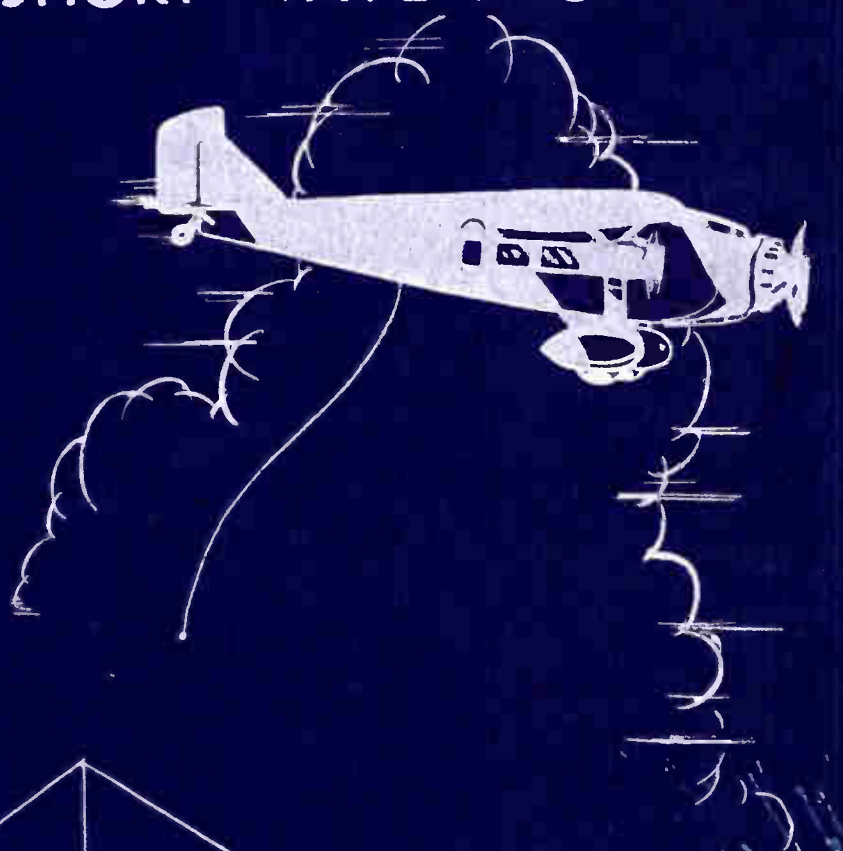
Vol. II

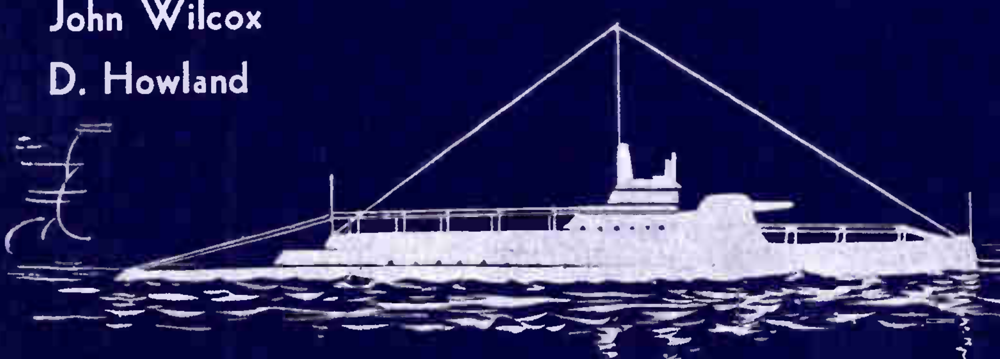
*The Manual of . . .*

# Short Wave Radio

## THE HOW AND WHY OF LONG DISTANCE SHORT WAVE RECEPTION

BY. . . . .
Zeh Bouck
James Millen
R. S. Kruse
Arthur H. Lynch
L. W. Hatry
Howard Allan Chinn
Dana Bacon
Frank H. Jones
Chester H. Johnson
John Wilcox
D. Howland





*Price 50*

COMPILED AND EDITED BY ZEH BOUCK

The How and Why of Long Distance Short Wave Reception

*The Manual of*

# Short Wave Radio

## *Volume Two*

BY

Zeh Bouck

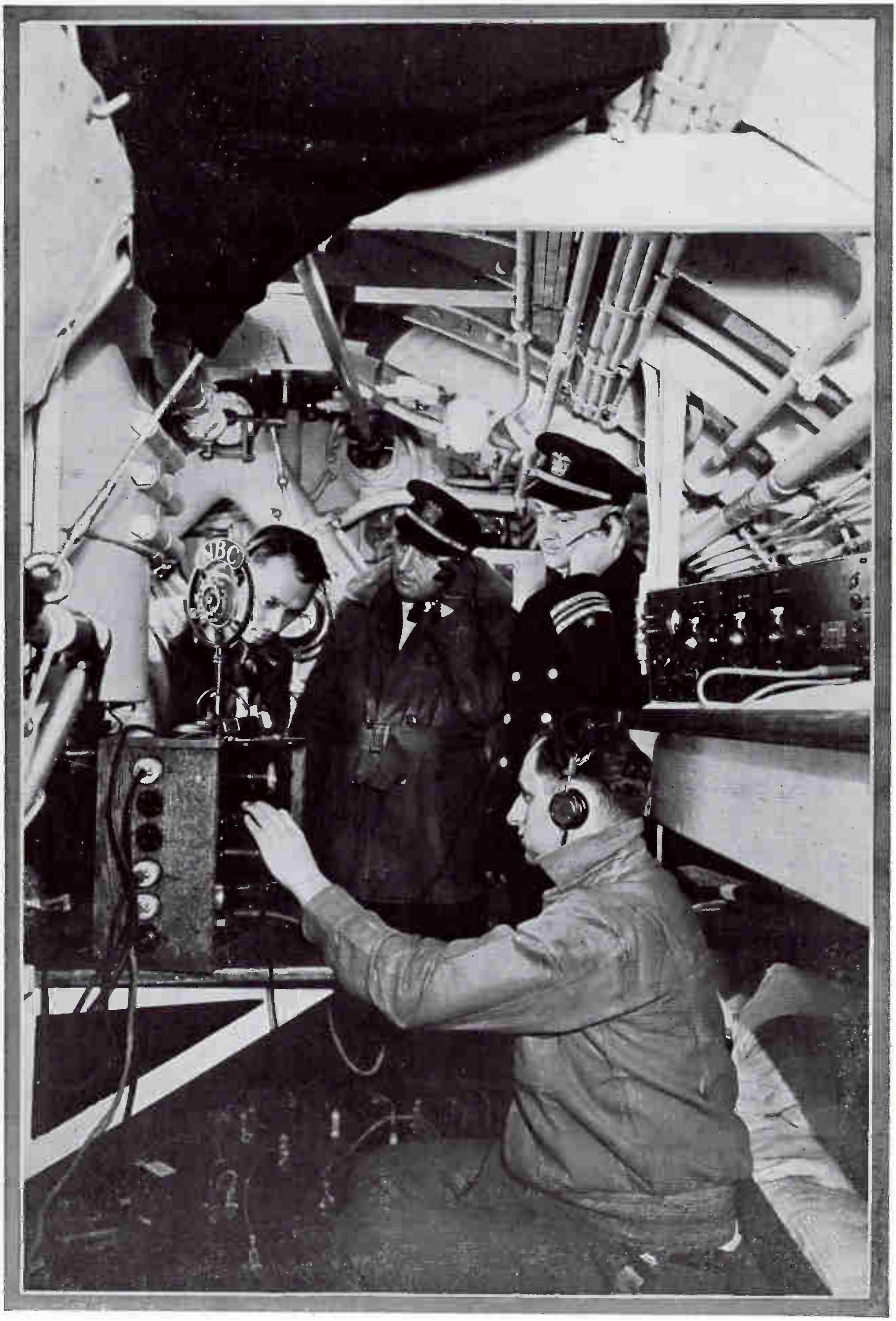
James Millen
R. S. Kruse
Arthur H. Lynch
L. W. Hatry
Howard Allan Chinn
Dana Bacon
Frank H. Jones
Chester H. Johnson
James Wilcox
D. Howland

Design · Engineering · Converters · Supers · t-r-f Receivers

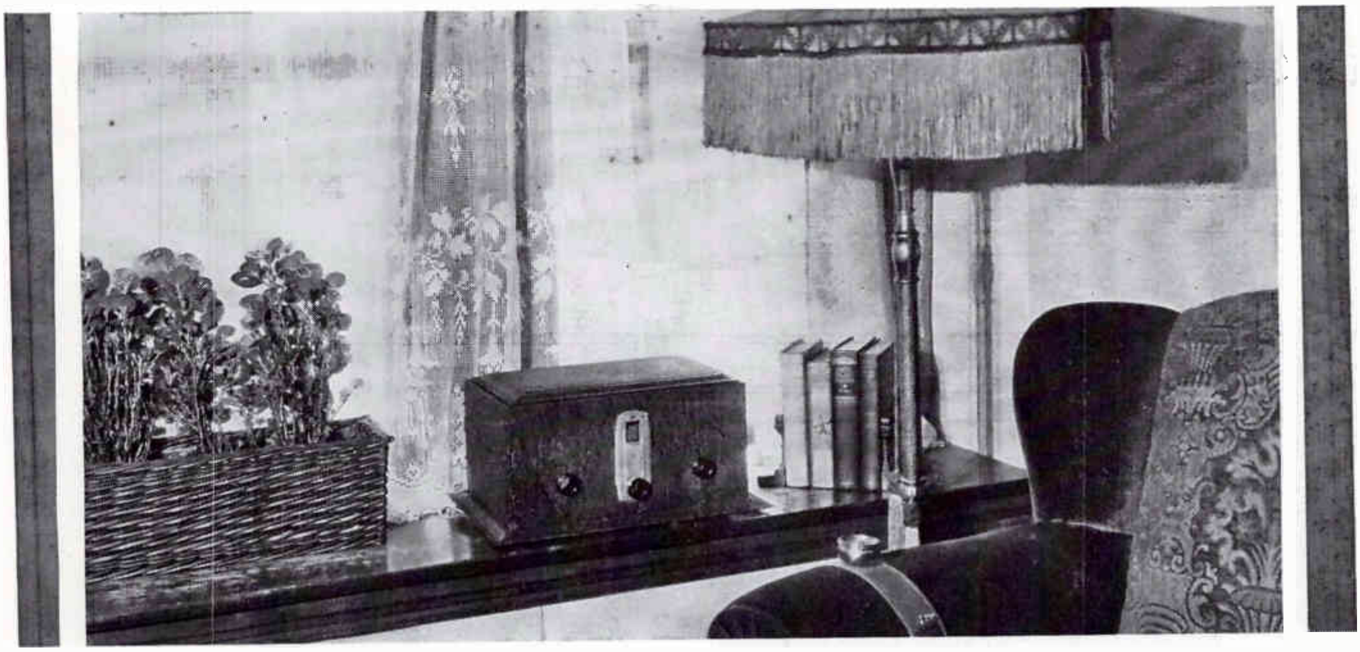
*THE PUBLISHERS of this book desire to acknowledge the co-operation and assistance of the staff of* RADIO NEWS *and express their appreciation to that magazine for the permission to republish much of the material contained herein. Similar acknowledgement is gratefully made to the American Radio Relay League and* QST, MODERN RADIO *and the Round Hill Research Division of the Massachusetts Institute of Technology.*

**Copyright 1932 by the National Company**
**Malden, Mass.**

# CONTENTS



Radio transmission from the depths of the sea! A broadcast program is being transmitted via short wave radio from a submarine, picked up at the surface and retransmitted on the usual broadcast waves. Short waves recognize few limitations



# Tapping *the* Short Waves

***Direct short-wave reception brings new entertainment to the parlor and a new thrill to the hobbyist***

**By Zeh Bouck**

THE era of international broadcasting has definitely arrived. The repeated appearances of Ramsay Macdonald in England, Cosgrave in Ireland, Mussolini and the Pope in Rome before the international short-wave microphone, and the almost universal rebroadcast on long waves, have stimulated the interest of the average broadcast enthusiast in the high-frequency impulses that carry their voices across the oceans. It is almost paradoxical that the really quite excellent reception of the long-wave rebroadcasts on standard receivers should result in a desire to receive such programs on the more direct and original waves. However, there exists an admittedly greater fascination in receiving the voice of Senatore Marconi direct from HVJ, the Vatican City, Rome, Italy, than via the intermediary of a local station. And aside from the intriguing element of direct contact, it is occasionally possible to secure better reception from a foreign short-wave station than from a semi-local rebroadcasting the program. Also many interesting programs are being broadcast by domestic short-wave stations which may be received with fairly consistent excellence, and the short-wave receiver thus contributes to the possible sources of radio entertainment. In rural communities, isolated from long-wave coverage, the s.w. receiver often provides the only reliable reception. The short-wave receiver has definitely emerged from the laboratory. In simplicity, reliability, battery or light socket convenience, and appearance, it compares favorably with the conventional broadcast apparatus. It may take its place in the parlor with the long-wave receiver or in a "short-wave nook" where its offerings are reserved for the privileged ears of the real radio fans of the family and where one can concentrate on its operation and programs without parlor distractions.

**THE CORDIAL recognition extended to the first volume in this series of Short Wave Manuals is responsible for its immediate extension in the publication of the present book. Volume One, however, is still available and is in no way duplicated or antiquated by the present and different Volume Two.**

The expression "short waves," offhand, is self-explanatory, but on further thought requires qualification. After all, the term is relative. Two hundred meters was a short wavelength ten years ago. Indeed, it was considered just about the lower limit available for practical communication purposes. Today one hundred meters is hardly among the conventional short-wave bands which, in general parlance, include the wavelengths between ten and sixty meters. The larger part of short-wave communication is carried on at present between fourteen and fifty-four meters, but successful experimental work has established two-way communication over short distances on wavelengths fifty centimeters long!

The wavelengths with which the broadcast listener is most familiar are those that bring to him his daily entertainment, generally comprising musical arguments for the purchase of some commodity. These wavelengths are between 200 and 550 meters.

Wavelength is a physical conception by means of which we are quite successful in representing how a radio signal travels along its route from the transmitting station to your receiver. A "wave form" is assumed, because a recording instrument placed anywhere within the influence of the signal would show a wavy line on the recording paper or tape. Such an instrument would show that the signal, starting at zero, would attain a certain maximum positive strength, then slowly decrease to zero again, to build up on the negative side to a similar maximum, again dropping to zero to recommence the "cycle." This cycle occupies a certain definite time, which can be measured directly and indirectly. Also, radio waves travel from the transmitting

**An efficient short-wave converter is a perfect complement to the usual broadcast equipment**

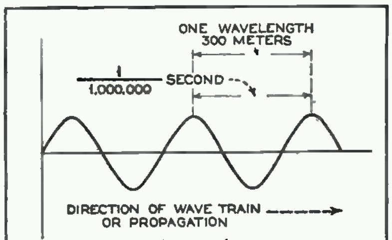



Figure 1

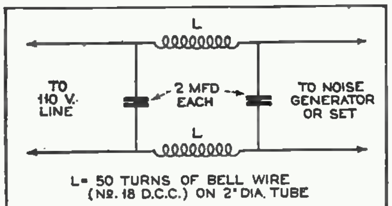



Figure 3

**Figure 1. A graphical conception of wavelength and frequency. This is the sort of a picture that a recording instrument would make of a passing wave train showing that length equals the velocity divided by the frequency. Figure 3. A simple form of wave filter that may be used effectively to reduce artificial static interference in short-wave reception**

antenna to the receiving antenna with a speed that has been definitely established at about 300,000,000 meters a second. Now if a railroad train, or any other object, travels at a known speed past a given point in a known time, the length of that object can be determined by dividing the speed of the train (let us say) by the time interval. This relationship, in reference to a wave "train," is shown in Figure 1. The time element in this case happens to be one-millionth of a second, and the wavelength is therefore 300 meters. If the time consumed by one cycle is one millionth of a second the frequency that a cycle will repeat itself in one second will be one million—or we can speak of the frequency of 300 meters as one million cycles.

The relationship is more simply expressed in the equation:

$$F = \frac{V}{\lambda} \text{ or } \lambda = \frac{V}{F}$$

Where F is the frequency in cycles per second, V the velocity of propagation or 300,000,000 meters per second and λ the wavelength in meters.

Thus, if we know either the wavelength or frequency we can always compute the other determinant by means of one of the two equations.

For scientific purposes, it is often more desirable to work with frequencies rather than with their corresponding wavelengths, principally because, regardless of wavelength, a certain definite frequency band is considered necessary for the transmission of radio telephone signals utilizing the systems employed today. This band is 10,000 cycles wide. That is, if a broadcasting station is transmitting on 300 meters, or one million cycles, it will occupy a band extending 5000 cycles on each side of the carrier frequency of one million cycles—*i.e.*, between 995,000 and 1,005,000 cycles. In order that no other station can overlap or interfere, the carrier of a second station must not be within 10,000 cycles of the carrier of the first station.

Due to the existence of this desirable frequency band, a broadcasting station operating on a fundamental of 300 meters will spread over a wave range of about three meters, and at 600 meters about twelve meters.

In other words, the amount of space required by a broadcasting station, in wavelength spread, varies with the wavelength, becoming greater as the wavelength increases. But the frequency band of ten thousand cycles remains constant. Hence, it is more convenient to compute many radio calculations in terms of frequency rather than those of wavelength.

Long wavelengths are low frequencies; short wavelengths are high frequencies. When frequencies become very high, it is less clumsy to group them into thousands of cycles—the kilocycle or kc.—and into millions of cycles—the megacycle or mc.

A wavelength of ten meters is equivalent to a frequency of 30,000,000 cycles, or 30,000 kilocycles or 30 megacycles.

Let us try to think in terms of frequency rather than wavelength. If at first you are somewhat confused, you may readily translate frequency to wavelength by means of computation, or the conversion chart shown in Figure 2.

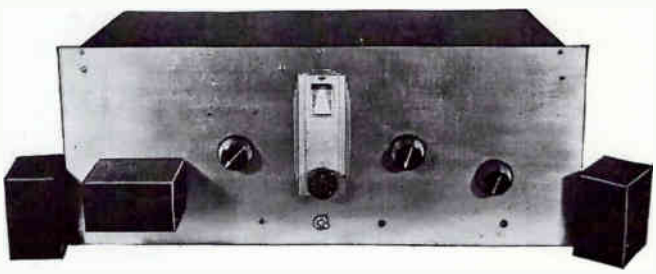
### *Characteristics of Short Waves*

One of the principal advantages of short-wave communication lies in the multiplicity of available radio channels as contrasted to the congested conditions existing above 200 meters.

The frequency corresponding to ten meters is, as we have shown, 30,000 kc. Between this frequency and that of 1500 kc., corresponding to 200 meters, there exists a 28,500 kc. band of usable frequencies. Dividing this by 10 (10,000 cycles, the recommended band for a broadcasting station) we find that 2850 broadcasting stations within interfering power distances could be accommodated without interfering with each other on a well-designed receiver. Between 200 meters and 600 meters, there is room for only 1000 similar stations.

High frequencies are characterized by an uncanny carrying power, low powers on low wavelengths transmitting over distances that could be spanned on long wavelengths only by the expenditure of hundreds of times the same power.

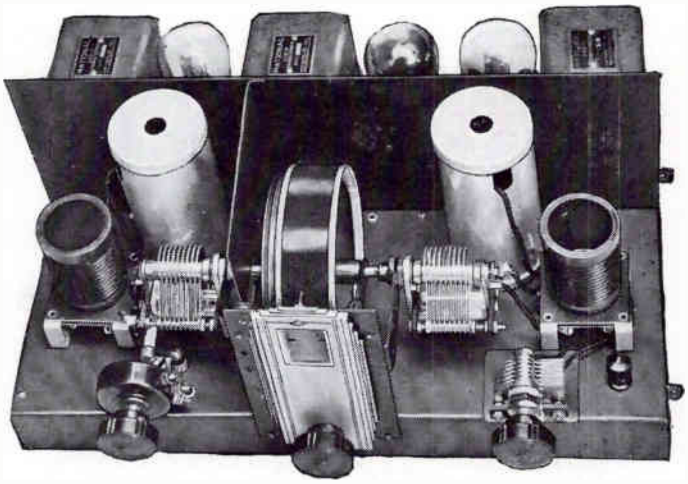
Short-wave signals suffer from peculiar fading and absorption effects from which long-wave signals are relatively free. The most unusual of these is, perhaps, the so-called "skip-distance" effect. For instance, the direct wave from a fifty-watt transmitter operating on 7500 kc. may be so attenuated at a receiving station five hundred miles away, by absorption or deflection due to terrestrial conditions, that the signal is entirely lost. However, another portion of the signal, traveling more directly upwards, collides with the somewhat



**The short-wave superheterodyne designed by Wireless-Egert. The shielded coils plug in front of the panel**

problematical Kennelly-Heaviside layer—a stratum of ionized gases high above the earth's atmosphere—and is reflected to the earth thousands of miles away from the transmitter. Thus a receiver in Australia might hear a transmitter in New York City, the signal from which is inaudible in New Orleans or Panama.

The tricks played by high frequencies vary with atmospheric conditions, the time of day and the frequency employed. But it is almost always possible, by making a shift in frequency, to pick out a short wavelength satisfactory for the communication desired. For instance, for consistent trans-oceanic telephone communication, three frequencies, approximating 20, 15 and 10 megacycles, are always available. During the day, the 20-megacycle frequency is generally used, shifting to 15 mc. in the evening and to 10 at night.



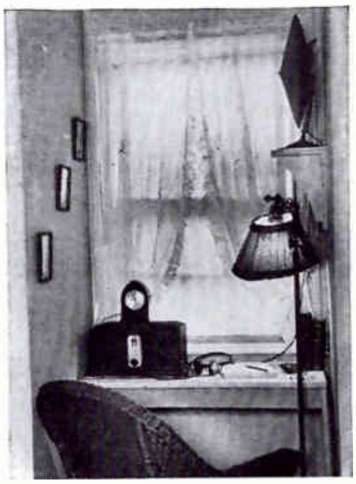
The chassis of the National tuned r.f. short-wave receiver—an efficient, medium-priced set available in both a.c.- and battery-operated models

### *Short-Wave Telephone Stations*

Only a small percentage of the available short-wave frequencies are given over to telephone transmission, but the actual number of such stations in regular operation exceeds the number of broadcasting stations in the United States. The average short-wave receiver will pick up several times as many telephone stations as the average broadcast receiver.

Short-wave telephone services may be divided into four classes—broadcast, amateur, trans-oceanic commercial and airplane. The broadcast stations are generally given over to the simultaneous transmission of long-wave programs and are operated in conjunction with a long-wave station. For instance, W2XE is the short-wave channel of WABC, New York City. The following are the international frequency allocations for short-wave broadcasting:

6000-6150 kc. (50-48.9 meters).
9500-9600 kc. (31.6-31.2 meters).
11,700-11,900 kc. (25.6-25.2 meters).
15,100-15,350 kc. (19.85-19.55 meters).
17,750-17,800 kc. (16.9-16.85 meters).



At the left is the short-wave nook in the author's home. Equipment—one s.-w. receiver, electric clock, pencil, log and plenty of cigarettes

No satisfactory international short-wave radio-telephone call-book is available at the present time. However, a few of the more prominent and popular stations are given in the next column:

| *Station* | *Location* | *Approximate Frequency* |
|---|---|---|
| W3XAL | Bound Brook, N. J. | 6100 kc. |
| W2XE | New York City | 15,150 kc., 11,880 kc., 6110 kc. |
| W2XAF | Schenectady, N. Y. | 9530 kc. |
| W3XAD | Schenectady, N. Y. | 15,160 kc. |
| HVJ | Vatican City, Rome, Italy | 15,100 kc., 6000 kc. |
| W9XAA | Chicago, Ill. | 6070 kc. |
| GBW | England | 15,200 kc. |
| W8XK | Pittsburgh | 6150 kc. |
| PCL | Holland | 15,350 kc. |
| G5SW | England | 11,850 kc. |
| GBS | England | 17,750 kc. |
| HRB | Honduras | 6160 kc. |
| HKC | Bogota, Colombia | 6170 kc. |

Many of the amateur phone stations will be found on

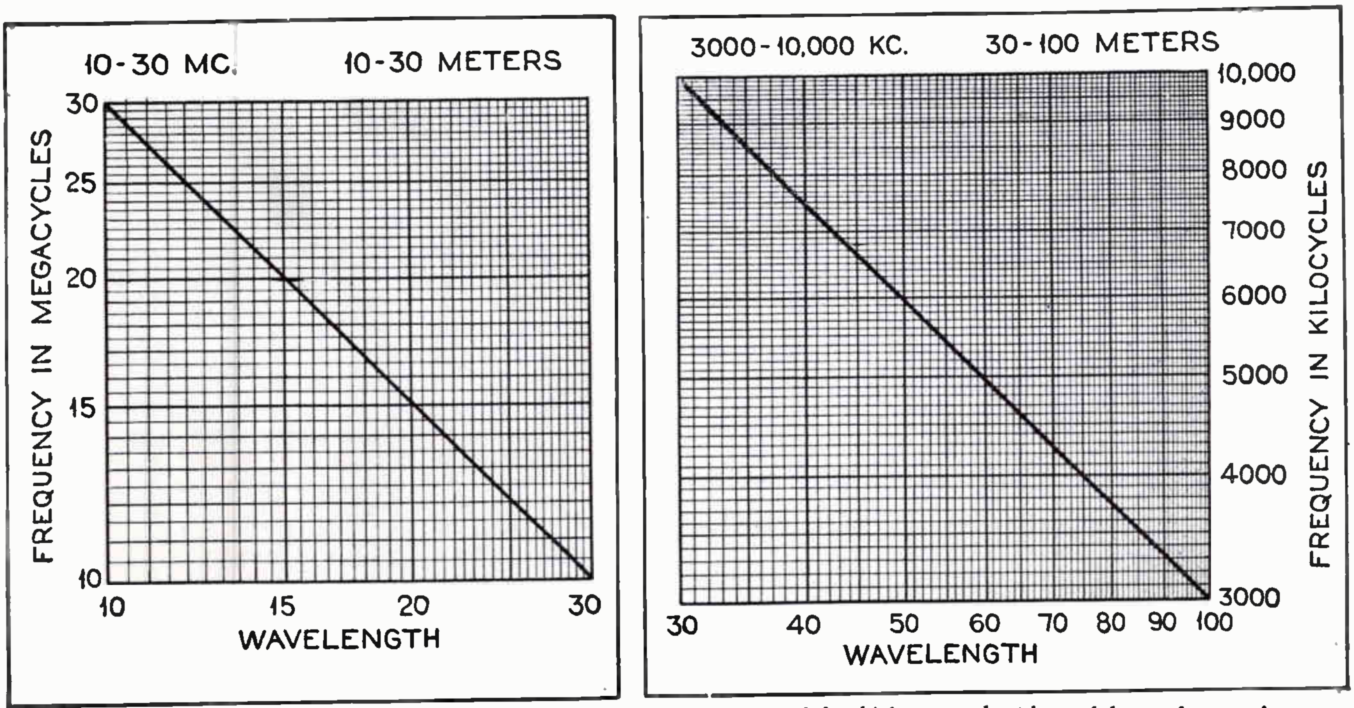



**Figure 2. Wavelength-frequency conversion chart. This may be used for higher wavelengths and lower frequencies merely by shifting the decimal point**

the 3,500-4,000 kc. and 14,000-14,400 kc. bands with the preponderance of traffic being handled on the first mentioned channel. While it is stretching the point somewhat to say that amateur radio telephone conversations are entertaining, they are occasionally interesting.

Commercial transoceanic telephony is generally conducted on the three fixed service bands from 17,800-21,450 kc., 15,350-16,400 kc. and 9,600-11,000 kc. These conversations are generally "inverted"—that is, intentionally garbled so that they sound to the casual listener exactly like Chinese. However, by beating the signal (permitting the receiver to squeal) at the correct frequency, it is sometimes possible to render inverted speech intelligible. The conversation between the technical operators is often carried on without garbling. On the occasions when commercial traffic is transmitted clearly, listening-in is quite as edifying as eavesdropping on a party wire.

Practically all airplane telephone traffic is handled on the 4,000-5,500 kc band, including point-to-point flying field and mobile services. This is often fascinating, always interesting, and some very reliable weather reports may be picked up from local airmail terminals.

Short wave signals can be received on a short wave receiver, or with an adaptor employed in conjunction with a broadcast range receiver. Where a suitable long wave set is available, the adaptor provides the most economical method of tapping the high frequencies. There are two types of adaptors—the simple regenerative design, which is merely a short wave receiver using the audio frequency channel of the broadcast set, and the superheterodyne converter, in which the s-w signal is transformed into an intermediate-frequency within the usual broadcast range, and then applied to the r.f. amplifier of the standard receiver. This latter system is the more sensitive and complicated. Before investing in an adaptor, it will be well to determine, by asking expert advice, whether it will work successfully with your receiver. The combination is not a felicitous one on some broadcast sets, notably superheterodynes.

On the selection of a short wave receiver itself, the buyer will be guided by the same considerations that determined his choice of a broadcast band set—price, a.c. or d.c., design and appearance. The price range of short wave receivers is equally extensive and here, too, the superheterodyne tops the list in price and efficiency. However, quite reliable round-the-world reception may be obtained with the medium priced receivers comprising one stage of screen-grid t.r.f. followed with a renegerative detector (preferably screen-grid) and the usual audio system.

Four sets of coils are generally required to cover the short wave spectrum in which we are interested—22 to 13 m.c., 14 to 7 m.c., 8 to 4 m.c., and 5 to 2 m.c. An interesting super has recently been developed by Wireless-Egert in which the shielded coils are plugged into the front of the receiver, making it unnecessary to open the cabinet in shifting bands.

The choice of an a.c. or battery-operated receiver is not determined altogether by the existence or otherwise of the convenient power supply. The a.c. design, due to superiority of the tubes, is inherently more sensitive. It is, therefore, doubly affected by the limitations of line noise by sensitivity and the conductive coupling to the line. In some apartment house installations, the a.c. receiver will be unbearably noisy, and in such instances battery operation is obviously recommended. The use of a simple filter between the line and the noise generating equipment, such as an electric refrigerator, will reduce the disturbance to within tolerable limits. When it is impractical to get at the source of the interference, the filter may be connected between the short wave receiver and the line with a grateful reduction in artificial static. The ideal apartment house installation comprises the a.c. receiver with the heater and plate potentials supplied respectively from a four volt storage battery and a "B" battery. This is somewhat hard on the "A" battery, but the superiority of the a.c. tubes is retained along with the isolated and relative quietness of d.c. operation.

The short wave receiver or adaptor should be installed as far away from any motor-driven electrical equipment—elevators, refrigerators, etc.—as possible.

An easily acquired knack of tuning contributes an artistry to short wave reception which is lacking on the broadcast band. The variation in technique may be attributed to the fact that the short wave receiver is generally tuned with the circuit oscillating—i. e., with the regenerative control so adjusted that a whistle is heard each time a carrier frequency is crossed. (Most of these whistles will be broken up into the characteristic dots and dashes of the code transmitter.) The typical short wave receiver has three controls—the main tuning control, the regeneration or oscillation control, and the trimmer. These controls are much more closely interlocked than the comparable knobs on the broadcast receiver, and even a slight variation of one of them will appreciably alter the wavelength to which the receiver is tuned. In tuning, the regenerative control should be maintained just beyond the oscillation point. When the circuit is oscillating a distinct hiss is audible in the 'phones or speaker, the background noise is considerably intensified and a whistle will be heard whenever a carrier frequency is encountered. At the correct tuning point—with the circuit just oscillating—the background noise and signal response will be at a maximum. In other words the receiver is at its most sensitive adjustment. To maintain this condition while tuning, it will usually be necessary to vary the regeneration control for every ten degrees or so on the tuning dial. When a telephone carrier is crossed, readily identified by the steady whistle and generally modulated by voice or music, reduce the regeneration (retuning slightly with each variation in the regenerative control) until the circuit is no longer oscillating and the carrier is clear. A faint "swish" will now locate the carrier (if unmodulated) as the tuning dial receives its final adjustment. In some instances of very weak signals, it is desirable to "zero beat" the carrier, rather than stop oscillations. As the carrier is approached with an oscillating receiver, the pitch of the whistle becomes lower, vanishing at zero beat—the exact resonance or tuning point—trailing off again into a squeal on the other side. Occasional stations are best received at zero beat with the circuit just oscillating. In achieving this adjustment a slight body capacity effect may make it necessary to tune slightly to one side of zero beat, the beat becoming zero when the hand is removed from the tuning control.

The short wave receiver will operate effectively on a very short indoor antenna. Ten to fifteen feet of wire are quite sufficient.

As already intimated, the efficacy of the various short wave bands varies with the time of the twenty-four-hour day. The greatest distances will be received on the three principal bands in accordance with the table given below:

| | |
|---|---|
| 22 to 14 m.c. | daytime. |
| 14 to 10 m.c. | morning and evening twilight. |
| 10 to 2 m.c. | night. |

It will often be interesting to log the stations, and the author suggests ruling off a sheet of paper to accommodate the following observations:

*Date, Time, Coil, Dial, Frequency, Call Letters, Language, Remarks.*

The station may be logged in local time, but in corresponding with the station for verification of transmission, the hour should be given in G.M.T.—which is Eastern Standard Time plus five hours. (See page 57.)

Harmonics of long wave broadcasting stations may fool you at first. However, such spurious short wave signals can generally be identified by their position in reference to international allocations and the very mushy quality of speech. Local short wave stations can be recognized without waiting for the quarter hourly signature, by checking for simultaneous broadcasts on the long waves—though this is not altogether reliable in these days of chain broadcasts. However, in the vicinity of New York City, W2XE is readily checked by listening to WABC.

A foreign language does not necessarily place a station beyond the confines of the U. S. A. The babel from W9XAA has been responsible for many fantastic tales of dx fish. But a station failing to sign at quarter hour periods may be tentatively logged as a foreigner.

# Tapping *the* Short-Waves

***In the preceding chapter the author called attention to what short-wave broadcasting offers the radio enthusiast. Now he introduces the subject of code reception as a captivating pastime for the broadcast fan***

## Part Two

### *By* Zeh Bouck

In our foregoing chapter we described the characteristics of short radio waves—the high frequencies, to employ the more convenient designation of frequency rather than wavelength. Briefly recapitulated, these peculiarities include the skip-distance effect, describing a signal easily heard at a relatively great distance from the transmitter, but inaudible several thousand miles nearer the source; the uncanny carrying power of the high frequencies whereby low powers practically encircle the world; and the selection of certain bands for day and night transmission, making possible consistent long-distance communication without the familiar low-frequency dependence upon night.

These effects were considered in relation to radio telephone signals. However, there exists no inherent difference between code or voice radio (or between wireless and radio, if you prefer a popular but unjustifiable discrimination), and the same effects are to be observed on code signals. As a matter of fact, the only difference between code and voice signals is a matter of modulation, the manner in which the fundamental signal, or carrier wave, is broken up. In the code transmitter, it is interrupted in dots and dashes, which are nothing more than long and short "spurts" of radio power. In radio telephony, the carrier changes less regularly—in conformation with the vibrations of voice or music.

Had we considered radio in a chronological order, we should have written our article on tapping code signals first—for code transmitters were developed to a high degree of perfection long before radio telephony was practical over long distances. We considered the possibilities of short-wave music and speech transmission in our original article because it is the system with which most of us are more familiar, and because it is the arrangement by which radio entertainment is brought to the majority of radio listeners. However, code reception is by no means void of entertainment value, and to the type of radio enthusiast interested in DX and short-wave telephone reception, it exceeds broadcasting in its pleasurable possibilities. Code reception provides an altogether new field of entertainment, psychologically akin to puzzles, which has intrigued the human mind from the days of its inception. To take advantage of this fascinating phase of radio, it is not necessary to be a code expert, or even to bestow upon its study any more concentration than one concedes to the solution of the cross-word puzzle problem involving a three-lettered bird ending in "u," or a four-letter musical instrument with "o" as the first letter.

Above is shown a type of new home recording device which may be employed for making records of code transmissions which can then later be deciphered at leisure

The "International Morse Code" is the official name for the code employed in radio communication throughout the world. This radio code, as most of us appreciate, is a representation of the alphabet, numerals, punctuation marks and certain abbreviations, in what we call "dots and dashes." On paper they are actually dots and dashes—to the ear they are respectively a short sound and a longer sound. The relative length of the sound should always be the same—the dash being three times as long as the dot, the space between dots and dashes of the same letter, one dot long, between letters, three dots long, and between two words, five dots long. The actual timing, however, will vary with the speed of transmission. For instance, the expression "too bad" might be represented on paper as - --- --- -··· ·- -·· (though no operator writes down the dots and dashes in this fashion), and would be transmitted as: dash three-dot-space dash one-dot-space dash one-dot-space dash three-dot-space dash one-dot-space dash one-dot-space dash five-dot-space dash one-dot-space dot one-dot-space dot one-dot-space dot three-dot-space dot one-dot-space dash three-dot-space dash one-dot-space dot one-dot-space dot.

The International Morse Code is shown in Fig. 1. It is not necessary to memorize or study this in order to identify distant code transmitters, though a familiarity with the code will follow as the game is played.

### *Tuning for Code*

Code signals are tuned with a slightly different technique than that employed in telephone reception. We assume that the reader possesses either a short wave receiver or an adaptor similar to those described in the June article. The same receiver is used for short wave code reception. When listening to a broadcast program after it has been

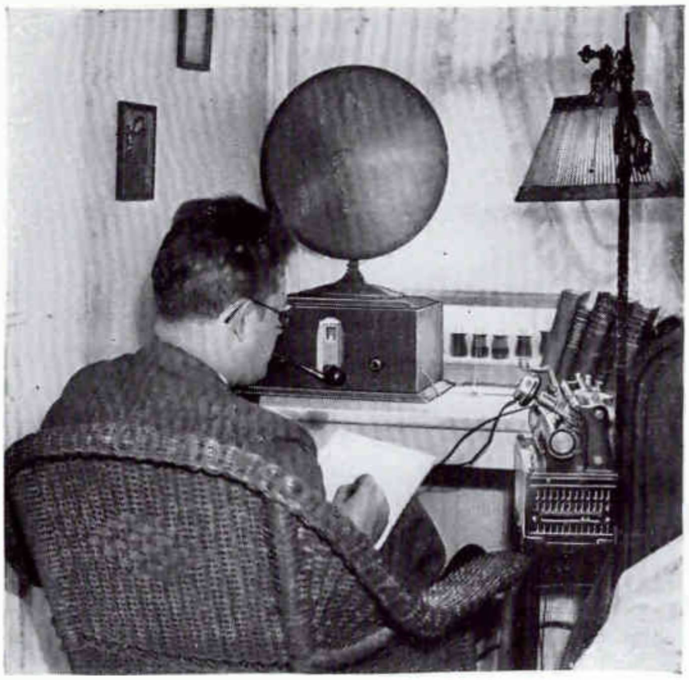
**INTERNATIONAL MORSE CODE**

| | |
|---|---|
| A | ·— |
| B | —··· |
| C | —·—· |
| D | —·· |
| E | · |
| F | ··—· |
| G | ——· |
| H | ···· |
| I | ·· |
| J | ·——— |
| K | —·— |
| L | ·—·· |
| M | —— |
| N | —· |
| O | ——— |
| P | ·——· |
| Q | ——·— |
| R | ·—· |
| S | ··· |
| T | — |
| U | ··— |
| V | ···— |
| W | ·—— |
| X | —··— |
| Y | —·—— |
| Z | ——·· |
| Ä (German) | ·—·— |
| Á or Å (Spanish-Scandinavian) | ·——·— |
| CH (German-Spanish) | ———— |
| É (French) | ··—·· |
| Ñ (Spanish) | ——·—— |
| Ö (German) | ———· |
| Ü (German) | ··—— |
| 1 | ·———— |
| 2 | ··——— |
| 3 | ···—— |
| 4 | ····— |
| 5 | ····· |
| 6 | —···· |
| 7 | ——··· |
| 8 | ———·· |
| 9 | ————· |
| 0 | ————— |

| | |
|---|---|
| Period | ·· ·· ·· |
| Semicolon | —·—·—· |
| Comma | ·—·—·— |
| Colon | ———··· |
| Interrogation | ··——·· |
| Exclamation point | ——··—— |
| Apostrophe | ·————· |
| Hyphen | —····— |
| Bar indicating fraction | —··—· |
| Parenthesis | —·——·— |
| Inverted commas | ·—··—· |
| Underline | ··——·— |
| Double dash | —···— |
| Distress Call | ···———··· |
| Attention call | —·—·— |
| General inquiry call | —·—· ——·— |
| From (de) | —·· · |
| Invitation to transmit (go ahead) | —·— |
| Warning—high power | ——··—— |
| Question (please repeat after ......)—interrupting long messages | ··——·· |
| Wait | ·—··· |
| Break (Bk.) (double dash) | —···— |
| Understand | ···—· |
| Error | ········ |
| Received (O. K.) | ·—· |
| Position report (to precede position messages) | — ·—·· |
| End of each message (cross) | ·—·—· |
| Transmission finished (end of work) (conclusion of correspondence) | ···—·— |

At the right is the complete International Morse code. It is possible to decipher many code signals without being an expert operator

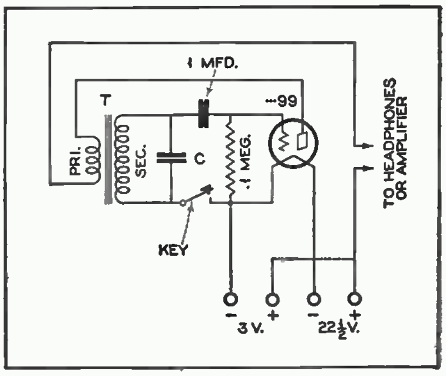
**THE field of code reception is generally considered alien territory for the broadcast fan—a part of radio that holds for him nothing in the way of interest or entertainment. We here demonstrate the fallacy of this idea, and points out that here is meat for the DX fan blasé with the familiar possibilities of the broadcast bands. Code reception may be played as a fascinating game, without actually learning the code, or it may be taken more seriously as an introduction to the king of hobbies—amateur radio telegraphy.**



**Shown above, a dictaphone is being used for copying a fast code signal which is later transcribed at a slower speed**

**(Below) Setting up a short-wave receiver on the Byrd Antarctic Expedition**

tuned, care is observed to keep the circuit from oscillating. If the circuit is oscillating an annoying squeal will almost invariably be heard. (The exception is the case of "zero beat," referred to in the previous article.) As the tuning control is adjusted, the pitch of the whistle, or note, changes, becoming lower as the exact tuning point of the station is approached from either side. In code reception it is most often this whistle to which we listen, varying its pitch by tuning until it is most readable—a condition determined by the quality of the sound, freedom from interference and intensity. Such stations are described as continuous wave stations. Many code stations are modulated, the dots and dashes coming through as a musical note impressed on the carrier. These stations, more or less incorrectly described as icw (interrupted continuous wave), may be tuned exactly as you would a phone station. However, when weak, even icw signals are most readily copied with the circuit oscillating. Several types of code signals will be readily recognized, from the low, rasping sixty-cycle modulations, through the musical scale from two hundred to a thousand cycles, to the pure continuous wave, cw signal. (For the sake of accuracy the author recommends the designation of modulated continuous waves, abbreviated mcw, for code signals this condition correctly describes. Interrupted continuous waves, or icw, will refer to signals secured by chopping or other systems whereby the carrier is more definitely interrupted.)



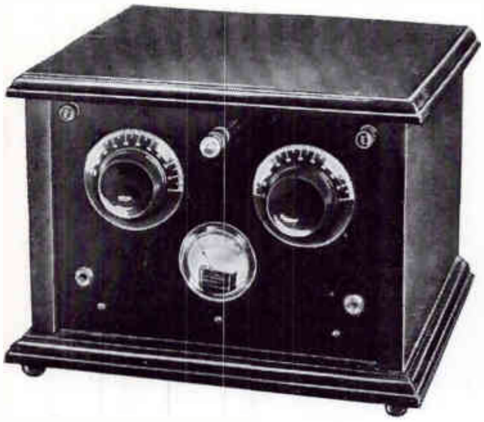

**A simple and inexpensive arrangement for code practice, giving a clear, clean note similar to that of a c.w. signal**

Having grasped the technique of tuning for code signals, let us investigate the high frequency spectra and discover just what is available for our delectation. Various frequency bands in this range have been definitely set aside for code communication of the various commercial services and amateurs. These short wave code bands are roughly divided by international agreement into the following allocations.

| Kilocycles | Meters | Services |
|---|---|---|
| 3,500– 4,000 | 87 –75 | Amateur |
| 4,000– 6,675 | 75 –45 | Airplane |
| 6,675– 7,000 | 45 –42.8 | Commercial |
| 7,000– 7,300 | 42.8–41 | Amateur |
| 7,300–14,000 | 41 –21.4 | Commercial |
| 14,000–14,400 | 21.4–20.8 | Amateur |
| 14,400–23,000 | 20.8–13.1 | Commercial |

(A complete list of allocations is contained in "Treaty Series, No. 767—Radiotelegraph Convention and General Regulations Between the United States and Other Powers," obtainable from the United States Government Printing Office for fifteen cents, and in "The Manual of Short Wave Radio," sold for fifty cents by the National Company, Malden, Mass.)

Of course, for the experienced radio operator, the entire code category unfolds a consistently fascinating source of interest. However, for direct transcription, the beginner will confine himself to commercial stations that are testing and amateurs calling "CQ." Fully half the commercial stations on the air at any one time are testing—transmitting a simple and characteristic signal, frequently interrupted with their call letters. The most common of these testers is what our good friend R. S. Kruse dubs—



Above is a simple short-wave transmitter made for the beginner

(Below)

A commercial form of code practice instrument operated by perforated tape and providing a pure c.w. note in the headphones. The speed may be regulated as desired


### *The "Dotters"*

Tune your short wave receiver or adapter, with the circuit oscillating, over the band best suited to the time of day (23,000 kc. to 10,000 kc. during the day and from 10,000 kc. to 3,500 kc. at night) and you will invariably run across a number of stations sending out a series of dots. These are sent out automatically by a tape transmitter. Every two or three seconds the series of dots will be broken by an irregular sequence—the call letters of the station. After you have heard them several times, you will be able to separate the groups and finally write down either the dots and dashes themselves, or the letters they represent. At first it will be easier to write down the actual code characters, such as ·· - · - ·- (two dots dash dot, dash, dot dash.) Referring to the code chart, you will interpret these characters as "FTA." By means of the call assignment list, given further along in this article, you may identify this transmitter as a French station. When a complete call list is available, the station can be definitely located.

Another common test signal is the letter "V," ···-, which is repeated over and over again, the sequence being broken with the call letters of the station. Occasionally the combination ·····-· is employed for testing, and quite often the simple sequence "ABC," ·- -··· -·-· is run off the tape for hours at a time. Test signals are used during off-traffic periods so that the receiving station may keep continually tuned to the transmitter and ready for the reception of the next message.

These various test signals are usually separated from the call by the letters "DE" (-·· .), which is Latin for "from."

The letters "RQ" will also often be identified on the commercial code channels, which signifies that the station so calling is requesting a correction on a previous message.

### *Amateur Stations*

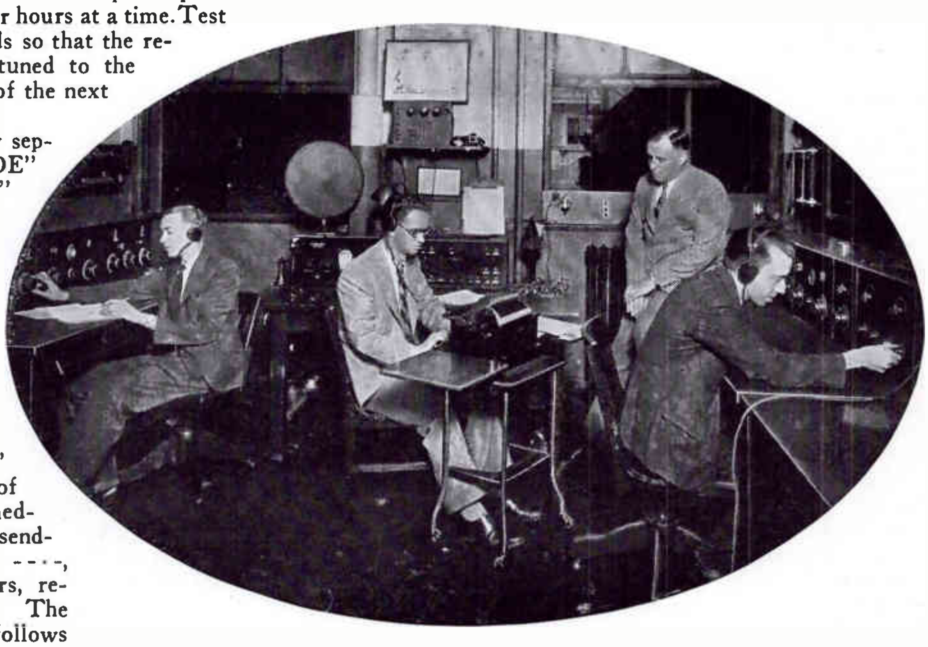
Amateur stations are logical fish in this new DX game due to the frequency of easily recognizable "CQ" transmissions. With the exception of stations working on a particular schedule, all amateurs open transmission by sending repetitions of the letters "CQ," -·-· --·-, which is a general call to all amateurs, requesting a reply from any listener. The call letters of the amateur station follows the usual separation "DE." Amateur stations are often equally generous in repeating call letters, and the stations are therefore readily identified by the beginner at code. When calling another station, the procedure is to send the call letters of the desired station a number of times, then "DE" and the sign of the calling station. The location of Amateur stations can be ascertained according to country by the table of initial letters given in this article.

American amateurs are further divided into nine zones, covering the following approximate territories: 1—New England, 2—New York and Northern New Jersey, 3—middle Atlantic states, 4—south Atlantic states, 5—south central states, 6—California and far western states, 7—Washington and north western states, 8—western New York, Ohio and Michigan, 9—north central states. For instance, W1MK is located in Hartford, Connecticut, while W5VY is in Galveston, Texas.

### *Gaining Code Proficiency*

As the game of logging code stations is continued, the player will necessarily develop an increased degree of skill in deciphering the fascinating combinations of dots and dashes. At first the code itself will automatically become memorized, and the chart will be referred to only occasionally. Then the listener will begin to recognize the more familiar groups, and occasionally will be able to write down entire words. He will graduate from the method of writing down the dots and dashes. Instead he will translate them mentally into the corresponding letters. At this point he will become interested in trying the key, which is perhaps the quickest system of building up speed to the ten word per minute rate. A simple code set is diagrammed on the second page of this article.

