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UNITED STATES ARMY

TRAINING MANUAL NO. 27

RADIO OPERATOR

INSTRUCTORS GUIDE
FOR ALL ARMS

Part I. RADIO SETS

PREPARED UNDER THE DIRECTION OF
THE CHIEF SIGNAL OFFICER

1925

WASHINGTON
GOVERNMENT PRINTING OFFICE
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CERTIFICATE: By direction of the Secretary of War, the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

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WAR DEPARTMENT,

WASHINGTON, *August 1, 1925.*

Manuals for training in the Army are to be prepared and revised from time to time by the branches of the service concerned, and when approved, published by The Adjutant General of the Army as training manuals.

In accordance with this plan there has been prepared by the Signal Corps a group of training manuals relating to signal communication specialists.

The training manuals in the series, relating to the training of Radio Operators, include the following:

Training Manual No. 20—Basic Signal Communication, Students Manual.

Training Manual No. 21—Basic Signal Communication, Instructors Guide.

Training Manual No. 26.

- Part I—Radio Sets, Students Manual.
- Part II—Vol. I—Code Practice, Students Manual.
- Part II—Vol. II—Tactical Radio Procedure, Students Manual.

Training Manual No. 27.

- Part I—Radio Sets, Instructors Guide.
- Part II—Vol. I—Code Practice, Instructors Guide.
- Part II—Vol. II—Tactical Radio Procedure, Instructors Guide.

This manual is published for the information and guidance of all concerned.

BY ORDER OF THE SECRETARY OF WAR:

J. L. HINES,
Major General,
Chief of Staff.

OFFICIAL:
ROBERT C. DAVIS,
Major General,
The Adjutant General.

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PREFACE.

1. Part I, Training Manual No. 26, The Radio Operator, is a training course on radio sets.

2. The plan followed in the preparation of this manual is the established Signal Corps training policy, namely, instruction by means of the applicatory method.

a. In order that the manual may meet Army needs, the knowledge and ability which radio operators with tactical units must possess has been analyzed and arranged in teaching units called *Unit Operations.*

b. Each of these unit operations contains all the requisite information, together with the directions for obtaining a solution of the various applicatory problems contained therein. These problems are so arranged that the radio operator by following them in order will find himself equipped with the necessary knowledge and manual skill for proceeding from each unit operation to the next.

3. It is highly desirable that radio operators should receive instruction in an orderly way and that their ideas and stock of information about their specialty should be built up and added to in a logical fashion. It is especially important that they should be well grounded in the fundamental principles and practice of radio operation and that they should be thoroughly familiar with such elementary circuits as those involved in simple receivers, transmitters, and amplifiers. For these reasons the SCR-54-A, SCR-74, and SCR-61 sets are used in this manual as starting points for instruction. Although these sets are becoming obsolete, a thorough study of the minimum instructional equipment required by any unit for the illustration of basic radio principles has resulted in the selection of these sets as well adapted for this particular purpose. Where they can not be obtained, models can be made which will serve the purpose.

NOTE.—Recommendations have been made to include these sets in Equipment B, in the new tables of equipment for all units required to train radio operators. (Letter, O. C. S. O. Jan. 12, 1924.)

4. Since different arms are equipped with different radio sets, the unit operations are so arranged that the directions for any sets not used by a particular arm may be omitted without destroying the general plan of instruction.

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5. The several unit operations constituting this manual have been prepared in accordance with the minimum specifications for the Radio Operator published by the Adjutant General of the Army. These specifications do not require instruction in radio theory. In this connection it should be noted that the Signal Corps policy with respect to instruction, as embodied in this manual, departs from the usual procedure which consists in teaching theory first and practice second, by teaching the practical first and permitting theoretical knowledge to grow spontaneously out of this practical training.

6. The essential element in training radio operators is the reduction of the time required for training to the minimum. What this minimum is and the best ways of attaining it must be determined in peace time and not left undecided until a national emergency arises. The second essential element in any program of training is the complement of the first, that the method adopted for war training shall be identical with that for peace training. The methods devised in peace must be so well tried and so trustworthy that they will not be abandoned when an emergency arises. At such a time, to devise and install new methods and to spread these throughout the Army requires considerable time that had better be spent upon the actual training itself.

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RADIO OPERATOR.

INSTRUCTORS' GUIDE

FOR ALL ARMS.

PART I. RADIO SETS.

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RADIO OPERATOR.

INSTRUCTORS GUIDE

FOR ALL ARMS.

Part I.—Radio Sets.

UNIT OPERATIONS.

PRIMARY BATTERIES USED IN RADIO COMMUNICATION.

Information.

Effects of electricity.—The word electricity has been applied to a form of energy, but just exactly what electricity is we can not say. Electricity is known to exist for the simple reason that it can be observed and measured. For example, electricity lights lamps, drives motors, raises to a high temperature all sorts of electrical heating devices, and energizes the telephone, the telegraph, and the electric bell. It also makes radio communication possible.

Electricity produces these various effects only when it is in motion, just as air must be in motion in order that wind may be produced. Moving air causes the windmill to revolve, and propels the sailing vessel. However, if air is not in motion no such effects are produced. In a similar way, electricity at rest has few effects of practical value. Electricity in motion is spoken of as a *current* of electricity.

Conductors; nonconductors.—In order to transfer electricity from its source to the point at which it is to be used, a path or *conductor* must be provided. For convenience and efficiency this conductor usually consists of a copper wire. Gold, silver, iron, lead, brass, zinc, carbon, and the earth are also conductors of electricity. Certain substances, such as glass, porcelain, hard rubber, bakelite, mica, and sealing wax, are poor conductors of electricity and are therefore called *nonconductors* or *insulators*.

Questions.

(1) *What is energy?*

(2) *What are some forms of energy other than electrical energy?*

(3) *What is meant by "energizing the telephone"?*

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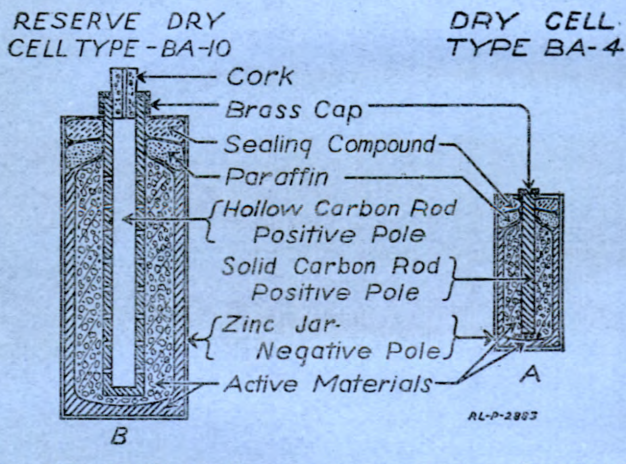
(4) *What are the usual sources of electricity?*

(5) *Why is it evident that such a thing as electricity exists?*

(6) *Will electricity produce any practical effects if no current is flowing?*

(7) *What is a conductor?*

Batteries.—The electricity necessary to operate the radio sets used in the Army is obtained from two sources, namely, an electric battery or a generator. For portable and small type sets the necessary electrical energy is supplied by a battery. Two types of batteries are used in general, one a primary battery and the other a secondary or storage battery.



Figures 1, A–B.—Sectional view of primary cells, types BA–10 and BA–4.

Primary batteries.—A primary battery consists of two or more units called *cells.* Each cell produces electricity by certain chemical actions which take place inside the cell. There are many types of primary cells. Those which contain a liquid which is easily spilled, or those in which the liquids are placed in glass containers are unsuitable for use where they are to be transported with radio sets accompanying troops in the field. The type of primary cell most practical for such use is known as the dry cell. The BA–4 cell is an example of this type of dry cell. (See Fig. 1, A, and Fig. 3, B.)

It consists of a small cylindrical zinc container, in the center of which a carbon rod is placed. The space between the carbon rod and the inner wall of the zinc container is filled with certain chemicals and absorbent materials. The top of the cell is sealed with sealing

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wax. The carbon rod is equipped with a small brass cap which acts as one terminal of the cell. The other terminal of the cell is formed by the zinc container itself.

EXPERIMENT NO. 1.

Equipment.

1 cell, type BA–4, serviceable, with leads soldered to terminals.
1 voltammeter, Weston model 280.

NOTE.—The voltammeter, Weston model 280, is a combination voltmeter and ammeter. When the voltammeter is used to measure voltage it will be spoken of as a voltmeter, and when it is used to measure amperes it will be spoken of as an ammeter.

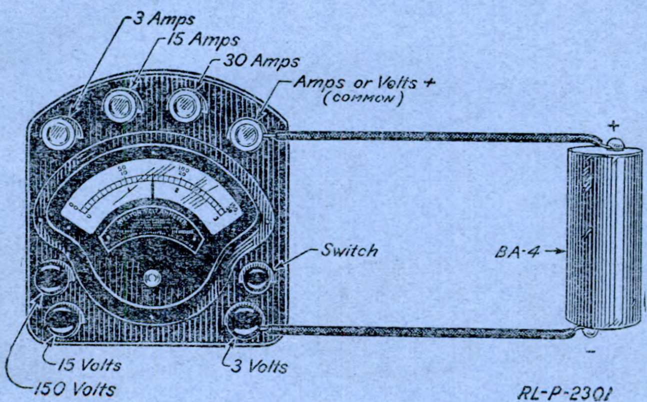

Fig. 2.—Method of connecting type BA–4 cell to a voltmeter.

Directions.

1. Connect the wire leading from the carbon rod or positive pole of the BA–4 cell to the terminal marked "Amps or Volts +" on the voltammeter. Connect the wire leading from the bottom of the zinc case or negative terminal of the cell to the terminal marked "3 Volts" on the voltmeter. (See Fig. 2.) Press the small button switch on the voltmeter and watch the indicating needle.

Questions.

(8) *In which direction does the indicating needle turn?*

(9) *Where does the needle come to rest?*

(10) *What is the voltage of the cell as indicated by the voltmeter?*

Directions.

2. Reverse the leads by connecting the lead from the positive terminal of the cell to the terminal on the meter marked "3 Volts,"

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and the negative lead from the cell to the terminal on the meter marked "Volts." Again press the small button switch and observe the needle.

Questions.

(11) *When the connections are reversed, in which direction does the indicating needle move?*

(12) *Which is the proper way to connect the meter, as described in direction 1 or as in direction 2?*

Information.

Direction of current.—The electricity generated by a dry cell is known as *direct current* electricity and flows in one direction through the wires and apparatus connected to the cell terminals.

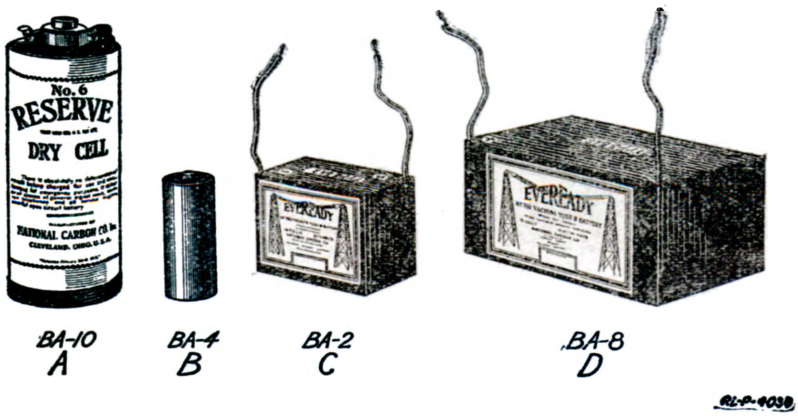

Fig. 3, A–B–C–D.—Types of dry cells and batteries used in signal communications.

The direction in which the current flows in a wire or piece of apparatus is determined by the connection to the cell terminals. The current generated by the cell is always considered as flowing outside the cell from the positive pole to the negative pole. It should be observed that if current flows from positive to negative *outside the cell,* in order to complete the electrical circuit it must flow from negative to positive *within the cell.* In referring to the direction of the current the *external* circuit is always referred to unless it is otherwise specifically stated.

Certain forms of electrical apparatus will not work unless the current flows through them in the proper direction. For this reason they must be correctly connected to the source of current supply,

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with respect to the positive and negative poles. The voltmeter in Experiment No. 1 is an example of this.

Question.

(13) *If the current generated by the cell flows from the positive to the negative terminal, why did the needle move to the left of the zero of the scale in Direction 2?*

Information.

BA–10 Dry Cell.—The BA–10 reserve dry cell is similar to the BA–4 cell. (See Fig. 1, B and Fig. 3, A.) It consists of a cylindrical zinc container in the center of which a hollow carbon rod is placed. The space between the carbon rod and the inner wall of the zinc case is filled with certain chemicals and absorbent materials. The top of the cell is sealed with an asphalt insulating compound. Two spring clip terminals are provided on the top of the cell, one being attached to the zinc case itself and the other to the carbon rod. A paraffin coated cork closes the opening in the top of the carbon rod.

The BA–10 cell differs from the BA–4 cell in that it must be charged by being filled with water before it is placed in service. (See U. O. No. 3, Basic Manual.)

A dry cell of the BA–4 type, when stored for a length of time, becomes useless due to certain reactions which take place inside the cell when it is not in use. The cell could be stored for a much longer period of time if during construction the water had been omitted from the chemical in the cell. This is done in the type BA–10 reserve cell, but the small size of the BA–4 cell, together with the manner in which it is used, prohibits the use of a device for adding water.

BA–2 Battery.—The type BA–2 battery shown in Fig. 3, C, consists of 15 dry cells, each cell being similar to the BA–4 type cell, but smaller. The cells are connected together in series and sealed in a cardboard container with sealing wax. Two wire terminals are brought out through the sealing compound at the top of the batteries. One of the wire terminals is covered with black insulation to indicate the negative pole, while the other wire is covered with red insulation to indicate the positive pole. It is important to remember these colors.

BA–8 Battery.—The type BA–8 battery (Fig. 3, B), is similar to the type BA–2 battery. The two batteries differ only in the size of the cells, those of the BA–8 battery being about twice the diameter of the cells of the BA–2.

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SUGGESTIONS FOR THE INSTRUCTOR.

PART I—GENERAL.

1. The instructor should bear in mind that the applicatory system means to *learn* by *doing* things. The radio operator who is of most use to his organization is the one who can actually operate his set. If he is first taught, step by step, to do the things necessary in the operation of that set, and at the same time the reasons for each step are explained, then the operator will have reached proficiency in the minimum of time. The successful operator reflects the successful instructor.

2. The method of instruction will depend to a great extent upon the fact as to whether or not the students have studied the Unit Operation before coming to class. Better results may be expected if the Unit Operations have been studied in advance.

3. The instructor should exercise close supervision over the work of the students, and require that they perform all the experiments as set forth in the Students Manual. He should also require each student to answer verbally, as many as possible of the questions contained in the Unit Operations in the Students Manual.

4. Students should be required to use words and terms correctly from the beginning. It is easier to learn a thing anew than to unlearn a wrong thing, and substitute the correct thing. Refer the students to the Information Topic and definitions. Technical terms may be written on the blackboard and the students required to make a list of them in a note book. The instructor should then hold the students responsible for the correct use of these technical terms in the future.

5. The time allotted to this course is limited. The instructor should constantly bear this in mind. It is therefore evident that the greater part of each period should be devoted to the practical side of radio. The instructor can determine from the results of certain tests and from questions asked in class whether or not any members of the class are interested in the theoretical side of radio. If there are any students who do take an interest in this study, they should be encouraged, and if any spare time remains it should be spent in a brief discussion of the "hows" and "whys" of radio phenomena. If the class as a whole is not susceptible to the explanations of the actions of radio apparatus, the entire time should then be devoted to practical work with sets.

6. Included in the Instructors Guide section of the equipment part of this Manual, there are "Instruction Tests." These tests are extremely valuable to the student and in addition enable the instruc-

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tor to obtain at frequent intervals data regarding the standing of a student. The student should be encouraged to regard these tests as a part of this training rather than as a definite check on his ability.

It will be noticed that the tests are arranged for the instructor in a simple convenient form. This form is briefly outlined as follows:

INSTRUCTION TEST (PERFORMANCE).

a. Equipment necessary for conducting the test.
b. How test is conducted, including any special instructions.
c. Directions to the student, including body of the test.
d. Method of scoring the test.

INSTRUCTION TEST (INFORMATION).

e. Short answer type of questions covering the Unit Operation, to be answered by the student.

If possible, the instructor should have the parts for the student (Nos. *c* and *e* above) mimeographed or hectographed in sufficient quantity for the needs of the class. If no method of reproduction is available, the instructor should copy the test on the blackboard.

7. The Information part of the Instruction Test is scored as follows:

a. Recognition questions (multiple choice questions)—

Allow one point for each correct answer.

b. True-false questions (plus or minus questions)—

The score for the true-false questions is obtained as follows: Add up the number of the questions which have been correctly answered; then add up the number of questions to which the wrong response has been given. Subtract the number wrong from the number right. This difference will be the net score. If the number wrong should be greater than the number right, call the difference *zero;* that is, do not assign a score of less than zero. Disregard omitted questions. For further explanations of this method of scoring, see the Instructors Guides; Training Manual No. 23, "Telephone Switchboard Operator," or Training Manual No. 25, "Message Center Specialist."

c. Completion questions—

The score for the completion questions is obtained by allowing one point for each blank space which has been filled in with a word or number which makes sense and at the same time is technically correct. There is no additional penalty for omissions.

NOTE.—A sample Proficiency Test for Radio Operators has not been included in this Manual, as this test is still in the stage of development. The instructor may prepare such a test using one of the progress tests as a guide.

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PART II—CLASS WORK.

1. The equipment listed in Unit Operation No. 1 of the Students Manual should be prepared in advance. The class should be divided into as many groups as there are sets of equipment. Groups should be small, and preferably contain only two or three men.

2. *a.* Discuss briefly the subjects treated in the information as far as "Batteries." First explain to the class that while electricity is invisible we know that it exists owing to the effects which it produces. Demonstrate to the class with an electric flash light that when the button is pressed an effect is produced, i. e., the lighting of the small lamp, which indicates that the case contains a source of electrical energy.

b. Call upon several students asking each one to name a source of energy other than electricity.

c. Call upon the remaining students asking each one to name an effect of electricity other than lighting a lamp.

d. Explain to the class that electricity must be transferred from one place to another by means of a path or conductor, using an analogy, such as water being transferred through a pipe.

e. Set up a storage battery and a lamp on the demonstration table. Procure a number of conductors such as gold, silver, iron, lead, brass, zinc, carbon, etc. (Any object may be used such as a ring, coin, nail, wire, etc.) Pick out any conductor at random and show the class that current will pass through it, as indicated by the lighting of the lamp.

f. Secure a number ofno nconducting objects consisting of material such as glass, porcelain, hard rubber, bakelite, mica, and sealing wax. Pick out any nonconductor at random and show the class that current will not pass through it, as indicated by the fact that the lamp does not light..

g. Instruct the class to mark off two columns on a page of their notebooks and to head one column with the word "Conductors" and the second column with the word "Nonconductors." Select at random any one of the conducting and nonconducting objects and hold the two wire leads from the battery and lamp against the object, at the same time stating to the class whether the object is of brass, mica, zinc, wax, or silver, etc. From their observations of the action of the lamp direct the students to write in the proper column the name of the composition used. Repeat this demonstration with each one of the remaining conducting and nonconducting substances and direct the students to write the name of the substance in the proper column.

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h. Explain briefly to the students that electricity used to operate radio sets in the Army is obtained from two sources, which are by battery and by generator. Procure a dry cell, such as the BA–4 cell, and a wet cell of any type; exhibit these to the class, merely using the wet cell to demonstrate the impracticability of this type of cell for use in the field. Name the parts of the cell and make certain that the students understand the polarity markings of the dry cell. Show a model 280 Weston voltmeter to the class and name the various terminals of the instrument.

3. The instructor should now direct the students to begin the experiments as listed in the Students Manual under Unit Operation No. 1. He should personally supervise the students' work, and assist them whenever necessary, but he should not perform any of the actual experiments for the student.

4. After these experiments have been completed the instructor should require each student to answer verbally as many as possible of the questions in this Unit Operation. In order to bring out further details he may also ask additional questions, such as the following:

a. How is it possible to tell from the action of a voltmeter needle in which direction the current is flowing?

b. How many cells does the type BA–2 battery contain?

c. How many cells does the type BA–8 battery contain?

d. How is it possible to determine the negative pole of a type BA–2 battery without using a voltmeter?

e. How is it possible to determine the positive pole of a type BA–8 battery without using a voltmeter?

f. Why is sealing wax used in sealing a type BA–2 battery? Why wouldn't it be better to use a metal top or case?

5. Important words in this Unit Operation are:

Conductors.	Primary cell.	Positive.
Nonconductors.	Voltmeter.	Negative.
Insulators.	Terminal.	
Batteries.	Connection.	

6. The instructor should review the experiments in the Unit Operation, stating specifically the reason for connecting the same and the knowledge which should result. For instance, in this Unit Operation the student should become familiar with the voltmeter, also with the types of dry cells and batteries. He should have some idea of the current flow in a simple circuit. He should also know how to determine the positive and negative terminals of a dry cell or battery by means of a voltmeter as well as by the markings of the terminals.

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SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

1. *a.* After Unit Operation No. 1 has been completed and all the questions in the text have been answered by each student the instructor should give the following Instruction Test, or devise one similar to it. This test is divided into two parts, namely, *Performance* and *Information.* For convenience, the Performance part of the test can be given to part of the class while the Information part is given to the others. The Performance part of the test may be typewritten or mimeographed. The Information part of the test should preferably be typewritten or mimeographed, but may be placed on the blackboard if found more convenient.

b. This test (Instruction) is designed to assist the instructor in determining those men who have fallen below the general average of the class and need further instruction. It also shows the student the knowledge he has failed to acquire during instruction periods.

2. *a.* The sample test here given is designed for instructional purposes, and the instructor should accordingly use it with that end in view. As a result of the classroom work, the student should have learned:

(1) How to measure the voltage of a dry cell;
(2) How to determine the direction of current through a simple circuit, and
(3) How to determine the positive and negative terminals of a dry cell or battery by means of a voltmeter.

This test should also demonstrate to the students themselves whether or not they have learned to do this work quickly and in the most workmanlike manner; also whether they correctly remember the names of the various parts of the equipment. The instructor should explain in detail the exact failings of each student, and if the results are unsatisfactory repeat the test after an interval of a day or two.

b. Should the instructor find it necessary to repeat the Information part of the test, or if for any other reason he desires to vary its form, it can be arranged very easily in the form of "observation" questions. To do this, simply provide a supply of tags numbered plainly from 1 to 10. Tie tag "No. 1" to a piece of carbon (obtained from an old dry cell) and write on the tag, "No. 1. Is this substance a conductor or a nonconductor?" To each of three more conductors and nonconductors tie a tag in a similar manner and write the above question on each. Place a tag on the positive lead of a type BA–2 cell and write on the tag, "No. . Is this the negative or positive terminal?" In a similar manner fasten a tag to each of the other parts of the equipment used and ask a question about the part. Supply each

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student with a slip of paper upon which he is to write plainly his name, the date, and the numbers 1 to 14. Then require each man to write down his answer opposite the corresponding numbers.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST NO. 1–A (PERFORMANCE).

Directions to the instructor.

Equipment.—Prepare in advance for each student:

2 type BA–10 cells (serviceable).
1 voltammeter, Weston, type 280.
4 feet of insulated wire.

Procedure.

1. Connect a 3-foot length of wire to each of the cell terminals. Tie a tag on the positive lead near the free end and mark it "A." Tie a tag on the negative lead near the free end and mark it "B." Conceal the dry cell in a box or wrap it in paper so that the terminals can not be seen by the student.
2. Prepare typewritten or mimeographed directions to the students.
3. Number plainly the positions where the equipment is laid out and place corresponding numbers on the sheets containing directions to the student.
4. Assemble the students either at their seats or at some point away from the equipment.
5. Ask if there are any questions; and if any, answer them.
6. Direct the students to go to their assigned positions and to face the instructor.
7. Direct "About face. Begin."
8. Note and record the time to the nearest second that the command "Begin" is given. Also note and record the time each individual student finishes. Following this, inspect and test each student's work. These records will provide the instructor with information which will indicate those students who fall below the general average of the class and who as a consequence will require further practice.

INSTRUCTION TEST NO. 1–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:

1 type BA–10 cell.
1 concealed cell with 3-foot leads.
1 voltammeter, Weston, type 280.
4 feet of insulated wire.

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2. When the instructor says "Begin," start the work promptly.

3. Perform the following operations *carefully* and quickly.

a. Using the insulated wire for connections, measure the voltage of the BA–10 cell with the voltmeter in the manner taught in Unit Operation No. 1. Record your reading on this line ....

b. Connect the voltmeter to the two leads extending from the concealed cell. Record the voltmeter reading on this line ....

c. One lead from the concealed cell is marked "A," the other "B." Determine which is the negative lead and which is the positive lead by the use of the voltmeter.

(1) The positive lead is marked by the letter ....

(2) The negative lead is marked by the letter ....

4. Notify the instructor at once when the work under *a*, *b*, and *c* has been completed by facing about and raising your right hand.

5. The instructor will then record the time it has taken to do the work. He will also inspect it.

Scoring.

1. The maximum score for this test is 4 points.

2. The score required to pass this test is 4 points.

3. *Directions for scoring.*

	Points.
a. If the student has correctly measured the voltage of the BA–10	1
b. If the student has correctly measured the voltage of the concealed cell	1
c. Correctly determined which is the positive lead and which is the negative lead	2

4. Where the student has failed to complete the test, or has failed to answer questions correctly, a grade of zero will be given for incomplete parts or incorrect answers.

INSTRUCTION TEST NO. 1-B (INFORMATION).

Part I.

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. Electricity is a name applied to a form of
(1) sound. (2) energy. (3) liquid. (4) solid. ......

b. Electricity is transferred from one point to another by
(1) a conductor. (2) a nonconductor. (3) an insulator. (4) a bakelite. ......

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c. Certain substances which are very poor conductors of electricity are termed

(1) meters. (2) reducers. (3) stems. (4) insulators. ......

d. The type of primary cell most useful for field radio communication is the

(1) wet cell. (2) crowfoot cell. (3) Lechlance cell. (4) dry cell. ......

e. The current generated by an electric cell flows outside of the cell from

(1) the negative terminal to the negative pole. (2) the zinc element to the carbon element. (3) the cover to the center. (4) the positive terminal to the negative terminal. ......

Part II.

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. Hard rubber is a good conductor of electricity. ......
2. The center or carbon electrode of a cell is the positive electrode. ......
3. Lead is a better conductor of electricity than copper. ......
4. The BA–10 cell must be charged by being filled with water before it is placed in service. ......
5. When the BA–10 cell is connected in a circuit such as a buzzer or bell circuit the current is said to flow from the carbon terminal through the external circuit to the zinc terminal. ......
6. In order to measure the voltage of a BA–4 cell with a Weston, model 280, voltammeter, the zinc terminal should be connected to the terminal of the voltammeter marked "Amps or Volts" and the carbon terminal to the terminal marked "3 volts." ......

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SERIES AND PARALLEL CONNECTIONS OF DRY CELLS AND BATTERIES.

Equipment.

1 type BA–4 cell (serviceable).
4 type BA–10 cells (serviceable).
2 type BA–2 batteries (serviceable).
1 type BA–8 battery (serviceable).
1 voltammeter, Weston, model 280.
1 ammeter, 0–50 scale.

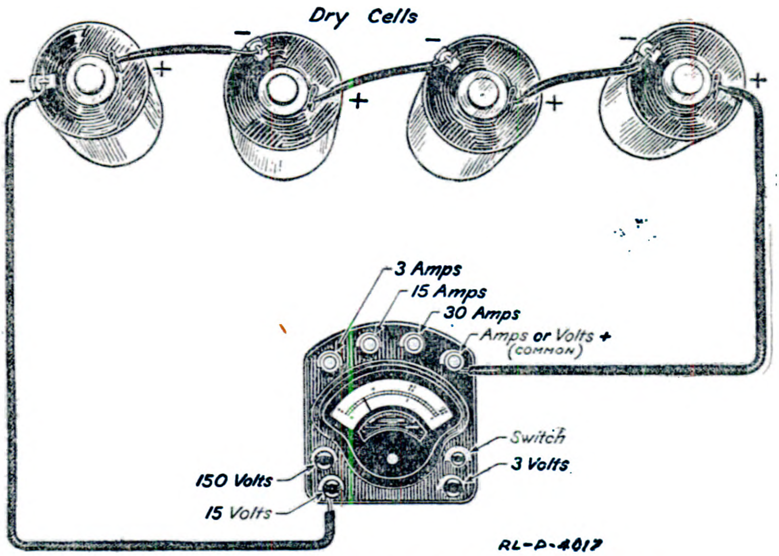

Fig. 4.—Method of connecting four dry cells in series.

Information.

Series connections.—At times it is necessary to use a voltage greater than the initial voltage of a single cell. As stated in the description of the BA–2 and BA–8 batteries, 15 cells are connected together in order to obtain 22 volts. When the cells are connected in this manner they are said to be connected in *series.* Fig. 4 shows how four type BA–10 reserve dry cells are connected in series for delivering current at a pressure of 6 volts.

Directions.

1. Measure the voltage of one of the BA–10 cells. Prepare a table similar to the one shown at the end of this Unit Operation. Record the reading obtained.

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2. Connect four type BA–10 cells in series as shown in Fig. 4. The positive terminal of one cell is connected to the negative terminal of the second cell. The negative terminal of the second cell is connected to the positive terminal of the third cell and so on. Measure the voltage of the four cells in series using the terminals marked "15 Volts" and "+Volts" on the voltammeter.

3. Record the reading in the table prepared.

Questions.

(1) *What voltage does the meter indicate?*

(2) *Multiply the voltage of one cell by the number of cells (4). What is the answer?*

(3) *Compare the answers to Questions 1 and 2. Would the same relation hold true if six cells were used in Direction 2?*

Information.

When measuring the voltage of a battery such as the type BA–2 or the type BA–8 battery, the terminals marked "Volts +" and "150 Volts" are used. The "Volts +" terminal is connected to the positive terminal of the battery while the "150 Volts" terminal is connected to the negative pole of the battery. With these connections the figures at the top above the scale are used. When measuring the voltage of a battery consisting of less than 10 dry cells, connections are made from the battery to the "Volts +" and the "15 Volts" terminals on the meter. The "3 Volts" terminal and the "Volts +" terminal are used when measuring the voltage of one or two dry cells. In this last case, the figures below the scales are used. When measuring the voltage of a battery, the voltmeter is always connected across the terminals of the battery.

Directions.

4. Measure the voltage of one of the BA–2 batteries using the terminals "150 Volts" and "Volts +" on the meter.

5. Record the reading in the table prepared.

6. Connect two of the BA–2 batteries in series. The positive or red wire lead of one battery should be connected to the "Volts +" terminal of the meter. The black or negative lead should be connected to the red or positive terminal of the second battery. The remaining black lead should be connected to the "150 Volts" terminal on the meter. Take the voltage reading and record it in the table prepared.

7. Measure the voltage of the BA–8 battery.

8. Record the reading in the table prepared.

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Question.

(4) *What difference is there between the voltage of a BA–2 battery and a BA–8 battery?*

Information.

Ammeters.—When using the meter shown in Fig. 2, as an ammeter, the connections are made with the terminals at the top of the meter.

(See Fig. 5 and Fig. 6.) The three terminals marked "3 Amps," "15 Amps," and "30 Amps" are the negative terminals. The positive or "Amps +" terminal is the same terminal used for the "Volts +" connection. When measuring the amperage of a dry cell or battery one terminal of the meter (usually the positive terminal) is connected directly to the positive terminal of the cell or

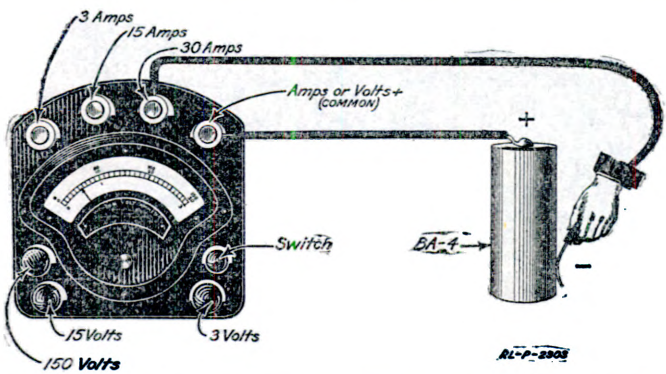

Fig. 5.—Method of making short-circuit test of type BA–4 cell.

battery. One end of the remaining wire is connected to the negative terminal of the meter. The other end of the wire is held against the negative terminal of the meter for an instant, just long enough to allow the needle to swing and come to a stop at the proper reading. This is important, for if the wire is held against the terminal too long the life of the battery will be shortened considerably.

Directions.

9. Measure the amperage of the BA–4 cell, making the connections as shown in Fig. 5. Take the readings quickly so as not to run down the cell. Record the reading in the table prepared.

10. Measure the amperage of the BA–10 cell using the terminal marked "30 Amps" and "Amps +" as shown in Fig. 6. Record the reading in the table prepared.

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Questions.

(5) *Which cell gave the greater amperage reading, the BA–4 cell or the BA–10 cell? Note the difference in size between the two cells.*

(6) *Which of the two cells will deliver the same current for a longer period of time?*

Directions.

11. Using the "15 Amps" and "Amps +" terminals on the meter, measure the amperage of the BA–2 battery. Record reading in table prepared.

12. Using the same terminals as in Direction 11, measure the amperage of the BA–8 battery. Record the reading in the table prepared.

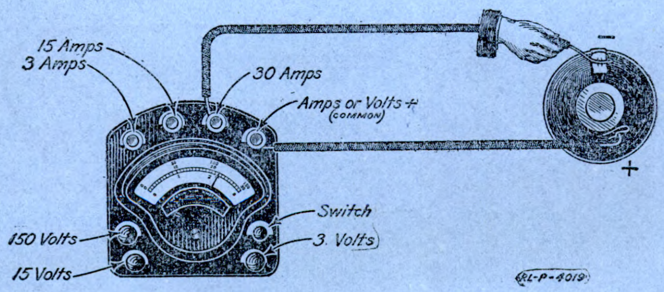

Fig. 6.—Method of making short-circuit test of type BA–10 cell.

Questions.

(7) *Which battery showed the higher reading?*

(8) *Why does one type of battery give a greater reading than the other?*

Information.

Parallel connections.—It is also possible to connect batteries in such a way that increased capacity in amperes may be obtained. Batteries connected in this way are said to be connected in *parallel.* Four reserve dry cells, connected in parallel are shown in Fig. 7. The positive terminals of the four cells are connected together and the negative terminals are connected together. One wire from the meter is connected to one of the positive poles while the other wire is connected to a negative pole, as shown. It is possible with this connection to draw four times the current which can be obtained from one cell.

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Directions.

13. Take four cells and connect all the positive terminals together and all the negative terminals together. (See Fig. 7.) Cells connected in this manner are said to be connected in parallel. Test the voltage of this combination. Record the reading in the table prepared.

Question.

(9) *How does this voltage compare with the voltage of one of the cells?*

Directions.

14. Connect two cells in parallel. Using the 0–50 scale ammeter (or two model 280 voltammeters with their 30 Amp. terminals con-

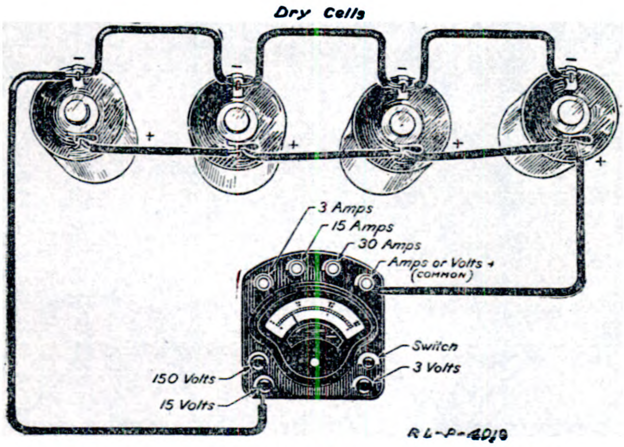

Fig. 7.—Parallel connections of four dry cells.

nected in parallel), make a short circuit test of the two cells thus connected. If the two model 280 voltammeters are used, the total current will be the sum of the readings of the two meters. Record the readings in the table prepared.

Questions.

(10) *How does this reading compare with the reading obtained when measuring the amperage of one cell?*

(11) *Multiply the reading obtained with one cell by the number of cells connected in parallel (two in this case). How does the answer compare with the meter reading of two cells in parallel?*

Directions.

15. Measure the voltage of the two cells connected in parallel. Record it in the table prepared.

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Question.

(12) *How does this reading compare with the voltage of one cell?*

Information.

From the above experiments it may be seen that when cells are connected in series the voltage of the combined cells is equal to the voltage of one cell multiplied by the number of cells connected in series. The amperage of the cells in series, however, is the same as that of one cell.

When the cells are connected in parallel the voltage of the combined cells is the same as that of one cell, while the amperage is equal to the amperage of one cell multiplied by the number of cells.

Directions.

16. Using the "15 Amps" and "Amps +" terminals on the voltammeter measure the short circuit current of the BA–2 battery.

17. Using the same terminals measure the short circuit current of the BA–8 battery.

18. Record the readings in the table prepared.

Questions.

(13) *Which battery gave the higher reading?*

(14) *Upon what does the capacity in amperes of a battery such as the BA–2 or the BA–8 depend?*

Directions.

19. Using the information obtained in the above experiment, insert the correct values in the blank spaces in the table prepared as below.

Arrangement of cells.		Type of cell or battery. BA–4.	BA–10.	BA–2.	BA–8.
1 cell	Volts				
	Amps				
2 cells in series	Volts				
	Amps				
4 cells in series	Volts				
	Amps				
15 cells in series	Volts				
	Amps				
30 cells in series	Volts				
2 cells in parallel	Volts				
	Amps				
4 cells in parallel	Volts				

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SUGGESTIONS FOR THE INSTRUCTOR.

1. The equipment listed in Unit Operation No. 2 of the Students Manual should be prepared in advance. All batteries and cells to be used in class should be tested prior to such use, and verified as to serviceability.

2. Divide the class into as many groups as there are sets of equipment.

3. Explain to the class what is meant by a "series" connection. Impress on the student's mind that in order to connect a cell, battery, or any piece of apparatus *in series* in a circuit, the circuit must actually be *cut* or *broken* and the apparatus then inserted. This will aid the student in distinguishing between *series* and *parallel* connections.

4. Explain that in connecting a piece of apparatus *in parallel* it is *not* necessary to *cut* or *break* the circuit.

5. Explain briefly the following and see that all students understand it thoroughly before proceeding further:

a. That in connecting cells or batteries in a circuit, that the greatest voltage (pressure) is obtained when the negative (−) pole of one is connected to the positive (+) pole of another, etc., i. e., *in series*, and that the voltage in a circuit can only be increased by *cutting* or *breaking* the circuit and inserting another cell, or battery; also, that the greatest amperage (current) of electricity is obtained by connecting all the negative (−) poles together, and all the positive (+) poles together, i. e., *in parallel.*

b. That the voltage of a number of cells connected *in series* is equivalent to the voltage of one (1) cell multiplied by the number of cells; and also, that the amperage (current) of a number of cells connected *in series* is equivalent to the amperage of one (1) cell.

c. That the voltage of a number of cells connected *in parallel* is equivalent to the voltage of one (1) cell, and that the current of a number of cells connected *in parallel* is equivalent to the amperage of one (1) cell multiplied by the number of cells.

6. The instructor should now direct the students to begin experiments listed under Unit Operation No. 2 in the Students Manual and render such assistance to the students as is necessary while supervising all of their work.

7. After completing these experiments each student should be required to answer as many as possible of the questions in this Unit Operation, and in addition the instructor may also ask such questions as follows:

a. Why will the BA–10 cell last longer in service than the BA–4 cell?

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b. Why does the BA–2 battery supply the same voltage as the larger type BA–8 battery?

c. Why does it shorten the life of a cell to keep it connected to an ammeter for a considerable time when it does not shorten the life by connecting to a voltmeter for the same length of time?

8. Briefly explain what is meant by a "series-parallel" connection. Show how two sets of three 4-volt batteries are connected in parallel, while the three batteries of both sets are connected in series. Explain how the total voltage is 12 volts, but that this arrangement will provide twice the current (i. e., last twice as long) as a single set of three batteries.

9. The important new words which occur in this Unit Operation are:

Series.	Amperes.	Capacity (of a battery)
Parallel.	Amperage or current.	Short-circuit current.
Ammeter.		

10. The instructor should review the experiments in this Unit Operation and state specifically the reasons for them. He should also state just what knowledge should have been obtained by the student. The student should now know:

a. How to connect cells or batteries in series and in parallel.

b. Which of the above arrangements gives him the most current or the most voltage.

c. How to find out whether or not a cell is serviceable by measuring both the voltage and the short-circuit current.

d. How to use an ammeter.

e. Information contained in the following table:

Arrangement	Number of cells	Voltage equivalent to—	Current equivalent to—
Series	10	10×1 cell	1 cell.
Parallel	10	1 cell	10×1 cell.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

1. After Unit Operation No. 2 has been completed and all the questions in the text have been answered by each student, the instructor should give the following Instruction Test, or devise one similar to it. For convenience, the *Performance* part of this test may be given to part of the class while the *Information* part is given to the rest of the class.

2. During the Performance part of this test it is necessary that the instructor personally supervise the work and record names of

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those students who are unable to connect the batteries properly. Such students should receive further instruction. The instructor should also observe that the students make connections to the proper binding posts on the voltammeter; otherwise this instrument may be damaged.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST NO. 2–A (PERFORMANCE).

Directions to the instructor.

Equipment.

4 batteries, type BA–2 or BA–8 (serviceable).
1 voltammeter, Weston, type 280.
6 feet of insulated wire (six lengths 6 inches long, two lengths 18 inches long).

Procedure.

1. Place available sets of the above equipment in suitable locations for conducting the test and assign the students who are to be tested to these positions.
2. Assemble the students and answer any questions they may wish to ask. Read and explain to the class the paragraph entitled "Caution" in the "Directions to the Student."
3. Distribute the previously prepared "Directions to the Student" and direct that the students go to their assigned places and face the instructor.
4. Direct "About face. Begin."
5. Note and record time to the nearest second that the command "Begin" is given.
6. Check the *series* connections that each student makes before allowing him to proceed with *parallel* connections and record names of those students who are unable to make proper connections.
7. Note and record the time each individual student finishes Performance part of the test.

INSTRUCTION TEST NO. 2–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   4 batteries, type BA–2 (or BA–8).
   1 voltammeter, Weston, type 280.
   6 feet of insulated wire.
2. When the instructor says "Begin," start your work promptly. Perform the following operations *carefully* and quickly.

CAUTION.—*In measuring unknown voltages or currents, connect first to the binding post on the voltmeter or ammeter used for obtaining maximum reading of the meter; otherwise the meter may be seriously damaged.*

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Problem No. 1.

1. Using the wire supplied for connections, measure the voltage of four type BA-2 (or BA-8) batteries connected *in series.* Record your reading on this line. ------------------

2. Measure the short circuit current of these batteries connected in series. Record your reading on this line. ------------------

3. Notify the instructor when you have completed this by raising your paper

Problem No. 2.

1. The instructor will then direct the class to connect the four BA-2 (or BA-8) batteries *in parallel.*

2. When the instructor says "Begin," connect the four batteries in parallel and measure the voltage. Record your reading on this line. ------------------

3. With the four batteries in parallel, now measure the current. (See CAUTION above.) Record your reading on this line. ---------------------------

4. Notify the instructor when you have finished by raising your paper.

5. The instructor will then record the time it has taken to do the work, and will also make an insoection of the work.

Scoring.

1. The maximum score for this test is 16 points.
2. The score required to pass this test is 12 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. If batteries are correctly connected in series	2
b. If battery terminals are correctly connected to the voltmeter	2
c. If voltmeter reading is correct	1
d. If battery terminals are correctly connected to the ammeter	2
e. If ammeter reading is correct	1

PROBLEM NO. 2.

a. If batteries are correetly connected in parallel	2
b. If battery terminals are correctly connected to the voltmeter	2
c. If voltmeter reading is correct	1
d. If battery terminals are correctly connected to the ammeter	2
e. If ammeter reading is correct	1

4. Where the student has failed to complete the test, or has failed to answer questions correctly, the grade of zero will be given for incomplete parts or incorrect answers.

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INSTRUCTION TEST NO. 2-B (INFORMATION).

Part I.

Directions to the student.—Below are a number of sentences. The last word in each sentence is omitted. Write the proper word on the dotted line.

1. When the positive terminal of one battery is connected to the negative terminal of the next, etc., the batteries are said to be connected in ....

2. When the negative terminals of all the batteries used are connected together and the positive terminals all connected together, the batteries are said to be connected in ....

3. Batteries are connected in series in order to obtain a greater ....

4. Batteries are connected in parallel in order to obtain a greater ....

5. In measuring the voltage of four BA-2 (or BA-8) batteries connected in series the positive battery terminal is connected to the voltmeter binding post marked "Volts or Amps+," and the negative battery terminal is connected to the voltmeter binding post marked ....

Part II.

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. What voltage is obtained by connecting four 1½-volt dry cells in series?

(1) 1½ volts. (2) 3 volts.
(3) 4½ volts. (4) 6 volts. ------

b. What voltage is obtained by connecting three 1½-volt dry cells in parallel?

(1) 4½ volts. (2) 9 volts.
(3) 1½ volts. (4) 6 volts. ------

c. If the short-circuit current produced by one dry cell is 20 amperes, what is the short-circuit current of a battery of four dry cells connected in parallel?

(1) 80 amps. (2) 1½ amps.
(3) 40 amps. (4) 20 amps. ------

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d. If the four cells in question *c* were connected in series, what would the short-circuit current be?

(1) 80 amps. (2) 20 amps
(3) 40 amps. (4) 6 amps. ------

e. A certain 1½-volt dry cell will light a 1½-volt flash-light lamp for 100 hours. How long would four cells, such connected in parallel, light the lamp?

(1) 100 hours. (2) 200 hours.
(3) 400 hours. (4) A fraction of a second. ------

f. How long would the same cells mentioned in question *e* light the same size lamp, if connected in series?

(1) 100 hours. (2) A fraction of a second.
(3) 400 hours. (4) 200 hours. ------

g. Why are cells or batteries connected in series?

(1) To obtain a greater current.
(2) To reduce the voltage.
(3) To make them last longer.
(4) To obtain greater voltage. ------

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STORAGE BATTERIES.

Equipment.

1 storage battery, type BB–14 (fully charged).
1 storage battery, type BB–28 (fully charged).
1 storage battery, type BB–41 (fully charged).
1 storage battery, type BB–5 (fully charged).
1 voltammeter, Weston model 280 (with leads).
1 pair battery leads, with clip terminals.
1 ruler.

Information.

Storage batteries.—The secondary battery or storage battery is somewhat similar to a primary battery. The storage battery, like the

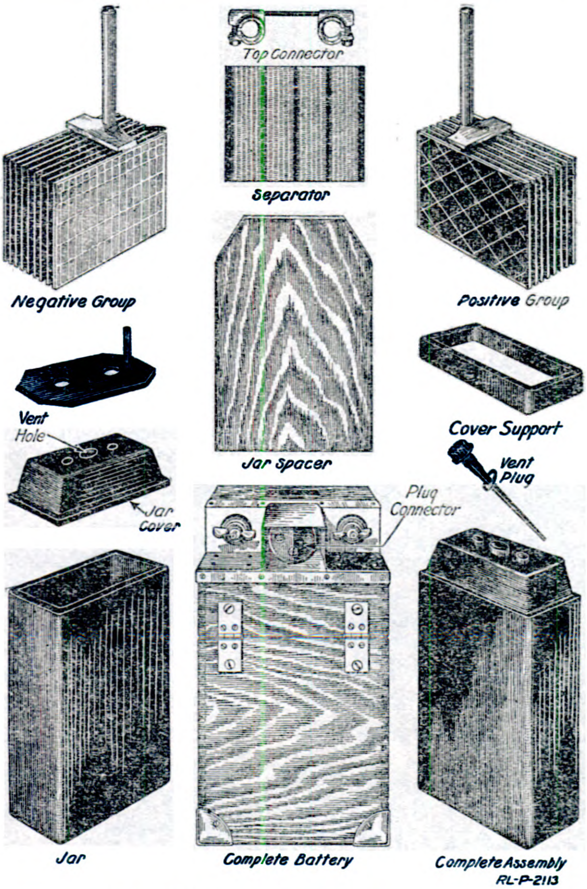

Fig. 8.—Various parts used in construction of type BB–14 storage battery.

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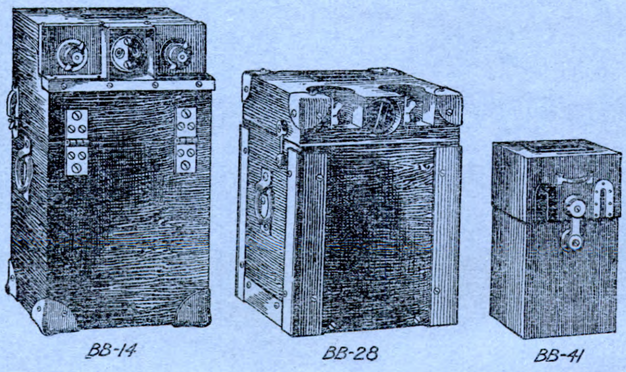
primary battery, generates electricity by chemical reaction. The principal difference, however, is that before the storage battery can generate electricity it must first be *charged*. In other words, a direct current from an outside source of electricity, commonly a generator, must be sent through the battery. Usually this current is applied for a number of hours until the necessary chemical changes have taken place inside the battery. The battery is then ready for use. When current is taken from a storage battery, the battery is said to be *discharging*. After a battery has been used for a certain number of hours, it becomes discharged and can not be used again until the charging process is repeated.

