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The National Co. Short-Wave Receivers

By James Millen, M. E.

General Manager, National Company

INTERNATIONAL broadcasting has taken the short-wave receiver from the experimental laboratory and placed it in the parlor of the broadcast enthusiast. The repeated appearances of Ramsay Macdonald in England, Cosgrave in Ireland, Mussolini and the Pope in Rome before the international short-wave microphone, and the almost universal rebroadcast on long waves, have stimulated the interest of the average broadcast listener in the high frequency impulses that carry their voices across the oceans.

However, regardless of the possibilities of rebroadcast reception, there exists an admittedly greater fascination in receiving the voice of Senatore Marconi direct from HVJ, the Vatican City, Rome, Italy, than via the intermediary of a local station. And aside from the intriguing element of direct contact, it is occasionally possible to obtain better reception from a foreign short-wave station than from a semi-local rebroadcasting of the program. Also many interesting programs are being broadcast by domestic short-wave stations which may be received with consistent excellence, and the short-wave receiver thus contributes to the possible sources of radio entertainment. In rural communities, isolated from long-wave coverage, the short-wave receiver often provides the only reliable reception.

The short-wave receiver has definitely emerged from the laboratory. In simplicity, reliability, battery or light socket convenience, and appearance, it compares favorably with the conventional broadcast apparatus. It may take its place in the parlor with the long-wave receiver or in a "short-wave nook" where its offerings are reserved for the privileged ears of the real radio fans of the family.

What Are Short Waves?

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

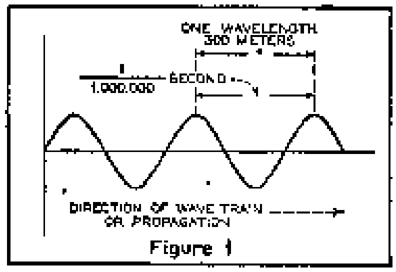

FIG. 1

Graphical representation of wavelength and frequency. Wavelength is shown as distance in meters measured from crest to crest and equals velocity divided by frequency. So frequency equals wavelength divided by velocity.

Wavelength and Frequency

Wavelength is a physical conception by means of which we represent how a radio signal travels from the transmitting station to your receiver. A "wave form" is assumed, because a highly refined recording instrument placed anywhere within the influence of the signal would show a wavy line on the recording paper or tape. Such an instrument would show that the signal, starting at zero, would attain a certain maximum positive strength, then slowly decrease to zero again, to build up on the negative side to a similar maximum, again dropping to zero to recommence the "cycle." This cycle occupies a certain definite time, which can be measured directly and indirectly. Also, radio waves travel from the transmitting antenna to the receiving antenna with a speed that has been definitely established at about 300,000,000 meters a second.

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

The relationship is more simply expressed in the equations:

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

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

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

Cycles, Kilocycles and Megacycles

For scientific purposes it is often more desirable to work with frequencies rather than with their corresponding wavelengths, principally because, regardless of wavelength, a certain definite frequency band is considered necessary for the transmission of radio telephone signals utilizing the systems employed today. This band is 10,000 cycles wide. That is, if a broadcasting station is transmitting on 300 meters, or one million cycles, it will occupy a band extending 5000 cycles on each side of the carrier frequency of one million cycles—i.e., between 995,000 and 1,-

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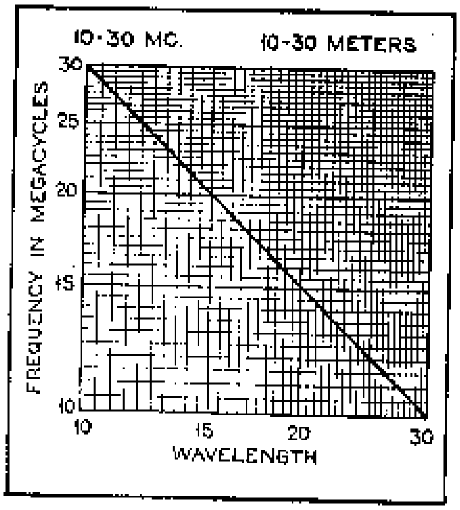

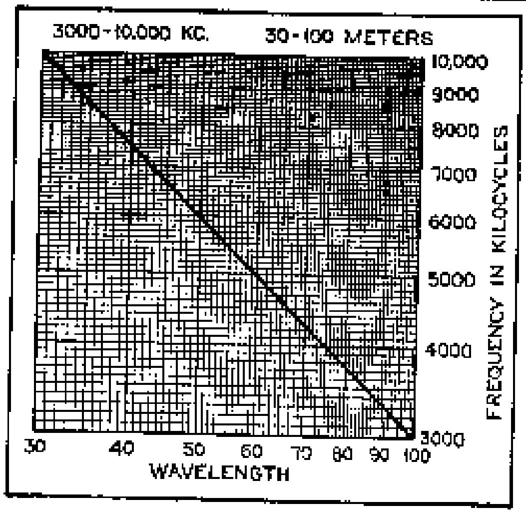

Wavelength-frequency conversion graphs. These may be used for higher wavelengths (lower frequencies) by merely shifting the decimal point. Use of these graphs will yield approximate results, sufficiently accurate for frequency location in tuning. The numerical conversion table, frequency to wavelength or wavelength to frequency, is printed on page 20 in its most accurate form.

(Continued from preceding page)

005,000 cycles. In order that no other station can overlap or interfere, the carrier of a second station must not be within 10,000 cycles of the carrier of the first station.