"T" is a standard audio frequency amplifying transformer, the make, radio and general excellence of which are not at all important. The circuit is self-explanatory. When the key is depressed, a whistle, similar to that of a cw signal, is audible in the head 'phones. It may be necessary to reverse the connections to the primary before the whistle is heard. The tone can be varied by changing the value of condenser C between .0005 and .01 mfd. In many instances this condenser will not be required. Similarly the grid condenser and grid lead



**The operating room of the New York *Times* short-wave station WHD, New York City. This station maintains schedules with expeditions the world over**

may be omitted if desired, if the click which accompanies keying is not annoying. With many transformers, no "B" battery will be required, and the 22.5-volt posts may be shorted, as suggested tentatively by the dotted line. A 3-volt dry-cell tube should be used, such as the type -99. The "A" battery is conveniently two dry cells in series. Care should be taken to send slowly and distinctly. If possible, enlist the occasional services of an experienced operator to criticize your sending. It will be a most excellent idea to amplify the output of this simple code set, and record your transmission on a dictaphone or home recording device, along the lines suggested farther on for code recording. Listen to your own transmission. If you can transcribe it—it will pass.

In learning the code, it is said that it is desirable to memorize the sounds rather than think of the characters as dots and dashes. (It is over twenty years since the writer learned to copy, so I can't speak from experience.) The idea is sound from the psychology of mnemonics. Think of A as dit dah, rather than dot dash—the dit being said quickly.

## *Home Recording as a Short-Cut to Proficiency*

Key work will have little or no effect on your receiving speed above ten words per minute. Nothing but copying will help here, and, unfortunately, there are very few stations transmitting at anywhere near this speed. It is discouraging to attempt copying speeds more than twenty per cent. faster than your reliable rate. Occasionally you will find commercial stations transmitting as slowly as fifteen words a minute, repeating each word. Such stations afford excellent practice, but the necessity for such transmissions are few and far between.

Here the distaphone and home recording arrangements, where variable record speeds are possible, are of genuine service. Clean-cut code signals may be recorded on these devices at high record speeds and decoded at a comfortable number of words per minute, with whatever repetitions as are necessary. The use of such arrangements is suggested in two of the illustrations. The note of the received signal should be pitched somewhat higher than for direct transcription, as this too will be lowered with the speed. It is possible, in this manner, to copy even high-speed automatic transmission above forty words per minute, which is faster than even a good operator can copy directly.

## *Using Press Dispatches for Code Practice*

After a certain amount of facility and speed are acquired, the press schedules between nine and midnight E.S.T. provide excellent practice. About the slowest press transmission (between eighteen and twenty words a minute) emanates from WPN, Garden City, N. Y., on 6515 kc.—46.05 meters. The "fist" is a little stiff, however, and it may bother the inexpert operator. For better though faster sending, KUP, San Francisco, on 6530 kc. or 45.94 meters is excellent practice. The stock market quotations, with which press dispatches are generally concluded, are about the best training on numbers you will find.

After your speed increases, you will get to recognize certain groups of letters, many of them three-letter sequencies beginning with "Q." These are the international "Q signals" or abbreviations, a complete list of which is contained in "Commercial and Government Radio Stations of the United States," which may be obtained from the Government Printing Office in Washington, D. C., for fifteen cents.

It is a simple matter to become inoculated with the code bug. Any experimenter who has followed us to this point is in a fair way to being bitten, and the ultimate stage of infection is an unquenchable desire to own and operate one's own station —to join the ranks of the many thousands of amateur operators who hold distant records bettered by no commercial stations in the world.

## *Licenses and Construction Permits for Amateur Stations*

The construction of an amateur transmitter is not difficult, and several simple transmitters can be purchased, completely assembled, for much less than the cost of a good receiver. Fundamentally, a transmitter is less complex than a receiving set. The construction, installation and operation of an excellent transmitter has been described in considerable detail by Don Bennett in the January, February, March and April, 1931, issues of Radio News. The existing amateur regulations are covered at length in the September, 1930, number.

It is of course essential that, before the experimenter can transmit, he possess both station and operator's licenses, procurable from the Radio Division of the United States Department of Commerce. It is illegal to transmit without such licenses, and the offense is a serious one.

## *Offices of the Radio Inspectors*

Station licenses, which assign the call letters, are issued only to persons holding operators' licenses. To secure this it is necessary to pass a code and written examination in the presence of the radio inspector of your district. The radio inspector nearest to you is the correct office to which license application should be made. Radio inspectors are located at the following addresses: Customs House, Boston, Mass.; Sub Treasury Building, New York City; Fort McHenry, Md.; Post Office Building, Atlanta, Ga.; Customs House, New Orleans, La.; Customs House, San Francisco, Calif.; Exchange Building, Seattle, Wash.; David Scott Building, Detroit, Mich.; Engineering Building, Chicago, Ill. There are several branch offices at which the examination can be taken, and in some instances a temporary license will be granted, upon evidence of proficiency, pending actual examination. Further information may be secured from the addresses listed above.

## *Code Examinations*

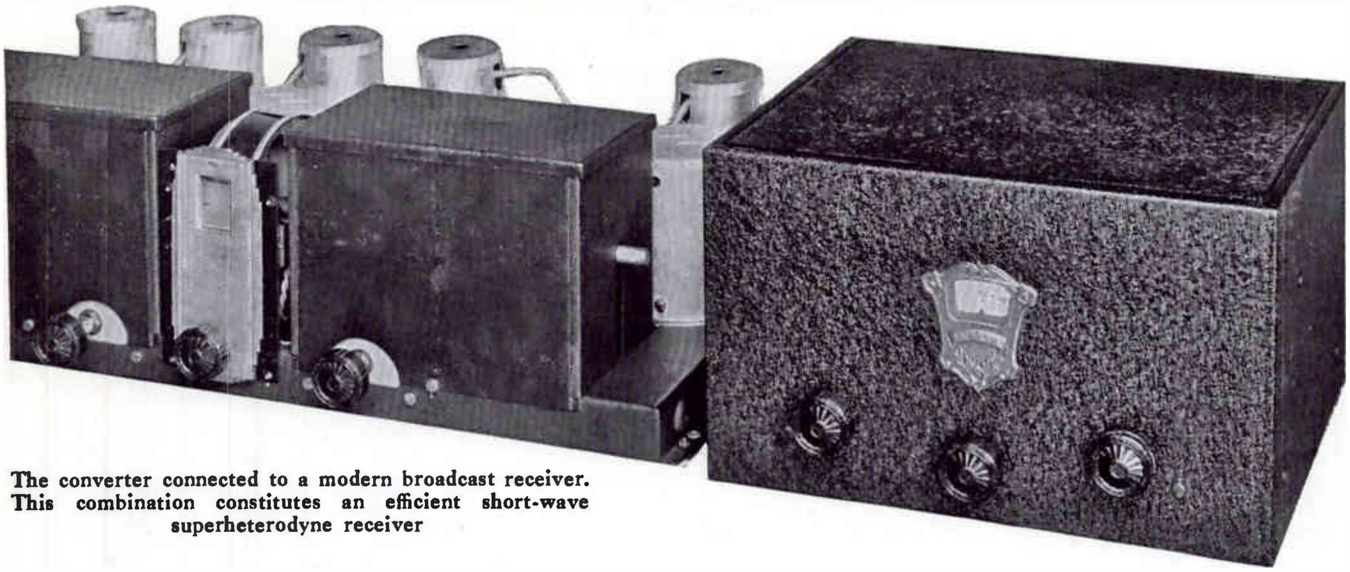
The code examination for a first-class amateur license is given at twelve words a minute, but the applicant is advised not to attempt the test unless he is sure of fifteen words per minute. The written examination covers the theory and operation of amateur transmitters and receivers, particularly in reference to tuning the former, and so adjusting the apparatus that it conforms with the national and international regulations. Questions are asked concerning radio law and the international abbreviations. The prospective amateur is advised to secure the government publications to which reference has already been made earlier in this article and to study their contents carefully.

## *Conclusion*

In conclusion it is only fair to point out that this short wave bed of roses has its thorns and that its possibilities are more accurately described in this article than in the advertising and publicity matter prepared by some of the manufacturers of short wave apparatus. While there may be less static above 6,000 kc. than below, there is invariably more noise caused by artificial strays. Every passing automobile is a potential short wave transmitter in competition with every doorbell in the neighborhood. Short period fading finds its realm in the region of megacycles and signals often flutter with a disconcerting wobble.

But all in all, intelligently operated, with no more than reasonable optimism, the short wave receiver possesses a genuine entertainment value and contributes a fascination to radio reception unapproached in the more familiar bands.

All of which just about concludes the story of "Tapping the Short Waves." It remains for us merely to conclude with the international expression of cordiality and good luck—"73."



The converter connected to a modern broadcast receiver. This combination constitutes an efficient short-wave superheterodyne receiver

# Receiving Short-Waves *on Your* Present Receiver

***A compact superheterodyne short-wave converter which may be connected ahead of a broadcast receiver to provide efficient reception on short waves from 13 to 115 meters***

***By* James Wilcox***

AT this time of the year radio reception on the regular broadcast bands is not only practically impossible in tropical countries, but the same situation is true in many of our Southern States. In such locations it has generally been necessary to forego the pleasure of radio broadcast entertainment during the greater part of the summer months.

Within the past year, however, many people in the areas so strongly affected by summer atmospheric disturbances have discovered that very satisfactory broadcast reception can be obtained by the use of short-wave equipment. Not only can the "chain" programs from all three of our main networks be received, but, in addition, excellent reception from a number of distant foreign broadcasters is possible.

In most instances the so-called short-wave receiver, entirely separate and apart from the regular set, has been employed, and the appearance on the market, just about a year ago, of a compact, single dial, a.c.-operated short-wave receiver tremendously increased the number of people enjoying radio reception throughout the year.

There are, however, a great many people who have a considerable investment in their broadcast receivers and who cannot well afford to purchase an additional set.

It was with this in mind that the Lafayette converter was designed for use with the average broadcast receiver, in order to extend its useful frequency range into the short-wave field. Unlike the earlier types of so-called short-wave adaptors, this new unit makes efficient use of all of the tubes in the regular broadcast receiver, rather than just those of the audio stages.

*Wholesale Radio Service Co., Inc.

**THE MOST simple efficient method of receiving short wave signals is by means of a converter. The next five chapters will be devoted to a series of converters, from the simple to the elaborate, establishing the basic principles and the practical methods of construction.**

The overall result is an extremely sensitive yet easily operated short-wave superheterodyne, which, due to the use of the high-grade –45 push-pull audio channel and dynamic loud speaker integral with the average good broadcast receiver, will result in tone performance obtainable from only the best of the strictly short-wave receivers.

While superheterodyne converters are not new, they have had to go through a long period of development before reaching their present state of reliability and overall satisfactory performance.

In designing the Lafayette converter much help was obtained from the experience of the National Company engineers in the development of their short-wave "Thrill Box," as described in the June, 1930, issue of Radio News. In fact, many of the parts developed by them especially for use in their receiver have, as will readily be seen from the illustrations, been employed in this converter.

Essentially the converter comprises a screen-grid short-wave detector, an oscillator, and a small power supply. Figure 1 gives the circuit details.

The single tuning dial is for adjusting the oscillator condenser, the setting of which is very sharp. The first detector tuning condenser tunes relatively broad and under actual operating condition is employed merely as an auxiliary control.

Having only one major control, and that control being independent of any changes in associated circuits, makes possible the use of a dial such as shown, on which the location of the various stations may be logged for future reference. Such practice is of tremendous help in short-wave reception where the frequency band to be covered is many times the width of the usual broadcast band.

Another aid to easy tuning is the use of the 270° straight frequency line high-frequency tuning condensers. These condensers have been developed specially for short-wave reception and in addition to spreading out the tuning range also incorporate several electrical features of extreme importance. One of these is the constant impedance pigtail for elimination of noisy operation on the ultra-high frequencies and which makes possible the maintenance of accurate logging. Another important feature is the insulated main bearing which prevents the condenser frame from acting as a short-circuited turn in a high-frequency field, which would also contribute considerable noise when the set was being tuned.

As a further important step in the elimination of that bugbear of short-wave reception, noise, this converter incorporates a highly efficient radio frequency switch by means of which any one of the various wave bands may be instantly selected.

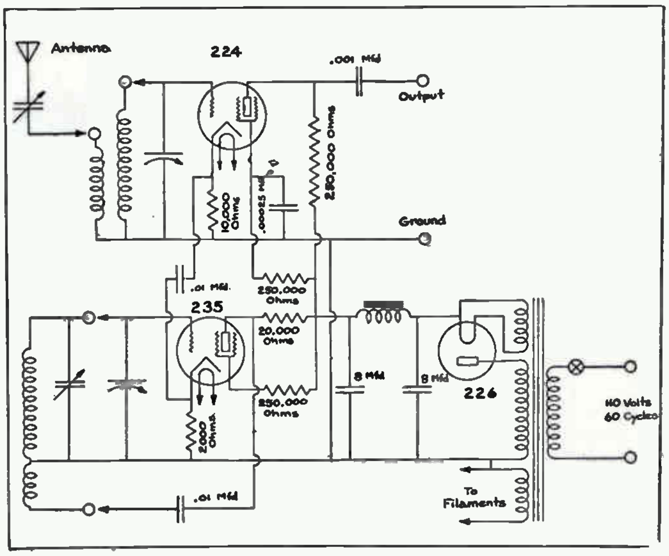
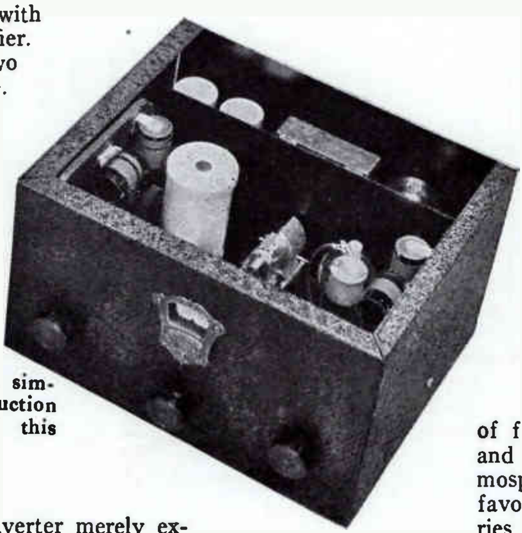



**Figure 1. The fundamental circuit. The –24 and –35 tubes are, respectively, the detector and oscillator. The –26 tube is used as the power supply rectifier. The wave-change switch is not shown**

The power supply is called upon to deliver but a very few milliamperes to the detector and oscillator and therefore employs a type –26 tube, with the plate and grid tied together, as a rectifier. The associated filter network comprises two 8 mfd. electrolytic condensers and a choke. A filament winding on the power transformer supplies the heater circuits.



**The inside view, showing the general disposition of the coils and tubes, with the power supply in the rear compartment**

**Compactness and simplicity of construction are features of this converter**

It is felt that the inclusion of the power supply in the converter is a really worthwhile feature, as it insures the proper voltages, the elimination of any possibility of overloading the power supply of the broadcast receiver, and, at the same time, this materially simplifies the connection of the converter to the broadcast receiver.

Perhaps it would be well to point out at this time the importance of using a good broadcast receiver in connection with the converter, for, in the final analysis, the converter merely extends the range of a broadcast receiver and unless it is sensitive, selective, and capable of good tone quality, just the addition of the converter cannot be expected to add any of these characteristics.

Any of the good screen-grid receivers manufactured during the past two years, employing two or three stages of r.f. amplification, should give satisfactory results. Do not, however, expect satisfactory results from some of the earlier a.c. receivers, especially those employing the –26 tubes in the radio-frequency amplifiers, as the majority of these receivers had very little r.f. amplification.

Contrary to general opinion, the converter may successfully be used in connection with a number of the present-day superheterodynes, resulting in a "double super" because the frequency is shifted twice and three detectors employed. This combination, strange as it may seem, appears to give very satisfactory results. There are, though, some commercial broadcast superhets with which the Lafayette will not give satisfactory performance.

Assuming the use of the converter with a fairly sensitive broadcast receiver, reception of foreign stations should be regular and with good volume, provided atmospheric conditions and location are favorable. Long-distance reception varies greatly with the time of day and with the season, and these facts must be given due consideration. In this connection reference is made to the introductory chapters of this book where the possibilities of S-W reception were described in detail.

The Lafayette converter is not limited solely to short-wave broadcast reception, for when used with a good broadcast tuner it will be found to make a very practical all-around short-wave receiver for amateur communication, experimental, and other such uses.

In receiving short-wave c.w. signals it is not necessary to employ an additional heterodyne oscillator, but merely to tune the broadcast receiver so that it picks up directly the carrier of a strong local broadcast station and thus uses the broadcast transmitter as a heterodyne oscillator. Of course, if preferred, a separate local oscillator, set to beat with the intermediate frequency or the wave to which the broadcast receiver is tuned, may be used for short-wave reception, and, since this will be unmodulated, it is somewhat preferable to the use of a local broadcast signal as heterodyne.

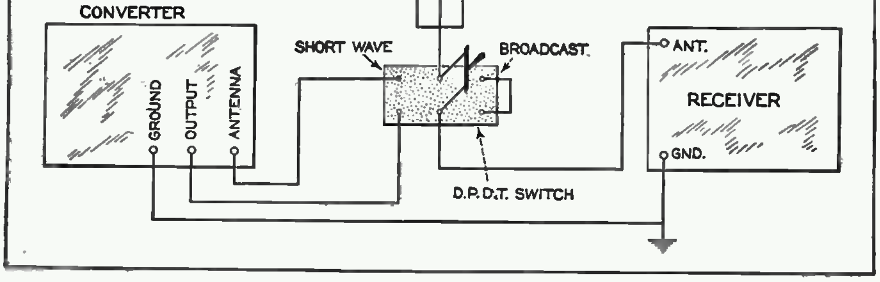



**Figure 2. A simple switching arrangement for cutting the converter in and out**

### *Operating Notes*

To put the converter into operation, disconnect the antenna from the broadcast receiver and connect it to the antenna post of the converter. Connect the output post of the converter to the antenna post of the receiver, and connect the ground posts of the converter and receiver together. The arrangement shown in Fig. 2 is convenient.

# The Jackson Converter

## *I-F Amplification Increases Gain and Reduces Noise Level by Matching Output Impedance with Receiver*

**By D. Howland**

THERE are three possible methods of receiving short wave signals—by means of a short wave receiver, a short wave adapter and a short wave converter, the last two being used in conjunction with any good broadcast receiver. General acceptance and convention has established a difference between the adapter and the converter. An adapter may be defined as a short wave receiver without audio frequency amplification, the output of which is plugged in or otherwise connected into the detection plate circuit of the broadcast receiver, which merely amplifies the audio output of the adapter. Obviously the radio frequency section of the broadcast receiver in no way contributes to reception, and is generally consuming filament and plate power to no avail. The use of an adapter is particularly wasteful when employed in conjunction with a super-heterodyne broadcast receiver where from four to eight tubes, depending on the size of the receiver, are idle. And we do not refer to waste merely from the point of few of tubes burning without contributing to reception. Rather it is the potential waste we have in mind—the tremendous amplifying power of the high-frequency and intermediate-frequency amplifiers which is in no way being utilized.

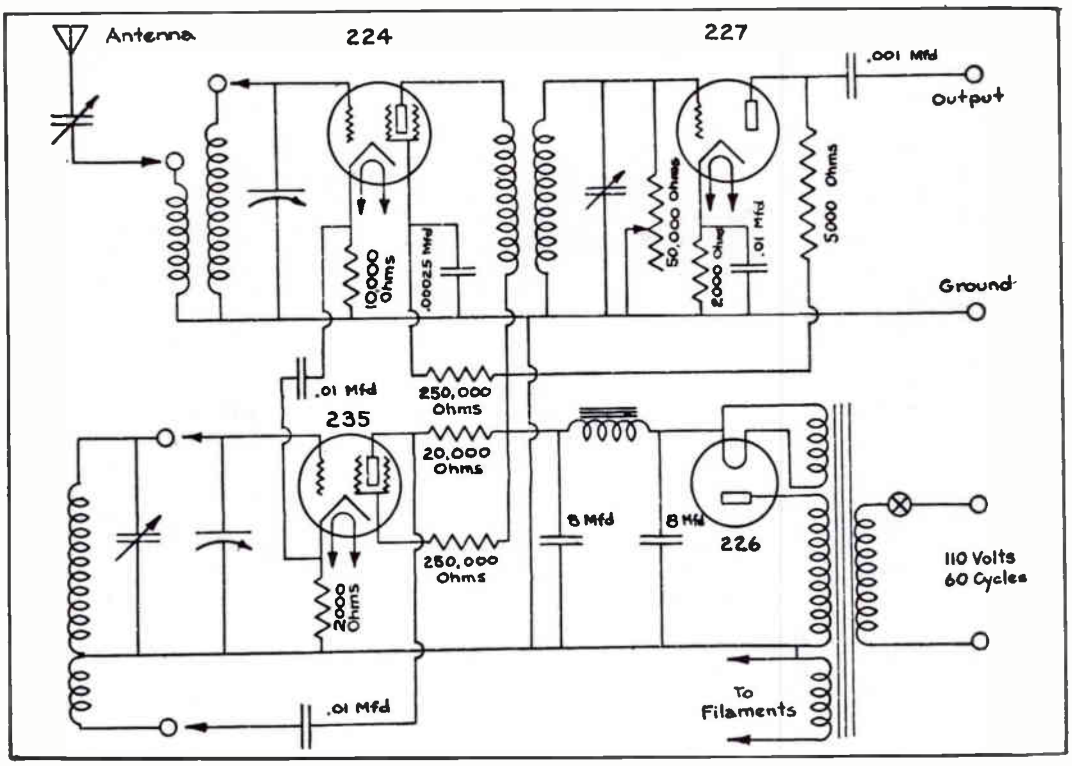
### *The S-W Converter*

The principal recommendation for the converter is the fact that it takes full advantage of both the radio and audio frequency amplifiers in the broadcast receiver, whether of super-heterodyne of tuned radio frequency type. This it does through the process of changing the frequency of the incoming short wave signal to the wavelength to which the broadcast receiver is tuned, and introducing the new signal into the broadcast receiver circuit. In other words the short wave signal is actually received on the long wave receiver exactly as if it were a conventional program. It goes through the same long wave amplification, and all tubes are utilized to their fullest advantage. Actually the amplification is often more effective than on some broadcast wave signals, due to the fact that an intermediate frequency is chosen at which the broadcast amplifier is particularly effective (the amplifying efficiency of most receivers varying somewhat over the entire broadcast range).

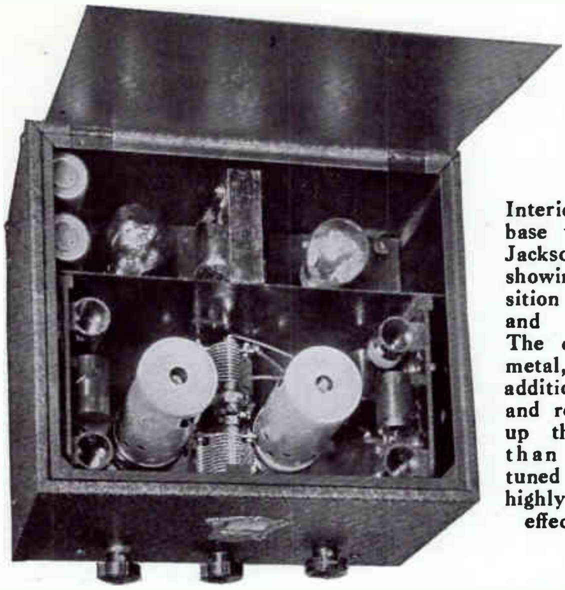
### *How the Converter Changes the Wavelength*

The conversion from short to long waves is accomplished by the more or less familiar system of heterodyning. It is a common physical law that when two frequencies combine in a single circuit, two additional frequencies are generated—the difference between the two original frequencies, and their sum. The converter is thus similar to the conventional super-heterodyne, and combines a high frequency circuit which can be tuned to the frequency of the desired signal and a local oscillator to supply the second or beating frequency. These two frequencies are "mixed" in the circuit of the first detector. If, for instance, we desire to intercept a radio telephone communication from an airplane operating on 95 meters, using a converter in conjunction with a high grade broadcast set, the following process is involved:

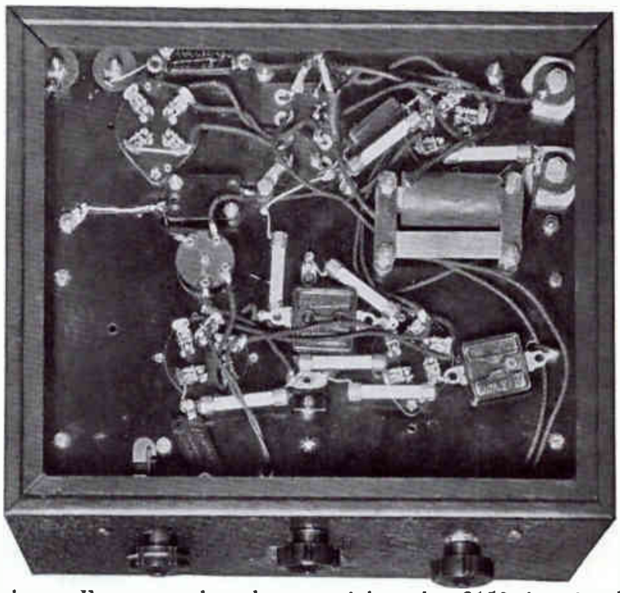
The wavelength of 95 meters has a frequency of 3150 kc. The converter has been designed to output a certain definite intermediate frequency, 575 kc. for example. The broadcast receiver is carefully tuned to this frequency, which represents a wavelength of 520 meters. The converter is engineered so that the frequency difference between the local oscillator and circuit by which the incoming signal is tuned, is always the intermediate frequency of 575 kc. In the instance of our 3150 kc signal, the oscillator frequency may be either 3150 kc




**The schematic diagram of the Jackson four tube high frequency converter. This converter may be considered as a compromise between the economy and simplicity of the Lafayette converter and the elaborate efficiency of the NC-5. Increased gain and reduction of noise are its features**



Interior and sub-base views of the Jackson converter showing the disposition of the tubes and other parts. The cabinet is of metal, providing additional shielding and reducing pick-up through other than the usual tuned circuits. A highly efficient and effective design



plus 575 kc (3725 kc) or 3150 kc minus 575 kc (2575 kc). In the case of a broadcast superheterodyne, the oscillator generally functions on the higher frequency side of the incoming carrier. However, on very short waves, considerations of stability and tracking make it desirable to operate the oscillator at the lower frequency, and so we shall assume that the oscillator circuit is oscillating at 2575 kc, setting up an intermediate frequency which is the difference between this oscillator frequency and the frequency of the incoming wave (3150 kc) or 575 kc. (The sum of these frequencies, or 5725 kc is also being generated, but is not utilized and is without importance as far as we are concerned.) The output of the converter is modulted in exactly the same manner as the incoming wave. Only its wavelength has been changed, and it is transferred to the broadcasting receiver for amplification and final output to the loudspeaker.

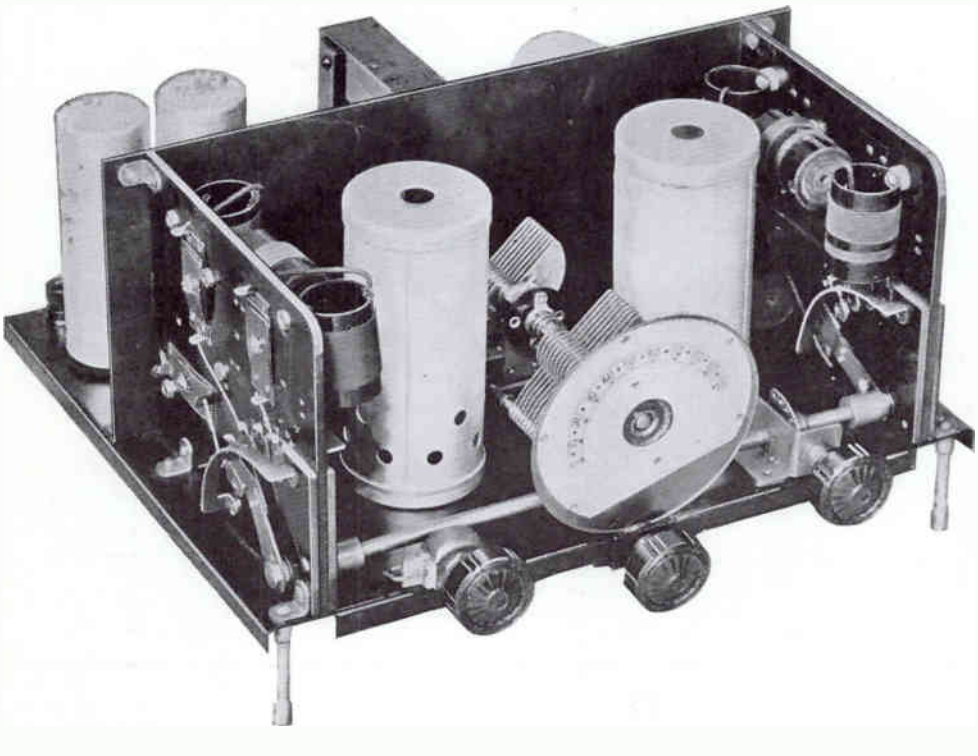
### *Problems of Converter Design*

While the converter, as has been explained, is nothing more than the forward end of a superheterodyne, the problems associated with its design are different in several respects from those of broadcast super engineering. Image frequency interference presents a less serious aspect in the short wave converter using a high intermediate frequency. The image frequency is a signal separated from the oscillator by the intermediate frequency on the side away from the desired carrier. For example when receiving the 3150 kc signal referred to in the preceding paragraphs, the oscillator frequency was 2575 kc. However, if a 2000 kc signal were also present, it too would give rise to an intermediate frequency of 575kc and would be passed on to the receiver, causing interference. However, the difference of 1150 kc is so great that the undesired signal will be detuned sufficiently to obviate the probability of interference. It is another story, however, on broadcast frequencies where an intermediate frequency of 175 kc is employed and the image frequency will be only 350 kc away from the desired carrier. In such receivers, preselection is absolutely essential.

The principal problems involved in converter design are the prevention of interlocking between the signal tuning and oscillator circuits, and the maintaining of efficient coupling between the converter and the receiver proper.

### *The Problem of Interlocking*

Any two very high frequency circuits which are closely coupled have a tendency to oscillate at a common frequency when they are individually tuned to relatively slight frequency differences. This effect has resulted in unstable and uncertain converter operation in many previous designs. In the Jackson converter, however, the coupling is effected through a common cathode circuit, where adequate mixing is secured while the mutual tuning effects of one circuit upon the other are virtually nil.



Skeleton view of the four tube converter, giving details of the dial arrangement, tuning condensers and the switching mechanism which enables the operator to shift short wave bands instantly—without changing coils. The coils are mounted in such a manner as to eliminate dead spot in the active coil caused by coupling effects. The ninety degree gear, controlling the wave change switch, is actuated by the right hand knob

### *Converter-Receiver Impedance*

Poor matching between the output circuit of the converter and the input or antenna circuit of the receiver has been responsible for much of the general inefficiency heretofore associated with converter operation. In some instances the matching has been so bad that the converter not merely failed to pass on the signal to the receiver with antenna intensity, but actually weakened reception. In other words, if the signal had a field intensity of say twenty microvolts per meter, the volume control on the receiver would be turned up to the point where, on broadcast reception, average volume would be secured on a signal having a field strength of say ten microvolts per meter. An incidental effect of this inefficiency is the raising of the noise level. Obviously if the match between the converter output and receiver input could be made so efficient that the volume control could be turned considerably down for the same signal strength, the noise level would be proportionately reduced. R. S. Kruse devotes particular attention to this effect in a later chapter in this book.

An output amplifying tube has been engineered into the Jackson converter which closely matches the converter impedance to the antenna circuit of the average receiver, at the same time functioning quite effectively as an amplifier at the intermediate frequency. The total effect of both improvements is equivalent to an amplification of about one hundred times

The circuit of the Jackson converter is shown in Figure 1 and is identical with that of the Lafayette converter, with the exception of the additional stage of intermediate frequency amplification.

### *Operation*

The operation of the Jackson converter is the same as that of the Lafayette, and an identical switching arrangement is recommended. The tuning ranges are the same, the curves of which are given on page 25. Any antenna that gives good results on the broadcast receiver may be used with the converter. The semi-fixed antenna series condenser is adjusted at the factory for a 50 foot aerial. If a longer antenna is used, the adjusting screw should be loosened about half a turn, and if a shorter aerial is employed, it should be tightened a quarter turn. The broadcast receiver should be set at a point closest to the intermediate frequency free from a broadcast carrier—unless cw reception is desired, when it should be adjusted to a powerful broadcast carrier as close as possible to the i.f. The volume control functions as usual.

---

## *International Commercial Call Letter Assignments*

**CAA to CEZ, Chile**
**CFA to CKZ, Canada**
**CLA to CMZ, Cuba**
**CNA to CNZ, Morocco, Algeria**
**CPA to CPZ, Bolivia**
**CRA to CRZ, Colonies of Portugal**
**CSA to CUZ, Portugal**
**CVA to CVZ, Rumania**
**CWA to CXZ, Uruguay**
**CZA to CZZ, Monaco**
**DAA to DZZ, Germany**
**EAA to EHZ, Spain**
**EIA to EIZ, Ireland**
**ELA to ELZ, Liberia**
**ESA to ESZ, Esthonia**
**ETA to ETZ, Abyssinia**
**FAA to FZZ, France and colonies**
**GAA to GZZ, Great Britain**
**HAA to HAZ, Hungary**
**HBA to HAZ, Switzerland**
**HCA to HCZ, Ecuador**
**HHA to HHZ, Haiti**
**HIA to HIZ, Dominica**
**HJA to HKZ, Colombia**
**HRA to HRZ, Honduras**
**HSA to HSZ, Siam**
**IAA to IZZ, Italy and colonies**
**IAA to JZZ, Japan**
**KAA to KZZ, United States and colonies**
**LAA to LNZ, Norway**
**LOA TO LVZ, Argentina**
**LZA to MZZ, Bulgaria**
**MMA to MZZ, Great Britain**
**NAA to NZZ, United States, mainly U. S. Navy**
**OAA to OBZ, Peru**
**OHA to OHZ, Finland**
**OKA to OKZ, Czecho-Slovakia**
**ONA to OTZ, Belgium and colonies**
**OUA to OZZ, Denmark**
**PAA to PIZ, Holland**
**PJA to PJZ, Curacoa**
**PKA to POZ, Dutch East Indies**
**PPA to PYZ, Brazil**
**PZA to PZZ, Surinam**
**RAA to RQZ, Russia**
**RVA to RVZ, Persia**
**RXA to RXZ, Panama**
**RYA to RYZ, Lithuania**
**SAA to SMZ, Sweden**
**CPA to SRZ, Poland**
**SUA to SUZ, Egypt**
**SVA to SZZ, Greece**
**TAA to TCZ, Turkey**
**TFA to TFZ, Iceland**
**TGA to TGZ, Guatemala**
**TIA to TIZ, Costa Rica**
**TSA to TSZ, Territory of the Saar Basin**
**UHA to UHZ, Hedjaz**
**UIA to UKZ, Dutch East Indies**
**LUA to ULZ, Luxembourg**
**UNA to UNZ, Jugo-Slavia**
**UOA to UOZ, Austria**
**VAA to VGZ, Canada**
**VHA to VMZ, Australia**
**VOA to VOZ, Newfoundland**
**VPA to VSZ, British colonies**
**VTA to VWZ, India**
**WAA to WZZ, United States**
**XAA to XFZ, Mexico**
**XGA to YUZ, China**
**YAA to YAZ, Afghanistan**
**YHA to YHZ, New Hebrides**
**YIA to YIZ, Iraq**
**YLA to YLZ, Latvia**
**YMA to YMZ, Danzig**
**YNA to YNZ, Nicaragua**
**YSA to YSZ, Salvador**
**YVA to YVZ, Venezuela**
**ZAA to ZAZ, Albania**
**ZKA to ZMZ, New Zealand**
**ZPA to ZPZ, Paraguay**
**ZSA to ZUZ, South African Union**

---

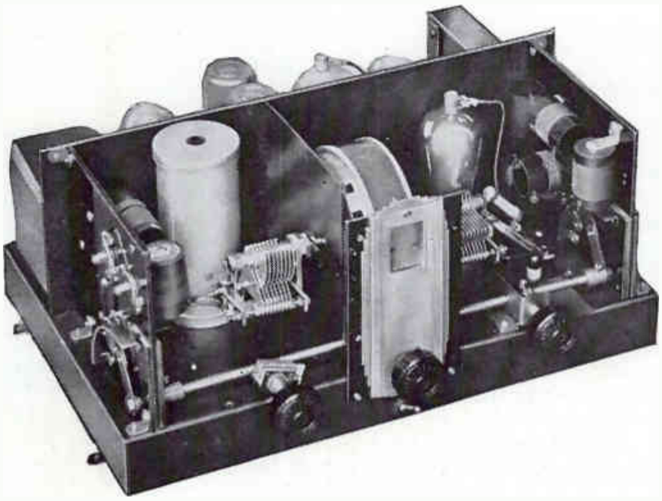
## *Characteristic International First Letters of Amateur Calls*

| | |
|---|---|
| **Abyssinia** | ET |
| **Afghanistan** | YA |
| **Alaska** | K7 |
| **Algeria** | CN |
| **Argentina** | LU |
| **Australia** | UO to VK |
| **Belgium and colonies** | ON |
| **British Isles** | G |
| **Bolivia** | CP |
| **Brazil** | PX |
| **Bulgaria** | CP |
| **Canada** | VE |
| **Chile** | CE |
| **Costa Rica** | TI |
| **Cuba** | CM |
| **Curacao** | PJ |
| **Czecho-Slovakia** | OK |
| **Denmark** | OZ |
| **Dominica** | HI |
| **Dutch East Indies** | PK |
| **Ecuador** | HC |
| **Egypt** | SU |
| **Esthonia** | ES |
| **Finland** | OH |
| **France and colonies** | F |
| **French Indo-China** | FI |
| **Germany** | D |
| **Guatemala** | TG |
| **Haiti** | HH |
| **Hawaii** | K6 |
| **Spain** | EAR |
| **Hedjaz** | UH |
| **Holland** | PA, PB, PC |
| **Honduras** | HR |
| **Uruguay** | CW |
| **Hungary** | HA |
| **Iceland** | TF |
| **India** | VO |
| **Iraq** | YI |
| **Ireland** | EI and GI |
| **Italy and colonies** | I |
| **Japan** | J |
| **Jugo-Slavia** | UN |
| **Latvia** | YL |
| **Liberia** | EL |
| **Lithuania** | RY |
| **Luxembourg** | UL |
| **Mexico** | X |
| **Morocco** | CM |
| **Newfoundland** | VO |
| **New Zealand** | ZL |
| **Nicaragua** | YN |
| **Norway** | LA |
| **Panama** | RX |
| **Paraguay** | ZP |
| **Persia** | RV |
| **Peru** | OA |
| **Philippines** | K1 |
| **Poland** | SP |
| **Porto Rico** | K4 |
| **Portugal** | CR and CT |
| **Rhodesia** | VQ |
| **Rumania** | CV |
| **Russia** | RA |
| **Salvador** | YS |
| **Siam** | HS |
| **Sweden** | SM |
| **United States** | W |
| **Switzerland** | HB |
| **Venezuela** | YV |

# The NC-5 De Luxe

***A new idea in short-wave superheterodyne job which includes an r.f. stage, detector, and works into the antenna circuit***

***By* James**



**The band shifting mechanism shown in this view has several unique features. The switches themselves are ganged by a shaft and controlled from the front panel. The same shaft manipulates a color screen in front of the main tuning dial illuminator. Thus the color of the dial illumination indicates the frequency range for which the converter is set. A switch is also provided for changing from converter to conventional broadcast operation. It is therefore possible to leave the converter permanently connected without the necessity for an exterior change-over system**

SHORT-WAVE converters are by no means new. During the past few years a great many have been described in RADIO NEWS and kindred periodicals. In the light of present-day performance standards, some of the early ones were pretty poor, but each succeeding one has, as a rule, had some new feature of sufficient merit to warrant it being classed as a step ahead of its immediate predecessor.

The general design, at present, seems to be along the lines of the Lafayette, described on pages 13 and 14 of this volume, which comprises a screen-grid detector, –35 type oscillator and self-contained power pack. A series of plug-in coils provide a wavelength range of from approximately 15 to 115 meters. Such a converter, when used with certain types of broadcast receivers, gives amazingly fine results, but unfortunately its excellence of performance is apparently dependent, to quite an extent, upon the type of broadcast receiver with which it is used.

### *Conversion and Amplification*

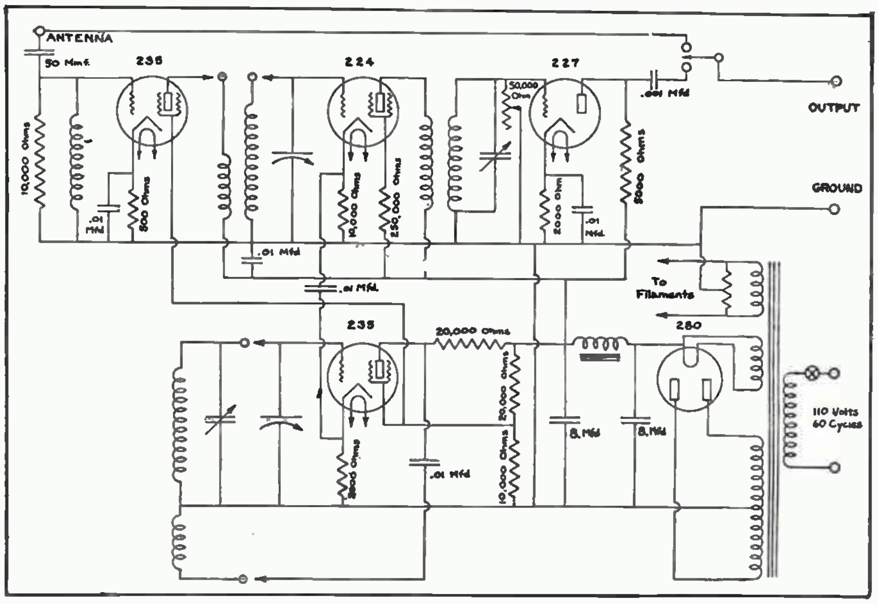
Such is also bound to be true of any converter which is merely a "frequency changer" and does not appreciably amplify the incoming signals. Thus it was evident that if a converter was to be designed that would give uniformly good performance regardless of the type of receiver with which it was used, such a converter would of necessity contain an appreciable amount of amplification both at signal frequency and intermediate frequency. Furthermore, it must overcome two other weaknesses inherent in all so-called three-tube type converters; namely, inefficient antenna coupling, so as to insure a strong signal on the first detector grid; and inefficient coupling between the output of the converter and the broadcast receiver with which it was being used, in order to insure some signal actually from the converter into the broadcast receiver regardless of whether the broadcast receiver used a low-turn input primary, a high-turn input, a coupling tube, an antenna-coupling condenser, or any one of the various other types of input systems resorted to by different manufacturers during the past few years.

It is this latter matter of coupling between the converter and the set that has caused so much difficulty with the varying performance of converters in the past.

Formerly it was thought that some sort of a tapped coupling transformer, for matching the output impedance of the detector plate circuit in the converter to the input of the broadcast receiver, would take care of this difficulty, but such practice was soon found to be a doubtful panacea.

It was then that L. W. Hatry, known to readers of RADIO NEWS as the designer of the HY-7 superheterodynes, hit upon the idea of using an additional (coupling) tube. Laboratory work during the past year has proven the wisdom of Hatry's suggestion, and, in fact, we have been able to go quite a step further in the design of the converter, in making the extra tube do double duty. In other words, in addition to being a coupling tube, it is also used as a high-gain i.f. stage so that the converter will give excellent results with some of the rather insensitive broadcast receivers, as manufactured prior to the advent of the screen-grid tube and the consequent high-gain tuned r.f.

From the foregoing it would seem that if cost were not of too much importance, there would be no reason, in the light of present engineering knowledge, why a really fine short-wave converter, universally applicable to any kind of broadcast receiver, could not be designed. As a result, we now have the design illustrated in the accompanying photographs. Including the rectifier, it employs five tubes, is the same size as a high-grade, short-wave receiver and uses about as many parts. Due to the use of the superheterodyne principle, it is, of course, much more selective than any of the standard type short-wave receivers, and when used with the average type of broadcast receiver will be found more sensitive and capable of greater volume, through the use of the broadcast receiver audio system and dynamic speaker. Of course, as with all "double detection" or superheterodyne receivers, the signal-to-

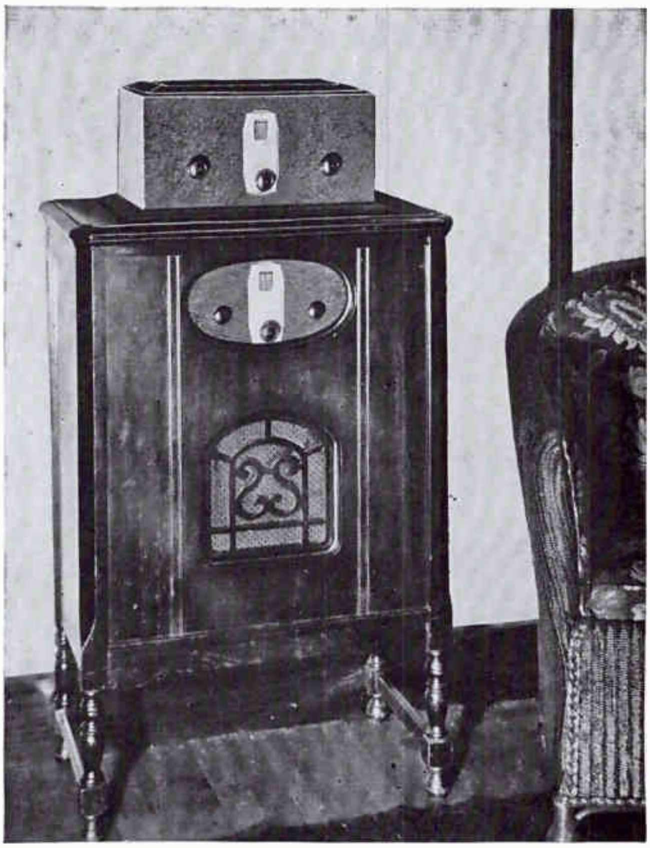



**The circuit diagram, details of which are provided in the text. Coils L1 and L2 are shown here as single coils, the range selector switch being omitted for the sake of simplicity**

# S-W Converter

***converters is represented in this five-tube oscillator, one i.f. stage and power supply, of any type of broadcast receiver***

## Millen



The new converter mounted atop a regular broadcast set and extending its range down to 15 meters when the switch on the converter is thrown to the short-wave position. Reversing this switch connects the antenna direct to the broadcast receiver

noise ratio on weak signals is far from being as favorable as with a "single-detection" or tuned r.f. receiver, such as the SW5 Thrill Box.

As short-waves come more and more into common use by the general public, the converter must be sufficiently attractive in appearance so that it may be placed in the living-room alongside the radio set with which it is to be operated. The new type converter is pleasing to the eye, has single-dial control and no plug-in coils. Furthermore, it is connected permanently in place and either the broadcast receiver or the short-wave combination is made available by merely turning a small switch on the panel of the converter.

### *The Circuit*

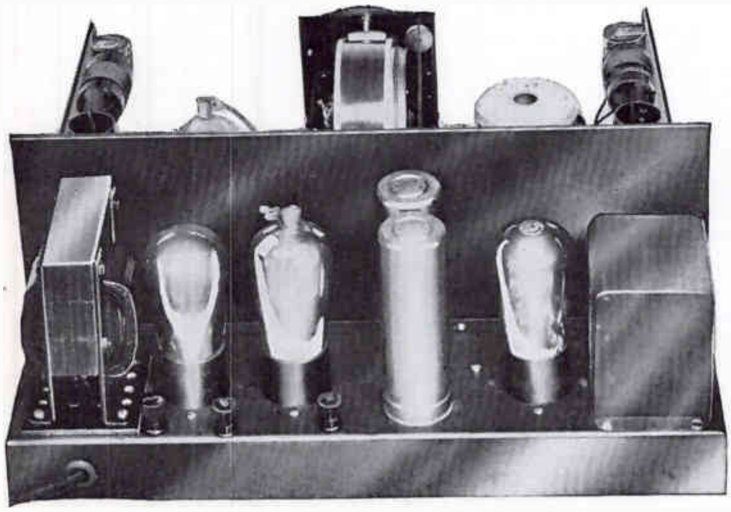
The circuit comprises a stage of "harmonic-tuned," signal-frequency amplification feeding into a screen-grid detector gang-tuned with the –35 oscillator. The beat-frequency output of the detector plate-circuit is fed through a special coupling transformer, peaked at 575 kc., into the combination i.f. amplifier tube coupling circuit which is in turn connected to the input of the broadcast receiver. A type –80 tube is used as the rectifier which supplies the plate current to the four tubes in the converter, thus making battery or difficult connections to the power pack of the broadcast receiver, with the consequent danger of overloading, entirely unnecessary.

The "harmonic-tuned," signal-frequency amplifier is an outgrowth of the system developed in the laboratory of the National Company several years ago, in connection with its original short-wave receiver, in that the antenna is hooked directly to the grid of the screen-grid amplifier tube and the grid-to-filament circuit is completed by means of a high-decrement choke coil having a natural period of around 100 meters. Harmonics of this natural period will then fall on all the principal short-wave reception bands. During its early use several years ago trouble was encountered with this self-tuning amplifier system due to cross-modulation from strong local stations, but the recent introduction of the type –35 variable-mu tube eliminates this difficulty and makes the use of this input system practical and efficient.

The tuning condensers in both the oscillator and detector grid circuit are of the straight-frequency-line type. The two condensers are mounted on either side of the type "HS" projection drum dial, to form the single tuning control.

The detector circuit has been developed along sound engineering principles, and represents a distinct advance in converter design. The characteristics of the –24 tube are such as to provide an exceedingly sensitive detector in a plate rectification circuit, an arrangement that is well adapted to the cathode system of coupling between the oscillator and detector circuits, effected through the .01 mf condenser. Students are referred to Ballantine's paper in the I.R.E. *Proceedings*, May, 1928.

In the accompanying diagram, the screen-grid detector works as a "plate circuit rectifier" due to the biasing furnished by the resistor in the cathode circuit. The grid condenser and leak shown are for the purpose of coupling the detector to the tuned plate-circuit of the initial r.f. amplifier tube.



