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A Knock-Out Short-Wave Receiver

Describing How to Build this Sensitive and Selective, Non-Radiating Receiver for Very Short Waves, Employing the Roberts Circuit

By ZEH BOUCK

FOREWARNED is forearmed, and the writer maliciously announces that resonance will be treated in this article in terms of kilocycles rather than wavelengths. This is at all times the more efficient and logical consideration. Eventually, wavelength will be considered only secondarily and no better start can be made in thinking in kilocycles, than in a discussion of short waves, which we already refer to familiarly as higher *frequencies*.

As a final magnanimous concession to the vanquished, we state that the wave range to be considered in this article is from about 1360 kilocycles—220 meters—to a shade over 3000 kilocycles, a bit under 100 meters. 1500 kilocycles is the frequency of 200 meters, and 2000 kilocycles the vibratory rate of 150 meters. If the reader insists on being inefficient, and must know the wavelengths of the intermediate frequencies, he will be under the necessity of dividing 300,000 by the number of kilocycles.

> **A Good Thing—and a Small Package**
>
> The possibilities of very short-wave transmission and reception have been appreciated for several years, but RADIO BROADCAST has consistently declined to publish data on a high-frequency receiver while the single-circuit oscillator offered the only simple and efficient receiving system. Mr. Bouck tells you why, and our forbearance is amply repaid in the receiver he has designed.
>
> Here is a receiver that will appeal most powerfully to the serious experimenter—the enthusiast interested in the short-wave transmission of KDKA at 3000 kilocycles (100 meters) and WGY at 2800 kilocycles (107 meters)—and to the relay amateur who will find this set designed with an especial, and perhaps instinctive regard to his particular problems by one of his own kind.—THE EDITOR.

THE REQUIREMENTS OF A SHORT-WAVE SET

THE higher radio frequencies are less stable, more difficult to tune and control than the lower conventional broadcasting frequencies. They therefore impose more exacting requirements on the possible methods of reception.

Various losses, which are comparatively negligible on the higher waves, become more pronounced and have a more detrimental effect on transmission and reception on amateur and sub-amateur waves. While it is probable that the magnitude of these losses has been exaggerated, they nevertheless exist, and every possible precaution should be taken to reduce them. Large size wires, with a practical minimum of insulation, should be employed in wiring and winding the inductances. The size of wire, of course, determines the actual resistances in the circuits, and the elimination of unnecessary insulation does away with a dielectric, which if employed consistently and needlessly, may add materially to capacity losses.

CAPACITY EFFECTS

AS THE frequency is raised the effect of capacity upon resonance becomes much more critical and marked. For instance, an addition of ten micro-microfarads (.00001 mfd.) to a circuit oscillating at 3000 kilocycles, at which frequency KDKA transmits short-wave telephony, will decrease the frequency by about 400 kilocycles. The same capacity added to a receiver or transmitter oscillating at 750 kilocycles (approximately the frequency of WJY, WOR and PWX) will cause a decrease of only 69 kilocycles.