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

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

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

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

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

Characteristics of Short Waves

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

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

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

Short-wave signals suffer from peculiar fading and absorption effects from which long-wave signals are relatively free. The most unusual of these is perhaps, the so-called "skip-distance" effect. For instance, the direct wave from a fifty-watt transmitter operating on 7500 kc may be so attenuated at a receiving station five hundred miles away, by absorption or deflection due to terrestrial conditions, that the signal is entirely lost. However, another portion of the signal, traveling more directly upwards, collides with the somewhat problematical Kennelly-Heaviside layer—a stratum of ionized gases high above the earth's atmosphere—and is reflected to the earth thousands of miles away from the transmitter. Thus a receiver in Australia might hear a transmitter in New York City, the signal from which is inaudible in New Orlaens or Panama.

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

The greatest distances will be received on the three principal bands in accordance with the table given below:

22 to 14 mc daytime.
14 to 10 mc morning and evening twilight.
10 to 2 mc night.

Short-Wave Telephone Stations

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

Shortwave telephone services may be divided into six classes—broadcast, television sound accompaniment, amateur, trans-oceanic, commercial, police radio and airplane. The broadcast stations are generally given over to the simultaneous transmission of long-wave programs and are operated in conjunction with a long-wave station. For instance, W2XAD is a short-wave channel of WGY, Schenectady, N. Y., U. S. A. The following are the international frequency allocations for short-wave broadcasting:

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

Many of the amateur phone stations will be found on the 3,500-4,000 kc and 14,000-14,400 kc bands with the preponderance of traffic being handled on the 3,500-4,000 kc channel. While it would be stretching the point somewhat to say that amateur radio telephone conversations are entertaining, they are occasionally interesting.

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

Airplane Traffic

Practically all airplane telephone traffic is handled on the 4,000-5,500 kc band, including point-to-point flying field and mobile services. This is often fascinating, always interesting, and some very reliable weather reports may be picked up from local airmail terminals. Police alarm stations, broadcasting to cruising squad cars, are shown in the call lists on page 19.

Four sets of coils are generally required to cover the short wave spectrum in which we are interested—22 to 13 mc, 14 to 7 mc, 8 to 4 mc, and 5 to 2 mc.

An easily acquired knack of tuning contributes an artistry to short-wave reception which is lacking on the broadcast band. The variation in technique may be attributed to the fact that the short-wave receiver is generally tuned with the circuit oscillating—i.e., with the regenerative control so adjusted that a whistle is heard each time a carrier frequency is crossed. (Most of these whistles will be broken up into the characteristic dots and dashes of the code transmitter.) The highest type of short-wave receiver has four controls—the main tuning control, the regeneration or oscillation control, a volume control, and the trimmer. These controls are much more closely interlocked than the comparable knobs on the broadcast receiver, and a variation of one of them may alter the wavelength to which the receiver is tuned.

In tuning, the regenerative control should be maintained just beyond the oscllation point. When the circuit is oscillating a distinct hiss is audible in the 'phones or speaker, the background noise is considerably intensified and a whistle will be heard whenever a carrier frequency is encountered. At the correct tuning point—with the circuit just oscillating—the background noise and signal response will be at a maximum. In other words the receiver is at its most sensitive adjustment. To maintain this condition while tuning, it will be usually necessary to vary the regeneration control for every ten degrees or so on the tuning dial. When a telephone carrier is crossed, readily identified by the steady whistle and generally modulated by voice or music, reduce the regeneration (retuning slightly with each variation in the regenerative control) until the circuit is no longer oscillating and the carrier is clear. A faint "swish" will now locate the carrier (if unmodulated) as the tuning dial receives its final adjustment.

Zero Beat

In some instances of very weak signals, it is desirable to "zero beat" the carrier, rather than stop oscillations. As the carrier is approached with an oscillating receiver, the pitch of the whistle becomes lower, vanishing at zero beat—the exact resonance or tuning point—trailing off again into a squeal on the other side. Occasional stations are best received at zero beat with the circuit just oscillating. In achieving this adjustment a slight body capacity effect may make it necessary to tune slightly to one side of zero beat, the beat becoming zero when the hand is removed from the tuning control.

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

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

The station may be logged in local time, but in corresponding with the station for verification of transmission, the hour should be given in G. M. T.—which is Eastern Standard Time plus five hours. Conversion can be readily made by means of the time chart on page 8.

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

Receiver Differences

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

The principal differences between the present receiver and its immediate predecessor, the SW-45, are best explained by reference to the wiring diagrams, Figs. 6 and 7, respectively the ACSW-58 and the DCSW-34. These are the substitution of the type 58 pentodes in the r-f and detector circuits ('34's in the d-c model), the provision for radio-frequency gain control and the radio-frequency filter in the plate circuit of the detector.

The new tubes, as intimated, have contributed in no small way to the high efficiency of this circuit. The high amplification factor, transconductance and, above all, high plate impedance, enable the designer to achieve a degree of selectivity and sensitivity that have heretofore been little more than experimental ideals. The use of these tubes naturally necessitated the redesign of the plug-in radio-frequency inductors. The coils, T1 and T2, are wound on the low-loss R-39 material and are available in various sets, covering from 12 to 2000 meters, and band-spread coils can be obtained for special portions of the frequency spectrum.

FIG. 3
Front view of cabinet of the former model short-wave receivers for a-c or battery operation.

Control of Volume

It has heretofore been considered that the simple regeneration control in the detector circuit provided adequate overall volume control. Such an arrangement, however, results in several forms of distortion. The radio-frequency tube is necessarily operating at maximum amplification at all times, resulting in considerable overload of both that tube and the detector on strong signals. Backing up the regeneration control to reduce the signal strength results in additional distortion, due to the fact that the detector tube is then being operated with decreased plate or screen voltage. The obvious solution is to employ a second control operating at the input to the r.f. stage.

