THE SCR-61 WAVE METER.

Equipment.

2 wave meters, type SCR-61.
1 small screw driver.
1 head set, type P-11.

Information.

ELECTROMAGNETIC WAVES.

It is a well-known fact that when a stone is thrown into a pond a series of ripples or waves is created. Similarly, if air is disturbed by the vibrating of a bell or the blowing of a whistle, sound waves are produced in the air. Light and heat are also transmitted by waves. In fact, many of the most familiar phenomena of everyday life are caused by wave motion.

The particular form of waves which have to do with radio communication are known as *electromagnetic* or *radio* waves. Electromagnetic waves travel through a medium called the ether which, though it is invisible, is supposed to exist everywhere throughout all space. Electromagnetic waves may be produced in the ether by electrical disturbances such as are caused by the electrical currents of a radio transmitting set. These waves possess energy and are capable of doing work. In other words, a radio transmitting set sends out energy in the form of wave motion. A radio receiving set placed at a considerable distance from the transmitting set intercepts the waves of the transmitter. The energy which has been transmitted over this distance by means of the wave motion operates the radio receiver and causes it to produce a perceptible signal.

Every wave has a length and this length can be measured. For instance, in the case of water waves, the wave length is usually determined as the distance between the tops of the crests of two successive waves. The wave length of any other kind of wave can be determined in the same way. It is common practice to use the symbol λ (the Greek letter lambda, pronounced lam-da) to represent wave length. This length is generally expressed in meters instead of feet.

A radio transmitting set is usually designed to send out waves of different lengths. For instance, a message may be sent on a wave length of 250 meters. By properly adjusting the transmitter the length of the wave may be changed to 300 meters, 500 meters, or some other desired length. The series of wave lengths over which a set will transmit is known as the wave-length range of the transmitter. The wave-length range is also spoken of as the wave-length band.

Questions.

(1) *How are sound, light, and heat transmitted?*

(2) *What kind of wave is used in radio communication?*

(3) *How is this wave produced?*

(4) *How is it known that the waves from a radio transmitting set possess energy?*

(5) *Between what two points is the length of a wave measured?*

(6) *In what units is the length of a wave usually expressed?*

(7) *Can a radio transmitting set be made to transmit on more than one wave length?*

(8) *What is meant by the wave-length range of a radio transmitting set?*

DETAILS OF THE WAVE METER.

Information.

General construction of the wave meter.—If, on an ordinary telephone party line, all of the subscribers attempted to carry on a conversation at the same time, considerable confusion would arise due to the fact that each party would be talking over the same circuit. In the same way if all radio transmitting stations were allowed to use any wave length they pleased at random, there would be considerable interference at the radio receiving stations due to the fact that a number of transmitting stations would probably be transmitting on the same wave length and the received signals would consequently be so jumbled together that it would be impossible to read them. To overcome this sort of interference in radio communication certain wave lengths are assigned to the various classes of transmitting stations in operation.

For instance, amateur radio stations are limited to a wave-length band of from 150 to 200 meters; Government stations are allotted certain wave lengths, such as 300, 600, 900, 1,200, 5,000 meters, etc. Radiophone broadcasting stations are confined to a wave-length band of from 250 to 700 meters.

In order to keep within the limits of these wave-length allocations and to facilitate efficient radio communications it is necessary to measure the wave length of a radio transmitter. As electromagnetic waves are invisible and can not be measured with ordinary measuring instruments an electrical instrument known as a *wave meter* is used.

The wave meter is an instrument by means of which it is possible to measure the length of electromagnetic waves generated by some outside agency, such as a transmitting set. The wave meter may also be used to generate and to emit (send out) waves of a known length. The radio operator uses the wave meter for both of these purposes when he measures the wave length of transmitting sets (both local and distant), and when he calibrates transmitting and receiving sets.

