HAMMARLUND SHORT-WAVE MANUAL

1929

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HAMMARLUND MFG. CO., INC.
424-438 W. 33rd St., New York, N.Y.

The *Hammarlund* *Short Wave Manual* 1929

NO EFFORT has been spared in the preparation of this manual to present concise and accurate data which will be of permanent value to the amateur, experimenter, and listener-in. Roughly, half of the text has been devoted to the theory of short wave receiver design and the other half to operation and practical constructional data. A quarter of the manual has been devoted to tables and curves which are of general utility. A small amount of catalog material has been included to give some data on the products which have made possible the realization of the exceptional possibilities of short wave reception. Since this is the first edition, it is too much to hope that there are no typographical and text errors. We should appreciate criticisms of any sort from readers, and particularly welcome any which would permit us to revise the manual and include new material of general interest.

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424-438 West 33rd Street, New York, N. Y.

 Printed in U. S. A.

Introduction

Byrd sails for the South Pole; the Southern Cross completes its trans-Pacific flight; the Roma prepares for her trans-Atlantic hop: these and a host of others have placed their confidence in a short wave transmission link with civilization. The short wave lengths they are using were considered virtually useless less than ten years ago!

What are "short" waves? What can they do that the longer ones can not? Why their sudden prominence?

"Short" waves are more or less arbitrarily considered those below 200 meters. Those below 5 meters are commonly called "ultra-short" waves. The trend is toward ultra-short waves so that the terms may be revised and only wavelengths below 50 meters, or so, called short waves. Progress in the "ultra-short" wave field is not limitless since the lower end of the ultra-short wave band merges with the upper end of the heat wave band. Electrical oscillations have been produced which are near the border line.

Short wave transmitters costing thousands of dollars have in many instances replaced long wave transmitters (working on from 5,000 to 24,000 meters) costing hundreds of thousands of dollars. They are not only much less expensive and much more compact but they provide reliable communication channels over tremendous distances and during daylight hours when consistent operation is ordinarily difficult.

A quantitative idea of their effectiveness may be gotten from a table published in the September, 1928, issue of the Proceedings of the Institute of Radio Engineers under "Considerations Affecting the Licensing of High-Frequency Stations" by S. C. Hooper, U. S. N. Some of the figures are given below:

	Average Distance	
Wavelength	*Day Miles*	*Night Miles*
13.0— 21.2	7000	Not useful at night
24.4— 25.6	4000	Over 5000
27.3— 31.6	2500	"
31.6— 35.1	1500	"
41.2— 45.0	1000	"
48.8— 50.0	600	"
54.5— 75.0	450	2500
75.0— 85.7	300	1000
109.0—133.0	150	500
150.0—200.0	100	250

Wavelengths rather than frequencies have been given for the convenience of the listener-in who is more familiar with the former. The distances are relative and are based on observations made with a one kilowatt continuous wave code transmitter and moderately sensitive receiver.

The advantage of the short waves is very evident. The advantage of using wavelengths of from 13.0 to 21.2 for daylight work which is ordinarily difficult is especially evident.

It is this performance that has made possible the use of short wave communication channels for trans-oceanic transmission with moderate power.

Short wave commercial phone transmission was at first confined to "rebroadcasting." This consists in receiving the signal from a distant station on short wavelengths and then amplifying and rebroadcasting it on the longer wavelengths. More recently much short wave broadcasting work has been done, particularly in Great Britain, on "colonial circuits" or on short wave lengths which may be received in distant colonies.

In the past few months many stations have begun broadcasting on short waves in this country. Additions are being made rapidly so that even the recently revised list on pages 13, 14, and 15 is incomplete but it will serve as a guide.

Reflection of Short Waves

The principal part of the short wave (high-frequency) signal does not follow the earth's surface, as the long waves do, but leaves the earth's surface and travels until it strikes and is reflected by a conducting layer, known as the Heaviside layer, after the famous British physicist who developed the theory of its existence. Below 50 meters (above 6000 k. c.) the zone over which the signal is rising toward the layer, or from it toward the earth, is "dead" and no signal is received. The distance between the point at which the wave leaves the earth and that at which it returns is known as the "skip" distance.

The height of the Heaviside layer, and the skip distance in turn, vary with the time of day and the season. Variations in the skip distance are at least partly responsible for "fading" and this is therefore especially severe below 50 meters (above 6000 k. c.). Even an ultra-sensitive receiver may, therefore, be unable to pick up stations within its theoretical range. The shielding effects of large buildings, metal structures and so forth, are also more marked so that these must be taken into account in considering the operation of a receiver.

We are all familiar with the fact that a "head light" type of reflection can be made to reflect heat, and since ultra-short waves are near the heat wavelengths it is natural to suppose that reflectors can be built to concentrate radio waves into a beam. This is being done today with the result that even more consistent long distance communication is possible by concentrating most of the energy into a beam directed toward the receiving station.

Exclusive Fields for Short Waves

Because of the compactness and light weight as well as the efficiency of short wave equipment it is used extensively in mobile stations. It is even more valuable in airplane work where weight is the controlling factor. The first airplane to keep in *constant* touch with the world while making a long flight was the Southern Cross. Her transmitter worked on approximately 34 meters. It is interesting to note that Hammarlund equipment "played no small part in the excellent performance of the equipment" to quote the designers.

What has made the interest in short waves appear sudden is that the long wave channels are badly overcrowded and new ones were urgently needed. This need, coupled with the exceptional performance, has resulted in almost a stampede for the short wave channels. A good part of the last international radio conference, held in Washington, was devoted to the question of their allocation. This question is of particular importance because of the very large interference area of a short wave transmitter.

Television is a field which brings out the advantages of short wave channels very well. A good television transmitter requires a band from 40 to 80 k. c. wide, which represents from 4 to 8 broadcasting channels. These can not be afforded in the broadcast band so the newer transmitters are working between 30 and 80 meters. The shorter waves are also more valuable because of their better carrying power and because "side-band cutting," with consequent loss of picture definition is less severe.

Short Wave Design Trends

The trend of short wave receiver design seems destined to follow the steps taken in the development of broadcast receivers although the accumulated experience is accelerating the progress. We have largely gone through the single regenerative detector tube stage into the use of a coupling tube and more recently into the tuned input radio frequency stage. The development of satisfactory radio-frequency amplifiers to work at the very high frequencies used in short wave receivers has been made possible largely by the development of the screen grid 222 tube. This tube was used experimentally in short wave Trans-Atlantic reception more than a year before it appeared on the market.

The development past the single tuned input radio-frequency stage will very probably be comparatively slow. The 222 tube puts the short wave receiver on a par with popular broadcast receivers of the type of the first Hammarlund-Roberts, the Browning-Drake, and the R. B. Lab that are still in common use and being built daily.

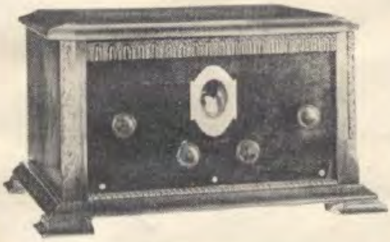
Developments will probably be in the line of elimination of regeneration in the detector circuit for phone reception, the introduction of multi-stage shielded receivers, and of superheterodyne receivers. The latter were designed for short wave work and seem destined to find their own in this field since the frequency of the incoming signal is lowered to one that can be amplified efficiently. There is the further advantage that only one or at most two coils need be plugged in for each range—one of the stumbling blocks in multistage receivers.

Because of the importance of the 222 tube in short wave receivers some of the simpler theoretical considerations involved in its use will be gone into.

Theory of the 222 Tube

Those who are interested in the theoretical amplification which may be obtained from a 222 tube in the radio frequency stage are referred to a simplified equivalent circuit of the tube in Figure 1. Here Cgp is the effective grid to plate capacity, .025-.03 mmfds, Rp the plate impedance of the tube which is approximately 800,000 ohms, Zin and Z1 the input and output impedances respectively. The effect of the load impedance on the amplification may be approximated at low radio frequencies by neglecting the circuit DCBAHG. The plate circuit is considered to have a generator giving a voltage of the amplification constant, mu, times the input voltage Eg. This amplification constant mu is about 270 for the average 222 tube.

The voltage drop across EF is that impressed across the following tube. Therefore the amplification on this circuit may be determined by considering the fraction of the voltage muEg developed across this circuit. If the impedance of the load Z1 is 100,000 ohms, then the total resistance in the circuit GDEFG is 900,000 ohms. It follows that one-ninth of the voltage will be impressed across EF. The amplification is then one-ninth of the mu of the tube, or, in this case, approximately 30.



Since the value Z1 is small as compared with Rp, this same value could have been approximated by multiplying the mutual conductance of the tube, Gm, by Z1. This follows from the fact that by definition the mutual conductance is the change in plate current produced by unit change in grid voltage. The numerical values in this case would be .000340 times 100,000 or 34. A micromho is one-millionth of a mho, so that the mutual conductance of the tube which is 340 is to be divided by a million before it is multiplied by the load impedance.

Effect of Grid-Plate Capacities in 222

Up to frequencies of approximately 1500 k. c. (down to 200 meters) the capacity Cgp is not very important. At the frequencies in which we are interested, however, this grid-plate capacity is of great importance, since the voltage which it impresses across Zin is in phase with, that is, helps, the incoming voltage. This results in regeneration and instability.

The tube will oscillate continuously if the voltage from the plate circuit through Cgp is equal to the original impressed voltage. If we assume a given load impedance which determines the amplification in the plate circuit, then the value of Zin or the maximum frequency for stable operation, if this impedance is fixed, may be determined. In the above case, for example, the voltage across DG is 30 times that across AH, because the amplification is 30 in the stage. To produce continuous oscillations it is necessary that the frequency be sufficiently high to reduce the reactance of Cgp to the point where approximately one-thirtieth of the voltage in the circuit DCBAHG is impressed across AH.

Limiting Frequency for Stable Operation

If the circuits Zin and Z1 are similar and the value of Zin is 100,000, the limiting stable frequency may easily be determined. This is the frequency at which the reactance of the grid-plate capacity is approximately 30 times that of Zin or 3,000,000 ohms. The reactance is numerically equal to one million divided by 6.28 times the frequency in cycles, times the capacity in microfarads. Solving this equation, a frequency of 1770 k.c. is obtained. Referring to the table on page 17 we see that this corresponds approximately to a wave length of 169 meters.

If the tube is to be used on higher frequencies, either the value of Zin must be decreased so that less of the voltage "reflected" from the plate circuit is impressed across it, or the value of Z1 must be decreased to decrease the amplification.

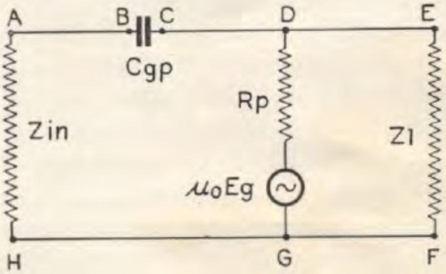


Figure 1—Equivalent circuit of a 222 tube used with a tuned output circuit and either a tuned or a resistance coupled input. The various components are described in the text.

In circuits of the type shown at A, Figure 7, and in Figure 15, the 222 tube is used as a coupling tube and the value of Zin is of the order of 5000 ohms. In this case, this impedance is very small as compared with the reactance of Cgp, even at high frequencies, and all the amplification possible may be secured in the tube itself. This permits the regeneration control in the detector to be advanced, increasing the effective impedance of Z1 and the amplification until the detector goes into oscillation.

Tuned Input Circuits

More amplification than is secured with the coupling tube may be secured by using a tuned input circuit of the type shown at B, Figure 7 and in Figure 18. In this case, the impedance of the tuned circuit may be quite high and not only the amplification but the selectivity is improved. At high frequencies, as pointed out above, the value of Z1 must be decreased, however, to secure stable operation. This circuit is especially valuable below 6 mega cycles (6000 k.c.—about 50 meters).

The equivalent input circuit of this type is shown in Figure 2. Here the dummy antenna is shown as an inductance, resistance, and capacitance in series marked DA. The capacitance C1 is the variable antenna coupling condenser, L and C the main tuning inductance and capacitance, and C2 the effective input capacitance of the tube, plus any fixed shunt capacitance.

Standard Antenna Constants

The "standard" antenna is considered to have the following constants: 200 mmfds. capacitance, 20 microhenries inductance, 25 ohms resistance, 4 meters "effective" height. The "effective" height is used in securing the voltage of the equivalent generator shown in Figure 2. The voltage of this generator is considered to be the "effective" height of the antenna (in this case four) times the field strength in micro volts, milli volts or volts per meter. If the field strength is 100 micro volts per meter, then the voltage of the generator is considered 400 micro volts or .4 milli volts.

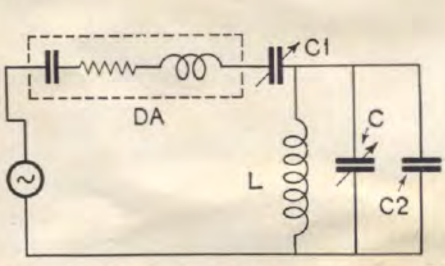


Figure 2—Equivalent input circuit of a 222 tube showing the tuned input circuit and dummy antenna. Constants for the dummy antenna are given on page 7.

In a circuit of this type when the antenna is tuned the voltage across L and C may be many times that of the generator itself. Those interested in the theory involved are referred to the Bureau of Standards circular No. 74, Radio Instruments and Measurements.

The equivalent output circuit for the 222 tube is shown in Figure 3. Here R corresponds to Rp in Figure 1. The effective output capacitance of the tube is C3; L4 and C4 are the main tuning inductance and capacitance and C5 is the effective input capacitance to the detector tube. The three capacitances in parallel tune L4 to the resonant frequency and give an equivalent dynamic resistance represented by Z1 in Figure 1.

The capacitance C3 is about 12 mmfd. for the 222 tube. This is largely the capacity between the screen grid and the plate. The input capacitance of the detector tube, C5, is much higher than the input capacitance of the 222, C2, in Figure 2.

Single Control for R. F. Circuits

When C and C4 are similar condensers and the inductance of L equals the inductance of L4, then if the two circuits are to be operated from a single control the capacitance of C3 and C5 in parallel must be duplicated across the inductance L. The capacitance C2 accounts for a small portion of this, and the effective capacitance of the circuit DAC1 may be controlled by varying C1 to bring the two circuits into alignment. This is done more easily if a small capacitance is connected in parallel with C. This should have a value of about 10 mmfds. It is shown as C7 in Figure 18. In the receiver described on pages 24 and 25, the antenna coupling condenser C1 acts also as a variable "trimming" or "padding" condenser.

Ganging C and C4 simplifies the operation without sacrificing amplification. This may be determined by first tuning in a station using separate controls on C and C4 with C1 at some fixed position and comparing the signal strength with that obtained by tuning C and C4 together and then adjusting C1 for maximum gain. Although the same number of tuning operations are involved there is the decided advantage that the signal may be received independent of the setting of C1. This may then be adjusted for maximum signal strength.

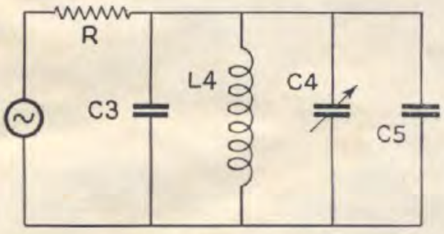


Figure 3—Equivalent output circuit of a 222 tube using a tuned plate coupling circuit. The values of the capacitances and the inductance are given in the text.