Under actual reception conditions, this additional control contributes several other advantages. The detector may always be operated on that portion of its characteristic at which best rectification is obtained, with a resulting improvement in tone quality and detecting efficiency. The receiver may also be operated in the condition of maximum selectivity by setting the regeneration control close to the point of oscillation and controlling volume altogether at the r.f. input. This latter feature is of particular utility in bringing in a foreign station having a frequency allocation close to that of a powerful local.

Plate Circuit Filter

The radio-frequency filter in the detector plate circuit is the result of careful study of the problem. Few experimenters seem to realize the difficulties encountered when excessive r.f. is permitted to invade the audio-frequency circuits. The most noticeable characteristic of such a condition is the presence of hand-capacity effects on all parts of the a-f. system, including the headphones and loudspeaker leads as well as the metal cabinet. Another symptom is the exasperating fringe howl as the detector approaches oscillation. A sticky regeneration control—an apparently excessive amount of lost motion—is directly traceable in many cases to inadequate filtering in the detector output circuit.

The use of a detector tube having a high plate impedance precludes the employment of a fairly large by-pass condenser, which would necessarily attenuate the higher audio frequencies, resulting in muffled tone quality and even unintelligibility of speech. The matter resolves itself into the familiar high radio-frequency problem of an efficient r-f choke design. The inductance of the choke used is only 2½ millihenries, but what is more important, the distributed capacity has been reduced to 1 mmfd.

Undesirable Coupling Eliminated

The remainder of the circuit is fairly conventional, and the important values are given in Figs. 6 and 7. Several electrical details, however, are worthy of special emphasis in reference to the general shielding and the design of the ganged tuning condensers.

It has been found that in the design of a single-control high-frequency receiver additional precautions must be taken to avoid coupling between the input and output circuits of the r-f. stage. Passing over the usual methods of circuit isolation, we come to a point which is often overlooked. This is the coupling through those portions of the tuned circuits which happen to be common in parts of the gang condenser frame. While the paths involved are very short, an inch or so represents an appreciable part of the total conductor length at frequencies above 15 megacycles, and is sufficient to cause instability and circuit interlocking.

To overcome this trouble, a special tuning condenser was developed, in which both rotors are entirely insulated from the condenser frame and from each other. This design makes it possible to isolate completely the input and output circuits of the radio-frequency stage, resulting in a perfectly stable system even at the highest frequencies to which the receiver will tune.

Plug-in coils are used in both the a-c and d-c models in preference to switching arrangements which necessarily introduce losses and concommitant complications inimicable to the highest efficiency in short-wave reception.

Separate Power Pack Used

The direct current model differs from the ACSW-58 principally in the tubes em-

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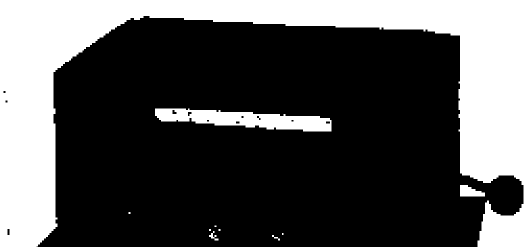


FIG. 4
Front view of the Thrill Box in new form, using latest tubes and having full-vision dial.

FIG. 5
The top view of the a-c receiver. The push-pull 245's are at right.

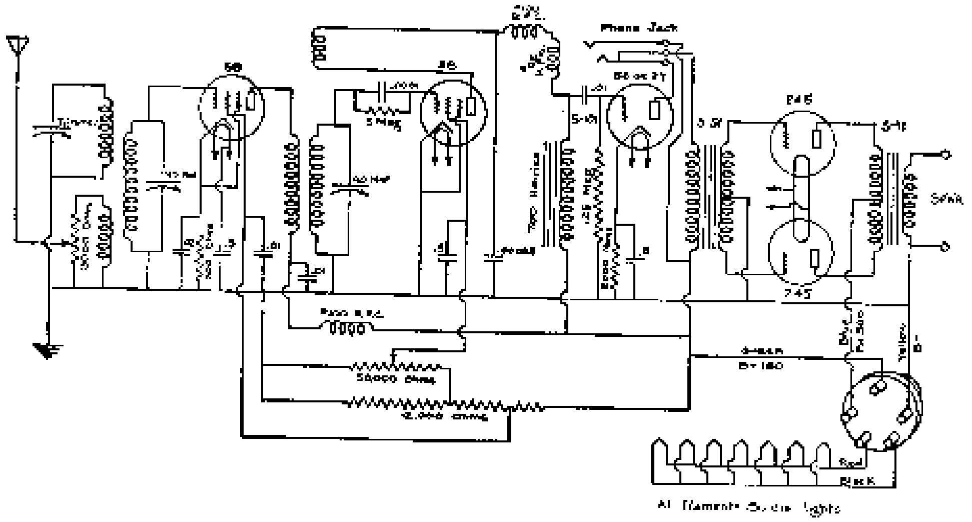


FIG. 6
The circuit diagram of the new model a-c short-wave receiver, the ACSW-58, with connections to power supply. It is important that the voltages are correct (B + 300, B + 180). The 3000-ohm potentiometer is a selectivity and input control, while the trimmer is for close resonating, requiring resetting for each coil set only. The detector plate chokes have unusually low distributed capacity.

(Continued from preceding page)
ployed. The general efficiency and operation are the same.

