New Edition Completely Revised

Twenty Radio Phone Diagrams and Hook-ups of Crystal and Vacuum Tube Rec Amplifying Circuits, Regenerative Circuits, Senders

Key Chart of Symbols and Pamphlet "How to Read Diagrams"

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HOW TO READ RADIO DIAGRAMS

Radio diagrams or wiring circuits, also called "Hook-ups," can be presented in two ways, one of which is in schematic or symbolic drawing, in which each instrument and part is represented by a certain symbol. These symbols have been adopted by radio engineers for convenience sake, as well as for the speed and accuracy with which schematic diagrams can be drawn.

However, many people entering the radio field have no knowledge of these symbols, and for them radio diagrams are drawn in perspective drawing, in which each instrument is represented actually as you see it.

A Key Chart showing the perspective view of the instrument, its name and the schematic symbol representing it, will be found on the back of this instruction leaflet.

You will note that there is a certain definite reason for each symbol. A coil of wire is represented by a series of curls as may be seen by referring to the vario-coupler symbol (4) in the schematic diagram. Variable contacts such as provided for by a series of switch points and levers (5) are represented in the schematic diagram by arrows. The plates of condensers, regardless of the number, are represented (7 and 12) by two parallel straight lines. If the condenser is variable, an arrow (2) is drawn through the two lines at an angle. A resistance is always represented by a line resembling the teeth of a saw. If it is fixed, the connections are made to the extreme ends (6). If it is variable, one connection goes to one end and the other to an arrow as will be seen by referring to the rheostat symbol (10) in Fig. 2. The elements of the vacuum tube, namely, the filament, grid and plate, are clearly shown in the schematic diagram (8) while in the perspective diagram the binding posts which are connected to the elements are labeled. The derivation of the symbol representing the phones (11) is easily seen. Since each cell of a battery has two elements, they are taken in consideration in the symbol for the battery and since many cells are connected in series, they are represented as shown in the "A" and "B" battery symbols, (9 and 13).

By thus referring from Fig. 1 to 2 and to the Key Chart, the reader can very soon accustom himself to reading schematic diagrams. It is advantageous to practice the reading of schematic diagrams as most circuits in newspapers and magazines are represented in this form.
This circuit is more selective and flexible than one using a single condenser, since the coil depends upon the wave length of the circuit to make it resonant. The condenser, however, is connected in series with the coil, so that when a certain frequency is to be received, the condenser connected to the grid slider will be adjusted to that frequency, and the other condenser is moved slowly until the signals are heard at maximum intensity. The second condenser is then adjusted to improve the audibility. To reduce interferences, the two sliders should be moved together so as to remain with the same number of turns forming the primary circuit between them.

(2) Loose Coupler With Crystal Detector

In this circuit a loose coupler is used, which may be of any size and connected in series with the coil, so that it works upon the ordinary tuning coil is that two circuits are used which may be coupled together more or less according to the interferences which it is desired to be received. When interference from another station is experienced, it may be cut out or reduced by loosening the coupling by moving the small coil outside of the primary.

(3) Single-Circuit Regenerative Tuner

The advantage of the single-circuit tuner is simplicity and ease of operation. A very important feature for the beginner. This circuit with which it is easier to obtain good results is a vario-coupler with the secondary acting as a tuner. It is wound of any wave length by increasing the number of turns of the tuning coil. This circuit does not possess any wonderful advantages of any other.

(4) Honeycomb Coil Receiver For All Wave Lengths

This is the standard circuit for a honeycomb coil receiving set with a vacuum tube detector. The coil used in the primary circuit is the honeycomb or vario-coupler and the coil used in the secondary circuit is a vario-tuner or vario-coupler. By using the proper sizes of coils and vario-tuners and vario-couplers, it is possible to obtain good results. If the plate circuit of a vacuum tube is used, the plate circuit of the tube when only the detector is used and the tube being operated by potential. Functions at maximum efficiency and inductance in both the circuits.

(5) Tuned Plate Regenerative Circuit

If the plate circuit of a vacuum tube detector is tuned by means of a vario-tuner, it is possible to obtain a very strong signal when it is turned in the proper direction and magnified when the signal is increased. The two tubes used in this circuit are called honeycomb coils and are wound in layers, is in a space from 2 to a yard square. The advantage of the vario-coupler is the ability to receive the wave length of the signal.

(6) Standard Short Wave Regenerative Set

In the standard short wave regenerative circuit, shown in the diagram, the tuning of the grid and plate circuits is accomplished by means of a vario-coupler and crystal detector. The transformer is wound of any wave length and variable. This circuit when used to receive strong signals, it is possible to get as much volume of sound as possible. In this circuit, the variable capacity, is adjusted in proper position and the proper distance is obtained that the use of the extra tube will be fully justified.

(11) Push-Pull Amplifier

Many radio amateurs desire to get as much volume as possible out of their receiving sets, but find that when their amplifiers are used, the receiving sets are not able to receive signals of any wave length. The advantage of automatic filament control in an amplifier is that it is not necessary to turn off the filament current of each stage of amplification. This control is obtained by using a plate circuit of the tube when only the detector is used and the tube being operated by potential. Functions at maximum efficiency and inductance in both the circuits.

(12) Reflex Circuits

By using a special hook-up employing a combination of both radio and audio frequency transformers, it is possible to make a single amplifier circuit. One of the advantages of these circuits is that the audio frequency transformers can be used in the place of the crystal detector. The transformer is wound of any wave length and variable. These transformers give clear and clean signals and will reduce the interferences. There are no special connections to the loudspeaker which is merely inserted in the circuit or the telephones.

(13) The Rehark Reflex

The popularity of the reflex circuits described in the above paragraph has become very great since their introduction to the radio world. These circuits have been used in various forms since some of them good and some of them bad. We present herein a description of one of the best of these.
and a crystal detector.

The transformer between the first tube and the crystal detector, F1, is constructed on the leads given by the manufacturers of the "D" frequency winding. The primary, however, consists of 32 turns of No. 24 D. C. E. B. The peculiar method of connecting the instruments in this circuit, a stabilizing potentiometer is not necessary and without it the set does not give the results operators using nearby receiving sets.