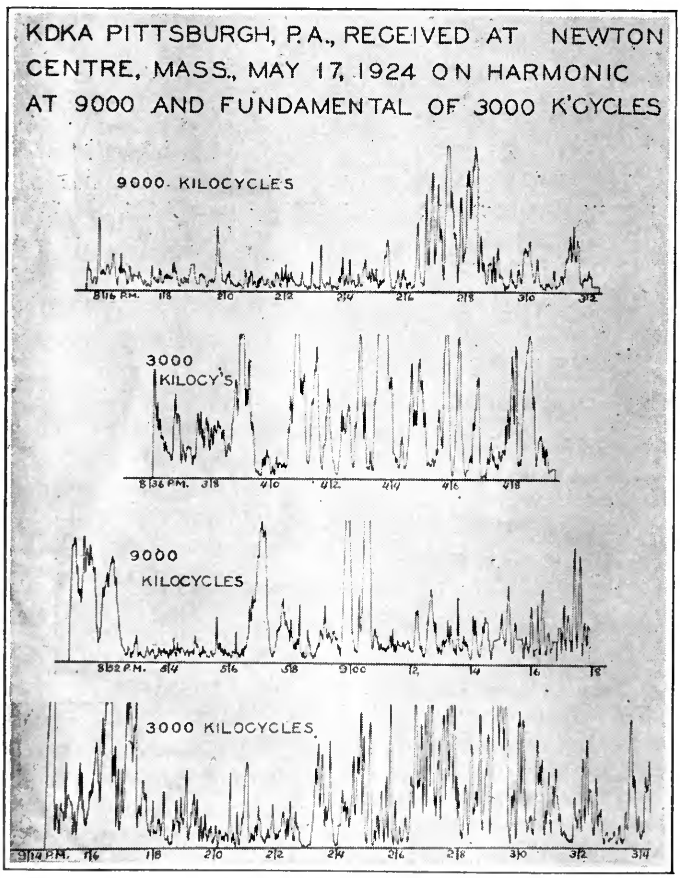

FIG. 1

Interesting graphs made by the signals themselves at the laboratory of Dr. Greenleaf Whittier Pickard. These tell why the short-wave receiver must not radiate

It is quite obvious that body capacity effects present somewhat of a genuine problem on these high frequencies, especially when it is considered that most of the receiving carried on in this region is beat-note reception of continuous wave telegraph signals. In a poorly designed short-wave receiver, a slight motion of the hand in the vicinity of the tuning controls will be sufficient to whistle a station clean across the audible scale—and out. In the receiver to be described, body capacity has been reduced to a satisfactory minimum, by mounting the oscillating coils at right angles to and away from the panel, by connecting the stationary condenser plates to the grids, and by using metal dials insulated from both the ground and the instruments they control. (Grounded shielding would immediately introduce losses. The individual control dials act partly as shields, and at the same time reduce the capacitative coupling between the body and the instruments by functioning as the common plate of two condensers connected in series).

The increased susceptibility of receivers of this type to capacity variations also makes vernier control a necessity. However, as a built-in vernier generally adds to the condenser losses, non-vernier condensers are recommended with vernier dials. The Accuratune dial, a true vernier and possessing the desirable insulated metal scale, was used by the author.

THERE MUST BE NO RADIATION

THE most important consideration of all is the necessity for a non-radiating receiver. This absolutely essential condition has proved a serious problem, for most of the communication carried on in the higher frequencies postulates a regenerative and oscillating receiver. It is an easy matter to build a single-circuit regenerator to operate in the region of megacycles but the radiation from such a receiver places it absolutely and irreconcilably beyond the pale. We are all painfully familiar with the havoc worked by such sets on the broadcasting frequencies. It is the writing on the wall, with an added and sinister emphasis, for radiation on amateur and