Lead cell battery.—There are two types of storage batteries, one the lead cell type, and the other the Edison battery in which the



Figs. 9, A–B–C.—Three types of lead cell storage batteries used in signal communication.

plates are made of nickel and iron. A storage cell of the lead type consists of a hard rubber or composition jar in which are placed two sets of lead plates. (See Fig. 8.) The plates of one set fastened together to a common terminal form the negative pole of the battery, while the plates of the other set also fastened together to a common terminal, form the positive pole of the battery. The negative plates are made with small rectangular indentations or pockets on both sides. These pockets are filled with active chemical material. The positive plates are made in the same manner, but are filled with a different active chemical material. The group of negative plates are immeshed with the group of positive plates in such a manner that beginning from one side of the cell the first plate is negative in polarity, the next plate positive, the next negative, and so on. In order to keep the plates from touching one another, a wooden or a hard rubber

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separator is placed between the plates. The cell jar is filled with a dilute solution of sulphuric acid and water.

The majority of storage batteries used in the Signal Corps for radio purposes consist of two cells. In order to protect the cells against damage, they are inclosed in a strong wooden box at the top of which terminals for connections are provided. The battery shown in Fig. 8 and Fig. 9, A, is the type BB–14 storage battery.

The type BB–28 storage battery shown in Fig. 9, B, is similar in construction to the type BB–14 battery. The type BB–41 is a portable, two-cell, storage battery which is much smaller in size than the other type of batteries. This battery is shown in Fig. 9, C.

As the short circuit amperage of a storage battery is very high it is impractical to determine its serviceability by the short-circuit test. *Under no conditions should an ammeter be connected across the terminals of a storage battery, as this action will result in the burning out of the meter.*

Question.

(1) *When dry cells are replaced by storage batteries what additional equipment must be provided?*

Directions.

1. Measure the height, length, and width of each of the three lead type batteries.
2. Open the cover of the BB–14 battery and note how the terminals on the cover are connected to the terminals of the cells. Also note the connection between the two cells.
3. Using the leads without the clips, connect the voltmeter to the outside cover terminals of the battery. A strip of red fiber marks the positive terminal of the battery, and a strip of black fiber marks the negative terminal. Measure the voltage of the battery.
4. Prepare a table similar to the one shown below and record the readings taken in this experiment and those following.

Type of storage battery.	No. of cells.	Voltage of one cell.	Voltage of battery.	Ampere-hour capacity.
BB–14..........	....	....	....	....
BB–28..........	....	....	....	....
BB–41..........	....	....	....	....
BB–5...........	....	....	....	....

5. Using the leads provided with the clip terminals, connect the voltmeter to the inside battery terminals, being careful to get the polarity right. Measure the voltage of the battery and record it in the table.

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6. Measure the voltage of one cell by clipping the meter leads to the cell terminals as shown in Fig. 10. Record the reading in the table.

7. Connect the voltammeter to the outside terminals of the BB–28 battery. The positive and negative poles are clearly marked on the cover. Read and record the voltage.

8. Open the cover of the BB–28 battery and connect the voltmeter to either one of the cells using the leads with the clip terminals. (See direction 5.) Measure and record the voltage.

9. Repeat directions 6, 7, and 8, using the BB–41 battery in place of the BB–28 battery.

Information.

Voltage and amperage.—The voltage of a lead storage cell when fully charged is about 2 volts. The capacity of a storage battery is represented by its rating in " ampere-hours." This rating theoreti-

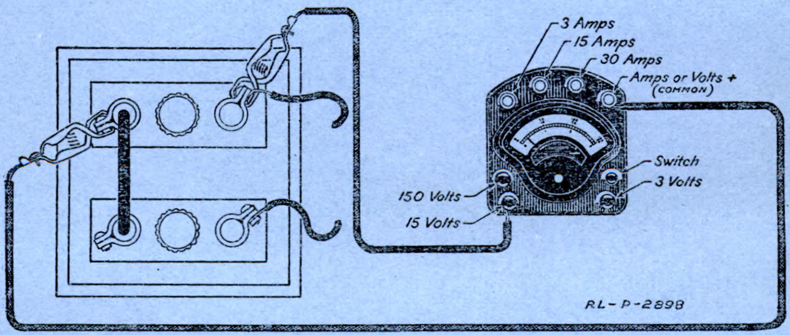

Fig. 10.—Method of measuring the voltage of one cell of a storage battery.

cally represents any discharge rate in amperes multiplied by the number of hours the battery may be discharged at that rate. For instance, a 100 ampere-hour battery will deliver 100 amperes for 1 hour, 50 amperes for 2 hours, 25 amperes for 4 hours, 10 amperes for 10 hours, or 2 amperes for 50 hours. It is not practical, however, to draw as many as 100 amperes for 1 hour from a storage battery of the small portable type, such as is used with radio sets. This rate of discharge is too great, and in a very short time would cause the battery to become completely ruined. It is necessary therefore to discharge the battery at a lower rate. A normal rate of discharge is usually specified by the manufacturer of the storage battery. The normal discharge rate is the rate at which experience has shown can not be exceeded without more or less injury to the battery. For instance, if the normal discharge rate of a 100 ampere-hour battery is

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20 amperes, in no case should the battery be discharged at a higher rate than at 20 amperes.

The ampere-hour capacity of a battery depends mainly upon the size and number of plates in the cells. The greater the size and number of plates there are in a cell the greater will be the ampere-hour capacity of the battery.

The type BB–14 storage battery is a 100 ampere-hour battery consisting of two cells. Since the voltage of one cell is 2 volts and the cells are in series, the battery is rated at 4 volts.

The type BB–28 storage battery is a 90 ampere-hour battery. Since it contains two cells, the battery is rated at 4 volts.

The type BB–41 storage battery is a 2-cell, 4-volt, 16 ampere-hour battery. The plates are smaller in size and therefore the capacity of the battery is much less than the type BB–14 or BB–28 batteries.

Directions.

10. Fill in the ampere-hour capacity for all three batteries in the table prepared under Direction 4.

Questions.

(2) *Upon what does the voltage of a storage battery depend?*

(3) *Upon what does the ampere-hour capacity of a storage battery depend?*

(4) *A certain lead-cell type of storage battery has three cells connected in series and is rated at 60 ampere-hours. What is the voltage of the battery? For how many hours will it deliver 2 amperes of current?*

(5) *Which would be the easiest to carry in the field, the BB–14, BB–28, or BB–41?*

(6) (*a*) *A radio set which uses the type BB–41 battery is to be placed in service for continuous use with a combat unit in the field. This set requires 4 amperes for operation. Batteries can be delivered only once each night. How many batteries should be supplied in order to operate the set?*

(*b*) *If a BB–28 is used, how many batteries should be supplied for the same set?*

(*c*) *If a BB–14 is used, how many batteries should be supplied for the same set?*

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(7) (*a*) *How many men would be required to carry the batteries in question* (6) (*a*)*?*

(*b*) *How many men would be required to carry the batteries in question* (6) (*b*)*?*

(*c*) *How many men would be required to carry the batteries in question* (6) (*c*)*?*

(8) *Which type of battery would a radio section chief decide to carry for the set in question* (6) *if he were given his choice? Why?*

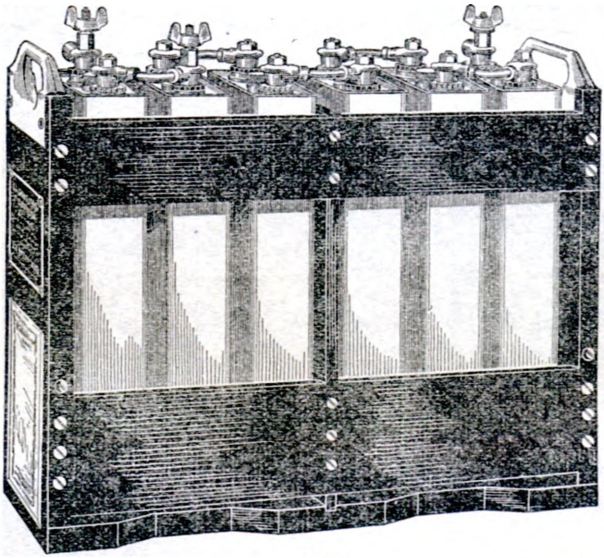

Fig. 11.—Edison storage battery, type BB–5.

Information.

Edison battery.—The Edison battery generates electricity in the same manner as the lead cell type of battery; that is, by chemical reaction. The Edison battery differs from the lead battery in construction, however, the positive plates of the Edison cells being composed of nickel while the negative plates are of pure iron. The cell jars are made of nickel-plated sheet steel. The solution used in the cells consists of caustic soda and water. The type BB–5 storage battery is an Edison battery having 6 cells. (See Fig. 11.) For situations requiring a portable battery, the Edison cells are contained in sheet-steel boxes, while for permanent installations a wooden rack is provided as a container for the cells.

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Questions.

(9) *What is the chief advantage of the storage cell?*

(10) *What is the chief disadvantage?*

Directions.

11. Measure the voltage of the type BB–5 Edison battery. Measure the voltage of any one cell. Record the measurements in the table prepared under Direction 4.

The type BB–5 storage battery is a 6-cell, 8-volt, 100 ampere-hour Edison battery. The voltage of each cell is about 1.25 volts. Since there are 6 cells, the battery is rated at 7.5 volts.

Questions.

(11) *What is the difference between a secondary battery and a primary battery?*

(12) *How is a storage battery charged?*

(13) *How does the Edison storage battery differ from the lead cell type of battery?*

(14) *What is the approximate voltage of a fully charged lead type cell? Of an Edison cell?*

CARE OF STORAGE BATTERIES IN THE FIELD.

Information.

Spilling of acid.—Some of the lead storage batteries used by the Army for field service are of the nonspill type. However, this will not prevent the acid from leaking should the battery be overturned. To avoid this always keep the storage battery in an upright position. If any acid should spill or leak from the cell it must be carefully wiped off at once as it causes corrosion of the cell terminals. Take care never to get the acid on the hands or clothes as it may cause a burn or eat holes in the clothing.

Keeping terminals clean.—The action of the acid on the terminals of the cell is such as to cause a green insulating material to collect upon them. Should this material collect to too great a degree it will thoroughly insulate the terminal thus making it impossible to secure a good contact. Care must be taken that both terminals of the storage battery are kept clean as all times.

Testing.—Never short-circuit a storage battery to determine its state of charge as this may buckle the plates and permanently ruin the battery. The testing of a storage battery in the field should be by means of a voltmeter. When the battery is fully charged the

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voltage should be from about 2.0 to 2.2 volts per cell. The voltage drops as the battery is used until at discharge it is about 1.8 volts per cell.

Using one cell.—Sometimes it may be necessary to use only two volts instead of four volts. If only one cell of the battery is used the cells should be used alternately so as to discharge the cells to the same degree. This is to facilitate charging.

Dropping of batteries.—The case of each cell is made of hard rubber which if subjected to severe usage will crack and allow the acid to leak. Never throw the battery down on the ground or drop it.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Prepare in advance the equipment as listed in the Students Manual. Divide the class into as many sections as there are sets of equipment. Sections should be small, and preferably contain not more than two men.

2. Explain carefully to the students that the storage battery does not actually *store* electricity nor is it *charged* with electricity in the same manner as a condenser, but that it converts chemical energy into electrical energy while discharging, and vice versa while charging.

3. Make clear the distinction between a primary and secondary battery. Explain that the primary cell is usually one that is discarded when discharged, while the storage battery is much more permanent, being charged repeatedly and continuing to give service until worn out.

4. Explain that the short circuit current of a *dry cell* can be measured with an ammeter, because this current is within the range of the average ammeter. Also explain that the storage battery is capable of producing such a great amount of current when short circuited, that the average ammeter will be burned out when connected across a storage battery. Stress the fact that one should *never* attempt to measure the short-circuit current of a storage battery with an ammeter.

5. Include an explanation to the effect that a storage battery if turned upside down will leak electrolyte, and that this will not only harm the battery, but will also burn the hands as well as the clothes of the operator, since electrolyte is an acid. A full explanation of the term "electrolyte" should be included.

6. Point out that the case of each cell in a storage battery is made of brittle hard rubber. If the battery is dropped to the ground, the case will be broken, causing a leakage of the electrolyte and rendering the battery useless.

7. Show the class the four types of storage batteries as indicated below:

a. BB–14.—Open the cover of the battery and explain how the cell terminals are connected by flexible leads to the terminals on the cover, pointing out the polarity markings on the cover. Explain the markings of the terminals, i. e., red indicating the positive terminal and black the negative terminal. Compare the size of the BB–14 battery with other batteries.

b. BB–28 and BB–41.—Open the cover of the BB–28 and BB–41 batteries and explain that connections are made direct to the battery

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terminals on the cells. Show where the terminals are marked on the cover both with the "+" and "−" signs and with red and black colors.

c. BB–5.—Show the class the BB–5 battery and compare it in size to a lead-cell storage battery of the same capacity. Explain the polarity markings. Explain also that the two end terminals are used to obtain 7½ volts, while the terminals on the first and sixth cell are used to obtain 6 volts.

8. Emphasize the fact that extreme care must be exercised when connecting voltammeters to storage batteries. The voltammeter will be burned out if the batteries are connected to the wrong terminals. Emphasize also that the storage battery must not be short-circuited, as this will injure the battery and may result in rendering it entirely useless.

9. Explain the term "ampere-hour" capacity, and have the students observe the size of each battery in relation to the ampere-hour capacity of each.

NOTE.—Additional information may be obtained from Training Pamphlet No. 8, "Storage Batteries."

10. Require each member of the class to perform all the steps of the experiments contained in the Students Manual. Supervise the work in person and see that each student answers verbally as many as possible of the questions asked in the Unit Operation. In order to bring out further details, the following additional questions may be asked:

a. Which is the heavier, an Edison or lead-type battery of the same capacity?

b. Which of the above types of batteries is less liable to breakage in field work?

c. What is meant by "buckling" of the plates of a storage battery?

d. How would you test an Edison battery for condition?

e. Does the specific gravity of the electrolyte in an Edison battery decrease with the discharge of the battery?

11. Important new words in this Unit Operation are:

Storage battery.	Chemical.	Normal (charge or discharge).
Secondary battery.	Separator.	Nickel.
Charge.	Dilute solution.	Iron.
Discharge.	Electrolyte.	Caustic soda.
Edison battery.	Sulphuric acid.	Corrosion.
Lead-cell battery.	(Battery) Leads.	Buckle.
(Battery) Plates.	Ampere hour.	
Hard rubber.	Rate (charge or discharge).	
Fiber.		

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12. The instructor should review the experiments in the Unit Operation, stating specifically the reason for conducting the same and the knowledge which each student should have obtained. To cite, for instance, in this Unit Operation, the student should know all the types of storage batteries used, by number, and also be able to recognize any one of them by its size, shape, and general appearance. He should know the important parts of both the Edison and lead-cell batteries; the voltage of one cell of each of the above type; the ampere-hour capacity of each of the four types of batteries; how to test them as to condition of charge, how to care for and handle them in the field.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 3–A (PERFORMANCE).

Directions to the instructor.

Equipment.—Prepare in advance the following equipment:

1 battery, type BB–14 (or BB–28), discharged.
3 batteries, type BB–14 (or BB–28), fully charged.
1 voltammeter, Weston, model 280, with leads.

Procedure.

1. Instruct the students to read the directions and to proceed as soon as the command "Begin" is given.
2. Note and record the time that the command "Begin" is given and note the time that each student finishes.
3. Inspect and test the results of the students' work.

INSTRUCTION TEST No. 3–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
 1 battery, type BB–14 (or BB–28), discharged.
 3 batteries, type BB–14 (or BB–28), fully charged.
 1 voltammeter, Weston, model 280, with leads.
2. When the instructor directs "Begin," start work promptly. Perform the following operations *carefully* and quickly:
3. Measure the voltage of each battery and determine which one is discharged. Record the number of this battery on the dotted line. --------------------
4. Notify the instructor when you have finished by raising your paper.
5. When the instructor again directs "Begin," connect the three fully charged batteries in series, and measure and record the voltage on the dotted line. --------------------

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6. Notify the instructor when finished by raising your paper.

7. The instructor will then record the time it has taken to do the work and will also inspect it.

Scoring.

1. The maximum score for this test is 8 points.
2. The score required to pass this test is 8 points.
3. *Directions for scoring.*

	Points
a. Selecting the discharged battery	6
b. Measuring the correct voltage of the three storage batteries connected in series	2

4. Where the student has failed to complete the test, or has failed to perform it correctly, a grade of zero will be given for incomplete parts or incorrect answers.

INSTRUCTION TEST NO. 3–B (INFORMATION)

Part I.

Directions to the student.—Below are a number of questions. Each question requires an answer of only *one* word or number. Write this word or number on the dotted line at the end of the question.

1. How many cells has the Edison type BB–5 battery? ------
2. How many hours (theoretically) will a 100 ampere-hour battery deliver a current of 5 amperes? ------
3. What color is the negative terminal of a storage battery painted? ------
4. What color is the positive terminal of a storage battery painted? ------
5. What is the ampere-hour capacity of the type BB–20 storage battery? ------
6. If a 4-volt dynamotor draws 6 amperes, which battery will operate it the longer, the type BB–41 or the type BB–14? ------

Part II.

Directions to the student.—Below are a number of questions. Each question has four answers, only one of which is correct. Write the number of the correct answer *on the dotted line* at the end of each question.

a. What voltage is supplied by the type BB–14 battery? ------
(1) 2 volts. (2) 4 volts. (3) 6 volts. (4) 7½ volts. ------

b. What voltage is supplied by the type BB–28 battery?
(1) 7½ volt. (2) 2 volts. (3) 4 volts. (4) 6 volts. ------

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c. What is the voltage of one cell of an Edison battery fully charged?

(1) ¾ volts. (2) 1¼ volts. (3) 1½ volts. (4) 2 volts. ------

d. What is the voltage of one lead type cell?

(1) 1¼ volts. (2) 1½ volts. (3) 2 volts. (4) 1 volt. ------

e. What is the ampere-hour capacity of the BB–28 battery?

(1) 60 A. H. (2) 90 A. H. (3) 100 A. H. (4) 16 A. H. ------

f. Upon what does the voltage of a storage cell depend?

(1) The size of the cell. ------
(2) The distance between plates. ------
(3) The ampere-hour capacity. ------
(4) The kind of plates and electrolyte used. ------

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RESISTANCE.

Equipment.

1 4-volt storage battery.
1 VT-1 vacuum tube.
1 VT-1 vacuum tube socket, attached to small board; the filament terminals on the socket should be wired to Fahnestock terminals on the board.
1 voltammeter, Weston model No. 280.
2 5-foot lengths No. 18 B. & S. magnet wire.
2 1-foot lengths No. 18 B. & S. magnet wire.
1 5-foot length No. 32 B. & S. magnet wire.
1 10-foot length No. 32 B. & S. magnet wire.
2 battery clips.
1 resistor (approx. 0 to 20 ohms).

Information.

Electrical resistance and conductors.—It is well known that pipes offer opposition or resistance to the flow of water through them, due to the friction between the running water and the sides of the pipes. In a somewhat similar way all bodies offer some opposition to the passage of an electric current through them. Hence all conductors of electricity, even the best, offer some opposition to the flow of an electric current. This opposition is termed the electrical resistance of a substance. Electrical resistance is measured in units called *ohms*. The resistances of different conductors vary according to the substances of which the conductors are composed. A pure silver conductor, for instance, offers less resistance to a flow of current than any other conductor of the same size. Due to its low resistance, silver makes the best conductor of electricity. For this reason silver is used as a standard with which to compare the resistances of other conductors. Next in order to silver in its readiness to conduct electricity ranks copper. While its resistance is higher than that of silver, yet it is somewhat lower than the resistance of any other substance. Because of this low resistance, together with its comparatively small cost, copper wire is the most commonly used conductor of electricity in general use. Other substances which may be used as conductors, but which offer higher resistances than do silver and copper, are mentioned here in the order in which their resistances compare with that of silver beginning with the material having the least resistance. These substances are: Aluminum, zinc, brass, platinum, iron, nickel, tin, lead, German silver, and carbon.

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Resistance of wire.—The resistance of a conductor depends not only upon the nature of the substance of which it is made but also upon the size and length of the conductor. Thus the resistance of a copper wire depends upon its size (or cross sectional area) and its length. If two pieces of copper wire have the same length, but the diameter of the one is greater than the diameter of the other, then the resistance of the larger wire will be less than will that of the smaller wire. That is, the resistance of a wire conductor decreases with any increase in the size (or cross sectional area) of the wire. Also a piece of copper wire of a certain diameter and 10 feet long

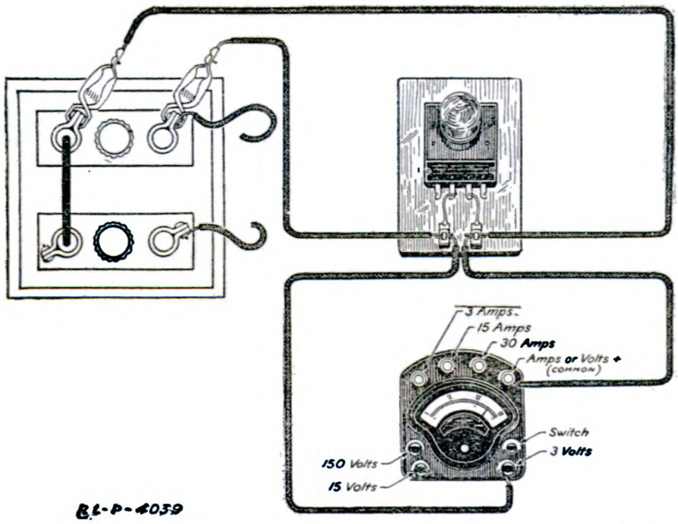

Fig. 12.—Method of measuring the voltage at the filament terminals of a vacuum tube or lamp.

will have a greater resistance than another piece of copper wire of the same diameter but only 1 foot long. In other words the resistance of a wire conductor increases with the length of the wire.

Directions.

1. The object of the following experiments is to show the effect of resistance in an electrical circuit. Attach a battery clip to one end of each of the two 5-foot lengths of No. 18 magnet wire. Open the 4-volt storage battery box and attach one of the clips to the positive terminal of one cell and the other clip to the negative terminal of the same cell. Connect the wires leading from the cell to the two Fahnestock terminals leading to the vacuum tube socket. (See Fig.

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12.) Using the two short lengths of No. 18 magnet wire, connect the 3-volt terminals of the voltmeter across the two socket terminals.

2. Measure the voltage of the cell to be used by pressing the small button on the meter. The meter should then read about "2 volts."

3. Prepare a table similar to the one shown below and record the results that are obtained in the experiments that follow.

Direction No. in the text.	The experiment.	The question.	The answer.
2	Measurement of the voltage of cell	Voltage is?	
4	Measurement of voltage with tube in socket (leads, No. 18 wires)	Voltage at tube terminals is?	
		Does tube light?	
5	Measurement of voltage with tube in socket (leads, 5 feet No. 18 wire; 5 feet No. 32 wire)	Voltage at tube terminals is?	
		Does tube light?	
6	Measurement of voltage with tube in socket (leads, 5 feet No. 18 wire; 10 feet No. 32 wire)	Voltage at tube terminals is?	
		Does tube light?	

4. Place the vacuum tube in the socket. To do this properly, turn the tube until the pin on the side of the base clips into the slot in the side of the socket. Press the tube down and turn to the right until it is locked in place. Notice whether or not the filament of the tube is lighted. (The filament when properly lighted glows a dull red.) Press the button on the voltmeter and note the reading. Record observations in the table that has been prepared.

5. Remove one of the 5-foot No. 18 wire leads from the circuit and replace it with the 5-foot No. 32 wire. Note whether or not the filament of the tube lights. Press the button on the meter and note the reading. Record the observations in the table.

6. Remove the 5-foot length of No. 32 wire from the circuit and replace it with the 10-foot length of No. 32 wire. Note whether or not the filament of the tube lights. Again take a voltmeter reading. Record the observations in the table.

7. The amount of current flowing through the vacuum tube filament is indicated by its brilliancy. The more current the greater the brilliancy. Any change in brightness clearly demonstrates that the current in the circuit has changed. Thus the vacuum tube in these experiments shows us at once relative amounts of current flowing through it.

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Questions.

(1) *Look at the table which you have completed. Is there a difference in the readings of the voltmeter in Directions 2 and 4? If there is a difference, to what is it due?*

(2) *Why did the filament light up in the experiment under Direction 4, but not light in the experiment under Direction 5?*

(3) *What does the voltmeter show regarding two pieces of wire which are of the same length but of different sizes?*

(4) *Which wire delivers the smallest amount of current to the tube, the 5-foot No. 32 wire or the 10-foot No. 32 wire?*

(5) *What is the object in placing a resistance in a circuit?*

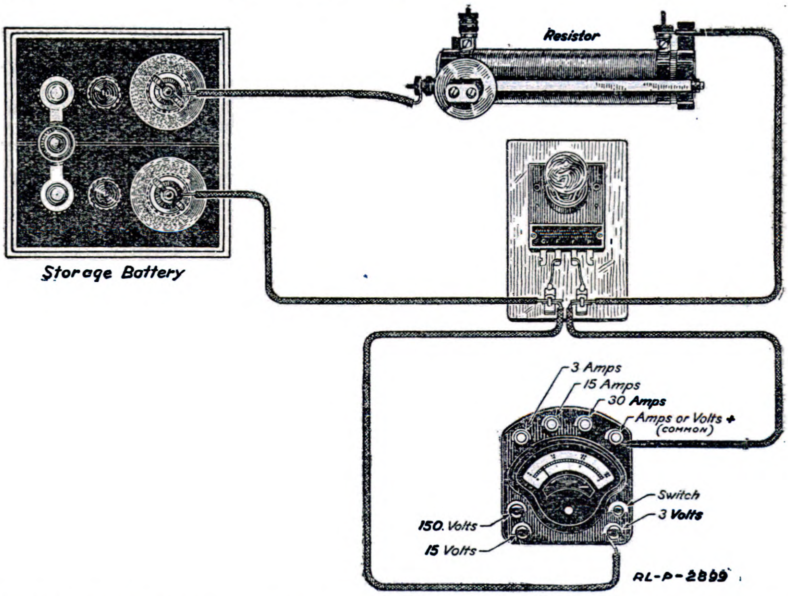

Fig. 13.—Method of connecting a resistor in series with a vacuum tube and storage battery.

Information.

Resistors.—If a certain length of resistance wire, for example, German silver wire, is inserted in a vacuum tube circuit in which a current is flowing, the pressure at the terminals of the tube will be reduced, and at the same time the flow of current through the tube will be reduced. If the length of the resistance wire is increased the voltage and current will be still further reduced. Fig. 13 shows a resistance inserted in series with a VT–1 vacuum tube and battery. The resistance in this case is a device known as a *resistor* or *rheostat.*

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The resistor consists of a tube of insulating material upon which is wound a number of turns of German silver or composition resistance wire. The ends of the coil thus formed are fastened to connecting terminals attached to the ends of the tube. A fastening device at each end of the tube supports a slide rod placed above the coil. A slider makes connection between the slide rod and the resistance wire by means of a contact spring attached to the slider. The number of turns of resistance wire, in other words the length of the wire in use, may be varied by moving the slider. The storage battery in Fig. 13, is a 4-volt battery. The filament of the tube shown requires only 2.5 volts in order to burn at proper brilliancy.

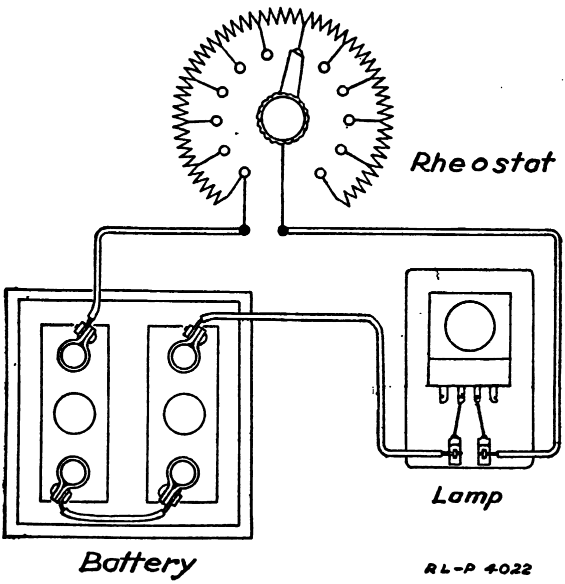

Fig. 14.—Rheostat connected in series with a lamp and a storage battery.

Directions.

8. Replace the 10-foot No. 32 wire with the 5-foot No. 18 wire so that the connections will be the same as originally made in Direction 4. Cut one of the 5-foot leads in the middle and remove the insulation from the ends of the wires. Connect these ends to the resistor exactly as shown in Fig. 13, making sure the slider on the resistor is placed at the terminal end of the rod. Press the button switch on the meter and note the reading. Note whether or not the filament of the tube is lighted.

Question.

(6) *What is the reading of the voltmeter?*

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Directions.

9. Move the slider about one-fourth of an inch toward the opposite end of the rod and notice any change in the voltmeter reading as well as any change in the lighting of the filament.

10. Move the slider gradually in the same direction until the filament of the tube glows a bright red. *Caution:* Do not move the slider beyond a point at which the voltmeter needle swings to the end of the scale (3 volts), as there will then be danger of burning out the filament of the tube.

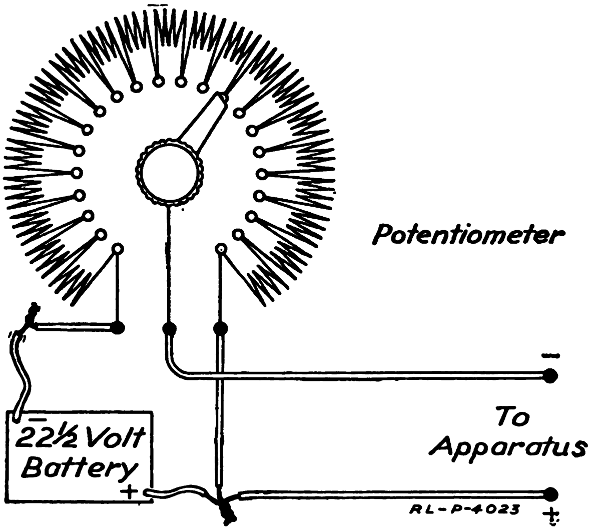

Fig. 15.—Method of connecting a potentiometer.

Questions.

(7) *What voltage was indicated by the voltmeter in Direction 10?*

(8) *Why does the filament burn brighter with less resistance in the circuit?*

(9) *Why is it necessary to use a resistor in this circuit?*

(10) *Does the voltage reading of the meter increase or decrease as the filament of the tube burns brighter?*

Information.

Resistances, Rheostats, Potentiometers.—Resistances or rheostats are also made in a circular form. Taps are taken off from a resistance winding and connected to switch points. The amount of resistance included in a circuit is varied by turning a rotary switch arm which makes contact with the switch points. A rheostat of the cir-

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cular type properly connected in series with a VT–1 vacuum tube and battery is shown in Fig. 14.

Another method of connecting resistance in a circuit is shown in Fig. 15. The resistor when used in this manner is called a *potentiometer*. With the connections shown, it is possible to obtain any voltage desired from zero up to the full voltage of the battery. The potentiometer is similar in construction to the rotary type of rheostat. The resistance wire of the potentiometer is much greater than that of the rheostat. This high resistance is necessary due to the fact that the wire is connected directly across the terminals of the battery. As shown in Fig. 15, the resistance winding of the potentiometer is connected directly across the 22½-volt battery. The switch arm is connected to one terminal of the apparatus to be used while the other terminal is connected to one side of the battery. By turning the switch arm the voltage delivered to the terminal of the apparatus is varied accordingly.

Questions.

(11) *Why is the circular form of rheostat more practical for use in a radio set than the straight type resistor?*

(12) *Why could not a potentiometer, used as in Fig. 15, be constructed with a low resistance similar to a rheostat?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. The equipment listed should be prepared in advance. Divide the class into as many groups as there are sets of equipment. Endeavor to keep these groups as small as possible.

2. *a.* Show the class one length of No. 18 magnet wire and one length of No. 32 magnet wire, pointing out the difference in diameter of the two wires. Explain that if these two wires were hollow tubing, that more water could be passed through the larger one than the smaller. Explain that similarly more electrical current flows through the larger wire than the smaller one, i. e., when the same voltage is applied to each.

b. Explain how these wires are connected to the battery clips. Give a detailed explanation of the circuit with special reference as to the manner in which the VT sockets are connected to the two center socket terminals, explaining further that the filament is connected across these.

3. The instructor should now direct the students to begin the experiments listed under Unit Operation No. 4 and render such assistance as is necessary, at the same time supervising their work.

4. After completing these experiments each student should be required to answer as many as possible of the questions in this Unit Operation, and in addition the instructor may also ask such question as the following:

a. Why is copper universally used as a conductor?

b. Is it the current or the voltage that makes the filament light?

c. Why is the filament of any electric lamp inclosed in a so-called vacuum tube?

d. Why is the voltmeter put directly across the filament of the tube rather than across the battery terminals?

5. The important new words in this Unit Operation are:

Resistance.	Vacuum tube.	German silver.
Resistor.	VT socket.	Zinc.
Rheostat.	Fahnestock terminals.	Brass.
Potentiometer.	Magnet wire.	Platinum.
Ohm.	Silver.	
Filament.	Aluminum.	

6. The instructor should review the experiments in this Unit Operation, stating specifically the reason for each experiment. He should then explain just what knowledge should have been obtained by the student, and before proceeding further assure himself that each

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student has a thorough understanding of what has gone before. The student should have learned from this Unit Operation the following:

a. What resistance is and how it affects the flow of electric current.

b. Which metals are the best conductors of electricity.

c. How the resistence of a wire depends upon the kind of metal the wire is made of as well as its length and diameter.

d. What resistors, rheostats, and potentiometers are and their uses.

e. Why a resistance is used in the filament circuit of a vacuum tube.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

1. After Unit Operation No. 4 has been completed and all the questions in the text have been answered by each student, the instructor should give the Instruction Test given below, or devise one similar to it. For convenience the *Performance* part of the test may be given to part of the class while the *Information* part is given to the remainder.

2. The instructor should exercise close supervision over each student's work, especially the connections, stressing the fact that the voltammeter will be damaged through incorrect usage.

INSTRUCTION TEST NO. 4–A (PERFORMANCE).

Directions to the instructor.

Equipment.

1 battery, BB–14 (BB–28), fully charged.
1 resistor (approximately 0 to 20 ohms).
1 vacuum tube, type VT–1.

Procedure.

1. Place available sets of equipment in suitable locations for conducting the test and assign the students who are to be tested to positions at these locations.

2. Assemble the students for final instructions and answer any questions they may ask.

3. Distribute the papers marked "Directions to the Student." Direct the students to go to their assigned positions and face the instructor.

4. When ready, direct "About face. Begin."

5. Note and record the exact time that the word "Begin" is given.

6. When the students have made the connections, they will raise their right hands. Note and record the time that each student finishes.

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7. Inspect the connections each student has made, recording their correctness. Make connections where necessary before going on with the next part of the test.

8. When ready, direct "Ready. Begin," and again record the exact time when the word "Begin" is given.

9. As the students finish they will raise their papers. Note and record the time each student finishes. This is conveniently done by marking the time directly on the student's paper.

INSTRUCTION TEST NO. 4–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 battery, type BB–14 (BB–28), fully charged.
   1 resistor (approximately 0 to 20 ohms).
   1 vacuum tube, type VT–1.
2. When the instructor says "Begin," start your work promptly.
3. Perform the following operations *carefully* and quickly.

Problem No. 1.

1. *a.* Connect the battery, resistor, vacuum tube, and one Weston voltammeter (as an ammeter) in series.

b. Connect the other Weston voltammeter (as a voltmeter) across the filament terminals of the vacuum tube.

2. When you have finished the connections, notify the instructor by raising your right hand.

3. The instructor will supervise your work and record the time it has taken to do it.

4. When the instructor again says "Begin," perform the following operation:

Problem No. 2.

1. Set the resistance at a point where the ammeter will read 0.5 ampere, and by varying the resistance "step up" the current 0.1 ampere at a time and take a voltage reading at each step. Continue until a reading of 1.2 is obtained. Record your reading in the table below:

Current (amperes).	Voltage (volts).
0. 5	------
0. 6	------
0. 7	------
0. 8	------
0. 9	------
1. 0	------
1. 1	------
1. 2	------

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2. When you have finished, notify the instructor by raising your paper.

3. The instructor will then inspect your work and record the time it has taken to do it.

Scoring

1. The maximum score for this test is 12 points.
2. The score required to pass this test is 10 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. If the equipment, excluding the voltmeter, is correctly connected in series	2
b. If the voltmeter is correctly connected across the filament	2

PROBLEM NO. 2.

a. For each correct voltage reading	1

4. Where the student has failed to complete the test, or has failed to correctly solve the problems, a grade of zero will be given for incomplete parts or incorrect answers.

INSTRUCTION TEST NO. 4–B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. The resistance of 5 feet of No. 18 copper wire is 1 ohm. How many ohms resistance is there in 20 feet of the same size and kind of wire?
(1) 2 ohms. (2) 4 ohms. (3) 1 ohm. (4) 3 ohms. ------

b. Name a good resistor.
(1) Copper. (2) Brass. (3) Carbon. (4) Silver. ------

c. What is the unit of resistance?
(1) Volt. (2) Ampere. (3) Watt. (4) Ohm. ------

d. Which of the metals mentioned below is the best conductor of electricity?
(1) Carbon. (2) German silver.
(3) Silver. (4) Copper. ------

e. Which of the wires below has the smallest diameter?
(1) No. 18. (2) No. 20. (3) No. 32. (4) No. 24. ------

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f. What causes the filament to burn brighter?
(1) Increasing the resistance.
(2) Decreasing the resistance.
(3) Adjusting the potentiometer.
(4) Decreasing the voltage. ------

g. The diameter of four copper wires of the same length is given below. Which one has the greatest resistance?
(1) $\frac{1}{32}''$. (2) $\frac{1}{4}''$. (3) $\frac{1}{8}''$. (4) $\frac{1}{2}''$. ------

h. Why could not a potentiometer be used in place of a rheostat for a vacuum tube, type VT–1?
(1) Its resistance is too small.
(2) It is not designed to carry a heavy current.
(3) It is too large.
(4) It would burn out the filament of the tube. ------

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MAGNETS.

Equipment.

30 feet No. 24 copper magnet wire.
1 small bobbin or spool (with removable iron core).
1 type BA–10 reserve dry cell (charged).
1 small piece of iron (iron nail).
1 head set, type P–11.
1 test buzzer.

Information.

Two sorts of magnets will be discussed in this Unit Operation: Permanent magnets and electromagnets.

Permanent Magnets.—Nearly every one is familiar with the permanent type of magnet. Usually, it consists of a magnetized steel

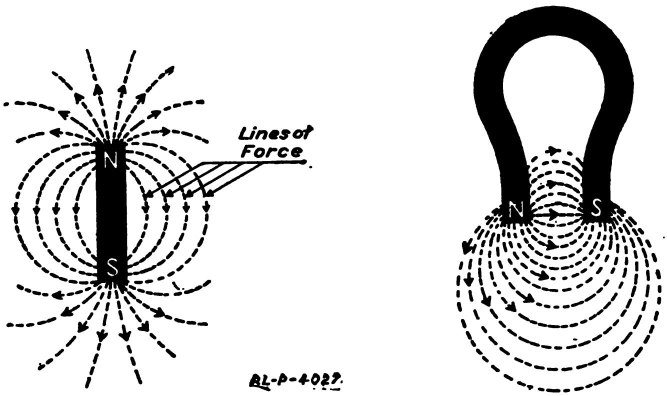

Fig. 16.—A straight bar magnet and a horseshoe magnet.

bar bent in the shape of a horseshoe. If this magnet is held near other small pieces of iron or steel the latter will be attracted and cling to it. This attraction is due to the magnetic lines of force which extend about the ends of the magnet. The area surrounding the magnet which includes these magnetic lines of force is known as the *magnetic field.* Fig. 16 shows a horseshoe type of magnet and also a bar magnet with the magnetic fields which surround each. The ends of a magnet are called the *poles.* One end is known as the *north* pole and the other end as the *south* pole.

If a piece of steel is placed across the poles of a permanent magnet and then forcibly pulled away it will be found that the piece of steel has itself also become slightly magnetized and that it will attract other pieces of iron or steel. In other words, if a piece of

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steel comes in contact with the poles of a magnet or is placed within the fields of a magnet, it will still retain some of the magnetism after it has been removed. In this respect steel differs from pure iron. A piece of pure iron which has been placed across the poles of a magnet will at once lose all traces of magnetism when it is pulled away.

Electromagnets.—When a wire conductor is carrying a current, a magnetic field is produced around the wire as shown in Fig. 17, A. Fig. 17, B shows the magnetic field produced when an insulated wire is wound in the form of a coil and connected to a battery. In addition to the magnetic field immediately around the circumference of the wire itself, a general magnetic field is produced about the coil formed by the wire.

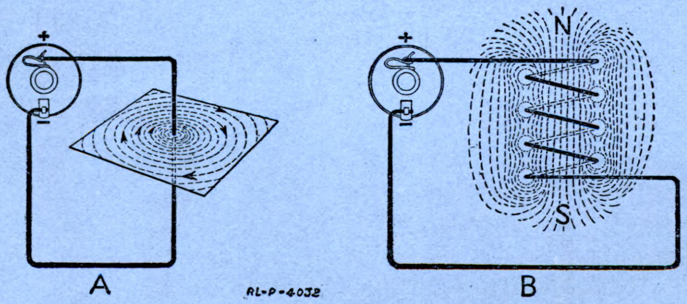

Fig. 17, A.—Magnetic field produced around a straight wire conductor.

Fig. 17, B.—Magnetic field produced around a coil of wire carrying an electric current.

Directions.

Construction of an Electromagnet.—1. Take the spool or bobbin and wind it full with magnet wire. To do this start winding at one end of the spool, leaving about 8 inches of the wire free at the beginning for a connection. Wind the turns close together and evenly until one layer has been completed. Then wind the second layer back over the first layer. Continue winding in this manner in layers until all the wire has been wound on the spool but about 8 inches, which is to be left for a connection or lead wire. Scrape off the insulation at the ends of the two short lengths of wire which have been left extending from the winding.

2. Hold the small piece of iron or the iron nail close to one end of the iron core provided and note whether or not there is any magnetic attraction between the two.

3. Place the iron core inside of the spool of wire and repeat Direction 2.

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Question.

(1) *Was there any magnetic attraction between the iron core and the piece of iron in the above experiment?*

Direction.

4. Connect the leads from the coil to the terminals on the battery. Repeat Direction 2.

Questions.

(2) *Does the flow of current through the coil have any effect on the iron core? Explain.*

(3) *Why is the piece of iron not attracted by the iron core when no current is flowing through the coil? (See Direction 3.)*

Information.

Electromagnet.—If a bar of iron is placed inside a coil of wire which is connected to a battery, the iron will be found to be magnetized and will attract other pieces of iron or steel. Now if the current passing through the coil is switched off, the field around the coil will disappear or collapse and the iron bar will be found to be no longer magnetized. The iron bar will remain magnetized just so long as the current is turned on, but as soon as the current is turned off the iron loses its magnetism. A bar of iron surrounded by a coil of insulated wire, as described above, is an example of an *electromagnet.* The principle of the electromagnet is made use of every day in the construction and operation of electric bells, telephones, arc lamps, motors, generators, etc.

Question.

(4) *If an unmagnetized steel core were placed inside a coil and a current sent through the coil, would the steel core retain any magnetism after the current was turned off?*

Information.

Telephone receivers.—Telephone receivers, which are necessary with every type of radio receiving set used in the Signal Corps, depend both upon the electromagnet and the permanent magnet for their operation. One of the standard types of telephone receivers for radio work is illustrated in Fig. 18.

Directions.

5. Remove one of the telephone receivers from the head band and examine it closely. Notice the two wires leading into the receiver through the holes in the case.

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6. Unscrew the hard rubber cap. Carefully remove the thin iron disk (the diaphragm) by sliding it from the receiver case. Note carefully that the two sides of the disk are not colored the same and that the light colored side is toward the magnets.

Question.

(5) *Are the coils of the receiver wound with coarse or with fine wire?*

Directions.

7. Notice the permanent horseshoe magnet at the bottom of the receiver case.

NOTE.—The soft iron cores of the two coil magnets are attached by steel supports to the poles of the permanent magnets located at the base of the receiver.

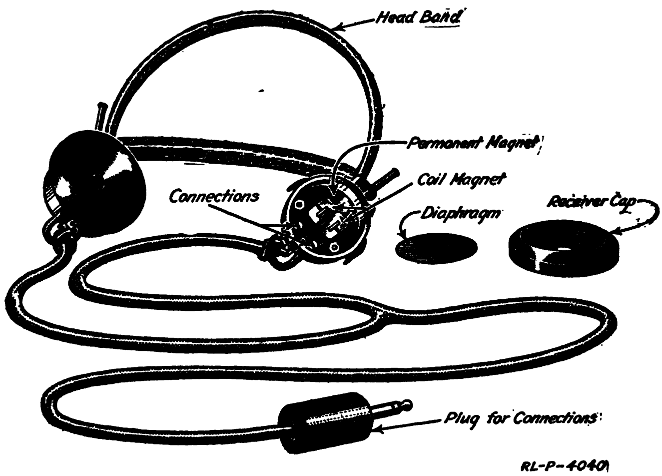

Fig. 18.—Headset, type P–11, with caps and diaphragm of one receiver removed.

Question.

(6) *If the cores of the two small electromagnets are made of soft iron, why is it that they exert a pull upon the diaphragm of the receiver?*

Directions.

8. Carefully replace the diaphragm making sure the light colored side is toward the magnets. Screw the cap on the receiver case.

Information.

The Telephone Receiver.—The action of a telephone receiver is as follows: Whether there is any current passing through the coils or not the poles of the permanent magnet exert a steady pull upon

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the diaphragm. This causes the diaphragm to be curved slightly inward toward the poles of the magnet, but without quite touching them. If a small current is now passed through the coils, the magnetic field produced by the coils will either help or hinder the magnetic effect of the permanent magnet, depending upon the direction of current through the coils. If the permanent magnet field is strengthened by the field of the coils, a stronger pull will be exerted upon the diaphragm causing it to move closer to the magnet poles. If the permanent magnet field is weakened by the field of the coils the magnetic pull on the diaphragm will be reduced, thus causing the diaphragm to move away from the poles of the magnet. The rapid opening and closing of a switch placed in series with a telephone receiver and battery will cause an intermittent or broken-up current to pass through the coils of the magnet. This intermittent current in turn will produce a series of back and forth motions of the diaphragm. The motions of the diaphragm will set up vibrations in the air and these vibrations will become noticeable to the ear in the form of a series of clicks. By substituting in place of the switch a make-and-break device which will interrupt the current very rapidly, a note will be heard in the receiver, the pitch of which will depend upon how rapidly the current is being interrupted.

Since only very small currents are available, from a radio receiving set, a great many turns of insulated wire must be wound on the telephone receiver magnets in order to produce a magnetic field strong enough to cause a movement of the diaphragm. A fine wire is used in order that the necessary number of turns may be wound in the small space provided. Since the wire is very fine the resistance of the coils is high. For example, the resistance of the type of receivers shown in Fig. 18, is approximately 1,100 ohms.

The receivers used in a head set are connected in series. In this case the total resistance of the receivers is 2,200 ohms.

Directions.

9. Connect one of the phone cord terminals to one of the dry-cell terminals. Place the receivers on the head. Touch the other terminal of the dry cell several times with the remaining cord terminal.

Question.

(7) *What happens when this is done?*

Information.

The Electric Buzzer.—The buzzer is another electrical device which utilizes the electromagnet. The buzzer shown in Fig. 19 is the

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type used in conjunction with radio sets. It consists of a composition base, upon which is mounted a small two-coil electromagnet, the core of which is made of soft iron. Directly in front of the poles of the magnet is a strip of spring steel which is fastened to a part of the magnet support. A set-screw terminal is provided on this part of the support. A small piece of silver or alloy metal is fastened to a spring structure attached to the strip of spring steel. This small piece of low-resistance metal is known as a contact. The spring-steel strip is called the vibrator or armature of the buzzer. A second contact is provided on the end of a thumbscrew mounted directly in front of the contact on the vibrator. The support of this contact screw is provided with a small-screw terminal. A third thumbscrew is used to adjust the tension of the spring vibrator.