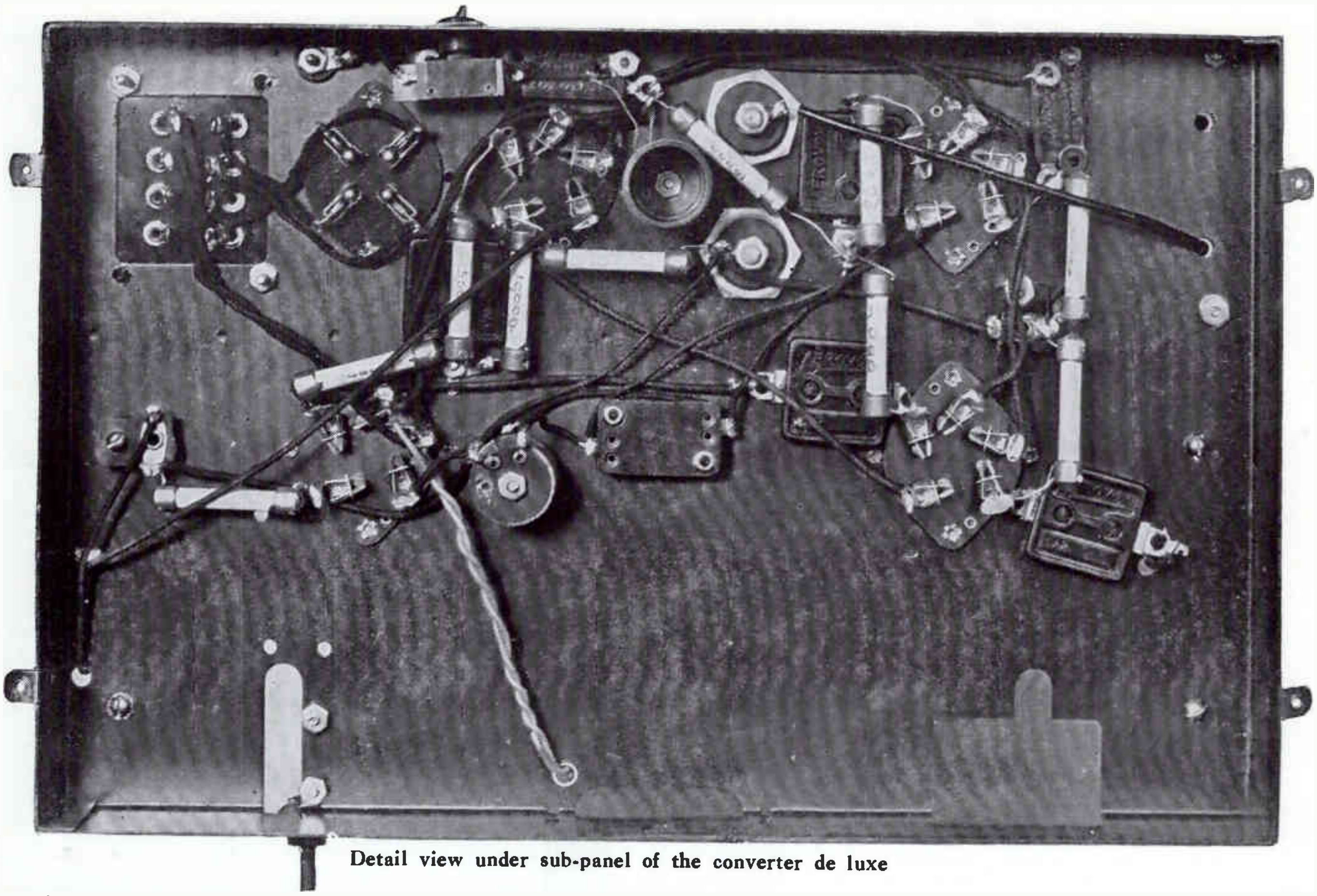
The power transformer and filter are along the rear, shielded from the detector and oscillator circuits by the long metal center partition

Contrary to general opinion on the part of those who have not made extensive investigation in the field, plate detection that is as sensitive as the usual triode grid detection can be obtained with a type –24 tube when used with the proper circuit constants. Such a detector circuit is a feature of the new National converter described herewith.

### *The Coil Assemblies*

To cover the range from 15 to 185 meters, one set of oscillator and one set of detector grid coils are required, and a switching arrangement, as shown in the photograph, is employed to bring the proper pair of coils into the circuit. In order to simplify switch construction and eliminate unnecessary losses, the circuit and coils have been so designed as to have a minimum number of connections that must be interchanged.

While the radio frequency losses in the coils of a converter are not of the same importance as in a



Detail view under sub-panel of the converter de luxe

tuned r.f. short-wave receiver, nevertheless they should be kept within reason, consequently the forms used are molded of the R-39 material developed especially for the short-wave coil-transformer work by the Radio Frequency Laboratories. Ordinary bakelite is much less effective as a dielectric at short wave-lengths due to its tremendous losses.

The oscillator and detector tuning condensers are of such values as to properly track on the 45-to-85 meter range when the natural circuit and tube capacities serve as the "pads." On the shorter waves, the detector grid coils must be padded and on the longer wave-length range the oscillator requires the padding condenser. This latter condenser, due to the small difference in frequency between the signal and the intermediate frequencies, must of necessity be quite large in order to restrict the oscillator range to that of the detector input circuit. Mechanically, the padding condensers are small flexible brass tubes over the grid leads running from the coils to the band-shifting switch.

By properly adjusting the padding condensers at the factory, true single control, without the use of a trimmer, is obtained over the entire range of from 15 to 185 meters.

In order to have the oscillator coil-switching mechanism at ground potential, the oscillator circuit is of the shunt-feed, rather than the more usual series-feed, variety.

Two of the common faults of practically all converters in the past have been so-called "dead spots" and "interlocking." Both of these troubles are due to the design and construction of the coils more than to anything else. To prevent interlocking, the two groups of coils, namely, the oscillator and detector grid sets, must be shielded from each other. This is accomplished in the present design by locating them at opposite ends of the chassis and placing between them the steel partition shield shown next to the drum dial in the illustration. This separating of the two groups of coils, in conjunction with the special type of oscillator-detector coupling (a 10-mmfd. condenser between the grid of the oscillator tube and the screen of the screen-grid detector), results in complete elimination of interlocking tendencies.

Dead spots in the tuning range, it was found, were caused by unused coils coupling with the coil in the circuit. When it is considered how many different coils there are, including ticklers, primaries, etc., and the number of multiples of the fundamental period of each coil that is effective in producing a dead spot, the extreme importance of locating these coils relative to each other in such a manner as to eliminate undesired interaction is readily seen. The photos show the ingenious scheme worked out for eliminating this undesired coupling. In this layout all coils in each group have their axes at right angles to those of adjacent coils.

### *The Power Supply*

The rectifying circuit is fairly conventional and the type -80 tube is employed to supply the d-c plate potential from the high voltage a-c source.

In addition to the plate supply windings, the power transformer has the necessary 2½-volt heater windings. The filter comprises a small choke coil which, due to the low value of current drawn through it, can have an exceedingly small air gap and consequently high inductance without danger of saturation. On both sides of the choke are located 8-mfd. electrolytic filter condensers. The power pack is entirely shielded from the detector and the oscillator circuits by means of the welded-steel partition, running lengthwise along the chassis.

### *The Intermediate Frequency*

Before starting on the design of a converter embodying single-dial control and a tuned-coupling tube circuit, it is essential to know the intermediate frequency at which it is to be operated. It is a well-known fact that all of the more recent types of broadcast receivers are highly sensitive in the middle and upper range, and that all of the earlier types of receivers are of considerably higher than average sensitivity at these same frequencies, whereas they are unreliable on the higher frequency or lower wave length end of the tuning band. Furthermore, the fact that 575 kc. is sufficiently removed from 1500 kc. so that its use will permit tuning in signals fairly close to the end of the broadcast band where such procedure would be impossible if 1500 kc. were used as the i.f., also had some effect in influencing the selection of 575 kc. as the optimum frequency at which to set the broadcast receiver when used with the converter.

Knowing this frequency, it was then possible to design the fixed 575 kc. r.f. transformer coupling between the first detector plate circuit and the grid circuit of the combination i.f.

amplifier and coupling tube. It also permitted the selection of the proper values of the "padding" condensers in the r.f. oscillator circuit to insure single-dial control.

In order to prevent pick-up of local broadcast stations operating on or near 575 kc. from interfering with short-wave operation, the lead between the antenna post on the broadcast receiver and the switching device in the converter is thoroughly shielded. The switch connects the end of this shielded lead either to the antenna or to the output of the converter, depending upon whether short-wave or broadcast reception is desired, and eliminates the necessity of manually changing the antenna from the antenna terminal post of the converter to the similar post on the broadcast receiver.

### *Installation and Operating Instructions*

The NATIONAL NC-5 Converter is essentially a short-wave receiver designed to work in conjunction with a broadcast receiver. It consists of a semi-tuned r.f. stage employing a variable Mu tube, a screen-grid detector, a high-gain tuned transformer operating at a frequency of approximately 575 kc., an output coupling tube, and a short-wave oscillator. The power supply is built in.

Five tubes are required:

2 — 235
1 — 224
1 — 227
1 — 280

Any antenna that is suitable for good broadcast reception is satisfactory for use on short-waves. This does not apply to antennas that are built into the broadcast receiver console, however. A good outside antenna, as high as possible, having an overall length from 30 to 100 feet is desirable, but excellent results may be obtained with inside antennas. As a rule, lowest noise level will be had with an outside antenna 50 to 75 feet in length.

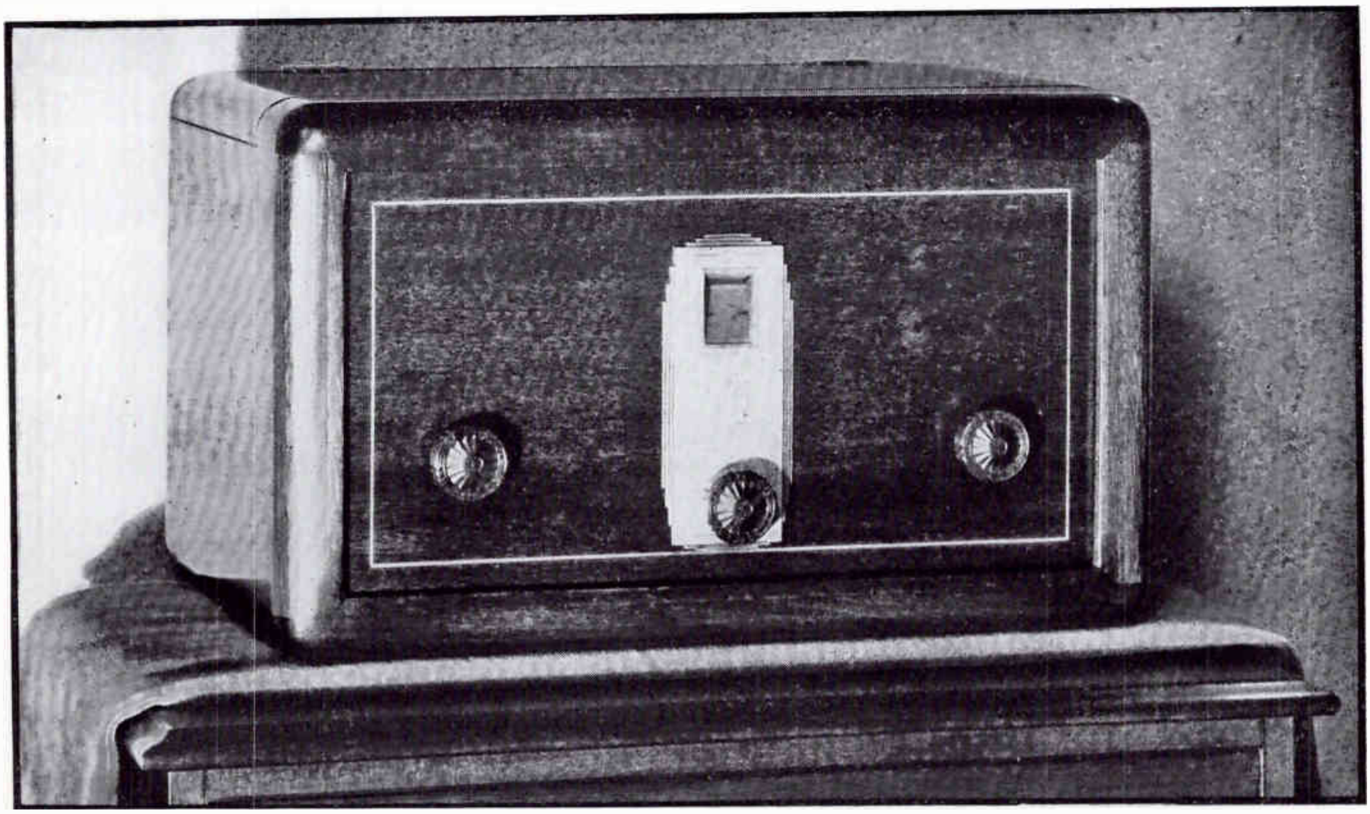
The NC-5 may be used with practically any broadcast receiver, the only requirements being fair selectivity and sensitivity. The receiver should have three or more tuned circuits and should have a sensitivity of 100 microvolts per meter or better at 575 kc. (522 meters). Practically, this means that nearly any receiver of the A.C. type, with the exception of "midgets" designed for local reception only, will have suitable characteristics. The modern midget superheterodyne is excellent, although tube hiss is apt to be bothersome. Noise of this nature is always somewhat emphasized when using a short-wave Converter.

To install the NC-5, the A.C. cord is plugged into a suitable A.C. line. The antenna is disconnected from the broadcast receiver and connected to the antenna post of the Converter. The output post of the Converter is connected to the antenna post of the broadcast receiver. The ground post of the Converter is connected to the ground post of the receiver. The broadcast receiver must be tuned to a frequency of approximately 575 kc. It is essential that some frequency between 560 and 590 kc. (510 to 535 meters) be employed, and it is also essential that no broadcast station be audible on the frequency selected. If broadcast signals are present, all short-wave signals will come in with a whistle which cannot be eliminated. In extreme cases, it may be necessary to shield the lead from the antenna post of the broadcast set to output post of the Converter. The shield should be grounded.

The toggle switch on the back of the Converter chassis switches the antenna from the NC-5 to the broadcast receiver. When the switch control arm is thrown toward the 280 tube, the antenna is connected to the broadcast set. When thrown toward the 235, the antenna is connected for short-wave reception. When adjusting the receiver to 575 kc., the switch should be toward the 280, in order to insure the selection of a channel free from interference. Weak interference is not harmful, since it will disappear when the switch is thrown to the short-wave position.

The NC-5 covers a range from about 16 meters to 190 meters, by means of four sets of coils. The ranges of the different coils are shown on the chart appearing on page 25. Selection of any range is accomplished by the righthand knob, which operates four switches, the range that is connected being indicated by the color of the dial illumination. When the range is shifted, it is essential that the knob be adjusted so that the desired color completely covers the dial window. The Converter will not operate properly when two colors show at the same time.

The several compression type trimmer condensers mounted on the coil and switch panels are carefully adjusted at the factory, and must not be touched. As there is no direct indication of their correct adjustment, it is almost impossible to readjust them correctly without special equipment. The trimmer condenser located just in back of the dial drum is for tuning the high gain 575 kc. transformer. This is also adjusted at the factory, but the setting may be easily checked by simply tuning in a short-wave signal and adjusting the trimmer for maximum volume with the receiver tuned to 575 kc.



The converter de luxe in a cabinet that befits its excellence and graces any receiver

# Progress In Converter Design

*The Engineering Considerations Involved in Converter Design, Showing Their Effects on Actual Reception. Where Amplification Should be Inserted and its Possibilities in Noise Reduction and Increased Conversion Efficiency*

by Robert S. Kruse

THE PERFORMANCE of the present crop of short-wave converters is in amusing contrast with the advertisements. Few of them seem to differ in any desirable way from the cigar-box mail-order contraptions of the last few years. Of course, the cabinet and the price have grown, the name on the label is more impressive—but it's the same old detector-and-oscillator with no serious attempt to provide proper coupling to the broadcast receiver, no apparent appreciation of the signal-noise problem, and frequently with two badly interlocking tuning controls, of which one is blandly alleged to be a trimmer and accordingly provided with an undergrown knob.

### Comparisons

As the owner of a Franklin motor car which will soon be antique, I am sympathetic toward those who desire economy—but have no great hope of seeing the present tubes used to produce a high-performance converter with but a detector and an oscillator. (Whether the power-supply rectifier is in the converter is immaterial.) The main claim that can be made for such simple converters appears to be that they produce little noise—or signal! This is said boldly in the face of testimonials written and testimonials spoken, first because such testimonials are subject to heavy discount and secondly because impartial reception tests and artificial-signal measurements show a large advantage in favor of more advanced designs.

In a series of reception-comparisons the results of the table were obtained. It was necessary to have some sort of a common standard and one might as well work with a standard noise level—for noise is certainly what limits short-wave reception with a converter. Since the converters themselves are without volume controls it was decided to set the broadcast receiver gain at such a point that a meter connected across the speaker would show that the speaker was receiving an average noise-level of 20 milliwatts when the converter was tuned just off the signal. This setting was repeated as each signal was tuned in—a tedious business. 20 milliwatts is a high noise level, but attempts to use a lower gain in the broadcast receiver caused some of the detector-oscillator converters to miss all signals whatever.

### A Kind Word for the Detector-Oscillator

There is, of course, room for improvement in the detector-oscillator variety of converter (the 2-tube sort if one neglects the rectifier). For example the Stewart-Warner device makes a useful compromise between the '27 and the '24 detector by using a '24 with the screen tied to the plate, thereby gaining a triode with low input capacitance, and with a plate impedence which is within reason and gives a chance of transferring some r-f to the relatively low-impedence input circuit of the broadcast receiver. Again, in the National LC-3 converter the usual nuisance of interlocking tuning is evaded by coupling the oscillator and detector, cathode-to-cathode and keeping the tuned circuits quite apart from each other, as is proper in an oscillator-detector with small tuning capacities and no protection against the variations caused by assorted antennas. This device is, quite properly, given a complete metal enclusure. Once again—in the Silver-Marshall 739 converter provision is made for "trimming-out" (adjusting for) the antenna effect, and an ingenious mechanical arrangement of the tuned circuits permits unit assembly with leads so short and rigid that variations during the general assemply are probably unimportant. Again a metal case is provided.

It is very probably that these and other refinements will further improve the 2-tube (plus rectifier) converter—

### Where to Place Amplification

None the less as long as the converter has neither an r-f amplifier ahead of its detector, nor yet an i-f amplifier *after* the detector the broadcast receiver must provide all the amplification. Thus the modern receiver is thoroughly capable of—but with a most distressing noise level as a result. It is a fairly general rule that quite reception comes from amplification early in the system—ahead of detection if possible. Suppose we had a receiver with a detector and 4 audio stages, and were able to tune this receiver to WCCO and then could remove the audio tubes one at a time and place them at the front end of the set as r.f. amplifiers. Always adjusting for the same signals from the speaker, we would find the detector-plus-4-audio to be a beastly noisy receiver. With one r-f and 3 audio we would be better off, with 2 r-f and 2 audio decent reception would become possible and with 3 r-f and one audio the noise level would be far down.

### Increasing Transfer Efficiency

The same thing has long since been admitted for superheterodynes, which formerly had 3 or 4 noisy intermediate stages and no r-f gain, but now have 1 or 2 intermediate-frequency stages, plus some r-f up ahead.

This lesson applies to converters: If they provide gain it is possible to operate the broadcast receiver (which is now an intermediate-frequency amplifier) at a lower gain, with less noise for the *same signal*.

From this it is fairly clear that we should provide ampli fier tubes in the converter, either at the signal frequency (tuned r-f ahead of the detector) or else at the intermediate frequency to which the broadcast receiver is tuned.

To provide an additional stage of amplification at the same frequency as that to which the broadcast receiver is tuned may seem silly. However, as was pointed out on page 20 of the July issue of Modern Radio under the heading of "An Adapter for Adapters", such a stage provides a plate circuit whose impedence is suited to the broadcast receiver's imput-circuit. The mis-matching between a detector's plate circuit and a broadcast receiver's input system is extremely wasteful. After the addition of a fixed-tune i.f. '27 stage (after the detector) the transfer-efficiency is so raised that the volume control of the broadcast receiver will need to be turned back some 2/3 of its range, indicating an increase of amplification of about 250. Thus a fixed stage of this sort is well worth whlie. The '27 tube has a favorable impedence for this work but if the broadcast receiver happens to have a tuned input circuit, or a "high impedence antenna coil" a '24 may be used, provided the screen is run at a fairly high voltage, as is done in the Pilot converter. Impedence matching is the excuse for the fixt-tune output stage and additional stages at this point have little to recommend them.

### *Reducing Antenna Capacity Effects*

The addition of r-f amplification before the detector of the converter can accomplish a number of things. One of them is to provide gain where gain is most needed—before any detection whatever. Another is to rub out the evil effects of the antenna capacity which is ever attempting to mis-tune the first circuit of any receiver—especially a short-wave receiver in which the tuning capacity is small and easily overwhelmed. Now we are at a puzzling fork in the road. We may wish to place perhaps two stages of tuned r-f amplification before the detector—whereupon we have a 5-tube receiver which really needs nothing at all of the broadcast receiver except a detector, an audio amplifier and a speaker. Our converter now has 4 tunable circuits, which is to say 4 tuning condensers and 4 complete sets of coils—perhaps 4 to a set. This is costly and one can hardly justify it from present market.

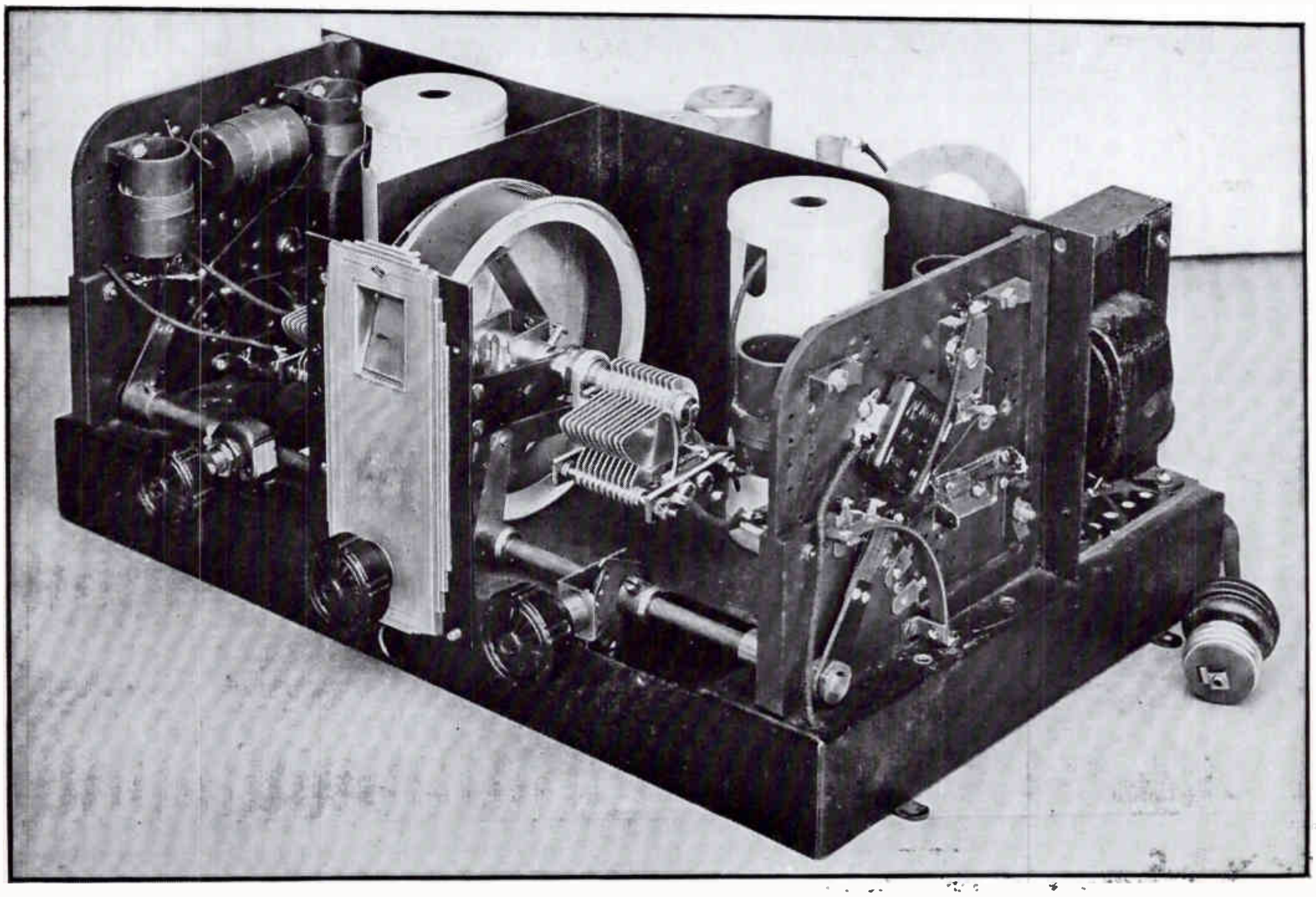
Removing one stage does not greatly damage the converter but the remaining single r-f stage is most desirable. In the National NC-5 herewith pictured and diagramed such a stage has accordingly been retained, but has been made tune-less by using a 10,000 ohm resistance and a 5-micro-microfarad condenser in series as an antenna coupling system. This obviously provides somewhat less front-end selectivity than would be obtained with a tuned input system and at the same time lowers the r-f gain at this point. However, it retains enough r-f gain to be thoroughly worth while, and it removes the antenna constants from the picture—a very essential gain. The normal tendency of resistance input systems toward collection of hums, long-wave signals and other rubbish is prevented by shunting the input resistor with a choke coil which goes through resonance just below 200 meters and thereafter presents a rapidly decreasing inductive reactance through which interferences (such as contrived to get through the small condenser) obligingly fall into ablivion. At the same time the small capacity of the series condenser minimizes shunting of signals away from the broadcast receiver when it is switched to the antenna.

### *The Tracking Problem on the Short-Wave Converter*

One now has the argument on which the NC-5 is based.

Since the device has 4 ranges as shown in the chart, and two tuned circuits as shown in the diagram, it follows that there are two tuning condensers, each with 4 coils, selected by switching. The arrangement of these things appears in the photograph. One has here the alignment problem of any superheterodyne oscillator-detector system, multiplied by 4! A study of the tuning chart will show that the "spread" is not the same for the different ranges—indeed must not be if tuning is to be convenient.

The general practice in broadcast superheterodynes has been to use inductive coupling between the oscillator and detector circuits, but this is by no means equally satisfactory in a short-wave device with much smaller tuning capacities and multiple ranges. In the current crop of converters this fact was apparently discovered too late and a brute-force cure attempted by either using close coupling or providing detector trimming condensers almost as large as the tuning condensers



**The NC-5—Detail photo showing the ingenious wave range switching arrangement actuated by the right hand knob**

*Comparison of Commercial Short-wave Superherterodyne Converters*

| NUMBER | TUBE EQUIPMENT | | | | | STATIONS HEARD ON LISTENING TESTS | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | *Voice* | | *Key* | |
| | *Input r-f Stage* | *Detector (mixer)* | *Output i.f. Stage* | *Oscillator* | *Converter Gain* | *Good* | *Total* | *Good* | *Total* |
| 1— | none | '24 | none | '27 | minus 8 | 1 | 4 | 7 | — |
| 2— | none | '24 | none | '27 | minus 2 | 4 | 6 | 12 | 22 |
| 3— | none | '24 | none | '27 | minus 3.5 | 3 | — | — | — |
| 4— | none | '24 | '24 | '27 | plus 21 | 6 | — | — | — |
| 5— | '35 | '24 | '27 | '35 | plus 30 | 8 | 13 | 35 | 154 |

**Notes:** *a*—**Tests made into Bosch model 48 T.R.F. receiver with tunable input circuit to provide best conditions for converters 1, 2 and 3.**
*b*—**Receiver gain adjusted at each point to produce 20 milliwatts average noise output.**
*c*—**Listening tests are average of results at 5 different times.**
*d*—**"Converter gain" obtained by measuring overall, then measuring broadcast receiver alone.**
*e*—**Number 5 is the converter here described.**

This uninspired combination easily results in an exasperating condition; all attempts to bring the detector into resonance cause the oscillator to shift, whereupon one loses the signal and is under the impression that an incorrect trimming adjustment has been made. Only by slow and *systematic* cut-and-try of many successive settings of the main and trimmer controls can one ever find actual detector resonance at the same time as the correct oscillator setting. If this is not done the converter gives much worse results than necessary.

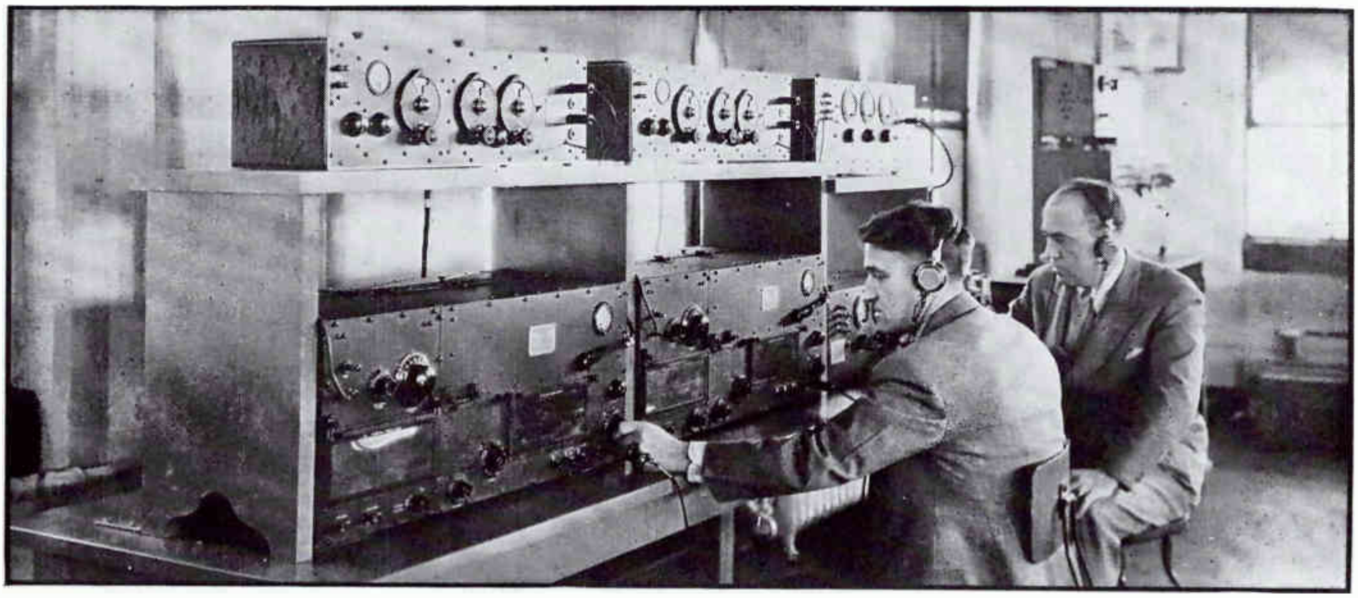
The necessity is evidently for a tuning system having little or no coupling between the tuned circuits as such. The cathode-coupling system mentioned before, and shown in the diagram, meets the requirements.

### *Padding Condensers*

Naturally there is little good in the possibility of exact resonance if the coils and condensers are not such as to attain it. Here one comes into the same need for matching tuning units as is found in broadcasting receivers, with the difference that the percentage-difference in the detector and oscillator tuning are much smaller at higher frequencies, therefore the oscillator curve can be allowed to depart a trifle from theoretical parallism while still remaining within the best part of the resonance curve of the detector tuned circuit. This especially the case as a tuning range (max. to min. wavelength) of only about 2/1 is wanted instead of the 3/1 desired in ordinary broadcasting. As a result the various oscillator ranges need be provided only with shunt "padding" condensers, instead of the combination of series and shunt padding needed in the 550-1500 kc. band. Further study of the curves will show that some of the detector curves (notably the "yellow" one) are also flattened down by the use of shunt padding. The oscillator coils do not have quite the same number of turns as the detector coils for the same ranges,, since the tuning condensers are identical.

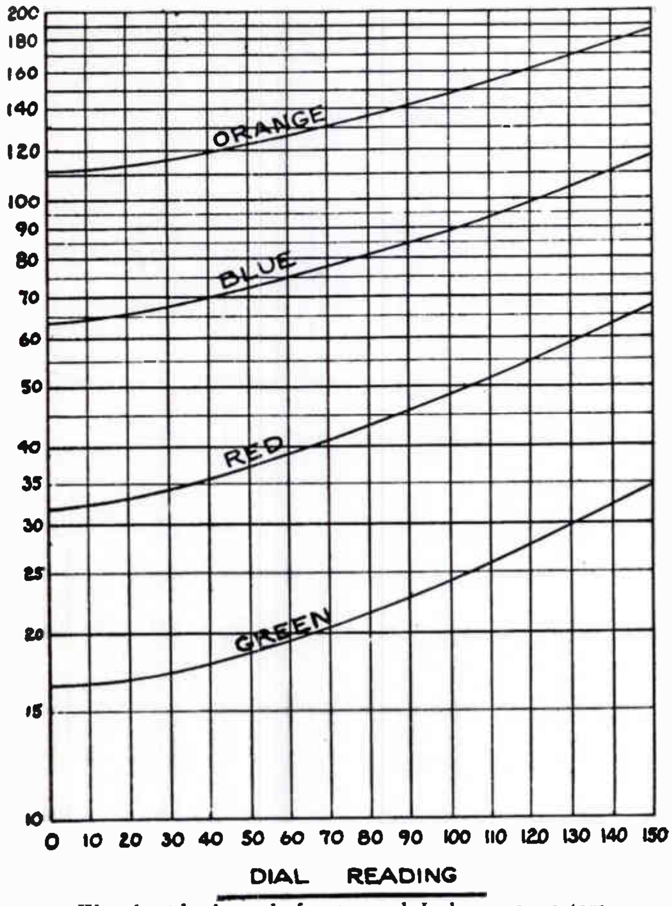
### *Mechanical Considerations*

Greater mechanical precision is needed than in the broadcast range. The coil-forms are accordingy moulded from the familiar low-loss special bakelite, R-39, after which threads are lathe-cut. R-39 is stubborn material and carballoy tools must be used. A set of coils is then assembled on a R-39 panel, wired to the range-selector switch and the padding condensers and adjusted at 3 points on the tuning scale, by comparison with a standard circuit. If a close agreement is not obtained the coils are rejected. This procedure permits the completed set to work without trimmers of any sort, which is to say true-control is provided. This seems unique amongst 1932 converters.

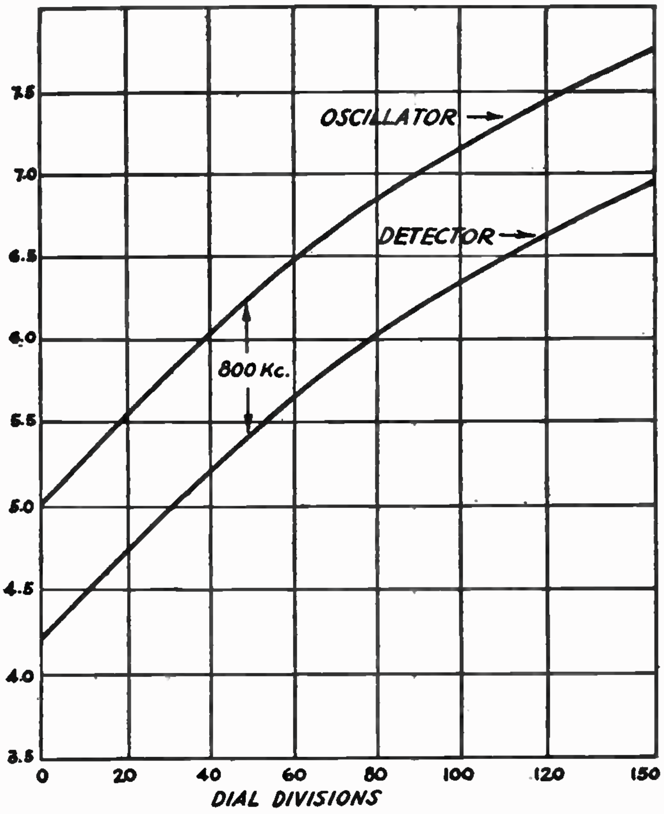


**Short wave radio station WAR, Washington, D. C. An example of S-W technique on a commercial scale**

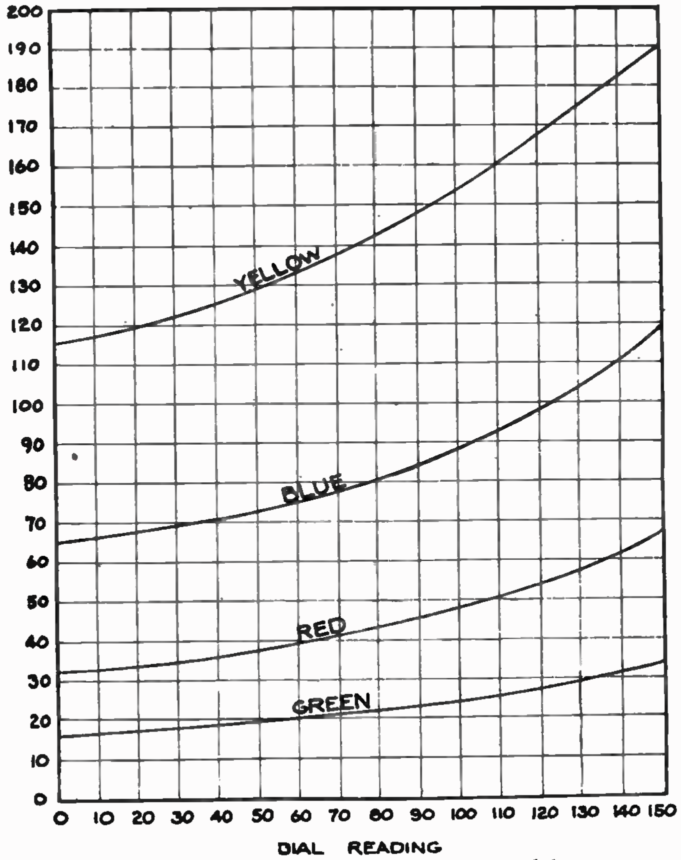
# Converter Tuning Curves




Wavelength chart, Lafayette and Jackson converters




Tuning curve and oscillator tracking for one set of coils with the Chinn converter. The calibration is in megacycles




Wavelength chart, the NC-5 Converter deluxe

## Chinn Coil Data

(Table II.)

| Coil Set No. | Detector Circuit Frequency Range, kc. | Oscillator $L_3$ Turns | Oscillator $L_3$ Turns per in. | Oscillator $L_4$ Turns | Detector $L_2$ Turns | Detector $L_2$ Turns per in. | Detector $L_1$ Turns |
|---|---|---|---|---|---|---|---|
| 1......... | 3400-5450 | 27½ | 20 | 16 | 44 | * | 16 |
| 2......... | 5000-7750 | 18 | 15 | 13 | 26 | 20 | 13 |
| 3......... | 7350-11,200 | 12½ | 10 | 10 | 15 | 15 | 10 |
| 4......... | 10,600-15,800 | 7 | 10 | 8 | 9½ | 10 | 8 |

* No. 24 d.c.c wire, not spaced.

All coils wound on Pilot ribbed coil forms, 1½ inches outside diameter.

All other coils space wound either No. 20 or No. 22 wire, with or without insulation.

All ticklers wound with No. 32 d.c.c. wire, not spaced.

# A Simple Converter FOR HOME

## Designed at WIAXV-WIXP

ANYONE who has had an opportunity to listen to a superheterodyne type short-wave converter used in conjunction with a good broadcast receiver has been immediately impressed with the excellent selectivity of the arrangement. Of course, the selectivity is determined by the characteristics of the broadcast chassis, which, in most modern receivers, provides 10- to 20-kc. band-pass action. Even a fair chassis, however, usually gives a selectivity far greater than that obtained with a short-wave receiver employing both a tuned r.f. stage of amplification and a tuned detector circuit. Another great advantage of this method of reception is that when receiving modulated signals it is possible to obtain very fine tuning by adjustment of the broadcast chassis control. This provides tuning in a high-frequency spectrum that is as easy as tuning in the broadcast band, and a comparison of the ease with which a 14-mc. phone station may be received with this arrangement, and the acrobatics that are necessary with some short-wave receivers to accomplish this, affords a striking example of one of the features of the converter. A good broadcast receiver is usually available, and by simple means it is possible to obtain the necessary filament and plate supply from its power supply unit, thereby providing a completely a.c. operated short-wave superhet receiver at the minimum expense and with the least additional equipment. This receiver is well suited equally for both c.w. and phone reception, although in the former case one of several simple methods to be described will have to be employed to produce an audible beatnote in the output of the second detector. Incidentally, the model illustrated is small enough to permit easy transportation, and it is quite a novelty to bring the converter to a friend's home and demonstrate the ease with which foreign broadcast stations, as well as amateur signals, may be received on his own set with quality that is usually as good and sometimes better than that of a relatively near-by broadcast station.

### *Single Dial Control*

The converter is strictly a single-dial receiver. "Yes," some will say, "but there are three knobs plainly visible on the model.' True, but the left-hand knob controls the strength of the beat frequency oscillator, and after being once adjusted requires no further attention. This control is made variable merely to provide a simple means of making adjustments that might be occasioned by aging tubes or low plate voltage. Normally there is no necessity to vary the strength of the beating oscillator and nothing is to be gained by making such an adjustment. The right-hand knob controls the midget condenser which is set at a particular value for each pair of coils and, once adjusted, need not be changed until the coils are changed. The value of this capacity for a given pair of coils is always the same and after the correct value for each of the four pairs of coils has been determined, it is merely necessary to make four appropriate marks on the front panel to permit quick adjustment of this knob to the desired position. Thus the tuning is accomplished entirely by means of one dial and should this be too critical, then fine adjustment is possible by slight manipulation of the tuning of the broadcast receiver.

An important feature of this converter is that the oscillator is coupled to the detector so that even though single control construction were not used, there is practically no reaction of the detector tuning on the oscillator frequency. Interlocking of the controls is one of the most irritating characteristics of almost all "converters" that have been described hitherto, and anyone who has experienced this difficulty will appreciate readily the advantages of the present arrangement.

The design of single-control superheterodyne receiver tuning circuits must be such that there is a constant differenct between the oscillator frequency and the first detector input circuit frequency. In this case this frequency difference must be of such value as to fall within the broadcast band; the coils used with this model were designed for operation with an intermediate frequency of 800 kc. To show the complications that this constant frequency difference requirement causes, Table I has been prepared. In this table there is listed the proposed frequency range of four oscillator coils covering the high-frequency spectrum from 3.5 to 15 mc., with suitable overlapping of the individual ranges. With a given oscillator tuning condenser and with the assumption that the circuit minimum capacitance is alike for all coils, the tuning range (that is the ratio of maximum to minimum frequency) will be constant. In order that the detector tuning circuit may properly track the oscillator, it is necessary that this circuit always be 800 kc. either above or below the oscillator frequency, the latter case being chosen for this receiver. Consequently, the detector tuning ranges are determined by the oscillator circuit characteristics, and it is immediately seen that the tuning range of the detector circuit is *not* constant for all coils. Obviously, if only one set of coils were to be used, it would be a simple matter to use the proper size variable condenser to obtain the desired range. But in this case four different tuning ranges must be provided; and, of the various methods of accomplishing this, one of the simplest is to provide a means of varying the minimum circuit capacitance and thus vary the tuning range of a given variable condenser. A detector circuit tuning condenser is chosen that is large enough to provide the maximum tuning range required and this is shunted by a midget variable condenser such that when adjusted to its maximum capacitance, the tuning range is reduced to the minimum required. The midget condenser is not, therefore, a trimmer condenser that must be adjusted for each setting of the main tuning control. It has four definite positions: for coil No. 1, it is set at a minimum capacitance, for No. 4 at the maximum, and for the other two coils at intermediate positions.

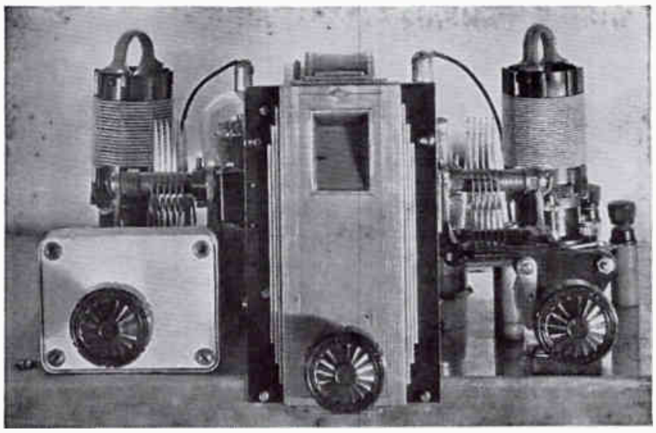
In order to show that the two circuits really do track and provide a constant frequency difference of 800-kc. calibration,

***THE manifold advantages to be derived from the use of a modern broadcast receiver as the intermediate frequency amplifier, second detector, and audio amplifier of a superheterodyne system for the reception of high-frequency signals has been appreciated for quite some time, and many "converters" have been designed for this purpose. In most cases, however, the converter introduced certain objectional operating characteristics that to a great extent counteracted the excellent features of the system. A converter that not only overcomes these difficulties but also which provides simpler tuning control has resulted from careful consideration of the problem.***

By

HOWARD ALLAN CHINN

# CONSTRUCTION



curves were made for each set of coils. The Chart on page 25 shows the curves for one set of coils. It is seen that the two circuits do maintain a constant frequency difference with an accuracy entirely adequate for these purposes.

The actual frequency ranges of the coils constructed for this receiver are given in Table II. This table gives the signal frequencies to which the detector circuit responds for operation at an intermediate frequency of 800 kc. To obtain the actual frequency of the oscillator circuit, it is necessary to add 800 kc. to the figures given.

With the present set of coils, the 3.5-, 1-, and 14-mc. amateur bands are confined to 31, 9 and 14 dial divisions, respectively, the seeming incongruity being caused by the fact that the 7-mc. band falls upon the lower part of the tuning curve where it is steep and the 14-mc. band (which is also 33% wider) falls on the upper part of the curve where its slope is not so great. Another coil could readily be designed to place the 7-mc. band on a more favorable portion of the curve, but for those who are interested another means of satisfactorily spreading all the amateur bands is available. To do this use is made of the fifth plug on the coil-form base to permit the tuning condensers to be shunted either across the entire coil or across a portion of it. By shunting the condenser across the proper amount of a suitable coil the band may be spread as much as is desirable. All the coils described herein, however, are arranged to have the tuning condenser across the entire coil, the details of connections when the other system is desired being shown in Fig. 2.

One error that is quite common in superherterodyne design is the attempt to utilize grid detection in the first detector circuit. This fallacy is probably brought about by the desire of the designer to obtain as much sensitivity in this part of the system as possible. It has been shown that grid detection under the usual conditions existing in the first detector circuit is quite impossible.

In fact when converting to an intermediate frequency in the broadcast spectrum, as is being done in this case, the detection factor has been shown to be less than a few percent of what it is for low audio frequencies. The possible reason that superheterodynes designed along these lines function at all is because of the amount of plate detection the tube is able to perform even under handicapped conditions. Plate detection with a triode in the usual first detector circuits is relatively insensitive, however, and it was not until the event of the tetrode that this disadvantage could be overcome readily. The four element tubes now available, ***when associated with the proper circuit apparatus,*** will permit plate detection that is an sensitive as usual triode grid detection.

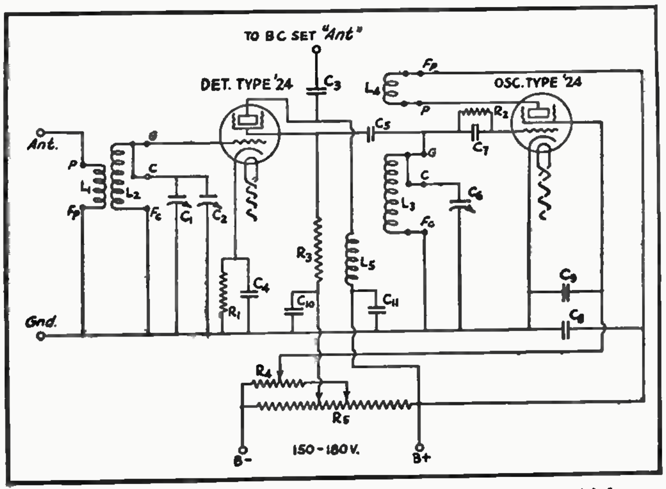


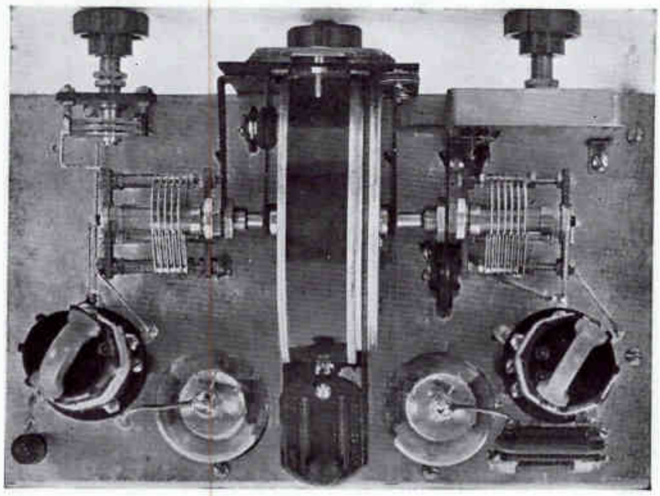

**Figure 1—The schematic diagram of the converter which can be readily constructed at home from readily available and standard parts**

In Fig. 1, it will be seen that the output of the oscillator is coupled into the detector circuit by means of the voltage drop across a resistor in series with the detector screen-grid lead. This is an adaptation of the so-called screen-grid modulation principle and, for the present purposes, gives excellent results. The use of this method of coupling eliminates almost entirely the reaction of detector tuning on the oscilator frequency. Even if individual control of the tuned circuits were utilized, instead of the single dial method shown, there is no interlocking of controls, provided the oscillator is carefully shielded.

With the circuit arrangement utilized, it is necessary to provide a strong oscillator if the maximum signal is to be realized. This is accomplished easily by choosing the oscillator grid leak and condenser of such size as to permit the generation of strong oscillations without squealing. Control of the strength of oscillation is obtained by variation of the screen-grid potential. This method recommends itself because the direct current flowing through the potentiometer, when placed in this circuit, is considerably less than if it were used in the plate circuit and, as a result, the useful life of the potentiometer is much greater.

The advantages of incorporating a "B" voltage divider right in the set, even when a tapped "B" plate supply is available, quite well known. This arrangement not only confines all the r.f. paths to the chassis but also simplifies the connection of the converter to the available power supply, only two connections being necessary. The model illustrated operates successfully with a power unit supplying both filament and plate potentials, from power obtained by tapping the broadcast receiver chassis, or from power delivered by a filament heating transformer and "B" batteries. The two tubes require 3.5 amperes at 2.5 volts for filament heating and 150 to 180 volts for plate potential, both of which usually can be obtained from the broadcast chassis. The r.f. and detector tubes in the broadcast receiver are usually the 2.5-volt heater type and an addition of two more tubes probably will not overload the filament winding of the power transformer. Two leads for filament supply should be run from the converter to the terminals on the power pack that supply the filament potential to the broadcast receiver r.f. tubes. This connection should not be made to the chassis itself inasmuch as an excessive filament voltage drop may result because of the additional current being drawn through the 2.5-volt supply cable.