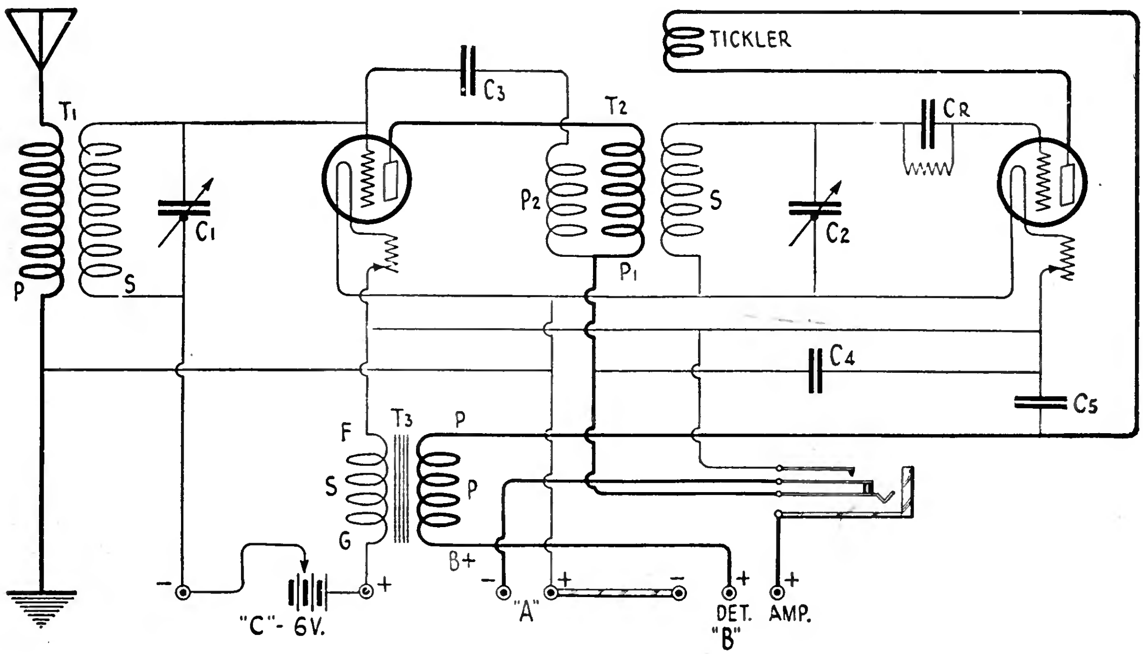

FIG. 2

The short-wave circuit. The C battery should be varied as one of the amplifier stabilizing adjustments.

sub-amateur waves possesses a remarkable carrying power that adds many miles to the radius of the interference area.

HOW THE HIGHER FREQUENCIES CARRY

THE possibilities of these very high frequencies are uncanny. Using a small regenerator with a ten *inch* antenna (needless to say, indoor), the writer has copied foreign low power stations operating in the neighborhood of 3000 kilocycles. Distant amateur stations have also been received on high harmonic frequencies which could represent only a small fraction of the already low power radiated on the fundamental. Dr. Greenleaf Whittier Pickard has had similar results in a room at the Commodore Hotel in New York City. Due to the freak element in these frequencies, distant broadcasting stations are often received much more consistently and loudly on their harmonics. KYW, at Chicago, is often recorded at Newton Centre, Massachusetts, on the 8th harmonic at greater intensity than on the fundamental. Doctor Pickard, in his study of short and long period variations, has made these extremely short waves photograph themselves; and has no unusual difficulty in obtaining a beautiful graph of the variations in WBBR's sixth harmonic at 7500 kilocycles. Fig. 1 shows a most remarkable photograph, which the author is reproducing with the kind permission of Doctor Pickard. This masterpiece of laboratory finesse shows the simultaneous variations in strength of KDKA's fundamental at 3000 kilocycles (already far above the region of conventional broadcasting) and its third harmonic at 9000 kilocycles.

HOW TO PREVENT RADIATION?

WHILE it was quite obvious that radiation must be practically eliminated, the manner of overcoming it was less apparent. A blocking stage of radio-frequency amplification will immediately suggest itself to the experienced reader, as it did to the writer. However, this would necessitate a plate coil, and as the tendency to feed back through the capacity of the tube increases with the frequency, the amplifying bulb would prove a far more powerful oscillator than the detector—unless *efficient* means were taken to stabilize the circuit.

THE ROBERTS CIRCUIT ON SHORT WAVES

IT WAS upon the suggestion of the editor of RADIO BROADCAST that the writer began experimenting in his own amateur station, radio 2PI, with the possibilities of the Roberts receiver especially designed for short waves. As our readers who have followed Mr. Roberts's articles, on his "Two-Tube Knock-out Re-