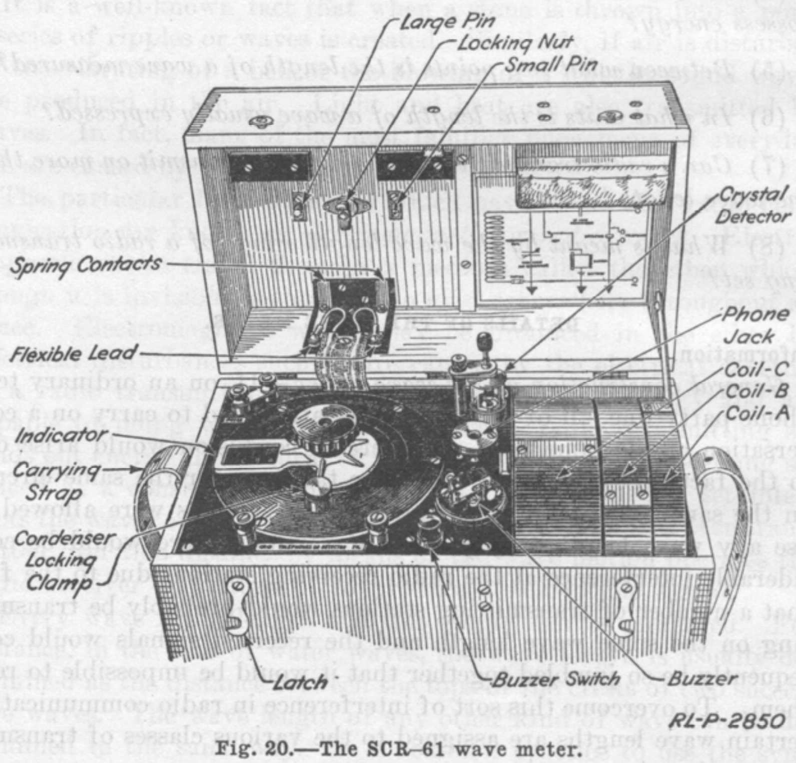

Fig. 20.—The SCR–61 wave meter.

The most important parts of an SCR–61 wave meter are the rotary condenser, inductance coil, buzzer, crystal detector, and the dry cell. See Figs. 20, 21, and 22.

Directions.

1. Unbuckle the leather carrying strap. Release the two latches on the front of the box and raise the cover. Study Figs. 20, 21, and 22 to learn the names of the important parts of the meter which can

be seen when the cover is raised. Learn the names of these parts so that they can be given promptly when required.

2. Take the three coils out of the right-hand compartment of the box. Note on just which coils the letters A, B, and C appear. Look in the cover of the box and locate the clamp by which the coils are fastened in place. Using this clamp, fasten coil A in place. (See Fig. 21.) Be careful that the coil is fastened firmly. Then remove coil A and try the other two coils in position, making sure that they fit.

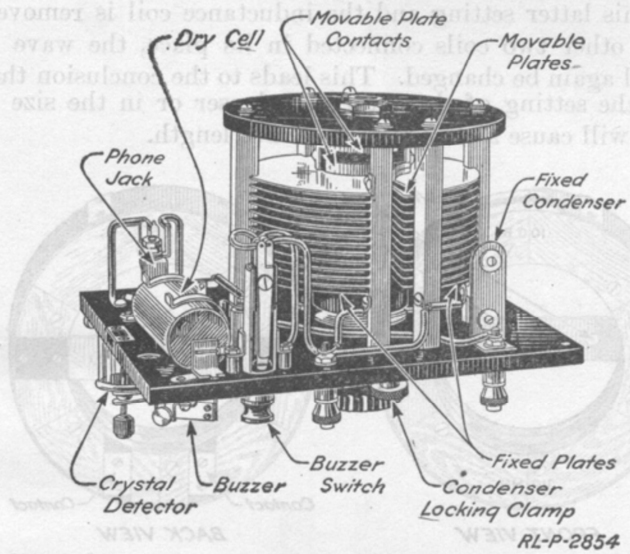

Fig. 21.—Panel of set box BC–37 removed to show interior parts.

Questions.

(9) *Why is it important to know the length of an electromagnetic wave?*

(10) *What is the purpose of the wave meter?*

(11) *How is the wave meter inductance coil constructed?*

(12) *What is the approximate size of each of the three coils?*

(13) *Which coil (A, B, or C) is the largest? Which is the smallest?*

(14) *Why were the two holes in the coil support made different in size?*

(15) *How is contact made with the wire on the coils?* (*See Figs. 20 and 22.*)

Information.

The Inductance Coils.—The two main parts of the wave meter are the *inductance coil* and the *rotary condenser.* These two parts control the length of the wave emitted by the wave meter and measure the waves emitted by a radio transmitter. For example, suppose one of the three inductance coils supplied with the wave meter is correctly inserted and connected in its proper place. If now the setting of the rotary condenser is changed to another setting the length of the emitted wave will be changed. If the rotary condenser is left at this latter setting and the inductance coil is removed and one of the other two coils connected in its place, the wave length emitted will again be changed. This leads to the conclusion that any change in the setting of the rotary condenser or in the size of the inductance will cause a change in the wave length.