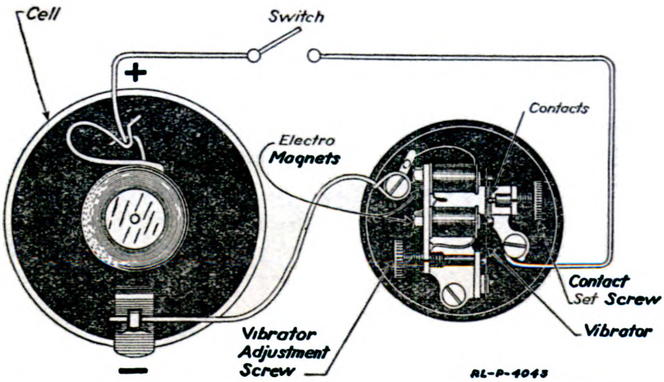

Fig. 19.—Test buzzer with cap removed to show parts and method of connecting to dry cell.

The wire connections of the buzzer are as follows: One end of one of the coils is connected to the screw terminal at the base of the buzzer. The other end of this coil is connected to an end of the second coil, thus placing the two coils in series. The other end of the second coil is connected to the vibrator.

Directions.

Connecting and Operating a Buzzer.

10. Examine the buzzer thoroughly. Trace the connections from the coils. Notice the various adjustment screws.

11. Adjust the thumbscrew controlling the tension of the vibrator arm, so that about one thirty-second of an inch space exists between the poles of the magnets and the vibrator. Adjust the contact thumbscrew in front of the vibrator so that it just makes contact

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with the vibrator. Connect one terminal of the dry cell to one terminal of the buzzer as shown in Fig. 19. Connect one end of a lead wire to the other terminal of the battery. Touch the vibrator terminal with the other end of the lead wire.

Question.

(8) *What happens when the vibrator terminal is touched with the end of the lead wire?*

Direction.

12. Connect the lead wire to the terminal of the contact screw located in front of the vibrator.

Question.

(9) *What happens when the above connection is made?*

Direction.

13. With the buzzer still running try adjusting the set screws on the buzzer and notice the pitch of the note obtained with each adjustment.

Information.

The Action of a Buzzer.—The action of a buzzer is as follows: When the switch in Fig. 19 is closed, the current passes through the positive lead to the contact screw, through the contact screw and vibrator, then through the coils in series, and back through the negative lead to the dry cell. When the current passes through the magnet coils the iron cores of the magnet become magnetized and attract the vibrator or armature. This attraction pulls the armature away from the contact thumbscrew and thus causes the circuit to be broken. As soon as the circuit is broken the electromagnets lose their magnetism and no longer attract the armature. The tension of the armature causes it to return to its original position, that is, resting against the contact screw. This movement results in the circuits again being completed and the armature again is attracted to the magnets. This action is repeated over and over again, causing the armature to emit a sound or note.

Question.

(10) *Upon what does the speed at which the armature vibrates depend?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. The equipment listed in Unit Operation No. 5 of the Students Manual should be prepared in advance. The class should be divided into as many groups as there are sets of equipment. Small groups are desirable, and if consistent should be limited to two or three men.

2. *a.* Give a brief discussion of "lines of force."

b. Place a horseshoe magnet, or any type of permanent magnet, on a table. Over it place a piece of smooth paper and sprinkle some iron filings on the paper. Shake the paper slightly and allow each student to see how the iron filings take the form of lines about the magnet. This demonstration should make clear to the student what is meant by "lines of force." Now remove the magnet and shake the paper slightly, thus demonstrating that, in the absence of the magnet, the filings do not assume any definite form.

3. *a.* Discuss *briefly* the importance of magnets and magnetism, including a statement as to some of its important uses, i. e., in motors, generators, electric bells and buzzers, telephones, etc.

b. Magnetize a piece of steel by rubbing it against the poles of the horseshoe magnet. Show by demonstration that this piece of steel then becomes a magnet in itself and consequently will attract another piece of steel, for instance a needle.

c. Rub also a piece of soft iron on the magnet and demonstrate its use as such. It will then be obvious that soft iron does not *retain* its magnetism and acts as a magnet only when it is in contact with a steel magnet.

4. The instructor should now direct the students to begin the experiments listed in the Students Manual under Unit Operation No. 5. He should exercise personal supervision over the work of the students and assist them whenever necessary, but should *not* actually conduct any of the experiments for any student.

5. After these experiments have been completed the instructor should require each student to answer verbally as many of the questions in the Students Manual as possible. In order to bring out further details, he may also ask additional questions, such as the following:

a. How would you make a permanent magnet out of a piece of steel?

b. How would you make a magnet out of a piece of soft iron?

c. What are meant by "lines of force"?

d. What is meant by the poles of a magnet?

e. If the magnet were cut in two, would each half have two poles?

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f. Is the compass needle a permanent or an electromagnet?

g. Which pole of a compass needle points toward north? Why?

h. Would a straight length of wire with current flowing through it act as an electromagnet?

i. Why is soft iron usually used for making an electro magnet?

6. The important new words in this Unit Operation are:

Core (of an electromagnet).	Magnetic poles.
Buzzer.	Magnetize.
Permanent magnet.	Magnetism.
Electromagnet.	Collapse (of a magnetic field).
Magnetic lines of force.	Diaphragm.
Magnetic field.	Armature (buzzer).
Bar magnet.	Contact point.
Horseshoe magnet.	

7. The instructor should review the experiments in this Unit Operation, stating specifically the reason for conducting them and the knowledge which should have been obtained. For instance, the student should now understand fully what both permanent and electromagnets are, and generally how they are made; he should also know what is meant by "lines of force," as well as in what direction these lines radiate in relation to their source. His knowledge should also include some information relative to the construction and operation of telephone receivers and buzzers.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

1. After Unit Operation No. 5 is completed and all of the questions in the Students Manual have been answered by each student, the instructor should give the following Instruction Test or devise one similar to it. The test is divided into two parts, namely, *Performance* and *Information.* If desired, the *Performance* part of the test may be given to a part of the class while the *Information* part is given to the remainder.

2. The instructor, in person, should supervise the students' work and require that all telephone receivers be reassembled properly. Care should be exercised to avoid damage to buzzers.

INSTRUCTION ON TEST NO. 5–A (PERFORMANCE).

Directions to the instructor.

Equipment.

5 head sets, 2 of which are good, 2 "open," and 1 with no magnetism.
1 battery, type BA–4.
1 buzzer, out of adjustment.

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Procedure.

1. Number each head set with a tag, from Nos. 1 to 5. Place available sets of equipment in suitable locations for conducting the test and assign students to positions.
2. Assemble the students and answer any questions they may wish to ask. Explain that if a connection in any part of the head phones is broken that phone is known as "open," i. e., there is an open circuit.
3. Distribute the papers marked "Directions to the student" and direct the students to go to their assigned positions and face the instructor. At this time distribute the "Information" test papers to the remainder of the class, directing them to begin work at the command "Begin," which will be given to the entire class.
4. When ready, give the command "About face. Begin," and note the exact time that the command "Begin" is given.
5. Notify students that when they have completed the first part of the Performance Test they will raise their right hands. Note and record the exact time each student finishes.
6. Inspect all of the head sets before going on with the next part of the test.
7. When ready for the second part of the test, give the command "Ready. Begin," and again record the exact time that the command "Begin" is given.
8. Notify students that when they have finished each will raise his right hand. Note and record the exact time each individual student finishes. This may be conveniently done by recording it on the student's paper.

INSTRUCTION TEST NO. 5-A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   - 5 head sets (numbered from 1 to 5), type P-11, 2 of which are serviceable, 2 have a broken connection, and 1 has no magnetism.
   - 1 battery, type BA-4.
   - 1 buzzer, out of adjustment.

2. When the instructor says "Begin," test each of the five head sets and write the numbers of the phones that are serviceable, open, or demagnetized in the spaces provided below:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Serviceable					
Open circuit					
No magnetism					

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3. When you have finished this test and have recorded the numbers as set forth above, notify the instructor that you have finished by raising your right hand.

4. The instructor will then record the time taken to do the work and will supervise your work in person.

5. When the instructor again says "Begin," take the buzzer before you, connect it to the battery correctly, and adjust it so that it operates satisfactorily.

6. When you have the buzzer properly adjusted, notify the instructor that you have finished by raising your right hand.

7. The instructor will then inspect your work and record the time taken to do the work.

Scoring.

1. The maximum possible score for this test is 12 points.
2. The score required to pass this test is 10 points.
3. *Directions for scoring.*

	Points.
a. If the student records correctly:	
(1) The numbers of the two good head sets	4
(2) The numbers of the two open head sets	4
(3) The number of the set which has no magnetism	2
b. If the student properly adjusts the buzzer so that it operates satisfactorily in a reasonable time	2

4. Where the student has failed to complete the test or has failed to answer questions correctly, a grade of zero will be given for incomplete parts or incorrect answers.

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. The diaphragm of a telephone receiver is made of hard rubber. ------
2. The armature of a buzzer is stationary when the buzzer is operated. ------
3. The contact point on the buzzer is made of carbon. ------
4. The north "pole" of a compass needle points toward the north. ------
5. An electromagnet usually uses a soft-iron core. ------
6. Steel loses its magnetism quickly. ------
7. Copper makes a good magnet. ------
8. It requires a current of at least 1 ampere to operate telephone receivers. ------
9. Permanent magnets are usually made of steel. ------

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10. In replacing the telephone receiver diaphragm the light-colored side should be placed toward the magnets. ------

11. An electromagnet is required for operating a buzzer. ------

12. An electromagnet is a permanent magnet. ------

13. The receivers of the type P–11 head set are connected in parallel.

14. The diaphragm should be attracted by the magnets in the telephone receiver, even when there is no current passing through the coils in the receiver. ------

15. Strong lines of force are always present around an electromagnet whether a current is passing through its coil or not. ------

16. If a permanent magnet is cut in halves, each half will have two poles, a north pole and a south pole ------

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SUGGESTIONS FOR THE INSTRUCTOR.

1. The first five Unit Operations are related, inasmuch as they all pertain to fundamental and basic principles and apparatus.

2. Before going on to Unit Operation No. 6, which starts work on radio sets and auxiliary equipment, it is advisable to find out at this point whether or not all of the students are sufficiently proficient to progress to a new group of subjects. The instructor should therefore give the Progress Test set forth below or devise one similar to it.

3. It is usually found more convenient to give the Performance part of this test to one part of the class, while the Information part is given to the remainder.

4. The instructor should maintain the same personal supervision over the work of the Performance part as has been the custom in previous Instruction Tests.

PROGRESS TEST NO. 1–A (PERFORMANCE.)

Directions to the instructor.

Equipment (for both problems).

4 type BA–2 batteries (serviceable).
2 voltammeters, Weston, No. 280.
1 type BB–14 storage battery (unserviceable).
1 type VT–1 tube.
1 tube socket (for VT–1) mounted on a board with filament terminals brought out to Fahnestock connector.
1 resistor (approximately 0 to 20 ohms).
2 pair of head sets, W. E., type P–11 (1 pair serviceable, 1 pair with no magnetism).

Procedure.

Problem No. 1.

1. Prepare in advance the above-listed equipment for both probems. Divide the class into as many sections as there are sets of equipment. Assign the students to their positions.

2. Number the serviceable pair of phones No. 2 and the pair with no magnetism No. 1 for each set of equipment. These numbers can be written on tags which are conveniently attached to each pair of head phones.

3. Assemble the entire class and *caution all students again* that in measuring an unknown voltage or current to use *first* the terminals on the voltammeter that read the maximum. After finding out what the current or voltage is in this manner, if a lower scale can be used, it should be employed in order to get a more accurate reading.

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4. It is not desirable, before starting a *Progress Test,* to answer any questions pertaining to the work covered by the test.

5. Distribute the papers marked "Directions to the Student" and the "Information Test Papers" and direct the students to go to their assigned position and face the instructor.

6. When ready, direct "About face. Begin." Note and record the exact time the word "Begin" is given.

7. When the students taking the Performance part of the test have completed Problem No. 1, each will raise his right hand. Note and record the exact time that each individual finishes. This is conveniently done by noting the time on the student's paper.

8. When ready for Problem No. 2, direct "About face. Begin," and again note the time the word "Begin" is given.

9. When the students have completed the Performance Test, each will raise his right hand . Note and record the exact time each finishes. Inspect the work as soon as possible.

PROGRESS TEST NO. 1–A (PERFORMANCE).

Directions to the student.

Problem No. 1.

1. The following equipment is laid out at your assigned position:
   4 type BA–2 batteries.
   1 voltammeter, Weston, No. 280.
   Connecting wire.

2. When the instructor says "Begin," start work promptly. Perform the following operations *carefully* and quickly:

a. Connect the four type BA–2 batteries in series. Measure the total voltage and record your reading on the dotted line to the right. --------------------

b. Leaving the batteries connected in series, measure the total short circuit current. Be careful to first make connections to the ammeter's highest-reading binding posts when measuring an unknown current. Short-circuit these batteries *only long enough to take a reading.* Record your reading on the dotted line to the right. ----------------

c. Connect the four batteries in parallel. Read the total voltage and record your reading on the dotted line to the right.------------ --------

d. With the batteries still in parallel, measure the total short-circuit current. (See CAUTION, question 2*b.*) Record your reading on the dotted line to the right. -------------------

3. When finished with these operations, notify the instructor immediately by raising your right hand.

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4. The instructor will then record the time you have taken to accomplish the above work and inspect it.

5. Turn and face the instructor and wait until he directs you to begin Problem No. 2.

Problem No. 2.

1. The following equipment is laid out at your assigned position:
   1 storage battery, type BB–14.
   2 voltammeters, Weston, No. 280.
   1 VT–1 tube.
   1 tube socket (mounted).
   1 resistor (approximately 0 to 20 ohms).
   2 pairs of head phones, W. E., type P–11 (1 pair serviceable 1 pair in poor condition).
   A supply of magnet wire (about No. 18 B. & S.) for making connections.

2. When the instructor says "Begin," start the following operations promptly. Do your work *carefully* and quickly:

a. Connect one voltammeter (*used as a voltmeter*) across the storage battery. Read and record voltage measured on dotted line to the right. ....

b. Connect in series the resistor and the filament terminals of the tube and connect to battery. Connect in the circuit a voltammeter (*as an ammeter*). Adjust the resistor until tube glows red (normal brightness) and measure and record the number of amperes of current being consumed, on the dotted line to the right. ....

c. Now connect the other voltammeter *as a voltmeter* so that you can measure the voltage across the filament terminals of the tube. Record the number of volts measured on the dotted line to the right, and then disconnect the battery. ....

Scoring.

1. The maximum possible score for this test is 38 points.
2. The score required to pass this test is 30 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. For correctly connecting the four type BA–2 batteries in series and reading the voltage	4
b. For correctly measuring and recording the short-circuit current for these batteries connected in series	6
c. For correctly connecting the four batteries in parallel and reading the total voltage	4
d. For correctly measuring the short-circuit current of these batteries connected in parallel	6

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PROBLEM NO. 2.

a. For correctly connecting the voltmeter and reading the voltage of the BB–14 storage battery	2
b. (1) For correctly connecting the resistor-filament terminals of the tube and battery in series	2
(2) For correctly connecting the ammeter in series with the above equipment	4
(3) For correctly reading the ammeter	2
c. (1) For correctly connecting the voltmeter in parallel with the filament terminals	4
(2) For choosing the headset which is serviceable	4

4. Where the student has failed to complete the test or has failed to perform it correctly, a grade of zero will be given for incomplete parts or incorrect answers.

PROGRESS TEST NO. 1–B (INFORMATION).

Part I.

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct), place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

Example.—Camp Vail is a Naval station. ------

1. Current generated by a cell or battery flows from the + terminal around through the circuit to the − terminal. ------
2. Very poor conductors of electricity are called insulators. ------
3. When the negative terminals of a number of batteries are connected and all the positive terminals are connected, the batteries are said to be connected in series. ------
4. Fiber is a good conductor of electricity. ------
5. Platinum is a better conductor of electricity than silver. ------
6. Lead is a better conductor of electricity than copper. ------
7. The BA–4 is a 22-volt dry battery. ------
8. The center or carbon electrode of a dry cell is the negative electrode. ------
9. The BA–10 cell must be filled with water before being used. ------
10. In order to measure the current with a Weston 280 voltammeter, the button switch must be pressed. ------
11. The normal voltage of one BA–10 cell is 1.5 volts. ------
12. The current obtained from two fully charged batteries connected in series is twice that of one battery. ------

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13. The voltage of a lead storage battery of 2 cells is 4 volts. ......

14. The BB–14 is a 100 ampere-hour battery. ......

15. The voltage of an Edison cell is greater than that of a lead cell. ......

16. Carbon is considered a very good conductor of electricity, due to its high resistance. ......

17. A potentiometer is used to regulate current. ......

18. Copper makes a good magnet. ......

19. Copper wire is used for making most rheostats. ......

20. Soft iron does not retain its magnetism after being removed from a magnetic field. ......

21. In replacing the diaphragm in a telephone receiver the light-colored side should be placed toward the magnet.

22. An electromagnet is a permanent magnet. ......

23. Steel is usually used for the core of an electromagnet. ......

24. A piece of steel rubbed against a permanent magnet makes the piece of steel a permanent magnet. ......

25. The positive terminal of a storage battery is painted black. ......

26. The BB–5 battery is an Edison type battery. ......

27. Greater voltage is obtained from two cells connected in parallel than from one cell. ......

28. When testing the voltage of two BA–2 batteries connected in series, the positive terminal of the batteries is connected to the post marked "Amps or Volts +" and the negative battery terminal is connected to the post marked "15 Volts." ......

29. In measuring the current flowing through any instrument the ammeter is connected in parallel across the instrument. ......

30. A buzzer requires an electromagnet to make it operate. ......

Part II.

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. What is the voltage of a type BA–8 battery?
(1) 1½. (2) 4. (3) 22. (4) 45. ......

b. What is the voltage of a BA–4 cell?
(1) ½. (2) 1½. (3) 4. (4) 22. ......

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c. What is the difference between the BA-8 and BA-2 type of battery?

(1) The BA-8 is smaller than the BA-2.
(2) The BA-8 produces a higher voltage than the BA-2.
(3) The BA-8 will last longer than the BA-2.
(4) The BA-8 is used to light the filaments of the tubes, while the BA-2 is used for plate voltage. ------

d. What is necessary to be done in order to make a new BA-10 cell serviceable?

(1) It must be filled with acid electrolyte.
(2) It must be filled with caustic soda.
(3) It must be filled with water.
(4) It must be charged for 24 hours. ------

e. How great a current can be measured by a Weston voltammeter, model 280?

(1) 3 amperes. (2) 15 amperes. (3) 30 amperes. (4) 50 amperes. ------

f. How great a voltage can be measured by a Weston, model 280, voltammeter? ------

(1) 3 volts. (2) 15 volts. (3) 150 volts. (4) 500 volts. ------

g. In measuring an unknown *current* where would you *first* make connections to the ammeter?

(1) "Amps or Volts" and binding post marked 150 volts.
(2) "Amps or Volts" and binding post marked 30 amps.
(3) "Amps or Volts" and binding post marked 3 amps.
(4) "Amps or Volts" and binding post marked 15 amps. ------

h. Theoretically, how long will a 90 ampere-hour battery deliver electric current?

(1) For 15 hours, drawing 4 amperes.
(2) For 10 hours, drawing 9 amperes.
(3) For 20 hours, drawing 5 amperes.
(4) For 6 hours, drawing 12 amperes. ------

i. Upon what does the ampere hour capacity of a storage battery depend?

(1) The voltage of the battery.
(2) The distance between plates.
(3) The thickness of the separators.
(4) The size and number of plates in the cells. ------

j. Which of the metals below are the best conductors of electricity?

(1) Platinum. (2) Gold. (3) Silver. (4) Copper. ------

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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

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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

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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.

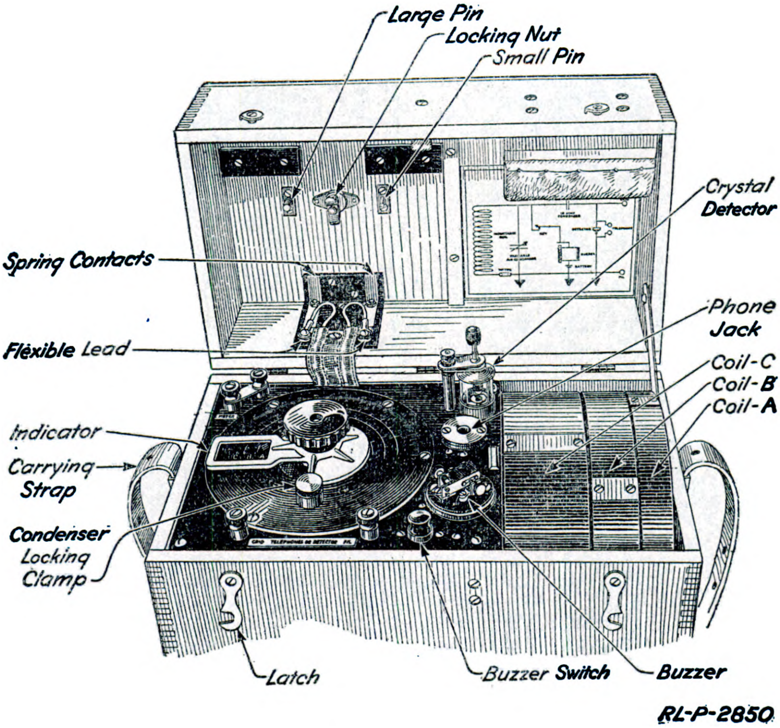

Fig. 20.—The SCR–61 wave meter.

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

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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.

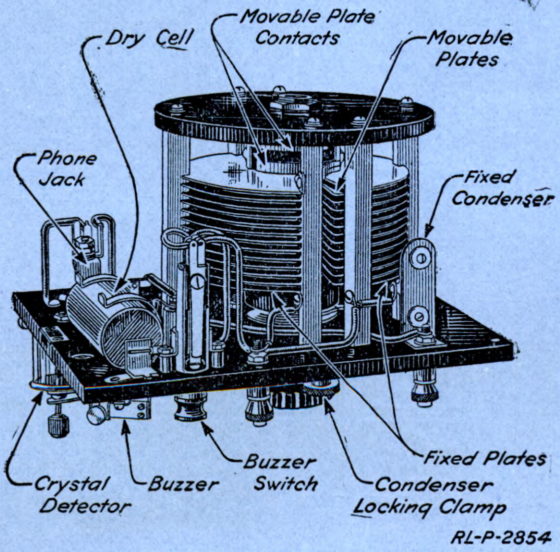

Fig. 21.—Panel of set box BC–37 removed to show interior parts.

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.*)

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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.

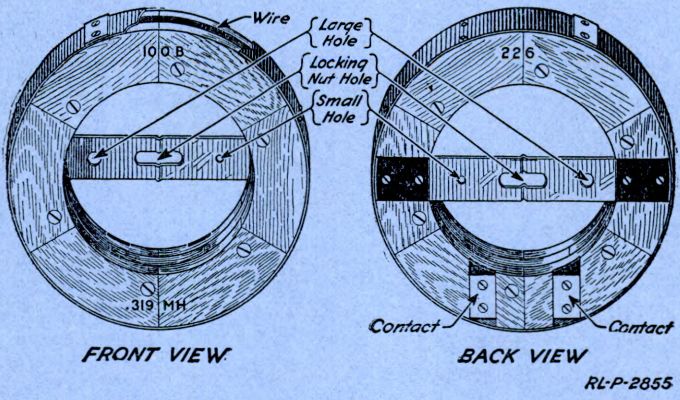

Fig. 22.—Details of inductance coils used in SCR–61 wave meter.

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?*

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(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

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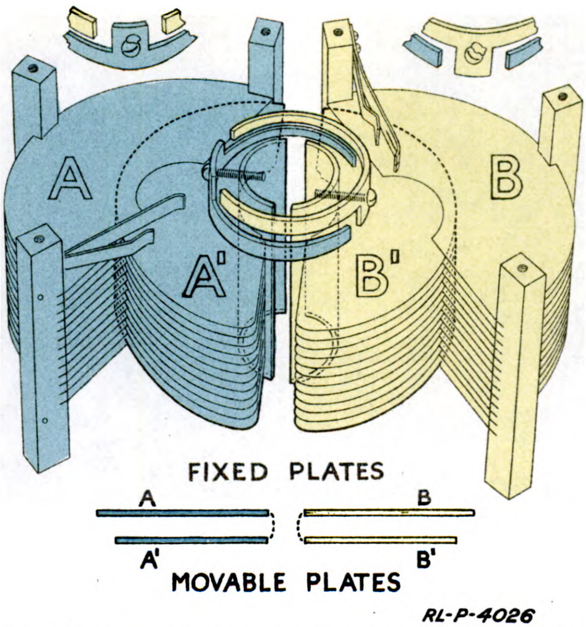

Fig. 23.—Schematic view of variable condenser used in the SCR–61 wavemeter, showing minimum capacity position of plates.

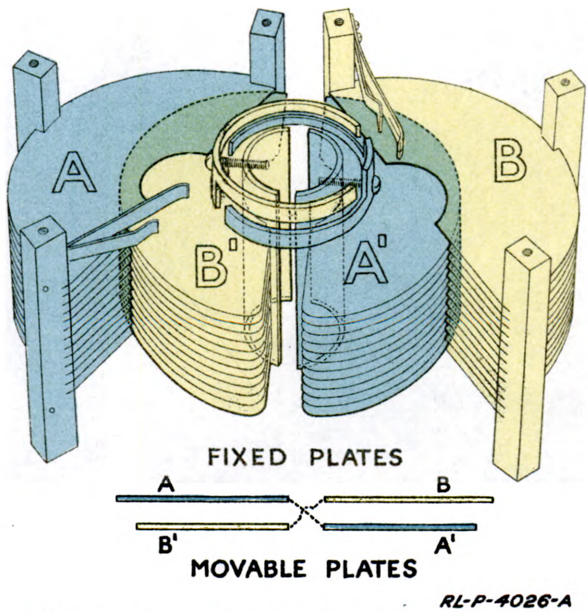

Fig. 24.—Schematic view, showing maximum capacity position of plates.

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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?*

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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.

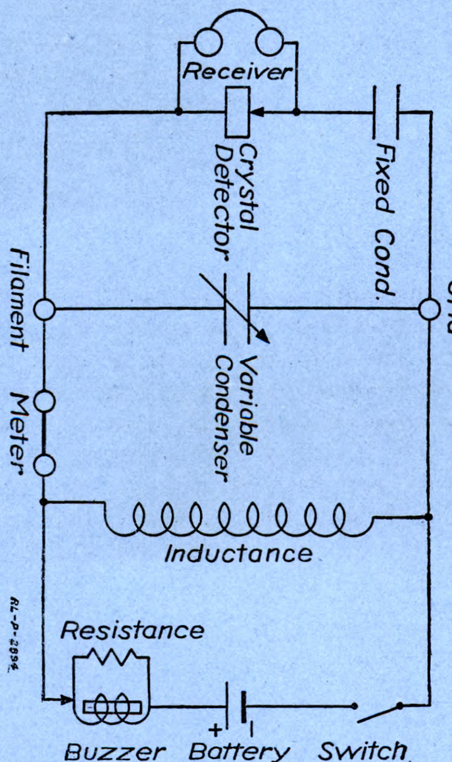

Fig. 25.—Schematic diagram of connections in the SCR–61 wave meter.

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.

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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

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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

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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 buzzer. Be

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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" coil 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

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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.

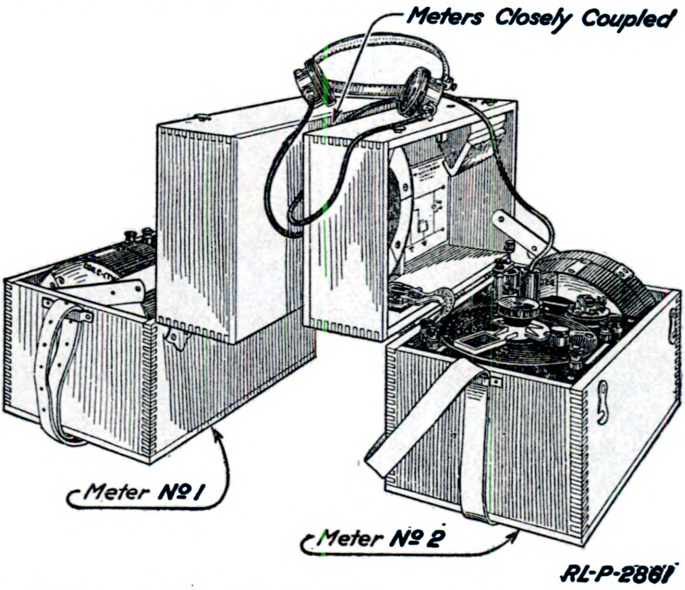

Fig. 26.—Method of obtaining close coupling between two SCR–61 wave meters.

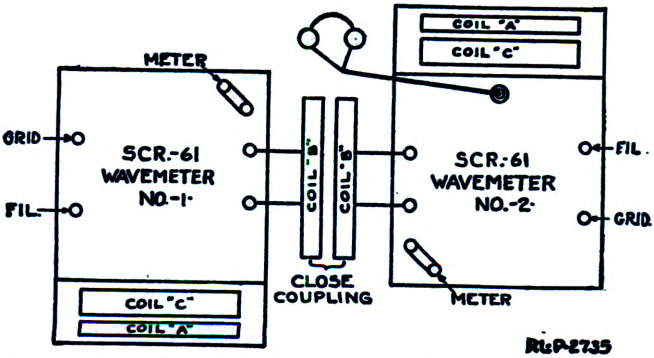

Fig. 27.—Schematic view showing relative positions of inductance coils when two SCR–61 wave meters are closely coupled as in Fig. 26.

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

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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.

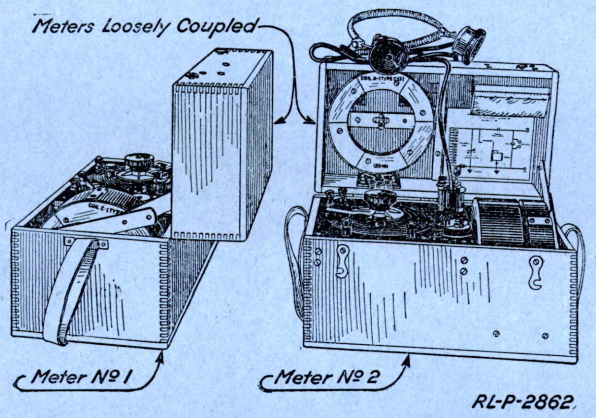

Fig. 28.—Two SCR–61 wave meters, loosely coupled.

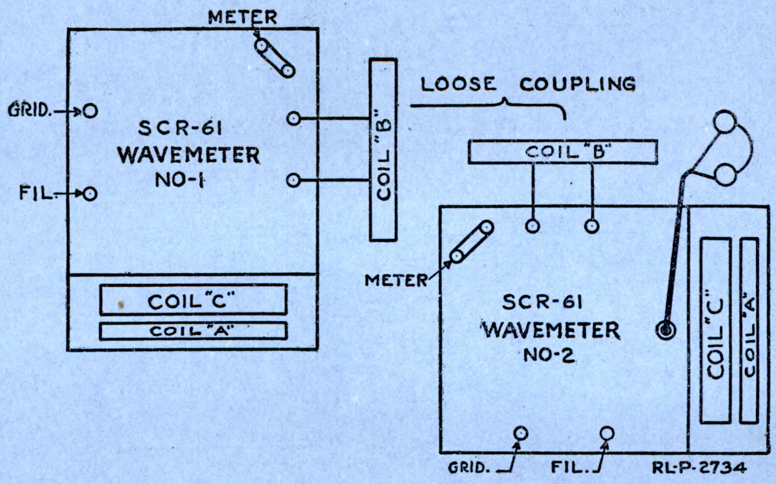

Fig. 29.—Schematic view showing relative positions of inductance coils when two SCR–61 wave meters are loosely coupled as in Fig. 28.

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

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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?*

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(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?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class discuss the subjects set forth below. If two tuning forks are set some distance apart on a table, one can be made to vibrate by starting the other one vibrating, *provided both tuning forks are of the same size.* Under this condition one fork may be said to be "in tune" with the other. If one of these forks is replaced by a fork of a different size, the fork substituted will not be affected by the vibrations of the other fork. (If tuning forks are available, this experiment may be carried out by the instructor to advantage.)

2. Show the relationship between the two tuning forks and two radio stations, being careful to distinguish between them, as follows:

a. In the case of the *tuning forks* energy is transmitted by sound waves, and the action of one fork in responding to vibrations of another is purely *mechanical.* The tuning forks illustrate how one station must be "in tune" with another in order to respond to it.

b. In *radio* it should be explained that the action is *not* mechanical, but *electrical.* Briefly explain that energy is generated in the receiving antenna by the electromagnetic waves sent on by means of the antenna of the transmitting station. In brief every receiving antenna can be thought of as a generator or tiny electric currents.

3. Explain briefly that if all sets were "tuned" alike that only two could communicate at one time without interference. In other words, it would be similar to the line telephone, and the "line would be busy" when any two stations were communicating. This would constitute a very serious obstacle to radio traffic. It therefore necessitates the assignment of many different "wave lengths" in the Army, so that a considerable number of messages can be handled at the same time, within a certain area, without interference. In comparison with line telephone a radio station might be said to have as many "lines" coming into its "switchboard" as there are assigned wave lengths to the station.

4. Explain that in order to accurately tune each station to its assigned wave length or wave lengths a "wave meter" is used, and that this instrument is, in reality, a miniature combination receiving and transmitting radio station, not usually used for a range of more than a few yards. It is accurately calibrated and can be used to measure the wave length of a received or transmitted signal.

5. Since the writing of the Students Manual new radio sets which are calibrated in terms of *kilocycles* instead of meters have been developed. As a consequence it is necessary for the student to

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thoroughly understand the relationship between *wave length* and *frequency*.

a. Explain that on some of the present existing Army radio sets the dials and other controls are marked in terms of wave length. If it is desired to send a message on a wave length of 300 meters, the dials and controls are adjusted to this reading. On the new sets to be issued the dials are marked in terms of *"kilocycles"* or *the number of waves emitted per second.* Bring out the fact that a close relationship exists between the *length of a wave* and the *number of waves per second.* For instance, when electromagnetic waves are emitted by a radio set there are three things to be considered, as follows:

(1) The speed at which the waves travel through the ether (velocity).

(2) The number of waves which pass through the ether per second (frequency).

(3) The length of a single wave.

b. It has been determined that the speed or velocity at which the electromagnetic waves travel through the ether is 300,000,000 meters per second (roughly 186,000 miles per second). If the length of a single wave is known, it is possible to determine the number of waves emitted per second (or frequency) by dividing the speed at which the waves travel (300,000,000 meters per second) by the length of a single wave. For example, upon measuring the length of the wave emitted by a certain radio transmitter it was found to be 300 meters. Dividing 300,000,000 (meters per second) by 300 meters (length of a single wave) the result will be a frequency of 1,000,000 waves per second. This number of waves per second (1,000,000) may be expressed in cycles (in this case 1,000,000 cycles) by *dividing* the number of cycles by 1,000. The resultant answer will be in *kilocycles* (in this case $1{,}000{,}000 \div 1{,}000 = 1{,}000$ kilocycles), a more convenient form.

c. In the same manner if the frequency or number of kilocycles per second is known it is a simple matter to determine the length of a wave. For example, a certain radio receiver is intercepting waves at a frequency of 600 kilocycles per second. Change 600 kilocycles to cycles by multiplying by 1,000 ($600 \times 1{,}000 = 600{,}000$). Divide the velocity (300,000,000 meters) per second by the number of cycles per second ($300{,}000{,}000 \div 600{,}000 = 500$ meters).

d. When the students understand the principle involved, give them several problems involving the conversion of kilocycles into meters and vice versa.

6. The instructor should now direct the students to begin the experiments listed in the Students Manual under Unit Operation No. 6. He should personally supervise their work and assist whenever necessary, but should not actually perform any experiment for them.

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7. After these experiments have been completed the instructor should require each student to answer all of the questions of this *important* Unit Operation, which covers basic radio theory. Each student should fully understand this work before progressing to following Unit Operations. In addition to the questions in the Students Manual the instructor may ask such questions as the following in order to bring out further details.

a. Does the distance that a signal is transmitted depend in any degree upon the wave length of the signal?

b. At what speed does the radio wave travel?

c. Why is it necessary to use an accurately calibrated wave meter in the Army?

d. Can communication be carried on for a short distance, using one wave meter as a transmitting station and another as a receiving station and vice versa?

8. The important new words in this Unit Operation are:

Wave meter.	Farad.
Electromagnetic wave.	Microfarad.
Radio waves.	Fixed and rotary plates (condenser).
Ether.	Heat waves.
Wave length and wave-length band.	Interference (radio).
Meters.	Radiophone.
Sound waves.	Broadcasting stations.
Light waves.	Tune.
Calibrate.	Audible.
Rotary condenser	Head set or phones.
Inductance coil.	Mineral.
Crystal detector.	"Cat whisker."
Capacity (electrical).	Ball and socket joint

9. This Unit Operation is most important, since it covers the important basic principles of radio. The instructor should review these experiments as often as necessary to insure a thorough knowledge by each individual student before progressing to the next Unit Operation. He should state specifically the reason for conducting these experiments and what knowledge the student should have acquired. Each student should know the meaning and function of the following subjects taken up in this Unit Operation:

a. Electromagnetic waves or radio waves.
(1) Similarity to sound, heat, and light waves.
(2) Wave length and how measured.

b. Meters (also kilocycles).

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c. Wave meter.
(1) As a receiver.
(2) As a transmitter.
d. Rotary and fixed condensers (capacity).
e. Inductance coils (inductance).
f. Crystal detector.
g. Calibration of wave-meter scale.
h. Coupling.
i. Measurement of transmitted waves.
j. Measurement of received waves.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

1. After Unit Operation No. 6 is completed and *each* student has answered *all* of the questions in the Students Manual the instructor should give the Instruction Test set forth below or devise one similar to it.

2. It will be found more convenient to give the Performance part of the test to part of the class, while the other part is taking the Information Test.

3. The instructor, in person, should supervise the Performance Test, assisting whenever necessary but in no case actually perform any experiment for the student.

INSTRUCTION TEST NO. 6–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
2 wave meters (complete), 1 concealed.
1 head set.

2. When the instructor says "Begin," start your work promptly. Do it *carefully* and quickly.

3. *a.* Open the cover on the wave meter before you and prepare it for receiving a signal. Plug in the telephone receivers in the proper place.

b. Near you is a concealed wave meter which is transmitting a signal at a certain definite wave length. Find this signal and record your wave-length reading in meters on the dotted line to the right. --------------------

c. When you have finished, notify the instructor by raising your right hand. The instructor will record the time it has taken to do the work and will inspect it.

4. Face about and wait until you are directed to begin the next part of the test. The instructor will then disconnect your telephone receivers from the wave meter you are using and connect them to

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the concealed wave meter. At the same time the instructor will set the concealed wave meter at some definite setting.

5. When the instructor says "About face. Begin," start your work promptly.

6. *a.* Prepare the wave meter in front of you as a transmitter. Put on the telephone receivers and adjust your transmitting wave meter by trying different coils until the signal is heard in your head set. This indicates that you have tuned the transmitting wave meter to the same wave length that the receiving wave meter is tuned to.

b. Read this wave length and record your reading on the dotted line to the right. ------------------

c. When finished, notify the instructor by raising your right hand. The instructor will then note the time it has taken to do the work and will inspect it. When all of the students have finished, you may ask the instructor to aid you on any part of the test which you do not understand.

Scoring.

1. The maximum possible score for this test is 16 points.
2. The score required to pass this test is 12 points.
3. *Directions for scoring.*

	Points.
a. (1) For preparing and correctly adjusting the wave meter as a receiver	2
(2) For correctly tuning in the transmitted wave	4
(3) For reading the correct wave length	2
b. (1) For correctly preparing the wave meter as a transmitter	2
(2) For tuning the transmitter to the desired wave	4
(3) For reading the correct wave length	2

4. Where the student has failed to complete the test or has failed to correctly perform the test, a grade of zero will be given for incomplete parts or incorrect performance.

INSTRUCTION TEST NO. 6–B (INFORMATION).

Part I.

Directions to the student.

1. Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

2. When the instructor says "Begin," start your work promptly. Do it *carefully* and quickly.

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a. How many inductance coils are furnished for use with the SCR–61 wave meter?

(1) Two. (2) Three. (3) Four. (4) One. ------

b. What instrument renders possible the hearing of signals in the telephone receivers, which otherwise would not be heard?

(1) Buzzer. (2) Detector. (3) Battery. (4) Buzzer switch. ------

c. How many scales are there on the wave-meter dial?

(1) Four. (2) Six. (3) One. (4) Three. ------

d. For what purpose is a wave meter usually used?

(1) To send messages.
(2) To receive messages.
(3) To measure wave lengths.
(4) As an auxiliary radio set. ------

Part II.

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what is says is not true (incorrect), place a minus (–) sign on the dotted line.

1. The SCR–61 wave meter can be used to transmit as well as receive signals. ------
2. The two main parts of this wave meter are the rotary condenser and the buzzer. ------
3. The wave-length range of the SCR–61 wave meter is from 160 to 2,600 meters. ------
4. The BA–4 bell must be connected to the wave meter with proper polarity. ------
5. The buzzer is used only for adjusting the detector. ------
6. When the coils of two wave meters are loosely coupled, the signal from one wave meter will be heard over several degrees of the scale on the other. ------
7. The three coils furnished with the wave meter are of the same size. ------
8. The buzzer of the wave meter is operated by a type BB–14 battery. ------
9. The adjustment of the crystal detector is easily disturbed by shocks or jars ------
10. The distance which a radio message may be transmitted depends upon the wave length. ------
11. A radio transmitting set can be made to transmit at practically any desired wave length. ------
12. The unit of inductance is known as the "farad." ------

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THE SCR-74-A TRANSMITTING SET.

(SET BOX BC-18-A.)

Equipment.

1 set box, BC-18-A only.
1 wave meter, type SCR-61.
1 head set, type P-11.
1 storage battery, 10 volts, type BB-3; or 3 batteries, type BB-14.

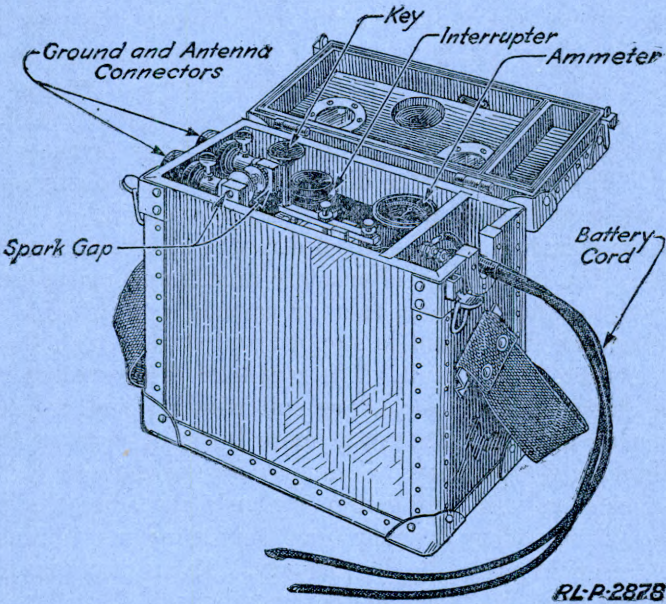

Fig. 30.—Set box, BC-18-A, with lid open.

GENERAL CONSTRUCTION OF THE SCR-74-A SET.

Information.

The SCR-74-A is an *induction coil* transmitting set of low power. (See Fig. 30.) The power supply is obtained from a 10-volt storage battery, which is connected to the primary of the induction coil through an ammeter and a key.

The induction coil is composed of two separate coils which are designated the *primary* and the *secondary*. These two coils are wound around a soft iron core. The primary winding, or coil, is formed of large wire wound directly on the core. The secondary winding is built outside the primary, in such a way that it incloses both the core and primary, and is constructed of small wire with

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many more turns than the primary. After the winding has been completed the two coils and the core are dipped in wax, paraffin, or some other good insulator. One end of the primary winding is connected to one of the battery terminals through an interrupter, similar to the one on an ordinary buzzer, and a telegraph key. The other end of the primary winding is connected to the other side of the battery. (See Fig. 30.) The ammeter connected in the primary circuit is used to indicate when the coil is working properly. The ends of the secondary winding are connected to the sparking surfaces or *electrodes* of the *spark gap.*

The function of the induction coil is to change the low voltage *direct current* from the storage battery in the primary coil to a high voltage *alternating current* in the secondary. It suffices to say here that an alternating current is an electric current which flows first in one direction and then reverses and flows in the opposite direction. This reversal of the direction in which the current flows occurs with great frequency—many times per second.

Briefly the change in current from direct to alternating is effected as follows: The *interrupter* alternately breaks and makes the electrical circuit of the primary, thereby causing a *pulsating current* to flow whenever the current is stopped and started with the opening and closing of the circuit. The *magnetic fields* created by this pulsating current cut the secondary coil winding and induce in it an alternating current. There are more turns of wire on the secondary than on the primary. Consequently the induced voltage is much higher than that supplied to the primary since the voltage induced in the secondary depends upon how many more turns there are in the secondary than in the primary. As an example, if there are ten times as many turns on the secondary as there are on the primary, the voltage of the secondary will be about ten times as great as that supplied to the primary. Some idea can be had of the secondary voltage of this coil from the fact that 20,000 volts will cause a spark to jump a gap of 1 inch.

Questions.

(1) *What does each of the following mean? Interrupter, spark gap, electrode, function, magnetic field.*

(2) *What is the difference between a direct current and an alternating current?*

Directions.

1. Open the set box by undoing the latches and throw back the lid. (See Fig. 30.) Unscrew the two thumbscrews and remove

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the two round bakelite nuts which hold the antenna and ground insulators in the box. Observe how these insulated connectors make contact with opposite sides of the spark gap. At the opposite end of the box remove the screws connecting the battery leads to the

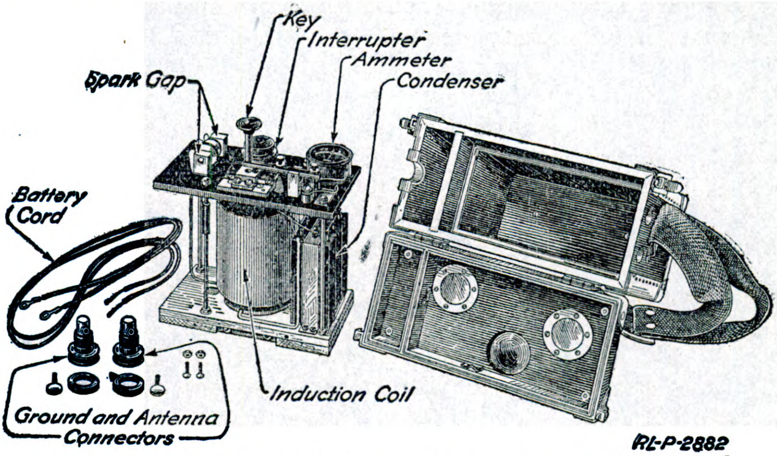

Fig. 31.—Set box, BC-18-A, disassembled to show various parts.

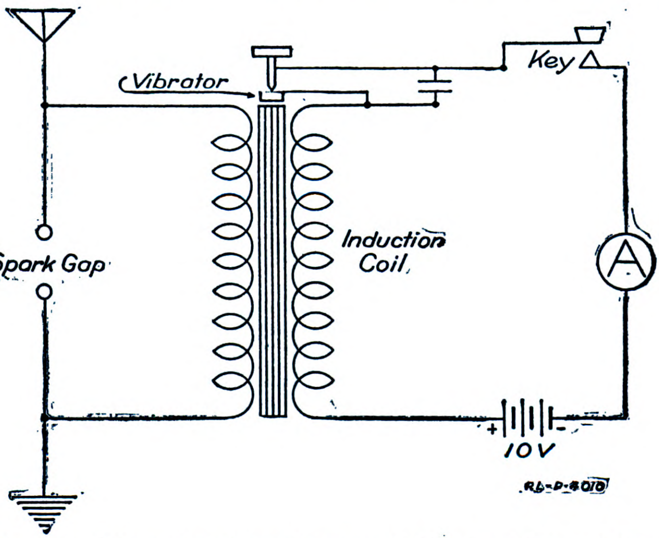

Fig. 32.—Schematic wiring diagram of SCR-74-A transmitter.

box. Turn the box over, holding the parts in place so they will not fall out, and remove the two screws in the bottom of the box. The panel and attached parts should now come out easily. (See Fig. 31.) Check the wiring with the diagram in the lid of the set box or with the diagram shown in Fig. 32. Compare the size of

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the wire coming out near the center of the coil with that on the outside. Note which winding is connected in the primary circuit and which is connected to the spark gap. Examine the interrupter and note how it is constructed and how it operates. Note how the key is connected, constructed, and adjusted, and how the condenser is connected in the primary circuit.

Questions.