The regenerative coupler consists of two coils L and L1, the coil is used to control the oscillations in a radio frequency circuit will operate consistently without any danger of oscillation in the radio frequency plate circuit. The modulation transformer and a station tuned in, the filament of the first tube is extinguished. If desired, a standard vario-coupler and rewind it.

As will be noticed, the leads and most of the radio frequency amplification is the one described in diagram 14. The rest of the construction of this circuit is that one stage of radio frequency amplification builds up the incoming signals whereupon they are amplified by a layer of thin cardboard approximately 1/32nd of an inch thick. This method merely makes use with an indoor loop.

The frequency transformers may have a capacity of from .0003 to .0005 mf. They can be tuned carefully, now one stage of audio frequency amplification is the one described in diagram 14.

The modulation transformer and a station tuned in, the filament of the first tube is extinguished. If desired, a standard vario-coupler and rewind it.

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TO AERIAL

LOOSE COUPLER

TO GROUND

CRYSTAL DETECTOR

PHONE

CONDENSER

.0005 VARIABLE

CONDENSER

PHONES

.PRIMARY SECONDARY

LOOSE COUPLER

.001 VARIABLE

CONDENSER

.001 MF.

PHONE

CONDENSER

.001 MF.

CRYSTAL DETECTOR

PHONES

LOOSE COUPLER WITH

CRYSTAL DETECTOR
TO AERIAL

SERIES PARALLEL SWITCH

TO GROUND

VARIABLE CONDENSER

"B" BATTERY

GRID LEAK 3703 MEG.

CONDENSER 0.00025 MF.

HONEYCOMB SOIL RECEIVER FOR ALL WAVE LENGTHS

"A" BATTERY

"A" BATTERY

HONEYCOMB SOIL RECEIVER FOR ALL WAVE LENGTHS

"A" BATTERY
23 PLATE VARIABLE CONDENSER

65 T. NO. 18 S.C.C. WIRE

3½" DIA. TUBE

43 T. NO. 18 S.C.C. WIRE

TO GROUND

2 MEGHOMS

TO AERIAL

23 PLATE COND.

0.0025 MF.

G5 Tows °rive

SAME TUBE AS -5stab/izs

3'1" rueiE

WOUND

b'E-

6/1,11,11NC, CT 5-

463- BATTERY 22½ V.

COCKADAY FOUR CIRCUIT TUNER

"B" BATTERY 22½ V.
SHORT-WAVE REGENERATIVE SET WITH 2 STEP AMPLIFIER
TO TICKLER COIL OR PLATE VARIOMETER

GRID LEAK

CONDENSER

TO SECONDARY OF TUNER

"A" BAT.

AMPLIFYING TRANSFORMER

JACK

AMPLIFYING TRANSFORMER

JACK

"B" BATTERIES

ADDITIONAL AMPLIFIER

DETECTOR 2-STAGE AMPLIFIER WITH AUTOMATIC FILAMENT CONTROL JACKS.
PUSH-PULL TRANSFORMER

"C" BATTERY

"A" BATTERY

RHEOSTAT

TO LOUD SPEAKER

PUSH-PULL TRANSFORMER

"B" BATTERY 90 TO 120 V.

PUSH-PULL AMPLIFIER
THE HARKNESS REFLEX

VARIABLE CONDENSER .0005

TO AERIAL

VARIABLE CONDENSER .0005

TO GROUND

A.F. TRANS.

RHEOSTAT

VARIABLE CONDENSER .0005

CRYSTAL DETECTOR

AUDIO FREQUENCY TRANS.

P_32

PHONE.

THE HARKNESS REFLEX

"A" BATTERY

"B" BATTERY

STORAGE BATTERY

PRINTED IN U.S.A.

"B" BATTERY 45-90V.
TO AERIAL

6 TURNS OF No. 26 D.S.C. ON 3½" TUBE

4 TURNS OF No. 26 D.S.C.

A.F. TRANSFORMERS

.001 MF

.001 VAR. CON.

No. 26 D.S.C. ON 2½" TUBE

RHEOSTAT

.0005

.00025 MF.

.0005

45 TURNS OF No. 26 D.S.C. ON 4" TUBE

2 MEGOHMS

.001 MF

TO GROUND

"B" BAT. +22½ V. + 90 V.

"C" BAT.

"A" BAT.

THE TELEDYNE
**Measurement of Wavelength of Distant Transmitting Station**

**Calibration of a Receiving Set**

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**W—Wavemeter or driver.**  
**L—Coupling coil of one or two turns.**

**MEASUREMENT OF WAVELENGTH OF DISTANT TRANSMITTING STATION**

The apparatus required and the circuits employed are shown by figure 1 above. To obtain wavelength, first, using as loose coupling as possible, tune in signal on receiving set, next start buzzer connected to wavemeter (W) and adjust wavemeter until the maximum strength of signals is obtained in telephones connected to receiver. The wavelength of the wavemeter (W) is now the same as that used by the distant station.

**CALIBRATION OF RECEIVING SET**

First set up wavemeter so it will excite secondary (Fig. 2) of receiver. One or two small turns may be connected in series with secondary if wavemeter cannot be conveniently placed to excite it otherwise. Loosen coupling between primary and secondary of receiver as much as possible and set primary switches to shortest wavelength. Next adjust wavemeter to the lowest wavelength the receiver is designed for, and after starting buzzer, tune the secondary of the receiver until the maximum strength of signals is obtained in the telephones, which will be obtained when the receiver secondary is adjusted for the same wavelength as the wavemeter is tuned for. Note adjustment of receiver secondary when this has been accomplished and then increase wavelength setting of wavemeter by about 20 meters. Tune this wavelength in on the secondary and note adjustment. Continue in this way until you have the adjustment for every twenty meters over the entire range of the receiver. When you have accomplished this, plot your results on a piece of cross section paper.