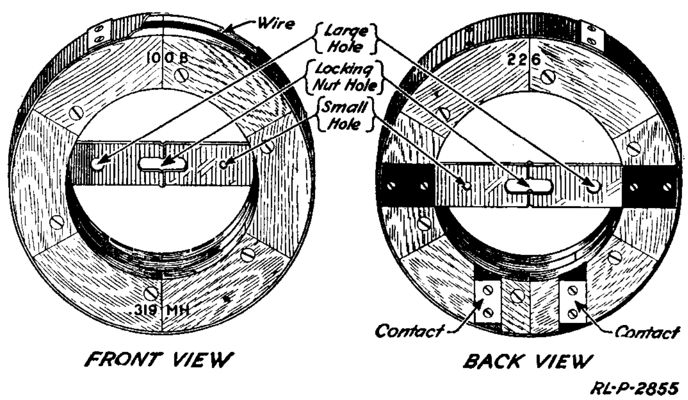

Fig. 22.—Details of inductance coils used in SCR–61 wave meter.

As stated above three inductance coils are furnished with each wave meter of the SCR–61 type. Each coil covers a certain band of wave lengths. Any wave length within this band may be obtained by adjusting the rotary condenser according to the scale on the meter. If after using any one of the three inductance coils in the wave meter, the desired wave length is not found within the wave-length band of the coil, it will be necessary to substitute the one of the two remaining coils which includes the desired wave length within its band. Using the three inductance coils a wave-length band of from 150 to 2,600 meters may thus be covered.

Questions.

(16) *What are the two main parts of the wave meter?*

(17) *What do these parts control?*

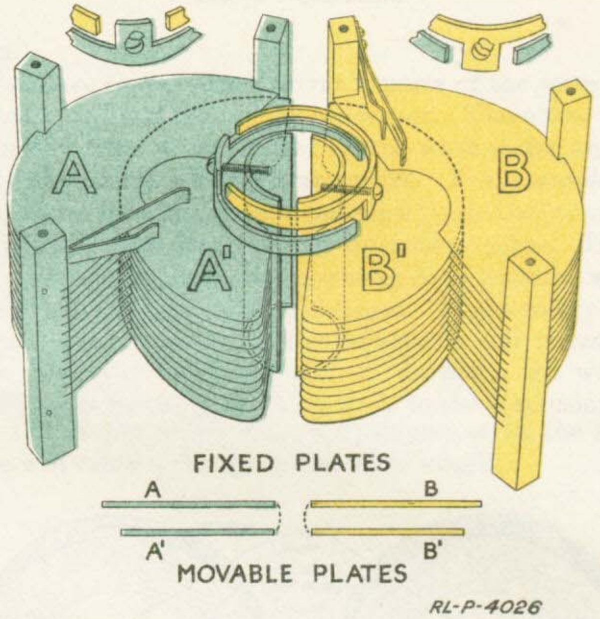

Fig. 23.—Schematic view of variable condenser used in the SCR-61 wavemeter, showing minimum capacity position of plates.

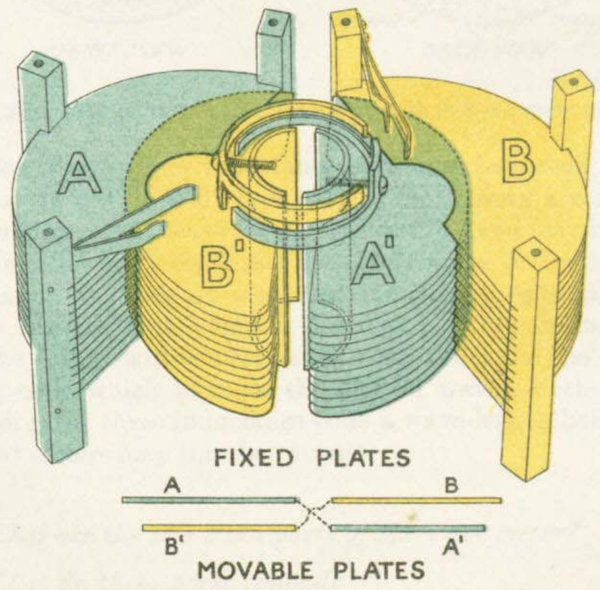

Fig. 24.—Schematic view, showing maximum capacity position of plates.