(3) *What is the meaning of each of the following? Bakelite, ground, insulators, antenna, ground lead.*

(4) *How is the key operated when the box is closed?*

(5) *Is the ammeter in the primary or secondary circuit?*

(6) *For what purpose is the fixed condenser used?*

(7) *What is the purpose of the interrupter?*

(8) *How is contact made between the spark gap and the antenna and ground leads?*

(9) *How is the spark gap adjusted?*

(10) *How is the interrupter adjusted? Does the lock nut on the interrupter contact screw up or down to lock the contact screw in position?*

(11) *Can the spark gap be seen when the lid is closed?*

(12) *Why are there thumbscrews on the antenna and ground lead in terminals?*

(13) *For what is the little compartment on the right of the box used?*

(14) *How is the distance between the contacts of the key adjusted?*

(15) *Does it make any difference which battery lead is connected to the positive pole of the battery?*

(16) *Which coil is wound with the larger wire. the primary or the secondary?*

(17) *Why are the windings of the induction coil dipped in wax or paraffin?*

(18) *Which two screws hold the apparatus in the set box?*

(19) *What is the voltage of the storage battery used with this set?*

(20) *What would be the effect of connecting a 20-volt battery in the primary instead of the 10-volt battery?*

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Directions.

2. Put the set back in the box, and replace all the screws, nuts, and leads.

Information.

When the SCR–61 wave meter is used as a transmitter, the inductance coil acts as a radiator of the rapidly vibrating or high frequency currents. The distance over which the wave meter is effective is limited to a matter of only a few inches. If a wire, suspended above the ground between two supports, were connected at one end to one of the coil terminals on the wave meter, the transmitting range would be increased considerably. A large

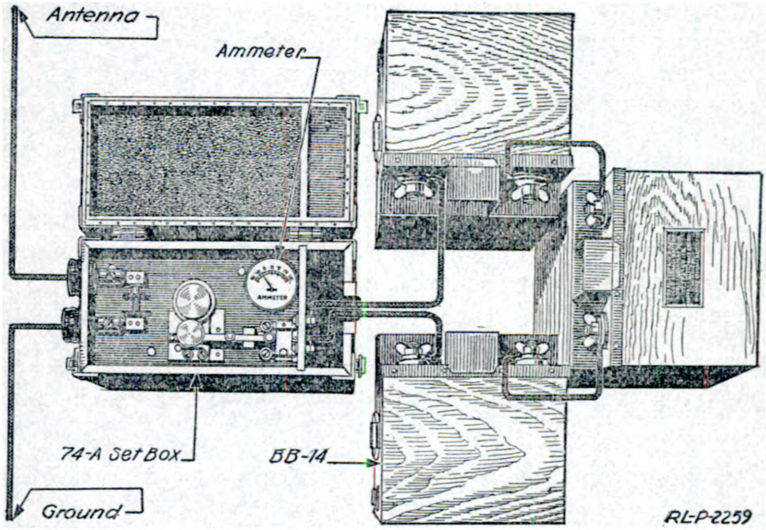

Fig. 33.—Cording diagram of SCR–74–A transmitter.

radiator or antenna of this type is necessary when using the SCR–74–A transmitter in order to reach the maximum distance range of the set.

EXPERIMENT No. 1.

MEASURING THE WAVE LENGTH RADIATED.

Directions.

3. Take the set box, battery, and wave meter over to the lead-in of the antenna indicated by the instructor. Connect the antenna lead, and ground or counterpoise lead to the set box. Set the spark gap to about one-eighth inch. Connect the battery leads to the battery. (See Fig. 33.) *Do not touch the spark gap or antenna, while*

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there is current in the primary, as there is danger of receiving a severe shock.

4. Never close the key until both the antenna and counterpoise are connected to the set, and be sure that the length of the spark gap is not over one-eighth inch. If the gap is greater than this there is danger of breaking down the insulation in the secondary winding of the spark coil.

5. Close the key and adjust the interrupter until it is giving a clear steady pitched note and the ammeter registers about 5 to 7 amperes. Adjust the spark gap, being careful not to touch it while the current is on, until it has a good blue-white spark playing steadily between the sparking surfaces.

6. By means of the wave meter take a reading of the wave length being transmitted by the set. Begin by trying to obtain this reading close to the set and then move out toward the end of the antenna until the reading is fairly sharp. Record the results.

EXPERIMENT NO 2.

7. Repeat the work performed in Experiment No. 1 on another antenna indicated by the instructor. Measure the wave length as in Experiment No. 1 and compare this wave length with the wave length measured on the antenna of Experiment No. 1.

Questions.

(21) *Why is it dangerous to touch the antenna when the key is down?*

(22) *On which antenna was the largest wave length reading obtained?*

(23) *Is the wave length on which this set transmits dependent on the antenna used?*

(24) *Is the signal readily tuned out?*

(25) *Could many of these sets work close together without interference?*

(26) *What is a high frequency current?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class describe the *induction coil.* Show the windings by means of a diagram on the blackboard. Explain the operation of the *induction coil* in simple terms.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important new words in this Unit Operation are as follows:

Induction coil.	Pulsating current.	Spark.
Secondary coil.	Generator current.	Interrupter.
Battery circuit.	Alternating current.	Clips.
Ground circuit.	Spark gap.	Polarity.
Direct current.	Spark-gap electrodes.	"Broad wave."

4. When the students have completed this Unit Operation they should know:

a. How to completely connect the SCR–74–A to the batteries, antenna, and ground;

b. How to properly adjust the spark gap; and

c. How to operate the set and make all necessary adjustments for operating.

5. When the class work has been completed, give the following Instruction Test (or one devised similar to it). The test should be conducted in the same manner as in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 7–A (PERFORMANCE.

Directions to the instructor.

Equipment.

1 set box, BC–18–A only (SCR–74–A).
3 storage batteries, type BB–14.
1 ground connection.
1 antenna and lead-in.
Wire for connections.

Procedure.

1. Place the equipment listed above in a suitable location for conducting the test. Most any type of antenna already erected will be suitable for this test. Provide a suitable "Ground" and label both ground and antenna leads with tags properly marked "Antenna" and "Ground."

2. Direct the student to connect the set completely, including antenna and ground connections, and to operate the set, making all proper adjustments

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3. When the student has completed the test, he will notify the instructor by raising the right hand, and the instructor will record the time taken by each student. The instructor will inspect the connections and the spark gap adjustment as soon as possible.

INSTRUCTION TEST NO. 7–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 set box, type BC–18–A (SCR–74–A).
   3 storage batteries, type BB–14.
   2 lead-in wires (from antenna and ground).
   Wire for connections.

2. When the instructor says "Begin," start your work promptly. Do it carefully and quickly.

3. *a.* Connect the equipment completely, including batteries, antenna, and ground.

b. Operate the set and make any adjustments necessary.

4. When this work is completed, face about and notify the instructor by raising your right hand. The instructor will then note the time it has taken to do the work and will inspect the connections and operation of the set.

Scoring.

1. The maximum possible score for this test is 6 points.
2. The score required to pass this test is 4 points.
3. *Directions for scoring.*

	Points
a. For properly making all connections	4
b. For properly adjusting the spark gap	2

4. Where the student has failed to complete the test or has failed to correctly solve the problem, a grade of zero will be given for incomplete parts or incorrect answers.

INSTRUCTION TEST NO. 7–B (INFORMATION).

PART I.

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. The ammeter of the BC–18–A set box is connected in the
(1) antenna circuit. (2) secondary coil.
(3) battery circuit. (4) ground circuit. ------

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b. The current which flows in the secondary of the induction coil is known as

(1) direct current. (2) pulsating current
(3) generator current. (4) alternating current. ------

c. The correct distance between the spark-gap electrodes should be about

(1) ½ inch. (2) ⅛ inch. (3) $\frac{1}{100}$ inch. (4) ¾ inch. ------

d. The voltage required to operate the induction coil is

(1) 4 volts. (2) 8 volts. (3) 15 volts. (4) 10 volts. ------

e. The length of the wave transmitted by the SCR–74–A set depends upon

(1) the size of the battery.
(2) the length of the spark gap.
(3) the size of the antenna. (4) the spark. ------

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. It is dangerous to touch the antenna when the key is down. ------
2. The key of the SCR–74–A set can not be operated when the set box is closed. ------
3. The interrupter is used to adjust the wave length. ------
4. The antenna and ground leads are held in place by clips. ------
5. The connections between the battery and the set box may be made disregarding polarity. ------
6. Only two SCR–74–A sets may be worked close together without interference. ------
7. The wave emitted by an SCR–74–A set is known as a "broad" wave. ------

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THE SCR-74-A TRANSMITTER.

(COUPLED CIRCUITS.)

Equipment.

1 set box, type BC-18-A.
1 antenna equipment, type A-3-A.
2 helical inductances with clips (bare wire or a copper strip).
1 hot-wire ammeter, scale 0-0.5.
1 wave meter, type SCR-61.
1 transmitting condenser, fixed, capacity approximately 0.004 mfd. (microfarad).
1 storage battery, type BB-3; or 3 storage batteries, type BB-14.

Information.

The SCR-74-A is an *untuned* induction coil or spark coil transmitter. This means that no provisions are made in the set box itself for tuning to any particular wave length. The only way in which the wave length of this set can be changed is by altering the dimensions of the antenna provided with the set. However, the set box of the SCR-74-A may be used with some additional apparatus to form different types of transmitting circuits which may be operated on more than one wave length.

The method of tuning certain circuits in conjunction with the SCR-74-A is somewhat similar to that used in tuning the wave meter to transmit any given wave length. In the wave meter three inductance coils are used which are not variable; that is, the number of turns of wire in each coil can not be varied. The capacity of the rotary condenser, however, can be varied, and thereby cause the wave meter to be tuned to a given wave length. In tuning the SCR-74-A to a given wave length one or two variable inductances and a condenser which can not be varied are used. In construction the inductance coils used with the SCR-74-A differ from the coils used in the SCR-61 wave meter. The coils of the wave meter are wound with small wire for the reason that the current carried is very small. The large coils used with the SCR-74-A are wound with large wire or brass strips in order to carry the large currents.

Directions.

1. Examine one of the large inductance coils.

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Questions.

(1) *How does the manner in which the larger coil is wound differ from the winding of the wave meter coils?*

(2) *What part of a clock or watch is wound similar to the large coil?*

(3) *Why is the coil constructed of such heavy wire or strip?*

(4) *What means are provided to make the inductance coil variable?*

Information.

Coupling.—When a radio set contains more than one circuit there must be a way provided to transfer the energy from one circuit to the other. This transfer of energy from one circuit to another is accomplished by what is known as *coupling*. Two circuits are said to be coupled when it is possible for the energy of one circuit to be transferred to the other circuit. Transfer of energy may be accomplished in any one of the following methods of coupling:

Direct coupling.—Two circuits are directly coupled when a part of one circuit is also a part of the other circuit.

Inductive coupling.—Two circuits are inductively coupled when the energy of one circuit is transferred to the other by means of a magnetic field.

Capacitive coupling.—Two circuits are capacitively coupled when the energy of one circuit is transferred to the other by means of condensers.

NOTE.—This form of coupling is limited in use and will therefore not be discussed further.

In some radio sets the coupling used between two circuits is a combination of all three of the above methods.

The degree of coupling between the two circuits is measured by the amount of energy that is transferred from one circuit to the other. When the greater part of the energy in one circuit is transferred to the other circuit the coupling is referred to as *close* or *tight* coupling. When only a small part of the energy is transferred the coupling is referred to as *loose* coupling.

The SCR–74–A set contains only one high frequency circuit; consequently no coupling is involved. In the experiments which follow, the set box, type BC–18–A, of the SCR–74–A, will be used with some additional apparatus to illustrate the subject of coupling.

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Questions.

(5) *How many high frequency circuits are there in the SCR–74–A?*

(6) *Can the wave length on which the SCR–74–A transmits be changed?*

(7) *What is inductive coupling?*

(8) *What is direct coupling?*

(9) *What is capacitive coupling?*

(10) *How is inductive coupling varied?*

(11) *How is direct coupling varied?*

(12) *How many inductance coils are needed in a direct coupled set?*

(13) *In what two ways may the coils of an inductively coupled set be moved in order to change the coupling?*

(14) *When an SCR–61 wave meter is used, what kind of coupling exists between it and the circuit which is being measured?*

EXPERIMENT NO. 1.

TUNING.

Information.

As previously mentioned a circuit may be tuned by changing either the capacity or the inductance. In high power spark transmitting circuits it is impractical to construct the condensers so that they may be continuously varied. It is therefore necessary to tune the transmitting circuit by changing the inductance of the circuit. In the following experiment the set box, type BC–18–A is used to set up radio currents in the circuit to which it is connected. This was done similarly in Unit Operation No. 7 when the set box was connected to the antenna system. The circuit used in this experiment can be considered as equivalent to the antenna circuit, with the exception that this circuit can be varied while the antenna circuit can not.

Directions.

2. Make the following connections as shown in Fig. 34.

a. Connect the antenna terminal on the set box, type BC–18–A, to one side of the transmitting condenser.

b. Connect the remaining side of the transmitting condenser to one of the clips which fit on the helix and place the clip on the fourth or fifth turn (counting from the center) of the helix.

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c. Connect the center of the helix to the terminal marked "Ground" on the set box.

d. Connect the three storage batteries, type BB–14, in series, and connect the battery leads from the set box to the 12-volt battery thus formed.

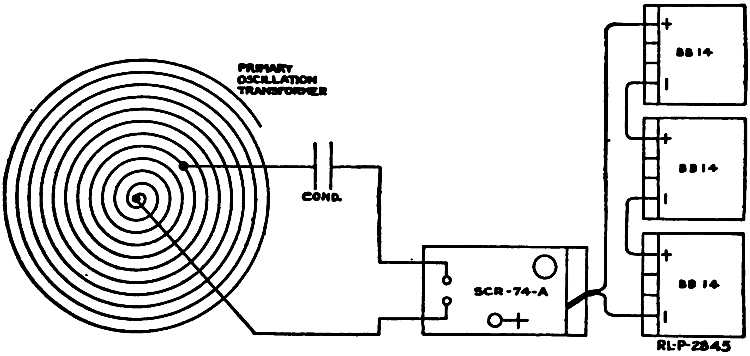

Fig. 34.—Method of connecting inductance and condenser to SCR–74–A transmitter.

3. Set the spark gap on the set box to about 1/16 of an inch, close the key, and adjust the interrupter until it is operating smoothly and the ammeter shows a current of from 5 to 7 amperes.

4. Using the SCR–61 wave meter measure the wave length on which the set is transmitting and tabulate the result in the following table:

Wave length.	Number of turns of inductance.
....	....
....	....
....	....
....	....
....	....

5. Increase the number of turns of inductance in the circuit by moving the helix clip out three or four turns and again measure the wave length and record in the above table.

6. Tune the circuit to transmit on a wave length of 200 meters by setting the wave meter to 200 meters and moving the helix clip until maximum signal strength is obtained in the wave meter. Record in the above table the number of turns required.

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Questions.

(15) *As the number of turns of the inductance which are in the circuit is increased, what happens to the wave length on which the set is transmitting?*

(16) *Do the inductance and capacity in this circuit take the place of the standard antenna with respect to the set transmitting on a definite wave length?*

(17) *If a smaller condenser were used in this circuit would the wave length be greater or less?*

(18) *Does one-half of a turn of the inductance make much difference in the transmitted wave length?*

(19) *Will a small variation of the wave-meter knob tune out the signal?*

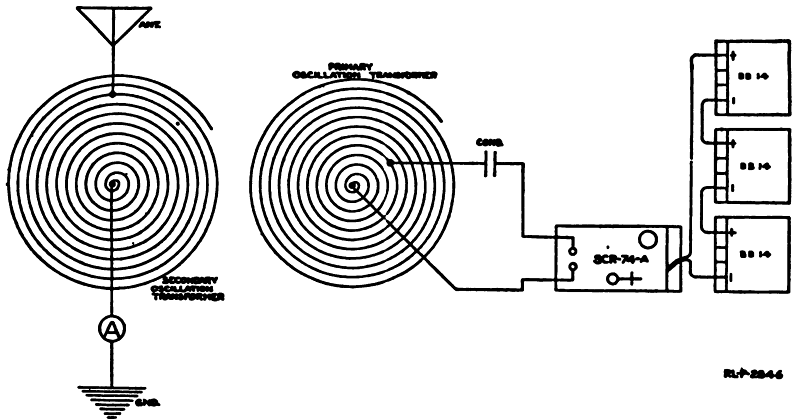

Fig. 35.—The SCR–74–A transmitter inductively coupled to the antenna circuit.

Experiment No. 2.

INDUCTIVE COUPLING.

Information.

It was probably noted in Experiment No. 1 that the signals could be heard over a considerable portion of the scale of the wave meter. A transmitter which produces signals of this character is said to be *broadly* tuned. If such signals were used in radio communication, there would be a great deal of interference between different stations transmitting at the same time. A receiving station would be unable to tune out the undesired transmitters. This difficulty may be, to a large extent, overcome by coupling the antenna or radiating circuit to the circut in which the signals are generated, instead of

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having them generated directly in the radiating circuit. In the following experiment inductive coupling is used to accomplish this result.

Directions.

7. With the inductance coil, set box, and batteries connected the same as in Experiment No. 1, place the second helical inductance coil close to and with its plane parallel to the first coil. Connect the antenna lead-in wire to the clip on the second coil and place the clip on about the eighth or ninth turn from the center. Connect the center end of the coil to one side of the hot-wire ammeter and the other side of the ammeter to the ground. (See Fig. 35.)

8. Start the set and observe the ammeter in the ground lead. Vary the number of turns in the secondary or antenna inductance until the highest possible reading is obtained on the ammeter. When the ammeter reads a maximum, the antenna or secondary circuit is in tune with the primary or closed circuit. Couple the SCR–61 wave meter to the antenna circuit by wrapping a turn of the ground wire around the lid of the wave-meter box and measure the wave length on which signals are being transmitted. Note particularly over how much of the wave-meter scale the signals can be heard. Vary the amount of inductance in the primary circuit without changing the antenna circuit, and note what happens to the signal strength.

9. With the planes of the two inductance coils still parallel, move the antenna circuit coil until they are about 3 inches apart and again adjust the number of turns in the antenna coil until the ammeter reads a maximum. Measure the wave length and again note over how much of the wave-meter scale the signals can be heard. Note how the signal strength compares with that obtained when the two coils were close together.

10. Adjust the set to transmit on a wave length of 250 meters with the greatest possible current as indicated by the ammeter in the ground lead. Have the coupling fairly loose.

Questions.

(20) *Could the signals be heard over as much of the wave meter scale in this experiment as in Experiment No. 1?*

(21) *Were the signals heard in the wave meter in this experiment as loud as those obtained in Experiment No. 1?*

(22) *When Directions 7, above, were followed, were the signals heard over as much of the wave meter scale as when Directions 6 were followed?*

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(23) *Bearing in mind the answer to the preceding question, state whether close or loose coupling should be used in order to reduce interference.*

(24) *Would the signals sent out in Experiment No. 2 cause more or less interference than those sent out in Experiment No. 1?*

EXPERIMENT No. 3.

DIRECT COUPLING.

Information.

It will be noted that the direct-coupled set requires only one inductance coil. For this reason this method of coupling insures lightness and portability of the set. However, there are certain dis-

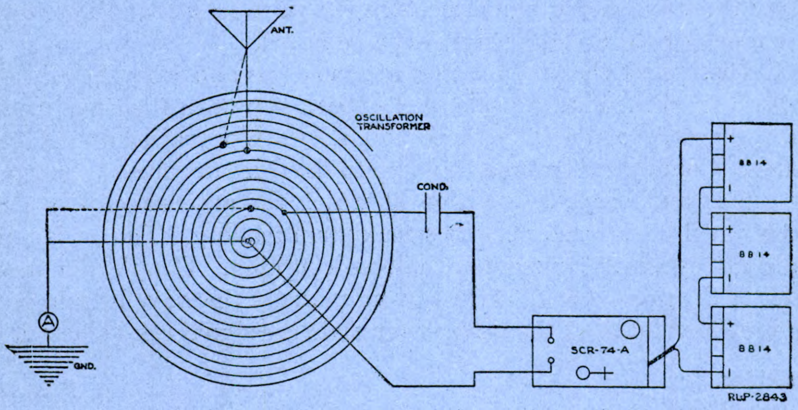

Fig. 36.—The SCR-74-A transmitter directly coupled to the antenna circuit.

advantages in direct coupling, which in most cases more than offset the above advantages. In the following experiment an attempt will be made to show some of the results obtained with direct coupling.

Directions.

11. With the inductance coil, set box, and batteries connected, the same as in Experiment No. 1, make the following additional connections:

a. Connect the ground lead to one side of the hot-wire ammeter.

b. Connect the remaining side of the hot-wire ammeter to the center end of the inductance coil.

c. Connect the antenna lead to a helix clip and place the clip on the eighth or ninth turn from the center of the coil. The completed connections are shown in Fig. 36. In this figure the dotted lines show how the antenna circuit leads are shifted in order to obtain loose coupling. When the connections used are the same as those

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shown by the solid lines, all of the turns of the inductance of the closed circuits are also included in the antenna circuit, while with the dotted line connections only a part of the closed circuit inductance is common to the antenna circuit.

12. With the connections given by the solid lines in Fig. 36, adjust the antenna lead clip until the hot-wire ammeter shows a maximum reading. Using the SCR–61 wave meter, measure the wave length on which the set is transmitting, and carefully note over how much of the wave meter scale the signals can be heard.

13. Place a helix clip on the lead from the hot-wire ammeter to the center of the coil, and connect the lead to the third or fourth turn from the center instead of to the center. Vary the position of the antenna lead clip until the ammeter gives a maximum reading. Using the wave meter, again measure the wave length and note over how much of the scale the signal can be heard.

14. Disconnect the antenna and ground clips and vary the clip on the lead from the antenna side of the spark gap until the wave meter when coupled to the inductance coil shows a wave length of 250 meters. Connect the ground lead clip to the third or fourth turn from the center and vary the position at which the antenna clip is connected until the ammeter shows a maximum reading. The set is now transmitting on 250 meters with loose coupling. Couple the wave meter to the ground lead of the set and measure the wave length, noting over how much of the wave meter scale the signal can be heard.

Questions.

(25) *When measuring the wave length of a direct coupled transmitter, over approximately what number of degrees on the wave meter scale can the signals be heard when the coupling is loose? When the coupling is close?*

(26) *Which signal was heard over a greater portion of the wave meter scale when direct, loose coupling was used or when inductive, loose coupling was used?*

(27) *Was more antenna current obtained with direct coupling or with inductive coupling?*

(28) *What type of coupling should be used in order to produce the minimum of interference?*

(29) *Is it as easy to change the degree of coupling with direct coupling as it is with inductive coupling?*

(30) *How is a direct-coupled set tuned to transmit on a given wave length?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class discuss "coupling" and distinguish between "loose" coupling and "tight" or "close" coupling, using blackboard diagram if possible.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Coupling.	Signal strength.	Tuning (a set).
"Loose" coupling.	Antenna.	Tuning, sharp.
"Tight" or "close" coupling.	Antenna circuit.	Inductively.
Inductive coupling.	Lead-in, antenna.	Conductively.
Conductive coupling.	Ground wire.	Directly.
Wave length.	Condenser, fixed.	Capacitively.
Wave meter.	Set box.	
Induction.	Set of inductances, transmitting.	
Capacity.	Radiate.	

4. When the students have completed this Unit Operation, they should know the names and purposes of all of the important parts of the SCR–74–A set and should be familiar with the working of these parts. From the experiments performed the students should know:

a. How to couple the set inductively or conductively to the antenna;

b. The reason for using coupling;

c. How to vary the transmitting wave length; and

d. How to make proper connections and adjust the set for transmitting on a given wave length.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 8–A (PERFORMANCE).

Directions to the instructor.

Equipment.

1 ammeter (hot wire or thermo-couple).
1 condenser, fixed (approximately 0.004 mfd.).
1 set box, SCR–74–A, type BC–18–A.
1 set of inductances, transmitting.
1 wave meter, type SCR–61.
1 antenna and lead-in.
Ground wire.

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Procedure.

1. Place the equipment listed above in a suitable location for conducting the test. Most types of antennæ (that may already be erected) will be suitable for this test. Provide a suitable ground, and label both ground and antenna leads.

2. Direct the student to connect up the set, coupling it inductively to the antenna circuit and to adjust the set for transmitting on a 200-meter wave length.

3. When the student has indicated that he has completed this work, record the time taken by each student, and as soon as possible inspect the connections made and check the wave length radiated by each set.

4. When ready for the second part, direct the student to couple the set to the antenna, using conductive coupling, and adjust for transmitting at a wave length of 250 meters.

5. When the student has completed the test, he will notify the instructor in the usual manner, and the instructor will again record the time and as soon as possible will inspect the connections and check the transmitting wave length.

INSTRUCTION TEST NO. 8–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   - 1 ammeter (hot wire or thermocouple).
   - 1 condenser, fixed (approximately 0.004 mfd.).
   - 1 set box, SCR–74–A (type BC–18–A).
   - 1 set of transmitting inductances.
   - 1 wave meter (type SCR–61).
   - 2 lead-in wires (from antenna and ground).

2. When the instructor says "Begin," start your work promptly. Do it *carefully* and quickly.

Problem 1.

1. *a.* Connect the equipment properly for transmitting, using *inductive* coupling to the antenna.

b. Adjust for a transmitting wave length of 200 meters.

2. When this work is completed, face about and notify the instructor by raising your right hand. The instructor will then note the time it has taken to do the work. He will also inspect the connections and check the transmitting wave length.

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Problem 2.

1. When the instructor again says "Begin," start work promptly on the following operations:

2. *a.* Connect the equipment properly for transmitting, using *conductive* coupling.

b. Adjust for a transmitting wave length of 250 meters.

3. When this work is completed, face about and notify the instructor by raising your right hand. The instructor will again note the time, inspect your work, and check the wave length.

4. When all students have completed their work, you may ask the instructor to aid you on any part of the test which you do not fully understand.

Scoring.

1. The maximum score for this test is 16 points.
2. The score required to pass this test is 12 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. (1) For making the proper connections and coupling inductively to the antenna	4
(2) For properly tuning the set to 200 meters wave length	4

PROBLEM NO. 2.

b. (1) For conductively coupling the set to the antenna	4
(2) For properly tuning the set to 250 meters wave length	4

4. When the student has failed to complete the test or performs the test incorrectly, the grade of zero will be given for incomplete test or incorrect performance.

INSTRUCTION TEST NO. 8-B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. When two coils are used for coupling the transmitting set to the antenna, and there is no metallic connection between these twocoils, how is the set said to be coupled?

(1) Directly. (2) Capacitively.
(3) Inductively. (4) Conductively. ------

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b. When the same coil (or coils) is used for tuning, the open circuit and the closed circuit, how is the set said to be coupled to the antenna circuit?

(1) Inductively. (2) Conductively.
(3) Capacitively. (4) Indirectly. ------

c. Why is coupling used?

(1) To increase signal strength.
(2) To change capacity.
(3) To change wave lengths.
(4) To sharply tune the transmitted wave. ------

d. How is the transmitting wave length of the SCR–74 set varied?

(1) By changing capacity. (2) By changing inductance.
(3) By changing coupling. (4) By using more current. ------

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. It is necessary to vary the capacity of the condenser when tuning the SCR–74–A to different wave lengths. ------
2. A transmitting set connected directly to the antenna and ground does not tune as sharply as one that is coupled to the antenna circuit. ------
3. The wave transmitted by a conductively coupled set is sharper than that of a loose-coupled inductively coupled set. ------
4. In an inductively coupled set, if the coupling is not changed, the antenna ammeter may be made to vary by changing the amount of inductance in either coil. ------
5. The hot wire ammeter is usually connected in the closed circuit. ------
6. When only one coil is used, as is usually the case in conductive coupling, part of the coil is in the open circuit and part is in the closed circuit. ------
7. It is just as easy to change the amount of coupling with direct or conductive coupling as it is with inductive coupling. ------
8. An inductively coupled set works best when one coil is set at right angles to the other. ------

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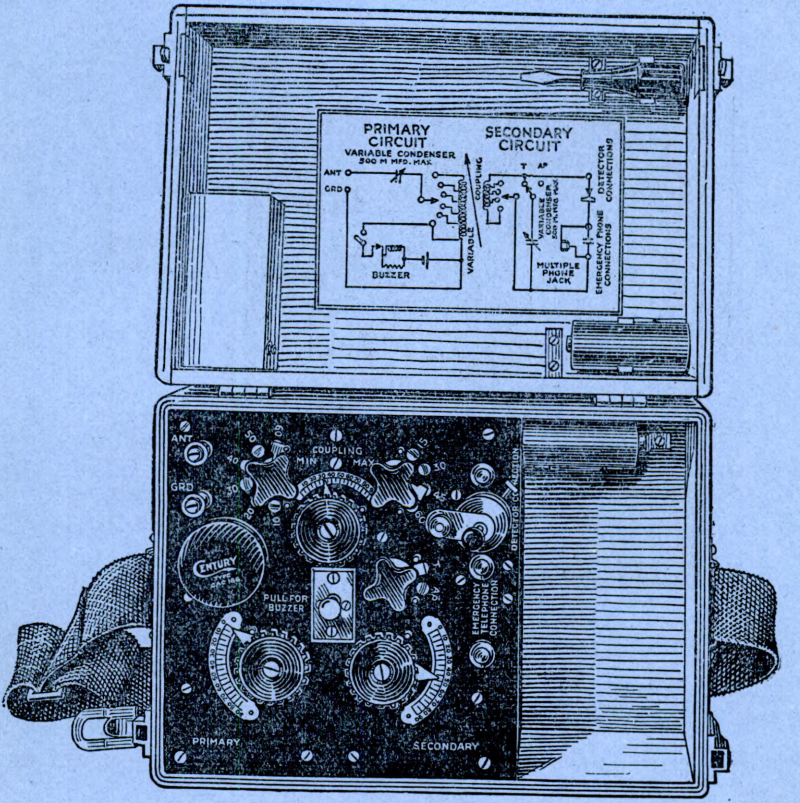
THE SCR-54-A RECEIVER.

Equipment.

1 SCR-61 wave meter.
1 SCR-54-A receiving set. (Set box BC-11-A only.)
1 antenna equipment, type A-2-A.
1 head set, type P-11.



RL-P-1935-C

Fig. 37.—Set box, BC-14-A with lid open.

Information.

The SCR-54-A (see Fig. 37) is one of the simplest types of radio receivers, designed for portable work in the field. It differs in construction from the SCR-61 wave meter, in that it has two tuning circuits instead of one. One circuit, called the *primary* circuit, includes the antenna, ground, and the primary tuning circuit; while the other circuit, called the *secondary* circuit, includes the secondary

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tuning circuit, the detector, and telephones. Both the primary and secondary tuning circuits consist of a tapped inductance coil and a variable condenser. The primary coil is stationary while the secondary coil is movable, the coupling between the two being changed by rotating the secondary.

The method of tuning the SCR–54–A differs slightly from that used in tuning the SCR–61 wave meter or the SCR–74–A transmitter. To tune the SCR–74–A transmitter the inductance is varied. In the SCR–54–A both the inductance and capacity of the primary and

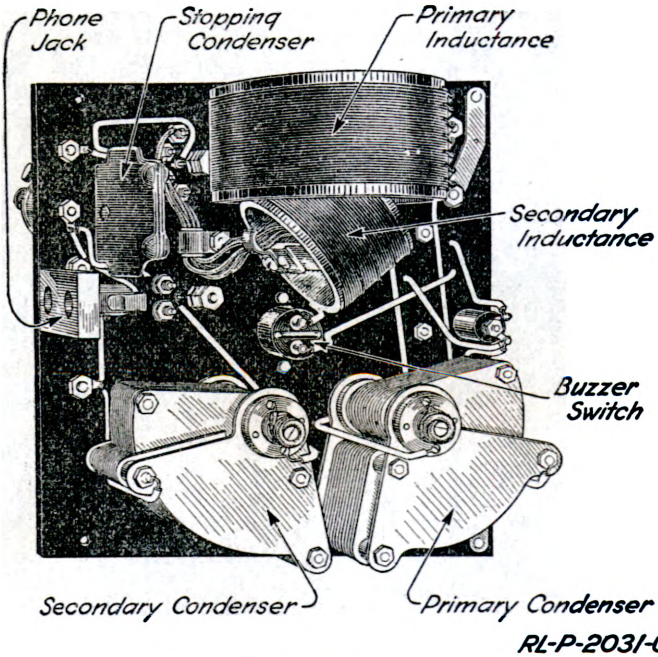

Fig. 38.—Rear of panel, set box, BC–14–A.

secondary circuits are varied when tuning the set to a certain wave length.

The *crystal detector* used in this set is similar to the one provided in the SCR–61 wave meter.

Directions.

1. Release the latches and raise the lid of the set box. Take out the four screws in the corners of the panel and remove the panel from the box. (See Fig. 38.) Place the panel in some convenient position, and trace the wiring of both the primary and secondary circuits. Compare with schematic circuit diagram shown in Fig. 39.

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Questions.

(1) *How is the battery in the set box connected to the buzzer on the panel?*

(2) *How are the two head sets connected, when their plugs are inserted in the jacks, in parallel or series?*

(3) *Is the buzzer circuit connected to the primary or the secondary circuits?*

(4) *Why is the buzzer provided?*

(5) *Is there any metallic connection between the primary and the secondary of the set?*

(6) *In which position* (up or down) *is the buzzer switch on?*

(7) *How is the coupling changed?*

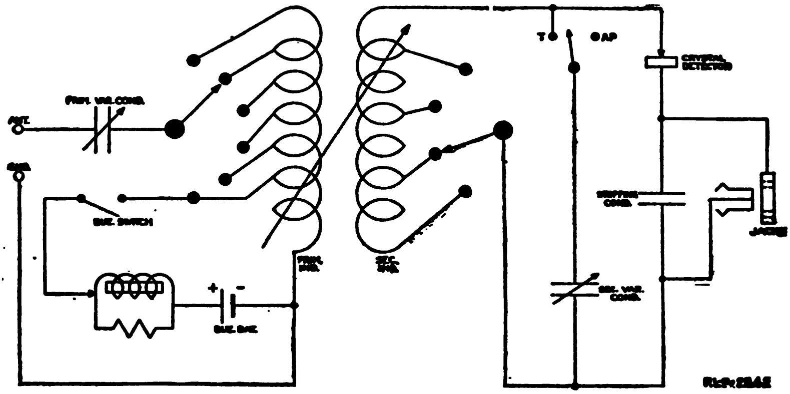

Fig. 39.—Schematic diagram of connections in set box, BC–14–A.

(8) *Why are leads brought out from the different points of the winding on the primary and the secondary coils?*

(9) *Why are the leads to the secondary inductance made flexible? Can the secondary be rotated or is it fixed in position?*

(10) *Count the number of turns on the primary inductance. See if the contact point numbers are the same as the number of turns connected in the circuit up to that point. What difference do you note?*

(11) *When the coupling scale on top of the panel indicates* "MAX" *what is the position of the secondary with respect to the primary? When it indicates* "MIN"*?*

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(12) *Is the primary inductance parallel with the back edge of the box?*

(13) *Examine the two variable condensers. How do they differ? Why? Examine the fixed condenser. How is the connection made with the fixed plates of the variable condenser?*

(14) *How is the connection made with the movable plates?*

(15) *Are the movable plates insulated from the stationary plates?*

(16) *What connection is changed when the "T–AP" switch is moved from one contact to the other?*

(17) *How is the fixed condenser constructed?*

(18) *How many telephones can be used simultaneously in this set?*

Directions.

2. Put the panel in the box and replace the screws. See that the buzzer operates.

Information.

The calibration of the set consists in determining the settings of the various variable switches and condensers for different wave lengths, so that the set can be readily adjusted to any desired wave length each time it is operated, without the necessity of using a wave meter. This is done by adjusting the variable members to the settings found by calibration.

EXPERIMENT No. 1.

CALIBRATING THE SECONDARY.

Directions.

3. Put the wave meter with its coil as close to the back of the set box as possible. (See Figs. 40 and 41.) Set the "T–AP" switch to "T" (abbreviation for "tuned"). Adjust the detector of the set by means of the buzzer test. Turn the coupling knob until the indicator points to the 90° or maximum mark, and set the secondary inductance on tap 15. Adjust the wave meter to emit a 200-meter wave. Rotate the secondary variable condenser until the signal is heard. If the signal can not be picked up with the secondary inductance switch on tap 15, advance the switch to tap 30 or higher. If the signal comes in too loudly over a large part of the condenser scale, loosen the coupling between the wave meter and set box by moving the wave meter away from the set box. It should be moved

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far enough away so that the signal can be heard over only a few degrees on the condenser scale.

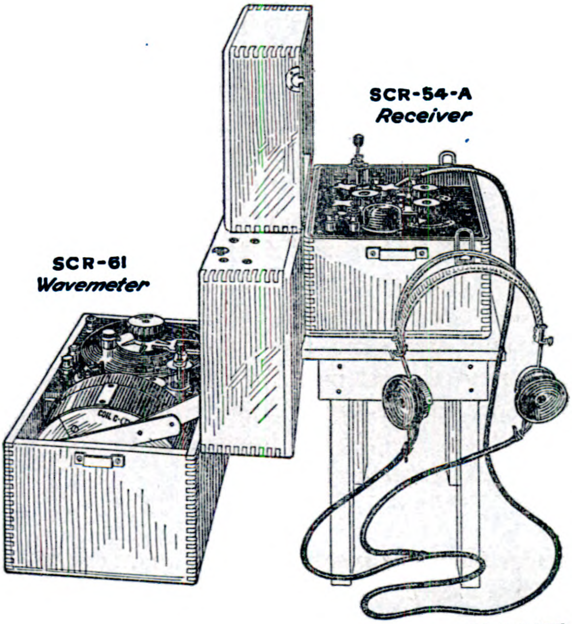

Fig. 40.—Method of coupling the SCR-61 wave meter to the secondary coil of the SCR-54-A receiver.

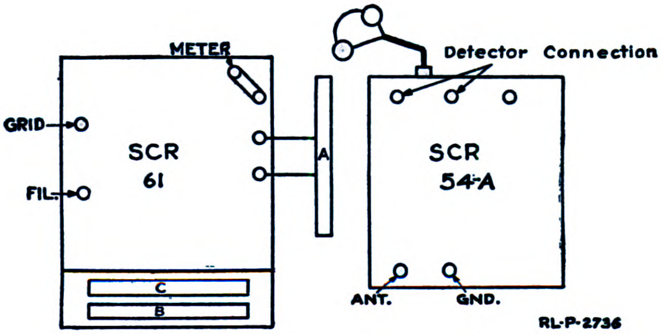

Fig. 41.—Schematic diagram showing relative positions of the SCR-61 wave meter and the SCR-54-A receiver when coupled as in Fig. 40.

4. Move the "T-AP" switch to "AP" (abbreviation for "aperiodic," meaning "untuned"), and endeavor to tune out the signal with the variable condenser. From the diagram of connections it will be seen that in the "AP" position the condenser is out of the

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circuit. Therefore the secondary circuit can not be tuned to the primary circuit. When a circuit can not be tuned it will respond to all wave lengths. For the same reason that the SCR–74–A transmits over a number of wave lengths when connected directly to the antenna and ground, the secondary circuit of the SCR–54–A will respond to a number of wave lengths when the variable condenser is disconnected from the circuit. This is very useful when the set is used to pick up a signal on an unknown wave length.

5. Make up a calibration table for the secondary of the SCR–54–A similar to the No. 1 shown at the end of this Unit Operation. Part of the table will be used in the next experiment. Start at 200 meters and determine the settings of the inductance tap and condenser to tune the secondary to this wave length. Next set the wave meter at 225 meters and determine the settings for this wave length. Similarly determine the settings for 250 meters, 275 meters, etc., until all the wave lengths listed have been covered. Record the readings in the table prepared. Remember to change inductance coils in the wave meter when receiving.

Questions.

(19) *Why was the wave meter put back of the set box instead of to one side? (See answer to Question 12.)*

(20) *What is the wave length range of the secondary of this set?*

(21) *What is the wave length range of the set?*

(22) *With the switch thrown to "AP" why is it impossible to tune out the signal of the wave meter?*

(23) *What is the difference in the position of the secondary coil when turned to "MAX," with respect to the back edge of the box?*

EXPERIMENT No. 2.

CALIBRATING THE PRIMARY.

Directions.

6. As the wave meter is not to be used in this experiment it should be placed several feet away from the BC–14–A set box. Connect the antenna and ground leads to the proper terminals on the set box. The "T–AP" switch should be turned to the "T" position. Adjust the coupling control so that the indicator points to the 20° mark. Adjust the secondary inductance switch and the secondary condenser to the settings for 200 meters as recorded in Experiment No. 1. Start the buzzer operating and adjust the crystal detector until a sensitive spot is found. With the buzzer still in operation

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vary the primary inductance switch and the primary condenser until the signal of the buzzer is heard in the headset with maximum intensity. Record the settings in Table No. 1. (See Direction 5.)

Questions.

(24) *In what way does the method used in calibrating the primary circuit differ from that used in calibrating the secondary circuit with the wave meter? Explain.*

(25) *Was the tuning of the primary circuit found to be fairly sharp?*

(26) *Why was the antenna ana ground connected in calibrating the primary circuit?*

EXPERIMENT No. 3.

EFFECT OF CHANGE IN COUPLING.

Directions.

7. Wind a complete turn of the antenna lead around the cover of the wave meter as shown in Fig. 42. This provides coupling between the antenna circuit and the inductance coil of the wave meter as shown in Fig. 43.

8. Adjust the coupling of the BC–14–A set box so that the indicator points to the 90° or maximum mark.

9. Adjust the primary and secondary controls to the settings recorded for 300 meters.

10. Start the buzzer of the wave meter in operation and slowly vary the control knob of the wave meter condenser until the signal of the buzzer is heard with maximum intensity in the head set. Note the wave length indicated on the wave meter scale.

11. Reduce the coupling in the BC–14–A set box by turning the coupling knob until it points to the 40° mark. Again vary the wave meter condenser until the buzzer signal is heard with maximum intensity in the head set. Note the wave length indicated on the wave meter scale.

Questions.

(27) *Was the wave length indicated by the wave meter in the experiment under Direction 11, the same as recorded in Table No. 1 for the control settings used?*

(28) *Were any of the following three changes noticed when the coupling was reduced in the experiment under Direction 12?*

a. Was the wave length changed?

b. Was the sharpness of tuning changed?

c. Was the intensity of the signal changed?

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(29) *When tuning an SCR–54–A receiver to a signal of known wave length using predetermined calibrations, what effect has a change in coupling upon the tuning of the primary and secondary circuits?*

(30) *Judging from the results of this experiment would you say, that the methods used in calibrating the primary and secondary circuits in Experiments 1 and 2 were accurate?*

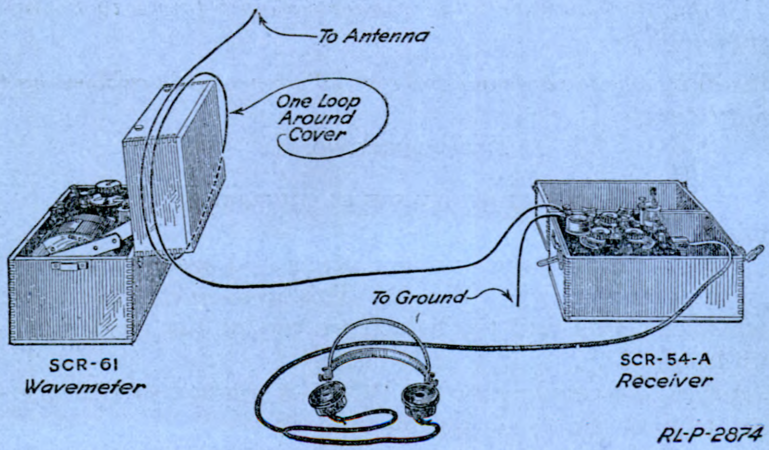

Fig. 42.—Method of coupling the SCR–61 wave meter to the primary circuit of the SCR–54–A receiver.

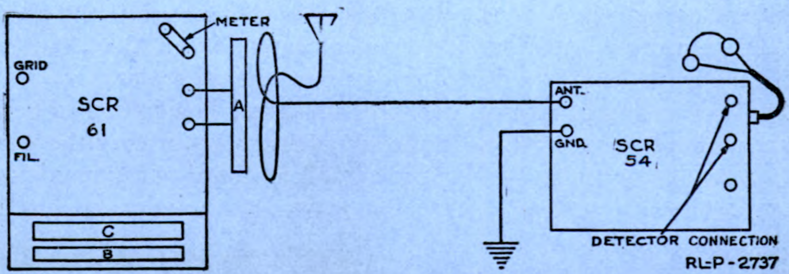

Fig. 43.—Schematic diagram of coupling arrangement as in Fig. 42.

Information.

The methods used in calibrating the primary and secondary of the SCR–54–A receiver in Experiments 1 and 2 produced only approximate results. In actually using any radio receiving set for the reception of messages or other information it is very important that the operator be able to set his adjustments, so that he knows that the set is accurately in tune on any given wave length. In order to

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accomplish this it is necessary to calibrate the set so that the calibration covers all of the adjustments of the set which have any influence on the wave length on which it receives.

EXPERIMENT No. 4.

CALIBRATING THE SCR–54–A SET FOR USE IN THE FIELD.

Directions.

12. Use the same set up of apparatus as used in Experiment No. 3. (See Fig. 42.)

13. Start the buzzer of the wave meter and adjust the wave meter to 200 meters. Set the coupling on the BC–14–A set box at 40°. Tune in the signal emitted by the wave meter in the following manner:

a. Set the "T–AP" switch on "AP."

b. Set the secondary inductance switch on tap 60.

c. Starting at the lowest tap, successively set the primary inductance switch on each tap and with each adjustment of the switch slowly turn the primary condenser over its entire scale. On one of the taps and at some setting of the primary condenser the signal sent out by the wave meter will be heard. When the signal is heard, carefully adjust the primary condenser until it is heard with maximum intensity.

d. Without changing the adjustments of the primary circuit, place the "T–AP" on "T." Starting at the lowest tap, successively set the secondary inductance switch on each tap, and with each adjustment of the switch slowly turn the secondary condenser over its entire scale. On one of the taps and at some setting of the secondary condenser the signal emitted by the wave meter will be heard. When the signal is heard, slightly vary both the primary and secondary condensers until the maximum possible intensity is obtained. The set is now tuned accurately to receive on 200 meters, which is the wave length on which the wave meter is transmitting. Note the settings of the primary and secondary inductance switches and the primary and secondary condensers. Prepare a table similar to Table No. 2 shown at the end of this Unit Operation and record in it the settings obtained.

14. Repeat the above directions for each of the remaining wave lengths in the table.

15. Due to slight changes which may occur each time the antenna system is erected or when a different antenna system is used the cali-

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brations of the antenna circuit may vary somewhat. However, the calibrations obtained in this experiment will be nearly right for the standard antenna. Each time a different standard antenna is used the calibrations of the primary circuit may be readjusted in the following manner:

a. Using the settings recorded in Table No. 2, adjust the primary and secondary controls to any desired wave length. Set the coupling to the reading given in the table.

b. Start the buzzer on the set box and vary the primary condenser until the signal from the buzzer is heard with greatest intensity in the head set. If the values of the antenna system are the same as those of the antenna used when the calibrations were made, the buzzer signal should be heard with maximum intensity on the setting for the condenser given in the table for that wave length. If the values of the antenna system are different, the settings of the primary condenser (and possibly the primary inductance switch) will be different from the settings given in the calibration table, but will be correct for that wave length and the new antenna system.

Questions.

(31) *What is the wave-length range of this set?*

(32) *Why was the wave meter coupled to the ground lead?*

(33) *With the "T–AP" switch on "AP" did the primary condenser tune very sharply?*

(34) *Why was the "T–AP" switch placed on "T" before attempting to tune the secondary circuit?*

(35) *Why was the coupling left in one position?*

(36) *What would be the effect on the sharpness of the tuning of the set if the coupling were decreased?*

(37) *If the set is used with other than the standard antenna equipment, would the calibrations of the primary circuit be absolutely accurate?*

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TABLE No. 1.

Settings for Experiment No. 1.			Settings for Experiment No. 2.			
Wave length.	Secondary inductance tap.	Secondary condenser.	Primary inductance tap.	Primary condenser.	Secondary inductance tap.	Secondary condenser.
200						
225						
250						
275						
300						
325						
350						
375						
400						
425						
450						
475						
500						
525						
550						
575						
600						

TABLE No. 2.

Settings for Experiment No. 4.					
Wave length.	Primary inductance tap.	Primary. condenser.	Coupling. (degrees).	Secondary inductance tap.	Secondary condenser.
200			40		
225			40		
250			40		
275			40		
300			40		
325			40		
350			40		
375			40		
400			40		
425			40		
450			40		
475			40		
500			40		
525			40		
550			40		
575			40		
600			40		

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class the following points should be discussed:

a. Show the students an SCR–54–A receiving set. Remove the four screws on the panel and withdraw the panel from the box. Point out and name the various parts, such as the *antenna binding post*, the *primary inductance coil*, *primary inductance switch primary variable condenser*, *ground binding post*, *coupling knob*, *secondary inductance coil*, *secondary inductance switch*, *"T–AP" switch*, *secondary variable condenser*, *buzzer*, *push-pull switch*, *dry-cell battery*, *telephone jack*, *and detector*.

b. Explain that the coupling may be varied by changing the position of the coils with respect to each other. Show the reason for the flexible leads to the secondary coils. Show also the position of the secondary when the coupling pointer indicates "MIN" when the pointer indicates "MAX."

c. Demonstrate to the class what action takes place in rear of the panel when the various knobs on the front are rotated. Show how the "T–AP" switch removes the secondary condenser from the circuit when it is turned to "AP."

d. Demonstrate the adjustment of the crystal detector when using the buzzer. Show also how the battery is connected to the buzzer circuit.

e. Explain the manner in which the telephone receivers are connected in the circuit.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Primary.	Detector.	Telephone jack.
Secondary.	"T–AP" switch.	Flexible leads.
Maximum.	Push-pull switch.	Twisted lamp cord.
Minimum.	Inductance switch.	Coupling knob.
Circuit.	Condenser, variable.	Binding post.

