.25
Life	7.00 reg., for...	6.75
McClure's	5.00 reg., for...	3.90
Mentor	6.00 reg., for...	5.25
Movie Weekly	7.00 reg., for...	6.25
People's Home Journal	3.25 reg., for...	2.65
Photoplay	4.50 reg., for...	4.25
Physical Culture	5.00 reg., for...	4.25
Popular Science Monthly	4.50 reg., for...	4.25
QST	4.00 reg., for...	3.60
Radio	4.50 reg., for...	4.00
Radio Broadcast	5.00 reg., for...	4.25
Radio Digest (52 issues)	7.00 reg., for...	6.25
Radio News	4.50 reg., for...	4.00
Radio World (52 issues)	8.00 reg., for...	7.25
Review of Reviews	6.00 reg., for...	4.75
Scribner's	6.00 reg., for...	5.25
Sunset	4.50 reg., for...	3.75
System	6.00 reg., for...	5.25
Today's Housewife	3.00 reg., for...	2.40
Vogue (26 issues)	7.00 reg., for...	6.25
Wireless Age	4.50 reg., for...	4.00
World's Work	6.00 reg., for...	5.25

Note: If you wish any TWO or more of these magazines with POPULAR RADIO, simply deduct $1.75 from the bargain club price quoted, then add POPULAR RADIO at $1.75. For example:

Collier's	$3.75 less $1.75 =	$2.00
Radio News	4.00 less 1.75 =	2.25
POPULAR RADIO, added at only		1.75
Remit this amount		**$6.00**

POPULAR RADIO, Dept. 111.
9 East 40th Street, New York City.

Enclosed is $..... Please see that yearly subscriptions are at once entered in my name for each of the magazines I have checked in the special bargain club list at the right.

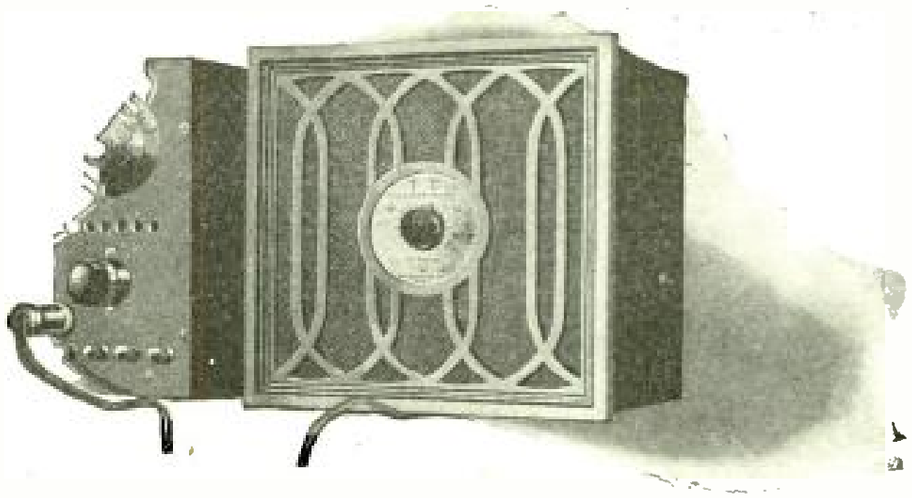
Name.....

Street and Number.....

City.....State.....

(If not a NEW subscription, please mark R after the name of the magazine, to indicate RENEWAL.)

Prices for Canada and foreign countries will be quoted on request.



Where do you keep your radio?

Gone is the day when radio was called "wireless" and kept in the attic or the kitchen. Today, radio is in the same room with the piano, phonograph and the floor lamp, for it is furniture and should be selected as furniture on a basis of beauty as well as utility. In other words

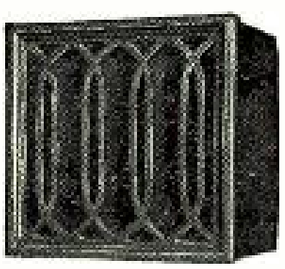
It's time to consider appearances

This applies particularly to loud speakers. Timmons Talkers, with their symmetrical lines and the rich hand-rubbed mahogany finish of their cabinets and grills are the most beautiful loud speakers in the world.

We have also perfected the most efficient method of tone reproduction ever known. It is ***reflected*** tone. Two concealed metal horns are used. Both are surfaced with "acousticoat"—a substance which makes them absolutely dead to distortion and false tones. Everything is heard as naturally as it is broadcast.

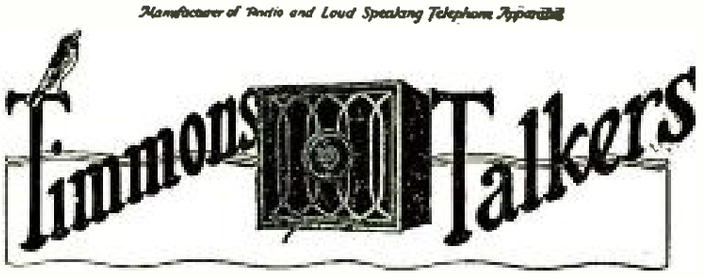
And now we ask you to hear and see the result of our work—the new Timmons Talkers. Your dealer carries both models—A, $35; N, $25.