Despite the increasing tendency toward unitary design with built-in power supply, the receiver under consideration is constructed for use with a separate power pack. Single unit construction necessitates a large amount of shielding in the r-f and detector circuits for the elimination of hum, and this excessive shielding, in order to be effective, must be of a different nature than that which amply fulfills the r-f isolation requirements. Shielding, at best, is a costly nuisance which tends to offset the increased efficiency attained through the use of low-loss insulation and careful design. These considerations strongly recommend the use of the separate unit with a high-frequency receiver, limiting the shielding to radio-frequency fields.

The mechanical details of the receiver are fairly obvious from the accompanying photographs. Rigidity in the radio-frequency circuits is obtained through the judicious use of Isolantite and R-39 supports and mountings. In the design of the dial, consideration was given to the concensus of opinion among several hundred amateurs and experimenters who favored a full vision or open scale arrangement. The dial has a scale seven inches long, insuring accuracy in reading. The pointer moves horizontally across the entire length in a linear relationship to the tuning control.

Installation and Operation

The importance of a good short-wave antenna cannot be overstated if the full possibilities of enjoyable reception are to be realized. Commercial companies have spent millions of dollars in the development of suitable short-wave aerial systems, while the average short-wave experimenter is content with a shoddy installation which experience has taught him works fairly well on his broadcast receiver.

Because an antenna is effective on the lower broadcast frequencies, it does not follow that it is a satisfactory short wave aerial. Induced currents, man-made static and leakage effects which would not be annoying on 300 meters, will seriously impair reception at 30 meters. The peculiar carrying power of the very high frequencies, which makes short-wave reception possible on almost any kind of an antenna is responsible for the slipshod aerial systems, which, in turn, are largely responsible for noisy reception and a retarded acceptance of short wave reception on the part of the average radio fan.

Wherever choice is possible the short-wave receiving station should be located away from power lines, electrically operated machinery of any kind and isolated, as far as practical, from roads carrying automobile traffic and monitored by traffic lights.

Aerial Advice

While the antenna should be carefully installed, it need not be in any way elaborate. A single horizontal wire, T or L type, twenty-five to fifty feet in length will provide ample pick-up. If possible, the antenna should be erected in the open, and as high as practical. It should be well insulated, at each end, and of fairly heavy wire—say number 14, insulated or bare. It should be erected as far away as circumstances will permit from possible sources of noise interference, and should not parallel power lines. It should preferably run at right angles to the nearest road. It should be clear of tree branches in the strongest wind.

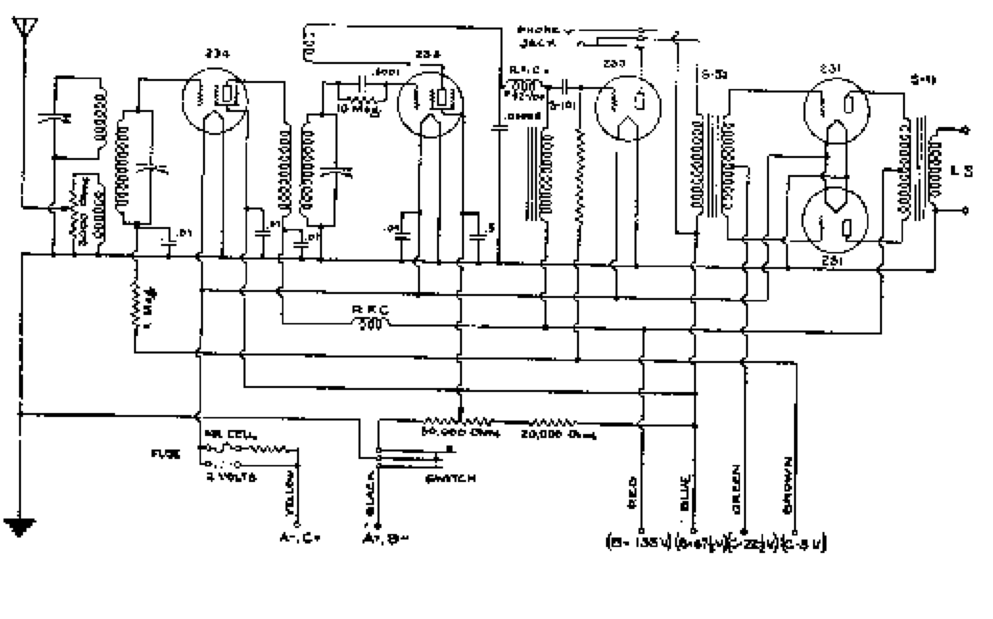
The leadin should be well supported, thoroughly insulated, and should be brought indoors through a leadin insulator not of the window strip variety. The lightning arrestor should be of the highest quality. Any joints in the antenna system—aerial, leadin and ground—should be soldered. It is particularly important that the leadin be kept as far away as possible from power lines, elevator shafts and electrical machines of all descriptions.

Equal care and attention should be directed to the ground connection. Where several possible grounds are available, they should be tried individually and in groups for the least noisy connection. The ground leads should be soldered to the clamps and the clamps themselves soldered to the pipes.

Transposed Loadins

Indoor antennas are very effective, but obviously it is seldom possible to erect them as far away from interference inducing sources as an outdoor antenna. The indoor antenna is really nothing more than "leadin"—and it is appreciated that the ordinary leadin will pick-up noise. The main idea of the outdoor antenna is to obtain a noise free pick-up so that the signal to noise ratio will be improved. If an indoor antenna is erected, the same precautions as to rigidity, insulation and preferred location should be observed.