4. When the students have completed this Unit Operation, they should know the names and uses of all of the important parts of the SCR–54–A set and should be familiar with the functioning of the various parts. From the experiments performed the students should know:

a. How to correctly connect the set for reception.

b. The manner of adjusting the detector and coupling for maximum signal strength.

c. How to properly tune the primary and secondary circuit.

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d. How to tune the set for reception—

(1) When wave length of incoming signals is known.

(2) When wave length of incoming signals is unknown.

5. When the instructor has assured himself that the students are proficient in the operation of the SCR–54–A set, the following Instruction Test, or one similar to it, should be given. The test should be conducted in the same manner as those in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 antenna.
1 set box, BC–14–A.
2 batteries, type BA–4.
1 head set, type P–11.
1 wave meter, type SCR–61.

Procedure.

1. Place the equipment in a suitable location for conducting the test. The antenna used in the test may consist of about 50 feet of twisted lamp cord, one wire of which is connected to the antenna binding post and the other wire to the ground binding post. The remaining ends of the wires should be free and insulated from each other. Sufficient coupling may be obtained by wrapping one or two turns of the antenna around the wavemeter cover.

2. Direct the student to connect the SCR–54–A set for reception.

3. When the student has indicated that he has completed this work, record the time taken by each student and make an immediate inspection of the connections.

4. If any errors appear while checking the connections, allow the student time to correct the errors before proceeding with the next part of the test.

5. When ready for the second part, couple a wave meter to the antenna of the SCR–54–A and adjust the wave meter to transmit on 300 meters or some other wave length unknown to the student.

6. When the student has completed the test, he will notify the instructor in the usual manner, and the instructor will again record the time and as soon as possible will determine whether or not the student has correctly tuned to the wave-meter signal.

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INSTRUCTION TEST NO. 9–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 antenna (consisting of twisted lamp cord).
   2 batteries, type BA–4.
   1 head set, type P–11.
   1 set box, type BC–14–A.
2. When the instructor directs "Begin," start work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

1. Connect the SCR–54–A set completely ready for operation. Consider the two leads from the twisted lamp cord as antenna and ground, respectively.
2. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will then inspect it.

Problem No. 2.

1. When the instructor again directs "Begin," start work promptly on the following operations:

The antenna of your set is coupled to an SCR–61 wave meter. The wave meter is transmitting a signal on an unknown wave length. Adjust your receiver and tune it properly to the signal of the wave meter.

2. When this work is completed, notify the instructor by facing about and raising your right hand. The instructor will again record the time taken to do the work and will also inspect the work.

Scoring.

1. The maximum score for this test is 8 points
2. The score required to pass this test is 6 points
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. For the proper connecting of the SCR–54–A set	2

PROBLEM NO. 2.

b. For the proper adjustment and tuning of the set to the wave-meter signal	6

c. Deduct one point for each of the following operations incorrectly performed by the student:
   (1) Detector adjusted for maximum signal strength.
   (2) Coupling adjusted correctly for maximum signal strength.
   (3) Primary properly tuned.
   (4) Secondary properly tuned.

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4. Where the student has failed to complete the test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or the incorrectly performed experiment.

INSTRUCTION TEST NO. 9–B (INFORMATION)

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. No space is provided for spare equipment in the BC–14–A set box. ------
2. The crystal used in the BC–14–A set box is made of glass. ------
3. The BC–14–A set box is designed for use with only one head set. ------
4. The crystal detector is used with the SCR–54–A to change the radio frequency currents to audio frequency currents so that the signals may be heard in the telephones. ------
5. Variable coupling is used in the SCR–54–A in order to allow sharper tuning of the set. ------
6. The primary circuit of the SCR–54–A is tuned by turning the T–AP switch of the set to "T." ------
7. The SCR–54–A can be changed from broad to sharp tuning by turning the T–AP switch from AP to T. ------
8. The battery in the buzzer circuit of the SCR–54–A makes the crystal more sensitive. ------
9. Reception could not be accomplished without the use of the buzzer. ------
10. The SCR–54–A is the principal radio telephone set in use by the Army at present. ------
11. The SCR–54–A may be used equally well with a crystal or vacuum detector. ------
12. When the coupling scale at the top of the panel indicates "MAX" the secondary coil is perpendicular to the primary coil. ------

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THE SCR–95, SCR–125, AND SCR–125–A WAVE METERS.

Equipment.

1 SCR–95 wave meter.
1 SCR–125 wave meter.
1 SCR–125–A wave meter.
1 SCR–61 wave meter.

GENERAL CONSTRUCTION OF THE SCR–95 WAVE METER.

Information.

The SCR–95 is a small portable wave meter covering a range from 500 to 1,100 meters. (See Fig. 44.) Unlike the SCR–61 in which the condenser is continuously variable and the inductance fixed, the SCR–95 wave meter has the inductance continuously vari-

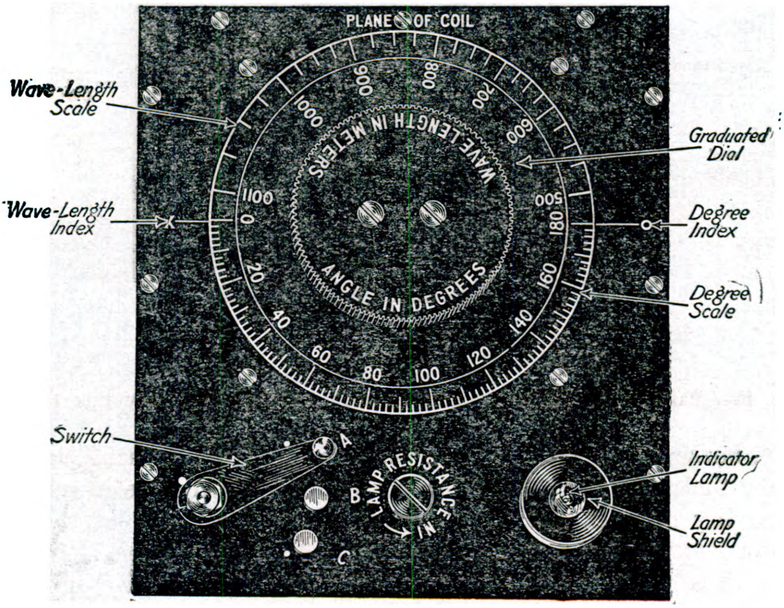

Fig. 44.—Top panel of SCR–95 wave meter.

able and the condenser fixed. The variable inductance consists of two windings connected in series, one within the other. (See Fig. 45.) The inner winding can be rotated through 180°, that is through one-half of a complete turn. When the inner winding is in such a position that the reading on the scale is 500 meters, the inductance is at lowest value. Similarly when the inner winding is rotated 180° to the position at which the scale reading is 1,100 meters, the inductance is at its highest value. The inductance value varies with different positions of the movable winding due to the magnetic effect between the fields produced by the two windings. This magnetic effect is increased or decreased according to the position of the inner winding with respect to the position of the outer winding. It will thus be seen that the inductance is continuously variable between the highest and lowest value, depending upon the position of the inner winding. A variable inductance of this form is called a *variometer*.

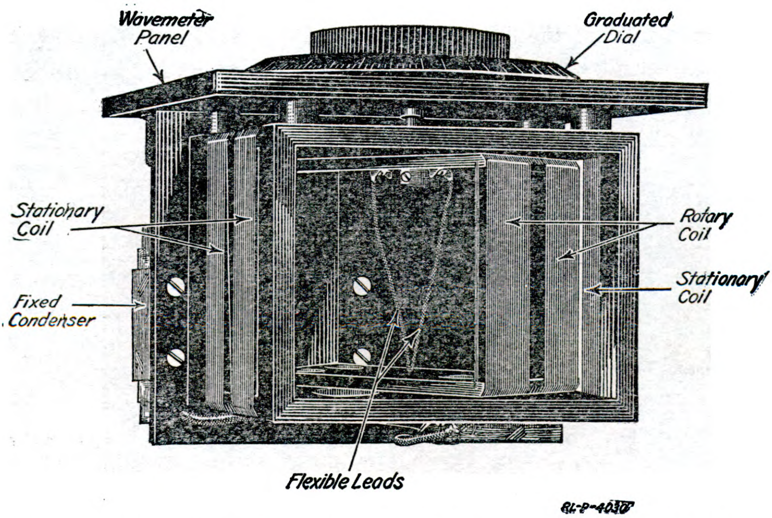

Fig. 45.—Panel of SCR–95 wave meter removed from box to show interior parts.

A buzzer is provided in the wave meter as an exciting device to make the meter act as a low-power transmitter for use in adjusting receiving circuits. A switch mounted on the panel of the wave meter controls the starting and stopping of the buzzer. (See Fig. 44.) The three switch contacts are marked "A," "B," and "C," respectively. In the illustration the switch arm is shown resting on contact A. In this position of the switch arm no current flows through the buzzer circuit. To start the buzzer, the switch is placed on contact B.

The wave meter is also provided with a small low-voltage lamp which is lighted by the same dry cell used to operate the buzzer. To light the lamp the switch arm on the wave meter panel must be placed on contact C. The amount of current flowing through the

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lamp is controlled by a special type of rheostat, which is in turn controlled by an adjustment knob on the wave meter panel, marked "lamp resistance."

A small specially-wound inductance, known as a "choke coil," is inserted in the lamp circuit to prevent the high frequency currents from passing through the battery circuit.

To find the wave length of a transmitting set, the switch on the panel is turned to contact C, and the resistance is adjusted so that the filament of the lamp just begins to get red hot. The wave meter is then coupled closely with the transmitting set. The indicating

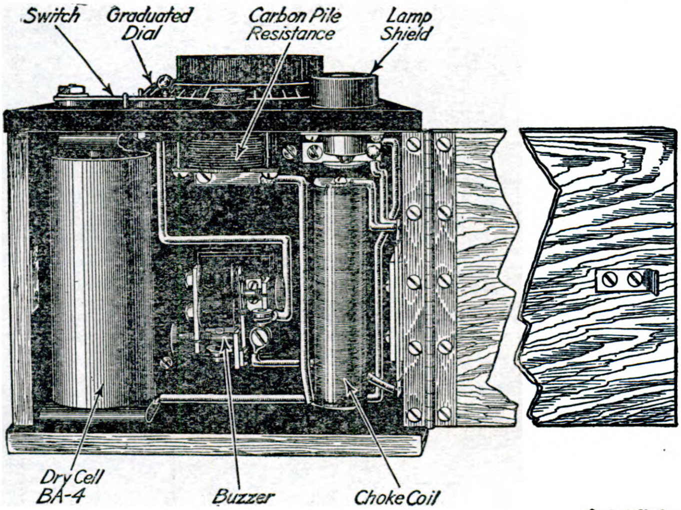

Fig. 46.—SCR–95 wave meter with side door open.

dial which varies the inductance is now turned slowly, and when the lamp glows brightly it indicates that the wave meter is in tune with the transmitting set. The wave length is read directly from the edge of the variometer dial. The SCR–95 wave meter, due to the nature of its indicating device, can be used to measure the wave length of all transmitting sets of the more powerful type. Its use in this connection will be taken up later.

Directions.

1. Examine the meter, noting all the markings on the panel. Open the door at the side and notice how the battery is inserted and the buzzer adjusted. (See Fig. 46.) Note the construction of the choke coil, the carbon pile resistance, and the small fixed condenser.

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2. Remove the nine screws from the edge of the panel. Remove the panel and attached parts from the box.

3. Note the construction of the variometer and how connections are made to the moving coil.

4. Check the wiring with the wiring diagram shown in Fig. 47.

Questions.

(1) *Describe the construction of the carbon pile resistance.*

(2) *How does this wave meter differ electrically from the SCR-61?*

(3) *Describe the construction of the fixed condenser.*

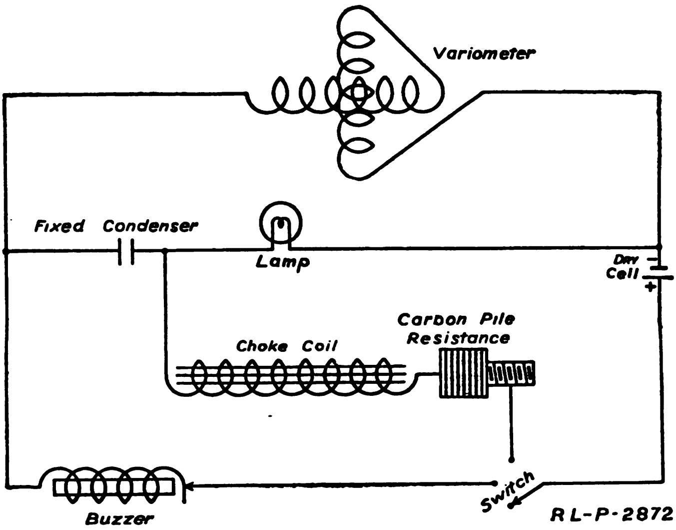

Fig. 47.—Schematic diagram of connections in the SCR-95 wave meter.

(4) *Can the battery be put in backwards, and would this damage it?*

(5) *Is there any current flowing from the battery when the small switch is on A? On B? On C? Where in each case? (Trace the circuit in detail.)*

(6) *Describe the construction of the variable inductance.*

Directions.

5. Replace the panel and parts in the box. Put the screws in place.

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Experiment No. 1.

CHECKING THE SCR–95 WAVE METER WITH THE SCR–61 WAVE METER.

Directions.

6. Set up the SCR–61 with the " B " coil in place. Set the switch of the SCR–95 on B and adjust the buzzer. Set the dial at 500 meters. Couple the SCR–95 closely with the SCR–61. (See Fig. 48.) Adjust the SCR–61 until the signal comes in loud in the head set and loosen the coupling until the tuning of the SCR–61 wave meter is fairly sharp. The coupling should be as loose as possible

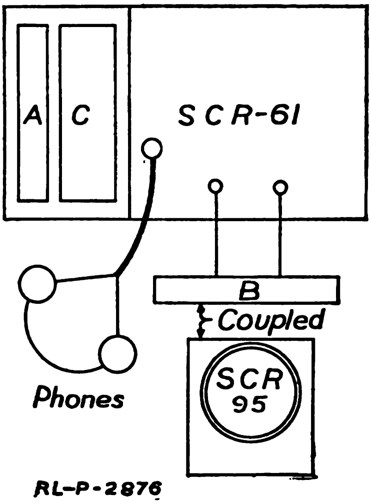

Fig. 48.—Method of coupling the SCR–95 wave meter to an SCR–61 wave meter.

to secure accurate results. Prepare a table similar to the one shown below. Take readings every 50 meters and record the results in the table.

Table.

Reading SCR–95 wave meter.	Reading SCR–61 wave meter.
500	....
550	....
Etc.	....

7. When the experiment is completed remove the battery from the SCR–95 wave meter.

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Questions.

(7) *How do the readings of the SCR–95 wave meter compare with the readings of the SCR–61 wave meter?*

(8) *Can the SCR–95 wave meter be used to receive the buzzer signals from the SCR–61 wave meter? Explain your answer.*

THE SCR–125 WAVE METER.

Information.

The SCR–125 wave meter is very similar to the SCR–95 wave meter both in appearance and construction. The main difference is in the wave-length ranges, the SCR–125 meter having three wave-length ranges which are as follows: 70 to 140 meters, 140 to 280 meters, and 280 to 560 meters. Thus the total range of the meter is 70 to 560 meters.

Close to the dial on the panel of the SCR–125 wave meter is a 3-point switch, marked "Multiply λ." The three positions of the switch are marked "2," "1," and "½," respectively. When the switch is adjusted to the middle position, marked "1," the 140 to 280 meter range is in use and the wave length is read directly on the dial. The wave-length dial reads directly in meters and its divisions are marked 140, 180, 200, 220, 240, 260, and 280 meters, respectively.

If the 70 to 140 meter wave-length range is desired, the switch must be placed in the position marked "½" and the reading on the wave-length dial multiplied by "½" (the same as dividing by 2). For example, if the wave length to be measured lies within the 70 to 140 meter range, the switch is placed in the position marked "½" and the dial is adjusted until the indicating lamp glows brightest. The wave-length reading on the dial may be, say 220 meters. Dividing this reading by 2, the correct wave-length reading is obtained—110 meters.

When the wave meter is being used to emit a wave within the 70–140 meter range, the desired wave length must be multiplied by 2 and the dial adjusted accordingly. For example, the desired wave length is 130 meters, which, multiplied by 2, is 260 meters. The wave-length dial is then adjusted so that the 260-meter mark is exactly opposite the "λ" mark on the panel.

If the wave length desired lies within the 280 to 560 meter range, the switch is placed in the position marked "2" and the reading on the wave-length dial must be multiplied by 2.

Directions.

8. Repeat directions 1, 2, 3, and 5, using the SCR–125 wave meter in place of the SCR–95 wave meter.

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Questions.

(9) *Describe the construction of the carbon pile resistance.*

(10) *How does the SCR–125 wave meter differ from the SCR–95 wave meter?*

(11) *Locate the three small fixed condensers. Describe this construction and use.*

(12) *Can the battery be put in backwards and would this damage it?*

(13) *Is there any current flowing from the battery when the small switch is placed on A? On B? On C? Where in each case? (Trace the circuit in detail.)*

(14) *Describe the construction of the variable inductance.*

Directions.

9. Replace the panel and parts in the box. Put the screws in place.

THE SCR–125–A WAVE METER.

Information.

The SCR–125–A wave meter is similar to the SCR–95 and SCR–125 wave meters both in appearance and construction. This meter has three wave-length ranges, 50 to 150 meters, 150 to 450 meters, and 450 to 1,350 meters, making the total wave-length range 50 to 1,350 meters. The three positions of the multiplier switch are marked "$\frac{1}{3}$," "1," and "3," respectively. If the wave length desired lies within the 150 to 450 meter range the multiplier switch is placed in the position marked "1" and the wave length is read directly on the dial. The wave-length dial reads directly in meters and is marked in divisions from 150 to 450 meters consecutively. When the 50 to 150 meter range is desired the multiplier switch is placed in the position marked "$\frac{1}{3}$." The wave length reading on the dial is then multiplied by "$\frac{1}{3}$" (the same as dividing by 3). Similarly, if the 450 to 1,350 meter range is desired the multiplier switch is placed in the position marked "3" and the wave length reading on the dial must be multiplied by 3.

Directions.

10. Repeat directions 1, 2, 3, and 5, using the SCR–125–A wave meter in place of the SCR–95 wave meter.

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Questions.

(15) *Describe the construction of the carbon pile resistance.*

(16) *How does the SCR–125–A wave meter differ from the SCR–125 wave meter?*

(17) *Locate the three small fixed condensers. Describe their construction and use.*

(18) *What type of switch is used to control the current to the buzzer and indicator lamp?*

(19) *Is the battery entirely disconnected from the buzzer and lamp circuits when the switch is in the middle position? (Trace the wiring and see.)*

(20) *Describe the construction of the variable inductance.*

Directions.

11. Replace the panel and parts in the box. Put the screws in place.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary meeting of the class discuss the difference between the SCR–61, SCR–95, SCR–125, and SCR–125–A wave meters. Explain also the use of the switch and the lamp rheostat.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Microhenry.	Fixed inductance.	Three-point switch.
Inductance.	Lamp rheostat.	Variable.

4. When the students have completed this Unit Operation, they should know the difference between the SCR–61, SCR–95, SCR–125, and SCR–125–A wave meters, as well as the use of the switch and lamp rheostat. From the experiments performed they should know how to determine the wave length of an incoming signal by means of the SCR–61 wave meter when coupled to the SCR–95, SCR–125, and SCR–125–A wave meters, respectively.

5. When the class work has been completed, give the following Instruction Test (or one devised similar to it), which should be conducted in the same manner as in previous Unit Operations:

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

3 SCR–61 wave meters.
1 SCR–95 wave meter.
1 SCR–125 wave meter.
1 SCR–125–A wave meter.
3 head sets, type P–11.
6 type BA–4 dry cells.

Procedure.

1. Place each of the three SCR–61 wave meters in different locations so that they are separated by at least 10 feet.

2. Couple the SCR–95 wave meter to SCR–61 wave meter No. 1 and tune the latter to receive on 600 meters. Close the lid of the SCR–61 wave meter, leaving the phones connected.

3. Proceed in the same manner and tune the SCR–61 wave meter No. 2 to 400 meters, using the SCR–125 wave meter as a transmitter.

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4. In the same manner tune SCR-61 wave meter No. 3 to 300 meters, using the SCR-125-A wave meter.

5. Direct the students to start first at position No. 1 and couple and tune the SCR-95 wave meter to the SCR-61 wave meter.

6. As soon as the first student finishes at the first position he is to proceed to position No. 2, and the next student will start at position No. 1. The test will be continued in this manner until each student has completed the three parts of the test.

7. Note and record the time taken by each student to complete the test and make an inspection of the work done by each student.

INSTRUCTION TEST NO. 10-A (PERFORMANCE).

Directions to the student.

1. At the direction of the instructor take your place at position No. 1.

2. When the instructor directs "Begin," start work promptly on the following problem:

Problem No. 1.

1. At position No. 1 an SCR-61 wave meter is tuned to receive a signal of a certain wave length. Put on the head set and set the SCR-95 wave meter in operation. Couple the SCR-95 wave meter to the SCR-61 wave meter and locate the wave length to which the SCR-61 wave meter is tuned.

2. Write your result on the dotted line to the right.

- - - - - - - - - - - - - - - - - - - -

CAUTION.—*Use extreme care in performing this test so as not to disturb the adjustments of the SCR-61 wave meter.*

3. As soon as you have finished proceed to position No. 2 and commence work promptly on the next problem.

Problem No. 2.

Directions to the student.

1. Using the SCR-125 wave meter, proceed in the same manner at position No. 2 and determine the wave length to which the SCR-61 wave meter is tuned.

2. Write your result on the dotted line to the right.

- - - - - - - - - - - - - - - - - - - -

3. As soon as you have finished proceed to position No. 3 and commence work promptly on the next problem.

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Problem No. 3.

Directions to the student.

1. Using the SCR-125-A wave meter, determine the wave length to which the SCR-61 wave meter is tuned.
2. Write your result on the dotted line to the right.

----

3. When you have finished the test, face about and notify the instructor by raising your right hand. The instructor will record the time it has taken you to complete the test and will inspect your work.

Scoring.

1. The maximum score for this test is 10 points.
2. The score required to pass this test is 6 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. Determining the correct wave length	2

PROBLEM NO. 2.

b. Determining the correct wave length	4

PROBLEM NO. 3.

c. Determining the correct wave length	4

4. Where the student has failed to complete the test, or has failed to perform it correctly, a grade of zero will be given for incomplete parts or incorrect answers.

INSTRUCTION TEST NO. 10-B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. The wave-length range of the SCR-95 wave meter is from
(1) 100 to 256 meters. (2) 500 to 1,100 meters.
(3) 250 to 500 meters. (4) 400 to 1,000 meters. ------

b. The inductance of the SCR-95 wave meter is
(1) 1,000 microhenries. (2) fixed.
(3) a single coil. (4) continuously variable. ------

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c. The wave-length range of the SCR–125 wave meter is from

(1) 70 to 560 meters. (2) 100 to 500 meters.
(3) 150 to 800 meters. (4) 500 to 1,600 meters. ------

d. When the three-point switch on the SCR–125 wave meter is adjusted to the middle contact, the wave-length reading on the dial is

(1) 100 meters. (2) multiplied by 2.
(3) read directly from the dial. (4) 400 meters. ------

e. The number of wave-length ranges controlled by the switch on the SCR–125 wave meter is

(1) two. (2) three. (3) five. (4) four. ------

f. The wave-length range of the SCR–125–A wave meter is from

(1) 100 to 3,000 meters. (2) 50 to 700 meters.
(3) 130 to 500 meters. (4) 50 to 1,350 meters. ------

g. When the three-point switch on the SCR–125–A wave meter is adjusted to the middle contact, the wave-length range is from

(1) 50 to 350 meters. (2) 100 to 200 meters.
(3) 150 to 450 meters. (4) 75 to 150 meters. ------

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THE SCR-105 SET.

Equipment.

1 SCR-105 (set box BC-53-A).
1 wave meter SCR-61.
1 antenna equipment, type A-10-A.
1 10-volt storage battery.

THE TRANSMITTER.

Information.

The SCR-105 (see Fig. 49) is a compact transmitting and receiving quenched spark radio set. It is designed to be used in communication over a distance of 5 miles. The set is intended for intermittent duty only and should not be used for continuous sending. The power necessary to run the set is supplied by a 10-volt storage battery.

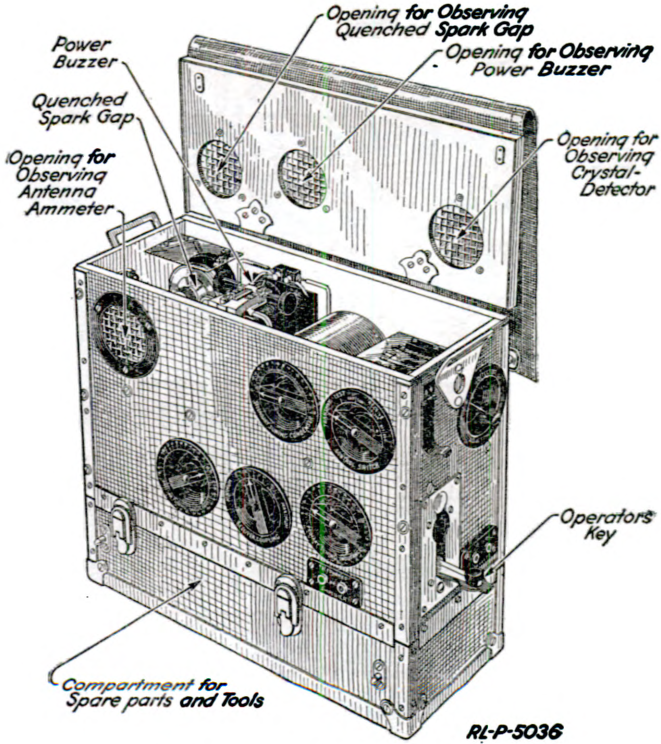

Fig. 49.—Set box, type BC-53-A.

The parts of the transmitter consist of a special buzzer transformer, a quenched spark gap, an oscillation transformer, a thermoammeter, a transmitting condenser, and a key. The purpose of the buzzer transformer is to change the low voltage direct current, supplied by the storage battery, into a high-voltage alternating current.

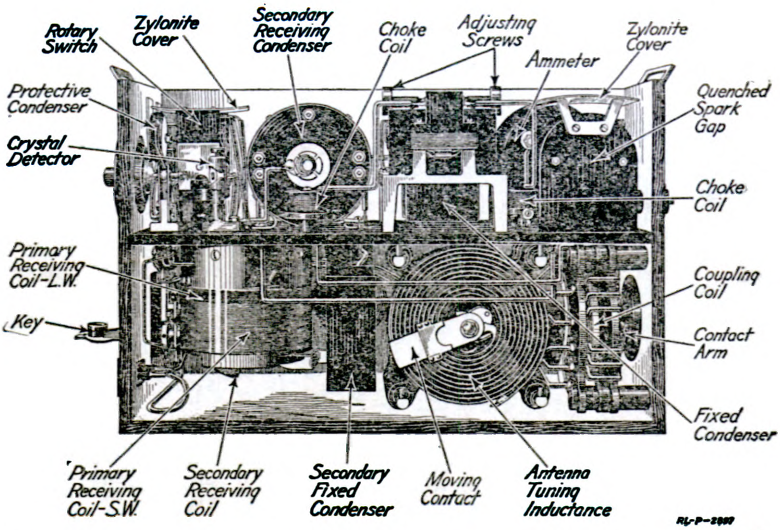

Fig. 50.—Set box BC-53-A with back and top removed to show interior.

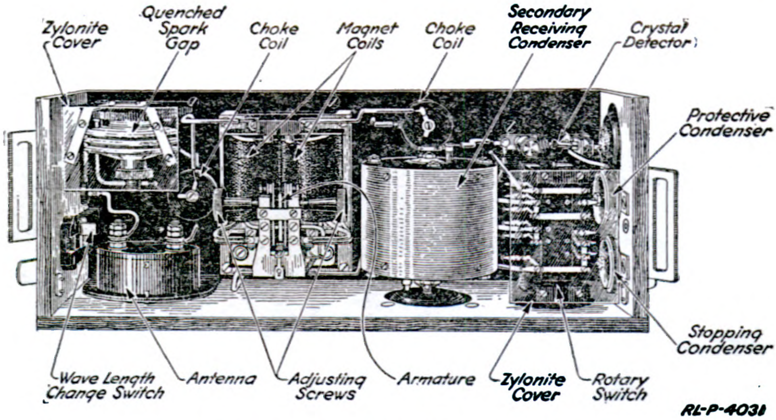

Fig. 51.—Top view of interior, set box BC-53-A.

The primary circuit of the transmitter includes the secondary or high-voltage spark gap, the transmitting condenser, and part of the oscillation transformer. The secondary or antenna circuit consists of the antenna, a series of inductance coils, a part of the oscillation transformer, the antenna thermoammeter, and the ground. Direct

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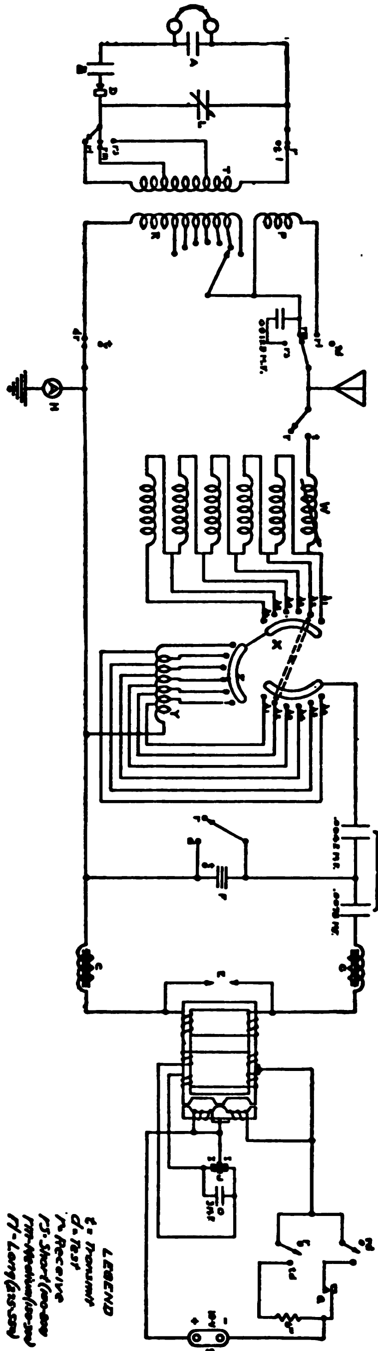

Fig. 52.—Schematic diagram of connections, SCR-105 set.

coupling is employed between the primary and secondary circuits of the transmitter. One of the inductance coils is permanently connected in the antenna circuit and is made continuously variable over its entire range by means of an adjustment controlled from the panel of the set. The primary and secondary are both tuned to the same wave length at the same time, by one switch, known as a "wave-change" switch. The primary circuit is accurately tuned to the desired wave length by this switch, but the secondary circuit is only roughly tuned to the same wave length. For this reason the calibrations of the wave-change switch refer to the wave length settings of the primary circuit. The fine tuning of the antenna circuit is accomplished by means of the variable antenna inductance. A handle located on the left side of the set box controls the coupling between the primary and antenna circuits.

Directions.

1. Remove the eight screws from the back of the set box, also the canvas cover from the front of the box. Unlatch the lid of the box and remove the top, back, and bottom of the set box. This will expose the parts to view as shown in Fig. 50 and in Fig. 51.
2. Move the various adjusting knobs on the front of the box and note carefully what they control inside of the box.
3. Observe the various parts in Figs. 49, 50, 51, and the wiring diagram in Fig. 52. Answer the following questions:

Questions.

(1) *Locate the wave-change switch inside the set box. What are the calibrations marked on the indicator of this switch?*

(2) *What contacts move when the wave-change switch is adjusted?*

(3) *Locate the antenna tuning inductance. How is it made continuously variable?*

(4) *Locate the control switch. What is its purpose?*

(5) *Locate the antenna ammeter. What is the range of its scale? How is it connected in the circuit?*

(6) *How are the transmitting inductances constructed?*

(7) *Why are the coils of the oscillation transformer insulated so heavily?*

(8) *How many turns has the antenna tuning inductance?*

(9) *How is the coupling of the transmitting circuit varied?*

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(10) *How many coils are there in the primary of the oscillation transformer?*

(11) *How is the key connected in the circuit?*

(12) *Can the key be adjusted easily? How?*

(13) *How many sections form the primary winding of the buzzer transformer?*

(14) *How many sections in the secondary winding?*

(15) *To what is the moving armature of the interrupter connected?*

(16) *How many stationary contacts has the interrupter?*

(17) *Of what material are the contacts made?*

(18) *Why are the adjustment screws of the stationary contacts heavily insulated?*

(19) *What is the purpose of the safety gap?*

(20) *Where and how are the secondary condensers connected?*

(21) *How is the quench gap constructed?*

(22) *How are the spark disks insulated from each other?*

(23) *How is the quench gap connected in the circuit?*

(24) *How many contacts has the rotary switch? (Count them on the instrument.)*

(25) *How are they insulated from the pin passing through them?*

THE RECEIVER.

Information.

The receiving side of the set contains two tuned circuits, one, the antenna or primary circuit, and the other, the secondary circuit. The antenna circuit consists of the inductance (which is varied by the handle on the front of the set marked "primary tuning inductance"); either a small fixed condenser or another inductance known as a loading coil, depending on the position of the "change over" switch; and the antenna system. For the reception of short waves the change over switch is placed on the receiving position marked "100–200." In this position the loading coil is not used and the small fixed condenser is connected in series with the antenna. For the reception of medium length waves the switch is placed on the

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receiving position, marked "150–300." In this position the series condenser is cut out and the antenna is connected directly to the primary inductance coil. The third position on the receiving side, marked "275–550," is the long wave position, and when used the loading coil is connected in series with the antenna.

The secondary circuit of the receiver consists of a secondary inductance and a variable condenser. Connected across the variable condenser are the crystal detector, two small fixed condensers, and the head set. The secondary inductance has two taps so that approximately one-third, two-thirds, or all of the inductance may be used. The amount of inductance used is controlled by the change over switch. The switch positions correspond to the three positions used to control the primary inductance. Inductive coupling is employed between the primary and secondary circuits and is varied by the handle on the front of the set box marked "Receiver coupling." A head set is connected in the circuit by means of a plug supplied with the set which fits in the double jack in the front of the set box marked "Telephone or Amplifier." The adjusting handle of the crystal detector protrudes from the right side of the set box so that the detector may be adjusted with the lid of the box closed.

Directions.

4. Note the various receiving controls and their markings.

Questions.

(26) *Locate the control switch. What are the wave-length markings?*

(27) *How many points has the receiver primary inductance switch?*

(28) *How is the receiver coupling control calibrated?*

(29) *How is the secondary condenser control calibrated?*

(30) *How is the crystal detector adjusted from the outside of the set box?*

(31) *How many headsets may be used with the receiver of the SCR–105 set?*

Directions.

5. Turn the various controls and note what moves in the rear of the panel. Note the various stationary parts.

6. From observations made and a careful study of the diagram shown in Fig. 52 answer the questions below.

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Questions.

(32) *How is the crystal detector adjusted?*

(33) *How is a new crystal put in?*

(34) *How is the long wave coil of the receiving circuit wound and where is it located?*

(35) *From the diagram of connections (Fig. 52) when is the long-wave coil in the circuit?*

(36) *Where is the short-wave condenser?*

(37) *When is the short-wave condenser in the circuit?*

(38) *Would the coils of the set be damaged if the battery was plugged in the wrong place?*

(39) *Is it possible to put the battery lead plug in the telephone or amplifier jack?*

(40) *How would you connect other telephone receivers if it were necessary?*

(41) *How is connection made with the movable plates of the secondary condenser?*

Directions.

7. Replace the back and bottom of the set. Replace the screws. Leave the top open.

EXPERIMENT No. 1.

TRANSMITTING.

Information.

Successful transmission with the SCR–105 set depends to a very great extent upon the ability of both the transmitting and receiving operators. The transmitter must be properly adjusted and tuned for steady, reliable operation. Also great care must be exercised when tuning the transmitter in order to obtain a sharp wave of a desired length and thus avoid interference.

Other than tuning adjustments, the only adjustment needed in the transmitting side of the set is that of the buzzer transformer. This instrument is adjusted by means of the two large insulated thumbscrews on either side of the vibrating contact and by means of the small screw near the upper pivot of the armature which controls the position of the armature. The buzzer transformer should be so adjusted that it will operate smoothly and evenly with very

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little sparking. When the control switch is placed in the *test* or *transmit* position the buzzer transformer should start operating and should not require tapping on the armature.

The control switch in addition to changing from transmit to receive, also has a position marked "Test." When in this position the receiving side of the set is in operation and the buzzer transformer should be vibrating feebly. The reason for this is to allow adjustment of the crystal detector. The switch should be left in this position only when the detector is being adjusted.

Directions.

8. To place the transmitting side of the set in operation and to tune it for transmission on a given wave length proceed as follows:

a. Erect the standard antenna system of the set.

b. Place the set box on the ground in one of the three following positions:

(1) If it is desired to transmit in one direction only, the antenna wire should be erected pointing in that direction with the lead-in end toward the station with which it is desired to communicate. The lead-in wire should be stretched out as a continuation of the antenna wire in the direction of the desired station and the set box placed on the ground at the end of the lead-in wire.

(2) Where directional effects not quite so pronounced (as in direction 1) are required, the set box should be placed on the ground near the foot of the mast supporting the lead-in end of the antenna wire.

(3) Where transmission in all directions is desired the set box should be placed on the ground underneath and as near the center of the antenna wire as the length of the lead-in wire will permit.

c. Connect the antenna lead-in to the post on the left side of the set box marked "Ant." and ground lead to the post marked "Gnd."

d. Connect the battery terminals of the battery cord to the 10-volt storage battery and insert the plug in the jack just below and to the right of the key on the right side of the box. Open up the key.

e. Set the wave-length change switch inside of the box to the desired wave length.

f. Set the antenna coupling switch on the left side of the box to the No. 1 position.

g. Throw the control switch to the transmit position. The buzzer transformer should now start operating, and when the key is pressed sparks should be visible in the quenched spark gap.

h. Keeping the key closed, vary the antenna tuning inductance until the maximum possible reading is obtained on the thermoammeter. (Remember that in order to cover the entire range of the antenna

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tuning inductance approximately eight complete turns of the controlling handle are required.) The set should now be transmitting on the desired wave length with the sharpest possible wave, that is, the wave which will produce a minimum amount of interference.

9. Closely couple the SCR–125–A wave meter to the ground lead of the set and measure the wave length which is being transmitted. (See Fig. 53.) Note carefully over how much of the wave-meter scale the signal can be heard.

10. Change the coupling to No. 6, readjust the antenna tuning inductance until a maximum reading is obtained on the ammeter, and again measure the wave length with the SCR–125–A wave meter noting over how much of its scale the signal can be heard.

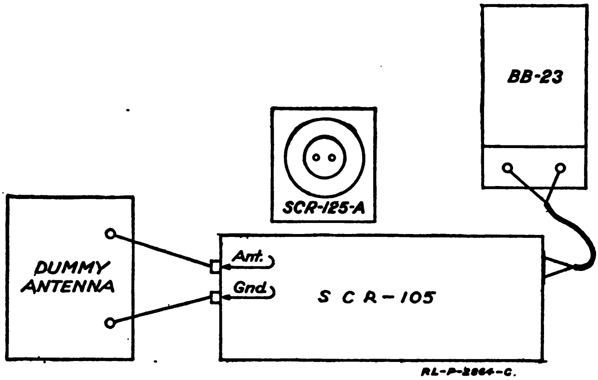

Fig. 53.—Method of coupling the SCR–125–A wave meter to set box BC–53–A.

Questions.

(42) *Does this set cause less or more interference than the signals obtained with loose coupling in Experiment No. 2 of Unit Operation No. 3?*

(43) *What is the advantage of using the spark gap of the quenched type?*

(44) *In what position of the coupling control should this set be operated? Why?*

(45) *Are the wave lengths, as marked on the wave length change switch, accurate according to the wave meter?*

(46) *Was greater antenna current obtained with close coupling or with loose coupling?*

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EXPERIMENT No. 2.

CALIBRATING THE RECEIVER.

Directions.

10. With the antenna, ground, and battery connected to the set as in Experiment No. 1, proceed with the following directions:

a. Insert the plug of a head set in the jack marked "Telephone or Amplifier" and adjust the head set to fit the head comfortably.

b. Turn the control switch to the test position. The buzzer should operate feebly.

c. Adjust the crystal detector until a sensitive spot is found on the surface of the crystal.

d. Turn the control switch to the 100–200 wave-length mark in the receive position.

e. Couple an SCR–125–A wave meter to a few turns in the ground lead of the set. Start the buzzer of the wave meter in operation. Set the wave meter to transmit on 150 meters.

f. Set the receiver coupling control so that the arrow points to the 30° mark.

g. Turn the primary tuning inductance switch to about the No. 5 mark.

h. Slowly rotate the secondary tuning condenser control until the wave-meter signal is heard with maximum intensity in the head receivers.

i. Readjust the coupling, primary inductance, and secondary condenser in the order mentioned until any small change in the adjustment of any one of the controls will cause the signal to disappear.

j. Prepare a table similar to the one shown below. Readjust the wave meter to the next wave length indicated in the table and tune the receiver to the signal using the method outlined in the above directions. Proceed in this manner until adjustments have been made for each of the wave lengths listed. Record the control settings in the table.

Wave length (wave meter).	Wave length setting "control" switch.	Receiver coupling.	Primary tuning inductance.	Secondary tuning condenser.
150........	....	....	....	....
180........	....	....	....	....
210........	....	....	....	....
240........	....	....	....	....
270........	....	....	....	....
300........	....	....	....	....

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Questions.

(47) *Was there any change in the signal strength when the primary inductance switch was slightly readjusted?*

(48) *When final tuning adjustments were being made, was the signal heard over a large or a small portion of the secondary condenser scale?*

(49) *Does the test position of the control switch give an indication as to the sensitivity of the detector?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class discuss the following:

a. Place an SCR–105 set on a table in front of the class. Remove the "tight" screws from the back of the set box and the canvas cover from the front. Unlatch the lid of the box and remove the top, back, and bottom of the box. Be certain that the students see how each step is performed.

b. Point out each part of the set and print the name of each part on the blackboard. Move the various adjusting knobs on the front of the box and instruct the students to notice what parts move inside the set box.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Quenched spark.	Change-over switch.
Buzzer transformer.	Loading coil.
Oscillation transformer.	Series condenser.
Thermoammeter.	Directional effects.
Wave-change switch.	Antenna coupling switch.

4. When the students have completed this Unit Operation, they should know the names of all of the important parts of the SCR–105 set and should be familiar with the working of these parts. From the experiments performed the students should know how to adjust the transmitter so as to produce a minimum amount of interference, also to calibrate the secondary circuit of the receiver.

5. When the instructor has assured himself that the students are proficient in the operation of the SCR–105 set, the following Instruction Test (or one devised similar to it) should be given. The test should be conducted in the same manner as in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 set box, type BC–53–A, SCR–105.
3 storage batteries, type BB–28.
1 wave meter, type SCR–61.
1 antenna system.
2 head sets, type P–11.
Wire for connections.

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Procedure.

1. Place the equipment in a suitable location for conducting the test. An antenna suitable for the purpose of this test may consist of a short wire strung inside the building between insulators. The antenna lead-in should be brought down near the equipment. A good ground connection should also be established.

2. Direct the student to completely connect and adjust the SCR–105 set for both transmission and reception.

3. When the student has indicated that he has completed this work, record the time taken by each student and as soon as possible inspect the connections and adjustments.

4. If any errors appear while inspecting the connections or the adjustments, allow the student time to correct the errors before proceeding with the next part of the test.

5. Direct the student to tune the transmitter of the SCR–105 set to a wave length of 350 meters.

6. When the student has indicated that he has completed this work, record the time taken by each student and as soon as possible check the accuracy of the work.

7. Direct the student to tune the receiver of the SCR–105 set to a wave length of 350 meters.

8. When the student has completed the test, he will notify the instructor in the usual manner, and the instructor will again record the time and as soon as possible check the accuracy of the student's work.

INSTRUCTION TEST NO. 11–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:

   1 set box, type BC–53–A.
   3 storage batteries, type BB–28.
   1 wave meter, type SCR–61.
   1 antenna lead.
   1 ground lead.
   2 head sets, type P–11.
   Wire for connections.

2. When the instructor directs "Begin," start work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

a. Connect the SCR–105 set completely for both transmission and reception.

b. Make the necessary adjustments on the transmitter for a clear note. Adjust the receiver properly.

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3. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will then inspect connections and adjustments.

Problem No. 2.

4. When the instructor again directs "Begin," start work promptly on the following operations:

Using the SCR–61 wave meter, tune the transmitter to a wave length of 350 meters.

2. Again notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time and will check the accuracy of your work.

Problem No. 3.

1. When the instructor again directs "Begin," start work promptly on the following operations:

Tune the receiver of the SCR–105 set to a wave length of 350 meters.

2. When this work is completed, notify the instructor by facing about and raising your right hand. The instructor will record the time and will check the accuracy of your work.

Scoring.

1. The maximum score for this test is 12 points.
2. The score required to pass this test is 8 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. For the proper connecting of the SCR–105 set	2
b. For the proper adjustment of transmitter and receiver	2

PROBLEM NO. 2.

For the correct tuning of the transmitter to 350 meters	4

PROBLEM NO. 3.

For the correct tuning of the receiver to 350 meters	4

4. Where the student has failed to complete the test, or has failed to perform it correctly, a grade of zero will be given for incomplete parts or incorrect answers.

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INSTRUCTION TEST NO. 11–B (INFORMATION).

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (–) sign on the dotted line.

1. The receiver secondary coil of the SCR–105 set would be burned out if the battery plug was inserted in the phone jack. ------
2. It is possible to put the battery plug in the phone jack of the SCR–105.
3. The safety gap of the SCR–105 is provided to indicate when the quenched spark gap is functioning properly. ------
4. The interrupter of the SCR–105 has three stationary contacts. ------
5. The antenna tuning inductance of the SCR–105 is varied by turning the antenna tuning inductance dial. ------
6. The SCR–105 can not receive without a crystal detector. ------
7. There are ten sets of coils in the primary of the oscillation transformer of the SCR–105 set.
8. The SCR–105 causes less interference than does the SCR–74. ------
9. The SCR–105 should be operated with the coupling as loose as possible. ------

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Unit Operations Nos. 6 to 11, inclusive, pertain to types and operation of radio sets and auxiliary equipment; consequently they bear a relation to each other. It is therefore advisable to ascertain at this time whether all students have attained a suitable proficiency before allowing them to proceed to further Unit Operations. The Progress Test set forth below, or a similar one, should now be given by the instructor.

2. It is usually found more convenient to give the Performance part of the test to a part of the class while the Information part is given to the remainder.

3. The instructor should exercise the same personal supervision over the work of the Performance part as in previous Instruction Tests.

PROGRESS TEST NO. 2–A (PERFORMANCE).

Directions to the instructor.

Equipment (*for all positions*).

1 set box, BC–18–A, SCR–74–A.
1 set box, BC–14–A, SCR–54–A.
1 set box, BC–53–A, SCR–61.
2 wave meters, type SCR–61.
3 head sets, type P–11.
3 batteries (2 SCR–54–A, 1 wave meter 61), type BA–4.
3 storage batteries (SCR–105), type BB–28.
4 storage batteries, type BB–14.
1 antenna system.
1 ground lead-in.
Wire for connections.

Procedure.

1. The equipment set forth above should be prepared in advance. Place the three set boxes in different locations so that they are separated by at least 5 feet. Mark them as Positions 1, 2, and 3.

2. Divide the class into as many sections as there are sets of equipment. Assign students to positions.

3. Assemble the class and explain the purpose of the test. Following this, answer any questions they may ask.

4. If desirable, a part of the class may be given the Performance part, while the remainder is given the Information part.

5. Distribute the papers marked "Directions to the Student" and the "Information Test" papers. Direct the students to go to their assigned positions and face the instructor

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6. When ready, direct "About face. Begin." Note and record the exact time the word "Begin" is given.

7. Direct the student to start at Position No. 1 and completely connect and adjust the SCR–74–A set for transmitting on a wave length of 385 meters. The student should then be required to verify the wave length by means of the SCR–61 wave meter.

8. The student should then proceed to Position No. 2, where he shall proceed in the same manner, completely connecting and tuning the SCR–54–A set to 300 meters, using the SCR–61 wave meter as a transmitter.

9. Upon completion of the work at Position No. 2 the student should begin work on that part of the test at Position No. 3. Direct the student to completely connect and adjust the SCR–105 set for transmission on a wave length of 410 meters, verifying the results through the use of the SCR–61 wave meter. Following this, the student should be directed to tune the SCR–105 to 410 meters, using the SCR–61 wave meter as a transmitter.