(18) *What does each inductance coil limit?*

(19) *Why are three inductance coils supplied with the meter?*

(20) *What is the purpose of the rotary condenser?*

Directions.

3. Remove the four screws from the corners of the panel and lift the panel from the box by means of the binding posts marked "FIL" and "METER." It will be necessary to disconnect the canvas covered wires leading up to the lid of the box. This is done by removing the three screws holding the wires in position. Put all the screws in the right hand compartment of the box in order that they will not be lost.

Questions.

(21) *Why was the panel lifted out by certain binding posts?*

(22) *How is the box lined?*

(23) *Do the screws holding the panel in place serve to make an electrical connection between the lining of the box and the wiring on the panel? Look under the panel where the screws go through and see how many connections are made in this way.*

Directions.

4. Hold the panel on edge and study the construction of the rotary condenser. Rotate the knob on the front of the panel and notice what turns behind the panel. Trace the connection between the fixed and movable plates. (See Figs. 23 and 24.)

Information.

The Rotary Condenser.—A rotary condenser usually consists of a number of stationary or fixed semicircular plates together with a number of movable or rotary semicircular plates. The movable plates rotate in such a way as to slip into the spaces between the stationary plates. A pointer moving over a circular scale indicates the position of the movable set of plates. (See Fig. 20.)

A condenser has the property of governing the flow of certain forms of electricity which occur in a radio set. This property is expressed interms of *capacity.* The unit for expressing the capacity of a condenser is the *farad.* A subdivision of the farad is known as a *microfarad*, which is $\frac{1}{1,000,000}$ of a farad.

As a close relationship exists between wave length and capacity, any change in the capacity of the rotary condenser in the SCR-61 wave meter will cause a change in the length of the wave emitted by the wave meter. The capacity of the rotary condenser may be changed by changing the position of the rotary plates with respect to the position of the fixed plates.

The details of the mechanical construction of the rotary condenser employed in the SCR–61 wave meter are rather complicated and do not come within the scope of this course. An understanding of the general principle involved will be sufficient.

From a careful study of the condenser in the wave meter itself together with the illustrations in Figs. 23 and 24, it will be evident that the condenser consists of two sets of fixed plates and two sets of movable plates. In the illustrations the sets of fixed plates are marked "A" and "B" while the movable plates are marked "A′" and "B′." The two sets of fixed plates have been separated at one end to show more clearly the details of the movable plates. Connections to the wave meter circuit are made from the two sets of fixed plates. The set of fixed plates marked A is connected to the set of movable plates marked A′ through a contact device. In the same manner the other set of fixed plates B are connected to the movable plates B′ through a similar contact device. When the movable plates A′ are entirely covered by the fixed plates A and the movable plates B′ are entirely covered by the fixed plates B the capacity of the condenser is at a minimum. (See Fig. 22.) When the movable plates are rotated to the opposite position so that the plates A′ are entirely covered by the fixed plates B and the plates B′ are entirely covered by the fixed plates A, the capacity of the condenser is at a maximum.

Questions.

(24) *How many sets of fixed plates are there in the rotary condenser of the SCR–61 wave meter?*

(25) *How many fixed plates are there in each set?*

(26) *How many sets of movable plates are there in the condenser?*

(27) *How many movable plates are there is each set?*

(28) *Are the movable and fixed plates connected together?*

(29) *How is the position of the movable plates varied?*

(30) *What is meant by the capacity of a condenser?*

(31) *What is the unit used for expressing capacity? What is a microfarad?*

(32) *What is the purpose of the rotary condenser in the SCR–61 wave meter?*

WAVE METER AS A TRANSMITTER.

Information.

In order that the wave meter may be used as a low power transmitter, a small buzzer is provided. The buzzer consists of two small electromagnets, an adjustable armature or vibrator, and an adjustable contact screw. The longer of the two thumbscrews on the buzzer is used to adjust the armature, while the shorter thumbscrew is used to adjust the contact with the armature.