When the secondary has been calibrated, the primary can be calibrated by using the circuit shown in Figure 1. From the table previously tabulated adjust secondary for lowest wavelength, and adjust wavemeter for the same wavelength. Now using a loose coupling tune primary until maximum strength of signals is obtained in telephones attached to receiver. Wavemeter, primary of receiver and secondary of the receiver are now all adjusted to the same wavelength. Continue in this way, noting setting of primary each time, until you have covered wavelength range of receiver again. A calibration curve for the primary can then be drawn similar to the one for the secondary.
Measurement of Fundamental Wavelength of Antenna
Three Methods

(a) BUZZER EXCITATION
The apparatus required and the circuits employed are shown by Figure 1. Care must be taken that coils of wavemeter and detector circuits are placed so that no energy is transferred from one to the other except via loops L₁ and L₂ and the antenna circuit.
To measure the wavelength of antenna, start the buzzer and then tune wavemeter until maximum signals are obtained in the detector circuit.

(b) BUZZER EXCITATION
The apparatus required and the circuits employed are shown by Figure 2. A battery and buzzer are connected across a small series inductance of one or two turns L₁ and the wavemeter is used as a detector circuit to measure the wavelength. The error due to the inductance L₁ is small and can be neglected.

(c) SPARK EXCITATION
Connect antenna and ground to two sides of a plain open gap (Fig. 3) which is supplied with current from secondary of power transformer. Condenser and oscillation transformer must be disconnected from the circuit. Use wavemeter as a detector circuit to measure wave length.

La—Small inductance of 1 or 2 turns.
Measurement of Capacity
Substitution Method

![Diagram showing electrical circuits](image)

**L**<sub>a</sub>—Variable inductance.
**L**<sub>c</sub>—Coupling coil.
**C**<sub>c</sub>—Standard calibrated variable condenser.
**C**<sub>e</sub>—Capacity to be measured.
**G**—Galvanometer and thermo element.
**W**—Wavemeter or driver.

The apparatus required and the circuits employed are shown by Figures 1 and 2 above. The principle of determining the capacity is the same in both figures, but different methods are employed to determine when the circuits are in resonance. In Figure 1 a detector and telephone receivers are employed; in Figure 2 a thermo element with a galvanometer.

To determine capacity of **C**<sub>e</sub> start buzzer connected to wavemeter and with switch thrown so as to cut **C**<sub>e</sub> in circuit, vary wavelength emitted by wavemeter until maximum strength of signals (Fig. 1) is obtained in telephone receivers, or a maximum deflection (Fig. 2) is obtained on galvanometer. When this has been accomplished, without disturbing the rest of the circuit, throw switch so as to disconnect **C**<sub>e</sub> and connect **C**<sub>e</sub> in circuit. Now vary capacity of **C**<sub>e</sub> until maximum strength of signals or maximum deflection is obtained again. The capacity of **C**<sub>e</sub> now equals the capacity of **C**<sub>e</sub> and as the capacity of **C**<sub>c</sub> is known, you have the capacity of **C**<sub>e</sub> for this setting.

If **C**<sub>e</sub> is a variable condenser you desire to calibrate, the capacity for every ten degrees of scale should be obtained by the method just outlined, and the result plotted on cross-section paper. An example of a calibration curve is shown above.

Note.—In the circuit shown in Figure 1 care must be taken to place the coils far enough apart and in such positions that there will be no direct transfer of energy from the driver to the detector circuit.
Measurement of Inductance of a Coil or Circuit

(Two Methods)

(a) SUBSTITUTION METHOD

The apparatus required and the circuits employed are shown by Fig. 1. To obtain inductance of $L$, start buzzer and with switch thrown so as to connect $L$ in circuit, tune wavemeter until maximum strength of signals is obtained in telephones connected to detector circuit. Next without disturbing the rest of the circuit, throw switch so as to disconnect $L$ and to connect $L_s$ in circuit. Now vary the inductance of $L_s$ until maximum strength of signals is again obtained in telephones. Inductance of $L_s$ now equals $L$, and as the inductance of $L_s$ is known you have the inductance of $L$. $L_s$ is generally a variometer, or a variable inductance consisting of two rollers, one of metal and the other of an insulating material, with means for winding wires from one to the other to obtain a continuous variation of inductance.

(b) BY CALCULATION

The apparatus required and the circuits employed are shown by Fig. 2. To obtain inductance, start buzzer and tune wavemeter until maximum strength of signals is obtained in telephones. Let $\lambda$ represent the wavelength obtained at this point. The inductance of $L_s$ can now be calculated by the following formula:

$$L_s = \frac{LC}{C}$$

where:
- $LC =$ Oscillation constant of $\lambda$.
- $C =$ Capacity in microfarads of $C$, Fig. 2.

If no tables giving oscillation constant are available the inductance can be calculated by this formula:

$$L_s = \frac{\lambda^2}{k'C}$$

where:
- $k = 59.6$ if inductance in centimeters.
- $k = 1882$ if inductance in microhenries.

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98 Park Place, New York City
Measurement of Antenna Inductance and Efficiency Capacity

The apparatus required and the circuits employed are shown by figures 1 and 2 above. Wavemeter and detector circuit inductances should be placed at right angles to each other to prevent the transfer of energy except through antenna circuit. After connections have been made as shown in Figure 1, start buzzer and tune wavemeter W until maximum strength of signals is obtained in telephones. As loose a coupling as possible should be used. When maximum signals are obtained note the wavelength.

Next insert a known inductance $L_n$ which should be large enough to increase the fundamental wavelength four times) in series with the antenna, and obtain the wavelength of the antenna with this inductance inserted in the same way as outlined above.

Next by formula (1) below find the LC values for the two wavelengths just obtained.

\[
(1) \quad LC = \frac{\lambda^2}{k^2}
\]

where:

- $LC$ = Oscillation constant.
- $\lambda$ = Wavelength.
- $k$ = 59.6 if inductance in centimeters.
- $k$ = 1882 if inductance in microhenries.

The capacity of the antenna can now be obtained by the following formula (2):

\[
(2) \quad C_s = \frac{LC_s}{L_n}
\]

where:

- $LC_s$ = Oscillation constant of wavelength obtained with $L_n$ in series with antenna.
- $L_n$ = Value of series inductance.
- $C_s$ = Capacity of antenna.