FIG. 7
The d-c model, circuit of which is shown herewith, requires batteries for the filaments of the '34, '30 and '31 tubes, but the B voltage may be supplied either by batteries or by an a-c B supply. The same fundamental circuit is used as in the a-c model. The d-c model is the DCSW-34. Note the isolation of the r-f from the C biasing battery applied to the radio frequency stage. An Air-Cell A battery may be used (2 volts), with small limiting resistor (fuse at upper position) or a storage battery



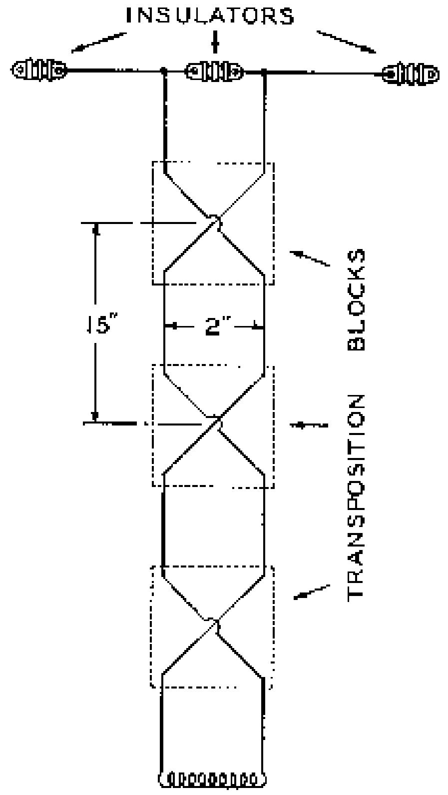
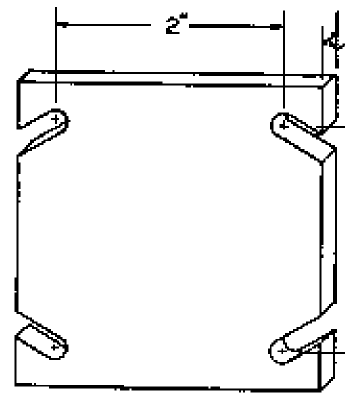


FIG. 8 (Left)
The transposed leadin system, used for noise reduction. The aerial is separated at the center and the double leadin is brought down by transposition.



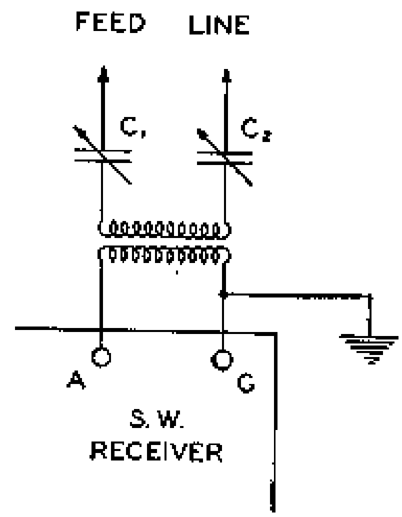


FIG. 9 (Left)
A rubber or bakelite slab may be used for making a transposition block. For instance, in the Fig. 8 requirement three such blocks would be used.

FIG. 10 (Right)
If a ground is essential, transposed leadins may be used with this coupler system.

Under no circumstances use any form of "patented" aerial tacked to the walls, under rugs, or socket type antennas and expect satisfactory short-wave results.

As mentioned above, with a properly located outdoor antenna, most of the noise is picked up by the leadin. With a special leadin, it is possible to reduce the noise pick-up considerably, thereby taking full advantage of the antenna pick-up. Such an arrangement is shown in Fig. 8. It will be observed that the aerial itself has been broken in the middle, and two leadins brought down, which are "transposed," or crossed, every fifteen inches by special blocks. These blocks which are from 2 to 2½ inches square, can be made from bakelite, by notching, as shown in Fig. 9.

The two leadins are connected to the antenna and ground posts of your receiver. No ground is used. If the receiver is unstable or hums without the ground, the ground may be connected providing the lead from the antenna primary, which connects to ground, is broken and connected directly to one of the leadins. An alternative circuit is shown in Fig. 7, whereby a special coupler is employed between the transposed leadins and the receiver. This coupler can be wound with ten turns of number 18 enameled wire on National R-39 standard coil forms. The two windings are close wound, and spaced ½ inch from each other. Condensers C1 and C2 are 30 to 60 mmf. midgets. Further details on transposed leadins can be obtained from the Lynch Manufacturing Company, 1775 Broadway, New York City, who are manufacturers of transposition blocks, antennae insulators and antenna couplers especially designed for short-wave reception.

Installation

The receiver itself should be located as far as possible from any interference source such as elevators, electric fans, etc.

The ACSW-58 must be operated with a power supply furnishing the exact potentials shown in Fig. 6 under the indicated loads. This receiver is designed to operate in conjunction with the National 5880 ABS power unit, to which all connections are made by means of the single plug on the end of the receiver power cable. If an adequate power supply other than the National 5880 ABS is available, the plug should be removed from the cable, and the connections made in accordance with the following color code:

Wire Color	*Connect to—*
Red or Black	2½ volts A.C.*
Yellow	B—
Green	B+180
Blue	B+300

It is strongly recommended that the National power unit be employed, due to ease of connection, reliability of operation and the elimination of any adjustment or experimentation.

The D-C Model

The DCSW-34 should be connected to the various voltage sources indicated in the diagram, Fig. 7, and on the leads of the connection cable. The most convenient "A" battery is the Eveready Air Cell, which will provide one year of average operation. If another source of filament potential is used, such as a storage battery or dry cells, a rheostat should be provided to maintain two volts at the set terminals.