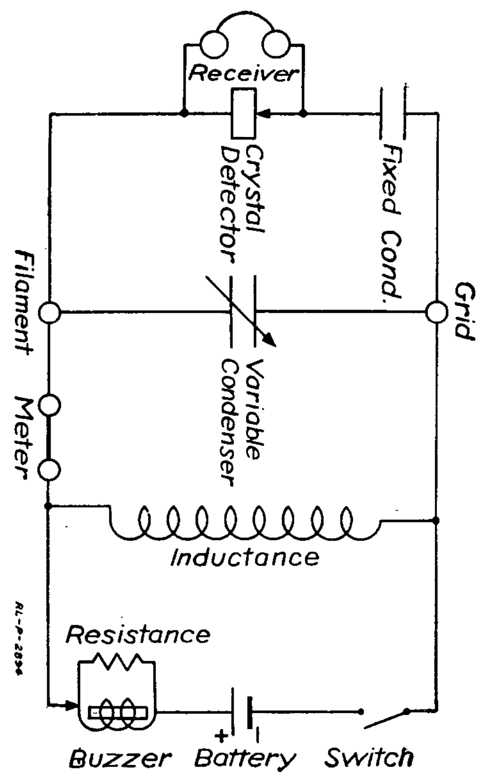

Fig. 25.—Schematic diagram of connections in the SCR-61 wave meter.

The buzzer is operated by a dry cell of the BA-4 type. It should be noticed that the support for the BA-4 dry cell is so arranged that the positive or center terminal of the cell makes contact with the spring terminal located close to the rotary condenser. The negative pole (the outside of the cell itself) makes contact with the brass lug located at the edge of the panel. The dry cell should never be put in the support backwards. In some types of wave meters if this is done, the dry cell will become short-circuited and run down in a short time.

A push-pull buzzer switch is provided on the panel of the wave meter to turn the current from the dry cell on or off. On some wave meters the buzzer is operated by pulling out the switch button. On others the button must be pushed in.

Sometimes an operator leaves the switch closed so that the current flows through the buzzer circuit. The wave meter may then be stored away without this fact being detected. Later some other operator may try to use the wave meter, but will be unable to do so for the reason that the cell will have become corroded and the contacts destroyed. To prevent an occurrence of this kind, *always see that the buzzer switch is open or else remove the battery.*

Directions.

5. Trace the wiring diagram of the wave meter with particular reference to the buzzer, buzzer switch, battery, small resistance, leads to the inductance coils, meter connections, and the variable condenser. Omit the wiring to the detector, fixed condenser, and phones. Remember that there must be a complete metallic circuit in order that the buzzer may operate.

Questions.

(33) *Will the circuit from the battery to the buzzer be complete if there is no inductance coil in place in the top of the set? Explain your answer.*

(34) *Why are the leads going to the inductance coils made flexible? Why are they inclosed in canvas?*

(35) *Will the buzzer operate if the two binding posts marked* "METER" *are not connected by the brass strap?*

(36) *What must be the position of the buzzer switch in order that current may pass through the buzzer?*

(37) *Could the battery be put in the meter backwards? If so, what damage would result?*

WAVE METER AS A RECEIVER.

Information.

When the wave meter is used to receive signals, the circuit must include, in addition to the inductance coil and the variable condenser, a fixed condenser, a detector, and a pair of telephone receivers.

The purpose of the telephone receivers is to convert interrupted or vibrating electrical currents into sound waves, as explained in Unit Operation No. 5. However, the electrical currents picked up by the inductance coil of a wave meter from a transmitting set are vibrating at an exceedingly high rate of speed. These vibrations are much too rapid for the diaphragm of the telephone receiver to follow. Due to this fact it becomes necessary to use a device which will alter the rapidly interrupted or high-frequency currents so that they will cause the diaphragm of the telephone receiver to respond and produce sound waves. The device used for this purpose is known as a *detector*.

There are various types of detectors. The one used in the SCR–61 wave meter is called a *crystal detector*. The crystal detector consists of two essential parts—a piece of mineral or crystal and a contact wire or point. The mineral or crystal is mounted in soft metal at the base of the detector, while the contact is fastened to an adjusting device just above the crystal. By the use of the adjustment knob, the contact wire may be brought to bear upon any point on the exposed surface of the crystal. This adjustment is provided for the reason that some points on the crystal are more sensitive to the tiny currents than are others.

Directions.

6. Trace the connection of the wave meter with respect to the detector, telephone jack, variable condenser, fixed condenser, and the inductance coils.

7. Turn the panel over and look at the top. Notice how the detector is constructed. Unscrew the nut at the top and take the detector apart. Remove the mineral and notice how it is mounted. Do not touch the surface of the mineral, since grease, dust, or other foreign matter on the surface of the crystal will impair its sensitivity.

Questions.