The inductance of the antenna can now be found by dividing the LC constant obtained with no inductance in series with the antenna by the capacity of the antenna. Formula (3)

\[
(3) \quad L_n = \frac{LC}{C_s}
\]

where:

- $L_n$ = Inductance of antenna.
- $LC$ = Oscillation constant for fundamental wavelength of antenna.
- $C_s$ = Capacity of antenna.
Measurement of Effective Antenna Capacity

The apparatus required and the circuits employed are shown by figures 1 and 2 above. To obtain the effective capacity of the antenna, vary the wavelength of W (Fig. 1) until maximum strength of signals is obtained in telephones connected to detector circuit. Note wavelength.

Next insert a known capacity C in series with the antenna (Fig. 2) and obtain the wavelength in the same way as outlined above. Note this wavelength. (The condenser inserted in series with the antenna must be of such size that it does not make over ten per cent. difference in the wavelength.) The capacity of the antenna may now be obtained by the following formula:

\[ C_a = \frac{C \cdot (\lambda - \lambda_s)}{\lambda_s^2} \]

where:

- \( C_a \) = Capacity of antenna.
- \( C \) = Capacity of series condenser (Fig. 2).
- \( \lambda \) = Wavelength without condenser in series with antenna.
- \( \lambda_s \) = Wavelength with condenser in series with antenna.

**METHOD (b)**

The procedure is exactly the same as with method (a) except that instead of using the wavelength of the driver circuit W, the capacity of the condenser is noted. This allows the effective capacity of an antenna to be measured when a calibrated variable condenser is available by means of the following formula:

\[ C_a = \frac{C_s (C - C_i)}{C_i} \]

where:

- \( C_a \) = Capacity of antenna.
- \( C_s \) = Capacity of series condenser (Fig. 2).
- \( C_i \) = Capacity of driver condenser W when resonance is obtained with series condenser C in circuit. (Fig. 1.)
- \( C_i \) = Capacity of driver condenser W when resonance is obtained with series condenser C in circuit. (Fig. 2.)
Measurement of Antenna Resistance

(Method described by Bu. Standards Bul. Vol. 9—L. W. Austin.)

Substitution Method

The apparatus required and circuits employed are shown by above diagram. The method in brief, is the substitution of an air condenser in place of the antenna and ground, keeping the inductance common to both circuits and introducing resistance in the dummy antenna circuit until the current becomes the same as that obtained with the antenna and ground connected. When this is accomplished the antenna resistance at the wave length used is the same as the inserted resistance R.

EXAMPLE.

Set wave meter or driver (W) to desired wave length and with antenna and ground connected (switch thrown to position "A") tune with L1 until resonance is reached. (This being indicated by maximum deflection of G.) If wave length is below fundamental it will be necessary to open switch shorting C2. Now throw switch to B and vary C1 until resonance is reached. Compare galvanometer deflections with switch thrown to A and B and insert resistance at R until deflection is the same with switch in either position. The resistance of the antenna for the wave length used is the same as the inserted resistance.

Proceed in the same way until the antenna resistance is obtained on enough wave lengths to allow a curve to be drawn similar to those shown above.

Above measurements should be made when there is no static and when receiving conditions are good.

It will be found that beginning with short wave lengths, antenna resistance falls rapidly until a wave length not quite twice the fundamental is reached. From this point the antenna resistance increases slowly if the ground resistance is low (Curves 2 and 3), and rapidly if it is high (Curve 1). The antenna resistance of a land station varies due to changing ground conditions.
Proper Filtration of the D.C. Plate Supply

Amateur filters have, to date, been haphazard affairs at best consisting of a choke coil and condensers of whatever values of capacity and inductance may be on hand. The new regulations governing amateur stations introduce a clause to the effect that a license to use the frequencies between 1500 kilocycles and 2000 kilocycles (150-200 meters) will be issued where the plate supply source is "adequately filtered." It is further stated that, "— a filter is not deemed adequate where the supply modulation exceeds five percent." This calls for an exceedingly good filtering arrangement which in the case of a high potential source of direct current from a motor-generator set should consist of at least ten henries inductance value in an iron core choke coil, with a shunt capacity of not less than four microfarads. Capacity alone, to the value of fifty to sixty microfarads is fairly satisfactory but is generally more costly than the somewhat better choke coil—shunt condenser combination.

In the case of rectified A. C. supply, an inductance of 30 to 50 henries is recommended with a shunt capacity of two microfarads across the line on either side of the choke in the familiar "brute force" arrangement shown diagramatically above. In applying for an amateur radio station license, the applicant should sketch his filter system on the application form and clearly show all value of capacity and inductance comprising such filter. This will enable the district Supervisor of Radio to judge whether your filter system is adequate and sufficient to entitle you to the wider band of frequencies.
Hartley Circuit Employing Full Wave Self-Rectification

It has been thought advisable to include a circuit suitable for five or fifty watt pirotrons using full wave self-rectification of the A. C. plate supply, raised to the proper potential by means of a standard plate supply transformer which also carries a filament supply winding. While this circuit, due to its A. C. supply, is not recommended for cities or congested districts, it has proven very satisfactory in less populated communities where the slight A. C. hum is not objectionable.