Shielding the R. F. Stage

In discussing the limiting amplification at high frequencies using the equivalent circuit in Figure 1 the value of .03 mmfds. for the effective grid to plate capacitance was used. If this value is increased the permissible gain or amplification for stable operation is decreased. It is important to remember that any capacitance between a wire connected to the control grid and one connected to the plate increases this capacitance. To minimize it shielding may be resorted to though it should be avoided if possible because of the mechanical difficulty of changing coils when a shield top has to be removed.

In a receiver of the type shown on page 24 shielding may be eliminated if the parts are laid out properly. The amplification in the radio frequency stage is of the order of that obtained in a corresponding circuit using a stage of radio frequency amplification and regenerative detector with a 201a at broadcast frequencies. These circuits can be used without shielding and the 222 tube at high frequencies "looks like" or behaves like the 201a at broadcast frequencies. Where the effective grid-plate capacity must be kept at an absolute minimum shielding should be used.

A suggested shielding arrangement for a single stage such as used in the "De Luxe" receiver (described on pages 24 and 25) is shown in Figure 4. The lead from the plate terminal of the socket should be made as short as possible. This can be done by putting the socket next to the shield with the P terminal next to the shield side. The antenna binding post should be mounted on the other side of the shield and the antenna lead to C made as short as possible. The leads to the condenser C2 should also be as short as possible.

The resistor R1 should have a resistance of between 5000 and 100,000 ohms. The capacitance of C2 may be .1 to .5 mfds. The 20 ohm mid-tap filament resistor is shown as R. Two circuit refinements are shown in this diagram which may be applied to Figure 18. These are the use of a 100,000 ohm potentiometer at R2 to control the screen grid voltage of the 222 tube, and the use of R1 to more completely isolate the screen grid circuit.

The variable resistors R2 and R3 may be mounted on the panel giving close control of the amplification, sensitivity and regeneration respectively. The resistor R2 provides a volume control down to quite low levels and when used in combination with the regeneration control it works very satisfactorily. The minimum level is otherwise too high.

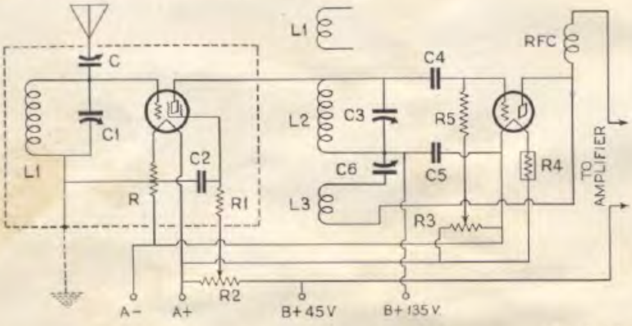


Figure 4—Suggested shielded arrangement for a 222 RF stage using a tuned input circuit. Potentiometers permit control of the screen grid potential and the voltage on the grid return.

Common Regeneration Controls

Smooth control of regeneration is a very important factor in short wave receivers. The requirements of a good control are that it operate smoothly, permit close adjustment and detune the secondary circuit as little as possible. Smooth and accurate control are important because for distant reception of phone signals the detector is operated near the oscillating point. If the detector circuit goes into oscillation with a "blop," the point of maximum sensitivity cannot be approached. Another objection to circuits which go into oscillation abruptly is that oscillations will continue after the control has been moved back several degrees past the point at which the set originally went into oscillation. This "drag," as it is called, is especially objectionable when tuning over the whole wave length range with the circuit adjusted for maximum sensitivity.

Circuit A, Figure 5, using a variable tickler coil has been abandoned both because of poor control and its effect on the secondary tuning. Circuits B and C, Figure 5, correspond to circuits B and A of Figure 6. In these circuits a fixed tickler is used and regeneration is controlled through a small variable condenser. Circuit A, Figure 6, seems to possess most of the requirements set forth above and is generally used.

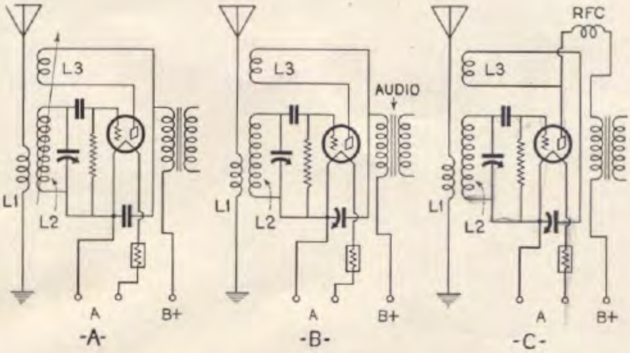


Figure 5—Three types of regenerative circuits which have been in common use. Circuits A and B should preferably have a radio frequency choke connected in series with the P terminal of the transformer. Circuit C gives the smoothest control and is generally recommended.

Dead Spots Due to Poor Choke

Since the B battery is at ground radio frequency potential, it may be seen that the choke coil RFC in A, Figure 6, is directly across the plate inductance L3 and the variable regeneration condenser. If the choke is a poor one, its low impedance at some frequency in the short wave bands may almost short circuit the output circuit and prevent the circuit oscillating. When chokes are used which do not have the uniformly high impedance of the Hammarlund type, the arrangement shown in B, Figure 6, should be used. Circuits A and B use what are known as shunt and series plate feed circuits respectively.

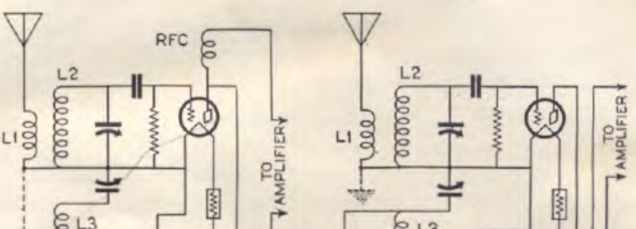


Figure 6—Circuit A uses a parallel feed plate circuit and circuit B uses a series feed plate circuit. The former gives very smooth control and is recommended when a high quality choke is available. Circuit B is recommended for poor chokes which have not the uniformly high impedance of the Hammarlund type.

If the receiver is to be primarily used for the reception of code signals a 10,-

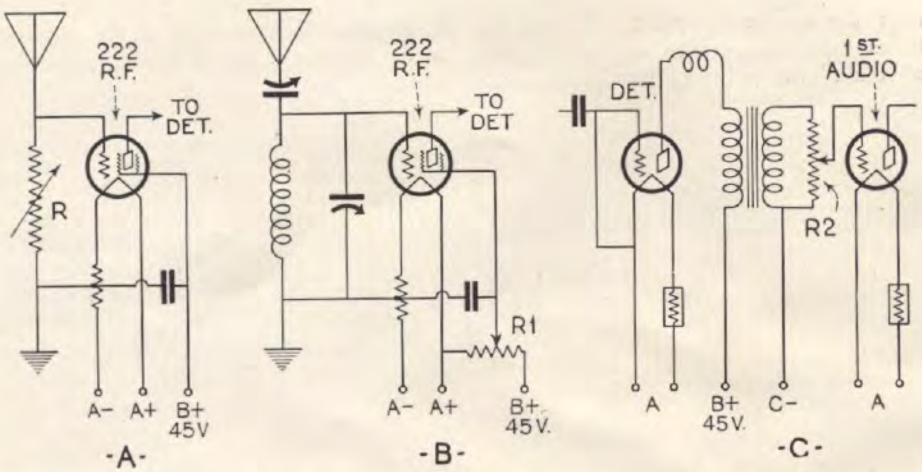


Figure 7—Three suggested volume controls for short wave receivers. Circuit A applies to coupling tubes and circuit B to tubes having a tuned input circuit. Circuit C gives an absolute low signal position and is very satisfactory where the signal does not overload the detector tube. The regeneration control should be used with all three as an added volume control for best results.

000 to 25,000 ohm resistor may be substituted for the choke. This offers a high impedance at the very high frequencies (low wavelengths) where a choke is apt to offer very little impedance. Best results may be obtained by using a 10,000 ohm resistor in series with the choke. This gives a much higher impedance at the low radio frequencies where it is needed. The detector plate voltage should be increased to from 67.5 to 90 volts to compensate for the drop in the resistor. The resistor is not recommended for high quality broadcast reception because of the reduced amplification of the low audio frequencies.

Where the regeneration condenser does not give sufficiently close adjustment, the regeneration may be controlled more smoothly by using a high variable resistance across this condenser, or, in some cases, across both the tickler coil and the variable condenser. This resistor may be one of the Universal Clarostat types.

Suggested Volume Controls

Volume controls which are satisfactory at broadcast frequencies are only partly so at very high frequencies. This is due to the fact that the coils in the receiver itself may pick up considerable energy and if the volume control is introduced ahead of the pick up, it very naturally provides little or no control at low levels.

As pointed out above, a 222 coupling tube is almost as satisfactory as a tuned input circuit type at frequencies above 6000 k.c. (below 50 meters). In a circuit of this type the antenna coupling resistor may be a variable one such as shown at A, Figure 7, and act as a volume control as well as a coupling resistor. Except on powerful stations, this control is quite satisfactory and when it is used with the regeneration control gives very good control.

Where a tuned input circuit is used, it is very desirable to have a control of the type shown at B, Figure 7. In this a potentiometer permits control of the screen grid voltage. This controls the mutual conductance and hence the amplification in the tube. This volume control does not give an "off" position, and either detuning or readjustment of the regeneration condenser must be resorted to on loud signals.

The volume control shown at C, Figure 7, has the advantage of giving a zero volume position even when there is direct pick up in the detector coils. It does not detune the secondary circuit, as a change in the regeneration control does and it is quite satisfactory since the incoming signal is rarely strong enough to overload the detector. This type of volume control is used in the receiver described on pages 24 and 25.

The only objection to this type of control is that it changes the frequency characteristic of the audio-frequency transformer. In practice it is found that the signal level is rarely high enough to require a very low resistance (low volume) setting and when it is very high the regeneration may be decreased without losing the station.

at the present time and it is probable that most of them will move into the range of from 60 to 80 meters in the future. The use of these short wave lengths is necessary because of the wide side bands. The high carrier frequency makes side band cutting less severe.

The width of the side bands is determined by the number of "dots" sent for each picture and the number of pictures per second. The definition of the picture will depend on the number of "dots" to each picture and the continuity or "smoothness" of motion on the number of complete pictures sent every second. High quality transmissions have side bands 40 or more k. c. wide.

Special circuits are necessary to receive this wide frequency band uniformly.

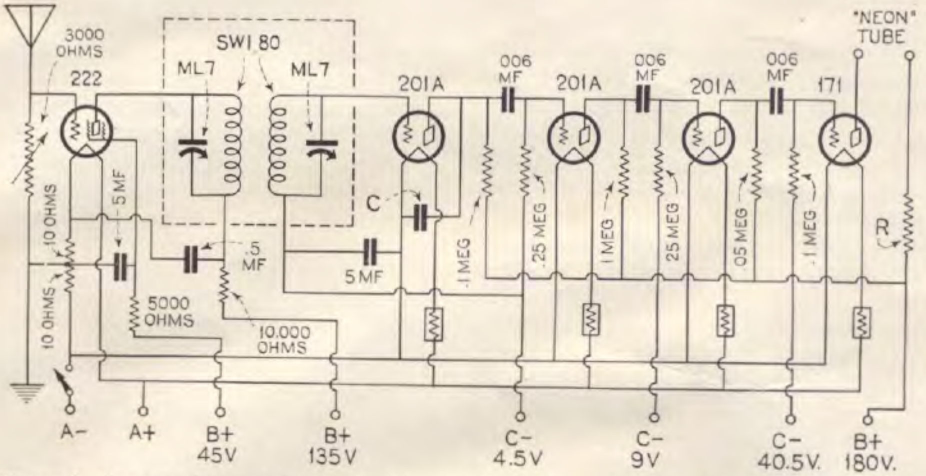


Figure 8—Suggested layout for a television receiver using a 222 coupling tube with a tuned band-selector circuit. The SWI-80 coils should be used to cover the range of from 52 to 107 meters and the SWI-40 coils to cover the range of from 27 to 59 meters. Grid leak condenser rectification and a tuned input circuit are not used since they would cause high frequency side band suppression. The audio channel shown will work very satisfactorily with the average "televisor".

Television Circuit Requirements

Those who are interested in reception of television signals between 30 and 80 meters are referred to Figure 8. This shows a circuit arrangement which will work very satisfactorily even when the modulating frequencies are as high as 40 k.c. Several stations are broadcasting television signals in this band

The radio-frequency circuits must be broad or of the band selector type. This means that regeneration should be used sparingly or not at all. The grid-leak-condenser detector is not used because it, too, supresses the high frequencies. A high quality audio channel must be used. Where compromises are made there will be a loss in definition of the received image.

The reponse curve of an ideal receiver for the reception of television signals is shown at A, Figure 9. This square top band with sharp cut off permits uniform transmission of the high side band frequencies. The curve B is that of a typical receiver using regeneration in the detector and shows how unsatisfactory such a receiver is. Figure 10 shows the theoretical curve A, and curves which may be secured in practice from an arrangement such as shown in Figure 8.

The circuit shown is one of the tuned plate—tuned grid band selector types which is used in the Hammarlund-Roberts Hi-Q 29 Master receivers. The two coils should be mounted so that they are very loosely coupled. The best value of coupling may be determined by putting a milliammeter in the plate circuit of the detector tube. If a variable frequency oscillator is available, its frequency should be varied over about 40 k.c. near the frequency to which the circuits are tuned. The coupling should then be tightened until there is a sharp decrease in the deflection of the meter, then a considerable frequency range over which the needle deflection does not change, and then an abrupt increase in current.

Carefully matched condensers and coils should be used to permit single control operation. An EC 35, 35 mmfd. equalizer should be connected across the ML 7, 140 mmfd. variable Midline condenser, used in the plate circuit of the 222 tube. This should be adjusted for maximum signal strength while the set is tuned to a station which is received near 60 on the dial and while the two coils are very loosely coupled. The adjustment of the coupling, suggested above, should then be made.

This circuit is very good for local or moderately distant reception. For long distance reception the circuit shown on page 23 should be used. The regeneration improves the sensitivity but at the cost of definition in the received picture.

A coupling tube is used since there is no attenuation of the side bands in this circuit. The resistance coupled amplifier shown gives very satisfactory response over the range needed in television reception. High mu tubes should not be used. The output circuit of the 171 should be that recommended for the neon tube used in the receiver.

(*Continued on page 18*)

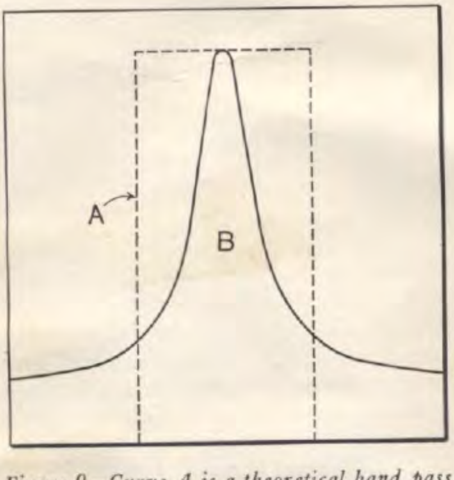


Figure 9—Curve A is a theoretical band pass curve with a flat top and sharp cut off. This is an ideal circuit for a television receiver. Curve B is representative of the usual circuit using regeneration in the detector circuit.