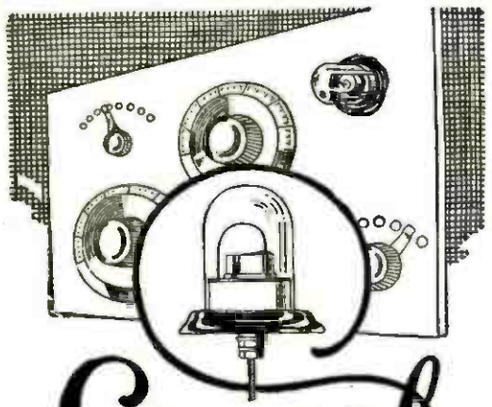
Ask him for our folder "Volume without Noise"—or write us



The screen of type A (Adjustable) is rich bronzed gold. Type N (Non-adjustable) has a screen of copper-color mercerized Madras.

J.S.TIMMONS
339 East Tulpehocken St.
Germantown, Phila., Pa.
Manufacturer of Portable and Loud Speaking Telephone Apparatus





Grewol

THE PERMANENT DETECTOR

OFTEN imitated but never equalled. Maximum detector efficiency made constant, lasting. No flimsy cat-whisker; no parts to wear loose, no hunting for the sensitive spot. The GREWOL is proof against all ordinary detector troubles. The *only* detector for reflex, duplex and all circuits. Fully patented. Unconditionally guaranteed. **$2.00**

Tested and approved by Jack Binns, radio editor of the N. Y. Tribune.

If your dealer has no GREWOLS, send $2. to us with your dealer's name.

Write for Booklet

RANDEL WIRELESS COMPANY
4 Central Ave. **Newark, N. J.**

For Radio Aerial Installation

THE BULL DOG MAST SEAT

FILLS A LONG FELT WANT by enabling anyone to install a firm and rigid mast, on either a peaked or metal ridge roll type of roof, with ordinary tools found around the home, thereby eliminating customary trouble, labor and expense. Supplying neat, substantial construction throughout the entire aerial.

Seat for 1½" mast, hinged type	$3.00
Seat for 1½" mast, peaked type, plain	2.50
Seat for 1" mast, peaked type, plain	2.00
Seat for 1½" mast, flat base	2.50

Jobbers and distributers write for discounts.

MAST SEAT MFG. CO.
119 5TH ST. S. E.
MINNEAPOLIS **MINN.**

Head Set $4.50

Loud Speaker $12.00

"ROYALFONE"

KING OF ALL

A head set far superior to the average and just as good as the best.

Equally good for all distances.

A loud speaker of superior qualities. Reproduces signals with no distortion at high amplification. A home instrument at a very moderate price.

Royal Electrical Laboratories
Ordway Bldg, Newark, N. J.

Royalfone
KING OF ALL

Pick Up Distant Stations Easier

with

The BROCKWAY VARIABLE CONDENSER

It gives greater efficiency in radio frequency, reflex neutrodyne and other critical circuits. Combines advantages that no other condenser can give.

Easier to Adjust

than a vernier. Two complete revolutions of dial (720 degrees movement) make accurate tuning easy.

Saves Space

behind panel, leaving more room for other instruments, tubes, B batteries, etc.

Improves Any Circuit

requiring 11 to 43 plate condenser. Gives longer distance reception.

If your dealer has no Brockway Variable Condenser in stock, ask him to order for you; or we'll send postpaid on receipt of price with dealer's name and address.

PRICE $3.50.

BROCKWAY LABORATORIES CO.
Factories Bldg., TOLEDO, OHIO

Still Time to Subscribe to Popular Radio at the Old Price!

Fill out the coupon below, and save from one to three dollars

IN its improved and enlarged form, POPULAR RADIO now sells for 25 cents on the newsstands. The addition of 56 more pages of reading matter beginning with this November issue, now in your hands, makes POPULAR RADIO the biggest value for the money that can be had in the radio magazine field.

And although the newsstand price has already advanced, the *subscription* price, for a few weeks longer, remains the same. You can still subscribe to POPULAR RADIO at the old rate—only $2 for 12 big issues of 192 pages each.

Save Money by Acting Now

A year's subscription to POPULAR RADIO placed now, saves you a dollar over what you would pay later. **Or better still, you can now get TWO YEARS of POPULAR RADIO for only $3.** This special offer means a saving to you of $3. In other words, by acting now you may get two years of POPULAR RADIO at exactly **half** the price you would pay a few weeks from now!

To either **new** subscribers or **present** subscribers this same liberal offer is made. If you are already a subscriber, you may *extend* your present subscription for one or two years at these low rates, thus insuring yourself of all the helpful hints and practical suggestions, interesting articles, new hook-ups, and the wealth of timely information on all phases of radio which will appear in the pages of POPULAR RADIO during the months to come.