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Much long distance work of late has been accomplished through the use of synchronously rectified alternating current of commercial frequencies as a source of plate potential. This scheme is rapidly gaining in favor and is gradually replacing the messy and inefficient chemical rectifiers. The construction of a four segment rectifier is extremely simple and merely consists of an insulating drum or rotor mounted on the shaft of a small motor and arranged with brushes placed in the relative positions indicated in the diagram. A very pleasing note is produced by this means and high efficiency attained.
What is probably one of the most stable and satisfactory of the regenerative receiving circuits, and probably the least known, is the Navy Standard two circuit receiver employing the tickler feed-back principle. Such a circuit offers a good degree of selectivity with a minimum of apparatus and is quickly and easily adjusted to the desired frequencies. It is equally effective on both amateur and broadcast reception and by use of the proper values of inductance capacity will respond efficiently to any wave length in use today. Constants suitable for 150-650 meter reception are indicated in the diagram above.
Among amateurs using C. W. transmission, it is generally conceded that the Reinartz receiving circuit is to date the ideal C. W. receiver for all around use. This is nothing more than a combination of the tuned plate and tickler feed-back circuits but is one which produces remarkable results with a minimum of tuning controls. The case of operation and lack of body capacity are of especial benefit in tuning quickly to the elusive whistles of C. W. transmitters. The circuit and all constants for Reinartz tuner to cover a wave range of from 150 to 450 meters appear above. To reach the higher wave-lengths of broadcasting stations and even the 600 meter commercial transmissions, it is merely necessary to add twenty-five turns to the antenna inductance. This will raise the fundamental minimum of the circuit slightly, due to added capacity effects but not to the extent where it is objectionable from the viewpoint of average amateur operations.
An exceptionally stable and easily operated C. W. transmitter may be connected up as shown herewith. A Standard C. W. transformer delivering 550 volts is used in connection with a 12 jar electrolytic rectifier. Any standard make of apparatus would give very good results in this circuit and in connecting it up care should be taken to see that the aluminum plates of the rectifier are connected to the plate circuit of the tubes.

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Radio Amateur's Practical Design Data

In the preparation of this collection of data and information, compiled by Howard S. Pyle,* and the Staff of Radio News Magazine, the thought constantly uppermost in the minds of the publishers, was to present, in clear, understandable form, the most popular C. W. transmitting and receiving circuits together with the necessary tables and data to enable the amateur to intelligently handle his equipment and get the most from it.

Intelligent operation of an amateur station does not mean the throwing together of some standard circuit with the parts on hand, with no idea of the value of the capacities, inductances and resistances entering into the complete assembly. True, such haphazard methods work, in nine cases out of ten, if the radiation ammeter may be considered an indication, but the gain in efficiency—in actually knowing that each part is performing its function to its greatest possible efficiency, gives an added zest to the actual operations and a higher standing among his fellows to the amateur who KNOWS his station.

It has been made simple, through the use of the accompanying tables and formulae as well as circuit diagrams, for the amateur to select the circuit best suited to his purpose and to intelligently build up, step by step, a really efficient amateur station, measuring his various units as they enter into the construction and finally posting such data in convenient form by means of the chart provided.

The advantages of such systematic methods are obvious and it is with the desire to further the cause of better amateur radio that the accompanying data is offered.

THE PUBLISHERS.

*Mr. Howard S. Pyle is a well known editor on Radio. He is Asst. U. S. Radio Inspector of the 8th District.
Measurement of Antenna Resistance

(Method described by Bu. Standards Bul. Vol. 9—L. W. Austin.)

Substitution Method

The apparatus required and circuits employed are shown by above diagram. The method in brief, is the substitution of an air condenser in place of the antenna and ground, keeping the inductance common to both circuits and introducing resistance in the dummy antenna circuit until the current becomes the same as that obtained with the antenna and ground connected. When this is accomplished the antenna resistance at the wave length used is the same as the inserted resistance \( R \).

EXAMPLE.

Set wave meter or driver \( (W) \) to desired wave length and with antenna and ground connected (switch thrown to position "A") tune with \( L_1 \) until resonance is reached. (This being indicated by maximum deflection of \( G \).) If wave length is below fundamental it will be necessary to open switch shorting \( C_1 \). Now throw switch to \( B \) and vary \( C \) until resonance is reached. Compare galvanometer deflections with switch thrown to \( A \) and \( B \) and insert resistance at \( R \) until deflection is the same with switch in either position. The resistance of the antenna for the wave length used is the same as the inserted resistance \( R \).

Proceed in the same way until the antenna resistance is obtained on enough wave lengths to allow a curve to be drawn similar to those shown above.

Above measurements should be made when there is no static and when receiving conditions are good.

It will be found that beginning with short wave lengths, antenna resistance falls rapidly until a wave length not quite twice the fundamental is reached. From this point the antenna resistance increases slowly if the ground resistance is low (Curves 2 and 3), and rapidly if it is high. (Curve 1). The antenna resistance of a land station varies due to changing ground conditions.
Measurement of Antenna Inductance and Efficiency Capacity

W—Wavemeter or driver.
L, L'<—Coupling coils.
L,—Known inductance connected in series with antenna.
D—Aperiodic detector circuit.

The apparatus required and the circuits employed are shown by figures 1 and 2 above. Wavemeter and detector circuit inductances should be placed at right angles to each other to prevent the transfer of energy except through antenna circuit. After connections have been made as shown in Figure 1, start buzzer and tune wavemeter W until maximum strength of signals is obtained in telephones. As loose a coupling as possible should be used. When maximum signals are obtained note the wavelength.

Next insert a known inductance L, which should be large enough to increase the fundamental wavelength four times) in series with the antenna, and obtain the wavelength of the antenna with this inductance inserted in the same way as outlined above.

Next by formula (1) below find the LC values for the two wavelengths just obtained.

\[ (1) \quad LC = \frac{\lambda^2}{k^2} \]

where:
- \( LC = \) Oscillation constant,
- \( k = 59.6 \) if inductance in centimeters.
- \( k = 1882 \) if inductance in microhenries.

The capacity of the antenna can now be obtained by the following formula (2):

\[ (2) \quad C_s = \frac{LC_s}{L_c} \]

where:
- \( LC_s = \) Oscillation constant of wavelength obtained with \( L_s \) in series with antenna.
- \( L_s = \) Value of series inductance.

The inductance of the antenna can now be found by dividing the LC constant obtained with no inductance in series with the antenna by the capacity of the antenna. Formula (3).

\[ (3) \quad L_s = \frac{LC_t}{C_s} \]

where:
- \( L_s = \) Inductance of antenna.
- \( LC_t = \) Oscillation constant for fundamental wavelength of antenna.
- \( C_s = \) Capacity of antenna.

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Measurement of Effective Antenna Capacity

METHOD (a)

The apparatus required and the circuits employed are shown by figures 1 and 2 above. To obtain the effective capacity of the antenna, vary the wavelength of W (Fig. 1) until maximum strength of signals is obtained in telephones connected to detector circuit. Note wavelength.