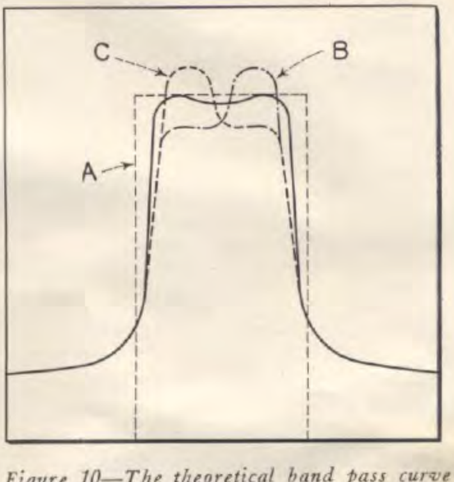


Figure 10—The theoretical band pass curve is shown at A together with typical curves obtained when using the circuit shown in Figure 8. Any of them are very much better than curve B, Figure 9.

SHORT-WAVE TRANSMISSIONS

Land Stations Throughout the World Working Below 100 Meters

The following is a revision of the list of stations which appeared in **Radio Broadcast.** The accuracy of the list cannot be guaranteed because of rapid changes in the allocation of short wave channels. Where necessary, changes in wave length or schedule have been made. Many new stations have been added. Beam stations on other than American circuits, ship and some minor military stations have been eliminated. Stations are arranged alphabetically. National prefixes have been used in accordance with the prevailing custom, that is, U2XAD indicates the American station 2XAD, G5SW, the British station 5SW and so forth. The time is given in G.C.T. or G.M.T. which were standardized in 1925. See the time chart on page 16 to determine the corresponding local time.

Call-Sign	Station	Wavelengths & Remarks
	A	
AFI	Konigswusterhausen	26.3.
AFJ	Konigswusterhausen	53.5.
AFU	Konigswusterhausen	39.7.
AGA	Nauen	14.9, 12.25, 13.5, 14.25, 16.0, 26.0.
AGB	Nauen	25.5, 26.6, 27.0.
AGC	Nauen	17.2, 26.0, 39.8, 40.2 (Phone occasionally).
AGJ	Nauen	56.7 (Phone occasionally after 1800 G. M. T.).
AGK	Nauen	11.0, 20.0 (2 kw.).
AIN	Casablanca, Ain Bordja	51.0 (Weather reports, 0830 and 1930 G. M. T.).
ANC	Tjililin, Java	26.2, 40.2 (Code).
AND	Tjililin, Java	18.8, 28.8, 37.5 (Code).
ANE	Bandoeng, Java	17.4 (Code and Phone).
ANF	Tjililin, Java	20.3 36.5, (Code).
ANH	Malabar, Java	17.4, 27.0, 32.0 (Code and phone. Phone on Saturday, 1200-1700 G. M. T., and at other times as then announced).
ANK	Malabar, Java	19.4, 30.20 (Exp. Tests).
AYG	Guayra, Venezuela	31.8.
A 2FC	Sydney, N. S. W.	32.0 (Phone).
A 2ME	Sydney	28.50 (Phone Sun., 1830-2000 G. M. T.).
A 3LO	Melbourne	29.8, 32 or 36 (Phone Sun., 1830-2030 G. M. T.).
	B	
BAM	Tahiti	40.0.
BVJ	R. N. College, Dartmouth	46.0.
BXY	Stonecutters Island, Hong-Kong	35.0.
B 82	Ucce, Belgium	40.0.
	C	
CG	Drummondville, Montreal	16.501, 32.128.
CH	Quilicura, Chile	15-20.
CRHA	Lourenco Marques, Portuguese East Africa	18.360.
CRHB	Praia, Cape Verde Islands	18.094.
CRHC	Laonda, Angola	18.182.
	E	
EAM	Madrid	30.7.
	F	
FL	Eiffel Tower	32.0, 75.0.
FW	St. Aisse, Cie. Radio, France	14.28, 23.25, 25.0, 41.95, 43.0 (Traffic with Buenos Aires).
FUA	Bizerta-Sidi-Abdallah, Tunis	42.5, 56.0, 73.0.
FUE	Mengam, France	38.5.
FUL	Beyrouth-Djedeide, Lebanon	28.0-80.0.
FUM	Montebourg (Air Station)	37.0.
FUT	Toulon-Mourillon, France	36.5.
F 8GA	Clichy	30.0.
F 8GB	St. Assise, Paris (S.F.R.)	75.0 (S. F. R. Bulletins).
F 8GC	Radio LL, Paris	60.0 (Phone).
	G	
GBL	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GBM	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GBO	Leafield (P. O. Station)	17.5, 21.5, 24.0, 30.0, 56.0.
GFA	Air Ministry, London	44.0.
GLH	Dorchester (Beam Station)	22.091 (American Circuit).
GLQ	Ongar (for communication with New York, Buenos Aires, and Rio de Janeiro)	24.5.
GLS	Ongar	15.0.
G 2BR	Chelmsford	15.0, 17.0.
G 2NM	G. Marcuse, Caterham	32.5 (Phone Tues., Thurs., Sat., Sun., 0600-0700, and Sun., 1600-1800 G. M. T.).
G 2YT	Poldhu	250, 32.0, 60.0, 92.0, 94.0.
G 5DH	Dollis Hill (P. O. Station)	21.7, 27.6, 35.3, 47.0.
G 5SW	Chelmsford (B.B.C. Exp.)	24.0 (Phone 1330, 1430, and 1930 onwards).
	H	
HBC	Berne, Switzerland	34.2.
HJG	Bogota, Colombia	22.0.
HVA	Hanoi, Tonkin	32.0.
HZA	Saigon	25.0.
H 90C	Telegraphic and Radio Service, Case No. 63, Poste Transit, Berne	32.0 (Relays Berne, Mon., Thurs., and Sat., 2000-2100).
H 9XD	Radio Club of Zurich	32.0, 85.0.
	I	
ICC	Coltano	18.0.
ICD	Rome (Cento Celle)	63.0.
ICF	Messina, Sicily	49.0.
ICJ	Bengasi, Cyrenaica	26.0, 53.0.
ICK	Tripoli	45.0.
ICO	Derna, Cyrenaica	54.0.
ICU	Tobruk, Cyrenaica	54.0.
ICX	Massawa	47.0.
IDO	Rome, San Paulo	33.0-37.5.
IDX	Amara, Erythrea	32.5, 64.00.
IHF	Catania, Italy	53.5.
IST	Chisimaio, It. Somaliland	38.0.
I 1AX	Rome, Via Savoia 80	45.0 (Phone occasionally).
I 1FC	Royal Frederico Cesi School, Rome	33.0, 34.0.
I 1MA	Rome, Via Bramante 3	43 (Sundays, 1700-1930 G. M. T.).
I 1RG	"Radiogiornale," Lake Como	10.0, 18.0, 35.0, 65.0.
	J	
JB	Johannesburg	32.0 (Phone).
JBK	Kagoshima, Japan	30.0, 40.5, 70.0.
JES	Osaka, Japan	24-71.
JEW	Osaka, Japan	24-71.
JFAB	Taipeh, Formosa	39.5, (0900 G. M. T.).
JHL	Hiroshima, Japan	32.0, 58.0, 74.0.
JKV	Kanasawa, Japan	37.5 (Temporary).

Call-Sign	Station	Wavelengths & Remarks
JOC	Otchishi, Japan	43.0.
JPP	Tokyo, Japan	16-73.
JPS	Sapporo, Japan	29.0, 38.0, 60.0.
JYB	Tokyo, Japan	16-73.
JYZ	Tokyo, Japan	16-73.
J 1AA	Iwatsuki, Japan	40.5.
J 1PP	Tokyo, Japan	20.0, 21.5, 35.0.
	K	
KAV	Norddeich	39.0, 68.0.
KDKA	East Pittsburgh, Pa. (Westinghouse E. & M. Co.)	26.3, 32.95, 58.75, 62.5, 63.66 (Phone from 2300 G. M. T.).
KDZ	Point Barrow, Alaska	21.4, 42.08, 74.77.
KEB	Oakland, Calif. (G. E. Co.)	18.62, 21.8.
KEG	Vancouver, Washington (Pacific Air Transport)	45.0.
KEL	Bolinas, Calif. (R.C.A.)	14.1, 29.3, 95.0.
KEMM	Bolinas, Calif. (R.C.A.)	14.29, 28.58.
KESS	Bolinas, Calif. (R.C.A.)	14.40, 28.80.
KET	Bolinas, Calif. (R.C.A.)	99.0.
KEU	Los Angeles, Calif. (Pacific Air Transport)	45.02.
KEUN	Bolinas, Calif. (R.C.A.)	14.08, 38.38.
KEWE	Bolinas, Calif. (R.C.A.)	14.08, 28.15.
KFD	Denver, Colorado (G. E. Co.)	17.7, 24.3.
KFQU	Holy City, Calif.	31.0, 53.0, 63.0.
KFWB	Los Angeles, Calif.	40.0.
KFY	Poinciana, Florida	68.4.
KFZG	Point Barrow	45.32, 69.25.
KFZH	Fairbanks, Alaska	44.71, 68.32.
KGE	Medford, Oregon (Pacific Air Transport)	46.06.
KGH	Hillspro', Oregon (Fed. Telegraphic Co.)	36.52, 46.99.
KGT	Fresno, Calif. (Pacific Air Transport)	46.06.
KIO	Kahuku, Hawaii (R.C.A.)	90.04.
KKC	Palo Alto, Calif. (Fed. Telegraphic Co.)	17.0, 27.5.
KLL	Bolinas, Calif. (R.C.A.)	21.85.
KMM	Bolinas, Calif. (R.C.A.)	14.29, 28.58.
KMV	Bandini, Calif. (Western Air Express, Inc., Morse)	49.5.
KNN	Honolulu (Mackay, R. & T. Co.)	17.2, 23.0, 23.7, 28.0, 34.4, 46.0, 47.4, 56.0.
KNR	Clearwater, Calif. (Fed. Telegraphic Co.)	29.5, 49.15.
KNW	Palo Alto, Calif. (Mackay, R. & T. Co.)	16.7, 17.0, 24.0, 33.4, 34.0, 48.0, 51.0.
KQS	Lone Pine, Calif. (City of Los Angeles)	45.77.
KQT	Los Angeles, Calif. (City of Los Angeles)	45.77.
KRP	Salt Lake City, Utah (Western Air Express, Inc.)	49.5.
KSS	Bolinas, Calif. (R.C.A.)	14.40, 28.80.
KSZ	McCamey, Texas	48.05.
KTA	Guam (Mackay R. & T. Co.)	18.0, 21.8, 22.0, 23.5, 36.0, 43.6, 44.0, 47.0.
KTF	Midway Island (Mackay R. & T. Co.)	21.6, 33.2, 43.2, 66.4.
KUN	Bolinas, Calif. (R.C.A.)	16.93, 33.88.
KUY	Bear Creek, Alaska	82.0.
KVR	Las Vegas, Nevada (Western Air Express, Inc.)	49.5.
KWE	Bolinas, Calif. (R.C.A.)	14.08, 28.15.
KWJJ	Portland, Oregon	53.54 (¼ kw.).
KWT	Palo Alto, Calif. (Fed. Telegraphic Co.)	34.85, 48.05, 49.97, 58.10.
KWV	Bakersfield (Pacific Air Transport)	66.48.
—	Lyons, Radio Lyon	39.5 (Phone 1700-1800 G. M. T., except Sundays).
	L	
LCHO	Telegraph Administration, Oslo	33.0.
LPI	Buenos Aires	34.0.
LPZ	Buenos Aires	36.0, 75.0.
LY	Bordeaux, Lafayette	32.0.
	N	
NAA	Washington	24.9, 37.4, 74.7.
NAJ	Great Lakes, Illinois	40.0, 76.0, 34.0.
NBA	Pensacola, Florida	40.0.
NAS	Balboa, Canal Zone	54.0.
NKF	Lakehurst, N. J.	80.0.
NEL	Naval Lab., Bellevue, Anacostia	16.0, 17.0, 20.8, 21.8, 25.5, 41.3, 54.4, 61.0, 71.3, 81.5.
NPC	Arlington	29.0, 37.4, 74.7.
NKL	Puget Sound, Washington	37.0.
NPO	San Francisco, Calif.	16.49, 32.98.
NPM	Honolulu, Hawaii	35.0 and 36.8.
NPG	Cavite, Philippine Islands	68.0, 70.0.
NPU	Tutuila, Samoa	37.0-40.0, 53.0.
NQC	San Diego, Calif.	75.0, 86.0.
NRRG	Winter Park, Florida	39.5, 82.0.
	O	
OCBA	Bamako (Soudan)	41.50.
OCCO	Conakry (French W. Africa)	33.0.
OCDA	Dakar (French W. Africa)	35.0.
OCDB	Djibouti	72.0.
OCDJ	Issy-les-Moulins	33.0 (1008-1028 G. M. T.), 65.0 (Corresponding with OCDB), 32.0 (Time Signal, 0756 and 0955).
OCNG	Nogent-le-Rotrou	29.0, 32.0, 45.0, 48.0, 72.0.
OCRB	Rinck, Meteo Aviation, Rabat, Morocco	36.0.
OCRF	Reggu, Morocco	74.0 (2130-2145 G. M. T.).
OCRU	Rufisque (French W. Africa)	39.0.
OCTN	Mourillon, Toulon	20.0 (Series of "a" from 1530-1540 G. M. T.), 33.0 (Series of "b" from 1545-1555 G. M. T.), 57.0 (Serial of "c" from 1600-1610 G. M. T. daily, except Sundays).
OCTU	Tunis la Casbah	48.0, 50.0.
OHK	Vienna	39.5, 40.6.
—	Paris, Radio LL	61.0 (Phone).
—	Paris, Radio Vitus	37.0 (Phone Wed., Fri., Sun., 2100-2245 G. M. T.).
	P	
PCA	Amsterdam	33.33.
PCG	Malabar, Java	17.0.
PCH	Scheveningen Port	20.0, 20.6, 20.69, 21.127, 28.800, 29.226, 29.283.
PCJJ	Hilversum, Holland (Philips Lamp Works)	30.2 (Phone).
PCLL	Kootwijk, Holland	46.0, 32.0, 18.0 (Wed., 1100 - 1600 G. M. T. and occasionally on Mon. and Fri.) and other wavelengths below 60 meters (40kw.).
PCMM	Ministry of Posts and Telegraphs, Kootwijk	25.0, 27.5, 36.0 and other wavelengths below 60 meters.
PCPP	Kootwijk, Holland	27.0 and other wavelengths below 60 meters.
PCRR	Kootwijk, Holland	20.0, 25.0, 37.0 and other wavelengths below 60 meters.
PCTT	Kootwijk, Holland	21.0, 29.5 and other wavelengths below 60 meters (10kw.).
PCUU	Dutch Colonial Ministry, The Hague	34.0.
PKD	Koepang	32.0.
PKE	Amboina	24.0.
PKH	Soerabaja, Java (D. E. Indies)	23.0.
PKP	Medan	21.5, 31.5.
PKX	Java	27.0, 32.0.
POF	Nauen	13.5, 18.0.
POX	Nauen	20.00.
POY	Nauen	25.0.
POZ	Nauen	47.0.
PTQ	Quartel-General, Brazil	30.5.
PVC	Curacao	15.0-20.00.
	R	
RABL	Habarousk	22.0.
RAU	Tashkent	23.0, 34.0.
RCRL	Central Lab., Leningrad	27.0.
RCT	Sebastopol	64.0.
RDI	Petrozavadosk	34.2.
RDRL	Leningrad	28.5.
RDW	Moscow	83.0.
RKV	Moscow	21.0, 34.0.
RLT	Tommot	23.00.
RRP	Nijni Novgorod	20.0-42.0.
RTRL	Tiflis	22.0-42.0.