Mail the Coupon Today

Do not delay filling out and mailing the attached coupon. This offer is good only until December 15th, 1923. After that date all subscriptions to POPULAR RADIO will be at the rate of $3 a year. By taking advantage of this offer now, you save from one to three dollars.

And in addition, POPULAR RADIO itself—besides keeping you in touch with all the rapid developments in this fascinating field, will save you many times its cost when constructing and improving a set of your own, and will safeguard you against many an hour wasted in costly experiment.

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

(This offer holds good only until December 15th, 1923)

This Coupon Saves You $1.00 to $3.00

POPULAR RADIO, Dept. 115,
9 East 40th Street, New York City

Please enter (renew. or extend) my subscription to POPULAR RADIO for ONE YEAR at the present rate of only $2.00 a year. **This saves me a dollar** over what I would pay later, when the price goes up. I enclose $2.00 (check, money order or registered mail).

Name.....

Address.....

.....

POPULAR RADIO, Dept. 115,
9 East 40th Street, New York City.

Please enter (renew. or extend) my subscription to POPULAR RADIO for TWO YEARS at the special low rate of only $3.00. **This saves me three dollars** over what I would pay later, when the price goes up. I enclose $3.00 (check, money order or registered mail).

Name.....

Address.....

.....

(No extra for Canada. Foreign, ONE YEAR, $2.25: TWO YEARS, $3.50).

The Romance of Science

CONQUESTS of science were the real achievements of Egypt's rulers. Instead of physical prowess, they sought the laurels of intellectual supremacy. Battles became experiments. Physics, astronomy, alchemy became the chessmen of their leisure. Where other nations plunged into wars and devastation, the Egyptians gave over their vigils to the investigation of natural phenomena.

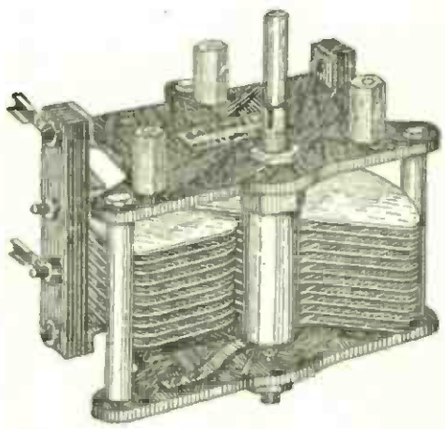
To symbolize this intellectual power and their ability to create, they conceived the Sphynx, and with unparalleled skill and persistence engraved their triumph on the face of History.

If you assemble your radio parts from plan or book, take time to drink in the romance of radio art. Know on what laws the perfection of your receiving set depends. To acquire such knowledge is not a boresome study, but an absorbing recreation. As you read, you will understand the impelling appeal of science which has ever tempted Masterbuilders to create craftsman-like products which are more than adaptations of existing designs.

By understanding the scientific basis of radio phenomena, you will begin to appreciate what every radio engineer knows concerning condensers:—that there are no condensers equal to Cardwell's.

Cardwell rotor-grounded condensers afford entire absence of body capacity effects and permit fine tuning of the most distant stations. They have such infiinitesimal losses, no laboratory has been able to measure them. Their mechanical ruggedness insures long usage and freedom from annoying difficulties. Not only will Cardwells often add a thousand miles to your receiving range but they permit the entire elimination of interference.

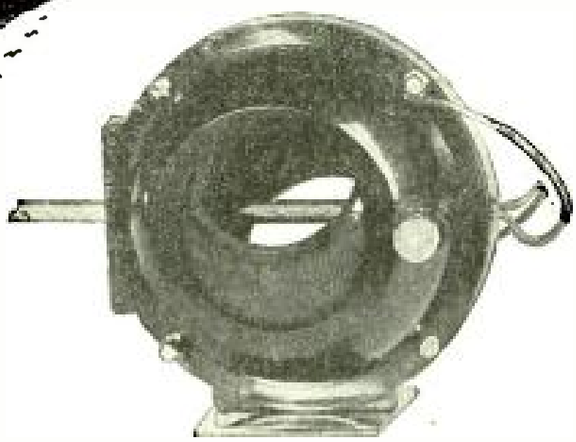
For Egyptian Nights' Entertainment, Read: "Cardwell On Condensers." Sent on Request.



Prices Vary From Three To Three Hundred Dollars

Sold Only Through Responsible Dealers

Raven Radio Instruments



Raven Bakelite Variometer
Catalog No. B-101

are the height of perfection. The result of long and rigid laboratory research.

Made of Genuine Bakelite with the hardware used nickel plated throughout.

Their size permits their use in an extremely varied number of applications.

Made to conform with all wave lengths for both amateur and broadcast listeners.

EVERY RAVEN INSTRUMENT IS UNCONDITIONALLY GUARANTEED

All Instruments are thoroughly inspected before leaving our factory and any purchase made by a Jobber, Retailer or User found defective in any way will be replaced by us with a new instrument free of charge to the purchaser.