Next insert a known capacity $C_s$ in series with the antenna (Fig. 2) and obtain the wavelength in the same way as outlined above. Note this wavelength. (The condenser inserted in series with the antenna must be of such size that it does not make over ten per cent. difference in the wavelength.) The capacity of the antenna may now be obtained by the following formula:

$$C_a = \frac{C_s (\lambda_1 - \lambda_s)}{\lambda_1^2}$$

where:

- $C_a$ = Capacity of antenna.
- $C_s$ = Capacity of series condenser (Fig. 2).
- $\lambda_1$ = Wavelength without condenser in series with antenna.
- $\lambda_s$ = Wavelength with condenser in series with antenna.

METHOD (b)

The procedure is exactly the same as with method (a) except that instead of using the wavelength of the driver circuit W, the capacity of the condenser is noted. This allows the effective capacity of an antenna to be measured when a calibrated variable condenser is available by means of the following formula:

$$C_s = \frac{C_a (C - C_s)}{C_a}$$

where:

- $C_s$ = Capacity of antenna.
- $C_a$ = Capacity of series condenser (Fig. 2).

$C =$ Capacity of driver condenser W when driver circuit is in resonance with antenna circuit. (Fig 1.)

$C_s =$ Capacity of driver condenser W when resonance is obtained with series condenser $C_s$ is in circuit. (Fig. 2.)
Measurement of Wavelength of Distant Transmitting Station

Calibration of a Receiving Set

The apparatus required and the circuits employed are shown by figure 1 above. To obtain wavelength, first, using as loose coupling as possible, tune in signal on receiving set, next start buzzer connected to wavemeter (W) and adjust wavemeter until the maximum strength of signals is obtained in telephones connected to receiver. The wavelength of the wavemeter (W) is now the same as that used by the distant station.

CALIBRATION OF RECEIVING SET

First set up wavemeter so it will excite secondary (Fig. 2) of receiver. One or two small turns may be connected in series with secondary if wavemeter cannot be conveniently placed to excite it otherwise. Loosen coupling between primary and secondary of receiver as much as possible and set primary switches to shortest wavelength. Next adjust wavemeter to the lowest wavelength the receiver is designed for, and after starting buzzer, tune the secondary of the receiver until the maximum strength of signals is obtained in the telephones, which will be obtained when the receiver secondary is adjusted for the same wavelength as the wavemeter is tuned for. Note adjustment of receiver secondary when this has been accomplished and then increase wavelength setting of wavemeter by about 20 meters. Tune this wavelength in on the secondary and note adjustment. Continue in this way until you have the adjustment for every twenty meters over the entire range of the receiver. When you have accomplished this, plot your results on a piece of cross section paper.

When the secondary has been calibrated, the primary can be calibrated by using the circuit shown in Figure 1. From the table previously tabulated adjust secondary for lowest wavelength, and adjust wavemeter for the same wavelength. Now using a loose coupling tune primary until maximum strength of signals is obtained in telephones attached to receiver. Wavemeter, primary of receiver and secondary of the receiver are now all adjusted to the same wavelength. Continue in this way, noting setting of primary each time, until you have covered wavelength range of receiver again. A calibration curve for the primary can then be drawn similar to the one for the secondary.

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Measurement of Fundamental Wavelength of Antenna

Three Methods

(a) Buzzer excitation.
(b) Buzzer excitation.
(c) Spark excitation.

\[ W_r \]—Wavemeter used as driver. (Fig. 1.)
\[ W_d \]—Wavemeter used as detector circuit (Fig. 2).
\[ W_f \]—Wavemeter used as detector circuit with detector connected unilaterally (Fig. 3).
\[ L_1, L_2 \]—Small loops used for coupling.
\[ L_s \]—Small inductance of 1 or 2 turns.

(a) BUZZER EXCITATION

The apparatus required and the circuits employed are shown by Figure 1. Care must be taken that coils of wavemeter and detector circuits are placed so that no energy is transferred from one to the other except via loops \( L_1 \) and \( L_2 \) and the antenna circuit.

To measure the wavelength of antenna, start the buzzer and then tune wavemeter until maximum signals are obtained in the detector circuit.

(b) BUZZER EXCITATION

The apparatus required and the circuits employed are shown by Figure 2. A battery and buzzer are connected across a small series inductance of one or two turns \( L_s \) and the wavemeter is used as a detector circuit to measure the wavelength. The error due to the inductance \( L_s \) is small and can be neglected.

(c) SPARK EXCITATION

Connect antenna and ground to two sides of a plain open gap (Fig. 3) which is supplied with current from secondary of power transformer. Condenser and oscillation transformer must be disconnected from the circuit. Use wavemeter as a detector circuit to measure wave length.

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Measurement of Inductance of a Coil or Circuit

(Two Methods)

The apparatus required and the circuits employed are shown by Fig. 1. To obtain inductance of \( L_s \), start buzzer and tune wavemeter until maximum strength of signals is obtained in telephones connected to detector circuit. Next without disturbing the rest of the circuit throw switch so as to disconnect \( L_s \) and to connect \( L_t \) in circuit. Now vary the inductance of \( L_t \) until maximum strength of signals is again obtained in telephones. Inductance of \( L_s \) now equals \( L_t \) and as the inductance of \( L_t \) is known you have the inductance of \( L_s \). \( L_t \) is generally a variometer, or a variable inductance consisting of two rollers, one of metal and the other of an insulating material, with means for winding wire from one to the other to obtain a continuous variation of inductance.

(b) BY CALCULATION

The apparatus required and the circuits employed are shown by Fig. 2. To obtain inductance, start buzzer and tune wavemeter until maximum strength of signals is obtained in telephones. Let \( \lambda \) represent the wavelength obtained at this point. The inductance of \( L_s \) can now be calculated by the following formula:

\[
L_s = \frac{LC}{C}
\]

where:

\( L_s \) = Oscillation constant of \( \lambda \).
\( C \) = Capacity in microfarads of \( C \), Fig. 2.