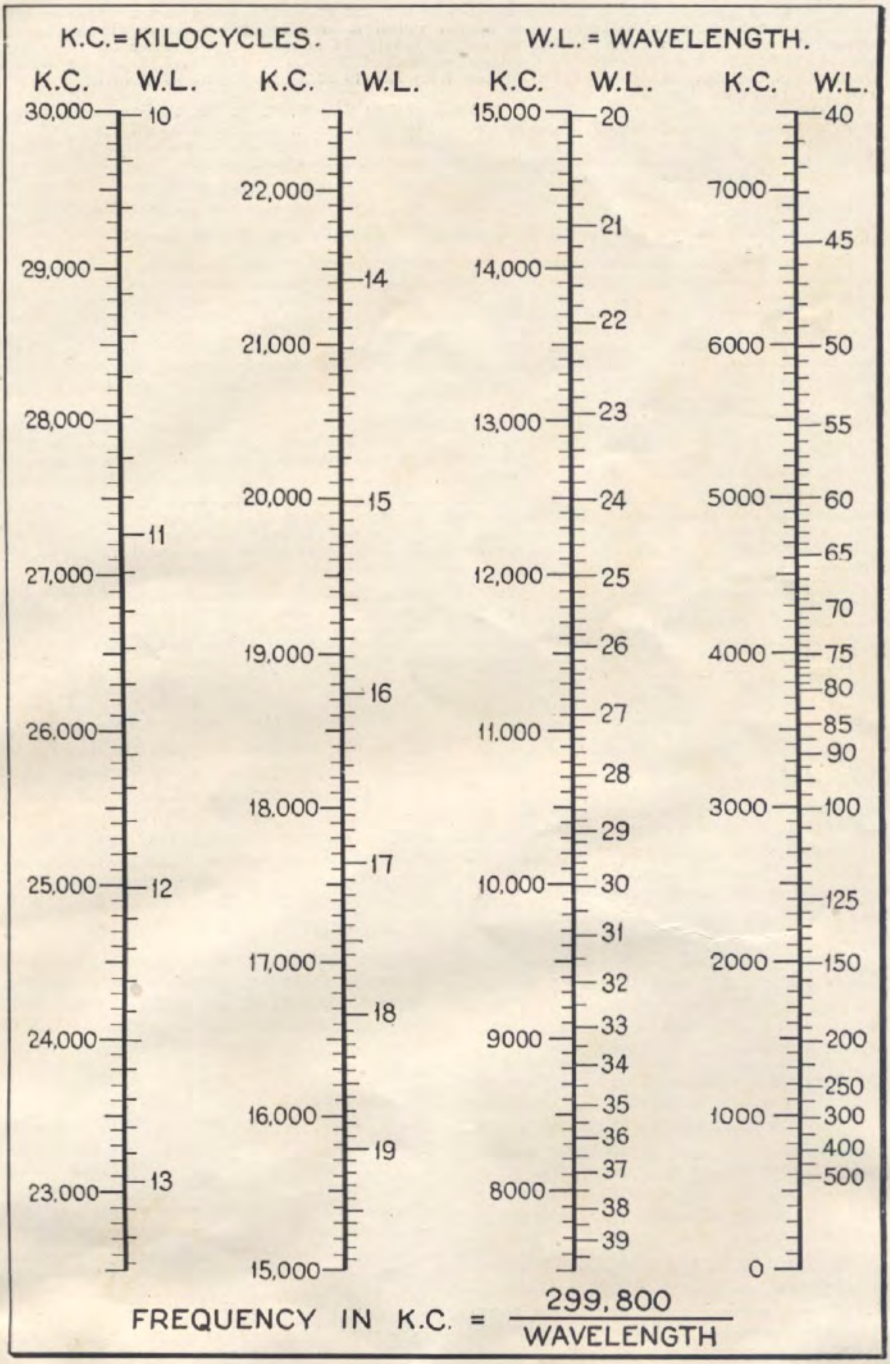
Call-Sign	Station	Wavelengths & Remarks
S		
SAA	Karlskrona	44.0.
SAB	Goteborg	36.5.
SAD	Flottans Stations, Stockholm	31.0-51.0.
SAJ	Karlesborg, Sweden	50.0.
SFR	Paris	75.0, 85.0.
SMHA	Stockholm	41.0.
SOK	Moskwa Sokolenlki Radio	37.0.
SPM	Radio Laboratory, Ministry of Posts, Helsingfors	47.0.
SPR	Sepetiba, Rio de Janeiro, Brazil	22.180 (Meteorological reports, 1530 local time).
SPW	Rio de Janeiro	29.3.
SPX	Rio de Janeiro	40.5.
SP 1	Rio de Janeiro	17.0, 44.5, 47.0.
SUC 2	Abuzabal (Cairo)	47.0.
T		
TFA	Reykjavik, Iceland	42.5, 49.5.
TUK	Tomsk, Siberia	20.0.
U		
U 1XAO	Belfast, Maine	40.0, 65.0, 60.0, 70.0.
U 1XAB	Portland, Maine (Congress Square Hotel Co.)	63.79 (250 Watts).
U 1XR	Manila, Philippine Islands	30.0.
U 2XAA	Houlton, Maine	22.99 (Phone after 2300 G. M. T.).
U 2XAC	G. E. Co., Schenectady, N. Y.	50.0.
U 2XAD	G. E. Co., Schenectady, N. Y.	21.96 (Phone Mon., Wed., Fri., 2300; Sat. 1900-2200 G. M. T.).
U 2XAF	G. E. Co., Schenectady, N. Y. transmitting program from WGY	32.7 (Phone Tues., Thurs. and Sat., 2300 G. M. T.).
2 XAI	Newark, N. J. (Westinghouse Electrical Co.)	43.0.
2 XAL	New York, short-wave transmitter of WRNY (Experimenter Publ. Co.)	30.91.
U 2XAO	Belfast, Maine	40.0, 56.0, 60.0, 70.0.
U 2XAP	New York (Bull Insular Line)	18.3, 18.7, 36.6, 37.5.
U 2XAQ	Newark, N. J. (Short-wave station of WOR)	
U 2XAW	G. E. Co., Schenectady, N. Y.	3.0-20.0, 15.0.
U 2XBA	Newark, N. J. (Short-wave Station of WAAM)	65.18 (Phone Mon., Wed., Fri., 2355-0500 G. M. T.).
U 2XBB	New York (R.C.A.)	1-5 (1kw.).
U 2XBC	Rocky Point, N. J. (R.C.A.)	14.09 and 5.35-18.74.
U 2XBI	Rocky Point, N.Y. (R.C.A.)	1-15 (10 kw.).
U 2XE	Richmond Hill, N.Y. (Short-wave of WABC)	22.1 (Phone after 2300 G. M. T.).
U 2XG	Rocky Point, N. J. (Western Electric Co.)	16.02 (Phone Mon. and Fri. after 1700 G. M. T.).
U 2XH	Schenectady, N. Y.	50.0.
U 2XI	Schenectady, N. Y.	30.0, 35.0, 38.0, 100.0.
U 2XK	South Schenectady, N. Y. (General Electric Co.)	65.5.
U 2XS	Rocky Point (R.C.A.)	14.93 (80 kw.)
U 2XT	Rocky Point, N. Y. (R.C.A.)	16.17 (80 kw.).
U 3XL	Bound Brook, N. J.	60.0 (30 kw.).
U 3XQ	Mountain Lakes, N. J.	37.95, 75.9.
U 4XK	San Juan, Porto Rico (Bull Insular Line)	18.3, 18.7, 36.6, 37.5.
U 5XH	New Orleans (Tropical Radio Telegraphic Co.)	42.0.
U 6XAI	Inglewood, Calif.	66.04 (Phone 2400 G. M. T., onwards).
U 6XAR	San Francisco, Calif.	33.00 (Phone 2400 G. M. T. onwards).
U 6XBR	Los Angeles, Calif. (Short-wave station of KFWB)	(Short wave KFWB).
U 6XI	Bolinas, Calif.	29.3.
U 6XO	Kahuhu, Hawaii	90.0.
U 8XJ	Columbus, Ohio	54.02.
U 8XK	East Pittsburgh (Westinghouse Co.)	26.8 (Mon. and Fri. 1900-2100 G. M. T.).
U 8XS	East Pittsburgh, Pa.	67.0, 96.0.
U 8XAL	Harrison, Ohio (Short-wave station of WLW)	(Short wave WLW).
U 9XU	Council Bluffs, Iowa	61.06 (Phone).
V		
VAS	Louisburg, Novia Scotia	52.0 (Press Reports).
VIS	Sydney	22.0, 26.0, 32.0, 42.0, 51.5.
VIT	Townsville, Queensland	22.0, 42.0.
VJZ	Rabaul, New Britain	22.0, 26.0, 32.0, 42.0.
VKQ	Garden Island, Sydney	25.0.
VQF	Kuching, Sarawak	32.38.
W		
WABC	Richmond Hill, N. Y. (Atlantic Broadcasting Corp.)	64.0 (Phone).
WAJ	Rocky Point, N. Y. (R.C.A.)	22.24, 44.48.
WAQ	Newark, N. J. (Westinghouse Elec. & Mfg. Co.)	44.03.
WBO	Dearborn, Mich. (Ford Motor Co.)	44.62.
WBU	Rocky Point, N. Y. (R.C.A.)	14.09.
WBZ	Springfield, Mass. (Westinghouse E. & M. Co.)	50.0, 70.0 (20 kw.).
WCFL	Chicago, Ill. (Fed. of Labor)	37.24 (Phone).
WCGB	Brooklyn, N. Y.	54.0 (½ kw.)
WCSH	Portland, Maine	63.79 (½ kw.)
WDJ	Harrison, Ohio (Crosley-Radio Corporation)	21.4, 26.3.
WDS	Rocky Point, N. Y. (R.C.A.)	15.86, 31.73.
WEAO	Columbus, Ohio (Ohio State University)	54.02.
WEDS	Rocky Point, N. Y. (R.C.A.)	15.86, 31.73.
WEGT	S. Juan, Porto Rico (R.C.A.)	21.75, 65.3.
WEM	Rocky Point, N. Y. (R.C.A.)	16.41, 32.84.
WEOP	Rocky Point, N. Y. (R.C.A.)	21.57, 43.14.
WEP	Cape Charles, Va.	99.9.
WEPE	Rocky Point, N. Y. (R.C.A.)	21.63, 43.33.
WEQB	Rocky Point, N. Y. (R.C.A.)	16.71, 33.42.
WEQX	Rocky Point, N. Y. (R.C.A.)	14.85, 29.71.
WFV	Poinciana, Florida (Florida RT Co.)	70.54.
WFX	Rocky Point, N. Y. (R.C.A.)	15.70, 31.59.
WGI	Alpena, Mich. (Alpena Marine Radio Service)	98.3.
WGT	S. Juan, Porto Rico (R.C.A.)	21.75, 65.3.
WGW	Vieques, Porto Rico (Bureau of Insular Telegraphs)	52.0.
WGY	Schenectady, N. Y. (G. E. Co.)	35.0 (Phone).
WHD	Sharon, Pa. (Westinghouse Co.)	49.0.
WHK	Cleveland, Ohio	66.04 (½ kw.).
WHR	Rocky Point, N. Y. (R.C.A.)	15.93, 31.96.
WHW	Highland Park, Ill. (Wireless Telegraph & Communication Co.)	45.02.
WIK	New Brunswick, N. J.	21.48, 21.5.
WIR	New Brunswick, N.J. (R.C.A.)	74.0 (20 kw.).
WIZ	New Brunswick, N.J. (R.C.A.)	43.35 (Phone occasionally from 2300 G. M. T.).
WJD	New York International News Service	37.01.
WJZ	Bound Brook, N. J. (R.C.A.)	18.17 (Phone).
WKC	Newark, N. J.	17.5, 27.9.
WKI	Newark, N. J. (Fed. Telegr. Co.)	17.3, 27.9.
WKK	Cuba, Porto Rico (Bureau of Insular Telegraphs)	52.0.
WLL	Rocky Point, N. Y. (R.C.A.)	16.57.
WLW	Cincinnati, Ohio (Crosley Radio Corporation)	52.02 (Phone 2200-0400 G. M. T. except Fri.).
WNBT	Elgin, Illinois	33.5 (Special Time Signals).
WND	Ocean Township, N.J. (American Telephone & Telegraph Co.)	13.88, 16.35, 22.38, 46.48.
WNU	New Orleans, La.	26.0, 40.0 (Press Reports).
WOP	Rocky Point, N. Y. (R.C.A.)	21.57, 43.14.
WOWO	Fort Wayne, Ind. (Main Auto Supply Co.)	22.80 (1 kw.) (Phone after 2300 G. M. T.).
WPE	Rocky Point, N. Y. (R.C.A.)	21.63, 43.14.
WQA	Rocky Point, N. Y. (R.C.A.)	14.13, 28.26.
WQN	Rocky Point, N. Y. (R.C.A.)	51.5, 54.5, 57.0.
WQQ	Rocky Point, N. Y. (R.C.A.)	14.8.
WQX	Rocky Point, N. Y. (R.C.A.)	14.85, 29.71.
WRB	Miami, Florida (Florida Radio Telegraph Co.)	70.74.
WRNY	Coteysville, N. J. ("Radio News")	30.91 (Phone Mon., Wed., Fri., 1930-2215 G. M. T.; other days, 2355-0500).
X		
XDA	Mexico City, Mexico	34.0 (Press Reports, 0500 G. M. T.).
Y		
YZ	Fort d'Issy, France	45-47.
Z		
ZWT	Bremerhaven	53.0.