A little experimentation with a voltmeter will show the location of the two terminals, providing the necessary high voltage and connection to these affords the plate potential. The total plate current drain is less than 10 ma., so there is very little danger of upsetting the operation of the broadcast set if its power supply is at all adequate. If a wiring diagram of the broadcast receiver is available it is a very simple matter to determine the best place to tap in on the power pack.



Top view. Detector to the left

The entire converter is built on 1/16-inch aluminum subpanel measuring 6½ x 11 inches, and it is designed to fit into a 7 x 7 x 12-inch cabinet. The flange bent on the front edge is 1 inch wide and to this is bolted the front panel and also the lower end of the drum dial assembly.

Subpanel tube sockets are used for the oscillator and detector tubes. The coil mountings are standard UY sockets mounted above the subpanel on fibre pillars so that the coils, when in place, are midway between the top of cabinet and the metal subpanel. These sockets arq also located a sufficient distance away from the edge of the base so that if a metal cabinet is used the coils will not be objectionably close to the walls. The midget condenser and the potentiometer are both mounted on the subpanel so that the converter can be completely wired and tested before attaching the front panel and placing it in the cabinet. The general arrangement or parts may be seen by inspection of the photographs. It should be noted that on the underside of the base, the numerous by-pass condensers are mounted by putting a screw through one end of the condenser and into the metal base, after first making certain that the terminal at the other end of the condenser does not protrude enough to also make contact to the base. Usually the ribs of the condenser are large enough to prevent this, but if the terminals are too long they may be filed or ground down. In spite of the fact that one side of each condenser is electrically connected to the subpanel, they are also wired together. Throughout the wiring of the converter, a wire ground circuit is used and no reliance is made upon circuits through the subpanel, dial, brackets, etc.

In order to save space, the small cartridge resistors are held between pieces of bus-bar wire with loops in their ends just large enough to receive the tips of the resistors, and when tests show the operation to be satisfactory a drop of solder permanently holds the resistor in place. Where wires pass through the metal subpanel, heavy insulation is advisable to prevent possible short circuits to ground. In this model small primary auto ignition cable was used for this purpose. All battery leads are confined below and all r.f. leads, which were made with bus-bar wire are above the subpanel.

TABLE I

| Oscillator | | | Detector | | |
|---|---|---|---|---|---|
| Freq. Range, Kc. | | Tuning Ratio | Freq. Range, Kc. | | Tuning Ratio |
| Minimum | Maximum | | Minimum | Maximum | |
| 3500 | 5250 | 1.5 | 2700 | 4450 | 1.65 |
| 5000 | 7500 | 1.5 | 4200 | 6700 | 1.60 |
| 7000 | 10,500 | 1.5 | 6200 | 9700 | 1.56 |
| 10,000 | 15,000 | 1.5 | 9200 | 14,200 | 1.54 |

The coils were wound on ribbed coil forms into which were cut shallow lathe notches. Good coils are very essential for good operation, and under no circumstances should they be wound on a solid spool unless the form is of special material such as the R-29 low-loss bakelite composition.

If a common ground connection is used on the converter and the broadcast chassis, it only is necessary to transfer the antenna to the converter and then connect the output post of the converter to the antenna post of the broadcast receiver. If either the filament or plate supply, or both, are being obtained from the broadcast set power pack, the ground connection to the converter had best be omitted or made through a series condenser, as in all probability either the "B" minus or the filament supply is already grounded.

To put the set into operation, it is usually advisable to first check the operation of the oscillator. The "B"-plus tap from the oscillator screen-grid potentiometer is set about one-third of the way up from the negative end of the "B" voltage divider. Then by listening in on an oscillating short-wave receiver, a monitor, or heterodyne frequency meter, determine whether the oscillator is operating strongly and smoothly over the entire range of the dial. Do not advance the oscillation control to a point where the tube squeals and emits a lot of mush and other superfluous noises. With the oscillator properly operating and with a broadcast receiver tuned to the desired intermediate frequency, its gain control on full, rotation of the converter's tuning dial should result in the reception of signals. For preliminary adjustments, it is convenient to tune to a commercial station that is located at the low-frequency end of the dial (condenser plates entirely enmeshed) and is sending the inevitable endless string of dots (incidentally, these are the result of removing the tape from the automatic transmitter). The midget condenser is now adjusted for the loudest signal. The approximate position of the rotor plates of this condenser for coil No. 1 is all the way out, for coil No. 2 one-third of the way in, for coil No. 3 two-thirds of the way in, and for coil No. 4 all the way in, or at maximum capacity. Make a note of the setting that results in the best signal, then tune to another station at the high-frequency end of the dial and repeat the adjustments. If the midget condenser setting is not the same, then the detector coil is not the correct size to properly track with the oscillator coil. If it is found that more capacity is necessary to properly tune in the second signal( the one at the high-frequency end), then the detector coil is too big. Conversely, if the midget condenser capacitance must be decreased for the higher frequency signal, then the detector coil is too small. The operation of each set of coils should be checked in this manner, not only at the end of the tuning condenser dial but at several intermediate points. If a continuous range heterodyne frequency meter is available, more thorough checking of the operation and curves, such as those shown in an accompanying figure, may be obtained.

The correct setting of the detector screen-grid voltage can best be determined by tuning in a suitable signal and then varying the position of the slider on the voltage divider. The approximate value of this potential is 20 volts and it is not very critical.

### *Use Receiver Volume Control*

It should be remembered that the oscillation control is not a volume control and an attempt should not be made to use it as such because poor success will be had. The volume control on the broadcast receiver is used in the usual manner.

There are several ways to heterodyne unmodulated signals so as to create an audible beat tone in the output of the second detector. The simplest method is to tune the intermediate frequency amplifier to a loud local broadcast station. Incoming short-wave signals, after passing through the first detector and being converted to an intermediate frequency, will beat with this broadcast station's carrier and produce an audible signal. In the event that the broadcast station's carrier is not strong enough (and this is often the case because of the extremely loud high-frequency signals that are received), a short antenna may be connected to the broadcast set's antenna binding post. If this still proves unsatisfactory, or if there is no suitable broadcast carrier near the frequency at which it is desired to operate the receiver, or if the modulation on the carrier spoils the reception of c.w. signals, then a local oscillator, tuned to the proper frequency (in this case 800 kc.)

may be constructed and placed near the broadcast set. Still another means of receiving unmodulated signals is to use a heterodyne frequency meter, or a monitor, whose fundamental frequency or a harmonic is close to the desired signal. In the case of scheduled operation with a station on a known frequency, this method is very handy, but if the entire band is being explored, it is inconvenient because it adds another control.

If a broadcast receiver with automatic volume control is available, an almost ideal combination results. Until one has had the pleasure of listening to short-wave reception under these conditions, the full benefit of modern receiver design has not been experienced.

It is very essential that the tubes are good. One way to check this is to place each tube to be used in the oscillator and, while listening on another receiver, determine whether they will oscillate. This is a rather unnecessary procedure if the tubes are known to be new and in good condition, but if they are at all doubtful it is advisable to make this test.

**(A visual check for oscillation can be made by connecting a small d.c. milliameter (0-10 ma, or so) in series with one of the "B"-supply leads. Oscillation is indicated when touching the grid terminal of the oscilator causes an abrupt increase in plate current —EDITOR.)**

The wiring of the input circuit of the broadcast receiver should be examined to ascertain whether it is suitable for coupling to the converter. Sometimes connection of the converter's output directly to the grid of the first r.f. tube gives better results than connection to the antenna binding post.

If it is found that everything works properly except that when the gain control of the broadcast set is varied the signal disappears entirely, reference should be made to the wiring to see that this adjustment does not cause some change in the broadcast receiver's input circuit. In many cases a dual volume control is used, consisting of two potentiometers, one of which varies the screen-grid voltage and the other varies the amount of signal from the antenna reaching the first tube. If the latter is removable from the circuit and the gain varied by adjustment of the screen-grid bias only, no detuning effects will result. The model described has been used with a number of popular broadcast receivers with excellent results, and it should not be difficult to obtain satisfactory operation in any particular case.

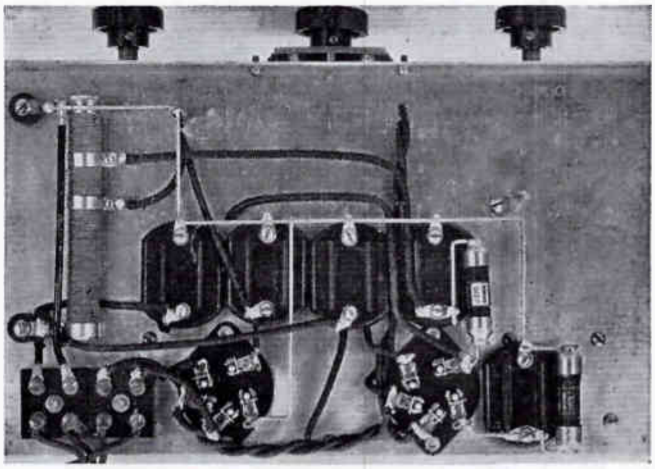
It must be remembered that the selectivity and the gain depend almost entirely upon the broadcast chassis and, unless this receiver is in good condition, proper operation cannot be expected from the system. The converter is equally well adapted to use with tuned r.f. or with superhertodyne broadcast receivers, but in the latter case, unless the oscillator in the broadcast set is well shielded, there is a possibility of many confusing and undesirable beats being generated between the two oscillators, between undesirable signals, etc.; this point cannot be too greatly stressed.

Do not adjust the midget condenser to a point very remote from the probable operating value. In the case of coil set No. 4, for instance, the condenser should be almost all the way in. If the capacity is decreased a very great amount, the detector circuit can be brought into tune with the oscillator since the latter is operating at a frequency 800 kc. higher than the frequency to which the detector should be tuned. Under these conditions, a combination of noises quite indescribable is likely to result.

Last, be certain that the principles involved in the converter are understood. Carefully read the chapters that have preceded this and follow the design as closely as possible unless you wish to experiment on your own account.

There are no data available concerning the operation of this receiver when constructed of other circuit elements, different coils and the like, so that it will be up to the individual to work out his own salvation if changes are made in the outlined construction.

Although the converter as described can usually be adapted to any broadcast chassis with little difficulty, the addition of a coupling tube would make successful operation a certainty. It was desired to make the present model as simple as possible and, consequently, this refinement consisting of an impedance matching stage was not incorporated.



**Bottom view showing neat sub-panel wiring**

The experimenter might also like to try the addition of a stage of two of tuned r.f. amplification in front of the first detector. Little difficulty should be experienced in accomplishing this, but for obvious reasons it might be advisable to change the range-determining condenser in the oscillator circuit under these conditions. Additional tuned circuits in front of the detector will reduce interference caused by the "image" frequency signal (the oscillator frequency minus the intermediate frequency, in this case). Operation of the model described has shown the interference from this cause to be quite small, however, inasmuch as the interfering signal is removed 1600 kc. from the desired signal. If this type of interference should be experienced in some particular case, it is an easy matter to shift the intermediate frequency enough to move the undesired frequency signal entirely out of the band in which operation is wanted.

By incorporating small, properly adjusted trimmer condensers in the detector coils, it would be possible to dispense with the midget band-determining condenser used in this model. The proper minimum circuit capacity to insure the desired tuning range would then be automatically placed in the circuit when the coil was plugged into place.

## *List of Parts*

*$C_1$—B50-mmfd. condenser, National SE-50*
*$C_2$—15-mmfd. midget condenser, National STE-15*
*$C_3$—500-mmfd. Sangamo mica condenser*
*$C_4$—$C_8$, $C_9$, $C_{10}$, $C_{11}$—0.01 mfd. Sangamo mica condensers*
*$C_5$—40-mfd. Sangamo mica condenser*
*$C_6$—60-mfd. condenser, National SE-60*
*$C_7$—100-mfd. Sangamo mica condenser*
*$R_1$—5000 ohms, Continental Carbon 2-watt size*
*$R_2$—100,000 ohms, Continental Carbon 2-watt size*
*$R_3$—25,000 ohms, Continental Carbon, 2-watt size*
*$R_4$—100,000-ohm potentiometer, Electrad No. 5 Super-Tonatrol*
*$R_5$—20,999 ohms, Electrad C-200 with 2 extra clips*

*Coil terminal letters indicate base connections: Fc is filament terminal nearest cathode; Fp is filament terminal nearest plate.*

*$L_1$ Antenna Coil*
*$L_2$—Dector Grid Coil*
*$L_3$—Oscillator Grid Coil*
*$L_4$—Oscillator Plate Coil*
*$L_5$—85-mh choke, Samson No. 85*
*Dial—National Type HS*

*See Table II.*

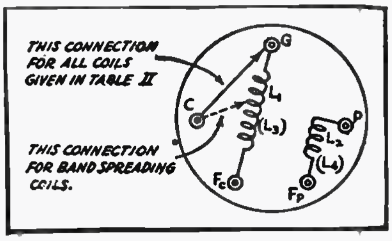



**Figure 2—Showing the coil connection to the plug-in forms. Other available plug-in forms may be used with only slight changes in winding instructions for varying diameters**

# An AMATEUR BAND Receiver

## A Set for the HAM! Combination a-c & d-c operation

*By* James Millen

THE advent of the 1931 crop of new tubes served to open up wider horizons in high-frequency receiver design than the tube and b.c. set manufacturers' advertisements would lead one to believe. The characteristics of several of the new types of tubes are such as to satisfy very nicely some of the requirements peculiar to amateur-band frequencies that were not so well taken care of by the tubes available in the past. Specifically, in the realm of a.c. type detectors, the new type '35 variable-mu provides a real solution of the regeneration control problem when using grid-leak detection; while the heater type '36 and '37 tubes wipe out the microphonic and other troubles that beset the d.c. receiver previously restricted to using the notoriously noisy '22's and '01-As. Still better, the coming of these d.c. heater type tubes, with their UY bases, has made possible the design of a single receiver that can be used optionally as an a.c. or d.c. set without making a major change in its internal connections. Where the appropriate heater type tubes are employed alternatively for either a.c. or battery operation, the same self-biasing resistors, by-pass condenser arrangement and other such circuit details, that generally vary so widely in the two types of receivers, become identical.

For complete battery operation the new 6-volt d.c. heater type tubes are far superior to any others previously available for such work. Gone are all the noises, microphonics, and other such troubles of former battery tubes. Also, the heater being designed for 6-volt operation restores to use the storage battery or "A" eliminator generally to be found in every amateur station.

In the case of the 3-tube receiver described herewith, the total current consumption at six volts is under one ampere. Unfortunately, however, at this writing a variable-mu screen grid battery tube has not as yet made its appearance, but no doubt when the advantages of the Type '35 become more generally realized, a companion battery tube will also make its appearance.

Of course there is always a demand for a d.c. receiver from those who must operate in localities where there is no a.c. available, and now with the new heater-type battery tubes it is possible to design a battery receiver of similar characteristics to the a.c. models. Thus the amateur in the rural districts, as well as those on exploration parties, expeditions, etc., may have essentially the same type of set as their brother operators located in the a.c. districts.

The peculiarities of amateur reception, both c.w. and 'phone, seem to be such as to make headsets preferable to loud speakers. For this reason there is little point in equipping the typical ham receiver with a power output stage; a single stage of a.f. amplification is ample. Such is particularly true when the detector is of the screen-grid type and preceded by an r.f. stage that actually has some gain.

As is understood by amateurs and experimenters familiar with short wave reception, the screen-grid type of tube, combined with certain design essentials, has made possible an r.f. stage that actually has real gain all the way up to 50 megacycles, and perhaps higher. The new '35 variable-mu tube, with its lower plate impedance, makes possible the further increase in gain from the r.f. stage of the a.c. set, and the similarly low plate impedance of the Type '36 screen-grid tube gives a corresponding advantage for the d.c. receiver.

While the combination of a single high-frequency stage and a regenerative screen-grid detector is not so selective as a double-detection or superheterodyne arrangement, it is equally as sensitive as any such receiver and has a very definitely better "signal to noise" ratio. This one feature alone should justify the one r.f. stage and screen-grid detector combination, in preference to a number of more elaborate circuits with their marked shortcomings in this respect.

Aside from the value of the gain obtained from the single audio stage, it serves as a very essential coupling medium between the output of the detector and the headphones, so as to insure smooth regeneration, freedom from fringe howl and backlash, as well as the elimination of undesired feedback from the 'phone cord to the input circuit of the receiver. Then again, the audio stage makes possible the calibrated attenuation control of which more will be said later.

While it would seem that the single stage of r.f. and regenerative detector type of circuit is about as simple an arrangement to build as can be imagined, such has been found far from true where just more than mediocre performance is demanded. Take, for instance, the shielding; if it is not serving its purpose, the r.f. tube will oscillate whenever the detector regeneration control is advanced. This condition exists to a surprising extent in both homemade and commercial receivers in use today. Such receivers are tolerated, it would seem, simply because the owners have never operated a properly functioning receiver employing the same circuit ***properly shielded***. There just isn't any comparison.

The mere fact that the r.f. stage is apparently stable when the detector is approaching an oscillating condition is not necessarily an indication of perfect shielding, as "interlocking" still may be present to a most obnoxious degree. There is, moreover, far more to shielding than the mere boxing off of the different parts of the circuit. Take, for example, the receiver being described. If you were starting to design such a job, wouldn't you try an arrangement as shown in Fig. 1A? At least, that is what we did, and the results were most disappointing. At first thought, this seemed an ideal arrangement because the coils, tubes and condensers of the two circuits were completely shielded from each other. It was found that with a "watertight" joint between the shield and the base there was no oscillation trouble with the r.f. amplifier, although there was an annoying amount of tuning interlocking. As soon as the chassis was put in a metal cabinet, however, and the cover closed, the r.f. stage oscillated violently!

Next tried was the arrangement shown at *B* in Fig. 1, but here the results were not even so satisfactory as the previous

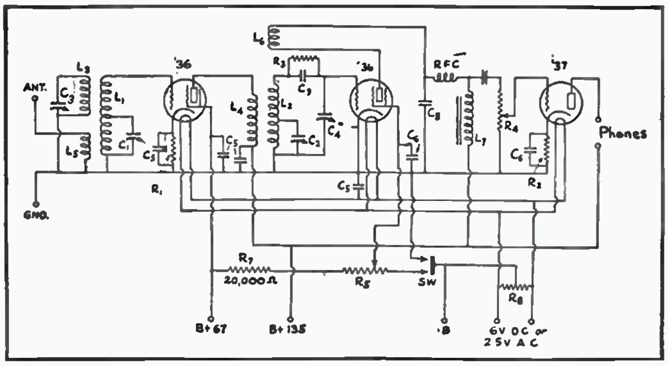



Figure 3. Combination a-c and d-c model. Specifications same as Figure 2, except that $R_7$ has a resistance of 20,000 ohms (2 watts), $R_8$ 50 or 100 ohms, and SW is a combination regeneration control and cathode switch

arrangement. Furthermore, the lack of symmetry of the shielding made it very difficult to gang the r.f. and detector tuning condensers.

The next attempt was as shown at *C* in Fig. 1. This arrangement worked fairly well in comparison with its predecessors, but here, too, there was still excessive interaction. Perhaps the compartments were so large that the shielding effect was nowhere near complete since the effect of isolation of the coil compartments decreases very rapidly as the compartment size increases. Another disadvantage of this arrangement was the requirement of tube shields. There was, however, no detrimental effect when the chassis was placed in a metal cabinet.

After the experience gained with models *A, B* and *C*, we were able to arrive at the arrangement as illustrated at *D*. Here the compartments were small enough to properly shield and yet large enough so as not to increase the coil losses appreciably. Furthermore, there was no common partition between the coil compartments as had existed in models *A* and *B;* and which, no doubt, was responsible for the "cover" effect. The small baffle between the r.f. tube base and the coil was found essential in order to shield the plate lead and prevent oscillation.

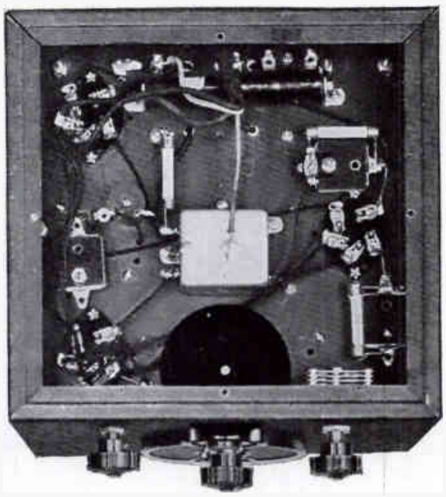
In the final model it was found advantageous to make the vertical parts of the shielding integral with the metal cabinet rather than to weld them directly to the chassis. It was found also of further advantage to insulate the vertical parts of the shielding compartments from the chassis itself with a ⅛" air gap and to weld them very thoroughly to the sides of the metal cabinet. The chassis, in turn, is grounded to the cabinet by several mounting screws on each side. Such an arrangement completed the shielding job by reducing interlocking to a negligible degree.

A further indication of the trouble to be experienced in attempting to use a common partition between the coils in a shortwave receiver is illustrated at *E* and *F* in Fig. 1. This problem was recently encountered in the design of another receiver employing the same circuit. The separate compartments completely eliminated the r.f. oscillation and interlocking difficulties.

At the present state of the radio art there is no excuse for a 2-condenser type receiver that is not truly single-dial control in the fullest sense of the term. In the present receiver, such control is obtained by the mounting of the two tuning condensers in tandem by means of a flexible insulating coupling unit.

The trimmer condenser, $C_3$ shown in the diagram and photograph is not an auxiliary tuning control to be juggled along with the main tuning dial. It is for the sole purpose of supplying the varying amounts of capacity "padding" required with the different transformers. This capacity well might be incorporated in the transformer itself it is were not for the unknown capacity-loading effect of the antenna system. Therefore, it is merely necessary to set the trimmer whenever a pair of r.f. transformers is plugged in and then not touch it until the transformers are replaced or a different antenna is connected. Many operators determine the proper adjustment of this trimmer condenser by adjusting for maximum background noise but a more accurate way is to adjust the trimmer for the point of minimum setting of the regeneration control that will produce oscillation in the detector circuit.

**This looks like effective shielding, but as explained in the text it is not recommended for a receiver of this type. Scientific shielding is necessary**



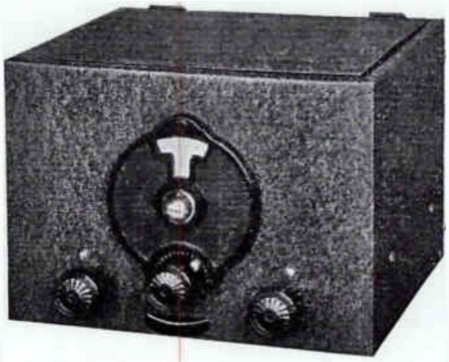
**Bottom view of the SW-3, showing the disposition of sub-panel parts. The black disk is the calibrated volume control described in the article**

The two tuning condensers are of the same maximum capacity, namely, 90 mmfd., and are of the straight-frequency-line type with 270° rotation. This latter feature gives a 50% greater spread of the tuning range for a given set of transformers; or, conversely, for a given degree of criticalness of tuning it reduces by 50% the number of coils required to cover the entire frequency range from 33 mc. to 1500 kc. While it might seem that a more compact and better mechanical arrangement would be the employment of a special single unit 2-gang condenser, such has proven not to be the case. It was found that even though the frames of the two separate condensers were grounded to the main chassis, the breaking of the common shaft by means of the insulated flexible coupling unit, in the manner illustrated, was a very important factor contributing to the complete elimination of the natural tendency of the r.f. stage to interlock and oscillate when the detector was thrown into oscillation by the regeneration control. In a specially constructed single unit, 2-gang condenser, using the same general type of design as employed in the individual condensers but having a common shaft, it was found that while shielding partitions would eliminate the greater part of this interlocking tendency, there was always a trace left that could not be completely cured.

The special mechanical features of the condensers, such as the insulated main bearings (to eliminate the shorted turn effect of the frame), the constant impedance have already been described in detail in volume one of this series of short wave radio manuals.

Following the policy of careful attention to all details of a simplified circuit, in order to secure maximum performance a special molding material was selected for the transformer forms. The use of this low-loss material permits the winding of the coil turns into grooves turned into the solid walls of the forms, thus resulting in a rigid transformer that will stand up under quite rough handling. This special molding material, known as "R-39," differs from the ordinary in that it contains absolutely no wood flour or other moisture absorbing filler, the presence of which has been discovered by the R.F.L. people to be the cause of the losses and variations in dielectric qualities of molded bakelite when placed in high frequency fields. As a result of the practical elimination of dielectric losses in the transformer field, not only is the sensitivity materially increased, particularly in the r.f. stage where no appreciable amount of regeneration exists, but also the selectivity is improved due to the very substantial reduction of the r.f resistance of the tuned circuits. In the case of the transformers that were developed for the 33- to 20-mc, range, it was found that the detector refused to oscillate when the coils were wound on forms molded of ordinary bakelite, whereas no difficulty whatsoever was encountered when the special "R-39" low-loss material was used in the same molds for making the forms for this range.

R.f. and detector stage transformers are identical except that a grid leak, grid condenser and trimmer condenser are incorporated in each detector transformer. The grid leaks are each 5 megohms, the grid condensers each 100 mmfd. and the trimmer condensers each approximately 8 mmfd. The plate winding ($L_3$ or $L_4$) is wound between the turns of the grid winding ($L_1$ or $L_2$), starting at the bottom of the coil. Additional details are given in the text.



The complete receiver—highly efficient and yet a decorative contribution to the operating desk of any station

While this new receiver is so designed that any of the standard six-prong transformers developed originally for another receiver may be used with it in order to cover the range from 33 mc. to 350 kc., since it has been designed primarily for amateur work it has a special set of band-spread transformers as standard equipment. The three pairs of band-spread transformers are for the 14-, 7- and 3.5-mc. amateur bands. In general appearance, as will be seen from the photographs, on pages 38 and 39, these coils differ from the conventional coils only in that a lead comes out of the top for clipping directly to the cap of the screen grid tube, in place of the lead built into the receiver. In order that the clips in the receiver may not dangle about and short circuit on the metal chassis or cabinet, dummy insulating terminals are furnished for fastening them out of the way.

Inside each detector coil form there is a small grid leak and grid condenser, as well as an adjustable low-capacity trimmer condenser. The schematic diagrams on pages 38-39 show how the band-spreading is accomplished. Here it will be seen that the regular variable tuning condenser, now shunts only a portion of the total inductance while the grid leak and the condenser connect directly to the top of the coil. Finally, the trimmer condenser shunts this whole arrangement and is in parallel with the tube capacity, connecting directly from the grid to the filament. Fig. 4 shows a sketch of the coil, indicating how the prongs of the coil are connected and the disposition of the screen grid leak which comes out of the top of the coil. The particular L/C ratio in this arrangement results in a circuit of a high order of sensitivity; sufficiently more so than with the conventional arrangement as to be readily detectable by listening tests.

## List of Parts

*$L_1$, $L_2$, $L_3$, $L_4$, $L_5$ and $L_6$. See table of r.f. transformer specifications.*
*$L_7$ — 750-henry plate coupling reactor. A good audio transformer with primary and secondary connected in series might be used.*
*$C_1$ and $C_2$ — 90-mmfd. ganged tuning condensers with insulating shaft coupling.*
*$C_3$ — Midget type trimmer condenser.*
*$C_4$ — 8-mmfd. detector transformer trimmer condenser (incorporated in coil form), Hammarlund No. 35.*
*$C_5$ — .01 mfd. non-inductive mica fixed condensers.*
*$C_6$ — .5 mfd. non-inductive paper fixed condensers.*
*$C_7$ — 100-mmfd. mica grid condensers, small type. Incorporated in detector r.f. transformer.*
*$C_8$ — 250-mmfd. mica by-pass condenser.*
*$R_1$ — 500-ohm cathode resistor, 2-watt type.*
*$R_2$ — 2000-ohm cathode resistor, 2-watt type.*
*$R_3$ — 5-megohm grid leak, one in each detector transformer.*
*$R_4$ — 500,000-ohm calibrated tapered type potentiometer.*
*$R_5$ — 50,000-ohm regeneration control potentiometer. See text.*
*$R_6$ — B-voltage divider, total resistance 12,000 ohms divided as follows: A, 6900 ohms; B, 2000 ohms; C, 3100 ohms.*

## R.F. Transformer Specifications

| Winding | 14,000-kc. Band | 7000-kc. Band | 35,000-kc. Band | Size Wire |
|---|---|---|---|---|
| $L_1$ and $L_2$ | 10 t. | 21 t. | 35 t. | No. 22 Enam. |
| Tap, turns from bottom | 2¼ | 5¾ | 16¾ | |
| $L_3$ and $L_4$ | 8 t. | 16 t. | 22 t. | No. 34 d.s.c |
| $L_5$ and $L_6$ | 3 t. | 4 t. | 4 t. | No. 34 d.s.c |

Full constructional details are given in the table of transformer specifications. In all three sets of transformers the grid winding has its turns spaced so that the length of winding is equal to the diameter. The primary or plate winding is then wound between the turns of the grid winding, starting from the "ground" end and working up approximately two-thirds of the way toward the grid end. The location of the tap for the tuning condenser must be accurate to the fraction of a turn indicated in order to spread the particular band over approximately 75 dial divisions. The tickler or antenna coil is wound in the slot at the bottom of the coil form and the center of this slot is located approximately ¼-inch below the end of the grid winding.

The value of approximately 8 mmfd. for the trimmer condensers given in the table is the capacity at which the condensers are set when in normal use. The particular condensers used for this purpose are the standard Hammarlund Type No. 35.

### The Variable Mu Detector

From a purely circuit point of view, one of the several outstanding features of the all-a.c. version of the receiver lies in the use of the Type '35 variable-mu tube as a regenerative detector. Perhaps the reasons that intrigued us into the investigation of the possibilities of the '35 as a high-frequency regenerative detector was the statement made on the data sheets supplied with the tubes, to the effect that their use as detectors was not recommended, plus George Grammer's story on this tube in *QST* magazine, in which he intimated that while perhaps the tube manufacturers were right with reference to the use of the '35 as a plate detector, it certainly ought to make a good grid detector. Numerous investigations and experiments during the past few months have borne out this theory.

This same characteristic of the '35 that permits of this higher order of regeneration also results in a more stable condition with regard to the holding of the regeneration adjustment when once set. There seems to be entirely lacking that tendency of regenerative detector tubes of ordinary kinds to suddenly "pop" into oscillation on the slightest provocation.

The detector output is impedance coupled to the single audio stage by means of a plate choke coil of extremely high inductance value. It was found that the use of an inductance of much higher order than possible with practicable transformer coupling resulted in much higher coupling efficiency and complete elimination of any tendency towards howling, roughness or "backlash" in the regeneration control. These difficulties were encountered to a very objectionable degree when straight resistance coupling was employed.

The grid leak of the impedance coupling arrangement is

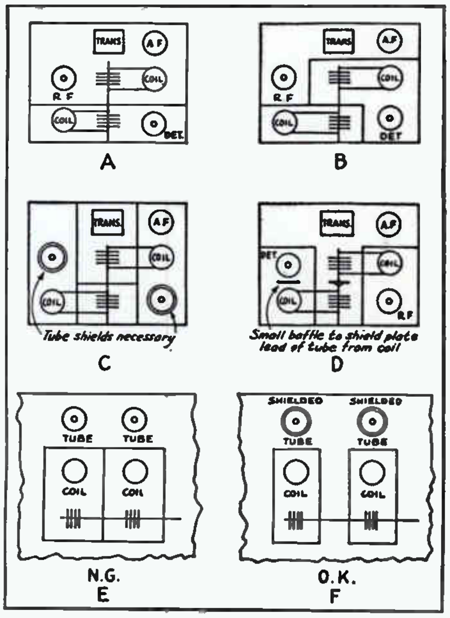



Figure 1 — A diagramatic study of different systems of shielding of varying degrees of efficiency. The system shown at D is that employed in the receiver under discussion — a detail contributing much to the success of the SW-3

the attenuation control potentiometer. Such a control was found essential due to the high sensitivity of the receiver and consequent "too loud for comfort" signals when using a head set. Such an audio coupling system results in an extremely flat characteristic over a wide frequency band, making the receiver ideally suited for phone reception.

Originally, serious consideration was given to the inclusion in the circuit of a tuned filter arrangement to follow this coupling device, so as to give a highly peaked audio characteristic for c.w. reception; but as a result of observing some investigations being conducted by Ross Hull, Jim Lamb, and George Grammer at A.R.R.L. headquarters, undoubtedly to be discussed in *QST* in the near future, the peaked audio idea was abandoned, at least for the present.

With a potentiometer in the grid circuit as the volume control, it has already been shown how it may perform the double duty of volume control and audibility meter. Fig. 4 shows how the taper of the resistor is determined so that the angle of rotation is directly proportioned to the "R" rating of signal intensity. In this case, the total resistance used is 500,000 ohms.

When the contact arm is at the high end, there is zero attenuation and the level of a signal just audible at such an adjustment would be "R1." Likewise, when the control arm is at the other extreme, only a signal of enormous intensity will "get through" and thus the rating of "R9." Physically, the attenuation control is mounted under the chassis; so, like all the other audio components, it is completely shielded from the r.f. circuits and consequently not likely to cause any back coupling which would result in fringe howl. Furthermore, the control wheel is so mounted that it may be operated simultaneously with the main tuning dial, leaving the other hand free for the regenerating control. After operating the receiver a short time, one finds that he unconsciously shifts the attenuation control up and down as he moves from station to station so as to maintain the same signal intensity to the ear, thus making available at a glance a sufficiently accurate audibility reading at all times.

For complete a.c. operation of the receiver, the type of power pack that has been previously described is recommended. This power unit employs a Type '80 tube as a rectifier, an r.f. filter and a 2-section hum filter. The power transformer, in addition, is equipped with an electro-static shield between the secondaries and the 110-volt winding, thus not only preventing any r.f. disturbances originating in the power supply from getting into the receiver, but also preventing r.f. disturbances originating in the rectifier tube from causing trouble. The elimination of this latter source of r.f. disturbance makes the operation of the receiver entirely free from the so-called "tunable" hum. As shown by the illustration and circuit diagram, the voltage divider resistor for the "B"-supply is located inside the receiver chassis, so as to eliminate any r.f.

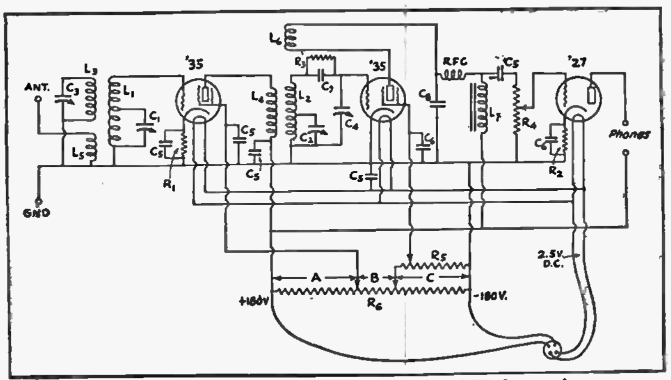



**Figure 2—The all a-c version of the SW-3 receiver**

or common coupling in the power supply leads. By having the power supply a separate unit, any a.c. hum due to coupling between the power transformer and the detector plate coupling impedance is completely eliminated, thus reducing hum in the output of the receiver to an extremely low level.

A unique feature of the battery model is its design to use either battery or a.c. type tubes. When used purely as a battery operated receiver, then the new 6-volt 5-prong heater Type '36 and '37 tubes are recommended so as to permit operation from the standard 6-volt storage battery or "A" eliminator. As will be seen from the circuit diagram, a separate "B-minus" lead is brought out in the battery model. Thus the standard a.c. tubes, also being of the 5-prong UY-base variety, may be plugged in at any time in place of the heater-type battery tubes and the receiver adapted to a.c. operation.

As mentioned previously, an arrangement finding particular favor with many experienced amateur operators at this time is the use of a.c. on only the heaters of the a.c. tubes, so as to take advantage of economical operating costs and the superior characteristics of the '35 as a regenerative detector, "B" batteries being used for plate supply in preference to the so-called "B-eliminator." The operating advantage of such a combination shows up mainly on weak c.w. signals where a higher order of detector stability is obtained, due probably to the elimination of plate supply variations caused by line voltage fluctuations. It would also seem that there is a slight increase in freedom from detuning effects of the regeneration cointrol when using batteries in place of "r.a.c." power supply. The extent of this improvement, of course, depends upon the type of power pack involved and is much more noticeable when using the conventional type "B-eliminator" than when using a special type of power unit designed strictly for high frequency receiver operation.

When using the battery model of the receiver with the combination a.c.-d.c. power supply, a common center-tap resistor should be connected across the heaters *inside the base of the chassis.* It has been found that erratic operation will result on some frequencies if this center tap resistor is placed across the heater terminals of one of the sockets, particularly the detector. If the receiver is to be used alternatively with a.c. and d.c. type tubes, provision should be made for removing this resistor from the circuit when operating with a filament battery so as not to impose a parasitic load on the batteries.

For complete battery operation, the 6-volt heater tubes were selected not only because of the conveinent 5-prong base making them interchangeable with the a.c. tubes and because of the general availability of their freedom from the microphonic howls that are causing so much grief where the 2-volt type d.c. tubes are being used. At this writing, a variable-mu tube with a low-current d.c. heater is not available so that it is necessary to use the Type '36 as the screen-grid detector, for the present at least. As soon as the value of the variable-mu tube as a regenerative high-frequency detector is more generally appreciated, however, battery operated models will no doubt become available.

Since the receiver meausres but 9¾" x 7", it should prove well suited to portable, aircraft, and other services where space is an important factor. Replacement of the Type '37 audio output tube by one of the Type '38 pentodes of the same series (in the battery model) provides a genuinely compact outfit for speaker operation. In fact, such a change in the audio system results in a rather good short wave b.c. receiver.

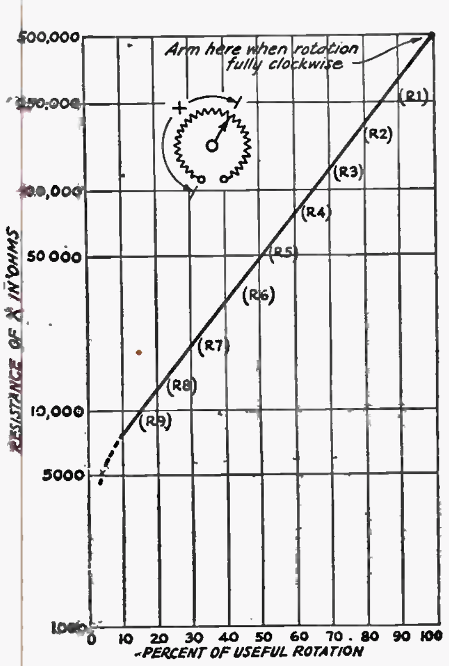



**Figure 4**

**Calibration curve of the combined volume control and audibility indicator. The control is rotated to a point where the signal is just audible, the marking on the disk, at this point, indicating audibility in accordance with the "R" system**

# Short Wave Reception

# The SW-45

## *A-C and Air-Cell*
## *13 to 600 Meters and Up!*

THE new 1931-32 models of the SW5 Thrill Box are practically the same as the previous models, which made such fine reputations for themselves during the past year. Generally speaking, the electrical and mechanical arrangement is unchanged, although some important refinements of detail have been made.

The new Thrill Boxes take full advantage of the progress of the Radio Art during the past year. New tubes, new materials, and new data have become available, and the Thrill Boxes show these new developments in their electrical design.

The following paragraphs describe the most important changes.

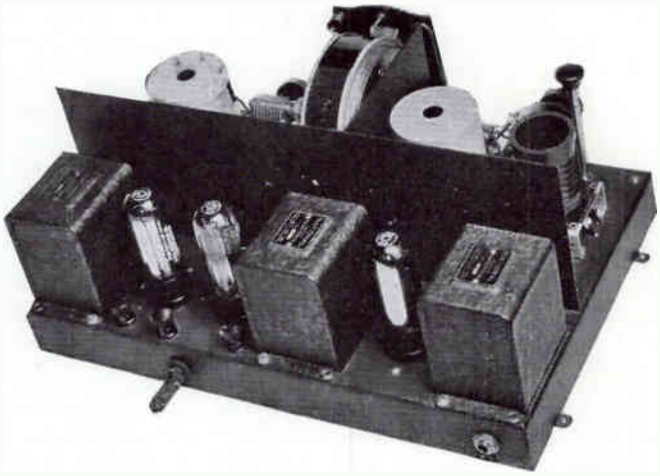
### *The Variable MU Detector*

While designed primarily for use in R.F. amplifiers in order to eliminate cross talk due to undesired rectification, we have found that the UX-235 variable Mu tube makes an ideal regenerative short-wave detector. True enough, the data sheets supplied with the tubes of this type, state that they are unsatisfactory as detectors. This reference, however, is to their use as plate rectifiers in broadcast receivers. As a grid leak-condenser regenerative detector, especially at the higher frequencies, numerous investigations made in our laboratory during recent months have shown quite the reverse to be the case.

From past experience in designing high frequency receivers employing the 224 type of screen grid tube as a grid leak-condenser regenerative detector, it has been found that of the various methods of regeneration control, the most satisfactory was the variation of screen voltage by means of a potentiometer. How would the action of the 235 tube as a grid leak-condenser regenerative detector differ from the 224 when its screen voltage was shifted? For some unknown reason, the tube manufacturers in their data sheets and their so-called engineering and specification reports, as supplied to the radio set manufacturers, seem to be surprisingly consistent in at least one respect; namely, the complete omission of any curves that might throw some light on the subject.

### *Reverse Exponential Relationship*

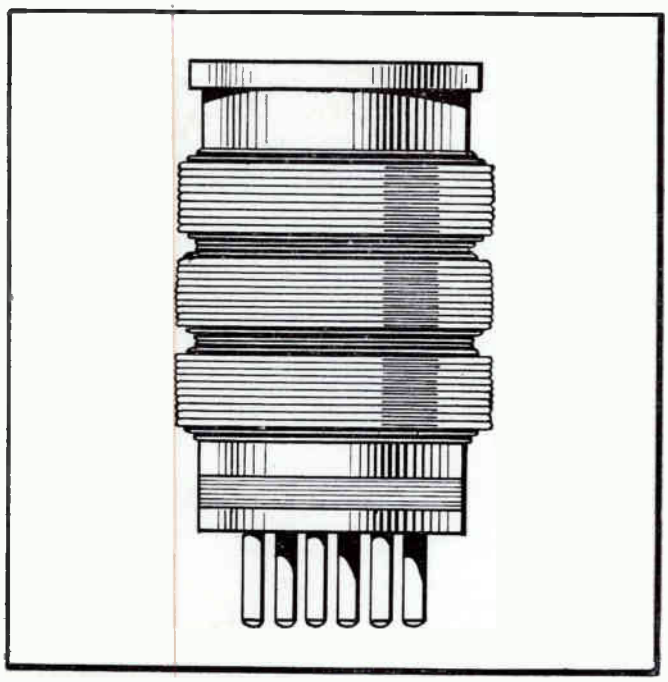
It was soon found, however, that this relation is of an inverse exponential nature. Thus when the screen voltage of the 235 is increased, the tube rapidly approaches an oscillating condition. The nearer the tube approaches the "spill over" point, however, the less effect the increasing of screen voltage has upon its tendency to oscillate. Consequently, it is a regeneration control that permits of readily obtaining and maintaining a higher degree of regeneration with the attendant smooth sliding into oscillation so much sought after in short wave receivers of the past and obtained only to a fair degree by the careful selection of tubes and the juggling of grid leak and condenser values.



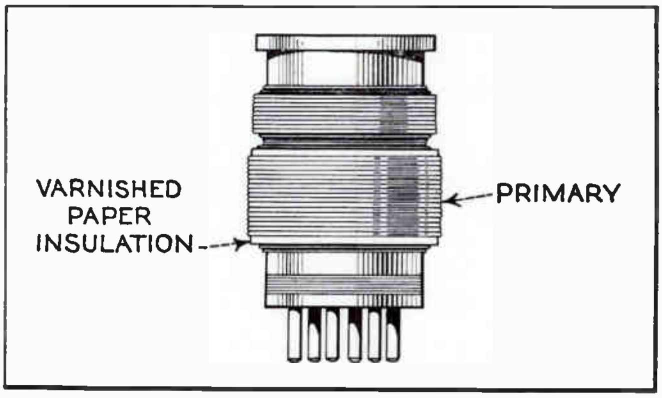
### *Stability of the 235*

This same characteristic of the 235 that permits of this higher order of regeneration, also results in a more stable condition with regard to the holding of the regeneration adjustment when once set. There seems to be entirely lacking that tendency of regenerative detector tubes of the past to suddenly "pop" into oscillation on the slightest provocation.

Of course the 235 is also used in place of the original 224 in the specific manner for which the 235 was developed, so



Details of the special three layer windings for long wave reception on the S-W-45



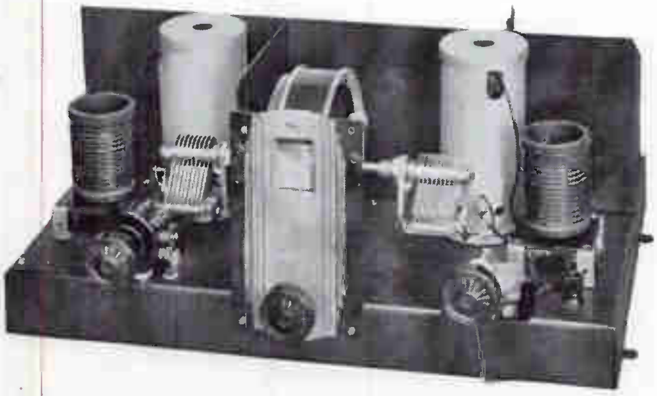
# —DeLuxe!

### by Dana Bacon

that anyone having one of the original SW-5 models and wishing to use the variable Mu in the R.F. and detector circuits will find that but one change is necessary namely, the substitution of a 500 ohm R.F. bias resistor for the 350 ohm employed in their set. No change in the detector circuit is required.

### *Steel vs. Aluminum*

Perhaps a word regarding our experiences with steel and aluminum as shielding material also might be of interest at this point. It is only too well known that on the extremely low frequencies, say for instance 60 cycles, iron is definitely better as a magnetic shielding material than aluminum. As the fre-

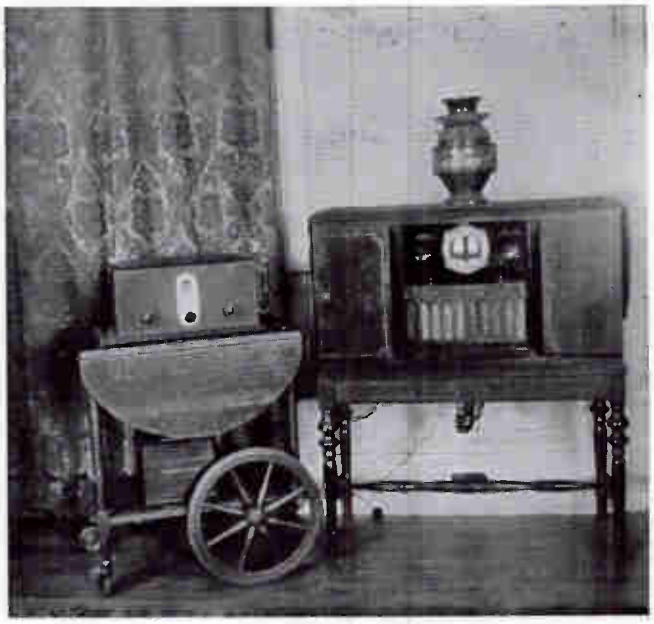


**To the left—The battery receiver using the new air cell battery. Above—Front view of the a-c chassis showing plug-in coils**

quency increases, however, this difference rapidly diminishes until at broadcast frequencies it has practically completely disappeared; and from then on up, from a purely shielding point of view, there appears little, if any, actual difference.

### *Shielding and Losses*

But there are several other aspects to be considered additional to the pure shielding effect. One of these is the introduction of losses when shielding is placed close to a coil. It is for this reason that in the design of the receiver care has been taken to keep the steel shielding partitions everywhere separated from the r.f. transformers by distances at least equal to the coil diameter. At this, or greater distances, there seems to be no noticeable difference in the resistance of the r.f. transformers whether the shielding be aluminum or steel. In the design of receivers where it is necessary to place the shield closer than the diameter of the coil at any point, then there



**The short wave receiver is taking its place in the parlor. Here we have the S-W apparatus mounted on a tea wagon. A simple plug arrangement makes it possible to utilize the broadcast receiver speaker**

is a marked advantage in using aluminum or some other non-ferrous material.

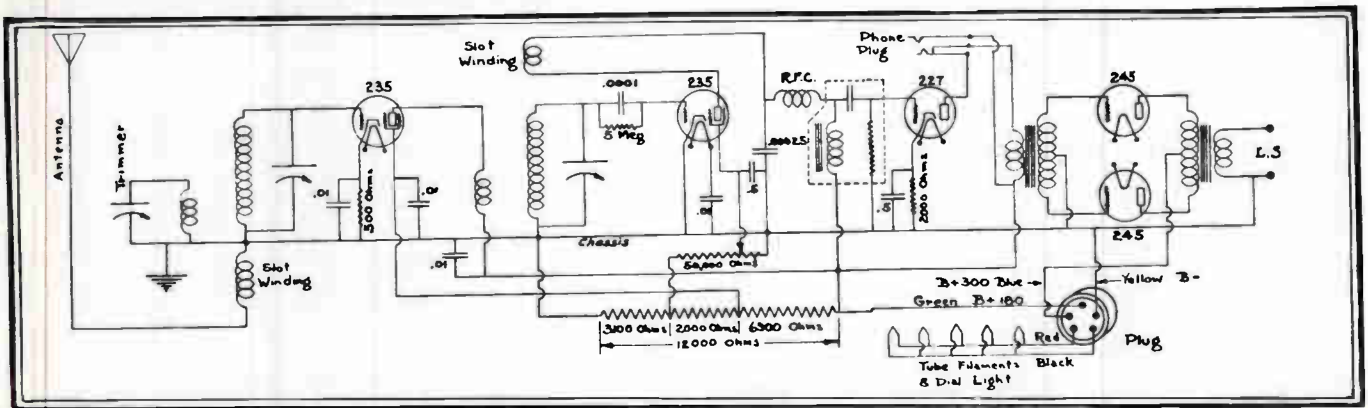
In high frequency work, our present concern, the real advantage of the use of steel over aluminum lies in its shielding of the receiver as a whole from the low frequency (60-cycle) magnetic field which generally so completely envelops the ham operating table and which, in many cases, results in a strong a.c. hum in connection with aluminum shielded battery type receivers. Then, of course, there is the matter of the so-called "water-tight" shield joints, which are so hard to obtain with aluminum and so easy to obtain commercially by welding with steel or by soldering with copper.