If no tables giving oscillation constant are available the inductance can be calculated by this formula:

\[
L_s = \frac{\lambda^3}{k'C}
\]

where:

\( k \) = 59.6 if inductance in centimeters.
\( k \) = 1882. if inductance in microhenries.
Measurement of Capacity
Substitution Method

\[ L_v \text{— Variable inductance.} \]
\[ L_r \text{— Coupling coil.} \]
\[ C_p \text{— Standard calibrated variable condenser.} \]
\[ C_s \text{— Capacity to be measured.} \]
\[ G \text{— Galvanometer and thermo element.} \]
\[ W \text{— Wavemeter or driver.} \]

The apparatus required and the circuits employed are shown by Figures 1 and 2 above. The
principle of determining the capacity is the same in both figures, but different methods are employed
to determine when the circuits are in resonance. In Figure 1 a detector and telephone receivers are
employed; in Figure 2 a thermo element with a galvanometer.

To determine capacity of \( C_s \) start buzzer connected to wavemeter and with switch thrown so
as to cut \( C_s \) in circuit, vary wavelength emitted by wavemeter until maximum strength of signals
(Fig. 1) is obtained in telephone receivers, or a maximum deflection (Fig. 2) is obtained on gal-
vanometer. When this has been accomplished, without disturbing the rest of the circuit, throw
switch so as to disconnect \( C_s \) and connect \( C_s \) in circuit. Now vary capacity of \( C_s \) until maximum
strength of signals or maximum deflection is obtained again. The capacity of \( C_s \) now equals the
capacity of \( C_s \) and as the capacity of \( C_s \) is known, you have the capacity of \( C_s \) for this setting.

If \( C_s \) is a variable condenser you desire to calibrate, the capacity for every ten degrees of scale
should be obtained by the method just outlined, and the result plotted on cross-section paper. An
example of a calibration curve is shown above.

Note.—In the circuit shown in Figure 1 care must be taken to place the coils far enough apart
and in such positions that there will be no direct transfer of energy from the driver to the detector
circuit.
Measurement of Distributed Capacity of an Inductance

W—Wavemeter or other form of driver.
L—Inductance being measured for distributed capacity.
C—Calibrated variable condenser.
D—Detector.

The apparatus required and the circuits employed are shown by the above diagram. To obtain the distributed capacity of L, take wavemeter readings with a number of different values of C. Plot these readings against the wavelength squared on a piece of cross-section paper. (See example above. The result will be practically a straight line. Continue this line to the negative value of C, which negative value of C will be the distributed capacity of the inductance under test.

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Undamped Wave Receiver Diagrams

Undamped wave receiver using magnetic coupling.

Navy type CN 240 undamped wave receiver using both magnetic and capacity coupling. Switches being provided to disconnect capacity coupling when coupling condenser set at zero degrees.

Constants of Navy Type CN 240 Receiver

- \( C_1 = 0.005 \text{ mF} \)
- \( L_a = 8.5 \text{ milli-henries} \)
- \( L_b = 21.8 \text{ milli-henries} \)
- \( L_c = 1 \text{ milli-henries} \)
- \( L_a = 1.1 \text{ milli-henries} \)
- \( L_c = 20.0 \text{ milli-henries} \)
- \( C_2 = 0.0018 \text{ mF} \)
- \( C_{C1-C2} = 0.0008 \text{ mF} \)
No. 51

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SCHEMATIC CIRCUIT DIAGRAM
RADIO TELEPHONE TRANSMITTING & RECEIVING SET
SIGNAL CORPS SCR-68
SCHEMATIC
C.W. 938 TRANSMITTER RECEIVER

CONDENSERS 49A & 49B ARE EACH MULTIPLE CONDENSERS CONTROLLED BY SWITCHES WITH VALUES AS FOLLOWS IN MMF:
-49A: 250 - 500 - 1000 - 2000 - 5000
-49B: 2.50 - 500 - 1000 - 2000 - 5000
1-500 UNIT OF EACH 49A COND IS PERMANENTLY CONNECTED

NOTES:
A. CONTACTS OPERATED BY CONTROL RELAY 205-A
B. WHEN G.E. TUBES ARE USED THIS TERMINAL IS CONNECTED TO FILAMENT OF TUBE THEREBY SHORTING 41-A RESISTANCE.
C. WHEN CW931 TUBES ARE USED THIS SWITCH IS CLOSED
SCHEMATIC DIAGRAM OF TYPE S.E.1100
(NAVY - FLYING BOAT) TELEPHONE & TELEGRAPH
TRANSMITTER

NOTE:
SWITCH IN RECEIVING POSITION
OPENS PLATE & TRANSMITTER CIRCUITS

No. 53
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<table>
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<th>L C</th>
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The table continues with similar entries for wavelengths between 200 and 20,000 Meters.
Table Giving Oscillation Constant and Frequency, for Wavelengths Between 200 and 20,000 Meters

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Measurement of Distributed Capacity of an Inductance

The apparatus required and the circuits employed are shown by the above diagram. To obtain the distributed capacity of \( L \), take wavemeter readings with a number of different values of \( C \). Plot these readings against the wavelength squared on a piece of cross-section paper. (See example above. The result will be practically a straight line. Continue this line to the negative value of \( C \), which negative value of \( C \) will be the distributed capacity of the inductance under test.)

W—Wavemeter or other form of driver.
L—Inductance being measured for distributed capacity.
C—Calibrated variable condenser.
D—Detector.

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Wavelengths of Inductance Coils

It is sometimes desired to find the wavelength of a particular coil used in series with an antenna and variable condenser. This can easily be found by obtaining the inductance of the coil in milli-henries and from this the wavelength. Table 1 below gives the inductance in milli-henries of various numbers of turns of No. 26 S. S. C. wire wound on a 3½ inch core. Table 2 gives the inductance of various numbers of turns of the same size wire wound on a 5 inch core. From these two tables you can then obtain the wavelength to which the coil will tune by referring to tables 3 and 4. The former is for use in connection with an antenna having a capacity of .0001 mf. and the latter for an antenna with a capacity of .0002 mf. The condensers indicated in tables 3 and 4 are placed in series with the coil and the ground.