The "C" potentials are preferably obtained from the usual batteries. Either "B" batteries or an eliminator may be employed as the high potential source. The National Velvet-B Type 3580 is recommended as a reliable and economical power unit for use in conjunction with the DCSW-34.

All connections should be thoroughly tightened. Pliers are preferable to fingers in making a permanent installation.

Antenna, ground and loudspeaker or output binding-posts are plainly marked. Telephone receivers are plugged into the jack, behind the set, by means of the conventional plug. When telephone receivers are used, the power amplifying stage and loudspeaker are automatically disconnected.

Tubes

Satisfactory short-wave reception is impossible without perfect tubes. Tubes that will "play" on a broadcast receiver may be altogether unsatisfactory on the higher frequencies. Poor tubes may result in noisy reception, erratic volume and regeneration control, fringe howl and exceedingly bad microphonic conditions. By microphonics, we refer to the ringing sound occasioned by tapping the table or cabinet. A distant foot step may give rise to this trouble if other than perfect tubes are used.

Spare tubes—a duplicate of each tube in the receiver—should be maintained at hand. Do not experiment with "bootleg" tubes. Only the products of the most reputable manufacturers are recommended for use in all National "Thrill Boxes."

The a-c model, type ACSW-58, requires two type 58 variable mu pentodes in the radio frequency and detector stages, a type 56 or 27 in the first audio socket and two type '45 tubes in the push-pull power stage. The d-c model, DCSW-34, employs two type 34 variable mu screen grid tubes in the r-f and detector sockets, a type 30 first audio and two type 31 output tubes. The tubes required are plainly engraved on the sockets.

Coils

Five sets of coils are furnished with each SW-58 and SW-34, two coils to a set, and covering wavelengths from 13.5 to 200 meters. One coil of each set is plugged into the r-f circuit (left-hand coil socket) and one coil into the detector coil socket. The two coils of each set are identical, and the wave bands they cover are indicated on the chart on the cover of the receiver. The coils for the a-c receiver are designed by numbers only, beginning with the number 60 and increasing with wavelength. The d-c coils may be identified by number—from 10 to 21 increasing with wavelength—and by the color strip molded into the top ring. The wavelength of the coils increases with the number of turns of wire.

Coils can be had extending the wavelengths of the receivers as high as 2000 meters and the coils forms are available for the home winding of special inductors.

Amateur bandspread coils may be ob-

(Continued on next page)

*The 2½-volt circuit center type must not be grounded directly, but is connected to B— (ground) through a 750-ohm, 10-watt resister, for biasing the 245 tubes.

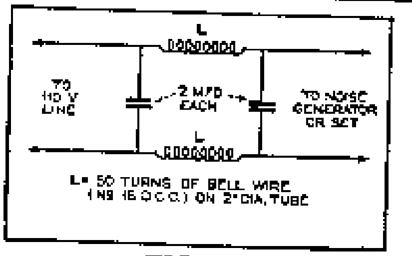


FIG. 11

A filter for reducing noises picked up from the power lines (not needed when the official Power Unit is used).

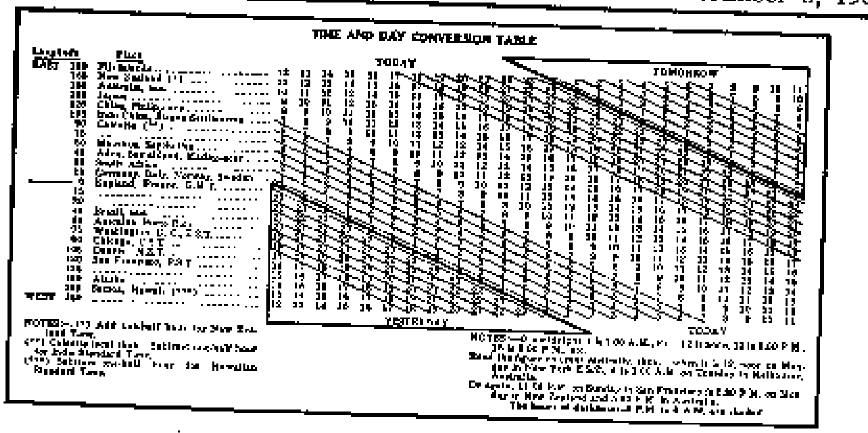


FIG. 12

Conversion table covering time and also the day in reference to the points of reception and transmission. The datum is EST time in New York, the converted time is Greenwich Meridian Time.

(Continued from preceding page)
tained which spread the amateur bands over 50 dial divisions. No changes in the receiver are necessary, and these coils are recommended to the experimenter interested in amateur reception. The windings of the bandspread coils can, of course, be changed to provide similar spreading over any narrow portion of the short-wave spectrum.

Choice of Correct Coils

Choose a set of coils covering the wavelength to which you wish to listen—making sure that the two coils used are from the same set. The process of choosing the correct coils for any station is very simple and becomes automatic after a few hours of experimental short-wave reception. First translate your local time into Eastern Standard Time, by means of the time chart, Fig. 12. Then refer to the call list on pages 18 and 19 and select a station broadcasting at that time.

For a start a station fairly close by is preferable. Note the wavelength and choose the coils covering that band as indicated on the same line with the station call letters. The correct coils are also indicated on the tuning curve on the inside cover of the receiver. Where due to overlapping, the wave desired can be tuned on two sets of coils, choose the higher wavelength coil.

If desired the 40 to 70 meter band coils may be chosen—No. 63 for the ACSW-58 and No. 13 (white band) for the DCSW-34—and the receiver tuned at random (but very carefully and slowly) with the certainty of running across several good stations.