10. When the students taking the performance part have completed the test at each of the three positions, each will raise his right hand. Note and record the exact time that each individual finishes. This is conveniently done by noting the time on the student's paper. The instructor should make a personal inspection of each student's work at each position immediately upon completion of the work at that position.

PROGRESS TEST NO. 2–A (PERFORMANCE).

Directions to the student.

Problem No. 1.

1. The following equipment is laid out at your assigned position.
   1 set box, BC–18–A, SCR–74–A.
   3 storage batteries, type BB–14.
   1 ground lead-in.
   Wire for connections.

2. When the instructor says "Begin," start work promptly. Perform the following operations carefully and quickly:

a. Connect the SCR–74–A set completely, including batteries, antenna, and ground.

b. Operate the set and make any adjustments necessary.

3. When you have finished, notify the instructor by facing about and raising your right hand. The instructor will record the time taken to do the work and will make an inspection of the connections and adjustments.

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Problem No. 2.

1. The following equipment is laid out at your assigned position:
 1 set box, BC–14–A, SCR–54–A.
 1 wave meter, SCR–61.
 2 batteries, type BA–4.
 1 storage battery, type BB–14.
 1 head set, type P–11.
 1 antenna system.
 1 ground lead in.
 Wires for connections.

2. When the instructor says "Begin," start work promptly. Perform the following operations carefully and quickly:

a. Connect and adjust the SCR–61 wave meter for transmitting on a wave length of 300 meters.

b. Connect the SCR–54–A set for receiving on a wave length of 300 meters. Adjust the set so as to bring in a loud clear signal.

3. When you have finished notify the instructor by facing about and raising your right hand. The instructor will record the time taken to do the work and will make an inspection of the connections and adjustments.

Problem No. 3.

1. The following equipment is laid out at your assigned position:
 1 set box, BC–53–A, SCR–105.
 1 wave meter, type SCR–61.
 2 head sets, type P–11.
 1 battery, type BA–4.
 3 storage batteries, type BB–28.
 1 antenna system.
 1 ground lead in.
 Wire for connections.

2. When the instructor says "Begin," start work promptly. Perform the following operations carefully and quickly:

a. Connect the SCR–105 set for both transmission and reception.

b. Make the necessary adjustments on the transmitter for a clear note and adjust the receiver properly.

c. Using the SCR–61 wave meter, tune the transmitter to a wave length of 410 meters.

3. When you have finished notify the instructor by facing about and raising your right hand. The instructor will then record the time taken to do the work and will inspect the connections and adjustments.

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4. When the instructor again says "Begin," start work promptly on the following operations:

a. Using the SCR–61 wave meter as a transmitter, tune the receiver of the SCR–105 set to a wave length of 410 meters.

b. Adjust for a loud clear signal.

5. Upon completion of this work notify the instructor by facing about and raising your right hand. The instructor will record the time taken to do the work and will inspect the accuracy of your work.

Scoring.

1. The maximum score for this test is 24 points.
2. The score required to pass this test is 18 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
a. For properly connecting the SCR–74–A set for transmission	4
b. For properly adjusting the spark gap	2

PROBLEM NO. 2.

a. For properly connecting the SCR–54–A set for reception	2
b. For properly adjusting the SCR–54–A for reception on a 300-meter wave length	4

PROBLEM NO. 3.

a. For properly connecting the SCR–105 set	2
b. For proper adjustment of transmitter and receiver	2
c. For correctly tuning the transmitter to a wave length of 410 meters	4
d. For correctly tuning the receiver to a wave length of 410 meters	4

4. Where the student has failed to complete the test, or had failed to perform it correctly, a grade of zero will be given for incomplete parts or incorrect answers.

PROGRESS TEST NO. 2–B (INFORMATION).

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and, if what it says is true (correct), place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (–) sign on the dotted line.

Example.—New York City is the capital of the United States. ------

1. Electromagnetic waves travel through the ether at 300,000,000 meters per hour. ------

2. The number of kilocycles is equal to 300,000,000 divided by 1,000 times the length of a single wave. ------

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3. When two tuning forks of different size are placed on a table, one tuning fork will be affected by the vibration of the other. ------

4. Wave length is equal to 300,000,000 divided by 1,000 times the number of kilocycles. ------

5. "Kilocylces" means the number of waves emitted per second. ------

6. All induction coils have secondary coils. ------

7. The SCR–74–A set is calibrated in terms of kilocycles. ------

8. The SCR–74–A set is used both for transmission and reception. ------

9. The induction coil is used to change the low-voltage *direct current* from the storage battery in the primary coil to a *high-voltage alternating current* in the secondary coil. ------

10. The SCR–74–A set will best reach its maximum distance range when using a very short antenna. ------

11. Wave length is varied by changing the coupling. ------

12. The SCR–54–A set may be coupled inductively but not conductively to the antenna. ------

13. Coupling is accomplished by interchanging the antenna and ground leads. ------

14. The SCR–74–A set is an untuned spark-coil transmitter. ------

15. A circuit may be tuned by changing either the capacity or the inductance. ------

16. The SCR–54–A set is calibrated in terms of wave lengths. ------

17. The spark gap is necessary in the operation of the SCR–54–A set. ------

18. The SCR–54–A set uses a crystal as a detector. ------

19. In the SCR–54–A set the switch "AP" cuts out the secondary circuit. ------

20. In the SCR–54–A set one variable condenser is in the primary circuit and one is in the secondary circuit. ------

21. A wave meter is used to accurately tune a station to its assigned wave lengths. ------

22. Wave meters are miniature transmitting and receiving stations. ------

23. The SCR–105 set is a transmitting and receiving quenched-spark radio set. ------

24. The SCR–105 set is used for communication over a distance of 20 miles. ------

25. When receiving short waves on the SCR–105 set, the "change-over" switch is placed on the receiving position marked "100–200." ------

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Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. Electromagnetic or radio waves are measured by an electrical instrument known as a
(1) hydrometer. (2) ammeter.
(3) wave meter. (4) variometer. ------

b. In radio communication certain wave lengths are assigned to the various classes of transmitting stations in order to eliminate
(1) static. (2) interference.
(3) regeneration. (4) storage batteries. ------

c. To convert kilocycles into wave length, divide 300,000,000 by
(1) 1,000 times wave length. (2) velocity.
(3) frequency. (4) number of volts. ------

d. A variable condenser has the property of governing the flow of certain forms of electricity which occur in a radio set. This property is expressed in terms of
(1) capacity. (2) inductance.
(3) henries. (4) ohms. ------

e. Capacity is expressed by
(1) henries. (2) farads. ------
(3) ohms. (4) volts.

f. The SCR-74-A is an *induction-coil* transmitting set of low power. The power supply is obtained from a
(1) 4-volt BB-14 storage battery.
(2) 10-volt BB-28 storage battery.
(3) 22½-volt BA-2 dry battery.
(4) 1½-volt BA-4 dry cell. ------

g. In the SCR-74-A set *direct current* is changed to *alternating current* by the
(1) spark gap. (2) interrupter.
(3) electroder. (4) magnetic fields. ------

h. In the SCR-74-A set the distance between the spark gap electroder should not be over ⅛ inch because
(1) it will break down the insulation in the secondary winding of the spark coil.
(2) the set will not transmit a clear note.
(3) melt solder on terminals.

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(4) fuse the contact points on the transmitting key. ------

i. In the SCR–74–A set the ammeter is connected in the primary circuit to indicate

(1) when the coil is working properly.
(2) when pulsating current is flowing in primary.
(3) when the "B" battery is low. (4) sharp tuning. ------

j. In the SCR–74–A set what is the antenna connected to?

(1) Secondary of the coil. (2) Primary of the coil.
(3) Terminals of ammeter. (4) The interrupter. ------

k. When a radio circuit contains more than one circuit, "coupling" is used to

(1) transfer energy from one circuit to another.
(2) vary the plate current.
(3) cause sharper tuning. (4) prevent interference. ------

l. When the greater part of the energy in one circuit is transferred to another circuit, the "coupling" is referred to as

(1) inductive coupling. (2) close coupling.
(3) loose coupling. (4) direct coupling. ------

m. The battery in the buzzer circuit of the SCR–54–A set

(1) makes the crystal more sensitive.
(2) operates the buzzer. (3) causes sharper tuning.
(4) is connected to the antenna. ------

n. What is the wave-length range of the SCR–54–A receiving set?

(1) 200 to 600 meters. (2) 340 to 440 meters.
(3) 150 to 400 meters. (4) 700 to 1,000 meters. ------

o. In tuning the SCR–54–A set the crystal is adjusted by means of the

(1) buzzer. (2) "T–AP" switch. (3) coupling knob.
(4) emergency telephone connections. ------

p. When searching for a station whose wave length is unknown, the coupling of the SCR–54–A set should be

(1) inductive. (2) conductive.
(3) capacitive. (4) direct. ------

q. The SCR–61 wave meter is equipped with the following number of coils:

(1) One. (2) Three. (3) Two. (4) Five. ------

r. The SCR–95 wave meter has a variable

(1) capacity. (2) voltage.
(3) current. (4) inductance. ------

s. When using the SCR–125 wave meter, if the 70–140 meter wave-length range is desired, the switch must be placed in the position marked

(1) ½. (2) ⅓. (3) ¼. (4) ⅕ ------

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t. How many wave-length ranges has the SCR–125–A wave meter?

(1) Two. (2) Three. (3) Five. (4) Four. ------

u. When using the SCR–125–A wave meter, if the 50–150 meter range is desired, set the multiplier switch at

(1) ⅓. (2) 3. (3) 1. (4) 4.

v. The SCR–105 set is designed to be used in communication over a distance of

(1) 5 miles. (2) 10 miles.
(3) 15 miles. (4) 17 miles. ------

w. In the transmitter of the SCR–105 set what kind of coupling is used between the primary and secondary circuits?

(1) Inductive. (2) Direct.
(3) Conductive. (4) Capacitive. ------

x. How many tuned circuits does the receiver of the SCR–105 set employ?

(1) Two. (2) One. (3) Four. (4) Three. ------

y. In the SCR–105 set when receiving medium-length waves the switch is placed on

(1) "150–300." (2) "100–200."
(3) "275–550." (4) "500–750". ------

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THE VACUUM TUBE DETECTOR, DT-3-A.

Equipment.

1 vacuum tube VT-1.
1 detector, DT-3-A.
1 wave meter, SCR-61.
1 SCR-54-A (set box BC-14-A only).
1 4-volt storage battery (BB-14).
2 batteries, type BA-2 (or BA-8).
1 voltammeter, model 280.
1 rule.

Information.

When using the SCR-54 or SCR-54-A receiving sets for receiving long distance signals, it may be found that the crystal detector of the set is not sensitive enough to detect the faint signals received. A

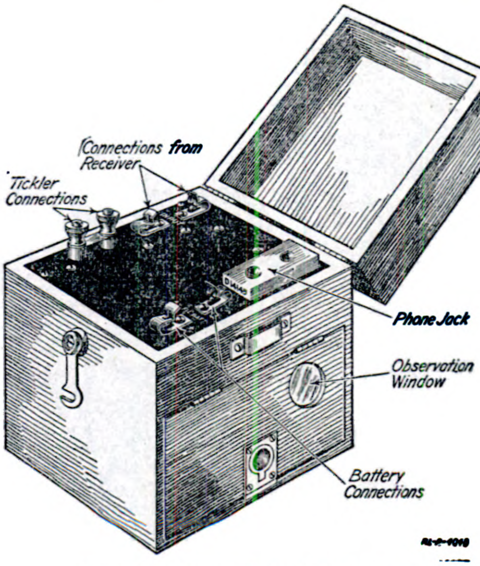

Fig. 54.—The DT-3-A detector unit.

more sensitive device, known as a vacuum tube detector may then be used to receive these very faint signals. This type of detector is provided in the DT-3-A equipment. (See Fig. 54.)

After this detector is once connected and adjusted no further adjustment is required and the operation of tuning in the receiving set is not altered in any way.

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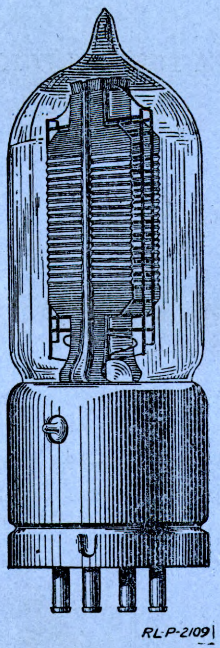

Fig. 55.—Type VT–1 vacuum tube.

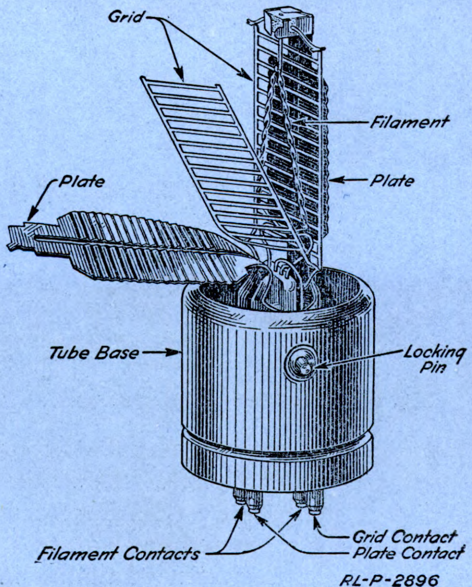

Fig. 55–A.—Details of VT–1 vacuum tube.

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The VT–1 vacuum tube (See Figs. 55 and 55–A) consists of three elements, namely the filament, the grid, and the plate which are all inclosed in a sealed glass tube from which the air has been pumped out. Leads from the filament, grid, and plate are brought out through one end of the tube and connected to four prongs. This

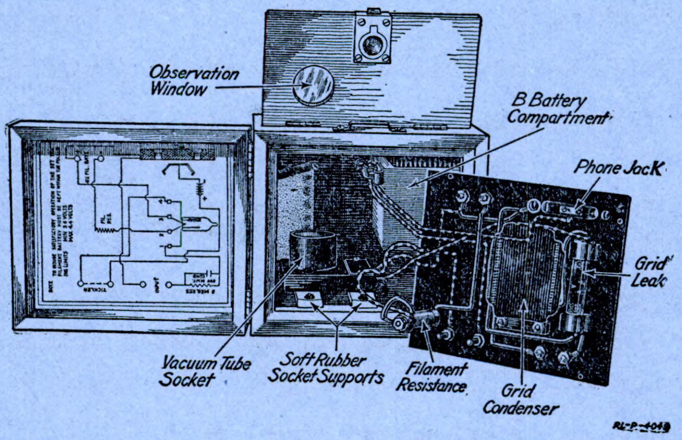

Fig. 56.—Panel of DT–3–A detector removed to show interior parts.

end is called the base of the tube. Two of the prongs are connected to the filament, the third prong to the grid, and the fourth to the plate.

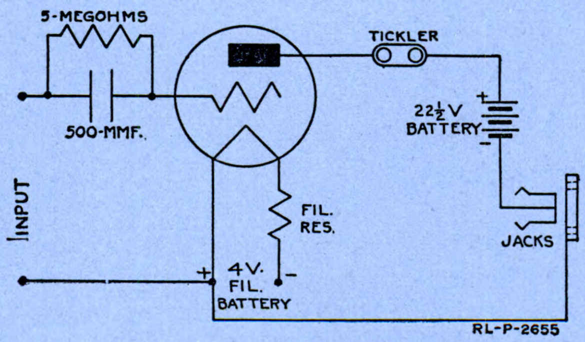

Fig. 57.—Schematic diagram of connections in the DT–3–A detector.

Directions.

1. Remove the four screws from the corners of the panel of the DT–3–A detector. Lift out the panel, being careful not to break the flexible wires attached to it. (See Fig. 56.) Trace the wiring and compare it with the diagram in the lid of the box and also with the schematic diagram in Fig. 57.

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2. Examine the resistance in series with the filament battery. Also examine the resistance across the grid condenser. Note how these resistances differ.

Questions.

(1) *What kind of clips are used to make the connection to the input circuit and the battery circuits?*

(2) *How many telephones can be plugged into this detector unit?*

(3) *How is the grid leak resistance constructed? What is its resistance?*

(4) *How is the filament resistance constructed? What is its resistance?*

(5) *How is the vacuum tube socket fastened in the box? Why?*

(6) *Which contacts on the vacuum tube socket make contact with the filament leads? Which with the plate? Which with the grid?*

(7) *How is the fixed condenser constructed?*

(8) *Which lead of the plate battery goes to the plate?*

(9) *Can the filament current be varied? How?*

Information.

When properly connected, the vacuum tube, type VT–1, has the property of conducting current in one direction only. The amount of current which it will conduct depends upon the amount of plate battery used and the filament current. These values vary with different tubes.

Directions.

3. Examine the VT–1 vacuum tube and note exactly how it is constructed. The filament is in the center and on each side of it are the grids. Outside of the grids can be seen the two plates. Both grids are connected together and the two plates are also connected together. (See Fig. 55–A.)

Questions.

(10) *Why is there a pin on the side of the base?*

(11) *Which two contacts on the bottom of the base go to the filament leads? (Insert the tube in the socket if necessary to discover this. Use the pin on the side as a reference point.)*

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(12) *Which contact goes to the grid? Which contact goes to the plate?*

(13) *How many cross bars are there in each side of the grid?*

(14) *Is there a grid on each side of the filament? Is there a plate on each side?*

Information.

The results obtained in the following experiments will depend upon the hearing ability of the student. Inasmuch as the sensitivity of the ear varies with different individuals the results recorded will only be approximate. However, they will be sufficiently accurate to bring out the idea intended.

EXPERIMENT No. 1.

COMPARISON OF SIGNAL STRENGTHS BETWEEN THE CRYSTAL DETECTOR AND THE VACUUM TUBE DETECTOR.

Directions.

4. Set up the SCR–61 wave meter as a transmitter and the SCR–54–A as a receiver, as shown in Fig. 40 of Unit Operation No. 9. Plug in a pair of receivers in the jacks of the SCR–54–A set. Start the buzzer of the SCR–54–A operating and locate a sensitive spot on the crystal detector. Turn off the current to the buzzer. Adjust the SCR–61 wave meter to a wave length of 250 meters and start its buzzer in operation. Tune the secondary of the SCR–54–A set so that the signal from the wave meter can be heard with maximum volume. Without changing any other adjustments reduce the coupling between the SCR–54–A set and the wave meter until the wave meter signal is just faintly heard in the telephone receivers. Try increasing the signal strength by readjusting the detector of the SCR–54–A set and by retuning the secondary. If an increase in signal strength is obtained, again reduce the coupling between the receiver and the wave meter until the signal is just faintly heard. This signal may be compared to the faint signal of a distant transmitting station which is received by an SCR–54–A receiver using a crystal detector. Measure the distance between the wave meter and the BD–14–A set box with the rule.

5. Without disturbing the tuning adjustments or the location of either the wave meter or the SCR–54–A set open the crystal detector circuit in the latter by removing the contact from the surface of the crystal. Remove the head set plug from the SCR–54–A set and insert it in the jack of the DT–3–A detector. Connect the input

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terminal of the DT–3–A to the extra detector terminals of the SCR–54–A. (See Fig. 58.)

6. Connect a 4-volt battery in series with the low reading ammeter (0-3 scale) and a small rheostat to the filament battery terminals of the set. Be sure to get the positive lead connected to the plus (+) binding post and the negative lead to the minus (—) binding post. Set the rheostat so all the resistance is in the circuit.

7. See that a serviceable type BA–2 battery is properly connected in the set box.

8. Open the side door of the DT–3–A and connect the proper leads from the "B" or 22½-volt battery to the binding posts.

9. Insert a VT–1 vacuum tube in the socket.

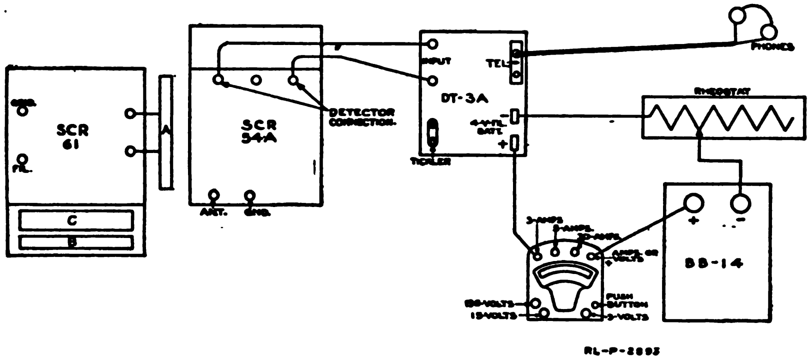

Fig. 58.—Method of connecting apparatus used in Experiment No. 1.

10. Increase the current in the filament of the VT–1 by cutting out the resistance of the rheostat until the ammeter reads 1.1 amperes.

11. Retune the secondary of the SCR–54–A receiver until the signal from the wave meter is heard with maximum strength in the telephone receivers.

12. Decrease the coupling between the wave meter and the BC–14–A set box until the signal from the wave meter is just faintly heard in the telephone receivers. Again measure the distance between the wave meter and the BC–14–A set box.

13. Leave the apparatus adjusted in this manner for the next experiment.

Questions.

(15) *What was the distance measured between the wave meter and the set box under Direction 4 in the above experiment?*

(16) *What was the distance measured between the wave meter and the set box under Direction 12 above?*

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(17) *From your observations in the above experiment, which is the more sensitive to a weak signal, the vacuum tube detector or the crystal detector?*

(18) *Which detector requires the more adjustment? Explain.*

(19) *Why was the coupling between the wave meter and the SCR–54–A set loosened?*

(20) *Is the tuning of the set any sharper when using a vacuum tube detector than when using a crystal detector?*

EXPERIMENT No. 2.

SIGNAL STRENGTH WITH DIFFERENT VALUES OF FILAMENT CURRENT.

Directions.

14. Increase the coupling between the wave meter and the set box until the signal from the wave meter is fairly loud in the telephone receivers.

15. Decrease the current in the filament of the VT–1 by increasing the resistance of the rheostat until the ammeter reads about 0.1 ampere.

16. Start decreasing the resistance of the rheostat until the point is reached where the wave meter signal is just faintly heard in the telephone receivers. Note the reading of the ammeter and the brightness of the detector tube filament.

17. Again slowly decrease the resistance until all of the resistance is cut out of the circuit. Note the reading of the ammeter at the point where no increase in signal strength is perceptible. Also note the brightness of the detector filament.

18. Turn off the filament current and be careful not to disturb any of the other adjustments as the same set-up will be used in the next experiment.

Questions.

(21) (*a*) *What is the lowest value of filament current for which the VT–1 will act as a detector?*

(*b*) *Did the filament burn with a bright red color or with a very dull red color at this value?*

(22) (*a*) *What value of filament current gives a signal of greatest strength?*

(*b*) *How bright did the filament burn at this value?*

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(23) *What is the value of the filament current with the rheostat resistance cut out?*

(24) *What is the best value of filament current?*

(25) *Would it be safe to connect a 4–volt battery direct to the filament battery contacts of the set? Does the small resistance in the set box, in series with the filament, protect it from being burned out?*

EXPERIMENT NO. 3.

SIGNAL STRENGTH WITH DIFFERENT VALUES OF PLATE VOLTAGE.

Directions.

19. Adjust the rheostat until the ammeter shows the reading which was found to be the best value of filament current in Experiment No. 2.

20. Reduce the coupling between the wave meter and the SCR–54–A set until the signal from the wave meter is just faintly heard in the telephone receivers.

21. Connect a serviceable type BA–2 battery in series with the BA–2 battery in the set box. To do this remove the negative lead of the BA–2 battery from the clip binding post on the side of the container. Connect this lead by means of a short piece of wire to the positive lead of the second BA–2 battery. With another piece of wire connect the remaining lead from the second battery to the negative clip binding post.

22. Note any change in the strength of the signal from the wave meter when the additional battery is used.

23. Turn off the filament current and disconnect the apparatus.

Questions.

(26) *Was there an increase in signal strength when the plate voltage was increased to 45 volts?*

(27) *From the observations made what would you say is the best plate voltage to use in conjunction with a VT–1 vacuum tube as a detector?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary meeting of the class discuss briefly the vacuum tube. Make a complete drawing of the vacuum tube on the blackboard, labeling the various parts. Show the class a DT–3–A detector unit. Remove the panel from the box and show the class the internal construction of the unit. Draw a picture of each part on the blackboard and label it properly. Draw a circuit diagram of the connections as shown in Fig. 57 and explain the use of the symbols representing each part in the unit.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Vacuum-tube detector.	Locking pin.	Jack.
Grid.	Tube base.	Plate battery.
Plate.	Filament battery.	Filament resistance.
Prongs.	Grid condenser.	
	Input circuit.	

4. When the students have completed this Unit Operation, they should be familiar with the practical operation of a vacuum-tube detector. They should understand the significance of the symbols used in the circuit diagram to represent the various parts, such as the vacuum tube, plate battery, filament resistance, etc.

5. When the class work has been completed, give the following Instruction Test (or devise one similar to it). This test should be conducted in the same manner as in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 set box, type BC–14–A (SCR–54–A).
1 wave meter, type SCR–125–A.
1 detector unit, type DT–3–A.
1 VT–1 vacuum tube (serviceable).
2 VT–1 vacuum tubes with filaments burned out.
1 4-volt storage battery, type BB–14.
2 batteries, type BA–2.
1 head set, type P–11.
Wire for connections.

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Procedure.

1. Select a suitable location for setting up the equipment.

2. Arrange the equipment on a table so that the student can start work promptly.

3. Adjust the wave meter to transmit a signal on a wave length of about 400 meters.

4. Couple the wave meter to the SCR–54–A set.

5. Direct the students to completely connect and tune the equipment so as to receive the signal of the wave meter.

6. As soon as the student finishes he will raise his right hand. Note and record the time taken by each student to do the work. Inspect the work of each student and determine whether or not the student has tuned in the signal.

INSTRUCTION TEST NO. 12–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 set box, type BC–14–A (SCR–54–A).
   1 wave meter, type SCR–125–A.
   1 detector unit, type DT–3–A.
   3 VT–1 vacuum tubes.
   1 4-volt storage battery, type BB–14.
   2 batteries, type BA–2.
   1 headset, type P–11.
   Wire for connections.

2. When the instructor directs "Begin," start work promptly. Do it carefully and quickly.

3. *a.* At your position an SCR–125–A wave meter is coupled to an SCR–54–A set. Connect the DT–3–A detector unit to the SCR–54–A set.

b. Connect the plate and filament batteries to the DT–3–A unit.

c. Two of the 3 VT–1 tubes are burned out. Select by trial the one that will work.

d. Tune the SCR–54–A set to the signal of the wave meter.

4. When this work is completed, face about and notify the instructor by raising your right hand. The instructor will note the time it has taken to do the work. He will also inspect the connections and will determine whether or not the set is tuned to the wave-meter signal.

SCORING.

1. The maximum score for this test is 10 points.

2. The score required to pass this test is 6 points.

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3. *Directions for scoring.*

	Points.
a. For properly connecting the detector unit to the SCR–54–A set----	2
b. For properly connecting the batteries to the detector unit--------	4
c. For selecting the serviceable vacuum tube----------------------	2
d. For properly tuning the set to the signal of the wave meter------	2

4. When a student fails to complete the test, or performs the test incorrectly, a grade of zero will be given for incomplete parts or incorrect performance.

INSTRUCTION TEST NO. 12–B (INFORMATION).

Directions to the student.—Below are a number of statements. Some are true and some are not true. Write on the dotted line to the right a *plus sign* (+) for those that *are true*, and a *minus sign* (−) for those that are *not true*.

1. The grid leak resistance is connected in series with the filament of the DT–1 and the 4-volt storage battery. ------
2. The positive lead of the plate battery in the DT–3–A is connected to the plate of the VT–1. ------
3. The vacuum-tube socket in the DT–3–A is mounted on strips of sponge rubber. ------
4. The two contacts nearest the lug or prong on the base of the VT–1 are connected to the filament lead. ------
5. The grid leak of the DT–3–A has a resistance of 10 megohms. ------
6. Two pairs of phones may be plugged into the jack of the DT–3–A. ------
7. The filament current of the DT–3–A can not be varied. ------
8. The grid of the VT–1 is outside the plates. ------
9. The filament of the VT–1 is inside the grid. ------
10. It is not safe to connect a 4-volt battery directly to the filament battery terminals of the DT–3–A. ------
11. When the VT–1 vacuum tube is properly connected, the current in the plate circuit can flow in only one direction. ------

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THE SCR–72 AMPLIFIER.

Equipment.

1 SCR–72 amplifier (set box BC–17 only).
1 SCR–61 wave meter.
1 SCR–54–A receiver (set box BC–14–A only).
1 SCR–55 detector (set box DT–3–A).
1 headset, type P–11.
1 4-volt battery, storage type BB–14.
1 plug with cord.
3 VT–1 vacuum tubes.
1 small rheostat.
5 22½-volt "B" batteries.
1 ammeter (0–5 amps. scale).
1 rule.

GENERAL CONSTRUCTION OF THE AMPLIFIER.

Information.

Radio signals are often so weak, due to the distance they are transmitted or for other reasons, that, although the detector will respond feebly, the converted currents from the detector are too weak to actuate the diaphragm of the telephone receivers. In such cases it is necessary to use some device which will increase the strength of the weak signals in the detector circuit in order that they may be heard in the telephone receivers. The device used for this purpose is known as an amplifier.

A vacuum tube when properly connected is an amplifier as well as a detector; accordingly the strength of the signals from a vacuum tube detector can be increased by the addition of one or more vacuum tubes connected as amplifiers. An amplifier consisting of one vacuum tube is known as a one-stage amplifier, while an amplifier consisting of two vacuum tubes is known as a two-stage amplifier.

When the currents in a radio circuit are vibrating slow enough to produce a sound in a pair of telephone receivers connected in the circuit, the currents are said to be vibrating at low or *audio frequency*. For this reason an amplifier, used to increase the values of the slowly vibrating currents in a detector circuit, is termed an "Audio Frequency Amplifier."

The SCR–72 amplifier is a two-stage audio frequency amplifier which will increase materially the strength of detected signals. (See Fig. 59.) A telephone jack is connected in the circuit of each stage; consequently the amount of amplification may be varied by plugging

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the telephone receivers in either jack. In addition, a third jack is provided which is connected indirectly through binding posts on the panel to the DT–3–A detector by means of a cord and plug. If amplification is not desired, the phones may be connected to the detector circuit by inserting the phone plug in this jack.

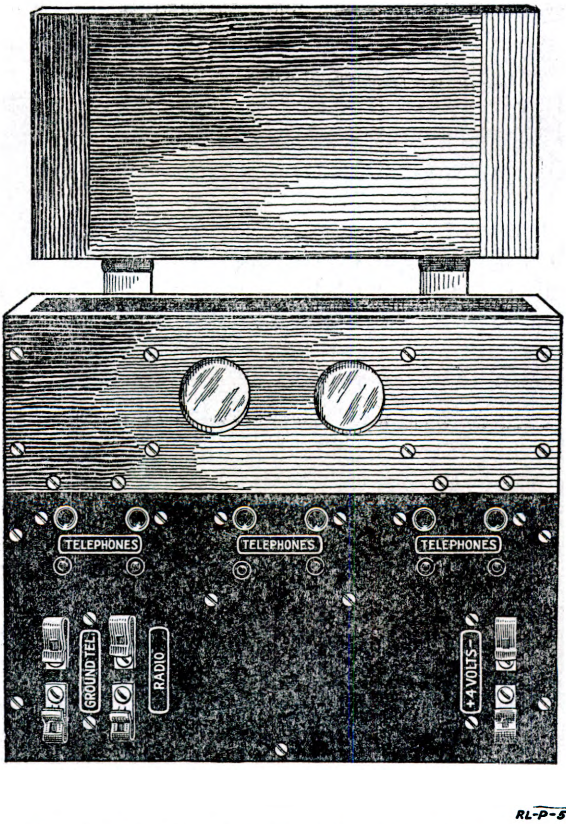

Fig. 59.—Set box, BC–17 of the SCR–72 amplifier.

The filaments of the two VT–2 vacuum tubes in the SCR–72 amplifier are lighted by a 4-volt storage battery. The amount of current supplied to each filament is limited by small fixed resistances connected in series with the filaments. The plate or "B" batteries are in a compartment inside the set box.

The SCR–72 amplifier may also be used in the circuits of ground telegraphy by connecting to the proper terminals.

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Directions.

1. Examine the front of the set box. (See Fig. 59.) Notice the type of terminals used for making connections. Open the lid of the box and see how the "B" batteries are put in and how the

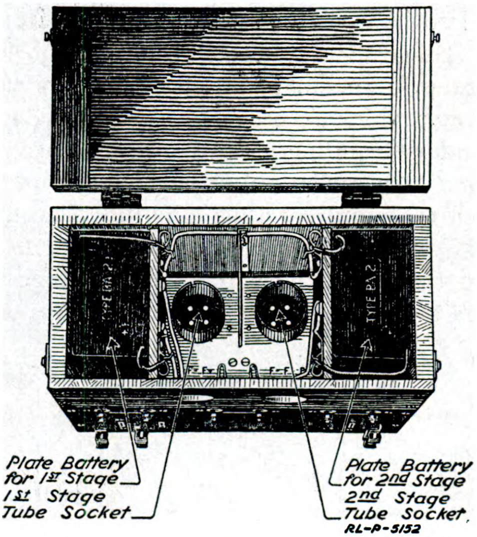

Fig. 60.—Set box BC–17 with lid open to show location of batteries and tube sockets.

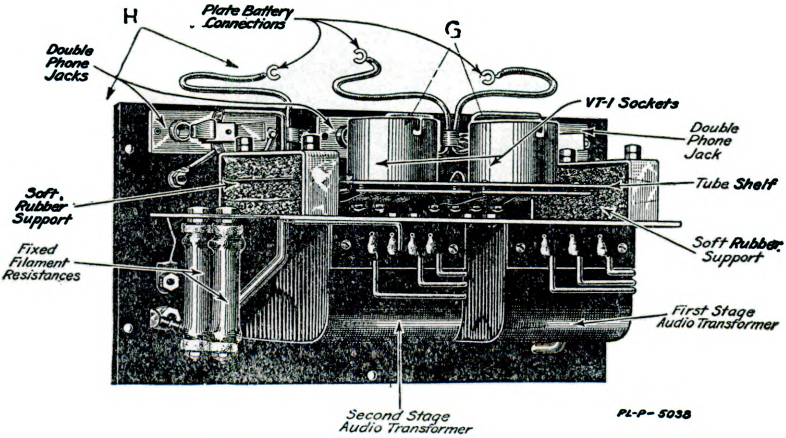

Fig. 61.—Panel of set box BC–17 removed to show interior parts.

vacuum tubes are inserted in their sockets. (See Fig. 60.) Note the three wires coming up to the "B" battery clip terminals. Remove these wires from beneath the screws and leave them loose so that the front panel may be removed. Take out the five screws

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from the edges of the bakelite panel. Carefully remove the panel and attached parts from the box. (See Fig. 61.) Check the wiring diagram shown in Fig. 62 with the wiring in the set itself.

Information.

It will be noticed in Fig. 61 that there are two iron covered parts marked "First Stage Audio Transformer" and "Second Stage Audio Transformer." Inclosed in each of the iron cases is a special type of transformer which consists of an iron core, a primary winding, and a secondary winding. Both windings are wound directly on the iron core. The purpose of the transformers is to provide coupling between the amplifier tube circuits. The first stage audio frequency transformer is used to couple the plate circuit of the detector tube to the grid circuit of the first stage amplifier tube. The second stage audio frequency transformer is used to couple the

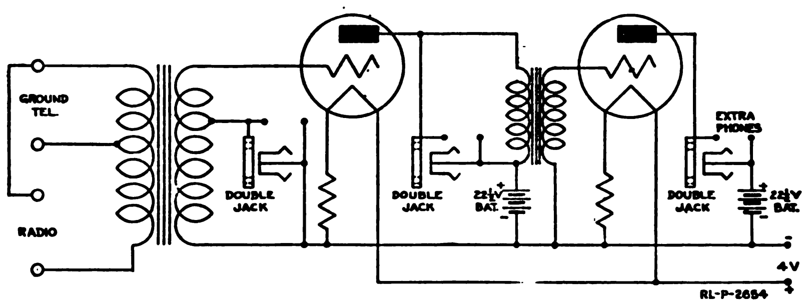

Fig. 62.—Schematic diagram of connections in set box BC–17.

plate circuit of the first stage amplifier tube to the grid circuit of the second stage amplifier tube.

Questions.

(1) *What is an amplifier? An audio-frequency amplifier?*

(2) *What is the purpose of the SCR–72 amplifier?*

(3) *Is it possible to vary the amount of amplification in the SCR–72 amplifier? Explain.*

(4) *How many telephone head sets can be connected to each stage of amplification?*

(5) *Can several head sets be connected to more than one stage at a time?*

(6) *What is the purpose of each of the small resistances located at the left of the amplifying transformers in Fig. 61?*

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(7) *How many volts are used in the plate circuit of this amplifier?*

(8) *For what type vacuum tube is this amplifier constructed?*

(9) *How many stages of amplification are provided?*

(10) *Does the amplifier contain any device for varying the filament current?*

(11) *How is the filament current kept low enough so as not to damage the vacuum tubes?*

(12) *How are the tube sockets mounted? Why are they mounted in this manner?*

(13) *What type of coupling is used in the amplifier circuits?*

(14) *What is the name of the device which provides this coupling?*

(15) *Why are two of these devices necessary in the SCR–72 amplifier?*

EXPERIMENT No. 1.

AMPLIFICATION WITH 22½ VOLTS IN PLATE CIRCUIT

Directions.

2. Replace the panel of the set box, being sure to get the leads to the "B" batteries back properly. If these leads are reversed the amplifier will not operate.

3. Make the same set-up of apparatus as in Unit Operation No. 11, with the following exceptions: (Also see Fig. 63.)

a. Connect leads from the telephone jack of the DT–3–A detector to the terminals marked "Radio" on the SCR–72 amplifier.

b. Connect a 4-volt storage battery direct to the DT–3–A detector. Also connect the positive terminal of the same battery direct to the positive terminal of the "4 Volts" terminal on the SCR–72 panel. Connect the negative terminal on the SCR–72 panel to one of the rheostat terminals and the remaining rheostat terminal to the positive terminal of the ammeter. Connect the negative terminal of the ammeter to the negative terminal of the 4-volt battery.

c. See that the plate or "B" batteries are connected in the set box with due regard to polarity.

4. Start the wave meter transmitting on 250 meters. Plug a head set in the first jack at the left on the SCR–72 amplifier. Adjust the rheostat so that no current flows through the amplifier tube filaments.

5. Tune the SCR–54–A receiver until the signal from the wave meter is heard with maximum intensity in the head set. Loosen the

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coupling between the wave meter and the SCR–54–A receiver until the wave meter signal is just faintly heard in the head set. With the rule provided, measure the distance between the wave meter and the SCR–54–A receiver. Prepare a table similar to Table No. 1 shown at the end of this Unit Operation. Record the measurement just made in the proper place in the prepared table.

6. Adjust the small rheostat so that the ammeter reads about 2.2 amperes. Disconnect the head set from the detector jack and plug it in the first stage jack (the middle jack on the SCR–72). Again loosen the coupling between the wave meter and the SCR–54– set until the signal from the wave meter is just faintly heard in the head

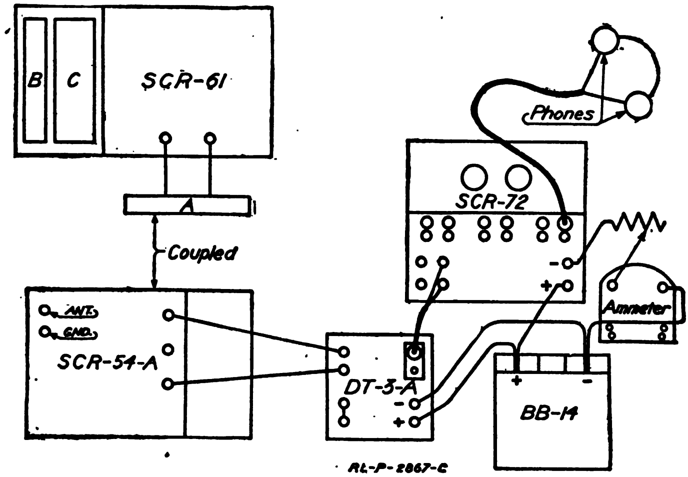

Fig. 63.—Cording diagram of connections when operating the SCR–54–A, the DT–3–A, and the SCR–72 sets together.

set. Measure the distance between the wave meter and the SCR–54–A set with the rule. Record this measurement in the table prepared.

7. Disconnect the head set from the first stage jack and plug it in the second stage jack (the jack at the right). Loosen the coupling between the wave meter and the SCR–54–A set until the signal from the wave meter is just faintly heard in the head set. Measure the distance between the wave meter and the SCR–54–A set and record this measurement in the table prepared.

8. Slowly decrease the filament current flowing through the amplifier tubes by adjusting the rheostat until a point is reached where the wave meter signal disappears. Note the reading of the ammeter as well as the brightness of the filaments.

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Questions.

(16) *Was the distance between the wave meter and the SCR–54–A set greater in Direction 6 than in Direction 5?*

(17) *Does this distance increase as the number of amplifier tubes is increased?*

(18) *What does the increase in this distance indicate regarding the action of the SCR–72?*

(19) *What reading did the ammeter show when the filament current was reduced according to Direction 8?*

(20) *When receiving a weak signal, what effect is produced in the SCR–72 amplifier if the filament current is slightly lowered?*

EXPERIMENT No. 2.

EFFECT OF CHANGING VACUUM TUBES.

Directions.

9. Interchange the vacuum tubes in the detector and amplifier units by placing the detector tube in the first stage socket, the first stage tube in the second stage socket, and the second stage tube in the detector socket. Repeat Directions 4, 5, 6, and 7 and record observations in the table prepared.

Questions.

(21) *Are the measurements recorded in this experiment different from those recorded on Experiment No. 1?*

(22) *If there is a difference, what does this indicate?*

(23) *Judging from the results obtained, what is a good plan to follow when using radio equipment provided with several vacuum tubes?*

EXPERIMENT No. 3.

AMPLIFICATION WITH 45 VOLTS IN PLATE CIRCUITS.

Directions.

10. Repeat Experiment No. 1, using 45 volts in the plate circuit of each amplifier tube. The additional voltage may be obtained as follows: Remove the two 22½-volt batteries from the container in the SCR-72 amplifier. Connect these two batteries in series, and with short pieces of wire connect their two remaining wire terminals to the clip terminal used for the first stage plate connections. Connect the two spare 22½-volt batteries in series and connect the two

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remaining leads to the clip terminals used for the second stage plate connections. Care should be taken that the connections are correct in polarity. Prepare a table similar to Table No. 2, shown at the end of this Unit Operation, and record all observations made in this Experiment.

Questions.

(24) *Do the results recorded in the table for this experiment show that there is an increase in amplification when the additional plate voltage is used?*

(25) *Is the increase in amplification sufficient to warrant using the 45-volt plate battery, if the signals are weak when using the 22½-volt battery?*

EXPERIMENT No. 4.

EFFECT OF WRONG CONNECTIONS ON AMPLIFIER.

Directions.

11. Increase the coupling between the wave meter and the SCR–54–A receiver until the signal from the wave meter is heard with fair volume in the head set. Reverse the filament connections to the amplifier and note any change in the signal strength in the head set.

12. Again reverse the filament connections to the amplifier, so that they are correct in polarity. Reverse the plate battery connections and note any effect on the signal strength.

13. Again reverse the plate battery connections, so that they are correct in polarity. Remove the second stage amplifier tube from its socket and note whether or not the wave meter signal can be heard. Replace this tube in its socket and remove the first stage tube from its socket. Note whether or not the signal can be heard. Replace the first stage tube in its socket.

14. Insert the head set plug in the first stage jack. Remove the first stage tube from its socket and note any effect on the signal strength. Replace this tube and remove the second stage tube from its socket. Note whether or not the signal can be heard.

Questions.

(26) *What is the effect of reversing the filament connections to the amplifier?*

(27) *What is the effect of reversing the amplifier plate battery leads?*

(28) *Will the amplifier operate with the head set plugged in the second stage jack if either tube is removed?*

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(29) *If the head set is plugged in the first stage jack, will the amplifier operate when the second stage tube is removed?*

(30) *If when using the SCR-72 amplifier the second stage tube suddenly burns out and a new tube is not available, what should the operator do?*

TABLE No. 1.

Observations (ammeter reading 2.2 amperes).		Brightness of filaments.	Distance between wave meter and SCR-54-A receiver.
Detector	Experiment No. 1	....	....
	Experiment No. 2	....	....
First stage	Experiment No. 1	....	....
	Experiment No. 2	....	....
Second stage	Experiment No. 1	....	....
	Experiment No. 2	....	....

TABLE No. 2.

Observations (ammeter reading 2.2 amperes).		Brightness of filaments.	Distance between wave meter and SCR-54-A receiver.
Detector	Experiment No. 3	....	....
First stage	Experiment No. 3	....	....
Second stage	Experiment No. 3	....	....

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SUGGESTIONS TO THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary meeting of the class, explain the term "Amplifier" and its use in connection with radio equipment. Exhibit an SCR–72 amplifier to the class. Using blackboard illustrations, describe each part of the amplifier. Make sure that each student is familiar with the names of the parts and the diagram symbols representing these parts.

2. Direct the students to proceed with the experiments in the Students Manual.

3. The important words in this Unit Operation are as follows:

Amplifier.	Ground telegraphy.	Plate circuit.
One-stage amplifier.	"B" batteries.	Grid circuit.
Two-stage amplifier.	Audio frequency transformers.	
Audio frequency.		

4. When the students have completed this Unit Operation, they should know the names and purposes of all of the important parts of the SCR–72 amplifier and should be familiar with the practical working of these parts. From the experiments performed the student should know—

a. How to completely connect the amplifier (including batteries).
b. The effect of changing tubes in the amplifier.
c. The difference in amplification with increased plate voltage.
d. The effect of wrong connections in the amplifier.

5. When the class work has been completed, give the following Instruction Test (or devise one similar to it). This test should be conducted in the same manner as in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 13–A (PERFORMANCE).

Directions to the instructor.

Equipment.

1 set box, BC–14–A (SCR–54–A).
1 detector unit, DT–3–A.
1 wave meter, type SCR–125–A.
1 set box, BC–17.
1 4-volt storage battery, type BB–14.
3 batteries, type BA–2.
1 plug with cord.
3 VT–1 vacuum tubes.
1 head set, type P–11.
Wire for connections.

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Procedure.

1. Place the equipment listed above in a suitable location for conducting the test. Couple the SCR–125–A wave meter to the SCR–54–A set. Adjust the wave meter to transmit on a wave length of 400 meters.

2. Direct the students to completely connect the SCR–54–A set, the DT–3–A detector unit, the SCR–72 amplifier, and to tune the SCR–54–A set to the signal of the wave meter.

3. When the student has indicated that he has completed this work, record the time taken by each student, and as soon as possible determine whether or not the apparatus is properly connected and adjusted to receive the signal of the wave meter with maximum intensity.

INSTRUCTION TEST NO. 13–A (PERFORMANCE).

Directions to the student.—The following equipment is laid out at your position:

1 set box, BC–14–A.
1 detector unit, DT–3–A.
1 wave meter, type SCR–125–A.
1 set box, BC–17.
1 4-volt storage battery, type BB–14.
3 batteries, type BA–2.
1 plug with cord.
3 VT–1 vacuum tubes.
1 head set, type P–11.
Wire for connections.

2. When the instructor directs "Begin," start work promptly. Do it carefully and quickly.

3. *a.* Completely connect the entire equipment ready for operation.

b. Tune the SCR–54–A set to the signal of the wave meter and obtain the strongest signal possible.

4. When the work is completed, face about and notify the instructor by raising your right hand. The instructor will note the time taken to do the work and will determine whether or not you have obtained the maximum signal strength.

SCORING.

1. The maximum score for this test is 6 points.
2. The score required to pass this test is 6 points.
3. *Directions for scoring.*

	Points
If the student has connected the equipment properly and has tuned the wavemeter signal to maximum strength	6

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4. When the student fails to complete the test, or performs the test incorrectly, a grade of zero will be given.

INSTRUCTION TEST NO. 13–B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* to the right of each question. Only one of the answers given in each case is correct.

a. The number of vacuum tubes used in the SCR–72 amplifier is
(1) one. (2) three. (3) two. (4) four. ------

b. The SCR–72 amplifier is used to
(1) decrease signal strength.
(2) change direction of current.
(3) increase signal strength. (4) amplify sound. ------

c. How many terminals are mounted on the front of the SCR–72 panel?
(1) Five. (2) two. (3) four. (4) six. ------

d. How many head sets can be plugged in each stage of the SCR–72 amplifier?
(1) Two. (2) four. (3) six. (4) eight. ------

e. Coupling between successive stages in the SCR–72 amplifier is obtained by means of
(1) condensers. (2) resistances.
(3) transformers. (4) choke coils. ------

f. Filament current in the SCR–72 amplifier is controlled by
(1) fixed resistances. (2) variable resistances.
(3) rheostats. (4) transformers. ------

g. The plate voltages used in each stage of the SCR–72 amplifier is
(1) 45 volts. (2) 90 volts. (3) 67 volts. (4) 22½ volts. ------

h. When 45-volt batteries are used in the plate circuits of the SCR–72 amplifier the
(1) signal strength is decreased.
(2) signals can not be heard.
(3) signal strength is increased.
(4) plate current is reduced. ------

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i. If the plate-battery connections in the SCR–72 amplifier are reversed

(1) the amplifier will still operate.
(2) the vacuum tubes will be burned out.
(3) the amplifier will not operate.
(4) the filament resistance will heat up. ------

j. About how long should a fully charged BB–14 storage battery continuously operate an SCR–72 amplifier if each VT–1 tube draws 1.1 amperes?