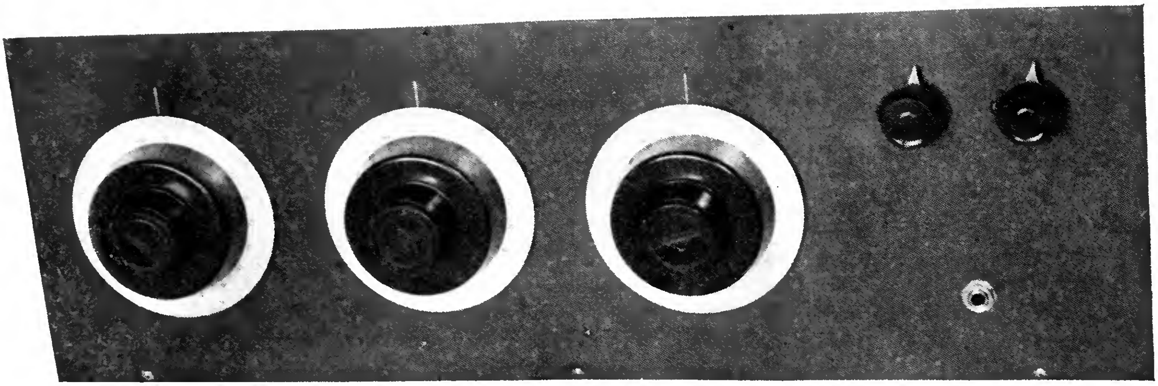

FIG. 3
Front view of the finished receiver. The dial arrangement is for left hand operation, the usual order of the tuning controls being reversed. The tickler is on the left.

ceiver" appreciate, this circuit employs one stage of tuned R. F. with capacity neutralization, bulb detection with regeneration, and one step of reflexed audio amplification. It was a happy thought of the editor and has developed into the receiver shown in the last five illustrations of this article, and which we have found to be in all ways the most desirable short-wave set we have ever operated. And we have played with many of them.

The circuit is shown in Fig. 2, and most of our readers will recognize it as the standard Roberts hook-up with a slight variation in T1. A semi-aperiodic primary has been substituted for the tapped coil which is quite unnecessary and actually detrimental in high-frequency reception.

All inductances, excepting the windings of the audio amplifying transformer, are spider-webs. The writer found it most convenient to obtain the standard Roberts broadcast wave coils, made by the Eugene Turney Laboratories and rewind them for the special short-wave set. If the reader desires to make his own forms, they should have an odd number, say seventeen winding spokes, with a first-turn-diameter of two and a half inches. Pasteboard is the preferred material.

The primary of T1 is wound with six turns of No. 18 wire. S, in both T1 and T2, has 25 turns (see General Instructions) with the inside terminals running to the grids. P1 and P2 in T2, is the combined primary and neutralizing winding. It is made as follows: Two No. 22 wires, from individual spools, are wound simultaneously for eight and a half turns. This results in two parallel coils. The *beginning* of one coil is connected to the *end* of the other, giving a common terminal which leads to the output jack. The remaining two connections run to the plate and to the neutralizing condenser C3 (it is immaterial which runs to which).

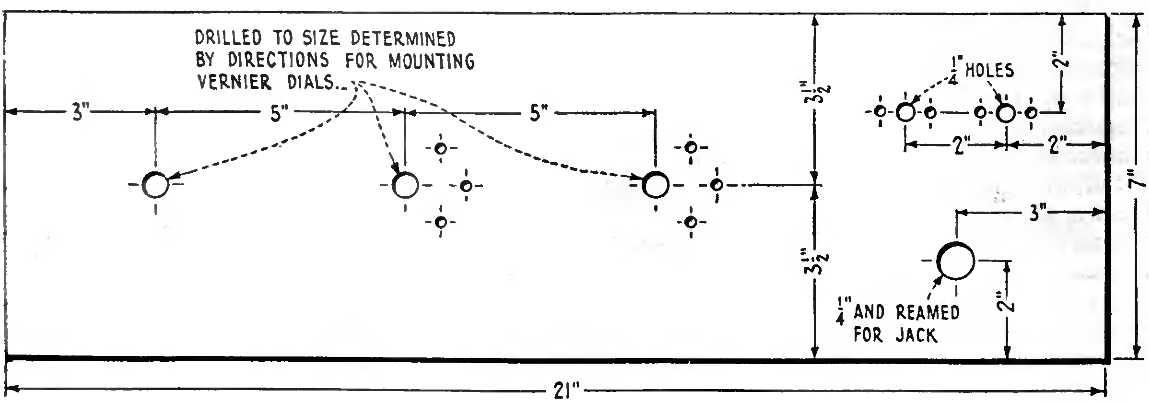

FIG. 4
The panel layout. The design is such as especially to suit the operating convenience of the majority of amateur stations

The tickler coil consists of eleven turns of No. 18 wire.