WORLD TIME CHART

Sweden Germany Switzer-land Italy	Petrograd Con-stantinople Capetown	Bagdad Persia	India	Borneo Java Dutch E. I.	P.I. China Western Australia	Tokio Central Australia	Sidney Mel-bourne Eastern Australia	Auckland New Zealand	Samoa	Hawaiian Islands	Pacific	Mountain	Central	New York-Wash-ington E. S. T.	Halifax Buenos Aires / N. Y. Daylight Saving	Rio de Janeiro Brazil	London Paris Madrid	G. M. T. or G. C. T.
1.00	2.00	3.00	5.00	6.00	8.00	9.00	10.00	11.30	Noon	1.30	4.00	5.00	6.00	7.00	8.00	9.00	Midnight	0000
2.00	3.00	4.00	6.00	7.00	9.00	10.00	11.00	12.30	1.00	2.30	5.00	6.00	7.00	8.00	9.00	10.00	1.00	0100
3.00	4.00	5.00	7.00	8.00	10.00	11.00	Noon	1.30	2.00	3.30	6.00	7.00	8.00	9.00	10.00	11.00	2.00	0200
4.00	5.00	6.00	8.00	9.00	11.00	Noon	1.00	2.30	3.00	4.30	7.00	8.00	9.00	10.00	11.00	Midnight	3.00	0300
5.00	6.00	7.00	9.00	10.00	Noon	1.00	2.00	3.30	4.00	5.30	8.00	9.00	10.00	11.00	Midnight	1.00	4.00	0400
6.00	7.00	8.00	10.00	11.00	1.00	2.00	3.00	4.30	5.00	6.30	9.00	10.00	11.00	Midnight	1.00	2.00	5.00	0500
7.00	8.00	9.00	11.00	Noon	2.00	3.00	4.00	5.30	6.00	7.30	10.00	11.00	Midnight	1.00	2.00	3.00	6.00	0600
8.00	9.00	10.00	Noon	1.00	3.00	4.00	5.00	6.30	7.00	8.30	11.00	Midnight	1.00	2.00	3.00	4.00	7.00	0700
9.00	10.00	11.00	1.00	2.00	4.00	5.00	6.00	7.30	8.00	9.30	Midnight	1.00	2.00	3.00	4.00	5.00	8:00	0800
10.00	11.00	Noon	2.00	3.00	5.00	6.00	7.00	8.30	9.00	10.30	1.00	2.00	3.00	4.00	5.00	6.00	9.00	0900
11.00	Noon	1.00	3.00	4.00	6.00	7.00	8.00	9.30	10.00	11.30	2.00	3.00	4.00	5.00	6.00	7.00	10.00	1000
Noon	1.00	2.00	4.00	5.00	7.00	8.00	9.00	10.30	11.00	12.30	3.00	4.00	5.00	6.00	7.00	8.00	11.00	1100
1.00	2.00	3.00	5.00	6.00	8.00	9.00	10.00	11.30	Midnight	1.30	4.00	5.00	6.00	7.00	8.00	9.00	Noon	1200
2.00	3.00	4.00	6.00	7.00	9.00	10.00	11.00	12.30	1.00	2.30	5.00	6.00	7.00	8.00	9.00	10.00	1.00	1300
3.00	4.00	5.00	7.00	8.00	10.00	11.00	Midnight	1.30	2.00	3.30	6.00	7.00	8.00	9.00	10.00	11.00	2.00	1400
4.00	5.00	6.00	8.00	9.00	11.00	Midnight	1.00	2.30	3.00	4.30	7.00	8.00	9.00	10.00	11.00	Noon	3.00	1500
5.00	6.00	7.00	9.00	10.00	Midnight	1.00	2.00	3.30	4.00	5.30	8.00	9.00	10.00	11.00	Noon	1.00	4.00	1600
6.00	7.00	8.00	10.00	11.00	1.00	2.00	3.00	4.30	5.00	6.30	9.00	10.00	11.00	Noon	1.00	2.00	5.00	1700
7.00	8.00	9.00	11.00	Midnight	2.00	3.00	4.00	5.30	6.00	7.30	10.00	11.00	Noon	1.00	2.00	3.00	6.00	1800
8.00	9.00	10.00	Midnight	1.00	3.00	4.00	5.00	6.30	7.00	8.30	11.00	Noon	1.00	2.00	3.00	4.00	7.00	1900
9.00	10.00	11.00	1.00	2.00	4.00	5.00	6.00	7.30	8.00	9.30	Noon	1.00	2.00	3.00	4.00	5.00	8.00	2000
10.00	11.00	Midnight	2.00	3.00	5.00	6.00	7.00	8.30	9.00	10.30	1.00	2.00	3.00	4.00	5.00	6.00	9.00	2100
11.00	Midnight	1.00	3.00	4.00	6.00	7.00	8.00	9.30	10.00	11.30	2.00	3.00	4.00	5.00	6.00	7.00	10.00	2200
Midnight	1.00	2.00	4.00	5.00	7.00	8.00	9.00	10.30	11.00	12.30	3.00	4.00	5.00	6.00	7.00	8.00	11.00	2300

NOTE: Crossing from dark to light area at midnight indicates following day. Crossing from light to dark area indicates preceding day. *See page 18 for instructions.*

FREQUENCY—WAVE LENGTH CONVERSION CHART



Note: Details for using the chart are given on the following page.

Instructions for Using World Time Chart

The world time chart is a valuable adjunct to any list of short wave stations. Because of the difference in time in different cities of the world, it is difficult to compare transmitting times in various cities without the aid of such a chart. It is customary to refer all times to Greenwich Mean Time (G. M. T.) or Greenwich Civil Time (G. C. T.). These two were standardized in 1925. The hours are numbered from zero to 23. Zero o'clock is midnight and 23 o'clock is 11 P. M. London time.

New York or 75th Meridian time is five hours earlier than G. C. T. If, therefore, a station is broadcasting at 17 o'clock G. C. T. it is broadcasting at 12 noon, Eastern Standard Time.

Station G 5 SW, as listed on page 13, transmits on a wave length of 24 meters and from "1930 onwards." Referring to the time chart, we see that 1930 corresponds to 2:30 P. M., Est., 1:30 P. M. Central Time, and 11:30 A. M. Pacific Time.

Instructions for Using Frequency-Wavelength Conversion Chart

The frequency wave length conversion chart on the preceding page is valuable in converting any wave length into any frequency. It has been constructed with the requirements of the short wave enthusiast in mind since the scale is "open" and may be read quite easily from 10 to 100 meters. Any other wave length range may be used, however. For higher wave lengths than those given, a zero should be added to the wave length number and one subtracted from the kilocycle figure given. For example, to secure the frequency of 210 meters which cannot be determined readily on the right hand scale, a zero may be added to 21 meters. The frequency corresponding to 21 meters is approximately 14,280. By subtracting a zero, we get 1428 which is the frequency in k.c. of 210 meters.

This may be generalized by stating that the scale holds if the frequency figure is pointed off as many places to the left as the wave length scale is to the right. The frequency scale might more conveniently have been plotted in megacycles or millions of cycles rather than k.c. except for this convenience in using it at other ranges.

The accuracy of the scale is improved at some frequencies, if the wave length and the frequency scales are reversed. That is, we may consider that the k.c. side of the scale is in every case replaced by the WL scale and vice-versa. The displacement of the decimal point mentioned above holds when the two scales are reversed. Therefore, 21,000 meters corresponds to a frquency of 14.28 k.c.

It is very difficult on the scale as given to determine the frequency corresponding to, say, 265 meters. Yet by referring to 26500 k.c. the reading on the WL scale is found to be 11.32. The wave length, however, is not 26500 but 265, so the decimal point of the WL figure must be moved two places to the right (that of the k.c. being two to the left) giving 1132 as the answer. This frequency of 1132 k.c. is much more accurate than could have been determined directly on the scale as given.

(*Continued from page 12*)

Operating Instructions

In all of the receivers described in subsequent pages regeneration is used in the detector circuit to improve both its selectivity and sensitivity. A non-regenerative detector circuit is not practical at the present stage of development of short wave receivers because of the relatively small amount of radio frequency amplification possible at very high frequencies. If the adapters are used with superheterodynes, the high frequency is converted into a lower one which may be amplified, and, in this case, the detector may be non-regenerative.

The operation of these receivers presents no difficulties to the man who has operated sets of the Browning-Drake, Everyman, and old Hammarlund-Roberts types using a stage of radio frequency amplification with a regenerative detector. The tuning principle is exactly the same, although the settings of the various tuning elements are in general more critical.

Distant stations may be found by increasing the regeneration condenser capacitance until a hissing noise is heard and the detector just begins to oscillate. This is the point of maximum sensitivity. The control should be kept as near as possible to the "just oscillating point" throughout the tuning range. When properly adjusted there will be a slight hiss and the carrier waves or "whistles" of the stations will come in with maximum intensity. A phone station may be identified by the fact that there are no breaks in the signal, that is no dots and dashes, and by the fact that there is a sort of mushy sound due to the modulation of the carrier by speech.

To be sure the receiver is oscillating touch the stator plates of the detector condenser. There should be a sharp click in the headphones or speaker. If there is no click increase the capacitance of the regeneration condenser.

When a station is located, the regeneration should be decreased slightly and the tuning condenser readjusted until the whistle is very low in pitch. Both adjustments should be made simultaneously so the pitch is very low at the point the receiver stops oscillating. A slight readjustment of the tuning condenser is necessary because the regeneration control effects the "tuning" or secondary adjustment slightly.

Grid Leak and Condenser Values

The values of the grid condenser capacitance and leak resistance are interdependent but in general about a 2 to 5 megohm leak and nearly maximum capacitance of the EC-70 equalizer grid condenser will be found best. The setting of the variable grid condenser, the resistance of the leak, its return connection (A+ or A—) and the detector plate voltage will determine the suddenness with which the receiver goes into oscillation. The set should not go into oscillation abruptly or with a "blop" as this makes it difficult to operate the receiver at the point of maximum sensitivity. A little experimentation will indicate the best setting for the grid condenser and the best plate voltage.

If a potentiometer return, as shown in Figures 4 and 18, is not used, the leak should be connected first to the negative and then to the positive A battery lead. The latter is usually preferable for the 201-A and 112-A tubes and the former for the 200-A tube. Different leak values should also be tried.

Points at which it is difficult to make the receiver oscillate are known as "dead spots." They may be due to a poor choke, but if the specified parts are used they are due to the fact that the receiver is tuned to either the fundamental frequency of the antenna circuit or one of its harmonics. At these frequencies, the effective coupling to the antenna is greatly increased resulting in an absorption of considerable energy. When such a point is reached the coupling of the primary should be decreased by setting this coil more nearly at right angles to the secondary. A good average setting will be found to be at an angle of approximately 45 degrees for the usual antenna. There is an optimum setting for each coil which must be determined experimentally with every antenna. Dead spots should not occur with the circuit shown in Figure 15.

Wiring Short Wave Receivers

The wiring in short wave receivers deserves much more attention than is accorded it in broadcast receivers. All leads should be as short and direct as possible, that is, "bee line" wiring should be used. In the receivers illustrated rigid bus bar wiring has been used for photographic purposes. Wires carrying radio frequency current should cross each other as nearly at right angles as possible and should clear each other as much as possible. A slight increase in lead length may be permitted to make these possible.

Capacitances between the grid and plate circuits are especially important and should be reduced to an absolute minimum.

A. C. Operation

A.C. operation of short wave receivers and converters has not been found altogether satisfactory. This is due to the fact that the B battery eliminator introduces many more extraneous noises on short waves. Since the receivers are operated near the oscillating point, or, in case of code reception, under oscillating conditions, the problem of A.C. modulation is also important.

The only converter shown for A.C. receivers is that given in Figure 13. This is of the single tube type and intended for use in place of a 227 type detector tube in the broadcast receiver. The plate current for the 227 tube is secured from the receiver itself. This arrangement is apt to be noisy and is recommended only for the reception of moderately distant stations. For quieter operation separate A and B batteries should be used. Where a two stage power pack type of amplifier is available, it is a simple matter to arrange a single pole double throw switch to throw the input of the first transformer from the detector of the broadcast receiver to the detector of the short wave receiver.

If the set is either an A.C. or D.C. type with separate eliminator, the detector plate supply lead from the eliminator (+45 or +67) should be disconnected. A small two pound 45 volt B battery may then be used to supply the plate current and prevent eliminator noises. The negative battery terminal should go to the B— post on the eliminator or to the A— lead on the converter. The +45 volt battery terminal is then connected to the +45 or +67 volt binding post on the broadcast receiver. If the receiver is an A.C. type separate number 6 dry cells with a 201-A or 112-A detector are recommended although a 227 type tube may be used with leads from the "H-H" adapter prongs to supply the heater current, as shown in Figure 13.

If a converter is to be used in a superheterodyne, it should be plugged into the first detector socket, the oscillator tube removed, and the converter then be made to oscillate and operated in this condition. Where the intermediate frequency is high, above 150 k.c. or so, the converter may work better when plugged into the second detector and operated in the usual manner.

Tubes Recommended

In general 112A detector and 222 radio frequency tubes are recommended for short wave receivers. The 112A has a high detection coefficeint (is more sensitive), a low plate impedance and is a stable oscillator. The 201A is almost as satisfactory and may be used where the effective input capacity must be low, for example, when working at the minimum wavelength of the circuit. The 200A detector tube may be used for increased sensitivity, but it is noisy. A 199 type may be used when the filaments have to be dry cell operated but the regeneration may be poor, especially at very short wavelengths.

Single Tube Short Wave Receiver—Converter Combination

The single tube short wave receiver-converter combination described below uses the simplest circuit that gives satisfactory operation at short wavelengths. Receivers of this type have been used by amateurs for years in carrying on transoceanic code work. A regenerative detector is used. No audio amplifier is included since it may be used as a converter by plugging into the detector socket of a broadcast receiver in which case the amplifier in the broadcast receiver is used.

When used with a single stage of audio-frequency amplification it will permit the reception of moderately distant and distant stations on head-phones. A two stage amplifier will permit loud speaker operation on short wavelengths and the Midline plate shape improves the tuning.

The schematic wiring diagram for a converter for battery operated receivers or those having an A eliminator is given in Fig. 12. If the SWAP adapter plug is used the green lead should be connected to the B+ 45 binding post, the maroon lead to the A— binding post and the brown lead to the positive A binding post.

The diagram shown in Figure 13 should be used if the receiver is to be used with an A.C. receiver having a 227 type detector tube. In this case, the green lead should go to the choke, brown and maroon leads to the H-H terminals of the socket and the black lead to the K terminal. The reader is referred to the operating details of the A.C. and D.C. types given on page 19.

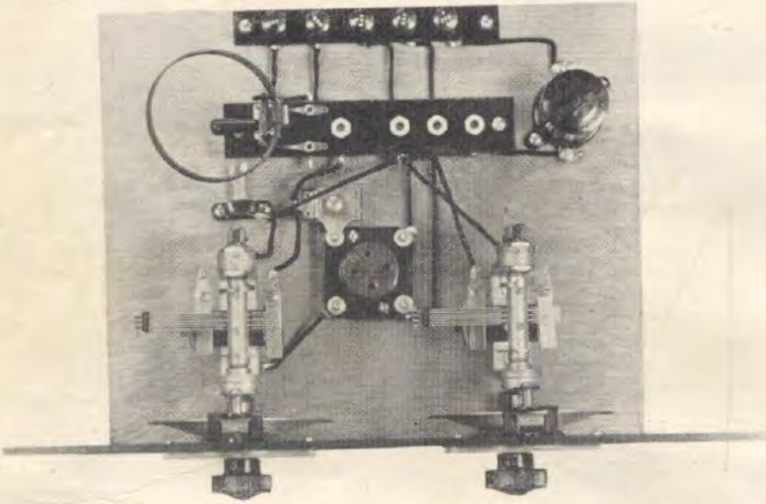


Figure 11—Top view of the receiver described above using the circuit shown in Figure 12. Note the spacing of the parts and the short direct leads used throughout. The plug-in coil has been removed to show the connections to the base. The primary is tilted back slightly farther than when in actual use.

moderately distant stations under the proper conditions. See page 4 for information on distant reception.

Its operation is similar to the old type broadcast receiver and the adjustments are therefore more critical than those of the modern receiver. The results secured will vary considerably with different operators and a little experience is necessary in tuning in distant stations. See the operating instructions on page 18.