(38) *Why should the student be careful not to touch the surface of the mineral?*

(39) *Describe in detail the construction of the small fixed condenser, and name its principal parts.*

(40) *Are all the joints soldered firmly in place? Why?*

(41) *How are telephones connected to the wave meter?*

(42) *Why is the crystal detector used in this set?*

(43) *Why is the metallic contact or "cat whisker" mounted in a ball-and-socket joint?*

(44) *Why is the detector inclosed in a glass case?*

NOTE.—There are times when an operator using a wave meter or crystal receiver experiences difficulty in locating a sensitive spot on the surface of the crystal, due to the fact that it has become covered with a film of dirt, grease, or other foreign matter. If the operator is unable to obtain a new crystal it is possible to restore the original sensitivity of the old one by cleaning it with gasoline or alcohol. The solution used in Pyrene fire extinguishers may also be used for this purpose with good results. The crystal should first be immersed in the solution for about one minute. It should then be brushed thoroughly with an old toothbrush and allowed to dry. Damp weather also has a tendency to impair the sensitivity of a crystal. In this case the crystal should be dried thoroughly and then covered with a thin film of oil, such as paraffin oil or linseed oil. This film will keep out the moisture.

A CALIBRATION OF WAVE-METER SCALE.

Information.

The dial on the variable condenser has four different scales. The outer scale is marked in degrees and the three inner scales are marked in meters. Each of the three inner scales has a letter at the left-hand end showing with which inductance coil it should be used. The hair line in the center of the pointer indicates the reading corresponding to any wave-meter setting.

It is difficult to obtain an accurate reading near the ends of the scales on the variable condenser. For this reason, part of the maximum readings on scale "A" are included in scale " B " and part of the maximum readings on scale " B " are included in scale " C." This is called the " overlapping " of the wave-length ranges.

Directions.

8. Look at the dial on the variable condenser and carefully notice the markings.

Questions.

(45) *In what kind of units are the three inner scales calibrated?*

(46) *Which scale would be used if coil "A" was fastened in the lid?*

(47) *What is the lowest wave length that can be read with coil " C "?*

(48) *What is the highest wave length that can be read with coil " B "?*

(49) *For what is the small locking nut used?*

Directions.

9. Replace the panel in the box. Fit the screws in their proper holes and tighten them up. Connect the flexible leads as they were before.

10. Examine the buzzer and its adjustment. Put one of the coils in the lid of the box and turn on the switch to start the buzer. Be

sure that there is a serviceable battery in the wave meter and that it has been correctly inserted. Now adjust the buzzer until it vibrates with a low pitched musical note. With the buzzer vibrating the set becomes a transmitter of a very low power

Questions.

(50) *What is the wave length of the transmitted wave with the "B" coil in and the pointer over the 300-meter mark on the "A" scale?*

(51) *Set the points of the wave meter on the 85 degree mark of the degree scale. What wave length does this correspond to when the "A" coil is used? When the "B" coil is used? When the "C" coils is used?*

Directions.

11. Put the telephone plug in the jack, with the buzzer vibrating, and move the contact wire about upon the surface of the mineral in the detector until a clear distinct note is heard in the telephone receivers. It may be necessary to search very carefully for the sensitive spot. Stop the buzzer as soon as a good spot is found, being careful not to jar the meter.

Questions.

(52) *When the buzzer is cut off after a sensitive spot is found on the crystal, will the set act as a radio receiving set?*

(53) *What is a band of wave lengths?*

(54) *What band of wave lengths can be received with the "A" coil in position?*

EXPERIMENT No. 1.

COUPLING.

Directions.

12. Take two SCR–61 wave meters and using one as a transmitter and the other as a receiver, perform the following experiments. Call the transmitter meter No. 1, and the receiver meter No. 2.

13. Open the two wave meters and put a coil A in each one. Start the buzzer on the receiver (No. 2) and carefully adjust the detector. Now put the No. 2 meter close to the No. 1 meter with their lids back to back. (See Figs. 26 and 27.) Test the detector again and see if it is still in adjustment. The meters placed in this way are said to be closely coupled and the effect of the No. 1 meter should be felt very strongly on No. 2 meter. Now start the buzzer to vibrating

on the No. 1 meter and set the pointer to 300 meters. Rotate the variable condenser on the No. 2 meter until the signal given out by the No. 1 meter is heard at maximum strength. Carefully check the wave length readings on both meters.