With the exception of the secondaries, all coils are wound over one, under one, in reference to the winding spokes. The secondaries, which are wound with No. 18 wire, are woven over three and under three.

Capacities C1 and C2 are .00025 mfd. low-loss, low minimum capacity variable condensers with the stationary plates connected to the grids. Duplex condensers were used by the writer. C4 and C5 are fixed capacities, respectively .001 mfd. and .002 mfd. (see General Instructions).

C4 is the grid condenser and leak, having respective values of .0005 mfd. and 250,000 ohms (refer to General Instructions). The neutralizing condenser, C3, is made by winding No. 24 wire over two inches of spaghetti tubing and slipping this on a convenient length of bus-bar wire left projecting from the grid terminal of the amplifying socket. The capacity of this condenser is varied by slipping the insulated tube farther on or off the bus-bar.

T3 is an Amertran audio-frequency transformer, connected as indicated by the marked terminals.

The output is plugged into a Carter open circuit filament control jack.

The reader need not confine himself to the specific parts used by the author. He may use the products of other manufacturers if he is certain that the substitute is of equal quality. But he must insist on this, for a single piece of inferior apparatus may impair the successful operation of a short-wave set.

THE PANEL

A BAKELITE panel, seven by twenty-one inches, was drilled according to the specifications in Fig. 3 and grained to a beautiful gray-black finish. The markers for the dial readings are scraped into the panel with the point of a dividers or scriber, and whitened with chalk or prepared paste. The simplicity of these three single lines is most pleasing, and harmonizes beautifully with the grained panel and the Accuratune dials.

CONSTRUCTION

THE various building details are clearly shown in the photographs, and adhere strictly to the theoretical implications contained in the earlier part of this article. Make all wiring as uncrowded and rigid as possible, using spaghetti sparingly and only where it is a necessity or a genuine convenience.