The dials used have a 10 to 1 reduction ratio and this aids materially in tuning. The special short wave type Midline condensers are designed for quiet operation at

The following parts, the list price of which is approximately $37.00, are necessary to construct the receiver:

1 Hammarlund Short Wave Coil Set, type SWT-3 (L1, L2, L3)
2 Hammarlund ML-7, .00014 mfd. variable Midline condensers (C1, C2)
1 Hammarlund RFC-250 Radio Frequency Choke (RFC)
1 Hammarlund type No. EC-80, 80 mmfd. Equalizer (C3)
1 Hammarlund Short Wave Adapter Plug Type No. SWAP
1 Benjamin four prong socket, No. 9040
1 Durham grid leak mount

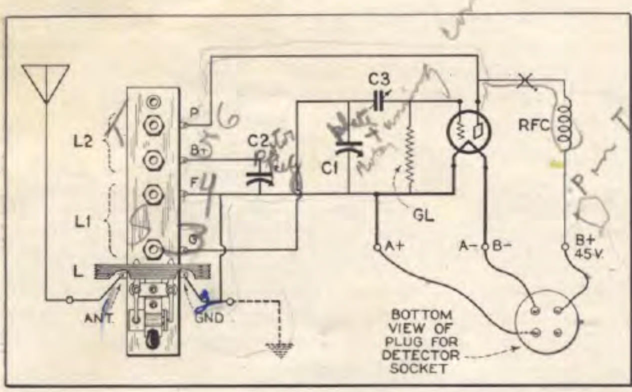


Figure 12—Single tube short wave receiver-converter combination for D.C. tubes. The leads should be connected to the type SWAP plug, as described in the text.

1 Durham grid leak, 2 to 9 megohms (GL—see page 18)
1 7x14x$\frac{3}{16}$ in. Westinghouse Micarta panel
2 National Velvet Vernier type E dials
5 Eby binding posts
1 Binding post strip
1 9x10 in. base board

No filament switch or filament resistance is provided since these are normally included in the receiver. If the unit is used as a separate receiver with or without audio amplifier a Yaxley number 10 midget battery switch and a 1A Amperite should be connected in the negative A battery lead.

The unit may easily be built by following the wiring as shown in Figure 11. The coil was removed to show the connections to the base. The lead from the terminal "G" on the base (see Figure 12) goes first to the equalizer and then to the stator plates of the left hand condenser (C1). The lead from the "F" terminal goes to the top terminal on the grid leak mount and to the frame of C1. The lower grid leak mount terminal is connected to the "G" binding post of the socket to which the equalizer (C3) is attached.

The coil base connections are shown in Figures 12 and 13. The primary, secondary and tickler coil are marked L, L1 and L2, respectively.

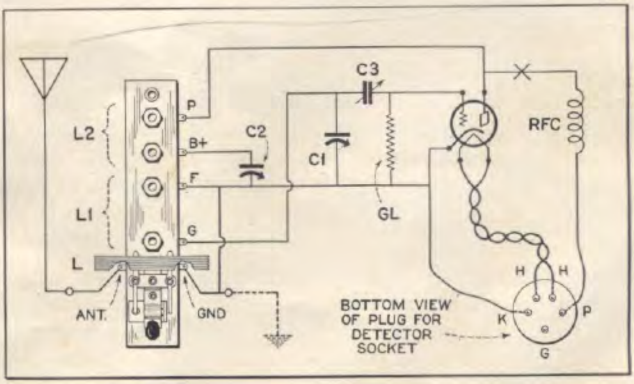
Reading from left to right in the photograph, the binding posts are "Ant.," "Gnd." "A+," "A—" and "B+."

When used as a single tube short wave receiver, the binding posts are connected as shown in the schematic wiring diagram. The phones or primary terminals of the transformer, if an audio amplifier is used, should be connected between the "B+" binding post and the terminal on the "B" battery. For best results try reversing A leads.

The type SWAP adapted plug is a five lead cable connected to a plug which fits into the 227 type tube base. There is also an adapter included which plugs into a four pin socket and which receives the five pin plug. This makes it possible to use the adapter plug with either four or five pin sockets.

The green lead goes to the P pin in the plugs, the brown and maroon go to the H-H pins of the 5 prong and the A pins of the four prong plug, the yellow goes to the G pin of both and the black goes to the K (which may be the C—) pin of the five pin and is not connected to the four pin plug.

Figure 13—Circuit of a single tube converter for A.C. receivers using the 227 type tube. This is recommended only for moderately distant reception because of the noises introduced by the eliminator in the receiver. See page 19 for operating instructions with a B battery.



Screen-grid Two Tube Adapter-Receiver Combination

This two tube receiver-converter combination, everything considered, represents the best "buy" in the short wave kit field. A similar arrangement is used in airplane receivers where *consistent performance* as well as high sensitivity are essential. It is commonly used by thousands of amateurs who demand the best in short wave sets. They have been quick to realize the advantages to be derived from using a screen grid coupling tube ahead of the conventional regenerative detector circuit. The circuit has detector is not directly coupled to the antenna and the antenna coupling does not have to be varied to prevent "dead spots."

Some years ago, when oscillating receivers became numerous, there was a crusade against them. The necessity for a similar crusade can be eliminated by the use of circuits employing the screen grid tube since this tube acts as a "blocking" tube and prevents direct radiation into the antenna.

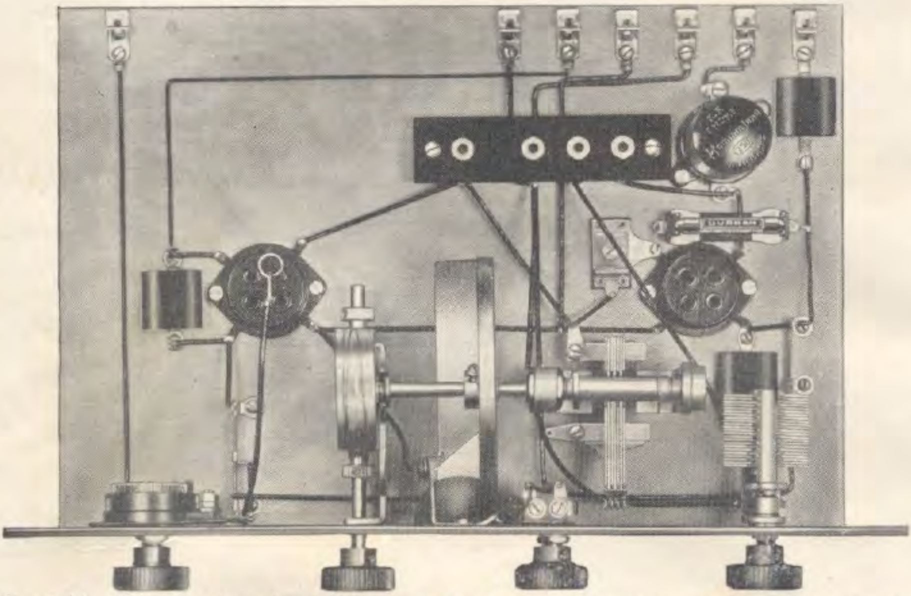


Figure 14—This top view clearly illustrates the layout of the parts and the wiring for the type SWK-2 kit using a stage of screen grid radio frequency amplification with a 201-A detector. Reading from left to right, the Fahnstock clips are connected to the antenna, B+135, B+45, A+, A— choke and by-pass condenser C5.

been tried, tested and not found wanting. The SWK-2 kit uses this circuit together with the best parts that can be found. A photograph of the complete unit in a Corbett cabinet is shown on page 5.

The use of the screen grid tube increases the radio-frequency amplification without complicating the operation in any way. In fact the operation is actually improved because the regenerative

Below about 50 meters the maximum possible stable amplification may be secured from the 222 tube in a coupling circuit. The only arrangement which is superior (and this principally above 50 meters) is that used in the "De Luxe" receiver described on pages 6 and 24.

The new type Hammarlund drum dial with its 5 to 1 reduction ratio permits the close adjustment which is so necessary on short waves.

The following parts are contained in kit SWK-2 listing at $35.00 and described on page 32:

1 Hammarlund ML-7, .00014 mfd. Midline Condenser (C).
1 Hammarlund SWC-3, Coil Set (L2, L3).
1 Hammarlund SDW, Knob Control Drum Dial (DL is the dial light).
3 Hammarlund SDWK, Walnut Knobs.
1 Hammarlund EC-80, 80 mmfd. Equalizer (C-2).
1 Hammarlund RFC-250, Radio Frequency Choke (L-4).
1 Hammarlund MC-23, Midget Condenser (C-1).
1 Hammarlund SWAP, Adapter Plug and Cable.
3 Sprague Type F .1 mfd. Condensers (C-3, C-4, C-5).
1 Yaxley No. 10 Midget Battery Switch.
1 Yaxley No. 820 C, 20 ohm Mid-tapped Resistor (R-1).
1 Yaxley No. 804, 4 ohm Resistor (R-2).
2 Eby No. 12 Sockets.
1 Durham Metallized Resistor, 2-9 megohms (R-3) (see page 18).
1 Electrad Type P Tonatrol (R).
1 Westinghouse Micarta, 7" x 14" Panel.
1 Baseboard 9" x 13" x ¾".
1 Package containing hardware necessary to complete receiver.

The construction has been simplified by providing a complete kit including a drilled panel, all parts and hardware as well as a full size picture wiring diagram.

Batteries are recommended because of the high sensitivity. The converter may also be used with sets having an A and B eliminator by disconnecting the detector supply lead (+45 or +67) from the set and connecting a small 45 volt B battery in its place. The +45 volt B battery terminal should go to the set and the — terminal to the B— binding post on the receiver. For further details see page 19. The A battery leads should be permanently connected.

The unit may be used as a separate receiver by adding one or two stages of audio-frequency amplification. A two-stage amplifier is shown in Figure 16. An open circuit jack is used in the first and second stages to permit headphone or loudspeaker reception. Loudspeaker reception may be expected consistently only over moderate distances.

The "P" terminal of the transformer is connected to the radio-frequency choke in the plate circuit of the detector and the "B+" terminal to the +45 volt terminal on the B battery. The A battery leads should be connected directly to the A+ battery lead and to the set side of the midget battery switch so that this turns off all tubes.

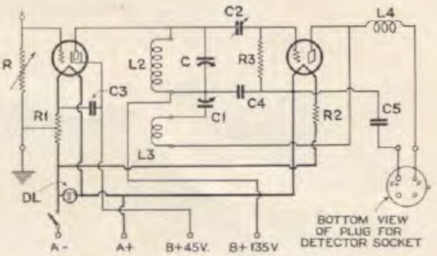


Figure 15—This is the schematic wiring diagram of the receiver described above, photograph of which is given in Figure 14. The by-pass condenser C5 permits the receiver A battery to be directly connected to the adapter and the plug to be inserted in the detector socket without the danger of short-circuiting the A battery.

When the type SWAP adapter plug is used its green lead should be connected to the Fahnestock clip going to the choke and its brown or maroon lead to the right hand clip going to the by-pass condenser.

There is an attractive standard 7x14x-10 inch Corbett cabinet available which may be used with the unit. It is shown on page 5.

The two stage audio frequency amplifier as shown in Figure 16 may be used with either the receiver described on page 20 or the two tube receiver described above. The terminal marked "plate lead" is connected to the binding post which goes to the radio frequency choke and the B+ 45 terminal is connected to the 45 volt tap of the B battery. Any standard high quality audio frequency transformers may be used.

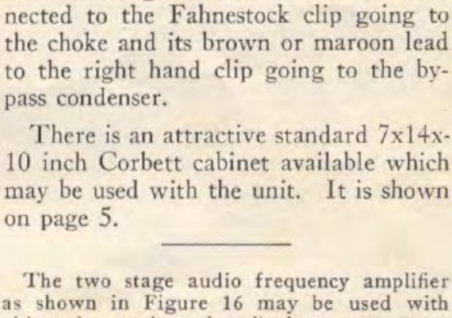


Figure 16—A two stage transformer coupled amplifier with jacks for head phone and loud speaker operation which may be used either with the receiver described on page 20 or 22.

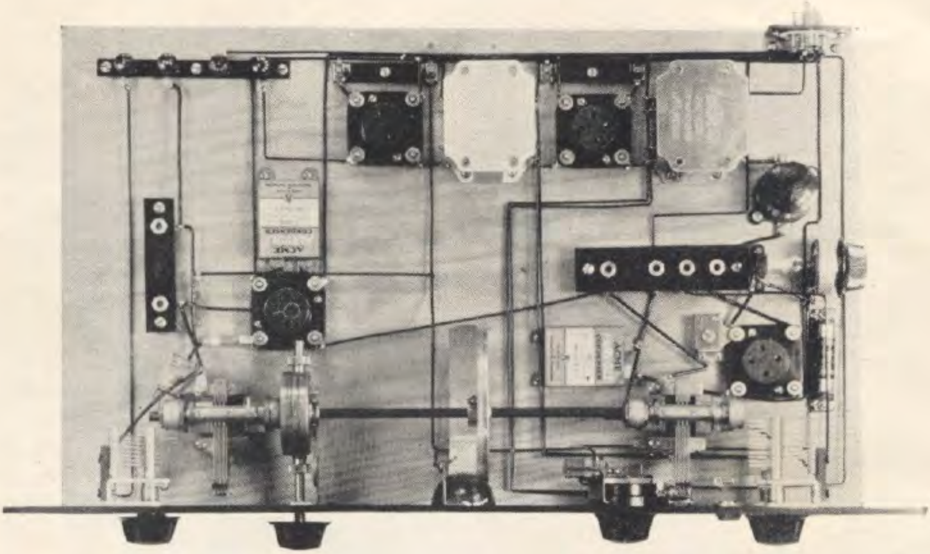


Figure 17—This is a photograph of the receiver described below. The schematic wiring diagram is given in Figure 18. Note the location of the coils which makes shielding unnecessary. The bakelite shaft shown should be replaced by a brass shaft with insulated coupling, code No. FC, to permit the close adjustment of the condensers which is necessary.

The De Luxe Four Tube Short Wave Receiver

The "De Luxe" short wave receiver is all that the name implies. Its screen grid tube with tuned input circuit insures the maximum practical amplification at all frequencies within the short wave band.

As shown in Figure 18 the two main tuning condensers C and C1 are ganged giving "single control." The potentiometer return for the leak permits close adjustment of the sensitivity. The best settings for code and phone reception (which are quite different) must be determined experimentally.

On all but very distant stations it is a "single control" receiver in the sense that all frequency adjustments are made with one turning control. The regeneration and variable antenna coupling condenser are operated separately. On very weak stations the antenna coupling condenser must be tuned. It acts as a "trimming" or adjustable vernier condenser and is set for maximum signal strength.

A brass shaft with a flexible coupling, to insulate the rotor of C1 should be used, instead of the bakelite one shown, since there is slight spring to the latter which makes very close adjustment difficult.

A high quality audio-frequency amplifier is used with an open circuit jack in the first stage for head phone operation on distant phone and code stations. A combination filament-switch-volume-control is used which, together with the regeneration control, provides smooth adjustment of the signal volume down to very low levels.

This receiver in a good location on the eastern coast may be expected to pick up British 5SW and Dutch PCJJ. In New York City it picks up the former consistently and the latter under favorable conditions.

Tuning the input to the screen grid (222) tube improves both the selectivity and the sensitivity above 50 meters and the selectivity from 15 to 50 meters. The theory of the operation of the tuned circuit is given on pages 7 and 8. The theory indicates (and practice substantiates) the fact that the stable amplification in such a receiver increases with wavelength so that it is particularly valuable above 50 meters. With this circuit it is possible to get all of the amplification the 222 will permit on short waves without oscillating.

Where a complete separate short wave receiver is available it is frequently advisable to install a separate antenna 20 to 60 feet long. A larger one is not necessary for short wave work and frequently is less satisfactory where a tuned input is used.