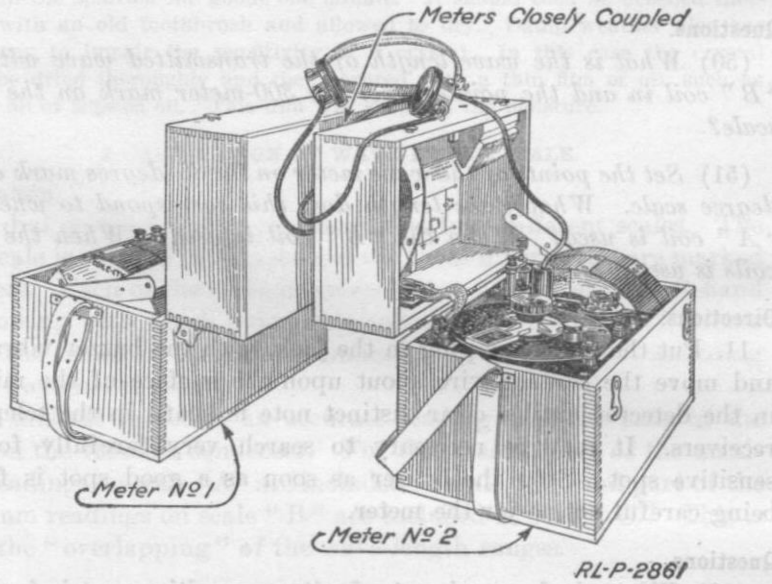

Fig. 26.—Method of obtaining close coupling between two SCR-61 wave meters.

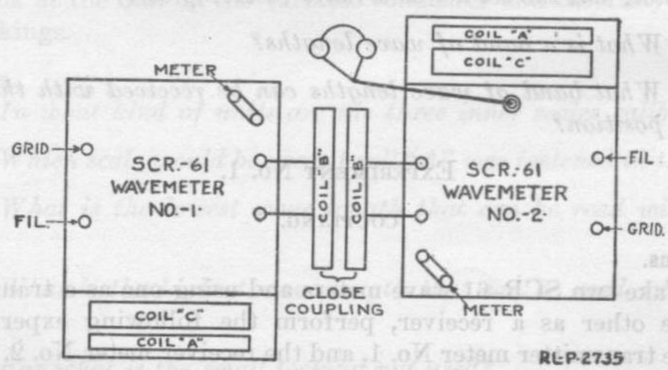

Fig. 27.—Schematic view showing relative positions of inductance coils when two SCR-61 wave meters are closely coupled as in Fig. 26.

14. Do not disturb the No. 2 meter in any way since this will destroy the adjustment of the detector. Loosen the coupling between the two meters by moving the No. 1 meter farther away from the No. 2 meter or by turning it so that its coil is not parallel with the coil of the No. 2 meter. In Figs. 28 and 29 the coil of the No. 1

meter is at right angles to the coil of the No. 2 meter. When two coils are closely coupled, the magnetic lines of force from one will pass through the other in large numbers; when they are loosely coupled very few of the lines of one coil will affect the other coil.

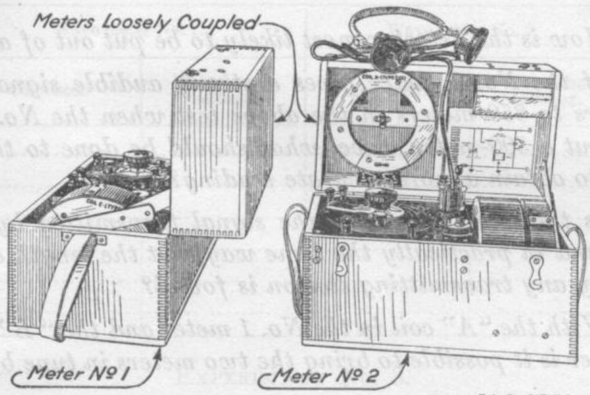

Fig. 28.—Two SCR–61 wave meters, loosely coupled.