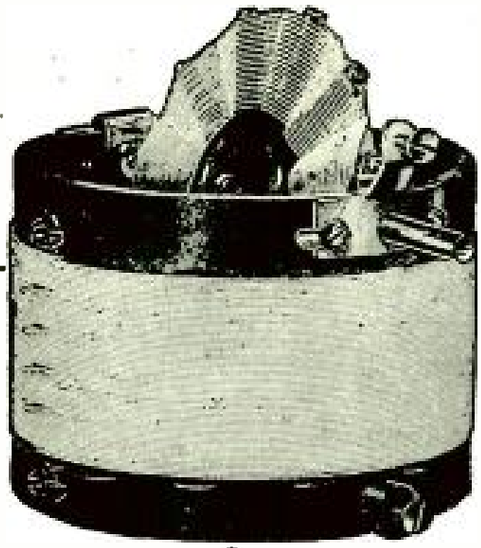
Raven Bakelite Variocoupler
Catalog No. B-102

Radio jobbers and dealers should write for our prices and descriptive literature on

Bakelite Variometer	**B-101**
Bakelite Vario-coupler	**B-102**
Bakelite Tickler Coil	**B-103**
Bakelite 180° Coupler	**B-104**
Bakelite 180° Tickler Coil	**B-105**
Bakelite Rheostat	**B-106**
Wooden Variometer	**C-101**
Wooden Tickler Coil	**C-103**

RAVEN RADIO, Inc.

8 Learned Street
ALBANY, N. Y.



HARTMAN

$6.50 VARIOCOUPLER $6.50

WITH SPIDER WEB ROTOR PAT'D

MINIMUM COUPLING—SELECTIVE TUNING

ROTOR—Spider Web design. 50 turns No. 25 d.s.c.wire STATOR—50 turns, No. 20 d.s.c. wire. 5 taps. SHAFT LENGTHS—for ⅛ in., ¼ in. and ¼ in. panels. Diameter—4 in. Height—4¼ in. Weight—1 lb.

The Hartman Electrical Mfg. Co. **Mansfield, Ohio**

Keep in Step
USE RAY COILS
for Distance and Volume

Ray Coils "A" for Reinartz, Ray Coils "B" for RCS and Ultra Audion Circuits, Ray Coils "C" for RCS, Ultra Audion and tuned radio frequency for RCS Circuits.

A = $2.50
B = 2.00
C = 2.00

Use the RCS Circuit with or without radio frequency for Simplicity in operation and results. Not equalled by any set for volume and distance.

Coils in Separate Box
With Wiring Diagram

Working blue prints of four sheets 12 x 18 of all standard circuits, such as The Variometer, Reinartz and RCS one and three tube sets. 50 cents a set.

If your dealer cannot supply you, send direct to us and we will mail them post paid anywhere in the U. S. A.

R. C. SCHOONHOVEN
Major Q. M. R. C.
ELGIN, ILL.

"UNITED" Radio
Condensers and Transformers

NO matter what you pay for radio parts you generally get just what you pay for—cheap parts are cheap—not only in price but in materials and workmanship, and you can only expect to get cheap results.

"United" Radio parts are not built to meet a price—but to meet the exacting requirements of the radio set owner. The price is then figured. Large production, modern machinery and plant—good management—all combine to keep the price way down and yet the products are built as well both mechanically and electrically as it is possible to build them.

You take no chance when you buy "United" parts. We are so sure that they are correct that we will sell them on a money back guarantee.

United Audio Frequency Amplifying Transformers
$4.50 Prepaid

"UNITED" Variable Condensers
without Vernier Dial and Knob

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

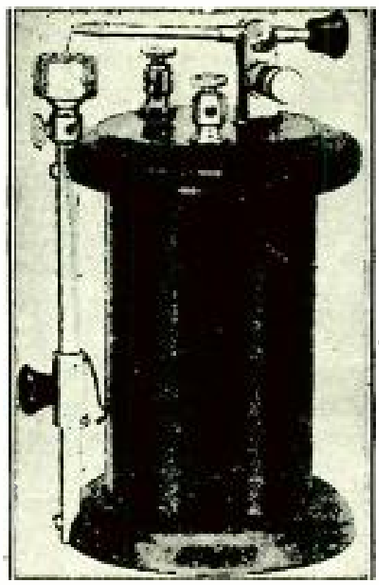
With Vernier Dial and Knob

46 plate $6.50 26 plate $5.50

If your dealer cannot supply, remit to us, sending in dealer's name.

UNITED MFG. & DISTRIBUTING CO.
9704 Cottage Grove Avenue **Chicago, Illinois**
New York Office: 50 Church Street, New York, N. Y.
San Francisco Office: 709 Mission St., San Francisco, Cal.

CRYSTAL SET



$3.50

"Neat, compact, efficient and remarkable value" is the expression used by one owner of a **Ritter Grand Crystal Receiving Set.**

Our guarantee: *Receiving range,* **25 miles or more.** *Wave length,* **500 meters.** *Audibility*—**Loud and Clear**

Outstanding Features: Roller bearing slider, nickel plated hardware, mahogany finished base and top, height 6".