(1) 30 hours. (2) 65 hours. (3) 100 hours. (4) 2 hours. ------

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THE SCR–121 AMPLIFIER.

Equipment.

1 SCR–121 amplifier (BC–44–A set box only).
1 SCR–61 wave meter.
1 SCR–54–A receiver (BC–44–A set box only).
1 SCR–55 (DT–3–A) detector.
1 head set, type P–11.
1 plug with cord.
3 VT–1 vacuum tubes.
1 4-volt storage battery, type BB–14.
3 22½-volt "B" batteries, type BA–2.
1 rule.

GENERAL CONSTRUCTION OF THE AMPLIFIER.

Information.

The SCR–121 is a two-stage audio frequency amplifier similar to the SCR–72 amplifier. (See Fig. 64.) It has a filament rheo-

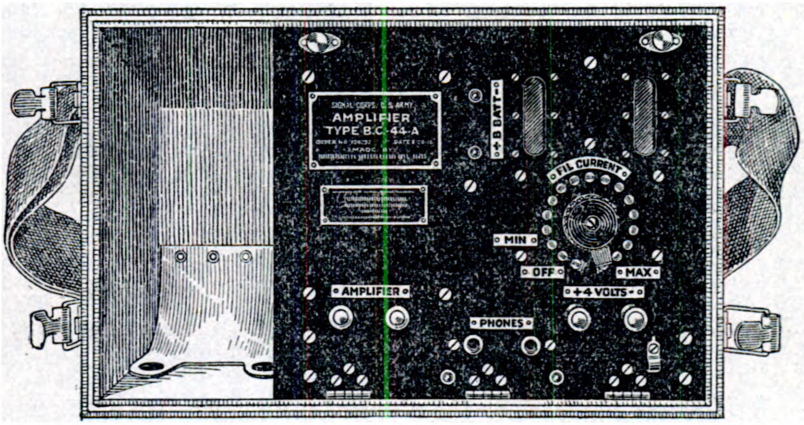

Fig. 64.—Set box, BC–44–A, of the SCR–121 amplifier.

stat for regulating the filament current and uses 45 volts on the plates of the tubes. Means are provided for plugging in phones on the second stage only.

Directions.

1. Examine the exterior of the set. Note the name plates, marking each separate set of binding posts. Also note the rheostat arrangement.

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2. Unscrew the two thumbscrews at the top of the panel and pull the panel outward. (See Fig. 65.) Note the position of the various parts inside the set. Notice how the rheostat resistances are constructed and fastened to the panel. Examine the small resistance between the tube sockets and the panel.

3. Examine the wiring of the set and compare it with the wiring diagram shown in Fig. 66. Note that the same "B" battery is used for both plate circuits

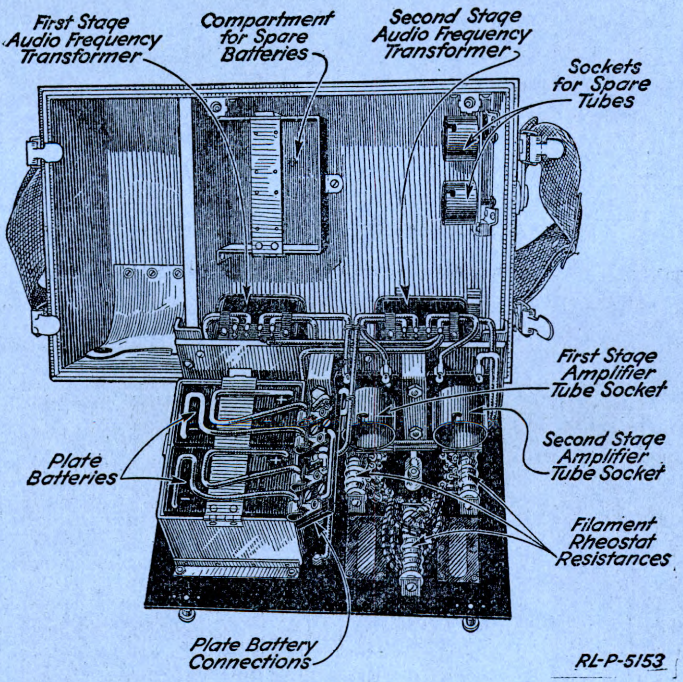

Fig. 65.—Panel of set box BC–44–A pulled forward to show interior parts.

Questions.

(1) *How are the leads to the rheostat insulated? Why?*

(2) *How are the rheostat resistances constructed?*

(3) *Why are the tube sockets mounted on sponge rubber cushions?*

(4) *How many transformers are used in this set?*

(5) *Is this set easier to repair than the SCR–72?*

(6) *How are the "B" batteries fastened in the case?*

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(7) *Can extra "B" batteries be carried in the box? How?*

(8) *Can extra tubes be carried? How?*

(9) *For what is the compartment at the left end of the set box used?*

10) *How is it ascertained that both tubes are burning when the panel is in its proper position?*

(11) *If one of the tubes was removed from its socket would the other still burn? Explain.*

(12) *If BA-8 batteries were provided instead of BA-2 batteries could the set be used? Where would connections be made?*

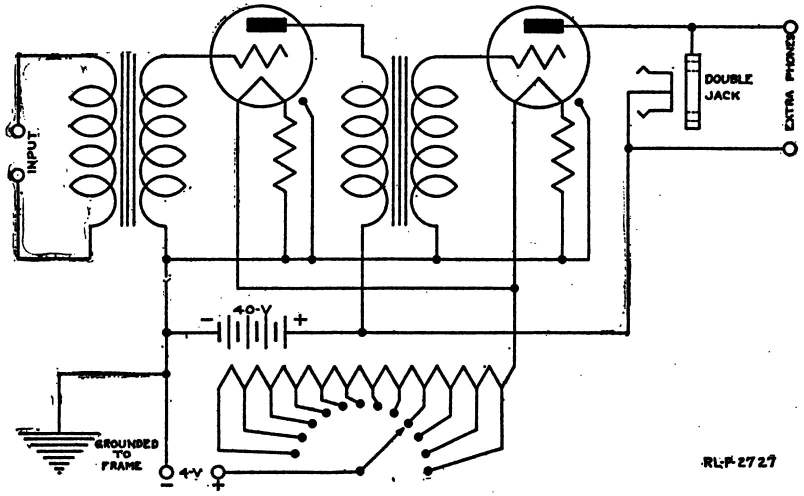

Fig. 66.—Schematic diagram of connections in the BC-44-A amplifier.

Directions.

4. Make a set-up of apparatus similar to the one used in Unit Operation No. 12, using the SCR-121 amplifier in place of the SCR-72 amplifier. (See Fig. 67.) To do this connect the leads from the jack of the DT-3-A detector to the binding posts marked "Amplifier" on the SCR-121. Connect the 4-volt terminals on the SCR-121 panel to the terminals of the storage battery with due regard to polarity. Turn the filament current rheostat to the "OFF" position. See that the two 22½ volt "B" batteries are properly connected in the set box. Insert a VT-1 tube in each socket (including the socket of the DT-3-A detector).

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5. Start the wave meter transmitting on a wave length of 200 meters. Remove the plug from the DT-3-A detector jack and insert the head set plug in the jack. Tune the SCR-54-A receiver to the wave meter signal. Reduce the coupling between the wave meter and the SCR-54-A receiver until the wave meter signal is just faintly heard in the head set. Measure the distance between the wave meter and the SCR-54-A with the rule provided.

6. Remove the head set plug and insert it in the SCR-121 amplifier jack. Insert the plug connected to the "Amplifier" terminals in the detector jack. Turn the rheostat control knob in the direc-

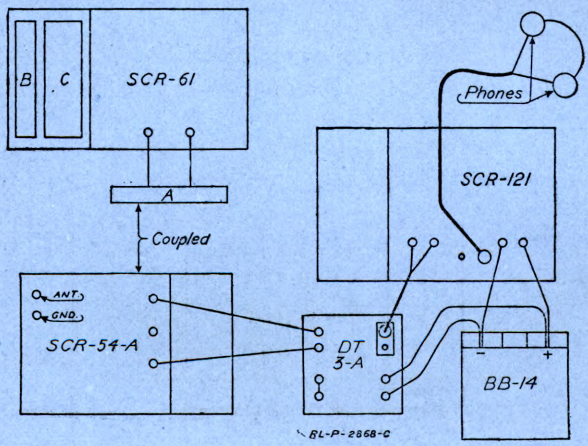

Fig. 67.—Cording diagram of connections when operating the SCR-54-A, the DT-3-A, and the SCR-121 sets together.

tion toward "Max," until the amplifier tube filaments burn at a bright red. Reduce the coupling between the wave meter and the SCR-54-A set until the wave meter signal is just faintly heard in the head set. Measure the distance between the wave meter and the SCR-54-A with the rule.

7. Reduce the filament current in the amplifier tubes until the faint signal from the wave meter just disappears. Note the brightness of the filament at this point; also the adjustment of the rheostat control knob.

8. Increase the filament current in the amplifier tubes until the signal is heard with maximum intensity. Note the brightness of the filament and the position of the rheostat control knob.

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Questions.

(13) *How does the SCR–121 amplifier compare with the SCR–72 amplifier? (Compare the measurements taken in the above experiment with those taken in the experiment using both stages in Unit Operation No. 13.)*

(14) *How bright do the filaments of the amplifier tubes burn when the amplifier ceases to operate?*

(15) *How bright do the filaments burn when maximum amplification is obtained?*

(16) *How many pairs of phones can be plugged in the SCR–121 amplifier?*

(17) *If a choice of amplifiers were left to the radio operator, which type would he most likely use, the SCR–72 or the SCR–121?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class exhibit an SCR–121 amplifier. Remove the front panel of the amplifier and show the class the interior parts. Illustrate each part on the blackboard and label properly. Point out the differences and similarities between the SCR–121 amplifier and the SCR–72 amplifier.

2. Direct the student to proceed with the experiments in the Students Manual.

3. When the students have completed this Unit Operation, they should be familiar with the practical working of the SCR–121 amplifier and should know how to completely connect up the SCR–121 amplifier in conjunction with the DT–3–A detector unit and the SCR–54–A receiver.

4. When the class work has been completed, give the following Instruction Test (or devise one similar to it). This test should be conducted in the same manner as in previous Unit Operations.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 set box, BC–14–A.
1 detector unit, DT–3–A.
1 wave meter, type SCR–125–A.
1 set box, BC–44–A.
1 4-volt storage battery, type BB–14.
3 batteries, type BA–2.
1 plug with cord.
3 VT–1 vacuum tubes.
1 head set, type P–11.
Wire for connections.

Procedure.

1. Place the equipment listed above in a suitable location for conducting the test. Couple the SCR–125–A wave meter to the SCR–54–A set. Adjust the wave meter to transmit on a wave length of 400 meters.

2. Direct the students to completely connect the SCR–54–A set, the DT–3–A detector unit, the SCR–121 amplifier, and to tune the SCR–54–A set to the signal of the wave meter.

3. When the student has indicated that he has completed this work, record the time taken by each student, and as soon as possible

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determine whetner or not the apparatus is properly connected and adjusted to receive the signal of the wave meter with maximum intensity.

INSTRUCTION TEST NO. 14–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 set box, BC–14–A.
   1 detector unit, DT–3–A.
   1 wave meter, type SCR–125–A.
   1 set box, BC–44–A.
   1 4-volt storage battery, type BB–14.
   3 batteries, type BA–2.
   1 plug with cord.
   3 VT–1 vacuum tubes.
   1 head set, type P–11.
   Wire for connections.

2. When the instructor directs "Begin," start work promptly. Do it carefully and quickly.

3. *a.* Completely connect the entire equipment ready for operation.

b. Tune the SCR–54–A set to the signal of the wave meter and obtain the strongest signal possible.

4. When the work is completed, face about and notify the instructor by raising your right hand. The instructor will note the time taken to do the work and will determine whether or not you have obtained the maximum signal strength.

Scoring.

1. The maximum score for this test is 6 points.
2. The score required to pass this test is 6 points.
3. *Directions for scoring.*

	Points.
If the student has connected up the equipment properly and has tuned in the wave-meter signal with maximum strength----------	6

4. When the student fails to complete the test, or performs the test incorrectly, a grade of zero will be given.

INSTRUCTION TEST NO. 14–B (INFORMATION).

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. The BC–44–A is easier to repair than the SCR–72. ------

2. There is no means of determining whether or not the tubes are burning while the panel is closed. ------

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3. The "B" batteries are held in place on the rear of the panel of the BC–44–A in a metal frame. ------

4. BA–8 batteries may be used instead of BA–2 batteries in the plate circuits of the BC–44–A. ------

5. One tube will not burn if the other tube is removed from the socket. ------

6. The BC–44–A has a metal clamp in the rear of the box for extra "B" batteries. ------

7. Four extra VT–1 tubes may be carried at the back of the box of the BC–44–A in sockets furnished for that purpose. ------

8. The BC–44–A gave greatest amplification when the filament current was at a minimum. ------

9. The filament voltage of the BC–44–A may be varied by a rheostat on the panel. ------

10. The BC–44–A may be used as a vacuum-tube detector. ------

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THE SCR-79-A AND THE SCR-99 SETS.

Equipment.

1 SCR-79-A (set box BC-32-A only).
1 SCR-125-A wave meter.
3 4-volt storage batteries (BB-14).
3 VT-1 vacuum tubes.
2 VT-2 vacuum tubes.
2 $22\frac{1}{2}$-volt batteries (BA-2).
1 antenna system, type *A9A* (complete).
1 dynamotor, type DM-1.
1 head set, type P-11.
2 cords, type CD *38* (battery connectors).
1 cord, type CD *48* (12-V lead).
1 cord, type CD *49* (key lead).

GENERAL CONSTRUCTION OF THE SCR-79-A.

Information.

The SCR-79-A and SCR-99 sets differ from each other only in wave-length range, the SCR-99 set having a range of from 900-1,900 meters. For this reason the SCR-79-A set only will be described.

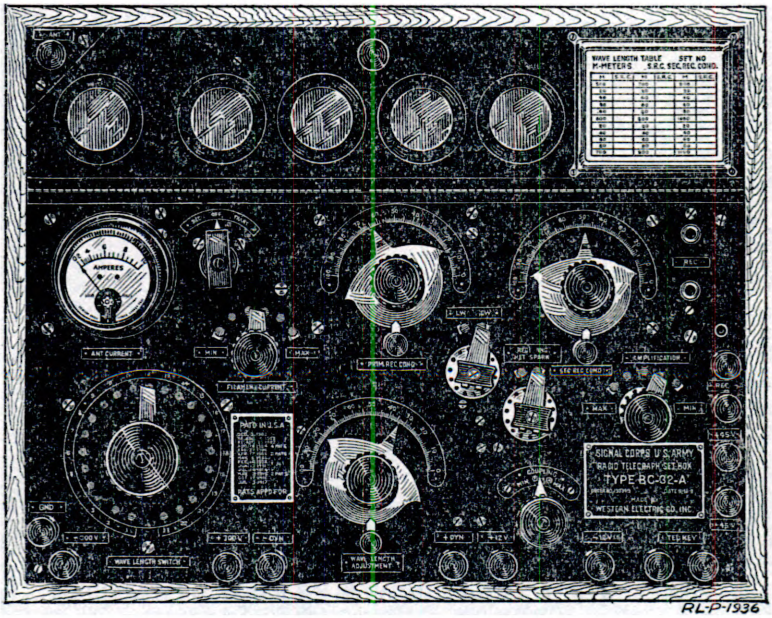

Fig. 68.—Set box BC-32-A of the SCR-79-A set.

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In addition to using a vacuum tube as a detector and amplifier of radio signals, one may also use it to generate currents of a high frequency when it is connected to the proper apparatus. In this capacity the vacuum tube, known as an *oscillator*, may be used in a radio transmitter to generate the high-frequency current which is radiated from the antenna system as electromagnetic waves. The waves sent out by a spark transmitter, such as the SCR–74 and the SCR–105, are called "damped" waves. The waves emitted by a vacuum tube transmitter are called "undamped" or continuous waves.

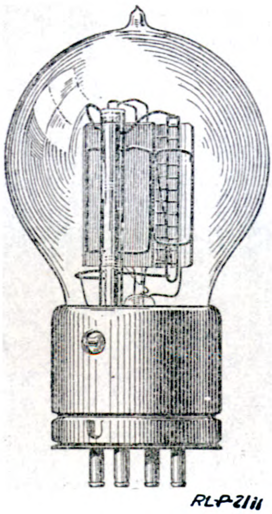

Fig. 69.—The type VT–2 vacuum tube.

The SCR–79–A is a vacuum tube set (see Fig. 68) designed for transmitting undamped wave signals and for receiving either damped or undamped signals. The wave length range of the set, for both transmitting and receiving, is from 500 to 1,100 meters. Two VT–2 vacuum tubes (see Fig. 69) are used in the transmitter and three VT–1 tubes are used in the receiver. Two sets of this type can communicate over a distance of about 30 miles.

Directions.

1. Examine the front of the panel of the BC–32–A. Carefully note the markings of all binding posts, knobs, dials, and meters. Pull the small knob in the center of the top edge and open the door. Note the construction of the tube socket mountings. (The VT–2 sockets have the slot in the socket offset about 45° from the

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position of the slot in the VT–1 socket.) Note how the "B" batteries are connected and carried.

Questions.

(1) *Which sockets are used for the transmitting tubes? Which sockets are used for the receiving tubes?*

(2) *How are the "B" batteries carried in this set?*

(3) *How is the connection made between the "B" batteries and the receiving set?*

(4) *Why are binding posts provided on the front of the set box marked "+ 45V." and "− 45V."?*

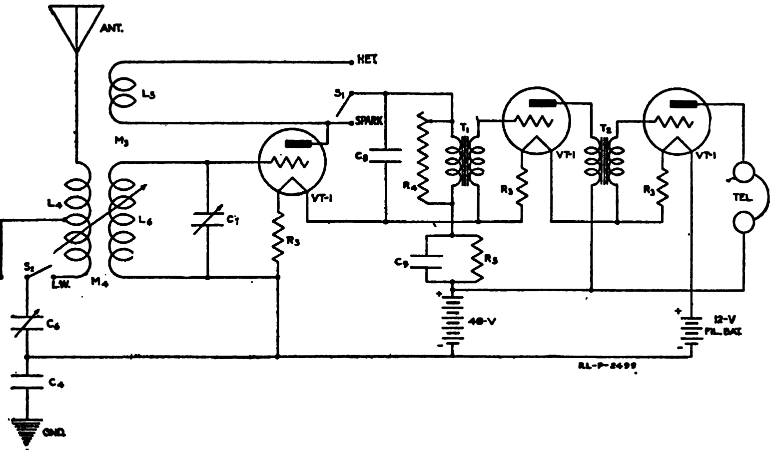

Fig. 70.—Schematic diagram of connections in the receiver of the SCR–79–A set.

(5) *To which binding post is the antenna connected? The ground?*

(6) *Where is the storage battery connection made? Does this supply the filaments of both transmitting and receiving tubes?*

(7) *Why does the storage battery have a voltage of 12 volts with this set when the VT–1 requires only a 4-volt battery to light its filament?*

(8) *What controls are varied on the front of the panel to change the primary receiving wave length?*

(9) *Which controls are varied to change the secondary receiving wave length?*

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(10) *Which controls are varied to change the receiving set from a damped wave receiver to an undamped wave receiver? What does this switch do to the receiving set?* (*See Diagram, Fig. 70.*)

(11) *How is the strength of the received signal varied?*

(12) *What is the purpose of the two binding posts marked* "REC"?

(13) *How many pairs of telephones can be plugged into this set?*

(14) *Can the filament current of the receiving tubes be varied or is it constant? Explain the answer.*

(15) *Why are rubber mountings used for the tube socket strip?*

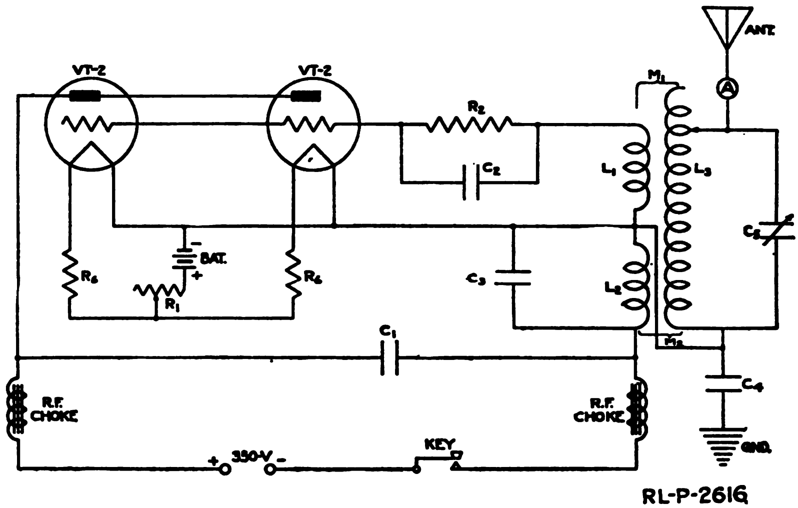

Fig. 71.—Schematic diagram of connections in the transmitter of the SCR-79-A set.

(16) *What is the purpose of the switch* "S_2" *on the front of the panel?*

(17) *How is the transmitted wave length varied?*

(18) *Is the filament current of the transmitting tubes fixed? Explain the answer.*

(19) *For what are the two binding posts marked* "+300 V" *and* "−300 V" *used?*

(20) *What connection is made to the two binding posts marked* "+Dyn" and "−Dyn"?

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(21) *To what binding posts is the key connected and what circuit is it in?*

(22) *What is the purpose of the "Wave length adjustment" condenser? (See Fig. 71.)*

Directions.

2. Look at the VT–2 vacuum tube (See Fig. 69) and note how it is constructed. The filament, grid, and plate are somewhat similar to the elements of the VT–1. Notice, however, that they are spaced differently. The wide spacing of the plate in the VT–2 is necessary on account of the high voltage used. Compare the base of the VT–2 with the base of the VT–1. (See Fig. 72.)

NOTE.—The amount of current consumed by the filament of the type VT–2 vacuum tube is approximately 1.3 amperes.

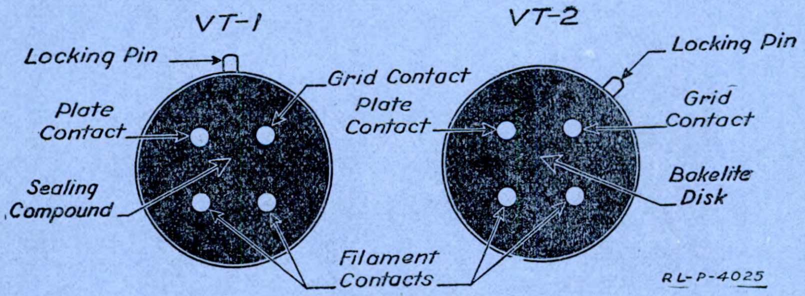

Fig. 72.—Relative positions of locking pins on type VT–1 and VT–2 vacuum tube bases.

Questions.

(23) *Is the position of the locking pin on the side of the VT–2 base different from the position of the locking pin on the VT–1 with respect to the four contact prongs?*

(24) *Will a VT–1 vacuum tube fit in a VT–2 socket? Explain the answer.*

(25) *Why were the tubes and sockets designed as explained in your answer to the preceding question?*

Directions.

3. Open the door at the top of the panel and remove the two screws holding the panel frame to the bracket. Remove the two screws from the lower corners of the panel. Lift the panel out of the box. Inspect the parts in the rear of the panel carefully. (See Fig. 73.) Move the control knobs on the front of panel and note what moves in the rear.

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Questions.

(26) *Where is the primary inductance of the receiving circuit?*

(27) *How many taps are there on the primary receiving coil? What switch varies the number of turns being used?*

(28) *Which is the secondary receiving coil? How many taps on it?*

(29) *Which is the tickler coil? To which coil is it most closely coupled? Why?*

(30) *What kind of coupling is used in this receiving set? How is it varied?*

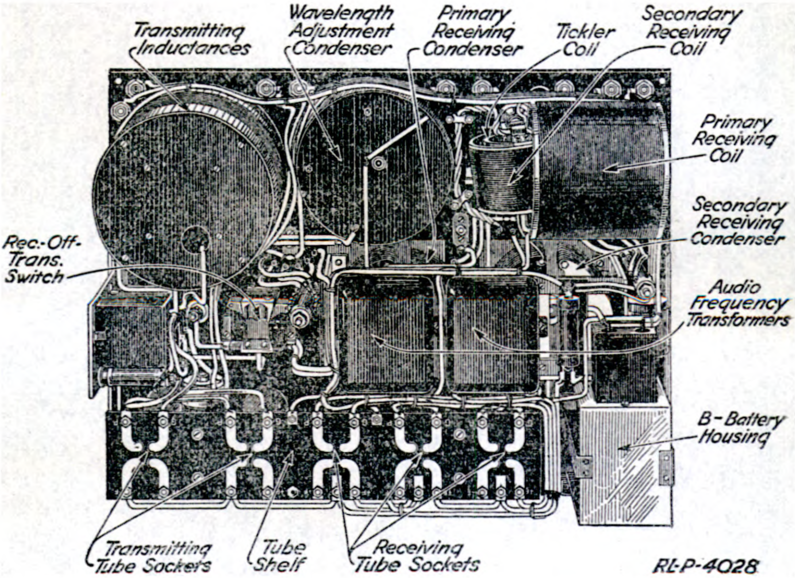

Fig. 73.—Rear, panel view of set box BC–32–A.

(31) *Why are stops placed on the coupling controls on the front of the panel?*

(32) *Where is the resistance and condenser unit in series with the plate of the detector and the "B" battery?*

(33) *What is the purpose of the above resistance and condenser?*

(34) *Where are the resistances R_3? Why are they placed in the circuit?*

(35) *Where is the ground lead condenser? Why is it used?*

(36) *Where are the primary and secondary variable condensers?*

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(37) *Where are the transformers of the first and second stages of audio frequency?*

(38) *Which is the detector tube socket? Which are the amplifier sockets?*

(39) *How many tubes are used for receiving in this set?*

(40) *How many stages of amplification are used?*

(41) *What type of tubes should be used in the receiving circuit?*

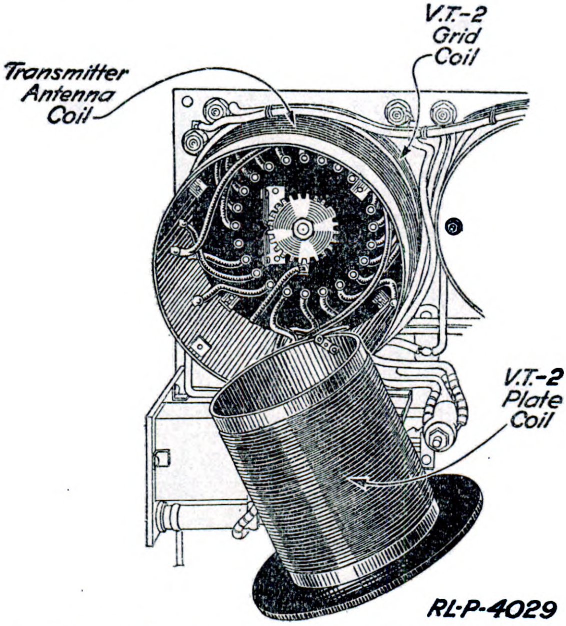

Fig. 74.—Details of the transmitting inductance of the SCR–79–A set.

(42) *What type tube is used in the sockets of the transmitting side?*

(43) *How many transmitting tubes are used?*

(44) *Which are the transmitting tube sockets?*

Directions.

4. Remove the four screws nearest the center of the rear of the transmitting inductance and lift out the end. (See Fig. 74.)

Questions.

(45) *Which is the grid coil, the plate coil, and the antenna coil?*

(46) *What does the "wave length switch" do?*

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(47) *What kind of coupling is used between the plate and grid coils?*

(48) *Can the filament current of the receiving tubes be varied? Explain the answer.*

(49) *Locate the resistance R_2 and the condenser C_2.*

(50) *Explain exactly what circuits the switch S_2 makes and breaks in each of its three positions.*

EXPERIMENT No. 1.

TO CONNECT UP AND TUNE THE SCR–79–A SET.

Information.

In connecting up the SCR–79–A set ready for operation there are two main divisions of the work, namely, the set connected as a

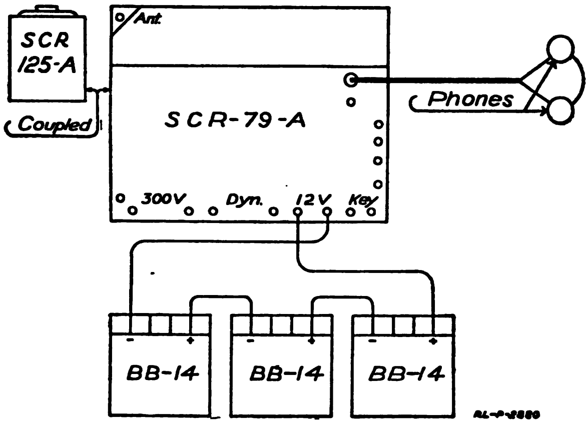

Fig. 75.—SCR–125–A wave meter coupled to receiving circuit of SCR–79–A set.

receiver and the set connected as a transmitter. The set may be connected up as a transmitter without fully connecting it up as a receiver, and vice versa. (See Figs. 75 and 76.) In like manner the tuning of the set as a receiver is separate and different from the tuning as a transmitter. A definite method must be followed in performing of these various operations.

Directions.

1. To connect up the set as a transmitter:

a. Place three BB–14 batteries in the form of a triangle on the ground near the foot of the mast holding the point of the "V" antenna. Connect the three batteries in series. To the negative

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terminal of the 12-volt battery thus formed connect the longer black lead of the cord, type CD-48. Do not connect the red lead.

b. Place the carrying chest of the set on top of the three storage batteries so that it is firmly supported and open up the top and front of the chest. (One of the storage batteries should be partly under the operating shelf formed by the front cover of the chest when open.)

c. Open up the top hinged portion of the panel by pulling on the knob in its center and insert two VT-2 tubes in the two left-hand sockets. Close the panel.

d. Place the "Trans.-Rec." switch on the "Off" position.

e. Connect the high voltage dynamotor leads (with the proper polarity) to the binding posts marked "+ 300 V" and "— 300 V."

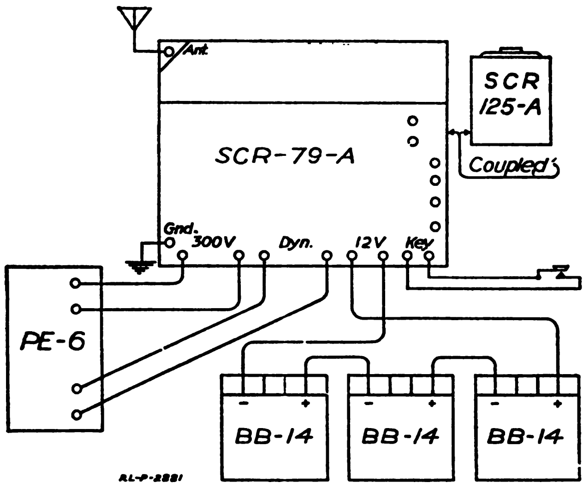

Fig. 76.—SCR-125-A wave meter coupled to transmitting circuit of SCR-79-A set.

f. Connect the low voltage dynamotor leads to the two binding posts marked "+ Dyn." and "— Dyn." with the correct polarity.

g. Connect the antenna lead-in wire to the post marked "Ant."

h. Connect the wire from the counterpoise or other ground system used to the post marked "Gnd."

i. Connect the short red lead of the cord, type CD-48, to the binding post marked "+ 12 V" and the short black lead of the same cord to the post marked " — 12 V."

j. Insert the key in its holder on the operating shelf and using the cord, type CD-48, connect it to the two binding posts marked "Key."

k. Check all connections to see that they are correct.

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l. See that the double-pole single-throw switch on the dynamotor is closed.

m. Connect the long red lead of the cord, type CD–48, to the positive terminal of the 12-volt battery. The set should now be ready to transmit by throwing the "Trans.-Rec." switch to the "Trans." position and by pressing the key.

Questions.

(1) *Why is it necessary to follow certain steps in a definite and particular order when connecting up this set?*

(2) *Why is the proper polarity important on any radio set?*

(3) *Why is the 12-volt battery circuit left incomplete until the last step in connecting up the set?*

(4) *Why is the "Trans.-Rec." switch placed on the "Off" position while connecting up the set?*

(5) *Why is the carrying chest placed on top of the storage batteries?*

Information.

The transmitter of the SCR–79–A is of such a type that the wave length on which it transmits is dependent upon the antenna system with which the set is used. It is therefore impossible to calibrate the transmitter permanently, and it is consequently necessary to use a wave meter to set it for any one of a number of wave lengths each time the antenna system is moved or changed in any way. Moreover, it is advisable to determine the settings of the transmitter for the different wave lengths on which it may be required to work before actually starting to handle traffic in a net.

Directions.

2. To tune the transmitter to a given wave length:

a. Set the filament rheostat at "Max."

b. Set the "Wave Length Switch" approximately at the wave length desired. (Suppose that the wave length desired is 700 meters. Seven hundred meters is a little less than halfway along the wave-length range of the set. Therefore, place the "Wave Length Switch," as a trial setting, a little less than halfway around toward "Max.")

c. Set the control of the "Wave Length Adjustment" condenser at the middle point of the scale.

d. Light the lamp in the SCR–125–A wave meter and adjust it to a dull red glow.

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e. Close the key and throw the "Trans.-Rec." switch to the "Trans." position.

f. Couple the wave meter to the transmitter by holding the side marked "Plane of coil" against the knob of the "Wave Length Switch" with the dial of the wave meter up.

g. Slowly turn the wave meter dial until the lamp glows most brightly.

h. If the wave meter lamp glows brightly at a wave length greater than that desired, decrease the antenna inductance by turning the "Wave Length Switch" down two or three taps; and if it glows brightly at a shorter wave length than the desired value, increase the antenna inductance by turning the "Wave Length Switch" up two or three taps.

i. Again turn the wave meter dial until the lamp glows most brightly. Continue this process until two inductance taps are found, one of which is above and the other below the desired wave length.

j. Set the "Wave Length Switch" on either of the two taps found in Direction *i* above. Set the wave meter to the exact wave length desired and vary the "Wave Length Adjustment" condenser until the lamp on the wave meter glows brightly. The set is now transmitting on the desired wave length.

Questions.

(6) *Why is the "Wave Length Switch" first set on approximately the correct position?*

(7) *Why is the control of the "Wave Length Adjustment" condenser first set at the middle point of the scale?*

(8) *What condition exists when the wave meter lamp glows most brightly?*

(9) *Why is the transmitter of this set not calibrated for use at all times?*

(10) *Why must the key be closed when tuning the transmitter?*

Information.

Although the receiver of the SCR-79-A is built in the same box as the transmitter and some of the parts are common to both, yet it is possible to connect up the set for receiving only when it is so desired. (See Fig. 75.) However, it is only for some special purpose that the receiver alone is connected up. The following directions explain how to connect up the receiver after the transmitter has been connected. Connections of the complete set are a combination

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of the operations involved in connecting up the receiver and the transmitter, and will be given later.

Directions.

3. To connect up the set as a receiver: After having made all of the connections given under the directions for connecting up the set as a transmitter the following additional connections will be needed in order to place the receiver in operation:

a. Open up the top hinged portion of the panel and insert three VT–1 tubes in the three right-hand sockets. Place two BA–2 batteries in the compartment, which is on the right side of the opening, and connect the leads from the batteries to the Fahnstock clips on the side of the compartment, making sure that the connections are correct in polarity. The two BA–2 batteries are thus connected in series in the receiver circuit. Close the panel.

b. Plug in one or two head sets, type P–11, into the jacks provided on the face of the panel. (If the cords of available head sets are not provided with plugs, the cord tips may be connected to the two binding posts marked "Aux. Tel.")

c. Put on one of the head sets and adjust it to fit the head comfortably. (The stirrups holding each receiver should slant "in" and not "out." If they slant "out," remove the receiver from its stirrup and turn the stirrup halfway around and replace the receiver.)

d. If the receiver only of the set is to be used, omit the items given under directions *c*, *e*, *f*, *j*, and *l*, describing the connections of the set as a transmitter.

Questions.

(11) *Why are the items given under Direction d, above, omitted where the set is to be used as a receiver only?*

(12) *For what reason are the two binding posts on the edge of the panel marked + and — 45 volts?*

(13) *Must the VT–2 tubes be placed in their sockets when the set is used as a receiver only?*

Directions.

4. *To connect up the set both as a transmitter and as a receiver—*

a. Place three BB–14 batteries on the ground in the form of a triangle near the foot of the mast holding the point of the "V" antenna. Connect the three batteries in series; and to the negative terminal of the 12-volt battery thus formed, connect the longer black lead of the cord, type CD–48. Do not connect the red lead.

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b. Place the carrying chest of the set on top of the three storage batteries so that it is firmly supported and open up the top and the front of the chest. (One of the storage batteries should be partly under the operating shelf formed by the front cover of the chest when open.)

c. Open up the top hinged portion of the panel by pulling on the knob in its center and insert two VT–2 tubes in the two left-hand sockets. Insert three VT–1 tubes in the three right-hand sockets. Place two BA–2 batteries in the compartment which is on the right side of the opening and connect the leads of the batteries to the Fahnstock clips on the side of the compartment, making sure that the connections are correct in polarity.

d. Place the "Trans.-Rec." switch on the "Off" position.

e. Connect the high voltage dynamotor leads (with the correct polarity) to the binding posts marked + and — 350.

f. Connect the low voltage dynamotor leads to the two binding posts marked "+ Dyn." and "— Dyn." with the correct polarity.

g. Connect the antenna lead-in wire to the post marked "Ant."

h. Connect the wire from the counterpoise or other ground system used to the post marked "Gnd."

i. Connect the short red lead of the cord, type CD–48, to the binding post marked "+ 12 volts" and the short black lead of the same cord to the post marked "— 12 volts."

j. Plug in one or two head sets, type P–11, into the jacks provided on the face of the panel. (If the cords of available head sets are not provided with plugs, the cord tips may be connected to the two binding posts marked "Aux. Tel.")

k. Put on one of the head sets and adjust it to fit the head comfortably.

l. Check all connections to see that they are correct.

m. See that the double-pole single-throw switch on the dynamotor is closed.

n. Connect the long red lead of the cord, type CD–48, to the positive terminal of the 12-volt battery. The set is now completely connected and ready to operate both as a transmitter and as a receiver.

Information.

In tuning the receiver to pick up desired signals several different cases will occur. They are as follows:

a. Tuning in a C. W. signal of known wave length.
b. Tuning in a damped wave signal of known wave length.
c. Tuning in a C. W. signal of unknown wave length.
d. Tuning in a damped wave signal of unknown wave length.

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Each of the above cases will be taken up separately and the necessary operations given under each case.

In the following tuning operations it will be noted that nothing is said about either the "Coupling Control" or the "Amplification" switch. The coupling control should be set on "Max." in all cases and only placed on "Min." after the desired signal has been tuned in and it is necessary to get rid of interference. When the coupling is changed from "Max." to "Min." it will require some little readjustment of the primary and secondary condensers. The "Amplification" switch should normally be left on "Max." and only turned toward "Min." when signals come in with so much volume that wearing the head set or reading the signals is uncomfortable.

Directions.

5. To tune the receiver of the set to a C. W. signal of known wave length proceed as follows. After the receiving side has been connected up as directed above:

a. Throw the "Trans.-Rec." switch to the "Rec." side.

b. Place the "Spk.-Het." switch on "Het."

c. Set the "LW-SW" switch and the secondary condenser to the desired wave length as given by the calibration of the set.

d. Vary the primary condenser until a distinct double click is heard and set the primary condenser about 5° to either side of the point where this double click is heard.

e. The receiving side of the set should now be in tune on the desired wave length, but due to inaccuracies which may occur the setting may not be exact enough to pick up the signal sought. It is therefore advisable to swing the secondary condenser slowly over an arc of about 10° (the middle point of which is the setting given by the set's calibration) until the sought for signal is heard.

f. A small further adjustment of the primary condenser may now be made in order to increase the loudness of the signal.

6. To tune the receiver to a damped wave signal of known wave length proceed as follows:

a. Same as *a* above.

b. Same as *b* above.

c. Same as *c* above.

d. Same as *d* above.

e. Place the "Spk.-Het." switch on "Spk."

f. Same as *e* above.

g. Same as *f* above.

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7. To tune the receiver to a C. W. signal of unknown wave length proceed as follows:

a. Same as *a* under Direction 5.

b. Same as *b* under Direction 5.

c. Set the "LW–SW" switch on "SW." Set the secondary condenser on about 5° and vary the primary condenser until the double click indicating resonance is heard.

NOTE.—For every position of the secondary condenser there should be a corresponding position of the primary condenser at which the primary or antenna circuit is in tune with the secondary circuit. In searching for a signal of unknown wave length the method should be to vary both condensers at the same time, attempting always to keep the primary condenser close to that point where its circuit is in tune with the secondary.

d. Starting with the secondary condenser at about 5° and the primary condenser at the point where it is in tune, slowly turn both condensers as outlined above over their entire scale. Repeat this several times until you are sure that the signal is not obtainable. (The primary condenser should increase as the secondary is increased.)

e. Set the "LW–SW" switch on "LW" and repeat *d.*

f. When the desired signal is found under either *d* or *e*, adjust very carefully the primary and secondary condensers for a loud, clear signal of a readable pitch.

8. To tune the receiver to a damped wave signal of unknown wave length proceed as follows:

a. Follow exactly the procedure outlined under Direction 3 until the desired signal is found. When found the natural tone of the damped wave will be badly distorted.

b. Throw the "Spk.-Het." switch to "Spk." and if necessary retune slightly both the primary and secondary condensers. The damped wave signal should not be heard with its natural tone but much weaker than when heard under *a.*

NOTE.—Damped waves may be received with the "Spk.-Het." switch on "Het.", if change in tone is not objectionable. The receiver will be far more sensitive than with the switch on "Spk."

Questions.

(14) *Why is it necessary to use different methods in tuning "known" and "unknown" wave lengths?*

(15) *If your receiver is not calibrated, what method would you use to tune in a C. W. signal of known wave length?*

(16) *After setting the secondary circuit of a receiver to any given wave length, why is it necessary to vary the primary circuit until a double click is heard in the head set?*

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(17) *In tuning in a signal of unknown wave length, why is it necessary to vary both primary and secondary controls at the same time?*

(18) *In tuning in a damped wave signal, why is the "Spk.-Het." first turned to the "Het." position?*

EXPERIMENT NO. 2.

CALIBRATION OF RECEIVER.

Directions.

9. Connect up the SCR–79–A set for receiving only as outlined under Direction 3 *d*, of this Unit Operation. Throw the "Trans.-Rec." switch to "Rec."

METHOD "A."

About 5 feet away from the set, couple the SCR–125–A wave meter to the ground lead by wrapping one or two turns of the lead around the wave meter. Set the wave meter on 500 meters and start the buzzer going with a smooth even note. Return to the set and place the coupling on maximum with the "Het–Spark" switch on "Het." Place the "SW–LW" switch on "SW" for wave lengths up to 800 meters and on "LW" for the wave lengths above 800 meters unless it is found impossible to tune in the primary circuit on the position stated. Vary the secondary condenser until the note of the wave meter is heard and then vary the primary condenser until a maximum signal strength is obtained. After adjusting the primary condenser it will be found that the secondary condenser will need a slight readjustment. In a table similar to the one shown below fill in the settings of the primary and secondary condenser and the "LW–SW" switch which have been found to give the greatest signal strength with the wave meter.

Wave length.	Primary condenser setting.	Secondary condenser setting.	Setting of "SW–LW" switch.
500			
550			
600			
650			
700			
750			
800			
850			
900			
950			
1000			
1050			
1100			

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Adjust to 500 meters. Repeat the above operations with the wave meter adjusted successively to wave lengths 50 meters apart until the entire wave length range of the set has been covered.

METHOD "B."

Set the SCR–125–A wave meter on 500 meters and start the buzzer going. With the various switches set as given in "Method A," hold the wave meter about 1 foot in front of the panel of the set. Vary the secondary condenser until maximum signal strength is attained. Shut off the wave meter buzzer and without moving the secondary condenser vary the primary condenser until a sharp and definite double click is heard. This click indicates that the primary circuit is now in tune with the secondary. Prepare a table similar to the one prepared under "Method A." Repeat the above operations for successive settings of the wave meter, 50 meters apart, and record in the table. Proceed until the entire wave-length range of the set has been covered.

Information.

In "Method A" both the primary and secondary circuits are tuned by reference to the wave meter, while in "Method B" the secondary circuit only is tuned to the wave meter, and the primary circuit is then tuned to the secondary. The normal way of tuning or calibrating the receiving side of the set should be by "Method B." However, if it is found impossible to obtain the definite click indicating that the primary circuit is in tune then "Method A" should be used. If, in "Method B," trouble is experienced in finding the point of maximum strength, due to interference from other radio sets, the antenna may be disconnected while the secondary circuit is being calibrated, but it must be connected again for calibration of the primary circuit.

Questions.

(19) *Can the primary circuit be set to a given wave length by holding the wave meter in front of the panel of the set?*

(20) *Why is the receiver calibrated with the coupling control on maximum?*

(21) *Why is the receiver calibrated with the "Spk.–Het." switch placed on the "Het." position?*

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(22) *Why is the wave meter coupled to the ground lead when calibrating a set by "Method A"?*

(23) *Which, "Method A" or "Method B," gives the more accurate setting of the primary condenser?*

EXPERIMENT No. 3.

TO TUNE THREE OR MORE SETS TO THE SAME WAVE LENGTH.

Information.

A number of SCR–79–A sets are operating in a net. They are all operating on the same wave length. In other words, all the sets are adjusted to transmit and to receive on exactly the same wave length. Any set in the net may start transmitting. All of the remaining sets in the net will receive the transmitted signals without readjustments of the secondary condenser control.

A number of SCR–79–A sets are being operated in a net on slightly different wave lengths. In other words all of the transmitters are not adjusted to exactly the same wave length. As a result, every time a different set starts transmitting, it is necessary for the remaining sets to readjust the secondary condenser control when receiving the transmission.

Questions.

(24) *Which of the two conditions, as outlined above, is the better for rapid and accurate exchange of messages in a net?*

(25) *If an operator is listening in under the second condition (as outlined above) during a silent period, what does he have to do constantly in order to receive any communications which may be transmitted?*

Information.

In tuning the SCR–79–A receiver it was noticed that the slightest movement of the secondary condenser caused the beat note to disappear. From this fact an idea may be obtained as to the amount of accuracy necessary when tuning to the same wave length all SCR–79–A transmitters in a net. There is sometimes a variation of as much as 25 or 30 meters between the readings of different SCR–125–A wave meters when they are used to measure the same wave length. For this reason it is not possible to tune all the transmitters in a net to exactly the same wave length by using a different wave meter for

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each set. In the following experiment a method will be used by which it is possible to adjust all sets in a net to exactly the same wave length.

Directions.

10. Set up and place in operation three or more SCR–79–A sets at a distance of at least 300 yards between each set.

11. One set is designated as the NCS (net control station) of the net and all stations are advised regarding the wave length to be used. Call signs are assigned to each station.

12. The NCS uses his SCR–125–A wave meter and tunes his transmitter to the designated net wave length (explained under "Tuning the transmitter" in Experiment No. 1). The NCS station then transmits as follows: $\overline{\text{VE}}$ ZVL ZVL V NCS NCS II ZVL ZVL ZVL (transmit signal ZVL for one minute) II $\overline{\text{AR}}$.

13. Each of the other or "secondary" stations must tune in the above transmission on the NCS in such a way that the best possible signal will be received.

14. The operator at each secondary station, without disturbing the adjustments of his receiver in any way, now tunes his transmitter to the designated net wave length in the usual way, that is by the use of a wave meter. The "Trans.-Rec." switch is then thrown to "Rec." and the buzzer on one SCR–125–A wave meter started. The wave meter is held in front of the panel and its dial slowly turned until the maximum sound is heard in the head set. Without changing the adjustment or position of the wave meter, throw the "Trans.-Rec." switch to the "Trans." position. Since the transmitter is already on about the correct wave length, it will only require a slight readjustment to make it exact. The "Wave Length Adjustment" condenser is therefore turned until the wave meter lamp glows most brightly and is then locked in this position. The adjustment of the transmitter and receiver should now be exactly on the wave length on which the NCS station is transmitting. Since all of the secondary stations are adjusted to the wave length of the NCS station, they should all be on the same wave length.

15. The NCS station will call each secondary station in turn, and when the secondary station replies, will note the position of the secondary condenser on which the reply is received. All secondary stations other than the transmitting station will also note the position of their secondary condenser dials where the transmission is received.