Tuning

The functions of the various controls have been indicated in the general discussion of the SW-58 and 34. From left to right they are the antenna trimmer, r-f volume control, tuning control and regeneration. The trimmer provides the most efficient lining-up between the antenna circuit and radio-frequency stage. It is not critical, requires little adjustment, and once set for the coils used, need be touched only for very weak stations. The r-f volume control increases clockwise and functions exactly as does the volume control on the conventional broadcast receiver. The tuning control is the familiar station selector. The regeneration control increases clockwise and also operates as a volume control, while performing additional function of throwing the circuit into oscillation which simplifies the location of stations and makes possible the reception of continuous wave code transmitters. (The circuit should go in and out of oscillation smoothly—without howling. If not, check as indicated under "Trouble Shooting.")

Picking Out a Station

For a start, it will be best to turn the r-f volume control up full, and adjust the trimmer, by visual inspection, until the condenser is half in. Turn up the regeneration control until a distinct background hiss is heard. The set will now be oscillating. In this condition it is extremely sensitive, and as the dial is turned rapidly, a series of whistles and squeals should be heard as many stations, code, telephone television, etc., are passed. Adjust the trimmer for the loudest hiss.

By reference to the curve chart on the cover of the receiver, locate the approximate position on the dial where the station in which you are interested (unless tuning at random) is located. For instance, if you wish to listen to W8XK, Pittsburgh, Pa., U. S. A., which broadcasts on a wavelength of 48.86 meters, it will be found at about 60 on the dial with the 40 to 70 meter coils. You will also find listed on the log inside the receiver cover, 5 "spot" locations, giving the exact dial readings at which these stations will be received.

Turn the dial knob slowly until a continuous whistle is heard (interrupted whistle indicates a code station). This is probably the carrier of a short wave telephone station, and if modulated by speech or voice, these sounds will be heard above the squeal. Tune until the squeal is loudest.

The squeal can now be cleared up by backing down the regeneration control until the receiver stops oscillating. A slight readjustment of the tuning dial may be necessary as the regeneration control is moved. Adjust volume to suit, either by means of the r-f volume control or the regeneration control (below the point of oscillation). As a general rule it is desirable to operate with the regeneration control about ¼ turn below oscillation (after the station is located) and the r-f control set for the desired volume. (For extreme selectivity, the regeneration control should be set just below the oscillating point.)

The receiver is most sensitive in an oscillating state when the regeneration control is just above the oscillating point. When tuning with this adjustment, the circuit may stop oscillating, necessitating the turning up, slightly, of the regeneration control.

Trimmer Adjustment

As already indicated, the trimmer adjustment need only be set for each set of coils, except for the reception of very weak stations, which may necessitate careful adjustment, all around, for best reception. On such stations, slight readjustment of the tuning dial may be necessary, following the movement of any of the other controls.

Code and television stations are good for practice tuning, and are located with the receiver oscillating as described. Code stations transmit either an irregular stream of dots and dashes, or a constant sequence of dots (for test purposes). Many code stations are modulated by a high pitched tone, and can be received when the regeneration control is turned below the oscillating point.

The carrier of a television station is constant, but is modulated by a variety of rising and falling tones. These tones alone are also received with the regeneration control turned down below the oscillation point. With the usual loudspeaker, the television signals are, of course, audible only. For picture reception, further amplification and a light reproducing system are required.

Trouble Shooting

Carefully assembled and wired the ACSW-58 and the DCSW-34 should be as free from trouble as a reliable long wave broadcast receiver. However, it can happen in the best of families, and the major causes of faulty operation, with their symptoms, are described below. In general, the troubles will be the same as those which occasionally afflict the longer wave receivers, and their location follows the same procedure—voltage and continuity tests, etc.

No Signal: Burned out detector or a-f tubes, no plate or heater voltages. Same possibilities as exist on longer waves.

Weak Signal: Mixed coils. In this case the adjustment of the r-f volume control and trimmer will have practically no effect. If coils are matched properly, check for continuity in the windings. Open coupling condenser in the impedance coupled amplifier will cause weak signals, accompanied with pronounced loss of low frequencies in 'phone reception. Check antenna, grid cap connections, etc.

Faulty Regeneration: Sticky controls, howling, etc. May be caused by a poor detector tube, incorrect value of grid leak and short circuited radio frequency choke coil.

Poor Quality: Check on several stations before being satisfied that the trouble is in the set. Garbled or inverted speech is deliberate with most commercial point-to-point short wave stations. Also, poor reception conditions, accompanied with fading, is a frequent cause of poor quality on certain stations. Make the usual check on voltages and tubes. Muffled tone may be due to over regeneration, while scratchy, hashed speech on strong signals points the finger of suspicion to the grid leak in the impedance coupled amplifier.

Noise: Discrimination between receiver noise and pick-up noise is more important on short waves, and is effected by the usual tests. If noise is consistent, and checks show that the receiver is not at fault, a filter system in the line, such as shown in Fig. 11 should be employed, and, as a last resort, an anti noise antenna as already described on page 10. In the d-c model, the "B" batteries (when used instead of an eliminator) can be suspected if they have been in operation for several months. The usual sources of noise give rise to similar disturbances in short wave receivers with an amplified degree of annoyance.

(Continued on next page)

FIG. 13
An ultra frequency receiver also among the National Company products. This is a superheterodyne, covering 40-75 mg. (about 4 to 7.5 meters) with four coils.