Sold by all dealers or by mail direct from factory.

RITTER RADIO CORPORATION
232 Canal Street **New York City**

Originators and makers of the famous

$1.00 Ritter Portable Loop

Some exclusive territories on Ritter products still open to distributors and jobbers

Your Choice!
—for Only 22 Cents in Stamps!

Hundreds of reliable hook-ups and circuit diagrams—practical hints and handy knacks—money-saving tips and pointers on how to make and improve your own sets. Take your pick of all this authoritative information on radio!

PERHAPS you haven't realized what a tremendous amount of information is available in the back issues of POPULAR RADIO. Since the first number was published, May, 1922, literally hundreds of requests have come to us for these valuable back issues of POPULAR RADIO which contain so many practical hints and worth-while suggestions.

There are still a few copies left of many of these back issues. *While they last* you can take your pick of them at only 22 cents each, to cover cost and mailing. Here's your opportunity to complete your files of POPULAR RADIO and to add to your store of information on just the subjects which interest you.

Glance over this partial list of contents of each issue. Then tell us which ones you want, enclosing stamps, check or money order to cover your requirements. Our stock is getting very low, so don't delay taking advantage of this offer!

May, 1922

—Harnessing waves to wire.
—How to make and install your own Receiving Set.
—How to tune a Regenerating Receiver.
—Symbols that help in reading diagrams.
—How to make soldered connections.
—How Radio waves are sent and received.

June, 1922

—Wireless that we can see.
—Can we talk to the dead by Radio?
—How to use your Radio Set in summer.
—How electricity is generated.
—Tones that do and don't broadcast.
—How to make a simple tube Receiving Set.

July, 1922

—Steinmetz on ether waves.
—How to learn the code.
—How to make a two-circuit Receiving Set.
—How high frequency currents are generated.
—Pointers for preventing interference.
—How to make a loose-coupler coil.
—How to use your Phonograph as a loud speaker.

August, 1922

—How machines are controlled by Radio.
—How Radio circuits are coupled and tuned.
—What "call letters" mean.
—Radio on your pleasure boat.
—How to make a variable condenser.
—The foolish fear of lightning.

September, 1922

—How to build the Armstrong Circuit Receiver.
—How the Vacuum Tube works.
—A resonance wave coil for reducing static.
—How to make a rotary plate condenser.
—The simplest receiving antenna.

October, 1922

—How to make a spider-web tuner.
—How the crystal detector detects.
—How to make your own grid condenser.
—Don'ts for Radio fans.
—How to use a Regenerative Set as a transmitter.
—How to restore worn-out crystals.

November, 1922

—Sir Oliver Lodge on ether waves.
—How to add a Vacuum Tube to your crystal set.
—The most popular transmitting aerial.
—Right and wrong ways of adjusting the Regenerative Receiver.
—How to make a novel variocoupler.

December, 1922

—Radio on your motor car.
—How to select the best coil for your set.
—How to make and use a loading coil.
—How the Vacuum Tube detects.
—A Receiving Set that takes notes.
—How to make a series-antenna condenser.

January, 1923

(This issue in which appeared Mr. Cockaday's full description of his "DX" Regenerative Receiver is completely exhausted. A special Reprint of Mr. Cockaday's article may be had, however, for 22 cents in stamps.

February, 1923

—20 tips on tuning.
—The Hoffman measurement charts.
—Shall I use a "hard" or "soft" tube?
—A novel tuner for shutting out interference.
—How the Audio-frequency amplifier works.
—Pointers on aerials.
—How to add an Audio-frequency amplifier.

March, 1923

—A Receiver without batteries.
—How to get the greatest efficiency out of your Radio circuits.
—How to make a one or two-step Audio-frequency Amplifier.
—How to make a Multi-Layer Coil.

April, 1923

—Regeneration without Radiation.
—A crystal detector from a spool.
—How the Vacuum Tube detects and rectifies.
—How to make a simple single tube Receiving Set.
—Circuit diagram of the Cockaday DX-3 Circuit Tuner, with instructions on how to add three stages of radio frequency.

May, 1923

(This issue, in which appeared Mr. Cockaday's description of his 4-Circuit Tuner, is completely exhausted. A special Reprint of Mr. Cockaday's article may be had, however, for 22 cents in stamps.

June, 1923

—How to use your Radio Set on your vacation.
—How the microphone transmitter works.
—How to build a good single tube receiver.
—How to make a crystal detector stand.

July, 1923

—How to install your Radio Set on your boat.
—The ratio in size between your antenna and your coil.
—Useful facts about ear-phones.
—How to make a dry-cell tube Regenerative Set.
—How to keep up your storage battery.

August, 1923

—How to build a Tuned Radio Frequency Receiver.
—Measurement chart for determining the constants for a loop antenna.
—How to calibrate your wave meter.
—Circuit diagram of the Cockaday 4-Circuit Tuner adapted for use with dry-cell tubes.