### *Short Wave Broadcast Reception*

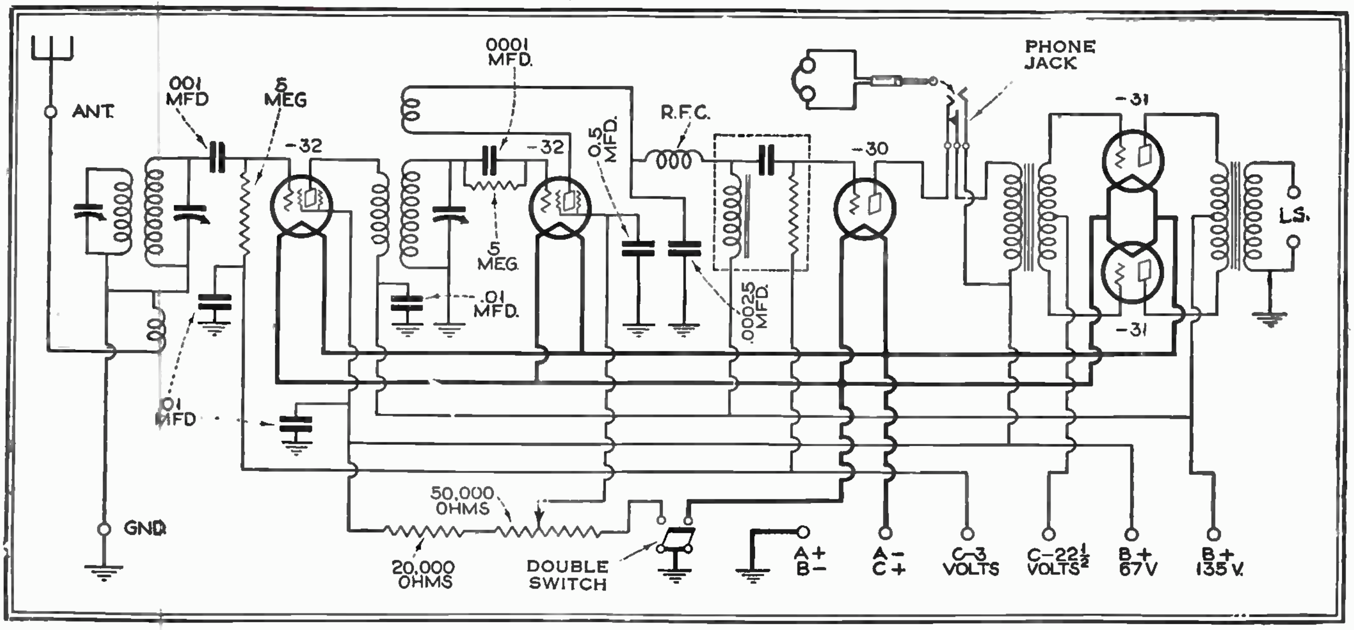
As the original receiver was designed primarily for experimental and communication work which required an extremely low hum level at the sacrifice of audio power output, the undistorted output on short wave broadcast reception was rather limited. Nevertheless these receivers found wide acceptance, especially in foreign countries, for short wave broadcast reception and consequently a special model has now been designed employing the UX-245 power output tubes in place of the 227s. While such a receiver is naturally not as well suited for communication work as the original type, it results in very fine tone quality and large volume on foreign broadcast reception.

The only physical difference in the receiver itself is that the broadcast model varies from the original in the use of 4-prong sockets in the push-pull output stage and the omission of the 1000 ohm biasing resistor.

The power pack, however, as will be seen from below




**The a-c circuit. A highly efficient short wave receiver with one stage of radio frequency amplification**




The battery circuit employing low current tubes which can be operated successfully from the air cell

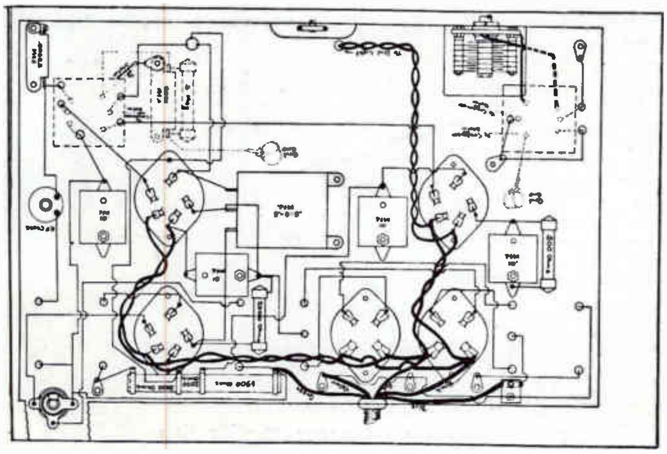
is quite a bit larger so as to supply the additional power and much higher voltage required for operating the power output tubes at full rating. As this broadcast model is primarily for use in foreign countries for receiving American short wave programs, there is considerable call for power packs designed for 25-40 cycles, as well as for 230 volts, in addition to the standard 110-115 volt, 50-60 cycle unit.

### *The R.F. Transformers*

Considerable progress has been made during the past year in the chemical research laboratories, working on synthetic insulation material for ultra high frequency work and advantage has been taken of some of the developments in this field to slightly change the formula for the NATIONAL R-39 molding material for coil forms, which played such a vital part in the success of the original receiver. This material, by the way, comprises mainly a very high grade of pure bakelite binder in connection with a pulverized mica filler, there being no wood flour or other such hydroscopic filler which would result in an appreciable percentage of included moisture in the finished coil.

It has been found that it is this "included moisture" getting into the molded material by absorption from the air by hydroscopic fillers that is the chief cause of radio frequency losses in ordinary molded bakelite coil forms. It is the elimination of this loss that has done much to contribute to the extremely low R.F. resistance of the R-39 R.F. transformers and consequent high sensitivity of the Thrill Boxes.

During the past year, a number of new transformers have also been developed, so as to extend the frequency range of the receiver from 9 meters all the way up to and including 850 meters.



Sub-base layout and picture wiring diagram

### *Long Wave Coils*

The tuning range of the receiver may be still further extended by winding additional coils in accordance with the following instructions: The coils are wound on National coil forms, as shown in the illustrations on page 34. The secondary is wound in three sections with three layers to a section.


The tickler is wound in a slot 3/16 inch wide and 1/4 inch from the bottom of the coil form. The two lower sections of the secondary are covered with a thickness of varnished paper, and a single layer primary would over it, in each case just covering the two sections.

The secondaries are wound with number 34 double-silk-covered wire, the primaries with number 36 enameled wire and the ticklers with number 36 double-silk-covered wire. The following tables indicate the number of turns for additional long wave tuning ranges:

#### *850 to 1200 Meters*

Total secondary winding 306 turns, 102 turns per section and 35 turns on the first layer of each section. The sections are spaced 1/8 inch. The tickler is wound to 25 turns.

#### *1200 to 1500 Meters*

Total secondary 396 turns, 132 turns per section and 45 turns on the first layer. Spacing 1/16 inch between sections. Tickler, 30 turns.

#### *1500 to 2000 Meters*

Total secondary 486 turns, 162 turns per section and 55 turns on the first layer. No spacing between sections. Tickler, 35 turns.

Band-spreading coils for amateur communication use have also been developed and these are described in the next chapter of the present short wave manual. Band-spread coils are not only available for the three amateur bands but for the various short-wave broadcast bands to make the reception of foreign short-wave broadcasting stations extremely easy for anyone experienced with short-wave reception.

### *The Air Cell*

All the improvements, however, have not been confined to the A.C. models. In co-operation with the Cleveland research laboratories of the National Carbon Company, the battery model has been redesigned to give extremely gratifying results in connection with that company's new Air Cell battery. This combination of Thrill Box with 2-volt low-current tubes and the National Carbon Company's Air Cell and B-battery, results in a full year's operation without power supply difficulties of any kind.

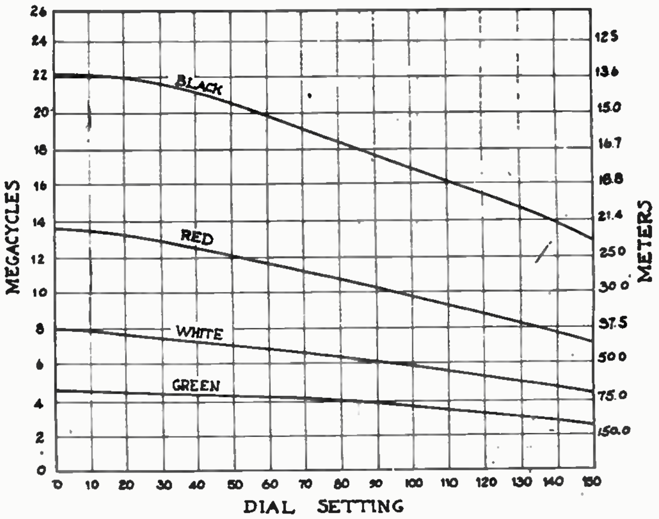
### *Utility of Plate Battery*

Although little over a year ago a.c. operation of an amateur-band receiver was generally considered rather impractical by the amateur fraternity, the readily recognized superiority of a.c. tubes over the battery type resulted in such an accelerated development of the a.c. receiver that it was not long before the problems of a.c. operation were rather well mastered and the use of a.c. operated receivers became pretty well recognized as standard practice.

In recent months, however, an increasing number of experienced operators has been switching to the use of combination a.c. and battery operated receivers. It is well known that unless an unusually high quality power pack is employed for the completely a.c. operated high-frequency receiver, it is generally found that the combination of a.c. filament heating and battery plate supply results in a steadier reception when receiving weak c.w. signals with an oscillating detector. Possibly this may be due to the isolation of the two sources of power supply, or perhaps merely to the elimination of fluctuations in the plate supply voltage caused by minor variations in the line voltage. Regardless of the exact reason, it must be admitted that battery plate supply is an improvement under some receiving conditions.

On the left—The Air Cell! This rather mysterious battery charges itself from the oxygen in the atmosphere. It will operate the S-W-45 for about one year

The power supply for the a-c model. Compact—efficient




**Tuning curves on the four short wave band coils. Special coils extend the tuning as high as 2000 meters**

### *Life of the "B" Battery*

The life of the "B" batteries will be long, with the usual few milliamperes drain demanded by a five-tube set, and the first cost of the Air Cell battery and 135-volt block of batteries will be considerably lower than that of a high grade "r.a.c." supply designed for satisfactory high-frequency receiver work. There is also another advantage to the use of "B"-battery plate supply and that is the complete elimination of that slight trace of regeneration-control "detuning effect" generally encountered to at least some degree in all completely a.c. operated ham receivers. Probably it is the superior "regulation" characteristic of "B" batteries that overcomes the trouble but, in any event, the combination a.c. filament supply "B"-battery plate supply type of operation seems to be as free from such trouble as when the receiver is entirely battery operated.

### *Dial Light Eliminated*

One of the interesting changes made in the D.C. model, in order to take full advantage of the new Air Cell, is the elimination of the dial light. *It was found that any of the standard dial light bulbs available for radio set use drew more current than the filaments of all of the tubes in the receiver put together.*

**The general appearance of the S-W-45, either in the battery or a-c operated designs. The metal cabinet is handsomely finished with a crinkled brown finish that is perfectly at home on the amateur's operating table, or alongside the family broadcast receiver. While this receiver is capable of giving excellent reception on foreign S-W broadcasting stations, and its simplicity recommends it to inexperienced operators, its high efficiency makes it a most reliable receiver for amateur and commercial code**

# *Solving* The Band-Spread

***A new and simple coil unit for short-wave receivers which allows stations in a given band to be "spread out," so to speak, over more than a mere few dial divisions. While selectivity is not increased, this new band-spread principle permits more accurate tuning and greatly improves real DX work***

ALTHOUGH it is said that comparisons are odious, in this case the comparison serves quite well to illustrate a point which, up to now, has received little or no attention in spite of its importance.

In a broadcast receiver we expect the condensers and coils attached to the dial to tune it over a range of from 550 meters to 200 meters, or, in kilocycles, from 550 kilocycles to 1500 kilocycles, a total spread over the tuning dial of less than 1000 kilocycles.

Yet, in short-wave reception, in our endeavor to satisfactorily cover from 15 meters to 150 meters, or, in kilocycles, from 20,000 kilocycles to 2000 kilocycles, we are confronted with the fact that there exists a tremendous spread of 18,000 kilocycles.

**The new band-spread coil, showing the trimmer condenser underneath which are the grid-condenser and grid-leak**

Obviously, it is out of the question to expect that a condenser dial will be able satisfactorily to cover this enormous range in one-half of its revolution and still permit easy tuning. And so we have become used in short-wave work, to employing as many as three or four sets of coils, so that this staggering total of 18,000 kilocycles may be covered by the one tuning condenser. Thus we have become used to talking about the 20-meter or the 40-meter or the 80-meter coils.

### *Critical Tuning on Short Waves*

While this arrangement solves the problem of covering all of the wave bands, each coil having a slight overlap over the next smaller size so that there will be no "holes" in the wave-band covered, there is set up one disadvantage which, although quite serious, has received little or no attention up to the present time.

This disadvantage has to do with the crowding of the dial for a particular wave-band. Let us suppose that for the 40- and 80-meter bands ample spread of the tuning response is obtained over the tuning dial. Yet when the 20-meter coils are plugged into the coil sockets the whole band might be bunched together within a few divisions of the dial. And this in spite of the fact that sound engineering principles had entered into the design of the receiver as in the case of the National SW-5 Thrill Box, where not only 270° straight frequency line tuning condensers were used but also a special vernier drum dial with large-scale diameter and high-reduction ratio.

### *The Old-Fashioned Remedy*

To overcome this evident crowding on the 20-meter band, some experimenters resorted to the expedient of removing plates from the tuning condenser, but this procedure had a detrimental effect on the tuning for other wave-bands. The pound of cure rather than the ounce of prevention.

It was in an effort to develop some ready means for wide band spread at any frequency without impairing the general purpose qualities of the SW-5 that the special band-spread coils were developed. These new coils are merely plugged in in the same manner as the standard coils and without making any changes in the receiver itself.

The result, in the case of the 20- and 40-meter amateur bands, is a 50-division spread, located right in the center of the dial.

Unfortunately it is impossible to spread the tuning out on the dial and still have the same wave range completely covered by a given number of coils. If it is desired to cover the same range but have the tuning opened up it can only be done by using a larger number of coils and lower tuning capacity or something else which will be the equivalent. However, it may be that the owner of a short-wave receiver is interested only in certain portions of the band between 20 meters and 200 meters. An amateur, for instance, may be interested only in the American amateur bands. All he wants is to cover a narrow band at 20 meters, another at 40 meters and another at 80 meters. The wavelengths in between hold little interest for him.

### *The Principle Employed*

It is in cases such as these that the new band-spread coils will be most useful. Instead of the entire winding of a coil being shunted by the tuning condenser, only a part of it is so shunted. The range of the coil is therefore accordingly reduced and the tuning is opened up proportionately. In order to shift this particular desired band to the most suitable place on the dial the trimmer condenser included in the coil is once adjusted and thereafter requires no attention unless some further movement of the band is desired at a later date. In other words, the trimmer condenser permits the operator to select the particular portion of the band to be included within the tuning range.

One consideration involved in shunting a tuning condenser across only a part of a coil is that when the condenser is adjusted for minimum capacity the coil is tuned close to its natural period. Unfortunately, the circuit resistance increases rapidly as the frequency approaches the natural period of the

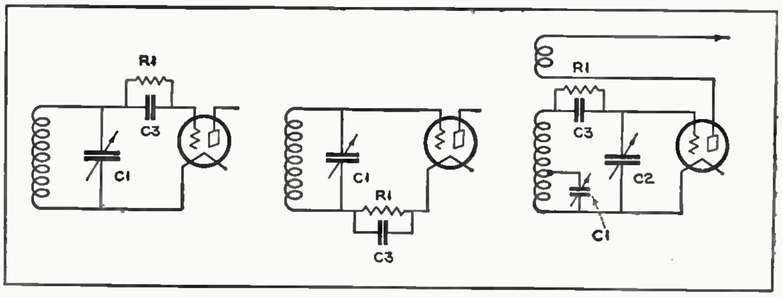


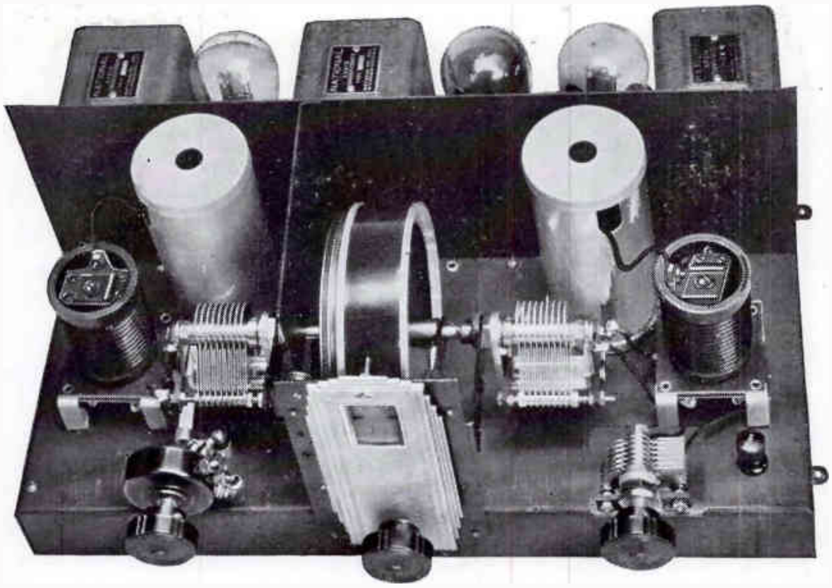

**Figure 1. (Left) The conventional detector circuit with grid-leak and condenser at the top of the coil between it and the grid of the tube. Figure 2. (Center) Here the grid-leak is located in the grid return to filament, providing same results as Figure 1. Figure 3. (Right) The band-spread circuit showing the grid-leak and condenser in a new position. C1 is a 100 mmfd. tuning condenser; C2, adjustable mica condenser in parallel with tube capacity (about 3 mmfds.); C3-R1, grid-leak and condenser located inside coil form**

# Problem

## *in Short-Wave Reception*

**By** Dana Bacon

coil. But in the case of the band-spread coils the shunt capacity furnished by the trimmer condenser plus the capacity of the tube itself keep the circuit well below the natural frequency of the coil. The variation in circuit resistance with an approach to the natural period of the circuit is illustrated in Figure 5.



**The SW-5 short-wave receiver with the new coil substituted for the old. This substitution does not involve any changes in receiver wiring**

### *Efficient Design*

In general appearance, as will be seen from the accompanying photographs, the new band-spread coil differs from the conventional s.w. coil only in that a lead comes out of the top for clipping directly to the cap of the screen-grid tube in place of the lead and clip built into the receiver. Inside the coil form, however, will be found a small grid leak and grid condenser as well as an adjustable low-capacity trimmer condenser. The coil form itself is made of R39, the low-loss short-wave coil material developed for use in this receiver by the Radio Frequency Laboratories of Boonton, New Jersey. The material in this coil form differs from regulation bakelite in that no coloring material, filler, or wood flour, the latter the ingredient that introduces the high-frequency losses, are used. Instead, the pure bakelite resin is mixed with finely ground mica.

To better understand the function of the new band-spread coil arrangement it is well to review briefly the circuits which have been universally employed.

In Figure 1 is shown the conventional tuned circuit for a detector stage. Here a coil is shunted by a variable tuning condenser, the top end of the coil connecting to the grid of the tube through a grid leak which is shunted by a grid condenser, while the lower end of the coil is brought directly to the filament. A variation of this circuit is shown in Figure 2, where the grid leak and condenser are located in the grid-to-filament return.

Figure 3 shows the new band-spread arrangement. It will be seen that C1, the regular variable tuning condenser, now shunts only a portion of the total inductance while the grid leak R1 and the condenser C3 connect directly to the top of the coil. Finally, the trimmer condenser C2 shunts this whole arrangement and is in parallel with the tube capacity, connecting directly from the grid to the filament.

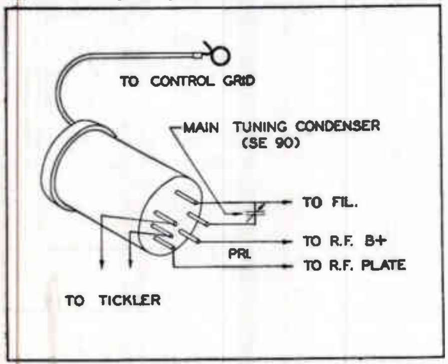



**Figure 4. Bottom of coil form, showing proper connections for use in SW-5 Thrill Box**

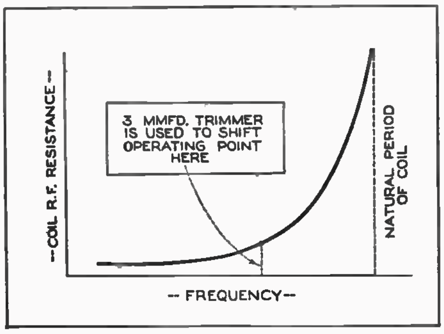



**Figure 5. An r.f. resistance curve, indicating the rise in resistance as the natural period of the coil is approached and how the operating point is shifted to a low resistance value by the use of the 3 mmfd. trimmer**

### *Prong Connections and Screen-Grid Lead*

Figure 4 shows a sketch of the coil and indicates how the prongs of the coil are connected, together with the disposition of the screen-grid lead which comes out of the top of the coil.

The particular L/C ratio arrived at in this arrangement results in a circuit of a high order of sensitivity. This, with the other advantageous features outlined here, make these new band-spread coils a happy addition to the short-wave receiver art.

Although the general theory concerning the use of this band-spread principle may be applied to practically all types of short-wave receivers, the design and construction of the coil units employing this feature is due to the efforts of the engineering staff of National Company to provide their a.c. short-wave receivers with this desirable quality.

### *Technical Details*

Full technical details concerning the design, construction and operation of this receiver appeared in the Manual of Short Wave Radio, Vol. I, and the latest design of this receiver is described elsewhere in this book, by R. S. Kruse and the present writer.

The photograph at the top of this page shows an SW-5 receiver, in which the original coils have been replaced by the new band-spread type. No alterations in the receiver itself or the wiring were required to make this substitution. With the new coils the frequency band covered by one will not overlap the bands covered by the next larger and the next smaller coils. Thus complete coverage of all short-wave bands is not obtainable with four sets of coils as with the older types. But with the new type the amateur can tune within the American amatur bands much more comfortably than heretofore. If he wants to tune in stations falling between these bands he can always use the old type coils interchangably with the new. The main advantage of the band-spread coils will therefore be offered to the amateur and to short-wave fans who are interested in listening on the amateur bands.

# *Practical* Short-Wave Super

***A discussion of the requirements involved in short-wave superheterodyne design and a description of an a.c. super, designed by the author, which he employs to pick up foreign programs for rebroadcasting purposes***

## *By* Frank H. Jones

> ***FRANK H. JONES is well known to American radio fans as the designer and operator of broadcast station 6KW (now CMHC), Tuinucu, Cuba. Of recent years this station has come to depend more and more on short-wave relays from American stations for its program material. Obviously the short-wave receivers designed by Mr. Jones for picking up these relay programs must be not only highly sensitive and selective, but also absolutely dependable, so when he writes on the subject of short-wave receiver design his articles are unusually well worth reading. It is therefore with pleasure that we present this chapter from Mr. Jones' pen.***
>
> —The Editor.

THIS paper will deal with the design of a short-wave superheterodyne receiver which will reproduce broadcast music with high quality and at the same time be selective to a high degree both as regards adjacent channel and image frequency selectivity. No modern broadcast receiver uses regeneration, as it is destructive of good quality, and so our receiver, which we will describe, will have no regeneration in any of its tuned circuits. Quality is our goal, along with elimination of avoidable interference of all ordinary types.

Certain ideas, well known to the art, we can decide at once as being necessary. Starting at the antenna connection, for instance, we know that loose coupling reduces noise level and increases selectivity. The few turns coupling the band selector to the first tuned radio-frequency stage makes for sufficiently loose coupling. To offset the losses in the band selector and the loose coupling we will use one stage of tuned radio frequency so as to hand on to our first detector a reasonable signal voltage.

On short waves it is difficult for various reasons to obtain very high potentials across the grid circuits. This prevents high amplification, but as we shall get most of our amplification in the intermediate amplifier, this aforesaid difficulty is not so important. Further, this arrangement will give us practically equal amplification throughout the entire short-wave range—a feature which is decidedly worth while.

Needless to say, the oscillator coupling is an important factor in a s.w. super. We will adopt the method of frequency change in the first detector as described by Kruse several years ago; namely, couple the oscillator to the first detector by a resistor to the control grid of the first detector and use this tube as a space charge detector. The oscillator coupling resistor also serves to put the correct positive potential on the grid. The screen grid goes to the grid leak and grid condenser.

When one is working up a superhet design it is obvious that one should not overlook the fact that the output voltage of the first detector varies as the product of the signal voltage as applied to the grid of the first detector and the voltage of the oscillator at the point where it is mixed with the signal voltage. With one stage of t.r.f. ahead of the first detector the oscillator voltage should be around six to ten volts. This voltage can be arranged to be varied manually in case you want maximum results on weakest signals.

But quiet operation demands that the oscillator voltage be not too high or too low. With a fixed voltage tap, this voltage for best quality should be adjusted by getting just the right number of turns on the tickler of the oscillator coil.

I am assuming that most of the readers of Radio News are already familiar with the general principles of superheterodynes, so I will proceed to discuss the intermediate radio-frequency amplifier.

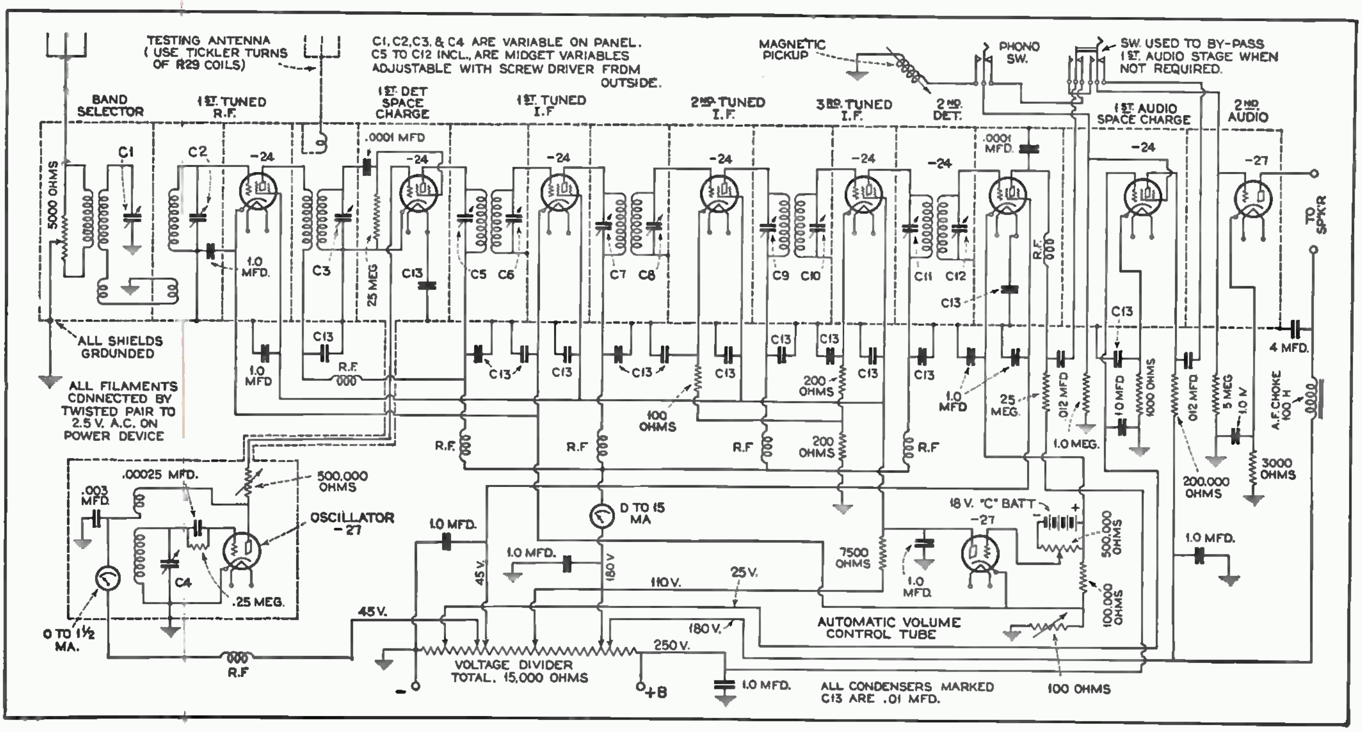



Figure 1. A complete circuit of the author's receiver, including an interesting method of automatic volume control

# Design

### *The Intermediate Amplifier*

The selection of the frequency for this amplifier calls for some careful thought. A low-frequency is very stable and capable of very high gain and feed-back is easier to avoid. It is also better for adjacent channel selectivity, which will be discussed in greater detail later on. A high intermediate frequency is better from the standpoint of image frequency discrimination.

However, a high gain is really possible at frequencies around 1700 kc. and others have recently stated that this high frequency is O.K. Curious enough, in the short-wave super I built last year, my experiments on the best frequency to adopt for the intermediate amplifier led me to adopt 1740 kc. This has the advantage, as Hatry has pointed out, of covering two wide bands with only one set of coils, with a few casual repeat points at the extreme ends of the dials. This is very close, also, to the frequency recommended by Schnell.

To illustrate this double band coverage, Figure 2 shows the oscillator dial settings for two bands with a frequency range of over 3000 kc.

### *Selectivity*

Selectivity in a super for short-wave work has to be considered from exactly the same standpoints as in a super designed for broadcast band reception and in this the intermediate amplifier is important. From certain standpoints the problem is easier and from other standpoints the problem is much more difficult. Three main problems must be given due consideration.

Adjacent channel selectivity. Image frequency or repeat points.

Intermediate frequency channel selectivity with special reference to the audio band that is to be passed.

We wish to pass an audio frequency up to 5000 cycles.

The overall selectivity must be such that the set can tune in a 500-watt station 1500 miles away without interference from another station of 40,000 watts 1500 miles away and in the same general direction and separated in frequency by 30 kc. This is no mean problem, but it can be done. The receiver described in this article does this and even better, if so desired. Selectivity of an extra order may be obtained with the use of special antennas, as described later in this text.

"Arithmetical" selectivity gain. Just what is this animal? McMurdo Silver (Radio News, October, 1930, page 331) says to consider a 1000 kc. and a 1010 kc. wave. In the tuned radio-frequency set they are practically impossible to separate. The percentage difference is 1 per cent. Changing these two frequencies to 175 and 165 kc. makes the percentage difference about equal to 6 per cent., or, as he says, "six times simpler." The above has reference to adjacent channel selectivity.

The higher the intermediate amplifier frequency, the less trouble from image frequency interference. Now a whole lot of image frequency can be eliminated or largely overcome by pre-selection before the first detector. Pre-selection also overcomes interference when two stations are separated in frequency exactly by the intermediate amplifier frequency.

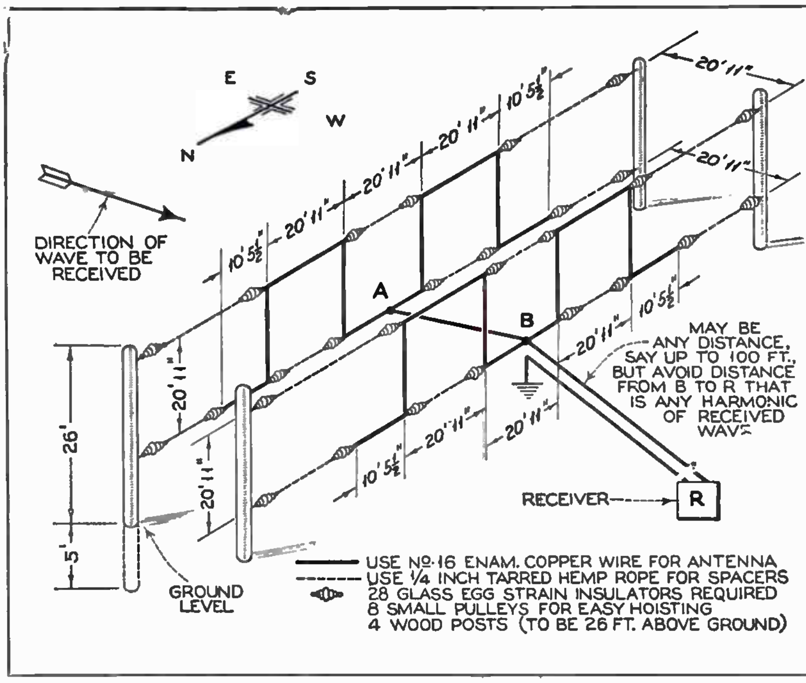
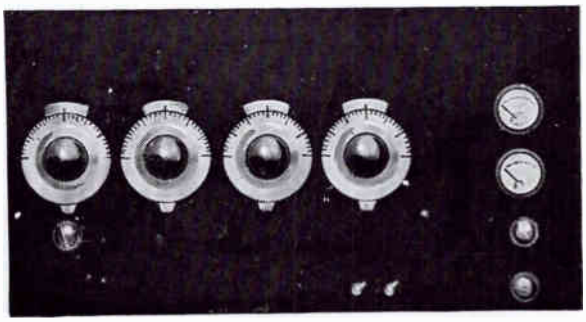



**Figure 4. Example of an antenna array for receiving directionally from the east on a wavelength of 25.53 meters**

In short-wave reception the frequencies we are dealing with are so extremely high that, for instance, when we wish to receive a 15,000 kc. wave free from interference from a 15,010 kc. wave, the percentage separation is only 6/100 of one per cent. The separation at 1500 kc. is 6/10 per cent. and the separation at 600 kc. is about 1 6/10 per cent. If we use a 1000 kc. intermediate frequency the per cent. frequency separation is about 15 times better than on the short waves direct and if we use a 1740 kc. intermediate frequency the gain is about 8 times greater. This is O.K., because by using the higher intermediate frequency we can cover two bands of waves with only one set of coils. So 1740 kc. has been selected as the intermediate amplifier frequency, bearing in mind that we are going to get a lot of selectivity in the three-stage intermediate amplifier.

In the receiver herewith described better quality with selectivity was obtained by using three stages of double tuned intermediate-frequency amplification a little more broadly tuned than would have been the case were only two stages used, giving as much selectivity. This receiver actually has twelve tuned circuits.



**The front view of the Jones a.c. short-wave superheterodyne, the design features of which are discussed in the present and following chapters**

### *Selectivity and Short Waves*

Let us digress for a moment to consider "selectivity" as it applies to short-wave reception. Inasmuch as short-wave signals usually arrive at a receiver with good signal strength (assuming sufficiently powerful transmitters and proper distance from receiver), the problem of selectivity is nearly the same as receiving local broadcast band signals, in the sense that you should not have to cut side-bands to get distance. Nevertheless, the selectivity, from the standpoint of the "arithmetical gain in supers" is inherently much more difficult, ten to twenty times more so than in the broadcast band. When any radio fan is bragging about the selectivity of his short-wave receiver, he must consider the following:

(a) Is he picking up a powerful transmitter at "best" reception distance, as against, say, a 30 kc. off-wave signal of a weak transmitter or a powerful transmitter at "wrong" receiving distance?

That's no selectivity at all!

*Example 1*—With a straight regenerative detector circuit using no radio frequency, either tuned or untuned, at a point "X" 1200 miles south of W8XK on 11880 kc. and 4000 miles west of G5SW on 11750 kc., it's not a case of selectivity that lets you listen to W8XK and not hear a peep from G5SW. At point "X" at about 5 p.m. E.S.T. the distance is just right for a wallop of a signal from W8XK. This also happens to be the "best" time for G5SW to point "X," so if your receiver will tune in G5SW under these conditions so you can't hear W8XK you may think you have a fairly selective receiver, but it's not so much for this frequency separation, as you can see, is 130 kc.

If you could not do better than this with a broadcast receiver you'd throw it in the junk pile.

(b) *Example 2*—A receiver is located at point "X," which is 1500 miles south of W2XAF and slightly southwest of W1XAZ on respectively 9530 kc. and 9570 kc. W2XAF uses 30 kilowatts and W1XAZ 500 watts (October, 1930). *Now note this:* Each of these stations is located about 1500 miles from point "X." At 5 p. m. they are both just right (also after 9 p.m.) to lay down good signals so that ½ kw. signal is not to be sneezed at, and 30 kw. at the other doesn't mean that the other is 30 times as strong, not by a long sight. Nevertheless, at this period it takes really good selectivity to listen to W1XAZ without a peep from W2XAF at receiving point "X."

Not to make a mystery out of receiving point "X" I'll just say that it is Tuinucu, Cuba, located almost exactly 80° west longitude and midway between the north and south coasts of Cuba.

However, a receiver with low selectivity can, normally, listen at this point to W2XAF with little bother from W1XAZ. And don't forget these frequency separations are 3 to 4 times greater than on the broadcast channels.

*Example 3*—But now, how are you going to receive PCJ (9590 kc.), 4500 miles easterly from "X," even if PCJ does use 30 kw. when its best time is about 6 p.m., under the barrage of W2XAF and W1XAZ? You only need 20 kc. selectivity to do it. More about this later, under directional antennas and direction receiving. A very powerful transmitter at the right time of day may give your receiver two or three wallops separated 1/7 and 2/7 seconds apart due to "round the world" signals, unless your receiver has directional pick-up suitable to the particular station you want to receive.

Radio Roma Napoli have a slightly lower frequency than W8XK on 11880 kc., and they are 4500 miles east of Tuinucu. They come through here best from 4:30 to 6 p.m. I believe they are using 10 kw. To receive them free from interference from W8XK, your selectivity must be such that when listening to "Radio Roma Napoli" your receiver for W8XK must be "down" at least 50 dbs.

*Example 4*—W2XE on 6120 kc. is at New York and W2XAL on 6100 kc. is near New York. Both are 1275 miles practically north of Tuinucu. W2XAL uses 11,000 watts and W2XE 500 watts (in October, 1930). Frequency separation is 20 kc. At Tuinucu the "best" times for either of these stations will be the same, so the problem is about the same as tuning in a distant station from a receiver in New York City on a frequency only 20 kc. away, say from WEAF.

These examples are enough to show that listening to "certain" stations with no interference from "certain" other short-wave stations at "certain" times and distances, may show only that one has a very poor receiver. (Note that this discussion of selectivity only refers to music and speech reception and not cw. telegraphy). Thirty kc. selectivity is fair to good, but 130 kc. selectivity is very, very poor. If you do manage to get 20 or 30 kc. selectivity by using regeneration almost to the point of oscillation, you may not be getting much over 25000 kc. in your audio band, which from the standpoint of quality would be strictly rotten.

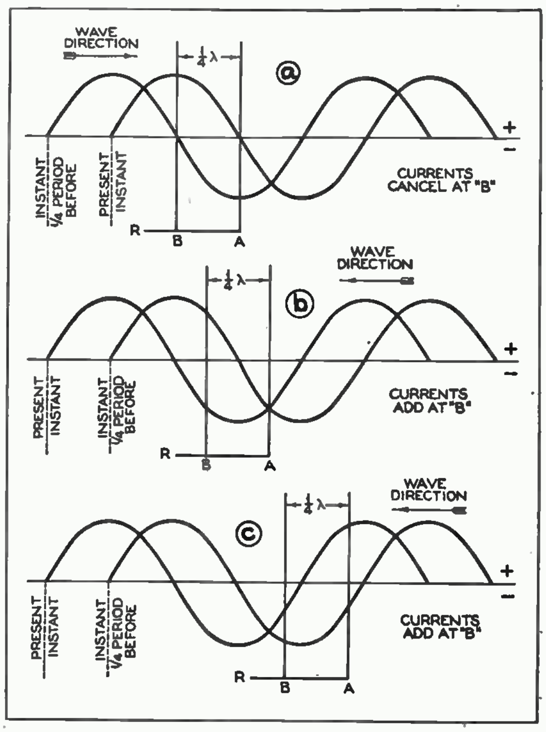



**Figure 5. Illustrating the signal voltage relationship which makes the "array" type of antenna strongly directional**

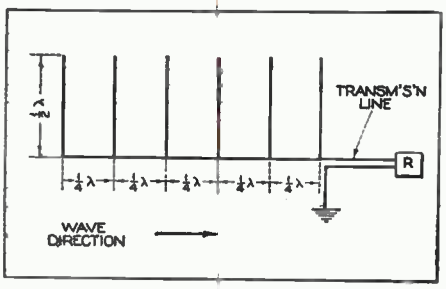
## *The Need for an R.F. Stage*

A writer in Radio News recently said "if he is to minimize complication, he is forced to omit r.f. amplification at signal frequency" ahead of the first detector, referring to short-wave superheterodynes (Radio News, November, 1930).

This might have been true before last year, but now the short waves are all becoming pretty well occupied and just about as crowded as the U. S. broadcast band, and will be more crowded from day to day and year to year. So we shall be forced to obtain a high degree of selectivity at signal frequencies just as we have been forced to do in the design of long-wave receivers of the superheterodyne type. As McMurdo Silver says in Radio News for December, 1930, "the real progress in design has been in the selection ahead of the detector" (referring to super design).

## *S-W Effects*

Tuning in a distant short-wave station signal at "not just the right time of day" alongside of a powerful signal which is at "just the right time of



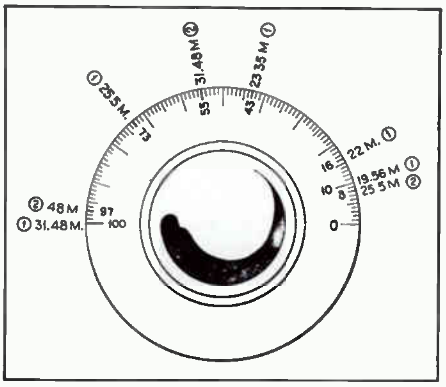




**Figure 6 (at left). This type of antenna is strongly directional with wave direction as shown. Verticals can be strung on individual poles and joined by running a wire near the ground. Three or four more verticals give greater directionality and better signal to static or noise ratio. Transmission line may be insulated twisted pair**

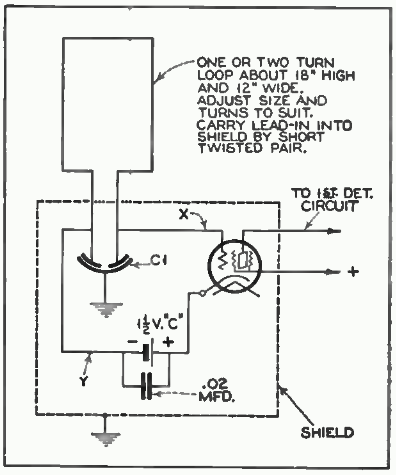



**Figure 2 (left, center). A few approximate settings of the oscillator dial to illustrate double coverage with one set of coils, using 1740 kc. intermediate frequency. Dial settings mark (1) are for the lower curve range; (2) the upper. Figure 3. Above. Arrangement for using a loop antenna with short-wave reception. C1 is a Cardwell "wedge" plate condenser having 11 plates. The center stator plate is cut out, leaving two 5-plate halves with a common rotor. Make leads "X" and "Y" equal in length**

day" is equivalent to the problem on long waves of tuning in a weak station next to a "powerful local." The selectivity must be such as to hold the powerful local down about 50 dbs. This can be accomplished in short-wave supers by having enough selectivity and amplification ahead of the first detector, and as the noise level is much lower down on short waves, this difficulty is less on short waves than on long waves.

To have a quiet, hissless superheterodyne, it is important to have a high signal level on the first detector. In the receiver shown here the band selector cuts down the signal somewhat, but the stage of tuned radio frequency boosts it up to good value again to pass it on to the first detector and the loose coupling in the band selector and antenna further highly attenuates any off-band frequencies.

A reference to the circuit diagram, Figure 1 shows that the automatic volume control is one that might be called duplex.

I am not now referring to the sensitivity control which is the potentiometer in the antenna circuit. The automatic volume control tube is a —27 and is so biased that the control grids of the first two radio frequency tubes increase their negative bias as signal strength increases, reducing volume. An inspection of the v.c. tube circuit will show that as the plate of the v.c. tube draws current it lowers the voltage on the above mentioned screen grids. Inasmuch as the 200 ohm resistor in the cathode leg of the v.c. tube is in the plate circuit of this v.c. tube, whenever the v.c. tube draws current, there is a voltage drop in this 200 ohm resistor. This resistor being in the control grid circuit of the above-mentioned r.f. tubes, it follows that their grid biases are increased and thus the output of the receiver is kept quite constant.

This is an instantaneous control device so no time compensation has to be introduced as in some systems that use the audio component as the control factor. In the method described it is the rectified component of the r.f. current that is made use of through the 100,000 ohm resistor in the cathode circuit of the second detector that operates to change the bias on the v.c. tube.

Incidentally, in any circuit using automatic volume control, it is essential to use not more than one audio stage if even volume level is desired.

My transmitter, which for many years was known all over the western hemisphere as "6KW, Cuba," is now fitted with new call letters since last year. The call is CMHC. My many relays of distant foreign programs, even those from London, are considered phenomenal by the people here in Cuba, as they never get such fine or interesting programs from any local station in Cuba.

Now let's spend a few moments on the subject of receiving antennas especially for short waves.

With a good short-wave receiver, any old piece of wire from ten to fifty feet long strung up almost any old way will give pretty good results, almost anywhere, but why in the name of goodness isn't it made right for the service intended, when the antenna system is actually the "door-way" for all the signals that expect to get into your receiver?

Besides the selectivity that we work hard to get in our receivers, don't overlook the fact that some of the easiest selectivity obtainable can be gotten in the antenna alone.

The receiver herewith described has greatly increased selectivity when used with a loop properly constructed. One or two turns about 12 inches wide and 18 inches high with a balanced center to ground to avoid "antenna" effects, will give a certain type of selectivity.

As an example. There is a powerful code transmitter in Mexico City which is due west of Tuinucu. Its wave length is slightly longer than W2XAF on 31.48 meters. Except with a receiver of very high inherent selectivity this code signal will modulate the W2XAF signal in the first r.f. tube. This balance loop is dead to Mexico City with the edge of loop north and south in line with Schenectady, New York.

This same scheme will receive Rome in spite of strong interference from W8XK when the loop is edgewise in line with Rome and Tuinucu. But as loops are bi-directional they won't help against any distortion that might be caused by "round the world" repeat signals. A loop antenna such as described is shown in Figure 3.

A Beverage antenna is very directional but needs a lot of space and has to be constructed for a particular band of frequencies and generally speaking is not practical for the usual back yard. However, those living in the country should experiment with it.

The Bell Telephone transatlantic radio system uses uni-directional receiving types of antenna "arrays' 'that are well worth a little study as these systems may be adaptable to the amateur on a smaller scale. These arrays consist of what amounts to a long wire doubled up and down on itself and hung between a long line of latticed supports. A long array, generally speaking, makes the system still more directional. This type of antenna receives broadside in distinction to the loop and is also bi-directional, but by placing two similar arrays one a quarter wave length behind the other, the combined system then becomes strongly uni-directional. It was only with the advent of the discovery of the great usefulness of short waves that such types of antenna became feasible. Even so, such an array as used by the Bell system may reach dimensions of the order of several hundred feet in length.

Such dimensions are of course impractical for the amateur, but I believe the same system using only a few sections would be worth while to any one who has a reasonably big back yard. Of course these special antennas are not flexible as regards usefulness for any wave except that for which they are constructed.

By referring to Figure 4 you will see a diagrammatic sketch of such an array on a small scale. This shows an arrangement set up anywhere in the United States for uni-directional reception from Europe of a wave length of 25.53 meters. This may by G5SW in England. The sketch shows the minimum number of bays or sections that could be useful and would require a free open space at least 25 feet by 100 feet in area. More sections in a longer array would be preferable. Arrays for different wave lengths can be calculated on the same method.

The theory on which this system works, as described in Bell Telephone pubications, is roughly as follows:

When a wave reaches the front, or A broadside of such an array the voltages which are produced in the vertical wires are in phase and the currents are additive. Voltages developing at central points in any of the vertical wires are also reflected back from the open ends of the antenna array with their phases reversed so that they reinforce just at the right instant, the point on the oncoming wave at the point where the receiver connection is taken off. The quarter wave length connection between the front and back array causes waves to cancel that come from the B side.

When a wave strikes the antenna from either end on, conditions are very much changed. The current produced at any instant by the advancing wave will be out of phase with the reflected waves and will cancel.

To bring out a little clearer this action, refer now especially to Figure 5 in connection with Figure 4. At (a) Figure 5 are shown two positions of a wave with respect to such an antenna. The arrow shows the direction of the wave. One curve shows the position of the wave where it coincides with sections B and A at the present instant.

Remembering that array A is connected to array B through a quarter wave wire, note the instantaneous voltages on the two antennas. The point on antenna A had a potential exactly equal and opposite at an instant just one-fourth period before the present instant, therefore its effect arrives at point B just in time to cancel the voltage there at the present instant.

By studying sketches (b) and (c) it will be seen that waves arriving from the opposite direction or broadside to antenna A will be additive at point B and so reinforce each other at the receiver.

A good explanation of the theory of this class of antenna arrays will be found in the Bell Laboratories Record describing their short-wave transatlantic radio telephone.

Figure 6 shows another form of array which is very directional to waves for which it is designed and will well repay a little time in construction and experimentation.

# Practical

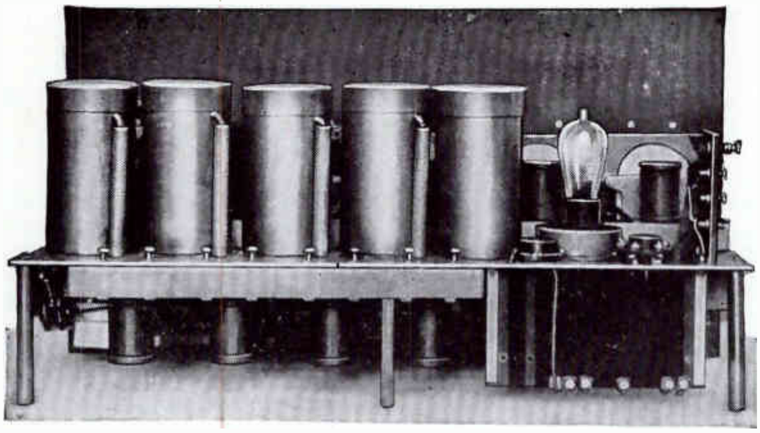


**Figure 9. The rear view with the shields removed from the r.f. coils, at the right, and the i.f. coils under the base, at left**

NOW let's go back to the receiver and touch on a few points in its design.

As may be noted, it has an extremely complete job of shielding. This has been thoroughly justified, as operation of the set, even when it is connected to a 15-watt power amplifier, shows an uncanny quietness. There is absolutely no sound in the absence of a wave. When the dials come to a point where a wave enters, it pops in, as one might say, out of a clear sky with full and beautiful modulation and no side-band cutting.