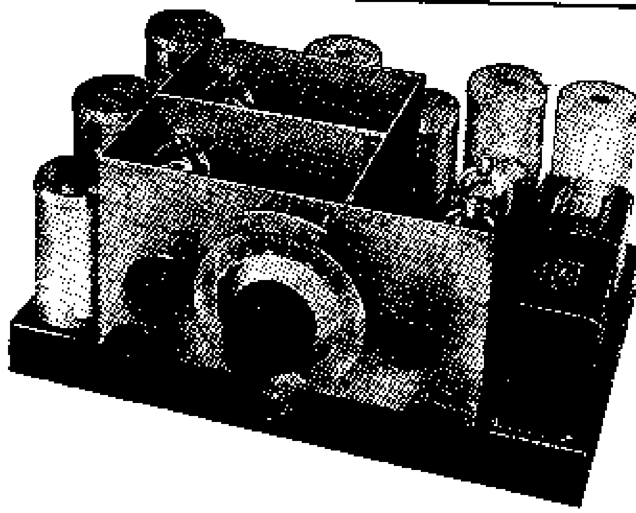


FIG. 14
The Model AGS communication receiver, 15,000 to 2,400 kc.

Radio Time the World Over

By the intelligent use of the foregoing time chart much futile listening on the short wavelengths can be avoided. In the revised call list shown on pages 18 and 19 transmission times are Eastern Standard. Eastern Standard Time (or any other time for that matter) can be translated into your local time by reference to the time chart, and stations listened to at the hours they are scheduled to be on the air.

Difference in time is a thing which is difficult for short-wave fans to understand. Listening to "Big Ben" strike midnight at 7:00 p. m. in New York should clarify the point, but still listeners who fail to hear European stations at 8:00 p. m. wonder why. Almost all stations broadcast at hours conforming with time in their part of the world. Europeans, with the exception of PCJ, who broadcasts special programs for American and Australian listeners, close down as early as 6:00 p. m. Eastern Standard Time. South Americans are heard from then on till midnight. Stations in Siam, Japan, and that part of the world, get busy while New Yorkers are thinking about breakfast. It is therefore quite natural that listeners should tune for European stations in the afternoons providing they live in the United States and tune for stations in the Antipodes, in the early mornings. Always keep a good station list on hand.

Familiarity Breeds Results

As already explained, tuning a short-wave set is somewhat different from tuning a regular broadcast receiver. All in all, it is simply a matter of the operator learning how to tune his set. A good receiver does not solve the question of results on short waves, for the operator must become familiar with the short waves and their peculiarities. To bring about this familiarity is the purpose of this booklet. Once this is mastered, it is just as simple to get distant stations under ordinary circumstances as to get local stations.

The first thing a new listener should do is to log as many local stations as possible as already suggested. There is room for fourteen stations on the log provided on the inside cover of each SW-58-34. Since stations do not appear on every part of the dials, these stations will act as guides to locating distant stations. The operator should also find just what each dial on his set does when tuned, and what effect they have on the stations once they are tuned in. Locating the spot where stations are heard the best is a good idea.

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

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

Pointers Listed

A few pointers for new listeners are:

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

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

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

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

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

Don't skim over the dials. Tune slowly.

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

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

Don't get into the habit of tuning haphazardly. Learn where stations should be found on the dials of your particular receiver.

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

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

[*The foregoing is one of a series of weekly articles on standard commercial receivers. Details are given in a single issue and with unparalleled completeness.*]

DX Corner

There have been numerous requests for various features to appear in this column weekly. Naturally the object of this corner is to supply the information and subject-matter that the greatest number of fans request. In other words, this is to be a department for the DX-er, and of course, that can mean only one thing. There are definite subjects that interest a DX-er.

Just to present a DX special program for a week in advance, with the actual hours of broadcast, means considerable correspondence with dozens of broadcast stations. If the proposed broadcast program is to be of any value it must be accurate. With this thought in mind we shall soon have some very interesting things to look forward to.

In the meantime let me impress upon you that you personally are invited to send along any interesting material or thoughts or experiences or ideas that will fit into a DX-er's life. There has come into the experience of every radio fan some unique idea or wrinkle that has been of some advantage, so send yours along so that the other fellow may share it.

In my personal contact with many DX-ers I found that there was much information that in many cases would be of considerable general value. The DX-er is generous but it was simply because in many cases they were not in the habit of writing information or suggestions.

* * *

From Canada Phillip H. Robinson, Shelburne, writes that he believes the DX column improves Radio World fifty per cent. He pulls in KSL, Salt Lake City, and XER, Mexico City.

* * *

H. M. Yvall, 103 Main Street, Leominster, Mass., writes his general approval of the Radio World and thoroughly believes in the idea of a DX column. He would like it to be "sincere and honest" and to avoid "printing the names of fellows who just want to see their names in print." He also suggests printing a schedule of stations with their time on the air. As a further suggestion he takes up the idea of types of antenna and ground, also of radio receiver.

* * *

Myles Swattlex, 302 Chestnut Street, Philadelphia, Pa., writes his approval of this corner and lists among his good thrills one 25, three 50, twenty-nine 100 and two 250-watt stations. All this on a two-tube set, using one 224-A screen grid and one 227 tube. He also uses an indoor antenna, with radiator for ground.

* * *

M. Velazque, 375 Bradford Street, Brooklyn, N. Y., just read the notice regarding the DX column and is anxious to see the column get under way.

* * *

From New Haven, Conn., George H. Baldwin, Jr., of 3439 Yale Station, Yale University, writes of his great interest in DX, and also of his further interest in a battery set suitable for DX. He also sends in a very interesting record which we shall try to use in an early issue.