September, 1923

—How to get a radio license.
—How weak signals are regenerated.
—How to make a battery charging rectifier.
—How to build the Haynes DX receiver.

October, 1923

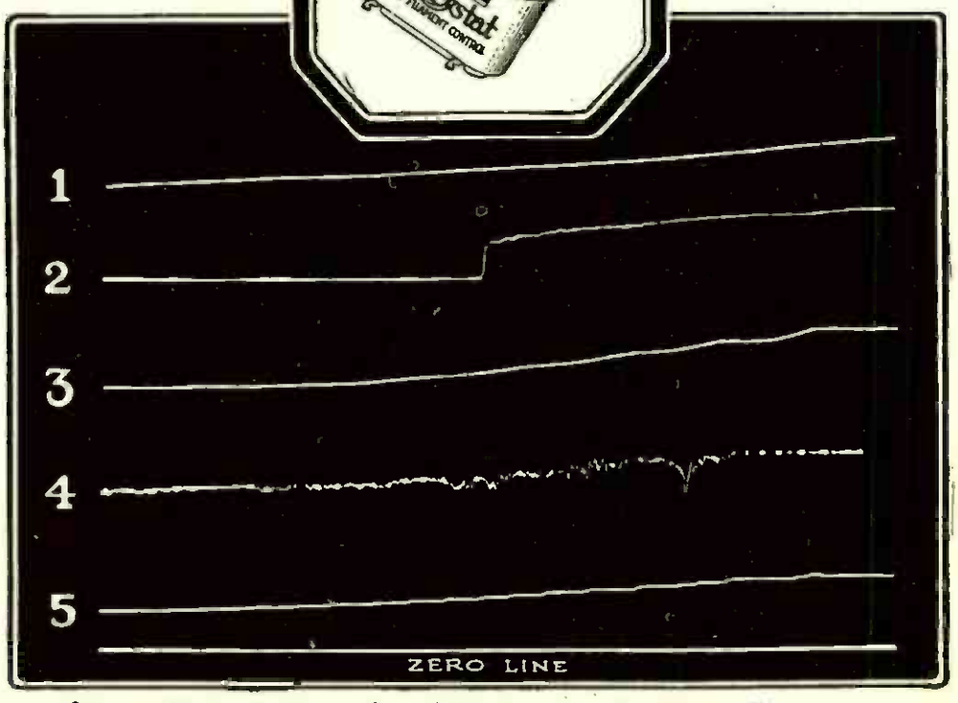
—Practical hints for Coil Calculations.
—How to make a Two-stage Audio frequency Amplifier.
—Ten good rules for Broadcast Listeners.
—How to make a simple Honeycomb Receiver.

POPULAR RADIO, INC.

9 East 40th Street **Dept. 113** **New York City**

STEPLESS • NOISELESS

COMPACT • PERMANENT

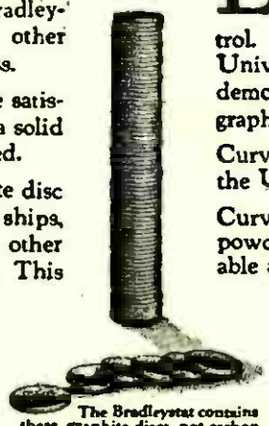


The Graphite Discs in the Universal Bradleystat Surpass All Other Resistors for Perfect Filament Control

SUBSTITUTES have been offered, from time to time, for the scientifically-treated graphite discs in the Universal Bradleystat. Carbon powder, dust, flakes and other materials have been tried without success.

For a time, such materials appear to give satisfactory service, but they soon pack into a solid mass and the filament control is destroyed.

The Allen-Bradley Co. has built graphite disc rheostats for over twenty years for battle ships, mines, rubber plants, textile mills and other places requiring smooth, stepless control. This wide experience has made possible the Universal Bradleystat, backed by a guarantee of excellence and performance which assures every Bradleystat purchaser of a filament control that is perfect and permanent.



The Bradleystat contains these graphite discs, not carbon powder or dust.

LABORATORY tests are made frequently to compare the performance of the Bradleystat with other types of filament control. A recent oscillograph test made at the University of Wisconsin is shown above to demonstrate conclusively the superiority of graphite discs over other resistance materials.

Curve No. 1 is the smooth perfect control of the Universal Bradleystat.

Curves No. 2 and 3 show the control of carbon powder or dust rheostats. Observe the unreliable and irregular control obtained.

Curves No. 4 and 5 illustrate the control of two types of wire rheostats.

Remember—The Universal Bradleystat can be used with any receiving or amplifying tube, and with 5-watt sending tubes.

Retail Price $1.85
In Canada $2.50

Allen-Bradley Co.
Electric Controlling Apparatus
276 Greenfield Ave. Milwaukee, Wis.

All Reliable Dealers Sell the Bradleystat

THE ALLEN-BRADLEY CO. HAS BUILT GRAPHITE DISC RHEOSTATS FOR OVER 20 YEARS

A Brand New Grid Leak

WITH

Stepless Adjustment from ¼ to 10 Megohms

CROSLEY
MANUFACTURING CO.
RADIO DIVISION
CINCINNATI OHIO

September 8, 1923.