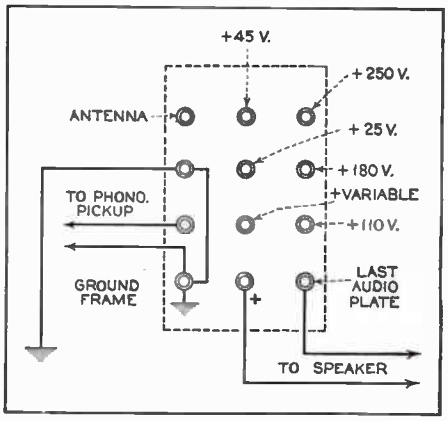



**Figure 12. The terminal board, which is located at the rear left-hand corner of the chassis and provides for all connections to amplier and power-pack**

All coils used are the highly efficient National coils wound on forms of the new R39 composition. Four of the "Blue" type coils (115 to 200 meters) are used in the intermediate amplifier. Eight Pilot midget variable mica-dielectric condensers are used to tune the plate and grid circuits of these four coils. By referring to Figure 7, which shows a bottom view of the finished receiver with the entire bottom shields removed, these midget condensers are just distinguishable below the brass floor of the receiver and over these intermediate coils. In this particular model of midget condenser the tops were removed and they were mounted directly under the floor. In this floor and directly over the centers of these condensers were drilled holes which were threaded for three-sixteenths, ½-inch round-head brass machine screws. The heads of these screws may be seen in Figures 9, 10 and 11. The grid condensers have one of their terminals mounted by a machine screw direct to the brass floor, as an inspection of the circuit will show that one terminal is grounded. The plate coil condensers are mounted ungrounded. In these condensers there is a small circular disc of bakelite about 1/16 inch thick. It is against these discs that the brass adjusting screws bear, so that by screwing the machine screws up or down one may adjust these condensers and bring all these circuits into resonance from the outside when all the shields are in place. These shields are about three and one-half inches square and four and one-quarter inches in depth. A heavy iron "U" clamp holds all four shields firmly in position so that any handling of the set later cannot throw out of tuned adjustment the intermediate amplifier.

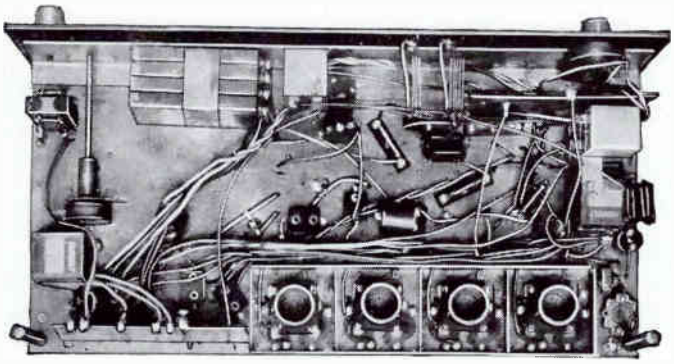


**Figure 7. The underneath view of the chassis with the shield removed, showing the i.f. stage coils at the lower right**

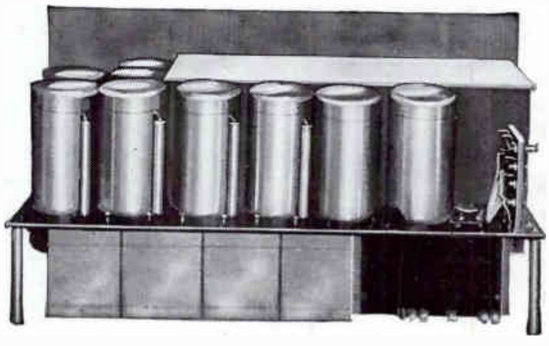


**Figure 11. Rear view with all shields in place. This gives an excellent idea of the completeness of the shielding employed**

In case one might wish later on to try some quite different intermediate frequency, other coils may be inserted in place of the present ones which are tuned now to 1740 kc.

The floor of the chassis is a piece of ⅛-inch sheet brass 25 inches long and 12 inches wide.

All of the tube shields with the exception of the oscillator tube are cylinders with top caps 3¼ inches in diameter and 6" in height.

The tuned radio-frequency stages and the oscillator unit are in rectangular shields about 4½ inches wide each, and 7 inches long from front to back, and 6 inches high.

At the right, looking from front, and back of the two meters, is a small shield completely enclosing four miniature Eveready No. 751 dry cells, which are used for the control grid bias of the volume control tube.

### *Parts Specifications*

All the shields are made of 1/32-inch sheet brass.

All of the coils mount in the special six-prong National sockets.

The variable condensers are the Cardwell taper or wedge-shaped plate type. The five-plate model works out the best.

The bottom milliammeter, a Weston 2¼-inch type, has a scale of 0 to 1.5 milliamperes and is in the plate circuit of the oscillator tube. I have found that in this set the best value here is one milliampere.

The top milliammeter, of the same type, has a scale of 0 to 15 milliamperes.

The voltage dividers are type 446, made by General Radio Co. They are wound in two sections, one of 15,000 ohms and a 1500-ohm section. One of these, at the left rear, is the voltage divider of the receiver, and a 7500-ohm tap is used on the other in the plate circuit of the automatic volume control tube.

All of the small fixed resistors are manufactrued by the Lynch Company.

By-pass condensers are Flechtheim and Parvolt.

Centralab variable resistors are used in the volume control circuit.

A Frost variable resistor is used in the antenna circuit, as this model has an extremely small capacity coupling between its terminals.

A small model Centralab 500,000-ohm variable resistor is used to couple the oscillator to the control grid of the first detector tube as the

# *Short-Wave* Super Design

***Mr. Jones has presented an extremely worth-while discussion on short-wave reception and included a general description of a short-wave super of his own design. He now continues with a more detailed discussion of this receiver***

*By* **Frank H. Jones**

PART TWO

small capacity that exists between the rocking plate in this resistor and the carbon element of the other terminal serves very nicely to couple the oscillatory current to the first detector, while the variable resistance serves to put just the right bias on the control grid of the detector.

The National dials are of the slow-motion type and are equipped with real vernier scales which read to tenths of degrees. These dials are absolutely free from back lash and while they are a bit expensive they are well worth while in any good short-wave set.

The overall dimensions of the set are somewhat greater than necessary, but it was thought better to err in this direction to avoid losses due to shields too closely placed. A reference to photograph Figure 9 shows four small vertical tubes diagonally back from the tube shields of the i.f. amplifier tubes and the second detector tube.

These tubes, which are made of brass, convey the grid leads from the coupling transformers to the control grid clips of the vacuum tubes. These brass tubes are ½ inch in diameter to keep losses low and at the tops of these tubes the grid wire continues into the vacuum tube shield through a spiral metal shield made of No. 16 copper wire coiled into the shape of a spring, bent over and soldered both to the brass tube and the vacuum tube shield.

The plate leads of the radio-frequency tubes go down directly through the brass floor of the set to the radio-frequency coupling transformers, and these leads are only one inch long. This design practically eliminates any chance of back coupling from any plate lead to any grid lead.

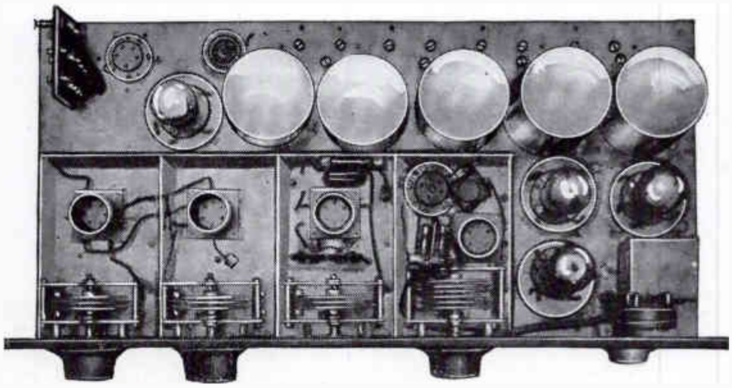


**Figure 10. Top view with part of shields removed to disclose layout**

The plate lead of the first tuned radio-frequency tube, the grid lead of the first detector tube, and the lead coupling the oscillator to the first detector tube go under the floor of the set and, to keep the shielding complete, all three of these leads are carried separately through ¼-inch copper tubes which can be seen in the bottom view of the set, and each of these copper tubes is grounded to the floor frame. All the external leads of the oscillator are completely shielded, even to the back of the oscillator milliammeter.

### *The Power Supply*

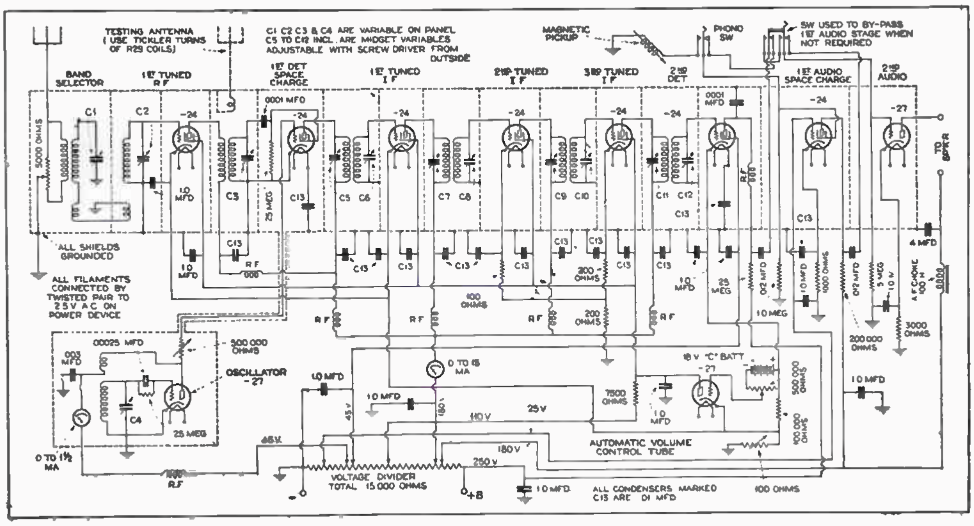
The power pack used for the set is the National Thrill Box short-wave set "A" and "B" power unit. The power transformer in this unit has an electrostatic shield between the primary and the secondary, and this shield is grounded. A Silver-Marshall power transformer for 2½-volt tubes is bridged across the Thrill Box filament secondary power unit, taking care to phase out the two secondary terminals so that they will be additive and not bucking. As the Thrill Box A-B power unit only has capacity for a filament load of five –24 type tubes, this extra filament transformer takes care of the other half of the load, as this is a ten-tube set. Also the center-tapped resistor in the Thrill Box A-B power unit then serves both filament secondaries. Of course the primary of the S.-M. transformer is connected to the 110-volt a.c. power line along with the input leads of the A-B unit.

The very complete shielding makes it impossible for any signal or disturbance of any kind to get into the set except through the small hole where the antenna leads into the first shield.

You might be wondering why a set with so much radio-frequency pick-up needs two stages of audio. Well, it does not, as a radio set, but the two audio stages were designed into the set to furnish a good amplifier for a phonograph pick-up.

This set was designed to work with one audio stage, directly into a 15-watt power amplifier dynamic speaker unit. The audio stage used with the radio is really the second stage, although by suitable coupling the second detector will operate the power amplifier direct, with very good volume.

However, due to the very low background noise level of this set it is possible to use the two audio stages on very weak signals.




**The circuit of the short wave superheterodyne which Mr. Jones uses for foreign rebroadcasts from his Cuban station**

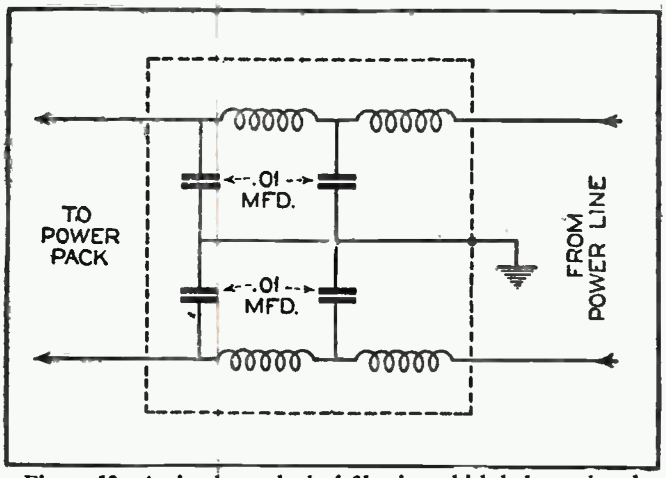



**Figure 13—A simple method of filtering which helps reduced noise in a-c operated s-w receivers**

If one wishes to raise the sensitivity of this set still more, the 100,000-ohm cathode resistor of the second detector can be changed to fifty or even twenty-five thousand ohms.

Also note that the second and third i.f. tubes have an upwardly graded negative control grid bias, in line with latest recommendations of Ballantine.

A small two-point switch (not shown in the circuit design) connects the antenna either to the band selector or to the extra winding on the coil of the first detector. When first calibrating the set, connect antenna to that coil of the first detector and inasmuch as his detector will then tune very broadly you can easily pick up stations using the dials of the first detector only with that of the oscillator. When you have stations spotted in this manner, then shift antenna back to band stage and it will be easy to find the first two dial settings. Thus you use the set normally as a two-dial set, but if you have interference, just shift over antenna and tune the first two dials and the interference will be no more. The first dial will then tune quite broadly, the second very sharp, the third slightly broad and the oscillator or fourth will tune right to a razor edge.

No attempt has been made to give detailed dimensions of all parts of this receiver, as it is believed that anyone who may build this set will probably wish to incorporate some ideas of his own in the actual construction.

It was found after this receiver was finished that the tube shields could be removed without causing the set to break into oscillation. However, this would leave the receiver open to pick up a lot of interference directly through the grids of all the radio-frequency tubes. So leave the shields on. Any short-wave receiver of high gain is always very susceptible and sensitive to interference caused by any "sparking" contacts in the immediate vicinity of the receiver whether the sparks originate in defective timer systems of automobiles or of lamp-socket switches being turned on and off in the lighting system near by.

In all a.c.-operated short-wave receivers, the last-mentioned interference will tend to find its way into the receiver through the power pack even though the power transformer has a grounded electrostatis shield between the primary and the secondary. In extreme cases of this sort it is necessary to shield the leads going from the power pack to the receiver, ground the shield of the power pack and install a shielded power line filter in the line before it enters the power pack. Figure 13 shows such a filter. The four chokes are made by winding one hundred turns of No. 12 double-cotton-covered copper wire on one-inch diameter fiber rods. The condensers must be the mica by-pass type to be absolutely safe in the power line.

For those who may wish maximum micrometer adjustment for close tuning in the oscillator circuit, I have found the following stunt to be very effective. It is not contained in this receiver but is easy to install if desired. Mount a small coil socket in the shield can near the oscillator coil. Place in this socket a coil similar to the oscillator coil. Connect a midget condenser of good quality across the terminals of this extra coil, and arrange to have the knob of this small condenser on the front panel. After one has tuned in a signal that has very close interference, then adjust the midget condenser for least interference. This condenser coil combination is just like an absorption wavemeter, as it is inductively coupled to the main oscillating coil. The effect is double. It can cause the oscillator frequency to shift slightly as well as "sharpen up" the oscillator frequency.

Finally, this receiver can have the condensers ganged if you want to go to a little extra work. The problem is really simple if you only want to cover say a 1500 kc. band. Small trimmer condensers can be installed in each of the four variable condensers cans to bring the four variable condenser cans to bring the four condensers into line.

However, one-dial control is not worth while at this stage of the advancement of the art, and personally I prefer the separate control.

The receiver I use for relaying to my CMHC 379 meter, 1000 watt transmitter for rebroadcasting W2XAF, W2SAD and W8XK I now have automatic v.c. control as described above and in addition there is another complete receiver of the regenerative type whose rectified detector output also directly controls the grid biases of the r.f. tubes of the first receiver. This added complication is well worth while as the output of the first receiver is then almost perfectly constant for any level to which it is set.

The Bell Telephone people use this method in their transatlantic receivers in a slightly different manner. In their superheterodyne receivers I believe they branch off at first detector with two intermediate amplifiers. One is used to carry through the signal and the other to give a rectified current in its second detector to operate the grid biases on the first detector.

With any of the methods above described, if you place a milliammeter in the plate circuit of the controlled r.f. tubes, the throw of this meter gives an accurate visual indication when you are exactly tuned to the peak of the signal.

Really a visual indicator is almost a necessity when using an automatic v.c. Such control is nearly as effective in the circuit described when the B plus lead for the oscillator is bled through a resistor from the plate of the v.c. tube. If this method is used alone you do not get good visual indication with a milliammeter in the plate circuit of the r.f. tubes, but you can place this low scale meter (scale 0-1½ M.A.) in the oscillator plate circuit. However, this method is better on long waves than on short waves. Its chief defect is that it tends to vary the oscillator frequency.

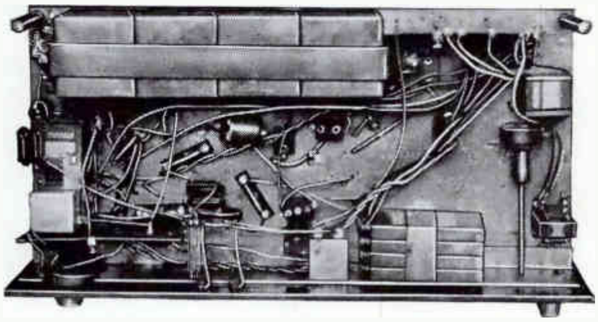


**Figure 8—Underneath the sub-panel—showing the general arrangement of parts and the wiring. The sub-panel is of sheet brass**

Also, don't expect quite as good results with automatic v.c. on short waves as on long waves. Fading effects on short waves are so serious at times that a signal will drop in level as much as 60 dbs. in a moment. When the signal drops on short waves it is more likely that the wave is getting to the receiver over different paths and out of phase. This causes low signal strength and what is worse, usually greatly impairs the quality, even though the automatic v.c. holds up the level, at the output of the receiver.

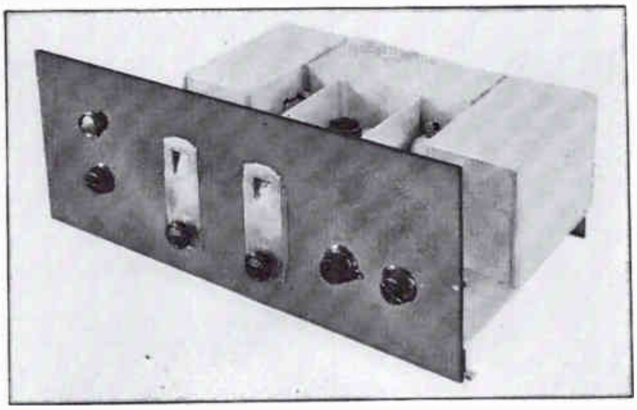
Today, as I "sign off" this story, I have just finished listening for one full hour to "Radio Roma" with W8XK's powerful wave ½ degree away and no interference. This was the program in which Mussolini spoke to America.

# A New "Super" for Circuit Experimenters

***Many requests have been received from readers for a receiver design which offers more than simply a kit assembly job. The answer is given here in a description of the JSW-4, an "all-wave" set using home-made coils and offering considerable flexibility so far as many other parts are concerned***

***By* Chesley H. Johnson**

***Part One***



THE FINISHED RECEIVER

*At the extreme left are the antenna series condenser control (above) and the heterodyne oscillator control. In the center are the r.f. and autodyne detector tuning controls. To the right of these is the i.f. amplifier renegeration control and at the extreme right is the volume control*

THERE are numerous arrangements possible for the reception of short-wave signals, and, with patience and care, results may be achieved with very simple, inexpensive equipment. However, experience with various types of receivers leads the writer to the conclusion that, if a dependable receiver is desired for short-wave work, one is forced to use some form of the superheterodyne. But one of the complications of the usual form, at wavelengths much under thirty meters, is the difficulty of designing a suitable pick-up coil between oscillator and first detector or modulator. The locking effect between these circuits is very troublesome, due to the necessity of tuning both circuits to nearly the same frequency. The second harmonic type might suggest itself as a solution, but the difficulty of adjustment and calibration is in the way.

Using an autodyne detector, there is obviously but a slight loss in sensitivity, due to the detector being but slightly off resonance (tuned to the incoming signal) and full modulation is achieved without the trouble in designing a suitable form of pick-up coil. The autodyne also makes it possible to dispense with one tuned circuit. However, since one tube is a small factor in the cost of a complex set such as a superheterodyne, and selectivity is sacrificed with the loss of this tuned circuit, it follows that the circuit may be replaced by an r.f. amplifier stage. This amplifier furnishes a considerable increase in sensitivity and sharpens up the tuning quite noticeably with no more controls and equipment than were at hand in the first place. The difficulty lies in coupling this amplifier to the autodyne detector.

### *R.F. Coupling*

Considerable experimenting shows that the use of the shunt feed choke method is satisfactory using a high-gain screen-grid tube. With a good choke, a high-impedance load is placed in the plate circuit without instability and a high radio-frequency voltage is fed to the autodyne tube through very loose coupling.

The use of alternating-current tubes is quite desirable both from the standpoint of efficiency and convenience. These tubes are far superior from the standpoint of not being microphonic, as may be determined by operating battery type tubes below 20 meters. No trouble with hum may be anticipated, if heater type tubes are used, using almost any type of power pack.

Referring to the schematic diagram, Figure 1, the antenna is coupled by a very small variable condenser to the first coil L1, in the grid circuit of the pentode tube r.f. amplifier which is tuned by C2. A small coil, L2, in series with the screen-grid circuit of this tube produces stability in this cir-

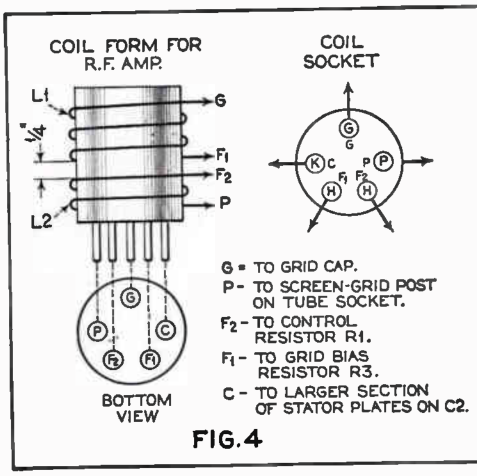



FIG.4

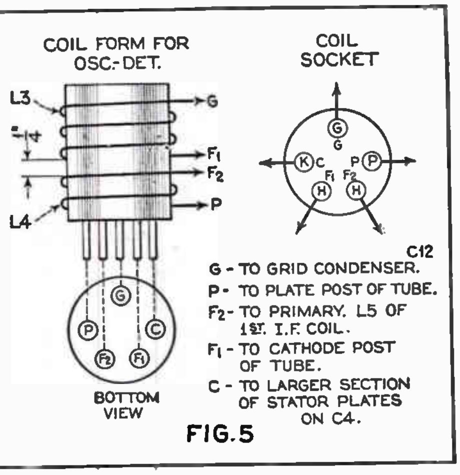
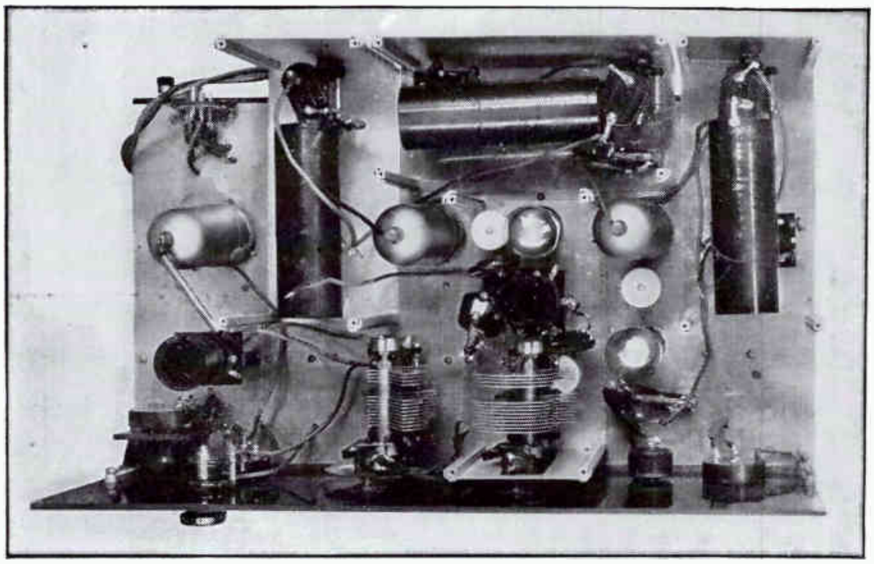



FIG.5

COIL DESIGN DATA

*Figures 4 and 5. R-29 coil forms are recommended. The tickler is wound in the slot at bottom of form with number 30 D.S.C. wire, in all cases. For the broadcast band and somewhat below use six turns on L2, arranged to cause regeneration, but for very short waves use one turn arranged to cause negative feedback, i.e., with terminals reversed or so as to oppose oscillation and produce stability of the r.f. stage. Use number 30 D.S.C. wire for all secondaries having over 40 turns. Use number 22 D.S.C. wire for all other secondary coils. Before soldering connect together the G and C prongs of coil forms for the broadcast range (200-550 meters). C is left unconnected on all other forms. All coils are wound in one direction and the grid end is taken as the top of the coil* cuit by feeding back a negative voltage, adjustable by R1. Where this neutralizing device is found unnecessary it may be left out or short-circuited by a wire. Or, at the longer wavelengths, this coil may be reversed to produce regeneration in the r.f. amplifier. This gives quite a gain, especially on the broadcast range. A small coupling condenser C11 feeds the output of the pentode to the grid of the autodyne detector. The plate circuit of the autodyne detector is coupled back to the grid coil L3 by the tickler coil L4 to produce oscillation and give the beat frequency or heterodyne. The degree of this oscillation may be controlled by R3. The plate circuit includes the coil L5, which feeds the signal to the i.f. amplifier. A condenser by-pass, C13, controls the intensity and somewhat tunes the input to the amplifier.



TOP VIEW WITH SHIELDS REMOVED

*All tuned circuits, including the i.f. coils and condensers are enclosed in box shields, with the single exception of the r.f. stage, which is unshielded*

### *Regenerative Second Detector*

The i.f. amplifier, as it uses screen-grid tubes, is impedance coupled for a high gain. It consists of two stages and feeds into a regenerative second detector. The second detector has a tickler coil L9 in the plate circuit to provide additional sensitivity and to permit c.w. signals to be received. The feedback is controlled by R11. An r.f. filter is provided by the two condensers, C23 and C27, and the choke RFC2. The pure audio signal is then fed through a transformer-coupled amplifier to the loud speaker.

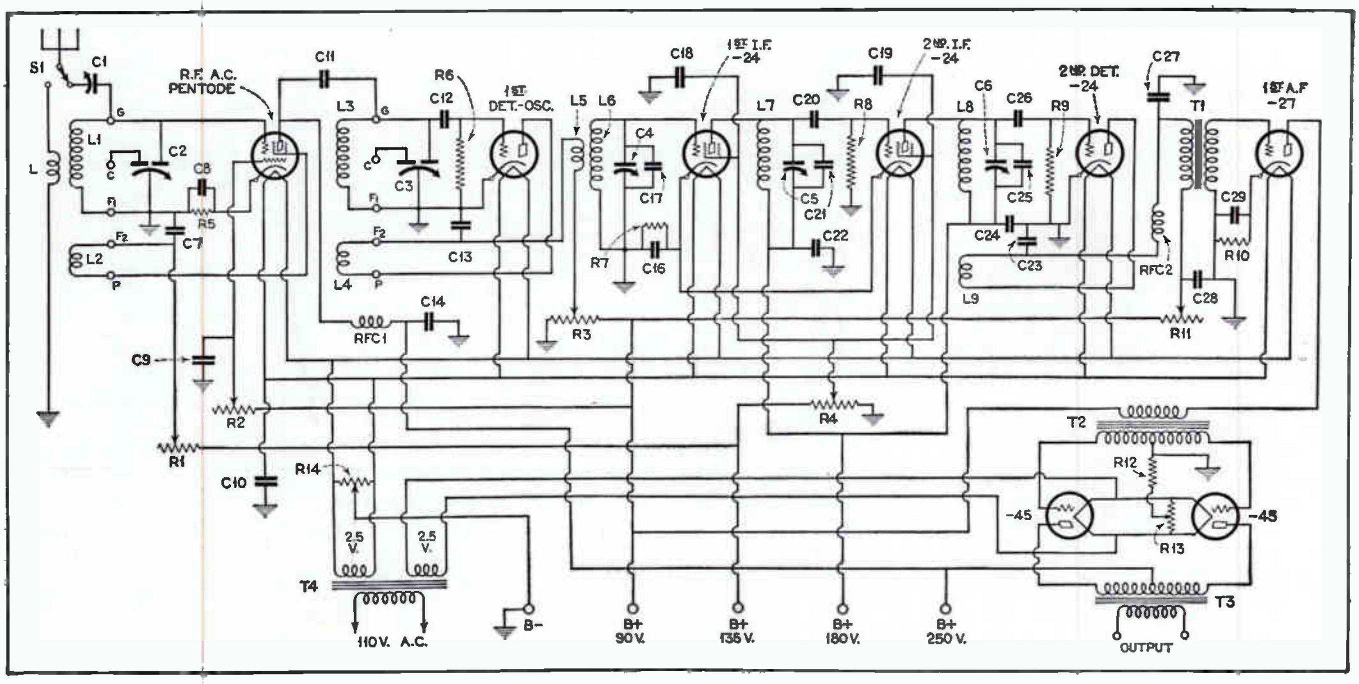
Analyzing the circuit, it will be observed that several interesting features are incorporated. So far as the writer is aware, they are new and never before used in this particular manner. There is a pentode tube to give r.f. amplification before detection and the tube is arranged for positive and negative feedback something similar to the oldtime Superdyne; also, a novel scheme to couple an r.f. stage to an autodyne detector and yet prevent the interlocking or "sticking" which is common to such a circuit. Double regeneration is available through the two detectors. Oscillation in the i.f. amplifier is controlled through R4, which regulates the voltage on the screen grids.

There are a large number of high-capacity condensers used, which, in conjunction with the variable type high resistors, serve to stabilize, filter and isolate the various circuits involved in the hook-up. These resistors serve both as a block to coupling currents and also to adjust the voltages to the best operating values. Although these resistors may also serve as volume controls, they should never be entirely cut out for the foregoing reason.

### *Coil Data*

The building of this set may be gathered from a close examination of the various sketches and the accompanying tables. The tables in this article give all the necessary data concerning the coils, while the sketches next month will show the wiring and the layout of the parts. It is not essential that the exact arrangement given be followed. One may have his own ideas of this.

An aluminum baseboard or chassis, beneath which are to be mounted all miscellaneous condensers and resistances, acts as a mounting support for the shields and associated apparatus.




THE CIRCUIT DIAGRAM OF THE RECEIVER

*Figure 1. This diagram includes the audio amplifier, in addition to the five-tube tuner circuit. The audio end, however, is not included in the chassis shown in the photos. The r.f. pentode tube is available (see list of parts), but for readers who prefer multi-mu tubes a modification of the circuit will be shown next month*

### *Coil Details*

The variable tuning controls and variable resistors are mounted on the front panel. All wiring, whenever possible, is run beneath the baseboard. The heater wires are twisted and of large carrying capacity. The other wiring should be heavily insulated fine wire and bushings should be used where wiring passes through the aluminum panel or partitions of the shields. Wires in grid and plate circuits while "hot" are kept above the panel. The various ground connections that are shown in Figure 1 are made by short, direct wiring to the cathode post, or resistor connected to it, for each tube concerned. This is to avoid radio-frequency currents circulating in unwanted paths in the aluminum base. The plug-in coil sockets are mounted on brass brackets somewhat above the sub-panel for two reasons; namely, to keep down eddy currents from the coils and to make readier access in changing the plug-in coils. These coils are made as directed in Figures 4 and 5 and the notes that are given with the table of coil specifications, on page 52.

The layout will be given in the next chapter. This will be found of great value in determining just which parts are to be located inside and outside of the shields. It is better to mount only the bases of these shields and fit them together after the wiring is nearly completed.

### *Avoid Losses*

Keep all "hot" parts of circuits as far from the shields as possible to reduce eddy current losses. The wiring that goes above the panel will follow shortly and the remainder can be gleaned from Figure 1. This was done for the sake of clarity. It is suggested that each item when completed be checked on the diagram, so as to avoid leaving out important elements. Unless this is done it may easily happen that several very important by-pass condensers may be omitted, as there are so many that are of the same size and similarly connected. Athough there are only two major controls (C2 and C4), there are four other controls that are shown as mounted on the front panels. These need only occasional adjustment and lend that additional flexibility to the set that is so desirable in very short-wave work.

Further drawings (next chapter) will show the main parts with their detailed dimensions and location.

### *Wire i-f First*

It is suggested that the intermediate amplifier be wired before the rest. After construction it should, preferably, be tuned by a suitable oscillator to some frequency around 300 kc. to make sure they are matched. If the coils are correctly wound, *i. e.,* occupy the same length of winding for the same number of turns and size, there is not any real need to do this. With all three stages alike, it is easy to adjust all three condensers as in any ordinary tuned radio-frequency set. This may be done later. It is necessary to mount the midget variable condenser, C4, C5 and C6 on a proper support with the last two insulated "above ground." The knob is removed from the condenser shafts and a saw-cut is made across the ends of the shafts to permit adjustment by a small insulated-handle screw-driver. Make small holes in the shield sides, just opposite the shafts so that they may be tuned by inserting the screw-driver while the shields are in place.

The design of the i.f. amplifier is such that it forms an approximate "one-spot super" on the broadcast waves. For example:

The i.f. amplifier being adjusted to a frequency of 300 kc., it is necessary that the oscillator tune between 167 meters and 353 meters for the broadcast range. This follows from 550 kc. + 300 ks. = 850 kc. or 353 m. and 1500 + 300 kc. = 1800 kc. or 167 meters. For this reason only stations above 1150 kc. will have repeat points, assuming harmonics to be negligible. This follows from 1150 ks. — 300 kc. = 850 kc., the top value. The 1150 kc. station being received at 1150 kc. + 300 kc. = 1450 kc. and 1150 kc. — 300 kc. = 850 kc.

It is interesting to note the great advantage of a small condenser for C3 on the short waves. For example, to receive 75 m. (4000 kc.) the oscillator may be adjusted for either 69.9 m. (43000 kc.) or 81 m. (3700 kc.). Only one of these will probably appear on the scale. At 40 m. (7500 kc.) the two points are 38.5 m. (7800 kc.) and 41.75 m. (7200 kc.). In this case both points appear on the oscillator dial. These points continue to draw closer together the further down the scale in wavelength one goes. However, at 20 meters they are far enough apart to cause no trouble and serve as additional means of locating stations.

In the following chapter we shall continue the constructional details and will also cover the detailed operating suggestions. In it will be included the panel, base and wiring layouts. The list of parts is included in the present article so that readers who desire to build the set may start preparations now.

### *List of Parts*

C1—Variable air condenser, Pilot J-5 (cap. 15 mmfd.)
C2, C3—Variable air condenser, National Special ET-27 (cap. .00035 mmfd.)
C4, C5, C6—Variable air condenser, Pilot J-23 (cap. 100 mmfd.)
C7, C8, C9, C10, C14, C15, C16, C18, C19, C22, C24, C28, C29—Fixed paper condensers, 200 volts (cap. 1 mfd.)
C11—Fixed mica condenser, Sangamo (cap. 70 mmfd.)
C12, C17, C21, C25—Fixed mica condensers, Sangamo (cap. 100 mmfd.)
C13—Fixed mica condenser, Sangamo (cap. 250 mmfd.)
C20, C23, C26, C27—Fixed mica condensers, Sangamo (cap. 100 mmfd.)
R1, R2, R11—Variable high resistors, Pilot Volumgrad No. 940 (0-50,000 ohms)
R3—Variable high resistor, Pilot Volumgrad No. 941 (0-100,000 ohms)
R4—Variable high resistor, Pilot Volumgrad (0-25,000 ohms)
R5—Fixed resistor, 300 ohms (Electrad)
R6, R8—Grid leaks, 3 meg. (Lynch)
R7—Fixed resistor, 250 ohms (Electrad)
R9—Grid leak, 0.5 meg. (Lynch)
R10—Fixed resistor, 2200 ohms (Electrad)
R12—Fixed resistor, 750 ohms (Electrad)
R13, R14—Fixed resistors, 20 ohms (center-tapped), Pilot
RFC1, RFC2—Choke coils, 85 mh., polarized (Hammarlund Mfg. Co.)
S1—Single-pole, double-throw switch
T1—Transformer, audio, 1st stage, National
T2—Transformer, audio, push-pull input, National type P-50
T3—Transformer, audio, push-pull output, National type P-50
T4—Transformer, filament, Aero 2.5-volt and 2.5 volt
1 panel, bakelite, 9 inches by 22½ inches by 3/16 inch
1 subpanel, aluminum, 12 inches by 22½ inches (preferably 14 inches by 22½ inches)
4 shields, aluminum, 4¼ inches by 8¾ inches by 5½ inches high
22 coil forms, R-39 or UY tube bases
2 dials, vernier type, National projection disc type
3 caps for screen-grid tubes
3 shields for screen-grid tubes
6 sockets, UY, Eby strip type for subpanel
2 sockets, UX, Eby strip type for subpanel
2 sockets, UY, Eby ordinary base
2 vacuum tubes, type –24
3 vacuum tubes, type –27
2 vacuum tubes, type –45
1 pentode r.f. vacuum tube, CeCo type P5 (This tube is available direct from the CeCo Company, Providence, R. I., if not obtainable from local dealers.)
Power unit capable of supplying 80 ma. at 300 volts maximum
3 pieces 1/32 inch bakelite tubing 2 inches o.d. by 6 inches in length, 1/32 thickness
1 pound wire, No. 30 d.s.c spool
½ pound wire, No. 32 d.s.c spool
1 pound wire, No. 22 d.s.c spool
Miscellaneous hardware

# A New "Super" for Circuit Experimenters

***The author continues the constructional description of his home-built superheterodyne, outstanding features of which were covered in the preceding pages. He also offers an alternate circuit providing for the use of variable-mu tubes in place of the r.f. pentode and the -24's, used in the original receiver***

**By Chesley H. Johnson**

*Part Two*

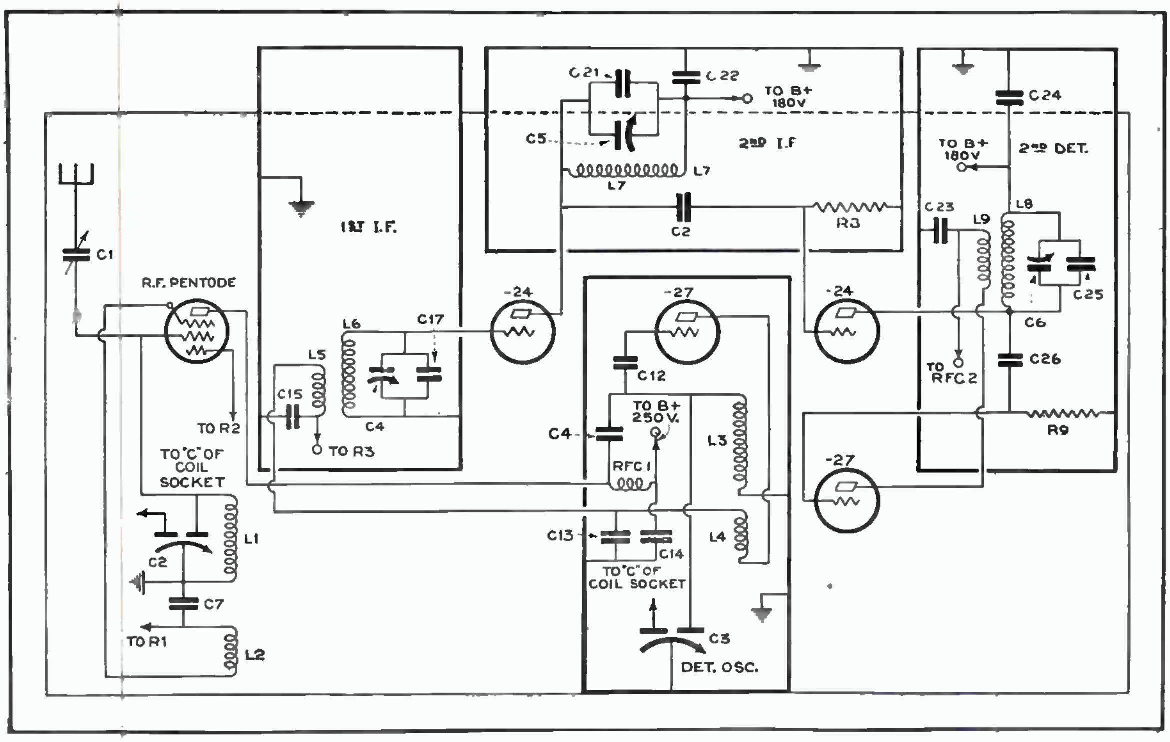
THE audio amplifier is standard in design and needs no comment. An open-circuit jack or binding posts had better be included in the wiring, although it is not shown. This may be connected directly across the primary of the first or second audio transformer. It is useful for phone reception. The audio amplifier should be wired after completing the i.f. amplifier.

At this point in construction it is well to check the operation of the two amplifiers. Wire up the power pack and determine if this part is correct by listening for any noises that may come through. A finger placed on the cap of the first i.f. stage control grid should produce a humming sound. The body may act as an aerial and cause loud noises from such as vacuum cleaner motors (any commutator type motors) to be heard in the speaker. If such sounds are heard it is well to adjust the midget variable condensers, C8, for maximum response. The condenser in the second detector circuit will probably be the most sensitive. Do not fail to adjust R4, as this will have, presumably, quite a bearing on any signals to be heard.

With the foregoing circuits in operation, the set may be completed by wiring the oscillator and r.f. amplifier. Especial care should be exercised to avoid undesirable coupling and all connections should be tight and rigid to avoid noises that are so easily set up on the shorter waves.

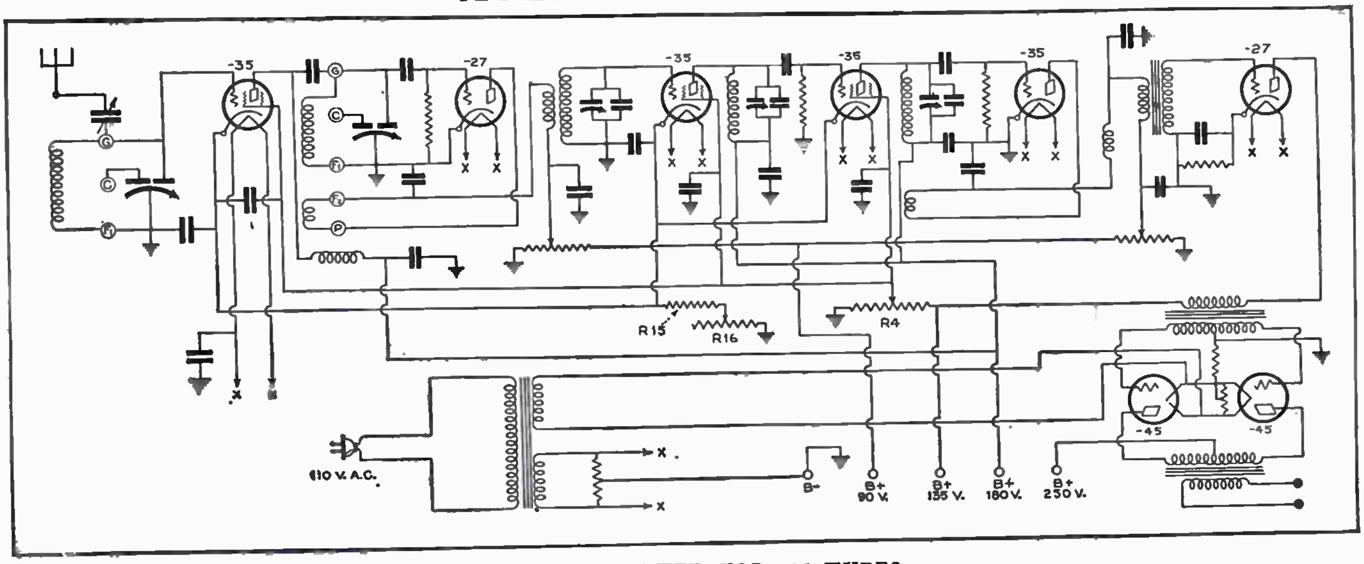
It is suggested that the broadcast band coils, L1, L2, L3 and L4, be the first of the plug-in coils to be constructed. With these coils plugged into the five-prong tube sockets, signals should be heard if the power pack and all auxiliary equipment is properly connected.

When signals are heard, it is advisable to adjust the oscillator for best operation. Vary R3 and notice if set squeals or goes dead if the resistor is turned all out. Signals should come through clearly with R3 turned not more than a quarter way around. Vary C4 and note whether set is properly selective. Stations should not take up over four or five points and weak ones but a point on the usual form of dial. Vary C2 and note whether this dial exerts any decided influence on selectivity. Vary C1, which should exert a decided influence on both volume and selectivity unless too long an aerial is being used.




WIRING LAYOUT

*Figure 6. Shows, in schematic form, all parts which appear above the base in the finished receiver*

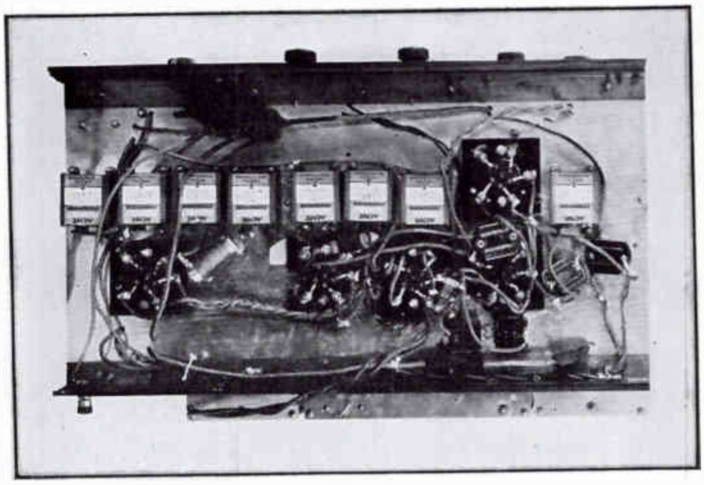



CIRCUIT ADAPTED FOR -35 TUBES

*Figure 7. For constructors who may prefer to use variable-mu tubes in place of the r.f. pentode and type -24 tubes used in Mr. Johnson's original model, he has provided this circuit. It will be noted that the antenna coil L and the plate coil L2, as well as the variable resistor R1, of the original circuit, have been eliminated. The resistors R15 and R16 have been added, these are a 100 fixed and a 5,000-ohm variable resistor, respectively. R4 of the original circuit has been changed from 25,000 to 100,000 ohms. These changes do not alter the original panel or base layout. R16 is mounted in the hole provided for the discarded R1*

Both C1 and C2 are very important controls on the very short waves but of not much importance on the broadcast band except on weak signals. Vary the regenerative control R11 and listen carefully for the whistle or strong breathing sound. If turning the knob for R4 completely in—cutting out all resistance—fails to make the set whistle, try reversing the tickler coil, L9. Try altering its position, which should be at the filament end of the coil L8. Move it in or out just a trifle. Add a few turns to L9 and repeat the preceding operations until it is possible to make the set regenerate properly. If too many turns are put on the tickler coil L9, the set will fail to function at all. The adjustment of this coil is quite a problem and must be done with care. Once adjusted, it should be fastened in place with a proper glue or shellac. The size of the various grid leaks has considerable influence on this adjustment.

Vary the volume control R4, which is in the screen-grid circuit of the i.f. amplifier. If the shielding is not very good or stray couplings exist, the amplifier may be unsteady and go into oscillation as the resistor is turned to the position of all out. Under such conditions the set becomes inoperative. Signals should come through with a tremendous rush as the knob is turned slightly away from the zero position. The amplifier may be said to be working properly if the set becomes unstable only when the knob is turned all around, putting full voltage on the screen grids of the i.f. amplifier.



THE BOTTOM VIEW

*The space beneath the base provides room for tube sockets and the numerous bypass condensers, as well as for low-potential and low-frequency wiring*

In the event that the set fails to function, the fault or faults may be located by a systematic procedure of "trouble shooting." Test each part for grounds or shorts. A better procedure would have been to have tested each particular part of the circuit as the wiring proceeded, in which event the trouble would have been remedied immediately and further fault eliminated in the final assembly. Failing to locate the fault, run a jumper from the first i.f. grid post to the second detector grid condenser, C26, and then remove the tubes in the i.f. amplifier. Local signals should now come through on plugging in the broadcast coils. Provided such is the case, investigate for some fault in the i.f. amplifier. However, for continued failure to receive signals, try placing a pair of headphones in series with the plate circuit of the pentode tube, just ahead of the large by-pass condenser C14. Weak signals should be heard on turning the condenser C2, if the aerial be connected. With this circuit operating, remove the phones and replace the wiring. Next, insert the phones in the plate circuit of the autodyne detector, just ahead of the large by-pass condenser C15, if the set still refuses to operate as a whole. Signals should be heard in the phones as the condensers C2 and C4 are turned. If the signals are very squeally a few turns may be removed from the feedback coil L4. If no signals are heard, add a few turns or try reversing the terminals of the coil. With the detector operating, the phones should be removed, the wiring replaced and signals should pass through the set.

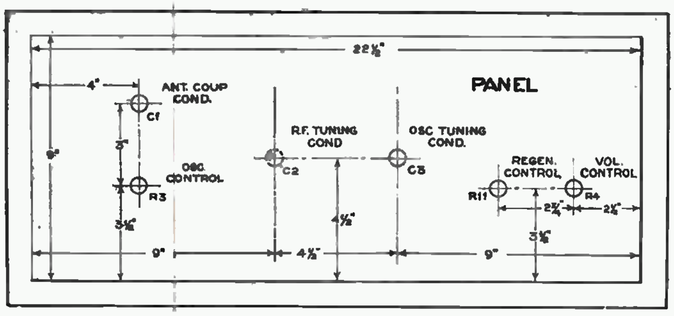
### *On the Short Waves*

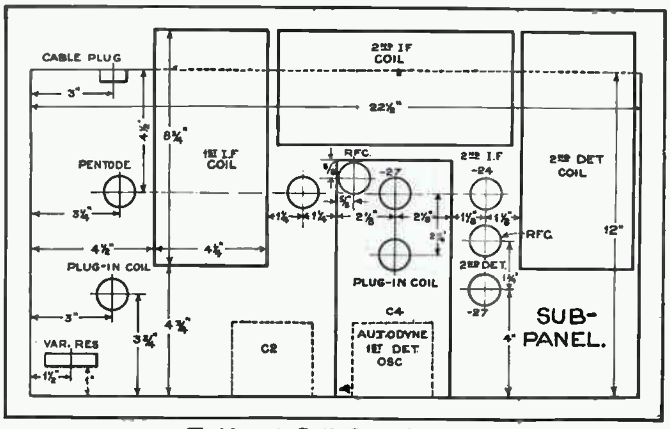
With the set operating properly on the broadcast waves, the various short-wave coils may be constructed with confidence in their ability to operate the set for the purpose for which it has been designed. Each coil as finished should be checked for proper connection and continuity of circuit.