The writer has arranged the various controls

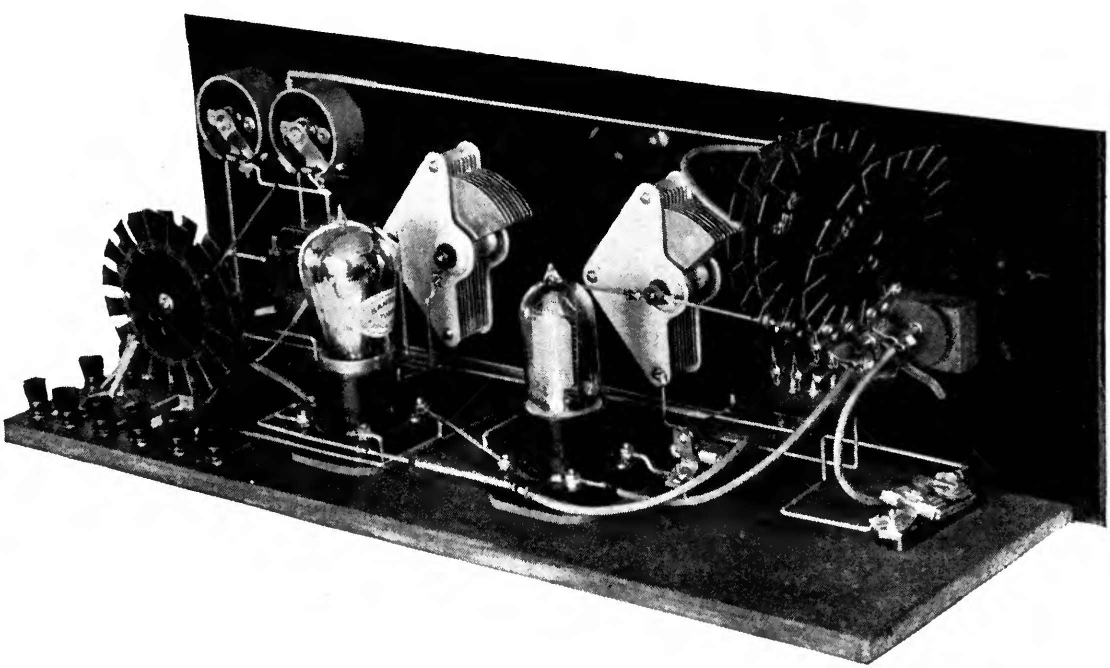

FIG. 5
Rear view. Spaghetti is used only where necessary, and on flexible leads

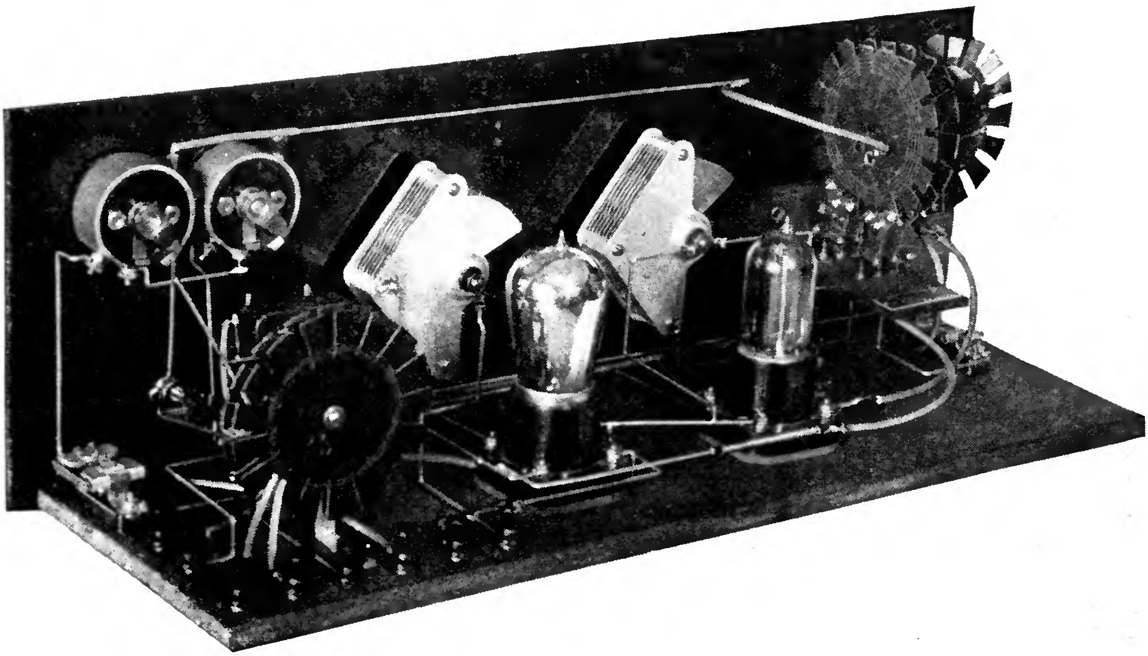

FIG. 6
The mountings for the Micadons and the combined grid leak-condenser mounting permit the clipping in and out of different values. This is desirable in the preliminary adjustment of the receiver

in an order the reverse of that usually employed, the antenna inductance and C1 begin on the right, following up to the tickler on the extreme left. This best suits the operating convenience at station 2PI, where the antenna switch and sending key are operated by the right hand and placed to the right of the receiving apparatus. The relay operator should consider these details, employ his own ingenuity, and vary the construction accordingly.