ALLEN-BRADLEY CO.
Milwaukee, Wis.

Gentlemen:—

I just received our laboratory report wherein the Bradleyleak is complimented very highly when compared with other adjustable leaks. The Bradleyleak gave smooth, uniform control without sudden alterations of the grid circuit, and is the only device tested in our laboratory which is stable in operation. We found it quite independent of atmospheric conditions, a factor not found in other adjustable leaks exceeding one megohm.

I cannot impress you too strongly with the great necessity of an adjustable grid leak for radio receiving sets and feel confident that the Bradleyleak will find a very popular field as soon as its operation is appreciated.

Yours truly,

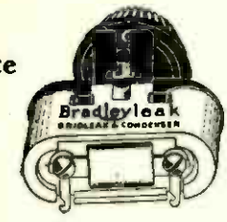
CROSLEY MANUFACTURING CO.

Crosley Laboratory Enthusiastic
over this remarkable grid leak

THE Bradleyleak is now ready for you! After months of laboratory research, a new and better adjustable grid leak has been developed which provides a stepless range of resistance from ¼ to 10 megohms. This problem has defied radio engineers for a long time, but finally has been solved through the use of two columns of discs of special composition placed under the variable pressure of the Bradleyleak knob. Any conceivable resistance is obtained with utmost accuracy by turning the adjusting knob. When once adjusted, the setting is permanent. [Read the letter from the Crosley Manufacturing Company's Laboratory.]

The radio world has been waiting for a real adjustable grid leak. Here it is! There is no substitute for the Bradleyleak, either in performance or accuracy. It is furnished with a grid condenser, if you desire. Your dealer will get the Bradleyleak for you. Avoid unreliable makeshifts, and improve your tube efficiency by installing the Bradleyleak.

Retail Price
$1.85
P. P. 10c



Condenser
.00025 mf.
35c extra

Unaffected by atmospheric conditions.
Smooth and uniform in adjustment.

BE UP-TO-DATE! MAIL THE COUPON

Allen-Bradley Co.
276 Greenfield Ave., Milwaukee, Wis.

I am glad to hear that a dependable, adjustable grid leak can now be obtained. Please send me your descriptive folder.

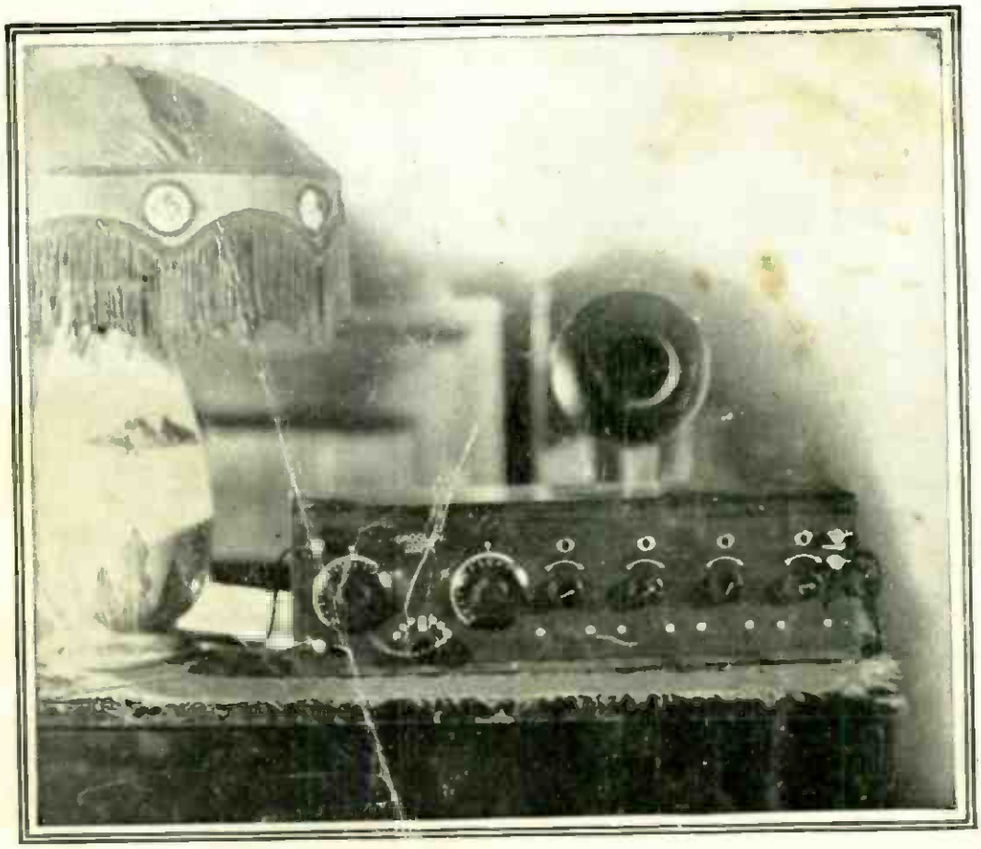
Name _____

Address _____

_____

Bradleyleak

THE PERFECT GRID LEAK



PERFECT PERFORMANCE

Crosley Model X Gives Better Radio Reception

THE popularity of Crosley Model X is becoming more manifest each day.