A 222 tube should be used in the radio-frequency stage (left hand front socket), a 112A or 201A in the right hand front and rear sockets and a 112A in the left hand rear socket. The batteries should be connected to the cable leads as marked in the schematic wiring diagram.

The SWI and SWT coils used should have corresponding wavelength ranges, that is, the SWI-40 should be used with the SWT-40 and so forth.

The tuning and regeneration controls should be operated according to the instructions given on page 18. Suggestions for the experimenter are included on pages 8, 9, 10, 11 and 19. The unit may be used as a converter by eliminating the audio-frequency amplifier and using the type SWAP plug as indicated for the type SWK-2 kit.

The following parts are necessary:

- 2 Hammarlund ML-7, Condensers (C, C1).
- 1 Hammarlund SWC-3, coil set (L2, L3).
- 1 Hammarlund SWI-3, coil set (L).
- 1 Hammarlund SDB, knob control drum dial.
- 1 Hammarlund MC-23, .0001 mfd., midget variable condenser (C2).
- 1 Hammarlund RFC-250, choke coil (L4).
- 1 Hammarlund MC-15, .000065 mfd., midget variable condenser (C6).
- 1 Hammarlund EC-80, 80 mmfd. Equalizer (C5).
- 1 Hammarlund EC-35, Equalizer, (C7).
- 1 Amertran 1st stage transformer (T1).
- 1 Amertran 2nd stage transformer (T2).
- 1 Yaxley No. 660 cable connector and plug.
- 1 Yaxley midget type open circuit jack (J).
- 1 Yaxley midget 400 ohm potentiometer (R6).
- 1 Yaxley 20 ohm mid tapped resistor (R).
- 1 Electrad Type WS Tonatrol (R5 and S).
- 3 Amperites, type No. 1A (R2, R3, R4).
- 4 Benjamin four pin sockets, No. 9040.
- 2 Parvolt, .5 mfd. by-pass condensers (C3, C4).
- 1 7x21x$\frac{3}{16}$ inch Westinghouse Micarta panel.
- 1 Durham metalized resistor, 2-9 megohms (R1) (see page 18).
- 1 Durham grid leak mount.
- 4 Eby binding posts.
- 1 Binding post strip.
- 1 ¾x20x11½ inch baseboard.

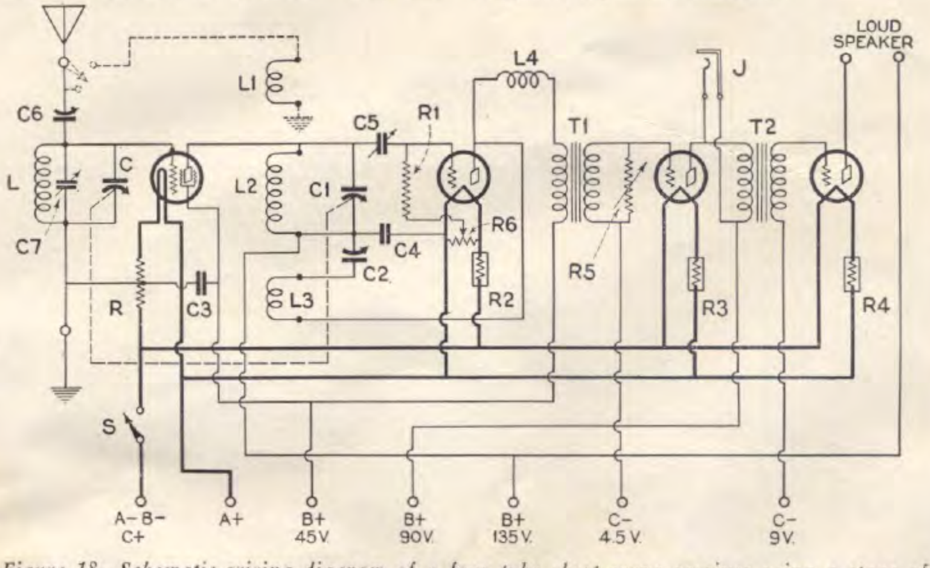
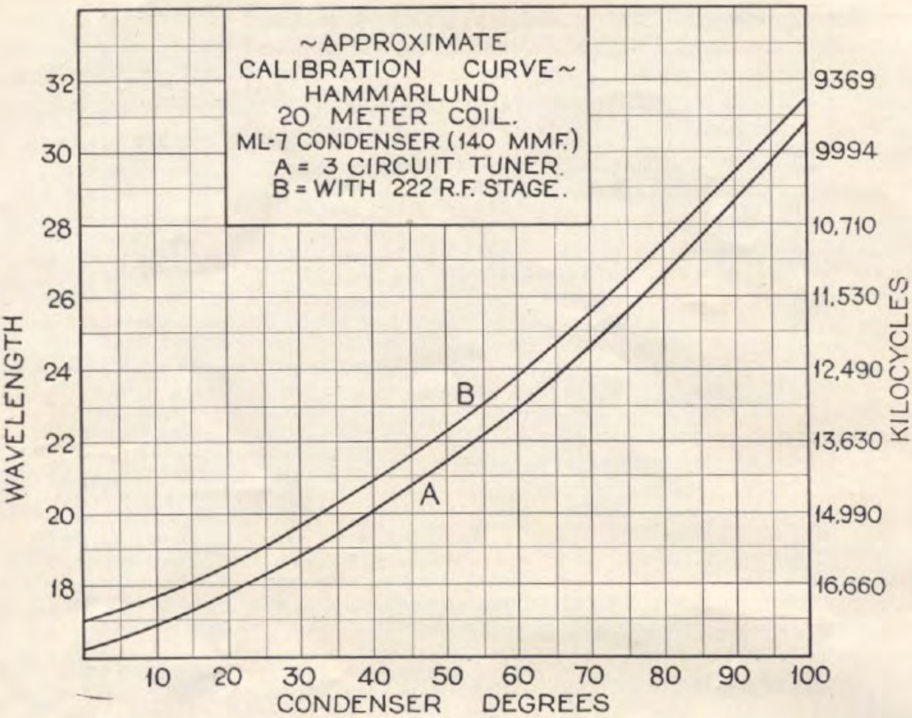
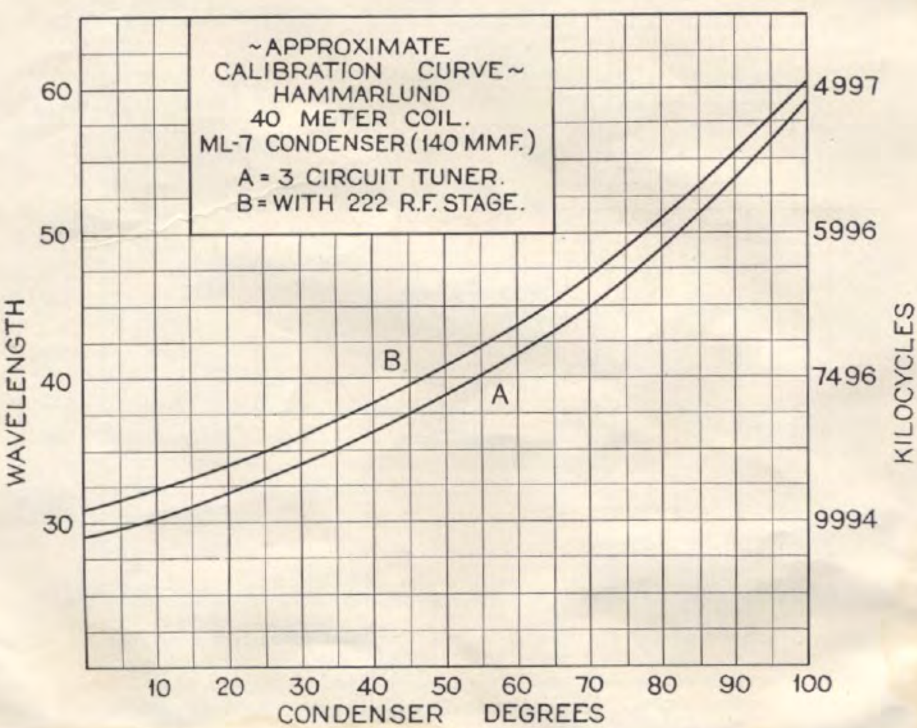
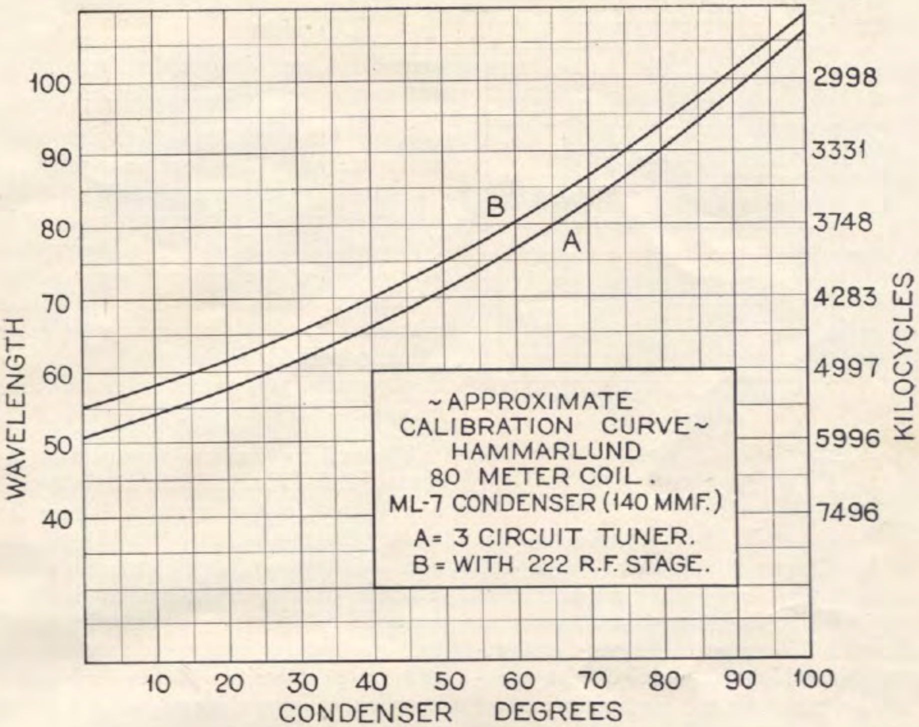
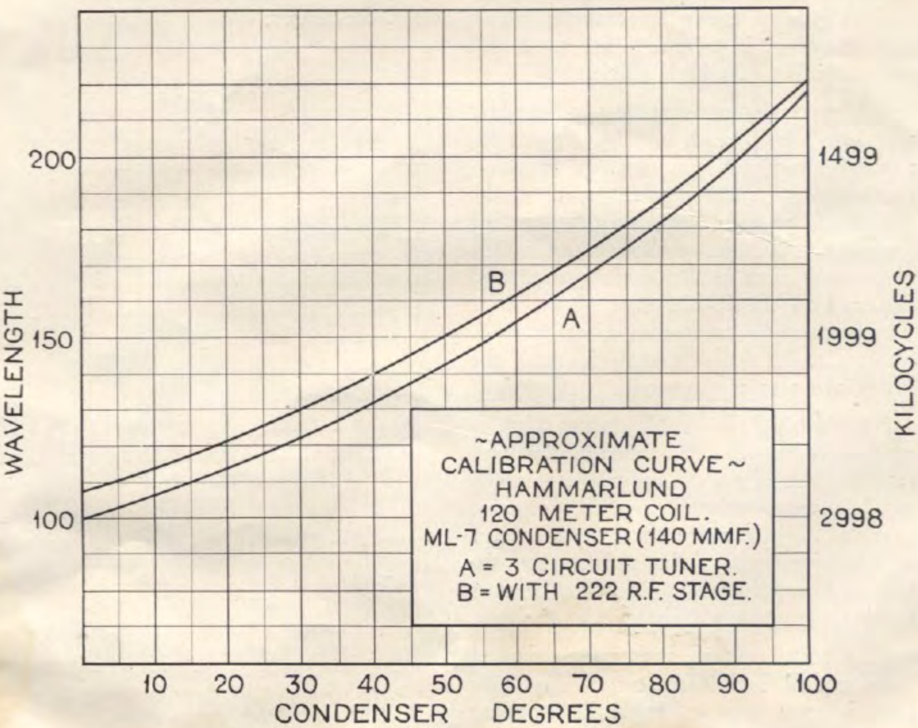


Figure 18—Schematic wiring diagram of a four tube short wave receiver using a stage of screen grid amplification with a tuned input circuit. This is the most sensitive of the receivers described in the manual and is very easily tuned since condensers C and C1 are on a single drum dial control. The potentiometer, R6, is shown near the middle right hand edge of the base board.


~APPROXIMATE
CALIBRATION CURVE~
HAMMARLUND
20 METER COIL.
ML-7 CONDENSER (140 MMF.)
A = 3 CIRCUIT TUNER.
B = WITH 222 R.F. STAGE.
WAVELENGTH
32
30
28
26
24
22
20
18
KILOCYCLES
9369
9994
10,710
11,530
12,490
13,630
14,990
16,660
B
A
10 20 30 40 50 60 70 80 90 100
CONDENSER DEGREES


~APPROXIMATE
CALIBRATION CURVE~
HAMMARLUND
40 METER COIL.
ML-7 CONDENSER (140 MMF.)
A = 3 CIRCUIT TUNER.
B = WITH 222 R.F. STAGE.
WAVELENGTH
60
50
40
30
KILOCYCLES
4997
5996
7496
9994
B
A
10 20 30 40 50 60 70 80 90 100
CONDENSER DEGREES


~APPROXIMATE
CALIBRATION CURVE~
HAMMARLUND
80 METER COIL.
ML-7 CONDENSER (140 MMF.)
A= 3 CIRCUIT TUNER.
B = WITH 222 R.F. STAGE.
WAVELENGTH
KILOCYCLES
CONDENSER DEGREES
100
90
80
70
60
50
40
2998
3331
3748
4283
4997
5996
7496
10 20 30 40 50 60 70 80 90 100
A
B


~APPROXIMATE
CALIBRATION CURVE~
HAMMARLUND
120 METER COIL.
ML-7 CONDENSER (140 MMF.)
A = 3 CIRCUIT TUNER.
B = WITH 222 R.F. STAGE.
WAVELENGTH
KILOCYCLES
CONDENSER DEGREES
200
150
100
1499
1999
2998
10 20 30 40 50 60 70 80 90 100
A
B

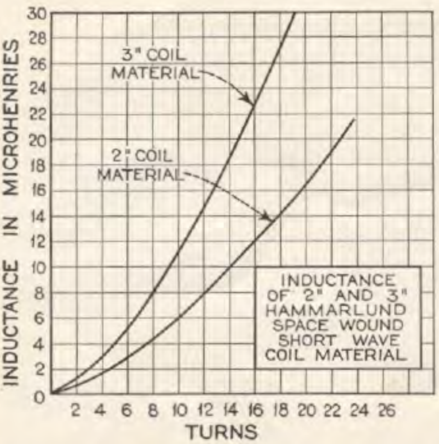


Figure 19—These two curves give the inductance for coils made of standard 2" and 3" coil material having various numbers of turns.

The Hammarlund short wave coil material was developed three years ago and immediately became the standard of comparison because of its very low resistance at high frequencies. Its adoption by many of the leading manufacturers of short wave receivers and coils and its general use in laboratories where only the best is tolerated are powerful testimonials to its high efficiency.