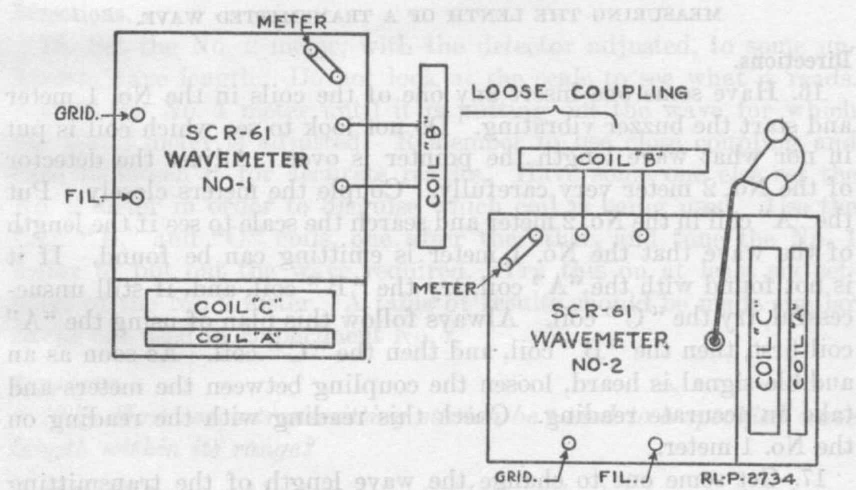

Fig. 29.—Schematic view showing relative positions of inductance coils when two SCR–61 wave meters are loosely coupled as in Fig. 28.

With the coils closely coupled the signal put out by the No. 1 meter should be heard over a number of degrees on the scale, but with the coils very loosely coupled the signal should be heard over only a very few degrees.

15. Put the " B " coil in meter No. 1 and set its pointer at 450 meters. Now rotate the condenser of meter No. 2 until a maximum

sound is heard. Compare the readings on the two meters. Be sure to read the scale corresponding with the coil used. When the maximum sound is heard in the No. 2 wavemeter, its circuit is said to be in tune with the circuit of the No. 1 meter.

Questions.

(55) *How is the detector most likely to be put out of adjustment?*

(56) *If the No. 2 meter gives a strong audible signal from say 250 meters to 350 meters in the above test when the No. 1 meter is putting out a 300-meter wave, what should be done to the coupling in order to obtain a more accurate reading?*

(57) *Is the wave length of the signal transmitted by the No. 1 meter found in practically the same way that the length of the wave emitted by any transmitting station is found?*

(58) *With the "A" coil in the No. 1 meter and the "B" coil in the No. 2 meter is it possible to bring the two meters in tune by adjusting them?*

EXPERIMENT No. 2.

MEASURING THE LENTH OF A TRANSMITTED WAVE.

Directions.

16. Have some one insert any one of the coils in the No. 1 meter and start the buzzer vibrating. Do not look to see which coil is put in nor what wave length the pointer is over. Adjust the detector of the No. 2 meter very carefully. Couple the meters closely. Put the "A" coil in the No. 2 meter and search the scale to see if the length of the wave that the No. 1 meter is emitting can be found. If it is not found with the "A" coil, try the "B" coil, and, if still unsuccessful, try the "C" coil. Always follow this plan of using the "A" coil first, then the "B" coil, and then the "C" coil. As soon as an audible signal is heard, loosen the coupling between the meters and take an accurate reading. Check this reading with the reading on the No. 1 meter.

17. Get some one to change the wave length of the transmitting meter and try the above experiment several times. Get at least six readings of this kind and make a table similar to the one shown below, including the readings of both wave meters. In this way it can be determined whether or not accurate values are being obtained.

Questions.

(59) *Why is it better to make the coupling close to start with?*

(60) *Can the No. 1 meter emit a wave that the No. 2 meter can not pick up?*

(61) *If it is desired to measure the length of a wave put out by a transmitting set which is transmitting on an unknown wave length, how would it be done?*

Adjustments of the wave meters.

	Wave meter No. 1.		Wave meter No. 2.	
	Coil used.	Wave length setting.	Coil used.	Wave length setting.
1				
2				
3				
4				
5				
6				

EXPERIMENT No. 3.

MEASURING THE WAVE LENGTH TO WHICH A RECEIVER IS TUNED.

Directions.

18. Set the No. 2 meter, with the detector adjusted, to some unknown wave length. Do not look at the scale to see what it reads. Adjust the No. 1 meter until it is putting out the wave for which the No. 2 meter is adjusted. Remember to use close coupling and then to loosen it for accurate results. Have some one else set the No. 2 meter in order to disguise which coil is being used. Use the "A," "B," and "C" coils, one after the other, and tune the No. 1 meter to put out the wave required. Try this on at least six settings of the No. 2 meter. A table of results should be made similar to the one used in Experiment No. 2.

Questions.

(62) *How can a transmitting station be tuned to a specified wave length within its range?*

(63) *When would a wave meter be required for use as a transmitter in field operations?*

(64) *How would the wave length of a transmitting station be measured by an operator at a receiving station?*

(65) *When putting a wave meter in storage, what is the last thing an operator inspects to see if it has been done? What will happen if this is not done?*