This four tube set—still priced at $55—maintains its marvelous record of bringing in distant stations.

A man writing from Chatham, Va., says, "First let me state I own a Crosley Model X and you couldn't buy it for the United States mint. I have picked up over 130 stations in the U. S. and have listened to Havana, Canada, North Dakota, San Francisco, all Texas and ships at sea. Keep up the good work!"

You can depend upon an instrument bearing the name

CROSLEY

This name has been accepted as a guarantee of the highest quality at the lowest cost.

All Crosley sets are equipped with the Crosley multistat, the universal filament control rheostat for all make of tubes.

Wave length range 200 to 600 meters.

Other Crosley parts include: Variable Condensers, Knobs and Dials, V-T Sockets, Variometers, Vario Couplers, Rheostats and the well-known Crosley Radio Frequency Amplifying Tuner.

A Crosley Instrument performs everything claimed for it—and more besides.

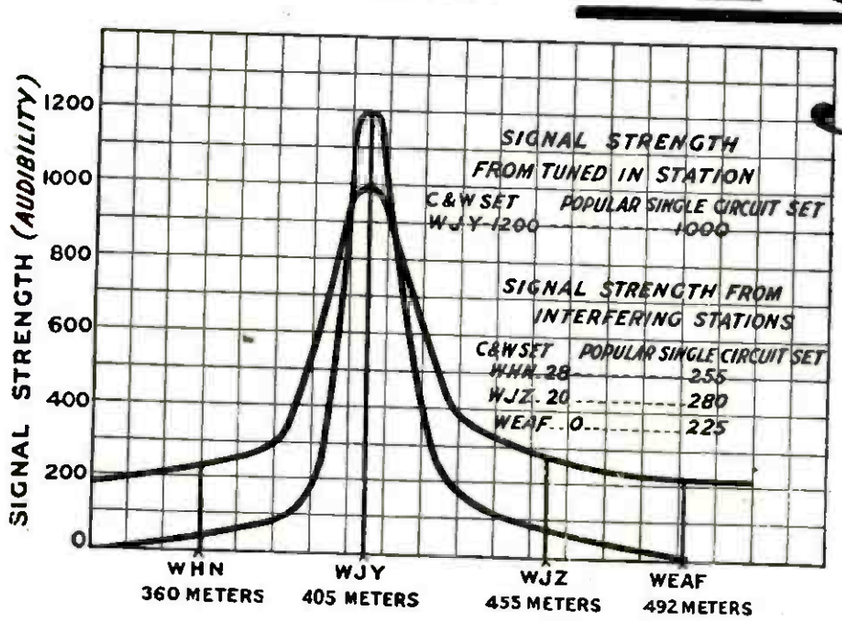
For Sale by Best Dealers Everywhere. Write for Free Catalog.

We announce a new model—to be known as Model X-J. This has all the features of Model X and in addition—new molded sockets, new rheostats, new condensers with molded plates and jack for head phones. Price $65.

CROSLEY MANUFACTURING COMPANY
916 ALFRED STREET CINCINNATI, OHIO

New York Office, C. B. Cooper, 1803 Tribune Bldg., 154 Nassau St., Phone Beekman 2061.
Boston Office, B. H. Smith, 755 Boylston St., Room 316.
Chicago Office, 1311 Steger Bldg., 28 E. Jackson Blvd., R. A. Stemm, Mgr.
Philadelphia Office, J. H. Lyte, 65 North 63rd Street.
St. Louis Office, Robert W. Bennett Co., 1326 Syndicate Trust Bldg.

Here is *Proof*



# of Cutting and Washington Superiority

Tested with other broadcast receivers—on the same antennae—listening to the same stations—the *audibility meter proves* that Cutting and Washington Sets give:

Greater Volume from the Station You Want to Hear.
Less Interference from all Other Stations.

Before you buy, *insist* on a demonstration of a Cutting and Washington Receiver (Armstrong patent). Ask your dealer or write direct for complete information.

Dealers: The set you can prove to be best is the easiest to sell. Write us.

Cutting and Washington Radio Corp.
Operating Station WLAG—"Call of the North"
Minneapolis Minnesota

How Test is Made

In the graph above a C&W Receiver and a popular single circuit set, using the same antennae, are tuned at New York to station WJY, 405 meters, 25 miles from New York City.

The micro-ammeter shows a signal strength of 1200 for C&W or 200 points greater than the other receiver.

Interference from other stations shown is 25, 20 and 0 for C & W — so low it is almost inaudible. Interference from other stations measures 255, 280, 225 for the other receiver—a serious annoyance.

This result is typical of C&W comparative tests.

Cutting and Washington