Dielectric losses increase very rapidly with frequency and for this reason an absolute minimum is used. For minimum losses successive turns must be evenly spaced (to secure uniform current distribution) and for this reason a thin continuous film of dielectric is used and fastened to the inside edge of the wire where there is minimum electric field. Short circuits which greatly increase the losses are also eliminated.

Number 16 B & S gauge wire is used to reduce the resistance of the wire itself. This is wound ten turns per inch so that the spacing between successive turns is slightly more than the diameter of the wire itself. This reduces the distributed capacitance and further reduces the high frequency resistance of the coil.

The standard coil material is wound in 2 and 3 inch diameters. The two inch is recommended for coils working at wavelengths below 50 meters (above 6000 k.c.). The 3 inch diameter is recommended for coils working from 50 to 150 meters (6000 to 2000 k.c.).

A coil has a minimum high frequency resistance when its diameter divided by its length equals approximately 2.46. This ratio may be higher over reasonable limits without seriously increasing the resistance but smaller ratios give large increases in resistance. The use of the diameters specified will result in more efficient coils for each range. For very short wavelengths even smaller coils may be used.

Figure 19 shows the approximate inductance of coils made from standard 2 and 3 inch coil material. Figure 20 shows the approximate wavelength to which different coils will tune with only a .00014 condenser. In an actual circuit from 15 to 25 per cent. must be added to these figures because of the circuit and tube capacities. The minimum wavelength is very nearly half the maximum in the usual circuits with a .00014 mfd. condenser.

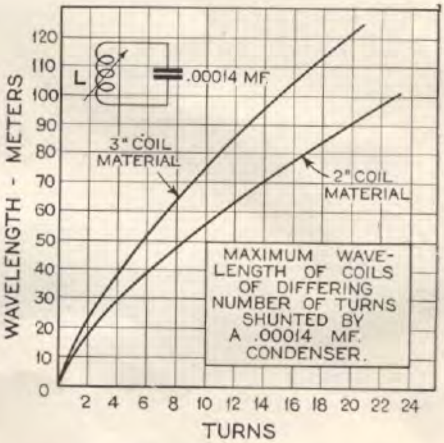
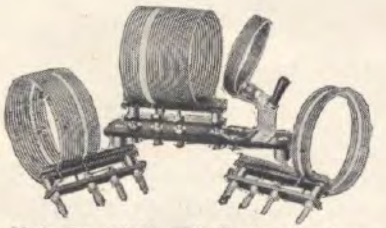


Figure 20—These curves show the maximum wave length to which coils made of the standard short wave coil material will tune with a .00014 mfd. condenser, but without any additionad circuit capacity. The total circuit capacity varies greatly in different circuits so that an approximate value must be estimated and a slight increase in wave length provided for.

HAMMARLUND SHORT WAVE APPARATUS



Made for .00014 mfd. Tuning Condensers

PLUG-IN SHORT WAVE TUNING COILS

Hammarlund short wave plug-in coils use the special space wound coil material described on the preceding page. They have exceptionally low losses and conserve the minute amount of energy which they receive. Dielectric losses are very important at high frequencies as are the stray capacitances, and for this reason the coil mounts have been carefully designed, giving good separation of terminals.

The standard SWT-3 and SWC-3 coil sets cover the range of from 15 to 107 meters with a .00014 mfd. condenser. There is ample overlap making the tuning very smooth over the whole wave length range. For this reason no change in the wave length assignments such as those that go into effect for the amateurs at the first of the year will affect the coil design or necessitate the substitution of new coils. Other coils are available which extend the range down to 8 meters and up to 215 meters.

The exact range of each coil depends on the maximum and minimum capacitance of the tuning condenser, the stray circuit capacitance, and the type of tube. The primary is adjustable and held in position by friction.

Code No.		Price
SWT- 3	Base and tuning coils for 20, 40 and 80 meter bands	$10.00
SWT- B	Base only	3.00
SWT- 20	Tuning Coil for 20 meter band, 15- 30 meters	2.50
SWT- 40	Tuning Coil for 40 meter band, 27- 59 meters	2.50
SWT- 80	Tuning Coil for 80 meter band, 52-107 meters	2.50
SWT-120	Tuning Coil for 120 meter band, 100-215 meters	3.00
SWC- B	Base similar to SWT-B less primary for all standard 4 prong coils	1.50
SWC- 3	Coil set containing one SWC-B base and one each of the SWT-20, SWT-40 and SWT-80 coils	8.50

SHORT WAVE PLUG-IN INDUCTOR COILS

These are single inductors mounted on a two pin plug-in base. They all plug into the standard SWI-B base. The windings correspond to the secondary windings of the SWT coils. They may be used in a tuned input circuit to a radio frequency stage, or in a band selector circuit for television or high quality speech reception.

Code No.		Price
SWI- 3	Base and inductors for 20, 40 and 80 meter bands	$6.00
SWI- B	Base only	1.00
SWI- 20	Inductor for 20 meter band, 15- 30 meters	1.50
SWI- 40	Inductor for 40 meter band, 27- 59 meters	1.50
SWI- 80	Inductor for 80 meter band, 52-107 meters	2.00
SWI-120	Inductor for 120 meter band, 100-215 meters	2.00

Made for .00014 mfd. tuning condensers.

SHORT WAVE COIL MATERIAL IN BULK

This coil material is recommended for special experimental coils or where coil material in bulk can be used. Both the 2" and 3" diameters are wound with No. 16 green silk over cotton insulation, 10 turns per inch. The coils are wound on very thin dielectric, which is fastened lightly but firmly to the inside surface of the wire where there is minimum electric field. The result is a very low loss coil, even at high frequencies.

This coil material has been used by a number of prominent manufacturers of short wave coils and by prominent laboratories and amateurs.

The coils average 20" in length and may be cut to any desired size.

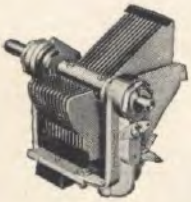
Code No. LWC-3	3" Diameter	40c per inch
Code No. LWC-2	2" Diameter	40c per inch

SHORT WAVE CONDENSERS

The .0001, .00014 and .00025 mfd. sizes of the Hammarlund Midline and SFL condensers now include special features which are invaluable in short wave reception. To avoid grating noises and clicks when tuning a condenser at very high frequencies, special construction must be resorted to. These condensers use carefully fitted cone bearings, a large non-short-circuiting pigtail and other features which make them as distinctive in their field as the standard Midline condenser is in the broadcast field.

Code No.	Maximum capacitance	Price
ML-11	.00025 mfd.	$5.00
ML- 7	.00014 "	4.75
ML- 5	.0001 "	4.75

THE IMPROVED HAMMARLUND MIDLINE CONDENSER

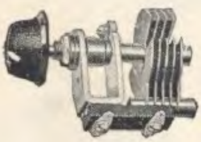


This condenser, which is made in the .000275, .00035 and .0005 mfd. sizes, has led the field for two years, and today the leadership of the improved type is even more outstanding. The established Hammarlund features include soldered, non-corrosive brass plates with tiebars; rib-reinforced, aluminum alloy frame; minimum dielectric; one-hole mounting with anchoring screw; bronze clock-spring pigtail; friction band brake; adjustable ball and cone bearings and a full-floating, removable rotor shaft.

The shaft supports no weight. Its length may be adjusted without cutting to accommodate any type of dial. It may be entirely removed and a longer shaft (metal or bakelite) inserted for coupling other condensers in tandem.

Code No.	Maximum capacitance	Price
ML-23	.0005 mfd.	$5.50
ML-17	.00035 "	5.25
ML-13	.000275 "	5.10

THE IMPROVED HAMMARLUND, JR., MIDGET CONDENSER



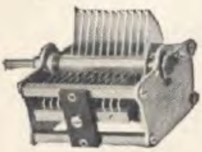
A high capacity ratio midget condenser with all the distinctive Hammarlund qualities—plus sturdier, simplified construction. Soldered brass plates; bronze clockspring pigtail; Bakelite dielectric; one-hole mounting. Has a new locking device for fixing rotor plates in any position. Its many uses are shown in circular packed with each condenser. Knob included.

The Hammarlund, Jr., is invaluable in many short wave circuits. It may be used as an antenna coupling condenser, in which case the MC-9, 11 or 15 is recommended, or it may be used as a compact inexpensive regeneration condenser, in which case the MC-23 is recommended.

Code No.		Price
MC- 5	16 mmfd.	$1.50
MC- 9	32 "	1.50
MC-11	50 "	1.75
MC-15	65 "	2.00
MC-23	100 "	2.25

Including Bakelite Knob

TRANSMITTING CONDENSERS

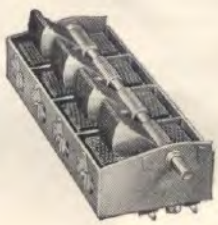


These condensers are designed to stand high currents since they use a solid brass sleeve with soldered brass plate, carefully turned cone bearings, and a firmly attached pigtail. The power factor is excellent, making them especially valuable in "tank" circuits.

The plate spacing is especially high to prevent breakdown at peak voltages of 3000.

Code No.	Capacity	Price
TC-12	.0001 mfd.	$6.00
TC-22	.0002 "	7.00
TC-43	.0004 "	10.00

THE NEW BATTLESHIP MIDLINE CONDENSER



These two, three and four gang condensers are the finest Hammarlund has ever produced. Infinite care is taken to carefully match and align the plates so that the capacitances of the various sections correspond within very close limits. A die cast frame is used and a ⅜" shaft turned down to ¼" at the ends is used. Prices do not include equalizers.

BSD-35	2	350 mmfd.	$ 9.50
BSD-50	2	500 "	10.00
BST-35	3	350 "	13.25
BST-50	3	500 "	14.00
BSQ-35	4	350 "	17.00
BSQ-50	4	500 "	18.00

NEW HAMMARLUND EQUALIZER

A small neutralizing or balancing condenser, having an exceptionally wide capacity range. Very useful as a compensator for equalizing the units of a multiple-tuning condenser. May be attached directly to socket binding posts or condensers, thus simplifying wiring connections.

The EC-35 is used as a compensating or equalizing condenser. The EC-70 is valuable as a variable grid condenser for short wave lengths where the capacitance need not exceed 70 mmfds. Minimum capacity of EC-35 and EC-70, 2 mmfds. Minimum capacity of EC-80, 20 mmfds.

Code No. EC-35 (35 mmfd.) Price........50c each
Code No. EC-70 (70 mmfd.) Price........60c each
Code No. EC-80 (80 mmfd.) Price........80c each

HAMMARLUND R.F. CHOKE COIL

The Hammarlund choke coil has an exceptionally low distributed capacitance made possible only by the use of its patented helical winding. In short wave work it is very important that this distributed capacitance be a minimum since the frequency range is very great and the choke is usually operated below its resonant frequency, that is, at frequencies for which the only radio frequency current which passes goes through the distributed capacitance.

Both the RFC-85 and RFC-250 may be used in shunt or series plate feed circuits of the type shown in Figure 6, page 9. The RFC-85 has a distributed capacitance of approximately 3 mmfds. and the RFC-250 a capacitance of 2 mmfds. at high frequencies. This means that the RFC-250 is a slightly better choke.

The direct current carrying capacity of both sizes is 60 milliamperes.

Code No. RFC-85 has an inductance of 85 millihenries, a capacitance of 3 mmfds. and a D.C. resistance of 215 ohms........Price $2.00

Code No. RFC-250 has an inductance of 250 millihenries, a capacitance of 2 mmfds. and a D.C. resistance of 420 ohms........Price $2.25

NEW KNOB-CONTROL DRUM DIAL

Hammarlund now offers a new illuminated drum dial of unusual beauty, rugged design and distinctive features.

It is controlled by a knurled knob giving a smooth vernier ratio of approximately 5 to 1 which insures the close tuning necessary at short wave lengths and is cleverly planned to be placed in any position on the panel desirable for attractive balance. Knobs fit standard ¼" shafts and are available either in walnut or black. The wave-length scale is of translucent celluloid, illuminated from the back.

Viewed from the front, the bronze escutcheon plate, embossed and oxidized, endows the panel with a classic beauty worthy of a place in any drawing room. Adaptable to all standard panel proportions.

Unique Control Mechanism

The drive is obtained by an exceptionally strong silk and linen cable, gripping a drum, snubber fashion. It cannot slip—absolutely no backlash or lost motion.

Under test this cable withstood 330,000 full-range movements of a large multiple condenser—equal to 50 years' average use!

Code No.		Price
SDB-1	(with black knob)........ Including template, electric bulb, mounting screws, instructions.	$4.00
SDW-1	(with walnut knob)........ Including template, electric bulb, mounting screws, instructions.	4.00
SDBK	Black Knobs........each	.25
SDWK	Walnut Knobs........each	.25

INSULATED FLEXIBLE COUPLING

The universal flexibility of this coupling permits operation of any number of condensers in tandem, without requiring exact alignment of condenser units. The two sides of the coupling being insulated from each other, condensers in gang can be operated as independent electrical units. Made of tough bakelized canvas, with brass bushings and four hardened steel set screws.

Code "FC"........Price, 60c each

HAMMARLUND MASTER SHIELD

Designed for the Hammarlund-Roberts "Hi-Q 29" Master Model, but may be used in short wave receivers as well. The sheet aluminum sides of the shield are clamped together by aluminum corner pieces which slide into place and make positive contact. An efficient, strong, easily assembled shield, allowing ample room for either the SWI or SWT coils (less primary) condenser, socket and tube.

Code AS-29 .... Price, $2.25

Hi-Q 29 MANUAL

The new Hammarlund-Roberts Construction Manual is an 80 page booklet chock full of invaluable information for the custom set builder, listener-in, and experimenter. It fully describes the theory and construction of both the Junior and Master AC and battery models. The Master model has a band selector circuit which makes it unique in the custom set field. The receivers, like the manual, have to be seen to be fully appreciated and we suggest the immediate remittance of 25c which is the nominal charge made to cover the bare cost of its production and distribution. Price $0.25

HAMMARLUND ADAPTER PLUG

The Hammarlund Adapter Plug and Cable, Code No. SWAP, connects any short wave adapter or converter to the audio amplifier of a broadcast receiver. This is done merely by inserting the plug into the detector socket of your receiver, and, as the plug fits either the UY type of socket used in A.C. receivers or the UX type of socket used in battery operated receivers, the Adapter Plug and Cable is universal in its application. Consists of a five lead 34″ cable equipped with a five prong plug and a four prong adapter plug.

Code No. SWAP .... Price $2.75

TWO TUBE SCREEN-GRID SHORT WAVE ADAPTER

Code No. SWK-2

Price, complete $35.00

This sensitive, non-radiating, easy-to-operate short wave receiver-converter is described in detail on pages 22 and 23. It is compact, reliable, easy to build, and, everything considered, is the best "buy" in the short wave field.

All parts, including drilled bakelite panel, sub-panel and hardware are packed as a complete kit including full-size picture wiring diagram and assembly and operating instructions. For detailed list of parts see page 23.

The adapter may be plugged into a standard broadcast receiver or power amplifier, or it may be operated as a completely independent unit by adding a standard two-stage amplifier.

There are thrills aplenty below 200 meters. Listen in on the "under-side" of the world; pick up the boom of famous "Big Ben"; experience the many pleasures that abound in the realm of "short waves," radio's fastest growing "baby".

HAMMARLUND MANUFACTURING CO., INC.

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