### Table 1

<table>
<thead>
<tr>
<th>Inductance in mil-henries</th>
<th>Number of turns</th>
<th>Length in inches</th>
<th>Feet of wire required</th>
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<th>Length in inches</th>
<th>Feet of wire required</th>
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<td>8.30</td>
<td>625</td>
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</table>

### Table 3

<table>
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<tr>
<th>Inductance in mil-henries</th>
<th>Shortest wave-length in meters</th>
<th>Longest wave-length in meters with 0.0005 mf.</th>
<th>Longest wave-length in meters with 0.001 mf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>103</td>
<td>169</td>
<td>179</td>
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<td>0.20</td>
<td>146</td>
<td>238</td>
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<td>358</td>
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<td>300</td>
<td>490</td>
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<td>750</td>
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<td>4.00</td>
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### Table 4

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<th>Inductance in mil-henries</th>
<th>Shortest wave-length in meters</th>
<th>Longest wave-length in meters with 0.0005 mf.</th>
<th>Longest wave-length in meters with 0.001 mf.</th>
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<td>380</td>
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<tr>
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<td>340</td>
<td>450</td>
<td>480</td>
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<td>0.60</td>
<td>420</td>
<td>550</td>
<td>590</td>
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<tr>
<td>0.80</td>
<td>480</td>
<td>630</td>
<td>680</td>
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<td>775</td>
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<td>16.00</td>
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<td>2800</td>
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# Table Giving Oscillation Constant and Frequency, for Wavelengths Between 200 and 20,000 Meters

## LC in Microhenries and Microfarads

<table>
<thead>
<tr>
<th>Meters</th>
<th>LC</th>
<th>Meters</th>
<th>LC</th>
<th>Meters</th>
<th>LC</th>
<th>Meters</th>
<th>LC</th>
<th>Meters</th>
<th>LC</th>
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</thead>
<tbody>
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<td>100</td>
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<td>0.2816</td>
<td>180</td>
<td>166,000</td>
<td>0.5127</td>
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<tr>
<td>210</td>
<td>1,425,000</td>
<td>0.01238</td>
<td>102</td>
<td>224,120</td>
<td>0.327</td>
<td>180</td>
<td>166,000</td>
<td>0.5127</td>
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<tr>
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<td>0.327</td>
<td>180</td>
<td>166,000</td>
<td>0.5127</td>
<td></td>
</tr>
<tr>
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<tr>
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## Frequency

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<tr>
<td>200</td>
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<tr>
<td>100</td>
<td>62,800</td>
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</table>

## Notes

- The Consolidated Radio Call Book Co., Inc.
- 98 Park Place
- New York City
- Price Inc.
<table>
<thead>
<tr>
<th>Meters</th>
<th>L C</th>
<th>Meters</th>
<th>L C</th>
<th>Meters</th>
<th>L C</th>
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</thead>
<tbody>
<tr>
<td>200</td>
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<td>210</td>
<td>1,425,000</td>
<td>220</td>
<td>1,380,000</td>
</tr>
<tr>
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<td>1,150,000</td>
</tr>
<tr>
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<td>420</td>
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<td>510</td>
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<td>450,000</td>
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<td>620</td>
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<td>710</td>
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<td>720</td>
<td>150,000</td>
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<td>810</td>
<td>100,000</td>
<td>820</td>
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<td>100,000</td>
<td>910</td>
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<td>920</td>
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<td>1,000</td>
<td>50,000</td>
<td>1,100</td>
<td>20,000</td>
<td>1,200</td>
<td>10,000</td>
</tr>
</tbody>
</table>

Table giving oscillation constant and frequency, for wavelengths between 200 and 20,000 meters.

L C in centimeters and microfards.

No. 1C
Copyright 1922 by Consolidated Radio Call Book Co., Inc.

92 Park Place
New York City

Price $2c.
## Antenna Characteristics

**AMATEUR RADIO STATION**

(call)

**Owner**

Location

Measurements by

Date

<table>
<thead>
<tr>
<th>WAVE LENGTH</th>
<th>RESISTANCE</th>
<th>CAPACITY</th>
<th>FREQUENCY</th>
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<tr>
<td>meters</td>
<td>ohms</td>
<td>mfd.s.</td>
<td>kc/s</td>
</tr>
<tr>
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<td>ohms</td>
<td>mfd.s.</td>
<td>kc/s</td>
</tr>
<tr>
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<td>ohms</td>
<td>mfd.s.</td>
<td>kc/s</td>
</tr>
<tr>
<td>meters</td>
<td>ohms</td>
<td>mfd.s.</td>
<td>kc/s</td>
</tr>
<tr>
<td>meters</td>
<td>ohms</td>
<td>mfd.s.</td>
<td>kc/s</td>
</tr>
</tbody>
</table>

To be posted in station.

Show fundamental wave length in red; normal working wave in green; other wave length adjustments in black.

No. 102. Copyright 1924 by the Conrad Co., Inc. (Formerly the Consolidated Radio Call Book Co., Inc.) New York City
A Spark Coil I.C.W. Transmitter

If you have difficulty in obtaining the high voltage for supplying the plate of a five watt transmitting tube, you may overcome this very easily by using the above hook-up, which is arranged for interrupted continuous wave transmission. Almost any small ignition coil or spark coil (up to one inch) may be used, but care should be taken to see that a very good high potential condenser of fixed value, C-3 is bridged across the secondary. The proper capacity can be readily determined by making up a makeshift spark gap of two darning needles, firmly held apart at a distance of about one-fourtieth of an inch (about the thickness of a piece of blotting paper). Capacity should then be added across the gap in steps until a value is reached which just permits a discharge across the gap. This represents a potential of five hundred volts, approximately, which is a safe value to apply to the plate of a five watt power tube.

The circuit shown, by reason of its inductive coupling to the antenna, insures a pure, non-swinging signal and entire absence of undesirable harmonic frequencies. The antenna circuit is tuned by the capacity C-1 while the frequency of the generating circuit can be adjusted to resonance by means of the variable capacity, C-2. This is an ideal circuit arrangement for the beginner as well as the more advanced transmitting amateur.

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