On the shorter waves burnt-out UY tube bases are satisfactory—especially for the r.f. amplifier. The specifications are given in the tables for these forms.

Plugging in the coils, tune with C4 and C2. Follow up C4 with C2 by listening for the background noises. If C2 is much off tune a steady roar will be heard; also when the oscillator has spilled over completely. The antenna condenser C1 is not very critical and for the shorter waves is turned toward a minimum amount of capacity. The coil L is to be used only on the broadcast or nearby bands and may be omitted entirely with not much loss.

With signals received, readjust all resistors for best results. Turn R3 only far enough to receive clear signals. Vary R2 and R4 for volume. Faint signals may be brought up strongly.




**Showing the panel layout, above and the base arrangement, to the right. This being an experimental superheterodyne the suggested disposition of parts may be varied considerably by the individual builder. Elasticity of design is a feature of Mr. Johnson's receiver**

by the regenerative control in the second detector. Quality and signal strength largely depend on the proper choice of grid leaks. A choking or popping sound indicates too high a leak. Too low means a great reduction in sensitivity as well as volume.

## *Check Voltages Carefully*

With the set operating, do not except exceptional results until it is adjusted properly. All the controls must be properly disposed. It is quite important that the proper voltages should be available.

The set described may seem expensive to construct. Much saving may be exercised, however, by a proper choice of substitute parts for those listed. A power pack may be purchased at cut-price stores for about ten dollars or it may be made up from parts. Miscellaneous parts may be utilized and some may be contrived. The pentode tube may be dispensed with and an ordinary screen-grid tube substituted for it by omitting the space-charge grid connection and joining the plate circuit to the 180 volts in place of the 250 volts as shown.

The usual type of UY socket may be mounted on top of the copper sheathed baseboard, and holes drilled through the board to pass the wiring. Although special variable condensers are listed, any good condenser that will permit the stator to be separated into two parts may be substituted. These sections contain a single plate and a nine-plate section taken from a condenser whose original capacity was 500 micromicrofarads. The rotor may be left unchanged or a plate or so removed such that two plates mesh the single stator plate on the end section.

The set has no body capacity if properly made.

Although this set has been experimented with for several months and is the fourth type developed during the past year, it is felt that many improvements may occur to investigators. However, as many sincere experimenters have found out, changes are not necessarily *improvements*. As outlined, this set offers almost endless opportunity for investigation and study.

However, after all, if the purpose of the operator is to listen in on the "whole wide world"—it were better to stick pretty closely to the indicated design.

*Table of Coil Specifications*

| Turns L3 | Turns L4 | Tuning Range Meters | Turns L1 | Turns L2 |
|---|---|---|---|---|
| 2½ | 2 | 14-16 | 4½ | 1 |
| 3½ | 3 | 15-18 | 5½ | 1 |
| 5½ | 4 | 17-23 | 7½ | 1 |
| 6½ | 5 | 20-28 | 8½ | 1 |
| 8½ | 6 | 25-35 | 10½ | 1 |
| 10½ | 7 | 32-45 | 12½ | 1 |
| 13 | 8 | 40-52 | 18½ | 1 |
| 16½ | 9 | 50-60 | 22½ | 1* |
| 21½ | 11 | 58-78 | 25½ | 2* |
| 29 | 12 | 75-130 | 34 | 3* |
| 58 | 18 | 200-550 | 85 | 6* |

* Connected for regeneration.

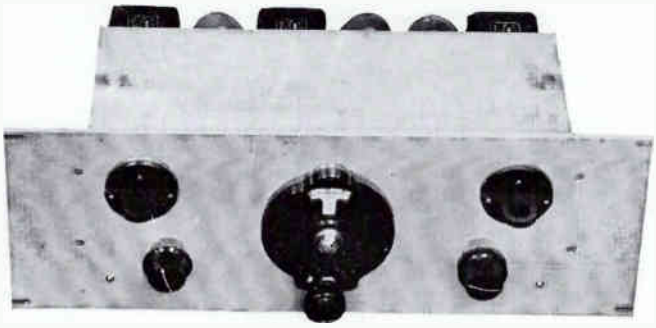
The above winding data are only approximate, as the tube characteristics as well as the individual features incident to the arrangement of parts quite appreciably affect the tuning range on the very short waves. All coils L1 and L3 are single layer, close wound. Spacing turns and larger size wire have some advantages on very short waves.

Coils L6, L7 and L8 are alike and consist of 300 turns of No. 30 d.s.c. wire wound single layer on bakelite tubing, outside diameter 2 inches.

The primary coil L5 has 110 turns and is mounted at the filament return end of coil L6. It is a single layer or a bunch-wound coil of No. 32 d.s.c. wire and may be wound on varnished cambric slipped over the form for L6.

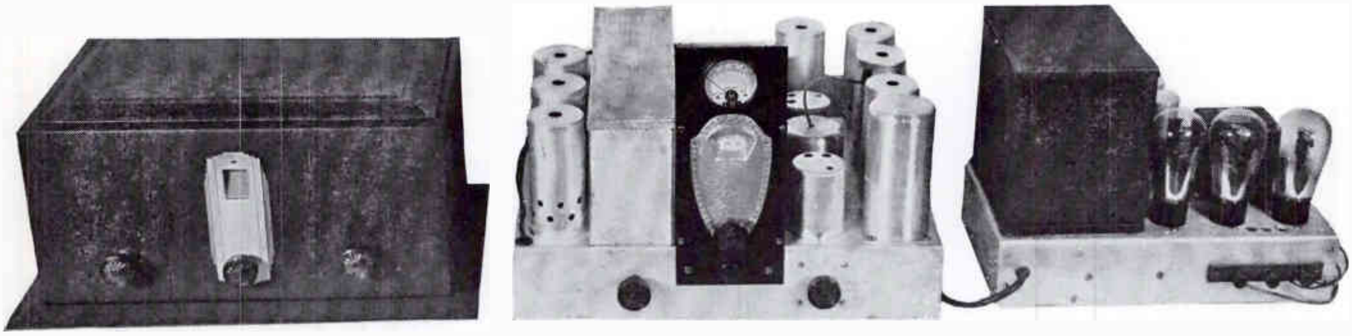
The tickler feedback coil L9 has from 15 to 25 turns and requires considerable experimentation before being satisfactory. Use 25 turns and cut if regeneration is excessive. It is wound with No. 32 d.s.c. wire on a narrow piece of bakelite tubing that will just slip over the form for L8, or may be wound on varnished cambric laid over the winding L8. The winding is placed over the filament end of the larger coil.

If a coil winding rig is not available, it is advisable to use a block of wood with a large wood screw driven into one end. Filing off the head and centering this piece in a chuck, it is a simple matter to wind the various coils. The block should be tapered slightly and the form for L6 slipped over it and fastened into place. Five holes, located by using the prongs of an SM form as a template, may be drilled into the end of the wood piece. These holes serve as a support to mount the form while winding coils L1, L2, L3 and L4.



**A commercial design of a short wave superheterodyne, which exhibits several points that can be incorporated into a permanent model of the receiver described in these pages by Mr. Johnson.**

**Wave change is readily effected from the front of the panel by means of plug-in coils with convenient handles. It is designed for relay rack mounting, a highly efficient system of experimental disposition**



The 1932 model Stenode being used in conjunction with the NC-5

# The STENODE on Short Waves

## *Using the N-C-5 Converter*

by Arthur H. Lynch

THE PREDOMINANT characteristic of the Stenode system of reception is extreme selectivity (of an order considerably better than 10 kc. without sacrifice of quality. The manner in which this is achieved is in perfect accord with mathematical and engineering principles and is in no way antagonistic to fundamental radio theory.

A brief consideration of the Stenode action will indicate its possibilities for short wave reception, particularly on the amateur telephone bands. The ordinary receiver, designed to give perfect quality reproduction on a wireless telephone signal, is engineered so that it provides very good response to all signals five kilocycles on each side of the point to which it is tuned. Quite obviously such a system gives entry to any unwanted signals within this band, resulting in a type of interference which is particularly vicious on the amateur bands where no regulatory efforts to space the stations are practicable. Also, as it is impossible to attain the ideal in a 10 kc. band pass receiver—a tuner that would cover exactly 10 kc. and no more—the slope of the resonance curve is necessarily gradual rather than precipitous, and signals considerably more than 5 kc. off resonance may be received with sufficient strength to create serious interference. Ordinary receivers are fundamentally a compromise between tone quality and 10 kc. selectivity—and where one of these qualities is more or less attained, the other is necessarily deficient.

The Stenode, on the other hand, functions on an entirely different principle. No effort is made to admit the sidebands which exist on each side of the carrier. As a matter of fact they are deliberately cut or attenuated, and the receiver is made to tune to a remarkable degree of sharpness by a quartz crystal in the intermediate frequency amplifier—the circuit being fundamentally that of a superheterodyne. This receiver is tuned so sharply that signals even a few kc. off resonance are so drastically attenuated that they are virtually non-existent. Obviously, no amount of amplification on the audio frequency end can bring back signals which have not passed into the intermediate frequency amplifying circuit.

It can be readily demonstrated, or shown mathematically, that audio frequency modulation exists in the carrier as well as being represented by the sidebands. As a matter of putting the horse before the carriage, it is these amplitude variations in the carrier that are responsible for sidebands. However, through what is known in physics as the persistence of oscillations, the dept of modulation (which determines the intensity of the audible signal) varies inversely with the audio frequency. In other words, as the modulation frequency increases, there is less time for each individual vibration to make its "dent" in the carrier before the next vibration comes along. The net result is that while the low frequencies come through with normal volume, the high frequencies are scarcely audible, and the tone is muffled—a result that has always been a characteristic of a sharply tuned circuit. In the Stenode, this condition is corrected by the inclusion of a special audio frequency circuit in which the high frequencies are amplified more than the low frequencies in the same degree that they are attenuated in the sharply tuned i-f circuit, resulting in perfect quality. We have already observed that signals slightly off resonance are practically unaffected regardless of the amount of audio frequency amplification, and actual gain in selectivity has therefore been made without sacrifice of quality.

Quite naturally, selectivity of this order greatly reduces heterodyne whistles caused by neighboring carriers beating with the desired signal. However, this characteristic can be still further emphasized by slightly unbalancing the crystal circuit (by means of a simple control) so that a form of single sideband reception results, with added discrimination against the carrier causing the whistle. It is possible, in this way, to reduce to practical elimination a 1000 cycle beat note. The advantages of such an action, where amateur 'phone traffic is handled, offer remarkable possibilities in the way of unscrambling the situation.

A secondary Stenode effect of considerable importance in short wave reception is the reduction of exterior background noises—such as those caused by automobile ignition, elevators, incinerators, traffic lights, and a host of other electrical devices which unfortunately act as remarkably efficient short wave broadcasting stations. Noises of this type are proportionate to the area under the resonance curve, and generally result from off-frequency disturbances beating against the desired carrier. Quite obviously, the sharper the receiver or resonance curve, the narrower the band of off-frequency disturbances which will be admitted.

There is no reason why these advantages should be limited to the usual broadcast frequencies, and preliminary experiments indicate the utility of the Stenode on short waves. While no practical data are yet available on the construction of a short wave Stenode, its possibilities may be realized by using the 1932 broadcast Stenode in conjunction with a highly efficient short-wave converter, such as the National NC-5. The combination then functions as a double super. The operation, in general, is the same as that of the converter used with other receivers.

The correct dial point for the intermediate frequency of 575 kc should be located with some precision, and either remembered or marked. The station should then be tuned in as carefully as possible on the converter, and the final tuning effected by using the high ratio (250—1) Stenode dial. Occasionally it may be desirable to return once to both the converter and Stenode dials. Before tuning to a new station on the converter, the Stenode should be reset to the exact intermediate frequency.

The combination should be operated with a reasonably long antenna, which permits the Stenode to function with the volume control set for minimum noise. Due to the efficiency of the crystal circuit, the selectivity will not be impaired by even a fairly long outdoor antenna.

# The Importance In SHORT

## A Mathematical


**Application of the principles outlined by Mr. Hatry make it possible to take full advantage of a vernier tuning action**

*By* L. W. Hatry*

The foregoing introduces a story telling you why Ci and Cgp are important to you and how they can effect your receiver's actual performance.

CI is the input capacity of a tube; the capacity between the grid and filament. The importance of this capacity is understandable when one realizes that it is across the tuning condenser (the tuned circuit) and consequently can affect the tuning range in R. F. circuits or the audio range in audio circuits. However, we shall ignore audio circuits in this article. By formula the input capacity:

$$Ci = Cgf + \left(\frac{\mu Rp}{Rp + rp} + 1\right) Cgp$$

Ci being the input capacity;
Cgf being the static or "real" capacity of grid to filament;
mu being the amplification constant of the tube;
Rp being the load resistance (external load connected in the plate circuit);
rp being the internal resistance of the tube;
Cgp being the grid to plate capacity of the tube.

### *Interpreting the Formula*

Don't scare at the formula. Suppose we replace the symbols with numbers, any numbers we think of, (tube data are not necessary). Then extracting a meaning from the formula proves very easy. Change Cgf to 1, mu to 8, Rp to 10, rp to 1 and Cgp to 1 the result will be:

$$Ci = 1 + \left\{\frac{8 \times 10}{1 \times 10}\right\} \times 1 = 7.2 \text{ approx.}$$

Which means nothing as it stands but if the process is contiued can teach several things without one knowing practical tube data. For instance if Rp is changed to 3 or to 20 the Ci result in 6 and 7.6 respectively. Now consider Fig. 1; the circuit shown is one to which the formula given can apply directly since the formula is correct only when D.C. conditions are approached and the load Rp is pure resistance. We have learned that the input capacity Ci across the tuning condenser C can vary between 6 and 7.6 or be increased by at least 25% by the great change of the load from three to six times that value. Thus we learn that plate circuit changes change the input capacity of the tube which being across the tuned circuit can change its tuning.

The formula also includes other information. If Cgp is increased in capacity, increased say to 2 in the case of our imaginary figures, the final figures for Ci are increased by slightly more than double or to between 13 and 16.2. Which means if anything that Cgp is important as a tuning factor in changing Ci and hence the tuning of the tuned circuit.

*Engineer, Hatry and Young.

### *Analizing the Regenerative Circuit*

To begin with, remember that in a regenerative detector circuit, Fig. 2, for example, we are not concerned with an Rp in the sense shown in Fig. 1, for the R. F. plate load has become T the tickler and its associated R. F. path. The tickler has reactance (which is opposition to current flow or ohms just as is resistance) and hence has an ohmic effect similar to Rp were its inductance changed or made variable. Fortunately we do not have to be concerned over a variable inductance tickler but we have other matters to concern us.

We control regeneration today most often either by making C1 variable or by means of a variable resistance R1. The resistance R1 is not our concern, it does not alter the R. F. resistance of the circuit appreciably but by altering the B voltage it does change rp the internal impedance or resistance of the tube. The effect of variation of rp (by means of R1), or the R. F. plate circuit ohms (reactance) by changing C1, from the facts of our formula will be to change Ci the input of the tube in shunt to the tuned circuit. Which means of course that the tuned circuit will be pushed off wave. This effect we find in regenerative receivers as the tuning effect of the regeneration control changes the beatnote.

### *Detuning Effects*

However, all detuning effects due to regeneration controls cannot be blamed against mere changes in tube input capacity. If the tickler T, for example, were variable there would be changes in mutual inductance of L and T which would cause detuning;; this was dropped years ago in short-wave work for that reason. Similarly when C1 is variable we have changes in the capacity of T to L as C1 is varied which is a detuning effect outside the tube.

This leads to a consideration of possibilities. If the elimination or reduction of the tuning effect of the regeneration

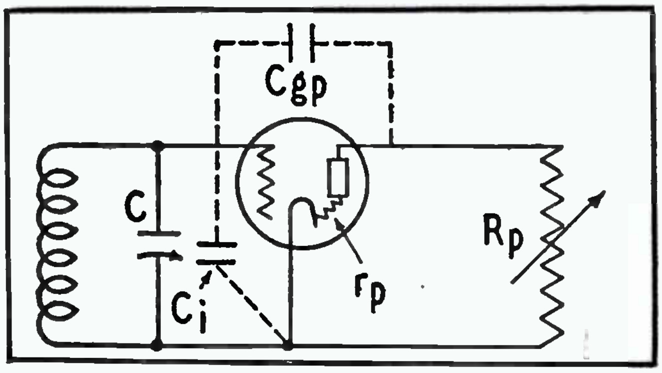
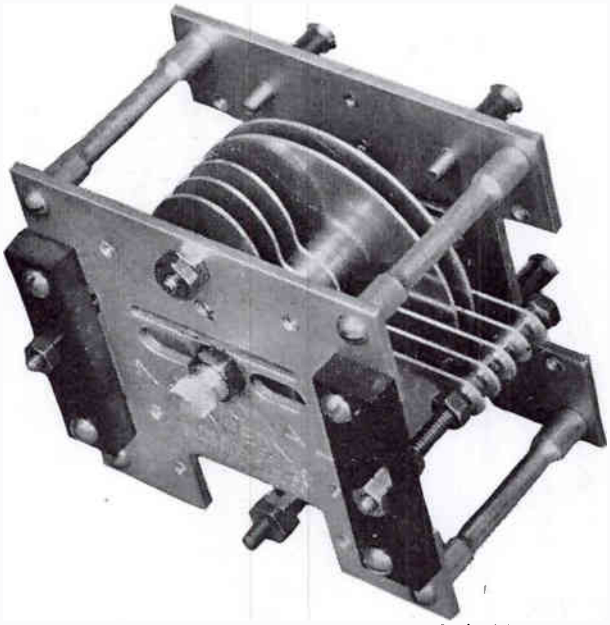



**Figure 1—Symbolic diagram of the conditions existing in a tube socket—showing the capacities and resistances associated with the circuit operation**

# of C sub I WAVE Sets

## Consideration



In receivers using triode detector it is often desirable to use a condenser having a high minimum capacity

control is important, and it is frequently useful in simplifying the operation of a receiver designed to be handled by inexperienced persons, we first must take all the steps that present design practice has shown to be desirable.

### *Eliminate Reactances*

First all reactance changes in the actual R. F. circuit should be eliminated, T and C1 both must be fixed. Therefore all methods of regeneration control affecting either must be disregarded. Our remaining regeneration control becomes B voltage control by means of variable resistor or potentiometer (limiting our case to triode tubes for the moment). This causes but one change affecting anything likely to detune the tuned circuit; it changes rp the internal resistance of the tube and hence changes Ci somewhat. rp is one of the factors whose action in the formula is multiplied by Cgp to give a final value of Ci. But also the formula shows that if Cgp is increased Ci variations become proportionally larger.

Therefore, once we have eliminated every variation except that in rp we can reduce the effect of rp changes by reducing Cgp. The lowest Cgp we can get is composed of the actual tube capacity, the capacity of the socket it plugs into and the capacity of the wiring attached to it. Of these things we have control of only (1), the wiring—and (2), the coil which is of course a part of the wiring. The capacity of L to T in Fig. 2 can increase the capacity of grid to plate. So likewise can the capacity of wires leading to grid and plate.

### *Shortening Leads*

Experimentally I altered one receiver from a normal baseboard layout to an arrangement whereby the tube hung horizontally from the adjacent coil-socket. The outfit had condenser control of regeneration, C1 of Fig. 2 was variable, there was no R1, so this was kept temporarily. By this means the total lead from coil to plate consisted of two soldering lugs or a "wire" length of three-quarter inch. Previously it had been a piece of wire two and one-half inches long having relation to a grid wire about three inches long including the grid-condenser. Under the original conditions the regeneration control "tuned out" a beatnote in three and one-half dial divisions (100 division dial). After the change the regeneration control required eleven and one-half divisions to tune out a beatnote. However, simply putting in an R1 for resistance regeneration control, not rewiring as in Fig. 3, will make as much improvement as that; whereas the final change with the short leads plus R1 results in a regeneration control (with C1 fixt) that will not complete its detuning in less than a half turn of the R1 knob.

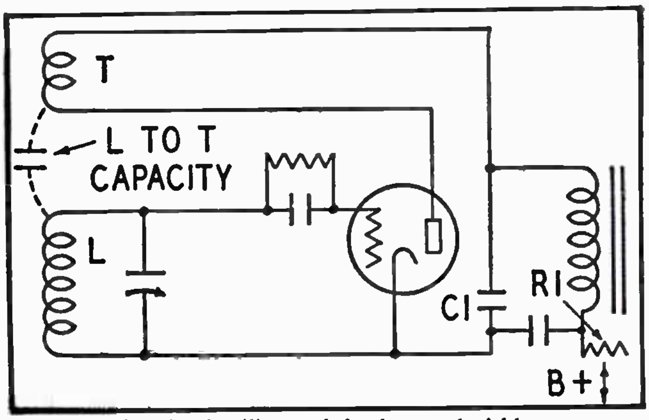



Figure 2—The familiar and fundamental tickler regenerative circuit with the inter-coil capacity indicated symbolically

### *Triode Detection*

In receivers using triode detectors the detuning effect can be further reduced merely by choosing the tube having the lowest interelectrode capacitances, such as the 199 and by using a tuning condenser with a large minimum capacity such as the General Radio 557 or by deliberately aiding the tuning condenser mimimum by increasing the circuit overall minimum through the addition of capacity in the vicinity of 25 to 50 picofarads.

What about the screengrid tetrode detector such as the '24 of '32?

### *Screen Grid Detection*

Again we wish to avoid tuning effect which is the same thing we must keep Ci from varying. Looking at our equation again we see that this means that both of the right-side parts of the equation must be kept constant and preferably small. There is no need to worry about Cgf for it was built small by bringing the grid into the top of the tube. As for the other parts of the right side of the equation, Cgp will be small and constant as long as the screen is allowed to act as a screen, which will happen as long as it is well bypassed to ground—therefore we must NOT use a variable screen-bypass. This leaves us the choice of varying the screen voltage, varying the plate voltage or varying an r. f. bypass in the plate circuit. By offhand inspection of the equation one might conclude that these three methods are equally good and the choice depends on the mu of the tube, and its loading. This would be correct in comparing the two voltage-control methods but it is bad judgment to conclude that the condenser-control method is allright because the equation has nothing bad to say about. Recollect that we told the equation that we were going to use a RESISTANCE plate load—and it isn't fair to ask it to prophecy about things it never heard of, such as capacity-reactances in the plate load.

# GOING DOWN!

## Short Wave Radio on Quasi-Optic Waves Below 10 Meters

### *By* James Millen

A new idea in radio design! Quasi-optic apparatus is unconventional in both appearance and results

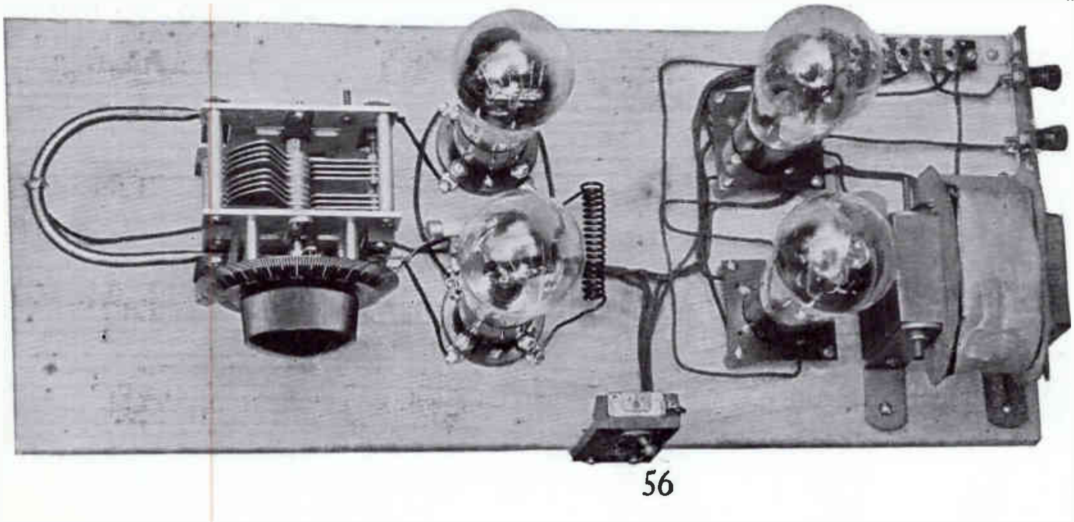
UNTIL a very few years ago, two hundred meters was a short wave. As a matter of fact it was considered about the minimum wavelength practical for radio communication. Today, the bulk of the world's wireless transmission is carried on between 10 and 150 meters. As the short waves became shorter, a limit was again placed on the highest useful frequency, and it was generally conceded that wavelengths under 10 meters would be useless for signal carrying purposes. Today, with the opening of the new nether region, The International Technical Consulting Committee on Radio has not merely admitted the utility of still shorter wavelengths, but has circumvented the possibility of another temporary limitation by including all frequencies between 30,000 kc. and those of heat waves in a possibly useful category, and has designated them as quasi-optical frequencies —wavelengths which behave more or less like light.

At the present time this wavelength range—from 10 meters to 2 x $10^{-6}$ meter—has been spanned. The range from 10 to 2 meters can be readily covered by fairly conventional systems employing the familiar tube oscillators, and the utility of these wavelengths for communication purposes has been definitely established. For still shorter wavelengths, different methods of generation are employed, and spark harmonics have been generated having wavelengths as low as .03 millimeter.

Wavelengths below 10 meters are "optical" in the sense that, like light, they follow more or less of a straight line, and cast definite shadows. They do not bend around obstacles or follow the curvature of the earth as do the frequencies with which we are familiar. Also, they possess a greater power of penetration, and, therefore, are not reflected or refracted to any great extent, by the Kennelly-Heaviside layer, and communication is limited approximately to points between which it would be possible to transmit light under perfect weather conditions. However, these short waves are quite independent of weather and will penetrate cloud and fog for hundreds of miles. This, too, is a familiar optical phenomenon, as the general tendency toward diffusion increases with the frequency. For instance, the sky appears blue, due to the fact that the blue light, of high frequency in the visible spectrum, is diffused in the atmosphere. Red light, of lower frequency, does not suffer so from diffusion, and is therefore better able to penetrate fog. Infra red is still more effective, and by means of this lower frequency the exact position of the sun may be detected by a photo cell through the heaviest clouds and used for navigating.

However, even in clear weather, the quasi-optical waves have the advantage over light waves, due to a slight diffraction, with increased range, and the higher efficiencies which can be obtained. When an incandescent lamp, or an arc, is lighted, only a small amount of the power is radiated as light. Most of it is dissipated as heat, a little remains for communication purposes. However, with the short radio waves, a considerably greater percentage of the power input is radiated, and very low powers may be used for consistent communication over distances exceeding 100 miles. Also, nature finds it difficult to generate these quasi-optical frequencies, and they are therefore remarkably free from static and similar noise. In 10 meter tests at Berlin, the noise level was only 1/10th that experienced on the regular broadcast frequencies. Due to the fact that there is practically no reflection, reception being the result of the direct ground wave without interference patterns, reception is unmarred by fading.

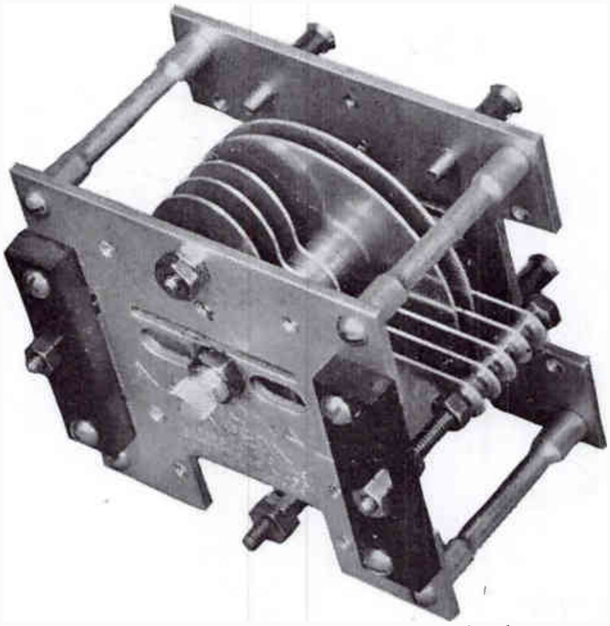
In answer to the very general need for theoretical and practical information on these ultra short wave transmitters and receivers, the publishers of this book have prepared a companion volume *The Manual of ULTRA SHORT WAVE RADIO*. It contains 64 pages, 120 illustrations, and a complete digest of practically everything that has been published on the subject. Sufficient details are given to enable the amateur and experimenter to build ultra short wave stations.



Ultra short wave transmission and reception opens a fascinating new field to the amateur and experimenter. This transmitter is an example of the breadboard type—familiar, yet different

# of C sub I WAVE Sets

## Consideration



In receivers using triode detector it is often desirable to use a condenser having a high minimum capacity

control is important, and it is frequently useful in simplifying the operation of a receiver designed to be handled by inexperienced persons, we first must take all the steps that present design practice has shown to be desirable.

### *Eliminate Reactances*

First all reactance changes in the actual R. F. circuit should be eliminated, T and C1 both must be fixed. Therefore all methods of regeneration control affecting either must be disregarded. Our remaining regeneration control becomes B voltage control by means of variable resistor or potentiometer (limiting our case to triode tubes for the moment). This causes but one change affecting anything likely to detune the tuned circuit; it changes rp the internal resistance of the tube and hence changes Ci somewhat. rp is one of the factors whose action in the formula is multiplied by Cgp to give a final value of Ci. But also the formula shows that if Cgp is increased Ci variations become proportionally larger.

Therefore, once we have eliminated every variation except that in rp we can reduce the effect of rp changes by reducing Cgp. The lowest Cgp we can get is composed of the actual tube capacity, the capacity of the socket it plugs into and the capacity of the wiring attached to it. Of these things we have control of only (1), the wiring—and (2), the coil which is of course a part of the wiring. The capacity of L to T in Fig. 2 can increase the capacity of grid to plate. So likewise can the capacity of wires leading to grid and plate.

### *Shortening Leads*

Experimentally I altered one receiver from a normal baseboard layout to an arrangement whereby the tube hung horizontally from the adjacent coil-socket. The outfit had condenser control of regeneration, C1 of Fig. 2 was variable, there was no R1, so this was kept temporarily. By this means the total lead from coil to plate consisted of two soldering lugs or a "wire" length of three-quarter inch. Previously it had been a piece of wire two and one-half inches long having relation to a grid wire about three inches long including the grid-condenser. Under the original conditions the regeneration control "tuned out" a beatnote in three and one-half dial divisions (100 division dial). After the change the regeneration control required eleven and one-half divisions to tune out a beatnote. However, simply putting in an R1 for resistance regeneration control, not rewiring as in Fig. 3, will make as much improvement as that; whereas the final change with the short leads plus R1 results in a regeneration control (with C1 fixt) that will not complete its detuning in less than a half turn of the R1 knob.

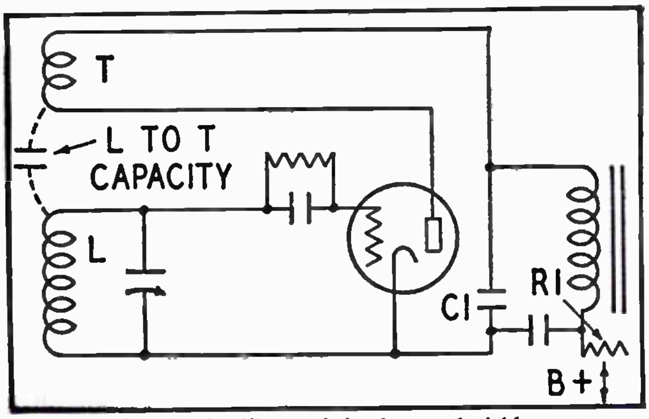



Figure 2—The familiar and fundamental tickler regenerative circuit with the inter-coil capacity indicated symbolically

### *Triode Detection*

In receivers using triode detectors the detuning effect can be further reduced merely by choosing the tube having the lowest interelectrode capacitances, such as the 199 and by using a tuning condenser with a large minimum capacity such as the General Radio 557 or by deliberately aiding the tuning condenser mimimum by increasing the circuit overall minimum through the addition of capacity in the vicinity of 25 to 50 picofarads.

What about the screengrid tetrode detector such as the '24 of '32?

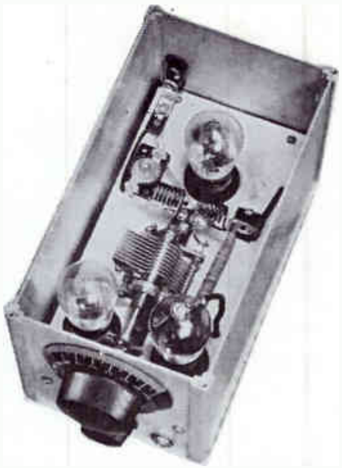
### *Screen Grid Detection*

Again we wish to avoid tuning effect which is the same thing we must keep Ci from varying. Looking at our equation again we see that this means that both of the right-side parts of the equation must be kept constant and preferably small. There is no need to worry about Cgf for it was built small by bringing the grid into the top of the tube. As for the other parts of the right side of the equation, Cgp will be small and constant as long as the screen is allowed to act as a screen, which will happen as long as it is well bypassed to ground—therefore we must NOT use a variable screen-bypass. This leaves us the choice of varying the screen voltage, varying the plate voltage or varying an r. f. bypass in the plate circuit. By offhand inspection of the equation one might conclude that these three methods are equally good and the choice depends on the mu of the tube, and its loading. This would be correct in comparing the two voltage-control methods but it is bad judgment to conclude that the condenser-control method is allright because the equation has nothing bad to say about. Recollect that we told the equation that we were going to use a RESISTANCE plate load—and it isn't fair to ask it to prophecy about things it never heard of, such as capacity-reactances in the plate load.

# GOING DOWN!

## Short Wave Radio on Quasi-Optic Waves Below 10 Meters

*By* James Millen



A new idea in radio design! Quasi-optic apparatus is unconventional in both appearance and results

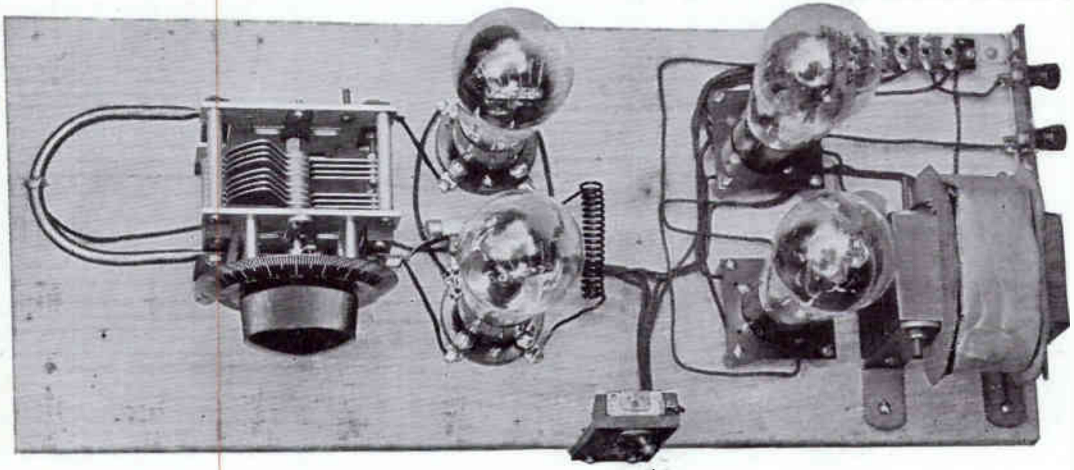
UNTIL a very few years ago, two hundred meters was a short wave. As a matter of fact it was considered about the minimum wavelength practical for radio communication. Today, the bulk of the world's wireless transmission is carried on between 10 and 150 meters. As the short waves became shorter, a limit was again placed on the highest useful frequency, and it was generally conceded that wavelengths under 10 meters would be useless for signal carrying purposes. Today, with the opening of the new nether region, The International Technical Consulting Committee on Radio has not merely admitted the utility of still shorter wavelengths, but has circumvented the possibility of another temporary limitation by including all frequencies between 30,000 kc. and those of heat waves in a possibly useful category, and has designated them as quasi-optical frequencies —wavelengths which behave more or less like light.

At the present time this wavelength range—from 10 meters to $2 \times 10^{-6}$ meter—has been spanned. The range from 10 to 2 meters can be readily covered by fairly conventional systems employing the familiar tube oscillators, and the utility of these wavelengths for communication purposes has been definitely established. For still shorter wavelengths, different methods of generation are employed, and spark harmonics have been generated having wavelengths as low as .03 millimeter.

Wavelengths below 10 meters are "optical" in the sense that, like light, they follow more or less of a straight line, and cast definite shadows. They do not bend around obstacles or follow the curvature of the earth as do the frequencies with which we are familiar. Also, they possess a greater power of penetration, and, therefore, are not reflected or refracted to any great extent, by the Kennelly-Heaviside layer, and communication is limited approximately to points between which it would be possible to transmit light under perfect weather conditions. However, these short waves are quite independent of weather and will penetrate cloud and fog for hundreds of miles. This, too, is a familiar optical phenomenon, as the general tendency toward diffusion increases with the frequency. For instance, the sky appears blue, due to the fact that the blue light, of high frequency in the visible spectrum, is diffused in the atmosphere. Red light, of lower frequency, does not suffer so from diffusion, and is therefore better able to penetrate fog. Infra red is still more effective, and by means of this lower frequency the exact position of the sun may be detected by a photo cell through the heaviest clouds and used for navigating.

However, even in clear weather, the quasi-optical waves have the advantage over light waves, due to a slight diffraction, with increased range, and the higher efficiencies which can be obtained. When an incandescent lamp, or an arc, is lighted, only a small amount of the power is radiated as light. Most of it is dissipated as heat, a little remains for communication purposes. However, with the short radio waves, a considerably greater percentage of the power input is radiated, and very low powers may be used for consistent communication over distances exceeding 100 miles. Also, nature finds it difficult to generate these quasi-optical frequencies, and they are therefore remarkably free from static and similar noise. In 10 meter tests at Berlin, the noise level was only 1/10th that experienced on the regular broadcast frequencies. Due to the fact that there is practically no reflection, reception being the result of the direct ground wave without interference patterns, reception is unmarred by fading.

In answer to the very general need for theoretical and practical information on these ultra short wave transmitters and receivers, the publishers of this book have prepared a companion volume *The Manual of ULTRA SHORT WAVE RADIO*. It contains 64 pages, 120 illustrations, and a complete digest of practically everything that has been published on the subject. Sufficient details are given to enable the amateur and experimenter to build ultra short wave stations.



Ultra short wave transmission and reception opens a fascinating new field to the amateur and experimenter. This transmitter is an example of the breadboard type—familiar, yet different

# RADIO TIME *the World Over*

**TIME AND DAY CONVERSION TABLE**

TODAY — TOMORROW

| Longitude | | Place | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAST | 180 | Fiji Islands | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | 165 | New Zealand (*) | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 150 | Australia, east | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 135 | Japan | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 120 | China, Philippines | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | 105 | Indo China, Straits Settlements | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| | 90 | Calcutta (**) | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 |
| | 75 | | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 |
| | 60 | Mauritus, Seychelles | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 |
| | 45 | Aden, Somaliland, Madagascar | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 |
| | 30 | South Africa | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 |
| | 15 | Germany, Italy, Norway, Sweden | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 |
| | 0 | England, France, G.M.T. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 15 | | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | 30 | | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 45 | Brazil, east | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 60 | Agentina, Porto Rico | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | 75 | Washington, D. C., E.S.T. | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 90 | Chicago, C.S.T. | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 105 | Denver, M.S.T. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | 120 | San Francisco, P.S.T. | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 135 | | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | 150 | Alaska | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| | 165 | Samoa, Hawaii (***) | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| WEST | 180 | | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

YESTERDAY — TODAY

NOTES:—(*) Add one-half hour for New Zealand Time.
(**) Calcutta local time. Subtract one-half hour for India Standard Time.
(***) Subtract one-half hour for Hawaiian Standard Time.

NOTES:—0 is midnight, 1 is 1.00 A.M., etc. 12 is noon, 13 is 1.00 P.M., 15 is 3.00 P.M., etc.
Read the figure columns vertically, thus:—when it is 12, noon on Monday in New York E.S.T., it is 3.00 A.M. on Tuesday in Melbourne, Australia.
Or again; 11.00 P.M. on Sunday in San Francisco is 6.30 P.M. on Monday in New Zealand and 5.00 P.M. in Australia.
The hours of darkness—6 P.M. to 6 A.M. are shaded

TUNING a short wave set is entirely different than tuning a regular broadcast receiver. A great many details make up this difference, as high frequencies or short waves have characteristics entirely unlike the long waves. Receivers, too, are made somewhat different inasmuch as the wavebands covered must be compensated for by different coils and not just one set of coils. All in all, it is simply a matter of the operator learning how to tune his set. A good receiver does not solve the question of results on short waves, for the operator must learn something about short waves and their peculiarities also. Once this is mastered, it is just as simple to get distant stations under ordinary circumstances as to get local stations.

The first thing a new listener should do is to log as many local stations as possible and mark down their dial settings. Since stations do not appear on every part of the dials, these stations will act as guides to locating distant stations. The operator should also find just what each dial on his set does when tuned, and what effect they have on the stations once they are tuned in. Locating the spot where stations are heard the best is a good idea.

In "fishing" for stations, the listener should time his reception, or tune on certain wavelengths at certain times of the day. From 14 to 20 meters all tuning should be done from daybreak till 3 P.M. local time. From 20 to 33 meters, stations to the east of the listener will be heard best from about 11 A.M. till 10 P.M. Stations to the west of the listener in this band should be heard best from midnight till about two hours after daybreak, when they will fade out. From 33 to 70 meters, distant stations can be heard only after darkness falls. Very little in the way of distance can be heard above 70 meters, although the ships, police, fire, coast guard and aircraft stations are all heard above that wavelength.

Short wave stations have a habit of changing in volume from time to time, these changes being affected mostly by the amount of daylight between the stations and the listener. For example, European stations are always best for American listeners during the summer months. In reverse, South Americans are best during the winter months. Each year we hear from hundreds of listeners arguing that winter months are best for distant reception and others that summer months are best. It depends mostly on the habits of the listener and his location. By habits we mean, the stations he generally tunes for. There is not the least doubt that European stations are best during the summer months and stations like G5SW, 12RO, PCJ, Zeesen and OXY are best during these months.

Difference in time is one thing which is hard for short wave fans to understand. Listening to "Big Ben" strike midnight at 7:00 P.M. in New York brings this to mind, but still listeners who fail to hear this station at 8:00 P.M. wonder why it is not found. Almost all stations broadcast at times to conform with time in their part of the world. Europeans, with the exception of PCJ, who broadcasts special programs for American and Australian listeners at times, close down as early as 6:00 P.M. South Americans are heard from then on till midnight, Eastern Standard Time. Stations in Siam, Japan and that part of the world get busy while New Yorkers are thinking about breakfast, and people in Japan are getting ready to go to bed. It is therefore quite natural that listeners should tune for European stations in the afternoons providing they live in the United States and tune for stations in the Antipodes, in the early mornings. Always keep a good station list on hand.

A few pointers for new listeners are:

*Don't* expect to find stations on all parts of the dials. Short wave stations are widely separated except in a very few places.

*Don't* expect stations to tune broadly. Most distant stations tune very sharp.

*Don't* expect to hear the world the first day you tune. It requires some knowledge of tuning to get excellent results.

*Don't* expect to hear a station simply because it is on the air. Many things govern short wave reception.

*Don't* get discouraged. If reception is poor one day, it may be fine the next.

*Don't* skim over the dials. Tune slowly.

*Don't* pass up any weak signals. Oftimes a weak program can be brought out plainly by a careful tuning.

*Don't* tune for stations when they are not on the air. Use the station list.

*Don't* tune haphazardly. Learn where stations should be found on the dials of your particular receiver.

*Don't* tune above 33 meters for distant stations in daylight.

*Don't* tune below 25 meters for distant stations after dark.