GENERAL INSTRUCTIONS

THE operation of the set is similar to that of the ordinary regenerative receiver. The three controls, C1, C2, and tickler, are quite analogous respectively to primary, secondary, and regeneration on the old and comparatively inefficient receivers.

Tubes

Your favorite detector and R. F. amplifying combination will work successfully. As will be seen in the photographs, the author employs the UV-201-A type in the amplifying circuit, and a Western Electric J tube as detector. It should be mentioned that only the modern low capacity amplifying tubes, such as the UV-199, the UV-201-A and the corresponding Cunningham and DeForest tubes, can be used in a short-wave amplifier circuit.

Wave Range

Using twenty-five turn secondaries as recommended the set will probably cover the stipulated range bounded approximately by 1400 kilocycles and 3000 kilocycles. The exact wave possibilities of the receiver are best determined by the use of a transmitting wavemeter, or a standard semi-short-wave receiver, such as the Grebe CR-3, on which the oscillating frequencies are approximately known. The wavemeter or former receiving set should be made to oscillate at 1500 kilocycles and the beat-note produced at a neighboring frequency on the new receiver. This will be quite high up on the condenser C2 scale. Now tune down for the second harmonic which will be found exactly on 3000 kilocycles. If difficulty is experienced in attaining this higher frequency, wire is removed, turn by turn, from the secondary of T2 until the harmonic beat-note is easily tuned with a few condenser degrees to spare. It is a simple matter to secure any desired high frequency by tuning for the second harmonic of a known lower frequency.

Wire should also be removed from the secondary of T1, until condenser C1 tunes to resonance at about the same dial reading as C2.

Coupling

The coupling between P and S of T1 is close, the two coils being separated by about one-half inch. In the case of the writer, similarly close coupling between P1 and S in T2 has proved more efficient that the loose coupling recommended by Mr. Roberts on the higher frequencies. The tickler coupling will of course vary with the degree of regeneration desired. In receiving continuous wave signals, the coupling should be loosened to within a few degrees of where the oscillations stop.

The Neutralizing Capacity

The primary adjustment of C3 is made to determine the setting at which the amplifying tube refuses to oscillate over the entire frequency range, a capacity that is seldom critical and which permits considerable leeway. A second and more exacting adjustment should be made during transmission of a near-by and powerful station to discover the point within the neutralized area where the incoming signal ceases to induce a howl.

Final Adjustments

In all cases it is desirable to experiment with the values of C4, C5, the grid condenser and grid leak. To facilitate this, Daven mountings have been used by the author for clipping in these parts. Two condenser mountings are necessary for C4 and C5, and a combined condenser-leak mounting for CR. C4 affects the stabilization of the amplifying tube, while the correct values of C5, the grid condenser and resistance for individual tubes, regulate the action of the local regenerative and oscillating circuit. These last values should be adjusted until the detector circuit goes into and out of oscillation over the entire range, smoothly and without howling.

Antenna

A special antenna will seldom be required for the operation of the short-wave set. It is used by the author on his double cage, fifty-five-foot L transmitting antenna.

A CONCLUDING WORD TO THE AMATEUR

REGARDLESS of the appeal to the experimenter, the transmitting amateur will find the receiver we have described particularly adapted to his own very exacting requirements. Passing over its great sensitivity and perfect wavelength range as being obvious and understood by the relay man, we desire to emphasize in closing the truly remarkable selectivity of this two-tube set. Key-click, excessive ripple, and other disturbances from near-by faulty transmitters are reduced to a most gratifying minimum. At 2PI little difficulty was experienced in copying a DX station through a local 50 watt rectified A. C. C. W. transmitter located less than one thousand feet away, both stations oscillating within four kilocycles of each other.

B–BATTERIES FROM YOUR LAMP SOCKET

CONSTRUCTION details and complete diagrams of an arrangement which will permit the use of 110-volt alternating current to supply the plate potential on any receiver *up to an eight-tube super-heterodyne will be printed in an early number of this magazine. The building of the device is not difficult and it can be made for about $25.*