# Short-Wave Station List

## *Broadcast - Phone - Television*

| Wave-length | Fre-quency | Call | Location | Service and Time |
|---|---|---|---|---|
| 9.68 | 31,000 | W8XI | Pittsburgh, Pa. | Phone to Rome |
| 9.96 | 30,105 | ...... | Golfo Aranci, Sardinia | Broadcast, Wd. & Sat. 5:50—7:50 A.M. |
| 13.04 | 23,000 | W2XAW | Schenectady, N. Y. | Broadcast. Relays KDKA |
| 14.01 | 21,400 | WLO | Ocean Township, N. J. | Phone to LMS, Buenos Aires 6 A.M.—4 P.M. |
| 14.15 | 21,130 | LSN | Monte Grande, Argentina | Phone 10 A.M.—2 P. M. |
| 14.50 | 20,680 | LSN-LSH | Monte Grande, Argentina | Phone to Europe. 10:30 P.M. |
| 14.50 | 20,680 | FSR | Paris, France | Phone to Saigon |
| 14.55 | 20,620 | PMB | Bandoeng, Java | Mon., Wed., Thurs., Sat. 5:40—10:40 A.M. |
| 14.62 | 20,500 | W9XF | Chicago, Ill. | Broadcast (WENR) |
| 14.65 | 20,450 | PMB | Malabar, Java | Phone. 10:00 A.M.; 3:00 P.M. |
| 14.70 | 20,400 | GBP | Rugby, England | 6 A.M.—2 P.M. Ships. |
| 15.03 | 19,950 | LSG | Monte Grande, Argentina | Phone to Paris and Nauen. 9:00 A.M.; 1 P.M. |
| 15.03 | 19,950 | DIH | Nauen, Germany, | Phone |
| 15.07 | 19,906 | LSG | Buenos Aires, Argentina | Phone to FTM—10:30 A.M.—3:30 P.M. |
| 15.07 | 19,906 | ...... | Monte Grande, Argentina | Phone to St. Assise 8 to 10 A.M. |
| 15.12 | 19,830 | FTU FTD | St. Assise, France | Phone |
| 15.14 | 19,780 | WMI | Deal, N. J. | Phone to GBU, Rugby, 6 A.M. 4 P.M. GBU |
| 15.30 | 19,600 | DFA-DIH | Nauen, Germany | Phone |
| 15.45 | 19,420 | FRO-FRE | St. Assise, France | Phone |
| 15.50 | 19,355 | ...... | Nancy, France | Broadcast, 4 to 5 P.M. |
| 15.50 | 19,355 | FTM | St. Assise, France | 10 A.M.—2 P.M. |
| 15.50 | 19,355 | PCP | Kootwijk, Holland | Phone |
| 15.50 | 19,355 | VK2ME | Sydney, Australia | Phone |
| 15.55 | 19,300 | FTM | St. Assise, France | Broadcast. 10 A.M. to Noon. |
| 15.57 | 19,250 | PPU | Rio de Janeiro, Brasil | Phone to FTM. 10:30 A.M.—3 P.M. |
| 15.60 | 19,220 | WNC | Deal, N. J. | Phone to GBU, Rugby. 6 A.M.—4 P.M. |
| 15.68 | 19,100 | TCO | Kootwijk, Holland | Phone. |
| 15.85 | 18,900 | XDA | Mexico City, Mexico | Phone 4 P.M. |
| 15.94 | 18,820 | PLE | Bandoeng, Java | Phone daily 10 A.M.—3 P.M. Tuesday 1:40—3:40 P.M. |
| 16.10 | 18,620 | GBJ | Bodmin, England | Phone to Montreal |
| 16.11 | 18,610 | GBU | Rugby, England | Phone to WMI 6 A.M.-2 P.M. |
| 16.12 | 18,600 | PDM | Kootwijk, Holland | Phone. |
| 16.30 | 18,400 | PCK | Kootwijk, Holland | Broadcast Daily 1 to 6:30 A.M. |
| 16.32 | 18,365 | FZA | Saigon, Indo-China | Phone to St. Assise, 6-8 P.M. Sun. |
| 16.35 | 18,350 | WND | Deal Beach, N. J. | Trans-Atlantic Phone. 6 A. M.-4 P. M. GBS |
| 16.35 | 18,350 | GBS | Rugby, England | Phone to N. Y. (To WND) 6 A.M. -2 P. M. |
| 16.38 | 18,310 | FZS | Saigon, Indo-China | Broadcast. 1-3 P.M. Sundays. |
| 16.44 | 18,240 | FTE | St. Assise, France | Phones to FZR—5-9 A. M. |
| 16.44 | 18,240 | FRO-FRE | St. Assise, France | Phone to Saigon. 8-9 A.M. |
| 16.50 | 18,170 | CGA | Drummondville, Ont., Can. | Phone to GBK, England 6 A.M.-2 P.M. |
| 16.52 | 18,150 | PMC | Bandoeng, Java | Phone to PCK—6-10 A.M. |
| 16.54 | 18,130 | GBW | Rugby, England | Phone to WNC 6 A.M.-2 P.M. |
| 16.57 | 18,120 | GBK | Bodmin, England | Phone to CGA 6 A.M.-2 P.M. |
| 16.60 | 18,070 | PCS | Kootwijk, Holland | Phone. |
| 16.61 | 18,060 | KQJ | Bolinas, Calif. | Phone. |
| 16.80 | 17,850 | PLF | Bandoeng, Java | Broadcast. |
| 16.30 | 17,850 | W2XAO | New Brunswick, N. J. | Phone. 11 A.M.-3 P.M. |
| 16.82 | 17,830 | PCV | Kootwijk, Holland | 6-9 A.M. Java. |
| 16.87 | 17,780 | W8XK | East Pittsburgh, Pa. | Relays KDKA |
| 16.87 | 17,780 | K7XI | Nautilus | Broadcast |
| 16.90 | 17,750 | HSITJ | Bangkok, Siam | Broadcast. Sundays 7-9:30 A.M.; 1-3 P.M. |
| 17.05 | 17,750 | GDLJ | S.S. "Homeric" | Phone. |
| 17.05 | 17,750 | GMJQ | S.S."Belgenland" | Phone. |
| 17.05 | 17,750 | GLSQ | S.S. "Olympic" | Phone. |
| 17.05 | 17,750 | WSBN | S.S. "Leviathan' | Phone. |
| 17.10 | 17,520 | G2IV | S.S. "Majestic" | Phone. |
| 17.34 | 17,300 | W2XK | Schenectady, N. Y. | Broadcast. Tues., Thurs., Sat. Noon to 5 P.M. |
| 17.52 | 17,110 | WOO | Deal, N. J. | Trans-Atlantic Phone. |
| 18.10 | 16,550 | G2AA | London, England | Phone to Ships. |
| 18.30 | 16,380 | G2GN | S.S. "Olympic" | Phone. |
| 18.37 | 16,320 | VLK | Sydney, Australia | Phone to England. |
| 18.40 | 16,300 | PCL | Kootwijk, Holland | Phone to Java. 10 A.M.-2 P.M. Broadcast. Sat. 1:40-2 P.M. |
| 18.44 | 16,250 | WLO | Lawrence, N. J. | Phone to LSM. 8 A.M.-4 P.M. |
| 18.50 | 16,200 | FZR | Saigon, Indo-China | Phone to St. Assise (also on 18.76) 11 A.M.-12 Noon. |
| 18.56 | 16,165 | GBX | Rugby, England | Broadcast 4-11 P.M. |
| 18.80 | 15,950 | PLG | Bandoeng, Java | Broadcast. |
| 18.90 | 15,875 | FTK | St. Assise, France | Phones to FZS 9-10 A.M. |
| 19.00 | 15,760 | EAJI | Barcelona, Spain | Phone to Buenos Aires |
| 19.50 | 15,375 | F8BZ | Paris, France | French phone to ships. |
| 19.56 | 15,340 | W2XAD | Schenectady, N. Y. | Relays WGY. 1-3 P.M. |
| 19.72 | 15,210 | W8XK | Pittsburgh, Pa. | Relays KDKA Wed. & Sat. 1-4 P.M. Broadcast Tues., Thurs., Sat. 8 A.M. to Noon. |
| 19.78 | 15,160 | K7XI | Nautilus | Broadcast (Trans-Arctic Submarine Corp.) |
| 19.83 | 15,120 | HVJ | Vatican City (Rome) | Broadcast. |
| 19.99 | 15,010 | CM6XJ | Central Tuinucu, Cuba | Relays Broadcast. |
| 19.99 | 15,010 | LSJ | Monte Grande, Argentina | Phone to WLO and Madrid. |
| 20.50 | 14,620 | WMI | Deal, N. J. | Phone to GBW 6 A.M.-6 P.M. |
| 20.50 | 14,620 | XDA | Mexico City, Mexico | Broadcast. 2:30-3 P.M. |
| 20.70 | 14,480 | GBW | Rugby, England | 9 A.M.-4 P.M. WNC. |
| 20.73 | 14,470 | WMC | Deal, N. J. | 6 A.M.-6 P.M.. GBW. |
| 20.80 | 14,420 | VPD | Suva, Fiji Islands | Broadcast. 10 P.M.-7 A.M. |
| 20.90 | 14,340 | G2NM | Sonning, England | Broadcast, Sundays 1:30-3 P.M. Monday 5-6 P.M. |
| 21.50 | 13,940 | ...... | Bucharest, Roumania | Broadcast. Wed. & Sat. 2-5 P.M. |
| 22.14 | 13,620 | F8BZ | Paris, France | Phone to ships. |
| 22.38 | 13,400 | WND | Deal Beach, N. J. | Trans-Atlantic Phone. 6 A.M.-6 P.M. |
| 22.50 | 13,325 | GFWV | S.S. "Majestic" | Phone. |
| 22.50 | 13 325 | GLSQ | S.S. "Olympic" | Phone. |
| 22.68 | 13,225 | ...... | S.S. "Belgenland" | Phone. |

| Wave-length | Fre-quency | Call | Location | Service and Time |
|---|---|---|---|---|
| 22.68 | 13,225 | ...... | S.S. "Homeric" | Phone. |
| 22.68 | 13,225 | ...... | S.S. "Leviathan" | Phone. |
| 23.00 | 13,200 | ...... | Rabat, Morocco | 8-9 A.M. Tues., Thurs. & Sat. Broadcast. |
| 23.00 | 13,200 | ...... | S.S. "Hamburg" | Phone. |
| 23.35 | 12,850 | ...... | Buenos Aires, Argentina | Phone to Spain. |
| 23.35 | 12,850 | W2XO | Schenectady, N. Y. | Broadcast. Noon-5 P.M. also 9 P.M. Monday to 3 A.M. Tues. |
| 23.86 | 12,630 | ...... | Rabat, Morocco | Broadcast. 8-9 A.M. 4-6 A.M. Tues., Thurs. & Sat. |
| 24.00 | 12,490 | G2GN | S.S. "Olympic" | Phone. |
| 24.23 | 12,350 | GDLJ | S.S. "Homeric" | Phone. |
| 24.40 | 12,295 | PLM | Bandoeng, Java | Phones to PCK. 5-9 A.M. |
| 24.41 | 12,290 | GBU | Rugby, England | 2-7 P.M. WMI. |
| 24.46 | 12,250 | FTN | St. Assise, France | Broadcast. 9 A.M.-1 P.M. Works Buenos Aires, Indo-China and Java. Phone to Rabat—5-9A.M. |
| 24.46 | 12,250 | KIXR | Manila, Philippine Islands | Broadcast. 5-9 A.M. except Sun. |
| 24.68 | 12,150 | GBS | Rugby, England | Trans-Atlantic phone to Deal, N.J. 4-9 A.M. VK2ME-VLK. 2-7 P.M. WND. |
| 24.80 | 12,090 | ...... | Tokio, Japan | Broadcast. 5-8 A.M. |
| 24.89 | 12,045 | NAA | Arlington, Va. | 8:55 A.M.-9:55 P.M. Broadcast time signals twice daily |
| 24.98 | 12,000 | FZR | Saigon, Indo-China | 5-6 A.M. 11 A.M.-12. Broadcast. |
| 24.98 | 12,000 | ...... | Oporto, Portugal | 8-9 A.M. 3-4 P.M. 6-9 P.M. Broadcast. |
| 25.24 | 11,880 | W8XK | Pittsburgh, Pa. (KDKA) | Noon—5 P.M. Tues., Thurs., Sat. Sun. (See note) Broadcast. |
| 25.24 | 11,880 | VUC | Calcutta, India | Broadcast. 8-10 A.M. |
| 25.34 | 11,840 | W2XE | New York | Broadcast. 8 A.M.-midnight. |
| 25.34 | 11,840 | W9XAA | Chicago, Ill. | 7-8 A.M., 1-2-4-5-6-7:30 P.M. |
| 25.42 | 11,800 | UOR2 | Vienna, Austria | Broadcast. 5-7 A.M. Wed. & Thurs., also on Tues. 2 hours later in day. |
| 25.50 | 11,765 | XDA | Mexico City, Mexico | Broadcasts. 3-4 P.M. daily. |
| 25.53 | 11,750 | PK6K | Makassar, Celebes | 6:40-9:40 A.M. Broadcast. |
| 25.53 | 11,750 | G5SW | Chelmsford, England | 7:30-8:30 A.M. daily; 2-7 P.M. daily except Sat. & Sunday Broadcast |
| 25.62 | 11,710 | K7XI | Nautilus | Broadcast. |
| 25.68 | 11,670 | KIO | Kahuku, Hawaii | Phone. |
| 26.00 | 11,530 | CGA | Drummondville, Ont., Can. | Phone. |
| 26.20 | 11,440 | KIXR | Manila, P. I. | Broadcast. 11:15-12:15 P.M.; 2-4 A.M.; 5-10 A.M. |
| 26.22 | 11,435 | DHC & DHA | Nauen, Germany | Broadcast. 5 P.M. Fri., Sat. & Sun. |
| 26.52 | 11,430 | DDDX | S.S. "Bremen" | Phone. |
| 26.70 | 11,230 | IBDX | S.S. "Elettra" | Marconi's Yacht. |
| 27.00 | 11,100 | OUITH | Vienna, Austria | 5:30-7 P.M. Broadcast Mon. & Thurs. |
| 27.27 | 11,000 | ...... | Posen, Poland | Broadcast. 11:30 A.M. to 5:30 P.M. |
| 27.5 | 10,800 | PCP | Kootwijk, Holland | Phone. |
| 28.00 | 10,700 | VAS | Glace Bay, N. S. | Broadcast. 5 A.M. to 2 P.M. |
| 28.8 | 10,400 | PLR | Malabar, Java | Phone. 6-10 A.M. |
| 28.20 | 10,630 | PLR | Bandoeng, Java | Broadcast. 7 A.M. Works with Holland and France. Starting time sometimes 2.5 hours later. |
| 28.50 | 10,510 | VK2ME | Sydney, Australia | Broadcast. 1-7 A.M. |
| 28.98 | 10,350 | LSX | Buenos Aires, Argentina | Broadcasts 7-9 P.M. |
| 29.00 | 10,340 | ...... | Paris, France | Broadcast. 1:30-3 P.M. Daily. 9 A.M. Sundays. |
| 29.00 | 10,330 | PCT | Kootwijk, Holland | Phone to S.S. "Columbia" near 1 P.M. |
| 29.15 | 10,300 | LSN | Buenos Aires, Argentina | Phone to GBP, FTN and Rabat. |
| 29.30 | 10,237.5 | TI4 | Heredia, Costa Rica | Broadcast. 10-11 P.M. |
| 29.47 | 10,160 | DHC | Nauen, Germany | Phone. |
| 29.98 | 10,000 | ...... | Belgrade, Jugo Slavia | Broadcast. 3-4 P.M. Monday. |
| 30.3 | 9,900 | LSN | Buenos Aires, Argentina | 6 P.M.—6 A.M. WLO. |
| 30.15 | 9,840 | FTL | St. Assise, France | Phone. |
| 30.15 | 9,840 | GBU | Rugby, England | 5-11 P.M. WMI. |
| 30.4 | 9,860 | EAO | Madrid, Spain | Phone. |
| 30.4 | 9,870 | WMI | Deal, N. J. | 4 P.M.-5 A.M. GBU. |
| 30.57 | 9,810 | LSOR | Buenos Aires, Argentina | Broadcasts 6-9 P.M. |
| 30.6 | 9,805 | GBW | Rugby, England | 5-10 P.M. WNC. |
| 30.75 | 9,750 | ...... | Agen, France | Broadcast. 3-4:15 P.M. Tues., Fri. |
| 30.77 | 9,750 | ...... | Deal, N. J. | 4 P.M.—5 P.M. GBW. |
| 31.10 | 9,640 | ...... | Monte Grande, Argentina | Broadcast. 10:30 P.M. |
| 31.26 | 9,600 | PCJ | Hiverson, Holland | Broadcast. Thurs. & Fri. 1-3 P.M. 6-10 P.M. Thur. |
| 31.28 | 9,580 | W3XAU | Byberry, Pa. | Broadcast. 4 P.M. 12 midnight daily except Thursday. |
| 31.28 | 9,580 | PCJ | Eidhoven, Holland | Wed. 12-3 P.M.; Thurs. 9 A.M.-1 P.M.; Fri. 5-9 P.M.; Sat. 1-3 P.M. |
| 31.35 | 9,570 | W1XAZ | Springfield, Mass (WBZ) | Broadcast. 7:30 A.M., 11 P.M. |
| 31.36 | 9,560 | NAA | Arlington, Va. | Broadcast. 3-7:30 P.M. |
| 31.48 | 9,530 | W2XAE | Schenectady, N. Y. | Broadcast. |
| 31.48 | 9,530 | K7XI | Nautilus | Broadcast. |
| 31.56 | 9,500 | OZ7RL | Copenhagen, Denmark | Broadcast. 7 P.M. |
| 31.60 | 9,490 | OXY | Lyngby, Denmark | Broadcast 2-6:30 P.M. |
| 31.80 | 9,430 | ...... | Posen, Poland | Broadcast. Tues. 1:45-4:45 P.M.; 1:30-8 P.M. Thursday. |
| 32.00 | 9,375 | EH9OC | Berne, Switzerland | Broadcast. 3-5:30 P.M. |
| 32.1 | 9,345 | CGA | Drummondville, Can. | Broadcast. 6 P.M.-6 A.M. GBK. |
| 32.06 | 9,350 | CM2MK | Havana, Cuba | Broadcast. 5-9 P.M. |
| 32.26 | 9,300 | ...... | Rabat, Morocco | Broadcast. Sun. 3-5 P.M. |
| 32.4 | 9,255 | GBK | Bodman, England | Broadcast. 6 P.M., 6 A.M. CGA. |
| 32.50 | 9,230 | FL | Paris, France | Broadcast. 4:56 A.M. Time Signals daily. 4-56 P.M. Last 4 min. |
| 32.59 | 9,110 | SUS | Rugby, England | Transatlantic Phone. |
| 32.70 | 9,175 | WND | Deal, N. J. | Broadcast. 5 P.M.; 10 A.M. GBS. |
| 32.85 | 9,130 | HB9OC | Berne, Switzerland | Broadcast. 6:30 A.M.-5 P.M. |
| 33.00 | 9,090 | VK3ME | Melbourne, Australia | Broadcast. 4-6 A.M. |
| 33.25 | 9,020 | GBS | Rugby, England | Broadcast. 6 P.M.-6 A.M. WND. |
| 33.70 | 8,900 | ...... | Posen, Poland | Broadcast. 11:30 A.M.-5 P.M. Sunday and Wednesday |
| 33.81 | 8,872 | NPO | Cavite, P.I. | Broadcast. 9:55 P.M. Time Signals |

| Wave-length | Fre-quency | Call | Location | Service and Time |
|---|---|---|---|---|
| 33.95 | .... | GFWU | S.S. "Majestic" | Phone. |
| 33.95 | .... | GLSQ | S.S. "Olympic" | Phone. |
| 33.95 | 8,835 | GMJQ | S.S. "Belgenland" | Phone. |
| 33.95 | .... | GDLJ | S.S. "Homeric" | Phone. |
| 33.95 | .... | WSBN | S.S. "Leviathan" | Phone. |
| 34.00 | 8,820 | VK3UZ | Melbourne, Australia | Broadcast. 3-5 A.M. Mon. & Wed. |
| 34.50 | 8,690 | HKF | Bogota, Colombia | Broadcast. 5-7 P.M., 11 P.M. to 1 A.M. |
| 34.68 | 8,650 | W2XCU | Ampere, N. J. | Broadcast. Mon. 7-9 P.M. |
| 34.68 | 8,650 | W3XE | Baltimore, Md. | Broadcast. 12:15-1:15 P.M.; 10:15-11:15 P.M. |
| 34.68 | 8,650 | W2XU | Long Island City, N. Y. | Broadcast. Wed., Fri. 8-10 P.M. |
| 35.54 | 8,440 | G2AA | London, England | Phone to ships. |
| 35.70 | 8,400 | VBS | Khabarovsk, Siberia | Broadcast. 5-7:30 A.M. |
| 36.4 | 8,240 | ...... | S.S. "Columbia" | Phone approximately at 1 A.M. |
| 36.74 | 8,160 | ...... | Leningrad, Russia | Broadcast. 2-6 A.M. Mon. Tues., Thurs., Friday. |
| 37.02 | 8,100 | EATH | Bandoeng, Java | Broadcast. 6-10 A.M. |
| 37.02 | 8,100 | JIAA | Vienna, Austria | Broadcast. 5:30-7 P.M. Mon., Thurs. |
| 37.36 | 8,030 | NAA | Bangkok, Siam | Broadcast. 8-10 A.M. Sunday. |
| 37.48 | 8,015 | ...... | Arlington, Va. | Broadcast. 8:55 A.M., 9:55 P.M. Time Signals twice daily, lasting 5 min. |
| 38.00 | 7,890 | VPD | Doeverits, Germany | Broadcast. 1-3 P.M. Reichpost-zentralamt Berlin. |
| 38.56 | 7,775 | F8BZ | Paris, France | Phone to ships. |
| 38.60 | 7,770 | FTF | Kootwijk, Holland | Broadcast. 9 A.M. starts at time given. |
| 39.15 | 7,660 | FTL | Kootwijk, Holland | Broadcast. 9 A.M.-7 P.M. |
| 39.40 | 7,615 | X26A | Nuevo Laredo, Mexico | Broadcast. 9-Noon. 1-2; 4-5 P.M. |
| 39.70 | 7,550 | HKF | Bogota, Colombia | Broadcast. 5-7 P.M., 11 P.M. to 1 A.M. |
| 39.80 | 7,535 | ...... | Rio Banba, Ecuador | Broadcast. Thur. 9-11 P.M. |
| 40.00 | 7,500 | ...... | Radio Touraine, France | Broadcast. 4 P.M. |
| 40.20 | 7,460 | FYR | Lyons, France | Broadcast. 10:30 to 1:30 A.M. Daily except Sunday. |
| 40.50 | 7,400 | ...... | Eberswalde, Germany | Broadcast. 1-2 P.M. Monday, Thursday. |
| 41.00 | 7,310 | ...... | Moscow, USSR | Broadcast. 7-7:45 A.M. |
| 41.10 | .... | ...... | Radio Bangkok, Siam | Broadcast. Mon. 10 A.M. to Noon. |
| 41.70 | 7,190 | VK6AG | Perth, Australia | Broadcast. 5-11:30 A.M. |
| 41.70 | 7,190 | VS1AB | Singapore. S.S. Beds. | Sun. Wed., Fri. 10:30-12 A.M. |
| 41.50 | 7,220 | HB9D | Zurich, Switzerland | Broadcast. 7 A.M. and 1 P.M. first and third Sunday. |
| 42. | 7,140 | HKX | Bogota, Colombia | Broadcast. 9-11 P.M. |
| 42.70 | 7,020 | EAR125 | Madrid, Spain | Broadcast. 6-7 P.M. |
| 42.90 | 6,995 | CT1AA | Lisbon, Portugal | Broadcast. Fri. 5-7 P.M. |
| 42.9 | 6,995 | GBS | Rugby, England | Broadcast. 6 P.M.-6 A.M. WND. |
| 43.00 | 6,980 | EAR110 | Madrid, Spain | Broadcast. 5:30-7 P.M. Tues., Sat. 7-8 P.M. Friday. |
| 43.00 | 6,980 | CT1AA | Santos, Portugal | Broadcast. 4-5 P.M. Friday. |
| 43.50 | 6,900 | IMA | Rome, Italy | Broadcast. Noon to 2:30 P.M. |
| 43.60 | 6,875 | F8MC | Casablanca, Morocco | Broadcast. Sun., Tues., Wed., Sat. |
| 43.60 | 6,875 | D4AFF | Coethen, Germany | Broadcast. 4-6 A.M. Sun. 12-2 P.M. Tues. & Fri. |
| 43.70 | 6,860 | KEL | Bolinas, California | Broadcast. 4-6 P.M. Thursdays. |
| 43.84 | 6,840 | VRY | Georgetown, British Guiana | Broadcast. 7:15-9:15 P.M. Wed. 5:45-8 P.M. Sunday. |
| 44.40 | 6,750 | WND | Deal, N. J. | Broadcast. 5 P.M.-5 A.M. GBS. |
| 46.06 | 6,430 | PCM | The Hague, Holland | Broadcast. 3-6 P.M. Sunday. 4-7 P.M. Monday and Sat. |
| 47.00 | 6,380 | CT3AG | Funchal, Madeira Islands | Broadcast. 5-7 P.M. Saturdays. |
| 47.00 | 6,380 | HC1BR | Quito, Ecuador | Broadcast. 8-11 P.M. |
| 47.00 | 6,380 | X1F | Mexico City, Mexico | Broadcast. 7-9 P.M., 11 P.M., 1 A.M. |
| 48.30 | 6,205 | HKC | Bogota, Colombia | Broadcast. 9:45-11:30 P.M. |
| 48.62 | 6,170 | HRB | Tegucigalpa, Honduras | Broadcast. 2-12 P.M. Mon., Wed., Friday. |
| 48.70 | 6,160 | VE9CL | Winnipeg, Canada | Broadcast. 5:30-11 P.M. |
| 48.70 | 6,160 | HKA | Barranquilla, Colombia | Broadcast. Tues., Thurs., Sat., Sun. 8-10 P.M. |
| 48.74 | 6,155 | W9XAL | Chicago, Ill. (WMAC) | Broadcast. 11:30-12 P.M. Sat. |
| 48.83 | 6,140 | KA1XR | Manila, P. I. | Broadcast. 3-4:30 A.M., 5-9 A.M. 2-3 A.M. Saturday. |
| 48.83 | 6,150 | W8XK | East Pittsburgh, Pa. | Broadcast. 5-12 P.M. Tues., Thurs., Sat. and Sunday. |
| 48.91 | 6,125 | 7LO | Nairobi, Kenya, Africa | Broadcast. 11 A.M.-2 P.M. |
| 48.99 | 6,120 | ...... | Motala, Sweden | Broadcast. |
| 48.99 | 6,120 | ...... | Chi-Hoa (Saigon) Indo-China | Broadcast. 6:30-7:30 A.M. |
| 48.99 | 6,120 | ...... | Toulouse, France | Broadcast. 2:30-4 P.M. Sun. |
| 48.99 | 6,120 | MTH | Rio de Janeiro, Brasil | Broadcast. 5-7 P.M. |
| 48.99 | 6,120 | EAR25 | Barcelona, Spain | Broadcast. 3-4 P.M. |
| 49.00 | 6,120 | HRB | Tegucigalpa, Honduras | Broadcast. 7-12 P.M. Sun. 8:30-9:45 P.M. |
| 49.02 | 6,120 | W2XE | New York, N. Y. | Broadcast. 8 A.M. to Midnight. |
| 49.07 | 6,110 | VVB | Bombay, India | Broadcast. 12:30-1:15P.M. Mon., Wed., Fri. |
| 49.10 | 6,110 | F3ICD | Chi-Hoa, Indo-China | Broadcast. 6:30-10:30 A.M. |
| 49.15 | 6,100 | W3XAL | Bound Brook, N. J. | Broadcast. 5-6:30 P.M., 11 P.M., 1 A.M. WJZ. |
| 49.17 | 6,095 | VE9GW | Bowmanville, Ont., Canada | Broadcast. 1:45-5 A.M. Daily. |
| 49.17 | 6,100 | W2XAL | Coytesville, N. J. | Broadcast. |
| 49.17 | 6,100 | VQ7LO | Nairobi, Kenya, Africa | Broadcast. 11 A.M.-2 P.M. |
| 49.18 | 6,100 | K7XI | Nautilus | Broadcast. (Trans-Arctic Submarine Corp.) |
| 49.31 | 6,080 | W9XAA | Chicago, Ill. | Broadcast. 6-7 A.M. |
| 49.31 | 6,080 | W6XAL | Westminster, California | Broadcast. 11-12 P.M., 10 P.M. Saturday. 6 A.M. Sunday. |
| 49.31 | 6,080 | HS2PJ | Bangkok, Siam | Broadcast. 6-6:30 A.M. |
| 49.34 | 6,075 | W9XAA | Chicago, Ill. | Broadcast. Daily except Sun. WCFL. |
| 49.34 | 6,075 | W2XCX | Kearny, N. J. | Broadcast. Daily except Sun. WOR. |
| 49.05 | 6,050 | XEVE9CL | Winnipeg, Man., Can. | Broadcast. 6:30 P.M. CJRW |
| 49.40 | 6,070 | UOR2 | Vienna, Austria | Broadcast. 5-7 A.M., 5-7 P.M. Tues., Sat. 9-10 A.M. Thurs. |
| 49.46 | 6,065 | SAJ | Motala, Sweden | Broadcast. 6:30-7 A.M., 11 A.M.-4:30 P.M. |
| 49.50 | 6,060 | W9XU | Council Bluffs, Iowa | Broadcast. |
| 49.50 | 6,060 | W3XAU | Byberry, Pa. | Broadcast. |
| 49.50 | 6,060 | W8XAL | Cincinnati, Ohio | Broadcast. 6:30-11 A.M., 1:30-3 P.M., 6 P.M.,-1 A.M. |
| 49.60 | 6,050 | HKD | Barranquilla, Colombia | Broadcast. Mon., Wed., Fri., Sun. 8-10 P.M. |
| 49.67 | 6,040 | W9XAQ | Chicago, Illinois | Broadcast. Thur. and Fri. |
| 49.67 | 6,040 | PK3AN | Sourabaya, Java | Broadcast. 6-9 A.M. |
| 49.83 | 6,020 | W9XF | Chicago, Illinois | Broadcast. 3:30-7 and 8:30 P.M. to 11 A.M. |
| 49.83 | 6,020 | W2XBR | New York, N. Y. | Broadcast. |
| 49.97 | 6,000 | ZL3ZC | Christchurch, N.Z. | Broadcast. 10 P.M.—M., Tues., Thurs., Fri. |
| 49.97 | 6,000 | HRD | Tegucigalpa, Honduras | Broadcast. 9:15-12:15 P.M. Mon., Wed., Fri. 11-12 P.M. Sat. |
| 49.97 | 6,000 | EAR25 | Barcelona, Spain | Broadcast. 3-4 P.M. Sat. |
| 49.97 | 6,000 | RFN | Moscow, USSR | Broadcast. 8-9 A.M. Tues., Thurs., Sat. |
| 50.00 | 6,000 | PK2AF | Djocjacarta, Java | Broadcast. 6:40-9:40 A.M. |
| 50.26 | 5,975 | HVJ | Vatican City, Rome | Broadcast. Daily, 10:30 to Noon. |
| 51.00 | 5,875 | CN8MC | Casablanca, Morocco | Broadcast. Sun., Tues., Wed. & Sat. |
| 51.11 | 5,870 | W6XAF | Sacramento, Calif. | Broadcast. (Dept. of Agri., Calif.) |
| 51.22 | 5,855 | XDA | Mexico City, Mexico | Broadcast. Daily 10-11 P.M. |
| 51.40 | 5,833 | HKO | Medillem, Colombia | Broadcast. 8:30-10:30 P.M. Daily. |
| 55.00 | 5,450 | F8BP | Ruggles, France | Broadcast. 7 A.M.-3 P.M. |
| 58.00 | 5,170 | OK-MPT | Prague, Cechoslovakia | Broadcast. 1-2:30 P.M. |
| 62.50 | 4,800 | W2XV | Long Island City, N. Y. | Wed. & Fri., 8-10 P.M. |
| 62.56 | 4,795 | W9XAM | Elgin, Illinois | Time Signal. |
| 67.65 | 4,430 | DOA | Doeberitz, Germany | Broadcast. 6-7 P.M. Mon., Wed., Fri. 2-3 P.M. |
| 70.00 | 4,280 | AHK2 | Vienna, Austria | Broadcast. 1-7 P.M. First 15 min. of each hour and Sun. only. |
| 70.10 | 4,280 | RV15 | Khabarovsk, USSR | Broadcast. 3-9 A.M. |
| 71.77 | 4,180 | WSBN | S.S. "Leviathan" | Phone. |
| 71.77 | 4,180 | GFWV | S.S. "Majestic" | Phone. |
| 71.77 | 4,180 | GLSQ | S.S. "Olympic" | Phone. |
| 71.77 | 4,180 | GMJQ | S.S. "Belgenland" | Phone. |
| 71.77 | 4,180 | GDLJ | S.S. "Homeric" | Phone. |
| 72.90 | 4,110 | WGBN | Deal, N. J. | Phone to ships. |
| 72.70 | 4,120 | GFWV | Constantine, Tunis, Africa | Broadcast. Mon. & Fri. |
| 80.00 | 3,750 | I3RO | Rome, It.,(Prato Smeraldo) | Broadcast. 11-1 P.M., 2:30-5:00 P.M. |
| 80.00 | 3,750 | F8KR | Arlington, Va. | Broadcast. 9 A.M.-10 P.M. Time Signal. |
| 82.90 | 3,620 | DUO | Doeberitz, Germany | Television. |
| 84.24 | 3,660 | OZ7RL | Copenhagen, Denmark | Broadcast. 6 P.M. Tues., Sat. |
| 94.76 | 3,166 | WCK | Detroit, Mich. | Police Department. |
| 98.95 | 3,030 | ...... | Motala, Sweden | Broadcast. 11:30-12 A.M., 4-10 P.M. |
| 105.3 | 2,850 | W2XR | New York, N. Y. | Broadcast. 4-6:30 P.M., 7:30-10 P.M. |
| 105.3 | 2,850 | W3XAD | Camden, N. J. | Television. |
| 105.3 | 2,850 | W9XR | Downers Grove, Ill. | Television. |
| 104.4 | 2,870 | ...... | Chicago, Illinois | Broadcast. 2 P.M. |
| | 2,750 | W9XAP | Chicago, Illinois | |
| 112.1 | 2,938 | W6XAF | Sacramento, California | Broadcast. Dept. of Agri., Calif. |
| | 2,750 | W2XAP | Jersey City, N. J. | Television. |
| | 2,750 | W7XAD | Portland, Oregon | Television. |
| 121.5 | 2,468 | WRDQ | Toledo, Ohio | |
| 122.0 | 2,458 | WPDG | Youngstown, Ohio | |
| 122.3 | 2,452 | W7XAU | Portland, Oregon | Police Department. |
| 122.3 | 2,453 | KGPP | Portland, Oregon | |
| 122.3 | 2,453 | WRBH | Cleveland, Ohio | |
| 122.25 | 2,470 | KGOZ | Cedar Rapids, Iowa | Police Department. |
| 124.2 | 2,416 | KGPB | Minneapolis, Minn. | Police Department. |
| 124.2 | 2,422 | KGPE | Kansas City, Mo. | Police Department. |
| 124.2 | 2,440 | WNDA | Miami, Florida | Police Department. |
| 124.2 | 2,422 | WMJ | Buffalo, N. Y. | Police Department. |
| 124.2 | 2,422 | WPDE | Louisville, Ky. | Police Department. |
| 124.2 | 2,422 | WPDJ | Passaic, N. J. | Police Department. |
| 124.2 | 2,422 | WPDS | St. Paul, Minn. | Police Department. |
| 124.2 | 2,440 | WPDF | Flint, Michigan | Police Department. |
| 124.2 | 2,440 | WPDL | Lansing, Mich. | Police Department. |
| 124.2 | 2,440 | WPDP | Philadelphia, Pa. | Police Department. |
| 124.2 | 2,416 | WPDH | Richmond, Indiana | Police Department. |
| 124.2 | 2,416 | WPDI | Columbus, Ohio | Police Department. |
| 124.2 | 2,416 | KGPA | Seattle, Wash. | Police Department. |
| 124.2 | 2,416 | W7XP | Seattle, Wash. | Police and Fire Departments. |
| 124.2 | 2,416 | WPDA | Tulare, California | Police Department. |
| 125.4 | 2,392 | W2XCZ | New York, N. Y. | Broadcast. (N.B.C.) |
| 125.41 | 2,392 | W1OXAL | New York, N. Y. | Broadcast. (N.B.C.) |
| 142.9 | 2,100 | W2XCW | Schenectady, N. Y. | Television. |
| 142.9 | 2,100 | W2XCR | Jersey City, N. J. | Broadcast, 8-10 P.M. Mon., Wed., Fri. |
| 142.9 | 2,100 | W1XAV | Boston, Mass. | Television. |
| 142.9 | 2,100 | W2XR | Long Island City, N. Y. | Television. |
| 142.9 | 2,100 | W3XR | Wheaton, Maryland | Broadcast. 8-10 P.M. Mon., Wed., Fri. |
| 142.9 | 2,100 | W2XBU | North Beacon, N. Y. | Broadcast. 1-2 P.M. |
| 142.9 | 2,100 | W2XCO | New York, N. Y. | Television. |
| 142.9 | 2,100 | W2XCD | Passaic, N. J. | Broadcast. 8-10 P.M. Except Sat. & Sun. |
| 150.0 | 2,000 | W1XAY | Lexington, Mass. | Television. |
| 150.0 | 2,000 | W1XY | Lawrence, Mass. | Television. |
| 150.0 | 2,000 | W2XX | Ossining, N. Y. | Television. |
| 150.0 | 2,000 | W3XAD | Bound Brook, N. J. | Television. |
| 150.0 | 2,000 | W2XBU | Beacon, N. Y. | Television. |
| 150.0 | 2,000 | W3XK | Silver Springs, Md. | Television. |
| 150.0 | 2,000 | W2XBO | Long Island City, N. Y. | Television. |
| 150.0 | 2,000 | W2XBS | New York, N. Y. | Television. |
| 150.0 | 2,000 | W2XCP | Allwood, N. J. | Television. |

*ANYONE interested in short-wave reception will certainly appreciate the difficulty of preparing a complete and accurate list of short-wave stations. In this presentation the Editors of this book have endeavored to give an accurate and complete list—in this case one confined to the short-wave stations, which it is believed are of greatest interest—namely, broadcast, phone, television and police. In preparing the list which appears here the official list of radio stations issued by the International Telegraph Union at Berne, Switzerland, has been employed and all available lists of short-wave stations have been checked against it.*

*The time shown is Eastern Standard Time, which is five hours earlier than Greenwich Mean Time, and, respectively, one, two and three hours later than Central Standard Time, Mountain Standard Time and Pacific Standard Time.*

# NATIONAL

***No. NW***
***6"***

## New 6″ Dial
## Velvet Vernier Dial, Type NW

An entirely new Velvet Vernier 6" Solid German Silver dial for amateur and laboratory use. Capable of extreme precision. Flush vernier eliminating parallax reads to 1/10 division and may be estimated to 1/20 division. Equipped with 3-point variable ratio, this dial is in a class by itself. Write for complete description and prices. NATIONAL Velvet Vernier Dials protected by U. S. Patent Nos. 1,744,675, 1,653,875, 1,656,532, 1,713,146. Other patents pending.

***No. N***
***4"***

## 4″ Dial
## Velvet Vernier Dial, Type N

This is the standard type N Velvet Vernier Dial containing the original and matchless vernier mechanism, vernier scale making accurate reading possible of 1/10 division and 3-point attachment for easy and accurate mounting.

***No. BM***
***3"***

## New 3″ Dial
## Velvet Vernier Dial, Type BM

A new 3" size of the well known Type B Velvet Vernier Dial, produced to meet a popular demand for a smaller dial with the V.V. mechanism, for use on small receivers and transmitters. Made with fixed ratio only: Type BMD with dual range 0-100-0 and type BMC 200-0 clockwise.

***Write for catalog sheet with full description and prices***

***Audio Transformers***

## Audio Transformers

Audio Transformer Type A100—Incorporating the latest advantages in audio-transformer design, this superior unit employs a special nickel-steel high permeability core and a split-secondary winding of new design. The result is a transformer of small size with unusually fine frequency characteristics. Turn ratio is 4-1.

Push-Pull Transformers—These new NATIONAL Audio Transformers are built with the same special nickel-steel alloy cores and method of coil winding employed in the Type A100. A test made in the laboratory of one of the largest radio-set manufacturers in the United States, has shown the curve of the frequency-characteristic of these transformers to be essentially a straight horizontal line from 30 to 5,000 cycles per second. Also input and output for "Class B" push-pull power amplifiers.

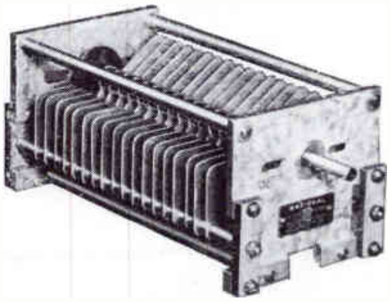
***Write to us for Special***
***Short Wave Bulletin No. 150***

**NATIONAL COMPANY, Inc.**
***Engineers and Manufacturers***
**61 SHERMAN ST., MALDEN, MASS.**

# TRANSMITTING and AMATEUR EQUIPMENT

## New Model TMU Transmitting Condensers

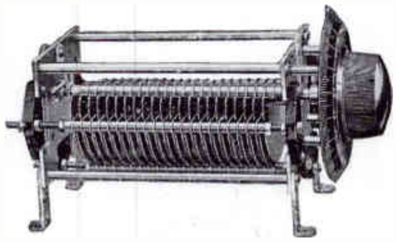
Designed especially to meet the demand for moderate priced stock transmitting condensers for higher power work than covered by our standard TM type. These condensers embody all the very latest features contributing to efficiency, steadiness of signal and rigidity of construction. The end plates are rugged cast aluminum; all rotor and stator plates have rounded and polished edges; ⅜" shaft operates in special accurately machined conical and ball bearings. Has special high current, low impedance, rotary brush type of rotor contactor. By special license agreement with RCA, genuine Micalex insulation is standard equipment in Type TMU Condensers.



*No. TMU*

## TMP Push-Pull Condensers

SPLIT STATOR TYPE HIGH VOLTAGE CONDENSER, for use in Push-Pull circuits. Constructed in standard TM frame. Plates are of heavy gauge polished aluminum with well rounded edges. Insulation is crolite. In 3000 and 6000 volt ratings.

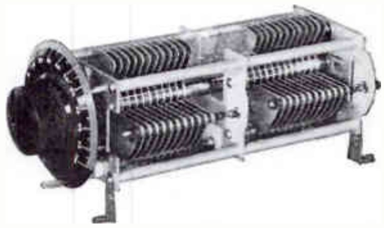


*No. TMP*

## Standard Model TM Transmitting Condensers

The NATIONAL Transmitting Condensers are widely used by the U. S. Government, broadcasting stations, communication companies and amateur transmitters, and are mechanically and electrically correct.

The condensers are supplied with either 3/16" or 3/8" spacing for high voltage work. Standard insulation for all the TM type condensers is crolite.

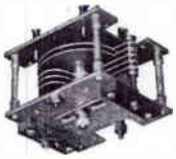


*No. TM*

## 35–70 Band Spread Condensers

Designed to have high minimum capacity for use in frequency meters and amateur band spreading circuits.

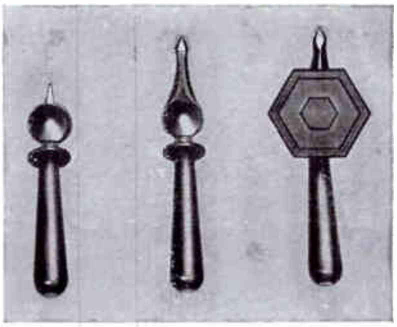
Min. Cap. 35 mmf.     Max. Cap. 70 mmf.



*35-70*
*B. S. Condenser*

## Lever-Type Indicators Types S, M and J

For transmitter panel use. Bakelite handles, bronze pointers, available for ¼" and ⅜" shafts. Details on request. Etched metal scale now included with M and J Indicators.



*Lever Indicators*

***Write for Bulletin No. 144 Giving Engineering Data Complete Specifications and Prices***

NATIONAL COMPANY, Inc.
*Engineers and Manufacturers*
61 SHERMAN ST., MALDEN, MASS.

## Velvet Vernier Dials

Types E and F

Types G and H

Type A

Type N

Types B and C

# NATIONAL

# Radio-for all Short-Wave

### *Distributed by*

ARIZONA
Nielsen Radio & Sporting Goods, 621 N. Central Ave., Phoenix, Ariz.
CALIFORNIA
Radio Supply Co., 912 S. Broadway, Los Angeles, Calif.
Radio Mnfrs. Sup. Co., 1000 S. Broadway, Los Angeles, Calif.
Herbert H. Horn Mfg. Co., 1629 South Hill Street, Los Angeles, Calif.
Western Radio, Inc., 1224 South Wall Street, Los Angeles, Calif.
Electric Supply Co., 329 Thirteenth Street, Oakland, Calif.
Wenger-Brill Co., 1020 Oak Street, Oakland, Calif.
Coast Elec. Co., 744 G Street, San Diego, Calif.
I. S. Cohen's Sons, Ltd., 1025 Market Street, San Francisco, Calif.
Offenbach Electric Co., 1450 Market Street, San Francisco, Calif.
Coast Radio Supply Co., 123 Tenth Street, San Francisco, Calif.
Inter-City Radio Stores, 405 American Avenue, Long Beach, Calif.
Kierulff & Ravenscroft, 121-131 Ninth Street, San Francisco, Calif.
Kierulff & Ravenscroft, 137-139 West 17th Street, Los Angeles, Calif.
COLORADO
Vreeland Radio Corp., 1639 Tremont Street, Denver, Col.
CONNECTICUT
Hatry & Young, Inc., 203 Ann Street, Hartford, Conn.
GEORGIA
Garvin Electric Co., 75 Forsyth Street, Atlanta, Ga.
ILLINOIS
Chicago Radio App. Co., 415 S. Dearborn Street, Chicago, Ill.
Newark Electric Co., 226 W. Madison Street, Chicago, Ill.
INDIANA
Kruse Radio Co., 33 W. Ohio Street, Indianapolis, Ind.
MASSACHUSETTS
T. F. Cushing, 345 Worthington Street, Springfield, Mass.
H. Jappe Co., 46 Cornhill, Boston, Mass.
Sager Electric Supply Co., 201 Congress Street, Boston, Mass.
Sager Electric Supply Co., 217 Commercial Street, Worcester, Mass.
Sager Electric Supply Co., 30 Spring Street, Lynn, Mass.
Sager Electric Supply Co., 26 Hight Street, Brockton, Mass.
Sager Electric Supply Co., 39 Washington Street, Quincy, Mass.
Sager Electric Supply Co., 315 Massachusetts Avenue, Boston, Mass.
Sager Electric Supply Co., Central Street, Salem, Mass.
Woodrow Radio Co., 166 Prospect Street, Cambridge, Mass.
MISSOURI
Walter Ashe Radio Co., 1100 Pine Street, St. Louis, Mo.
Burstein Applebee Co., 1408 McGee Street, Kansas City, Mo.
Kansas City Radio Co., 1314 McGee Street, Kansas City, Mo.
Graybar Elec. Co., 1644 Baltimore Avenue, Kansas City, Mo.
MINNESOTA
E. F. Johnson Co., Waseca, Minn.

***Write to Us for Special Short Wave Bulletin No. 141***

National MB-32 Tuner

Radio DeLuxe for Those Who Want "The Best" in Radio, Regardless of Price

# Precision-Built Products *types of* Receivers—

*Quality Radio Products*

*Distributed by*

**MICHIGAN**
Radio Specialties Co., 175 E. Jefferson Avenue, Detroit, Mich.
**NEBRASKA**
Sidles-Duda-Myers Co., Lincoln, Omaha
**OREGON**
Wedel Company, Inc., 443 Washington St., Portland, Ore.
Northwest Radio Snpp. Co., 305 Pine Street, Portland, Ore.
**OHIO**
M & M Company, 500 Prospect Avenue, Cleveland, Ohio
Cleveland Radio & Television Co., 1710 Chester Avenue, Cleveland, Ohio
Kladag Radio Labs., Kline Bldg., Kent, Ohio
Burns Radio Co., 140 East Third Street, Dayton, Ohio
**NEW YORK**
Wholesale Radio Service Co., 100 Sixth Avenue, New York City
Leeds Radio Co., 45 Vesey Street, New York City
Royal Eastern Elec. Sup. Co., 16 West 22nd Street, New York City
Stuyvesant Elec. Co., 53 Walker Street, New York City
Sun Radio Co., 64 Vesey Street, New York City
Gross Radio Co., 25 Warren Street, New York City
Ft. Orange Radio Dist. Co., 356 Broadway, Albany, N. Y.
Maurice Schwartz & Son, 710-712 Broadway, Schenectady, N. Y.
**PENNSYLVANIA**
M & H Sporting Goods Co., 512 Market Street, Philadelphia, Pa.
Radio Elec. Service Co., N. E. Cor. 7th & Arch Streets, Philadelphia, Pa.
Eugene G. Wile, 10 South 10th Street, Philadelphia, Pa.
Cameradio Co., 603 Grant Street, Pittsburgh, Pa.
Hall's, 3747 Derry Street, Harrisburg, Pa.
**OKLAHOMA**
Southern Sales Co., 130 West Third Street, Oklahoma City, Okla.
**TEXAS**
Ft. Worth Radio Supply Co., 104 East Tenth Street, Ft. Worth, Texas
Joseph F. Meyer Co., Houston, Texas
Straus-Frank Company, 1209-1217 Milam Street, Houston, Texas
Straus-Frank Company, 301-307 S. Flores Street, San Antonio, Texas
Strans-Frank Company, 209-211 N. Commerce Street, Harlingen, Texas
**WASHINGTON**
Wedel Co., Inc., 520 Second Avenue, Seattle, Wash.
General Radio, Inc., 2015 Third Avenue, Seattle, Wash.
Spokane Radio Corp., 528 First Avenue, Spokane, Wash.
**UTAH**
Felt Radio Co., 134 South State Street, Salt Lake City, Utah
**WISCONSIN**
Radio Parts Co., 332 South State Street, Milwaukee, Wis.
**DISTRICT OF COLUMBIA**
National Elec'l Supp. Co., 1328 New York Avenue, N. W. Washington, D. C.

## NATIONAL COMPANY, INC.

**61 Sherman St.** **Malden, Mass.**

*Velvet A-B Power Units. Manufactured under R.C.A. License*

*Power Transformer Type U*

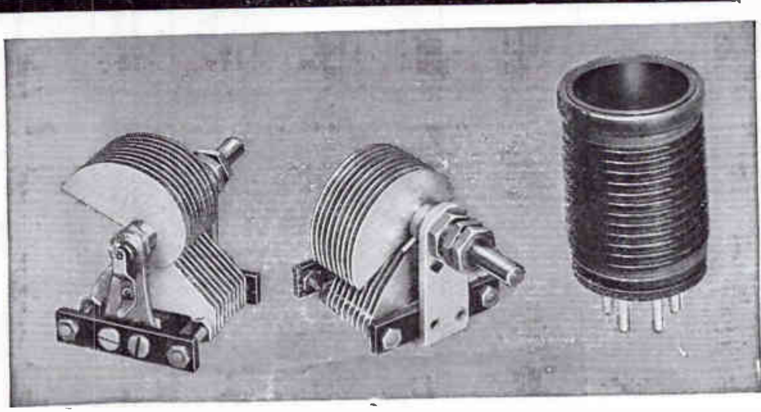
*Velvetone Audio Transformer*

*Girder Frame Tuning Condenser*

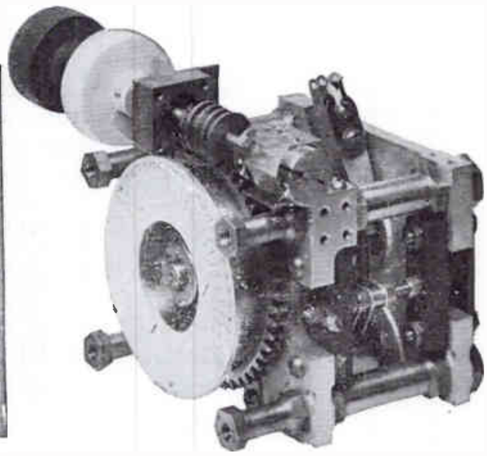
*Equicycle Short Wave Condenser*

*"Grid-Grip"*

*R. F. Choke*

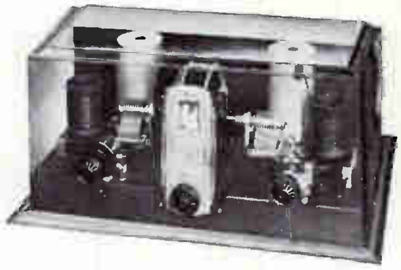


*Precision Parts for Efficient Short Wave Receivers*



*Laboratory Precision Condenser*

# "Works Perfectly and Surely brings in the DX"



So Says One Admirer of the

## NATIONAL SW-5 THRILL-BOX

(Range 9-2000 Meters)

### One Reason Why the THRILL-BOX Has Become an Outstanding Short-Wave Receiver

The THRILL-BOX now uses the new 235 Variable-Mu tubes. By employing a new and heretofore unused principle of these tubes with the THRILL-BOX circuit, the point of greatest sensitivity is approached along an inverse exponential curve. For this reason the same smoothness of control and the same sensitivity *is available on all signals* regardless of frequency, and without critical setting of the controls.

### HIGH-LIGHTS on the SW-5

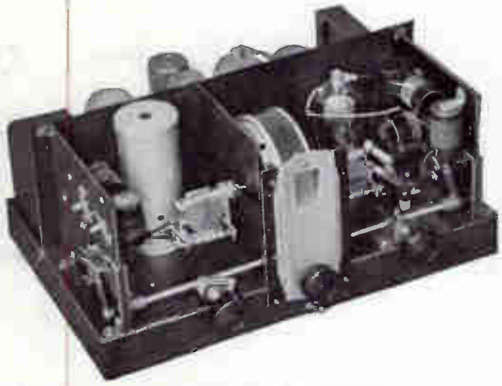
Range 9-2000 meters. Extremely high signal to noise ratio. True single-knob tuning. Set and forget the antenna trimmer. Easy to log with NATIONAL projector Dial, type H, no parallax. Special 270° Type S. E. Tuning Condenser with insulated main-bearing and constant-impedance pigtail makes gang-tuning possible on the short waves. Equipped with standard set of 4 pairs of R.F. Transformers covering range of 15 to 115 Meters, wound on forms of genuine NATIONAL R139. Uses the new UX-235 Variable-Mu tubes, giving improved sensitivity and less critical operation. Humless A.C. Power Supply with specal filter section. R.F. Filter on Rectifier Tube, and Electrostatic Shield. R.C.A. Licensed.

### Battery Model

Made also in Low-Drain Battery Model using new air-cell battery and 2-volt tubes.

### Special Broadcast Model

Model now available using 245's in Push-Pull for Audio output, for greater volume.



## NATIONAL NC-5

Short-Wave Converter

(Range 15-185 Meters)

A Radical New Type of short-wave instrument. For use with any Radio Set.

Unlike the ordinary converter, the NC-5 has two additional stages:—a high frequency pre-amplifier input tube and a high gain R.F. amplifier output tube, giving additional voltage gain of 100 and forming low-impedance coupling to radio set.

### HIGHLIGHTS of the NATIONAL NC-5 Converter

Easy to tune and log. Single Control Tuning with perfect "tracking"; high signal to noise ratio. Special HARMONIC TUNED INPUT CIRCUIT possible only with 235 tubes. Peaking on different short-wave broadcast bands. New coupling arrangement from cathode return circuits resulting in minimum background noise.

### NO COILS TO CHANGE

But really effective, silent coil-switching arrangement made practicable through R-39, super-efficient low-loss insulation material developed by R.F. Laboratories specially for NATIONAL Company. Different s.w. broadcast bands fall on approximately same settings on dial.

### COLOR OF DIAL-LIGHT

Indicates Frequency Range

As the coil-changing switch is turned, color of dial-light changes to show which coils are in circuit.

### ATTRACTIVE — COMPACT

Size, 8" x 17½" x 12"

Made in standard model with beautifully finished metal cabinet and special de luxe model in inlaid solid mahogany cabinet.

### New NATIONAL SW-3 Amateur HF Receiver

New single control Ham Receiver for A.C. or battery operation. Very high signal to noise ratio. Write us for Bulletin No. 152 giving full description and prices.

**NATIONAL**
COMPANY INCORPORATED
61 Sherman Street, Malden, Mass.

# THE SHORT WAVE LIBRARY

**THE MANUAL OF SHORT WAVE RADIO—Volume One**

Simple receivers for the beginner — Technique of tuning—Short wave supers

*by Zeh Bouck* 50c

**THE MANUAL OF SHORT WAVE RADIO—Volume Two**

Learning the Code — The converter handbook — Tuned r-f receivers and supers

*by Zeh Bouck* 50c

**THE MANUAL OF ULTRA SHORT WAVE RADIO**

Transmission and reception on the quasi-optical waves below 10 meters

*by James Millen and R. S. Kruse* 50c

**THE NATIONAL COMPANY, Malden, Mass.**