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16. If all stations are received on the same setting of the secondary condenser by the NCS station, the experiment will be considered complete; if not, it will be repeated until they are so received.

Questions.

(26) *Why is it important that when a net is working on one wave length all of the stations in the net transmit on exactly the same wave length?*

(27) *Are the calibrations on the SCR–95 wave meters at secondary stations used in making the final accurate setting of their transmitting wave length?*

(28) *Did your wave meter check with the calibrations of the wave meter used by the NCS?*

(29) *Were you able to hear all of the stations in the net without moving the secondary condenser?*

(30) *How much was it necessary to move the "Wave Length Adjustment" condenser from the position on which it was set with the wave meter when it was changed to the wave length of the NCS?*

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SUGGESTIONS TO THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly of the class explain carefully the information given in the Students Manual.

2. Remove the panel and attached parts from a BC–32–A set box. Point out and name each control used in the adjustment of the transmitter. Draw a circuit diagram on the blackboard similar to the one shown in Fig. 71 in the Students Manual. As each control or part is discussed, point out its location in the diagram. In the same manner explain the operation of the receiver side of the set.

3. Direct the students to draw the necessary equipment and to proceed with the experiments in the Students Manual.

4. The most important words in this Unit Operation are as follows:

Oscillator.	Undamped waves.	Dynamotor.
Damped waves.	Continuous waves.	Tickler coil.

5. When the students have completed this Unit Operation, they should know the names and purposes of all the important parts of the SCR–79–A set. They should be able to prepare a complete list of all the equipment necessary to establish a station using the SCR–79–A or the SCR–99 sets. From the experiments performed the students should know:

a. How to connect completely the transmitter and receiver of the set.

b. How to tune the transmitter to any given wave length.

c. How to tune the receiver to a given wave length or to an unknown wave length.

d. How to calibrate the receiver.

e. How to tune three or more sets to the same wave length.

6. When the class work has been completed, give the following Instruction Test (or devise one similar to it). This test should be conducted in the same manner as in previous Unit Operations.

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SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 antenna, type A–9–A.
2 batteries, type BA–2.
3 batteries, type BB–14.
1 cord, type CD–15.
2 cords, type CD–38
1 cord, type CD–47.
1 cord, type CD–48.
1 cord, type CD–49.
1 dynamotor, type DM–1.
1 head set, type P–11.
1 key, type J–12.
1 set box, type BC–32–A.
3 vacuum tubes, type VT–1.
2 vacuum tubes, type VT–2.
1 wave meter, type SCR–125–A.

Problem No. 1.

Procedure.

a. Place the equipment listed above in a suitable location for conducting the test and assign the student who is to be tested to this position.

b. Instruct the student to connect up the complete equipment, including the antenna system, ready for operation.

c. When the student is prepared direct "Begin."

d. When the student indicates that he has completed the work, record the time taken and check the connections. Point out any errors and allow the student time to make corrections.

Problem No. 2.

a. Start the SCR–125–A wave meter, transmitting on a wave length unknown to the student, and couple the wave meter to the antenna lead-in.

b. Direct the student to pick up the signal of the wave meter.

c. When the student has indicated that he has tuned the receiver to the signal, record the time taken and check the tuning.

Problem No. 3.

Direct the student to adjust the transmitting side of the set for best transmission on a given wave length, such as 650 meters. When the student has indicated that he has completed the test, record the time taken and check the tuning.

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INSTRUCTION TEST NO. 15–A (PERFORMANCE.)

Directions to the student.—The following equipment is laid out at your position:

1 antenna, type A–9–A.
2 batteries, type BA–2.
3 batteries, type BB–14.
1 cord, type CD–15.
2 cords, type CD–38.
1 cord, type CD–47.
1 cord, type CD–48.
1 cord, type CD–49.
1 dynamotor, type DM–1.
1 head set, type P–11.
1 key, type J–12.
1 set box, type BC–32–A.
3 vacuum tubes, type VT–1.
2 vacuum tubes, type VT–2.
1 wave meter, type SCR–125–A.

Problem No. 1.

1. *a.* When the instructor directs "Begin," connect this equipment correctly for both transmission and reception. Start work promptly. Do it carefully and quickly.

b. Notify the instructor when you have finished by raising your right hand.

c. The instructor will record the time taken to do the work and will check your connections. Correct any errors the instructor may point out.

Problem No. 2.

2. *a.* When the instructor directs "Begin," tune the receiving side of the set to the signal of the wave meter.

b. Notify the instructor when you have finished by raising your right hand.

c. The instructor will again record the time taken and will check the tuning of the receiver.

Problem No. 3.

3. *a.* When the instructor directs "Begin," adjust the transmitting side of the set for transmission on the wave length designated by the instructor.

b. Notify the instructor when you have finished by raising your right hand.

c. The instructor will again record the time taken and will check the adjustments of the transmitter.

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SCORING.

1. The maximum score for this test is 20 points.
2. The score required to pass this test is 15 points.
3. *Directions for scoring.*

	Points.
a. If the equipment is properly connected	10
b. If the receiver is properly tuned	5
c. If the transmitter is properly tuned	5

4. When the student fails to complete the test, or performs the test incorrectly, a grade of zero will be given for incomplete parts or incorrect performance.

INSTRUCTION TEST NO. 15-B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. The wave-length range of the SCR-79-A set is from
(1) 150 to 550 meters. (2) 700 to 900 meters.
(3) 1,000 to 3,000 meters. (4) 500 to 1,100 meters. ....

b. The total number of vacuum tubes used in the SCR-79-A set is
(1) four. (2) three. (3) five. (4) seven. ....

c. In the operation of the SCR-79-A the necessary filament voltage is supplied by
(1) one 4-volt battery. (2) one 6-bolt battery.
(3) three 4-volt batteries. (4) two 4-volt batteries. ....

d. The plate voltage required to operate properly the transmitting side of the SCR-79-A set is
(1) 150 to 160 volts. (2) 1,000 to 1,500 volts.
(3) 600 to 900 volts. (4) 300 to 350 volts. ....

e. The plate voltage of the transmitting side of the SCR-79-A set is supplied by
(1) a number of BA-8 batteries.
(2) a large storage battery.
(3) a dynamotor. (4) a ½-horsepower motor. ....

f. The transmitting circuit of the SCR-79-A set is tuned by
(1) a variable condenser and a variometer.
(2) a wave-length switch, a variable condenser, and a coupling switch.
(3) a variable resistance, a filament-current switch, and a receiver-transmit switch.
(4) two variable condensers, a coupling switch, and a fixed condenser. ....

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g. The receiving circuit of the SCR–79–A set is tuned by
(1) a variable condenser and a coupling switch.
(2) three variable condensers, a "Het spark" switch and an amplification switch.
(3) two variable condensers, a coupling control, and an "SW–LW" switch.
(4) an antenna ammeter, an amplification switch, a variable condenser, and a coupling control. ....

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a plus (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. The SCR–79–A set uses VT–1 tubes for receiving. ....
2. The SCR–79–A set uses five tubes for transmitting. ....
3. The large "WAVE-LENGTH SWITCH" on the panel of the SCR–79–A set is used to control the wave length of transmission. ....
4. The filament current of the receiving tubes is not controlled by a rheostat. ....
5. The primary receiving coil of the SCR–79–A set is tapped in five places. ....
6. The telegraph key of the SCR–79–A set is in the receiving circuit. ....
7. For the reception of continuous wave signals the "Receiving" switch of the SCR–79–A set should be turned to "Het." ....
8. The SCR–79–A set may be used for either telephone or telegraph communication. ....
9. Conductive coupling is used between the plate and grid coils and the antenna coil of the SCR–79–A set transmitting circuit. ....
10. Conductive coupling is used between the plate and grid coils of the SCR–79–A set. ....
11. The tickler coil of the SCR–79–A set is within the set box and closely coupled to the secondary coil. ....
12. Inductive coupling is used between the primary and secondary receiving coils of the SCR–79–A set. ....
13. The object of the "Wave-length adjustment condenser" is to tune the primary receiving circuits of the SCR–79–A set. ....

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THE SCR-67-A RADIO TELEPHONE SET.

Equipment.

1 SCR-67-A (set box BC-13-A only).
1 power board (BD-1-A).
1 SCR-125-A wave meter.
1 SCR-61 wave meter.
3 storage batteries, 4-volt, type BB-14.
2 dry batteries, 22½-volt, type BA-2.
2 VT-1 vacuum tubes.
2 VT-2 vacuum tubes.
1 transmitter, type T-3.
1 control button and cord (CD-25).
1 extension cord (CD-23).
1 headset, type P-11.
1 antenna system, type A-9-A.

GENERAL CONSTRUCTION OF THE SCR-67-A.

Information.

The type SCR-67-A set is a two-way radio telephone set for use on the ground in communication with a similar set or with airplane

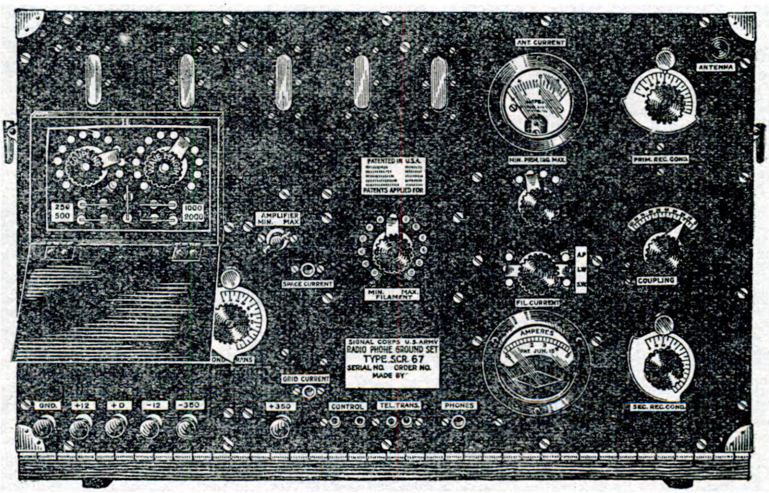

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Fig. 77.—Front panel of set box BC-13-A of the SCR-67-A set.

radio telephone sets. Communication between two sets of this type may be carried on over a distance of from 5 to 7 miles. When used with a suitable antenna, the range of wave lengths of the set is from

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250 to 450 meters when transmitting, and from 200 to 700 or 800 meters when receiving.

The SCR–67–A consists of two units: the BC–13–A set box and the BD–1–A power board. (See Figs. 77 and 78.) The BC–13 set box contains a vacuum tube, radio telephone transmitter, and receiver. The transmitting and receiving circuits are adjusted by the various controls on the front panel.

In order to operate the transmitter vacuum tubes properly, it is necessary to use 350 volts on the plates of the tubes. This voltage is

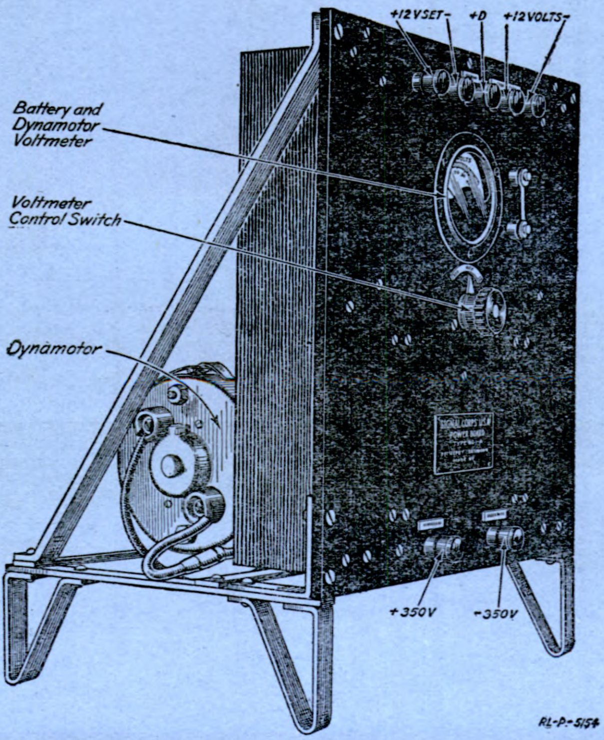

Fig. 78.—Power board type BD–1–A.

supplied by a dynamotor mounted in the rear of the BD–1–A power board unit. The 12-volt storage battery which is used to light the filaments of the transmitting and receiving tubes, also provides the current necessary to run the dynamotor.

Notice in the cording diagram that the two leads from the storage battery do not run directly to the set box but are directly connected to terminals on the power board. Thus a flexible extension cord may be used for all connections from the power board to the set box.

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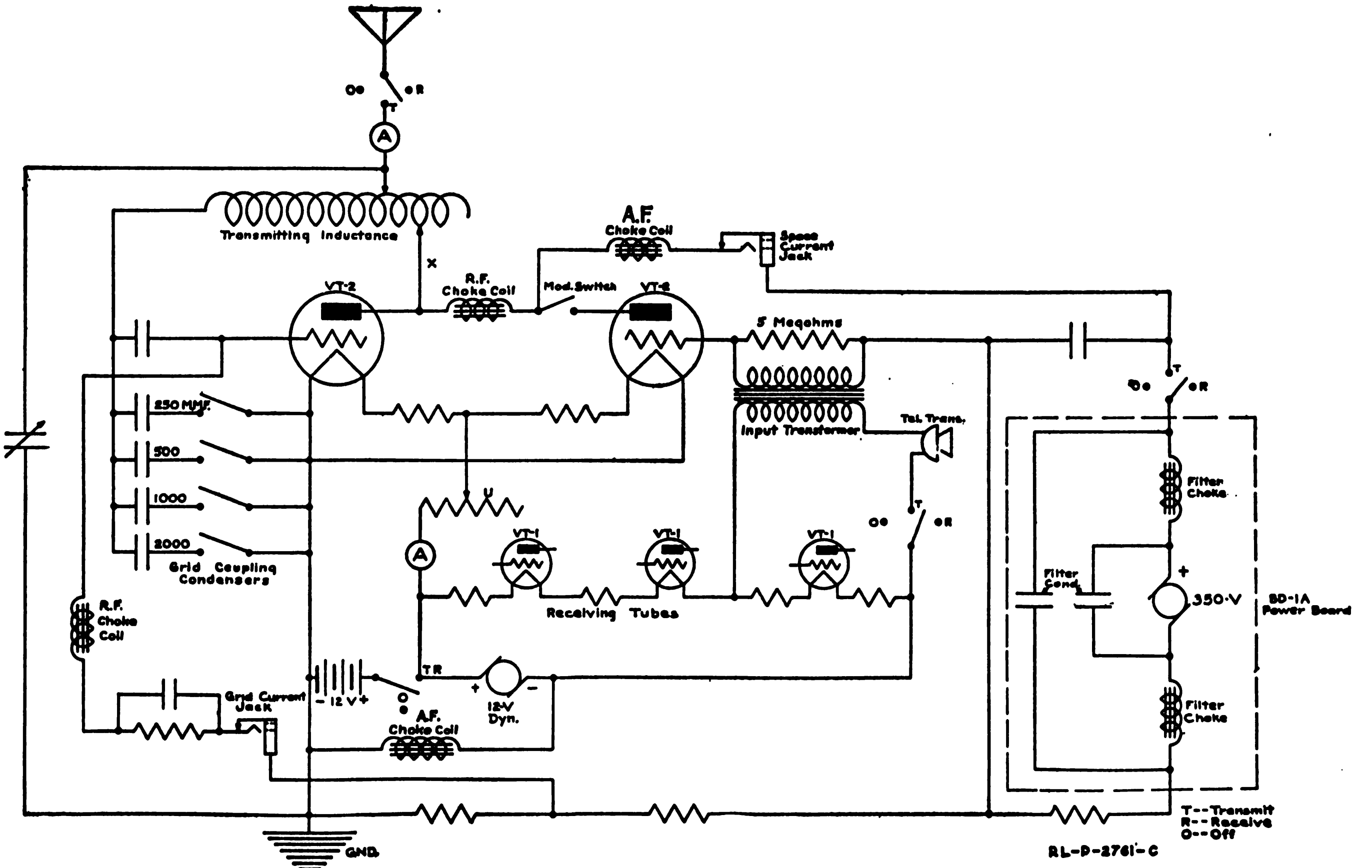

Fig. 79.—Schematic diagram of transmitter connections in the SCR-67-A set.

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With this arrangement the apparatus can be easily set up in a short time.

A voltmeter which reads from 0–50 volts is mounted on the power board. When the switch directly underneath the meter is turned to the position marked "12 volts" the meter will indicate the voltage of the storage battery. When the switch is turned to the position marked "350 V" the meter will indicate the high voltage of the dynamotor. It will be necessary to multiply the latter reading by 10, as only one scale is provided on the meter. The meter is disconnected from the circuits when the switch is in the "Off" position.

Directions.

1. Look at the front of the panel of the BC–13–A. Carefully observe the marking of all the binding posts, knobs, dials, and meters.

Questions.

(1) *Where is the antenna connected? The ground?*

(2) *Where are the filament lighting battery connections made?*

(3) *What circuit is controlled by the 13–point switch located at the center of the panel? Explain.*

(4) *Locate the ammeter marked* "*Fil. current.*" *Does it indicate the filament current used by the transmitting tubes alone? Explain.*

(5) *What connections are made to the binding posts marked* "+ 350" *and* "—350"*?*

(6) *What connection is made to the post marked* "*D*"*?*

(7) *What position should the three-position switch be in for reception only? (This switch is located below the compartment on the left of the panel.)*

Information.

In the SCR–67–A transmitter, the antenna circuit is coupled to the vacuum tube circuit through a single inductance coil. (See Fig. 79.) A wave-length change switch controls the number of turns in the inductance coil and thus controls the wave-length range of the transmitter. A variable condenser, marked "Antenna Cond.," connected directly between the antenna and ground terminals, provides a means for fine adjustment of the wave length.

There are two VT–2 vacuum tubes used in the transmitting circuit. The vacuum tube which is coupled to the antenna circuit is called the *oscillator tube.* The term "oscillator" implies that the tube is a generator of electrical impulses. As long as the filament of

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the oscillator tube remains lighted and the proper plate voltage is applied with proper coupling between grid and plate circuit, a continuous stream of electrical impulses will be generated and conveyed to the antenna, from which they will be radiated in the form of continuous waves. It will be noticed that there are four condensers in the grid circuit of the oscillator tube which are controlled by four single-pole switches. They are used to obtain the proper coupling between the grid and plate circuits, so that the tube will generate the electrical impulses.

The second vacuum tube in the transmitter is known as the *modulator tube*. The grid circuit of this tube is connected with a telephone transmitter through an induction coil or *modulation transformer* as it is called. When the telephone transmitter is spoken into, the voice vibrations are converted or changed into electrical voice currents. The modulator tube amplifies these currents and then combines them with the impulses generated by the oscillator tube. This is done in such a way that the combined currents are radiated from the antenna in the form of waves, the continuous waves formed serving as a carrier for the voice current waves. This process of impressing the voice currents upon the continuous or carrier wave is called *modulation*.

It will be noticed in the schematic diagram that the microphone or telephone transmitter is connected across the filament terminals and resistances of the detector tube in the receiving circuit. This was done to obtain the current required to operate the telephone transmitter. It is necessary, therefore, to have the filaments of the receiver tubes lighted or the telephone transmitter can not be made to operate. Notice also that there is a switch called the modulator switch in the plate circuit of the modulator tube. The operation of the modulator tube may be stopped by opening this switch. Wave length readings of the transmitter are taken with this switch open. It is also an aid in locating trouble if the transmitter is not working properly.

Directions.

2. Observe the transmitting controls on the panel of the BC–13–A set box. Pull the knob in the upper left-hand corner and open the door to the wave length adjusting compartment.

Questions.

(8) *How many points has the "Wave-length" switch? The "Coupling" switch?*

(9) *What is the purpose of the four small horizontal knife switches in the compartment?*

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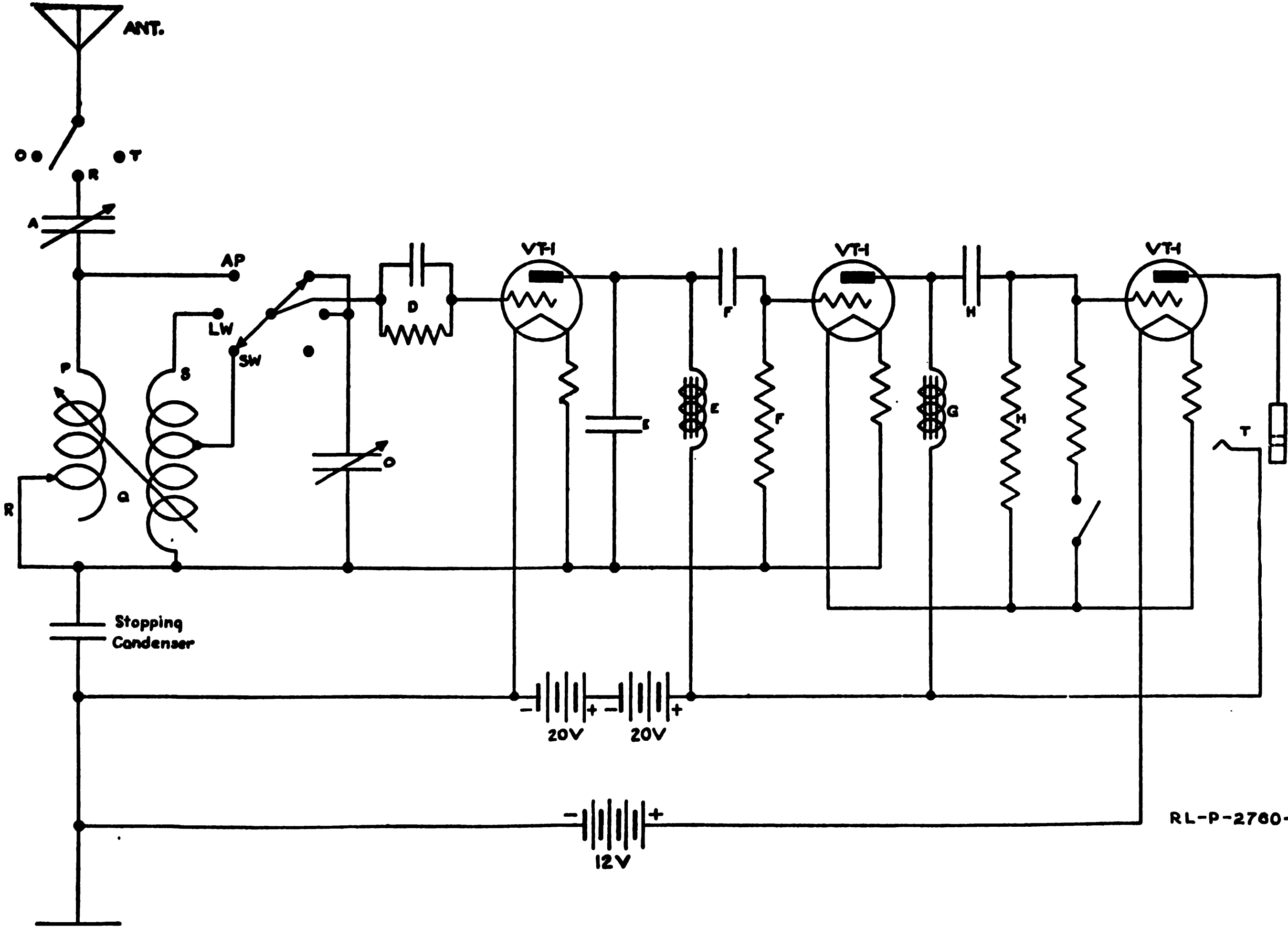

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(10) *What connections are made in the transmitting circuit when the small vertical knife switch is closed?*

(11) *Locate the "Con.-Trans." condenser. What is its purpose?*

(12) *What is the use of the meter marked "Ant. Ammeter"? Why is the red line drawn on its scale?*

Information.

The receiving circuit of the SCR–67–A is of the inductively coupled type. (See Fig. 80.) The primary circuit comprises the antenna, a variable condenser, an inductance coil variable in four steps, and the ground. The secondary circuit consists of an inductance coil (inductively coupled to the primary), variable in two steps, and a variable condenser. A three-position switch is provided so that for short waves one-half of the secondary coil is used, while for the longer waves the entire coil is used.

When the switch is in the "AP" (aperiodic or untuned) position, the secondary circuit is entirely disconnected and the primary circuit is directly connected to the detector. This position of the switch is used when searching for signals of unknown wave length.

A vacuum tube detector is used in the receiver. In addition, two stages of audio frequency amplification are provided. The 40-volt "B" battery (made up of two type BA–2 batteries in series), necessary to operate the receiver tubes, is contained in a holder inside the set box. In the amplifier circuit, choke coils are made use of instead of amplifying transformers. While the choke coils have only one winding and are connected differently in the circuit, the effect produced is similar to that when using transformers.

An "amplifier" switch is provided in the circuit between the two amplifier tubes. When this switch is closed, a high grid lead resistance is shunted by a comparatively low resistance, thereby decreasing amplification of the second stage.

Directions.

3. Observe the receiver controls on the panel of the BC–13–A set box.

Questions.

(13) *Locate the primary and secondary condenser dials. How many degrees are marked on each?*

(14) *How many switch points has the primary inductance switch?*

(15) *How many positions has the short and long wave switch?*

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(16) *What happens in the circuit when the switch is in the "AP" position?*

(17) *Locate the coupling control. Why is it provided?*

(18) *How many positions has the amplifier switch?*

(19) *How many pairs of phones can be plugged into this set?*

Information.

To carry on two-way communication between two sets of the SCR–67–A type, it is necessary to provide some means by which a change from transmit to receive can be made rapidly. This is accomplished by the use of the control push button, which is plugged

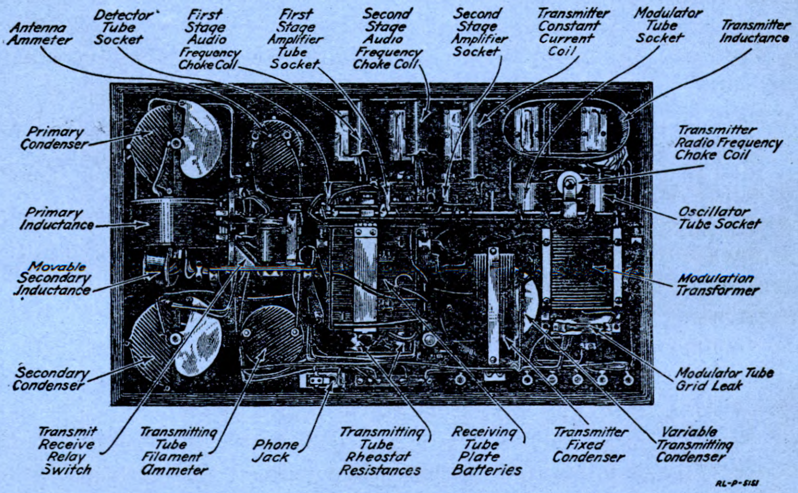

Fig. 81.—Interior of set box BC–13–A, showing parts mounted on back of panel.

into the jacks marked "Control." When the button is pressed, a relay switch is operated inside the set box which connects the "+ 350 V" to the plates of the transmitter tubes, connects the telephone transmitter in the circuit, and makes connection between the transmitting circuit and the antenna.

When the control button is released, the relay switch arm returns to its original position. This automatically connects the antenna to the receiving circuit.

Directions.

4. Unfasten the hooks on the side of the set box and pull the panel forward. (See Fig. 81.) Inspect the parts in the rear of the panel carefully. Move the control knobs on front of the panel and note what moves in the rear.

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Questions.

(20) *Locate the relay switch. What connections are made to the contacts on the movable arm?*

(21) *Which is the primary receiving coil? How many taps on it?*

(22) *Which is the secondary receiving coil? How many taps on it?*

(23) *Locate the primary and secondary variable receiving condensers. What is the purpose of each condenser?*

(24) *Locate the receiving grid condenser and grid leak. How are they connected in the circuit?*

(25) *What type of tubes are used in the receiving circuit?*

(26) *Locate the receiver-tube sockets. Which is the detector-tube socket? Which are the amplifier sockets?*

(27) *Why is a 12-volt battery connected in the receiving filament circuit, when a VT-1 vacuum tube requires only a 4-volt battery to operate the filament?*

(28) *What kind of coupling is used between the different stages of amplification? Locate these choke coils.*

(29) *Locate the resistance and condenser in the plate circuit of the detector tube. What is the value of the resistance?*

(30) *Locate the resistance and condenser in the plate circuit of the first amplifier tube. What is the value of the resistance?*

(31) *Locate the transmitter inductance coil.*

(32) *Which socket is the oscillator-tube socket? The modulator-tube socket?*

(33) *Locate the oscillator-tube grid condenser. Why are there a number of small condensers provided? How are they connected with respect to each other?*

(34) *Locate the modulation transformer and the resistance connected across its secondary winding. What is the value of this resistance?*

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Experiment No. 1.

RECEIVING WAVE LENGTH RANGE.

Directions.

5. Insert three VT–1 vacuum tubes in the receiving sockets. Insert and connect properly two BA–2 batteries. Close up the front panel of the set and fasten the hooks at the sides. Connect a 12-volt storage battery to the +12 and —12 binding posts. (See Fig. 82.) Throw the three-position switch to "Receive only."

6. Start the buzzer on the SCR–125–A wave meter vibrating as evenly as possible. Couple the SCR–125–A to the secondary receiv-

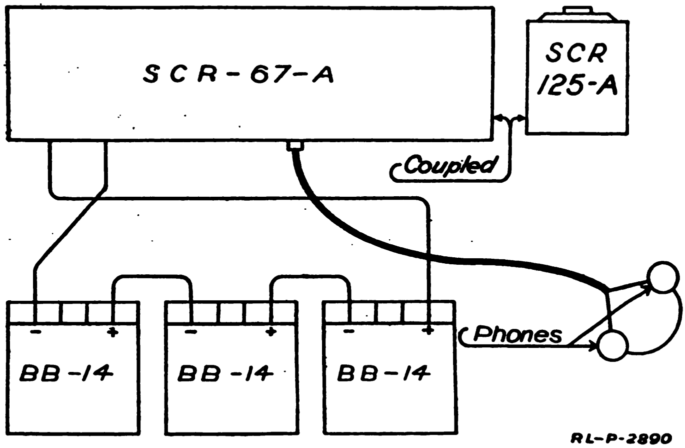

Fig. 82.—Method of coupling the SCR–125–A wave meter to the receiving circuit of the SCR–67–A set.

ing coil of the SCR–67–A. Set the secondary switch on "SW" and the secondary receiving condenser at 0. Plug in a pair of phones in the SCR–67–A and take a wave length reading.

a. Change the setting of the secondary variable condenser to "100" and take a wave length reading.

b. Change the setting of the secondary inductance switch to "LW" and the secondary variable condenser to 0. Take a wave length reading.

c. Change the setting of the secondary condenser to "100" and take a wave length reading.

d. Change the setting of the secondary inductance switch to "AP" and vary the secondary variable condenser, noting the point at which it is in tune.

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Questions.

(35) *From the above four wave length readings, what would you say was the receiving wave length range of the SCR–67–A?*

(36) *Does varying the secondary variable condenser change the received wave length of this set when the switch is on "AP"? Explain.*

(37) *Why is the "AP" circuit used in this set?*

Directions.

7. Disconnect the 12-volt storage battery from the set box BC–13–A.

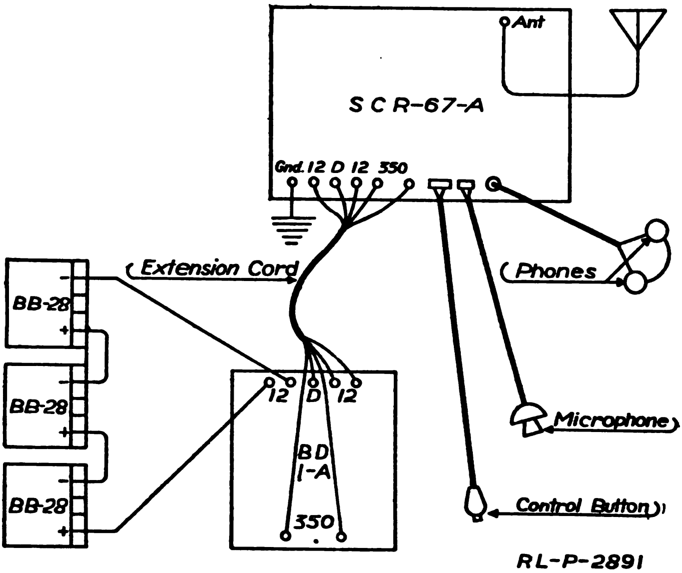

Fig. 83.—Method of coupling the SCR–125–A wave meter to the transmitting circuit of the SCR–67–A set.

EXPERIMENT No. 2.

TRANSMITTER CALIBRATION.

Directions.

8. Connect the 12-volt storage battery to the proper binding posts on the BD–1–A power board. (See Fig. 83.) Using the connection cord CD–23, connect the proper terminals on the BD–1–A power board to the corresponding terminals on the set box, BC–13–A. Plug in the telephone transmitter and the control button in the proper jacks. Open up the front of the set and insert two VT–2 tubes in the transmitting sockets. Close the front and fasten the hooks.

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Connect the antenna and ground leaks to the proper binding posts on the set box. Throw the three-position switch to "Power on."

9. Throw the switch on the power board to the 12 volts position and check the storage battery voltage. This should be at least 12 volts and may be 14 volts without damage to the set. After checking the voltage, throw the switch to "Off." Turn the filament current switch on the set box panel all the way to the left, to the position "Minimum." Open the modulator switch in the compartment.

10. Turn the three-position switch on the set box panel to "Trans.-Rec." This should light the filaments of all the vacuum tubes and start the dynamotor. Adjust the filament current so that the filament current ammeter reads 2.6 to 2.7.

11. Set the coupling switch at maximum. Set the wave length switch to "Minimum" and the "Trans. Cond." to 0. Adjust the grid condenser knife switches for 750 mfds. of capacity. Press the control button and, using an SCR–125–A wave meter, take a wave length reading. Observe the radiation reading on the "Ant. ammeter." Prepare a table similar to the one shown below and record the reading and adjustments in the proper columns.

12. Change the setting of the wave-length switch to maximum and set the "Trans. Cond." to 100. Take the wave length reading, remembering that the control button must be kept depressed. Note the radiation on the ammeter.

13. Adjust the wave meter to the different wave lengths listed in the table below. Adjust in rotation and in the order mentioned, the "Wave length" switch, "Cond. Trans." condenser, and the "Coupling" switch until maximum readings are indicated by the antenna ammeter. Record in the table the settings and readings for each wave length under the proper heading.

14. It will be necessary to readjust several times the "Coupling" switch, grid coupling knife switches, and antenna transmitting condenser to secure adjustments which will give a maximum reading on the antenna ammeter at the desired wave length. The radiation should be from 0.3 to 0.6 amp.

TABLE.

Wave length.	Antenna switch point.	Coupling switch. point.	Antenna transmitting.	Grid coupling condenser.	Antenna ammeter reading.
250........	....	....	....	....	....
300........	....	....	....	....	....
350........	....	....	....	....	....
400........	....	....	....	....	....
450........	....	....	....	....	....

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Questions.

(38) *From the above operation, what is the transmitting wave length range of the SCR-67-A?*

(39) *On what wave length tap, condenser settings, and grid capacity was the highest radiation obtained? What was this radiation?*

Experiment No. 3.

MODULATION.

Directions.

15. Adjust the transmitter to the wave length which gave the greatest radiation in Experiment No. 2. Close the modulator switch in the wave length adjustment compartment. Press the control button. With lips close to the telephone transmitter, whistle into it and note the movement if any of the radiation ammeter needle. Speak into the transmitter in an even tone of voice, not too high or loud, and note the action of the ammeter needle. Adjust the set to other wave lengths and note in each case the modulation indicated by the ammeter. Whistle and talk into the transmitter, listening carefully in the phones for clear and sustained speech modulation.

Questions.

(40) *Does the needle of the ammeter rise or fall as the transmitter is whistled into?*

(41) *Compare the movement of the needle when speaking into the transmitter with the movement made when whistling.*

(42) *Does the needle fluctuate more or less violently as the sound of the voice becomes clear and even in the phones?*

(43) *Is the set modulating well or poorly when the needle fluctuates a great deal and the sound in the phones is clear and even?*

Caution.—*Do not touch the modulator and grid condenser switches with bare hands when the power is on. A severe shock will result unless the operator is careful in this respect.*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. Show the class, during the preliminary assembly, an SCR–67–A set with the front panel and attached parts removed from the set box. Point out the important parts of the transmitting side of the set and name each part clearly and distinctly. Draw on the blackboard a circuit diagram similar to the one shown in Fig. 79 of the Students Manual. As each part on the set is discussed point out its location in the circuit.

2. In the same manner proceed with the receiving side of the set, using a diagram similar to Fig. 80 of the Students Manual.

3. Exhibit a BD–1–A power board to the class. Explain the use of the control switch, the marking of the binding posts, etc.

4. Review carefully with the class the information given in the Students Manual regarding the oscillator and modulator circuits.

5. The important new words in this Unit Operation are as follows:

Radio telephone.	Modulation transformer.	Microphone.
Modulator.		Voice currents.

6. When the students have completed this Unit Operation, they should know the names and symbols of the important parts of the SCR–67–A set. They should be able to prepare a list of the complete equipment necessary to install and operate an SCR–67–A set. From the experiments performed in this Unit Operation the students should know:

a. How to connect up the SCR–67–A set completely, ready for operation.

b. How to tune the transmitter and receiver to designated wave lengths.

c. How to calibrate the transmitter.

d. How to calibrate the receiver.

SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST.

Directions to the instructor.

Equipment.

1 antenna, type A–9–A.
1 set box, type BC–13–A.
1 power board, type BD–1–A.
1 wave meter, type SCR–125–A.
1 wave meter, type SCR–61.
3 vacuum tubes, type VT–1.
2 vacuum tubes, type VT–2.
1 transmitter, type T–3.
3 storage batteries, type BB–14.
2 plate batteries, type BA–2.
1 control button and cord, type CD–25.
1 extension cord, type CD–23.
1 head set, type P–11.

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Procedure.

Problem No. 1.

a. Place the equipment listed above in a suitable location for conducting the test and direct the student to connect this equipment so that it will transmit and receive signals. As each student finishes, record the time taken to do the work and check the connections.

b. Point out any errors made by the student and allow time for him to make corrections.

Problem No. 2.

Direct the student to tune the transmitter for maximum radiation on a given wave length. As each student finishes, record the time and check the tuning of the transmitter.

Problem No. 3.

Start the SCR–61 wave meter, transmitting on some wave length unknown to the student. Direct the student to tune the receiver of the set to the signal of the wave meter. As each student finishes, record the time taken to do the work and check the tuning of the receiver.

INSTRUCTION TEST NO. 16–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   1 antenna, type A–9–A.
   1 set box, type BC–13–A.
   1 power board, type BD–1–A.
   1 wave meter, type SCR–61.
   3 vacuum tubes, type VT–1.
   2 vacuum tubes, type VT–2.
   1 transmitter, type T–3.
   3 storage batteries, type BB–14.
   2 plate batteries, type BA–2.
   1 control button and cord, type CD–25.
   1 extension cord, type CD–23.
   1 head set, type P–11.

2. When the instructor directs "Begin," start work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

a. Connect up the SCR–67–A equipment completely, ready for transmission and reception.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will check the connections.

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Problem No. 2.

a. When the instructor again directs "Begin," proceed to tune the transmitter of the set to a wave length designated by the instructor. Tune the transmitter so as to obtain maximum radiation on this wave length.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

Problem No. 3.

a. When the instructor again directs "Begin," tune the receiver of the set to the signal of the wave meter, being careful to obtain maximum signal strength in the receivers.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

SCORING.

1. The maximum score for this test is 16 points.
2. The score required to pass this test is 16 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
If the SCR–67–A equipment is properly connected	8

PROBLEM NO. 2.

If the transmitter is properly tuned to the wave length designated	4

PROBLEM NO. 3.

If the receiver is properly tuned to the signal of the wave meter	4

4. Where the student has failed to complete this test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or parts incorrectly performed.

INSTRUCTION TEST NO. 16–B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

a. How many variable condensers are provided in the receiving circuit of the SCR–67–A set?
(1) One. (2) Four. (3) Two. (4) Three. ......

b. How many telephone jacks are provided on the SCR–67–A set?
(1) Four. (2) Three. (3) One. (4) Two. ......

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c. The positive terminal on the motor side of the dynamo connected to the binding post on the set-box panel is marked
(1) +12. (2) +350. (3) GND. (4) +D. ------

d. The instrument used to convert the sound waves into electrical vibrations is called the ------
(1) transformer. (2) magaphone.
(3) microphone. (4) amplifier. ------

e. The transmitting wave-length range of the SCR–67–A set is from
(1) 500 to 900 meters. (2) 800 to 1,000 meters.
(3) 250 to 450 meters. (4) 300 to 600 meters. ------

f. The receiving wave-length range of the SCR–67–A set is from
(1) 250 to 450 meters. (2) 200 to 700 or 800 meters.
(3) 1,000 to 3,000 meters. (4) 600 to 900 meters. ------

g. The total number of vacuum tubes used in the SCR–67–A set is
(1) three. (2) five. (3) seven. (4) four. ------

h. The transmitter side of the SCR–67–A set uses
(1) a VT–1 vacuum tube and a VT–2 vacuum tube.
(2) two VT–1 vacuum tubes.
(3) one oscillator tube and one modulator tube.
(4) two amplifier tubes. ------

i. The filament voltage of the transformer side of the SCR–67–A set is supplied by
(1) three 4-volt storage batteries.
(2) a dynamotor. (3) four BA–8 batteries.
(4) two 4-volt storage batteries. ------

j. The plate voltage in the receiving circuit of the SCR–67–A set is supplied by
(1) two 4-volt storage batteries.
(2) three type BA–8 batteries.
(3) two type BA–2 batteries. (4) one 22½-volt battery. ------

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct) place a (+) sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (−) sign on the dotted line.

1. The VT–2 tube will operate satisfactorily in a VT–1 socket. ------
2. When the transmit-receive control button is depressed, the receiving circuit is closed. ------

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3. When the transmit-receive control button is depressed, the ground circuit of the transmitter is opened. ------

4. When the transmit-receive control button is depressed, the plate circuit of the transmitting side of the SCR–67–A set is closed. ------

5. When the transmit-receive control button is depressed, the transmitting antenna circuit of the SCR–67–A set is closed. ------

6. It is possible to receive signals with the SCR–67–A set when the transmit-receive control button is depressed and the dynamotor is running. ------

7. The tuning of the receiver of the SCR–67–A set is made sharper by turning the secondary wave-length control switch to "AP." ------

8. The wave length and coupling of the transmitting side of the SCR–67–A set are controlled by the switches in the small compartment near the upper left-hand corner of the panel. ------

9. The amplification of the received signals may be varied by turning the amplifier switch on the panel of the SCR–67–A set. ------

10. The SCR–67–A set operates most efficiently with an antenna current equal to 0.2 ampere.

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THE SCR-130 SET.

Equipment.

1 SCR-130 (set box BC-7 only).
4 legs for set box, type BC-7.
3 vacuum tubes, type VT-1.
4 vacuum tubes, type VT-2.
3 storage batteries, type BB-14 or BB-28.
1 set box, type BC-102 with BA-8 batteries.
1 dynamotor, type PE-6.
1 head set, type P-11.
1 cord, type CD-88.
1 cord, type CD-90.
1 cord, type CD-91.
1 cord, type CD-92.
1 antenna system, type A-1-A.
1 wave meter, type SCR-95 or SCR-125-A.

GENERAL CONSTRUCTION OF THE SCR-130 SET.

Information.

The SCR-130 set is designed to transmit continuous wave radio telegraph signals and to receive continuous wave radio telegraph and telephone signals. The wave-length range for both transmitting and receiving is from 550 to 1,100 meters. The SCR-130 is intended for use with such organizations as require a set of this power and have ample motor or animal-drawn transportation to carry it

The transmitting and receiving circuits are connected to the antenna, as desired, by a triple-pole, double-throw switch, mounted on the front of the set box panel. (See Fig. 84.)

Directions.

1. Place the set box, type BC-7, on some convenient support. Unfasten the canvas cover and the three latches and lower the front door. (See Fig. 84.) Study the various controls on the panel and their markings. Notice the four large tuning knobs on the lower edge of the panel and determine the use of the smaller knobs located under the large knobs.

Questions.

(1) *What current does the ammeter on the panel indicate?*

(2) *What are the maximum and minimum amounts this meter will read?*

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(3) *Locate the "antenna tuning" and the "transmit" wave length control knobs. What is the purpose of the small knob located beneath the "antenna-tuning" knob?*

(4) *Locate the antenna and ground binding posts?*

(5) *What are the binding posts on the right-hand side of the panel used for? Those on the left?*

Information.

Four VT–2 vacuum tubes are used in the transmitter of the SCR–130. One of the tubes is used as an oscillator or generator of elec-

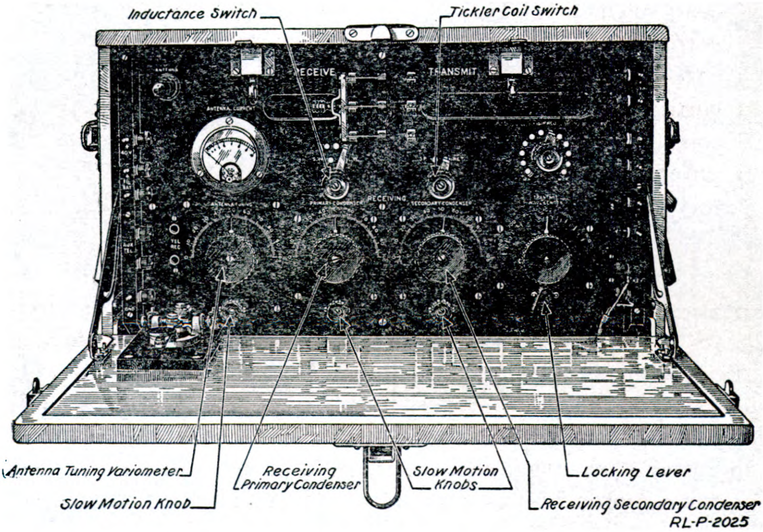

Fig. 84.—Set box BC–7 with front cover lowered to show panel.

trical impulses. The other three tubes, connected in parallel, are used to amplify the impulses generated by the oscillator tube. By using the tubes in this manner the antenna system does not affect in any way the wave length on which the set transmits. This is quite important for two reasons: 1. The set may be permanently calibrated for transmitting wave lengths. 2. The tone of the received signal will not vary when the transmitting antenna is swinging violently in the wind.

The amplifying vacuum tubes of the transmitter are inductively coupled to the antenna circuit. (See Fig. 85.)

The wave length of the transmitter is controlled by a variometer which is located in the right side of the set box. The antenna circuit is tuned by a variometer, located in the left side of the set box.

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When the "Antenna tuning" variometer is adjusted so that the antenna circuit is tuned to the same wave length to which the "Transmit wave length" variometer is adjusted, the "Antenna current" meter will give the highest reading, and the set will be transmitting

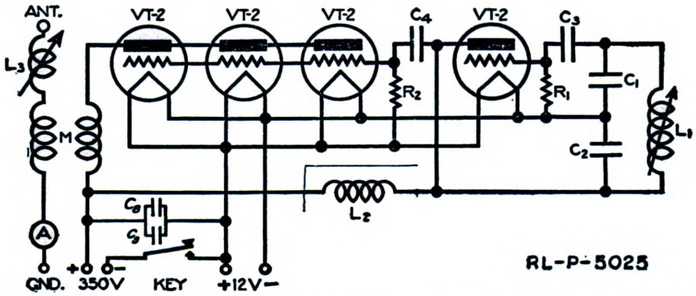

Fig. 85.—Schematic diagram of transmitter connections in SCR–130 set.

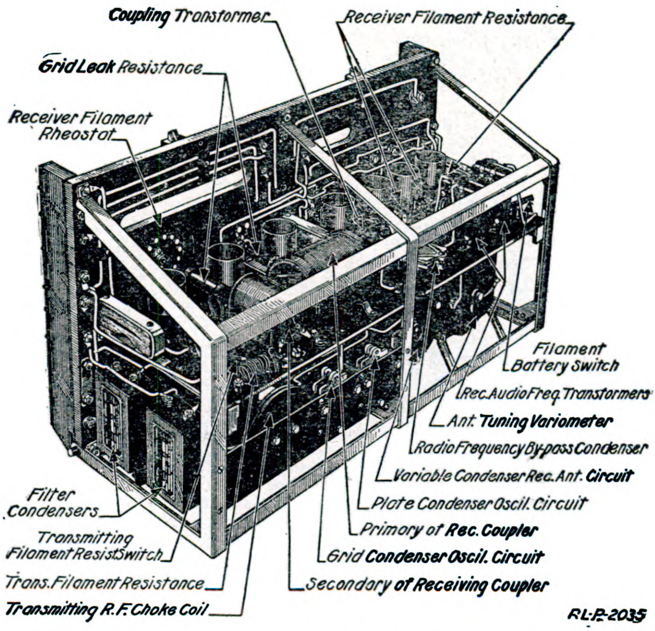

Fig. 86.—Rear view of panel and attached parts of set box BC–7.

efficiently on the wave length indicated on the "Transmit wave length" dial.

Directions.

2. Remove the four screws holding the two brackets to the operating table formed by the front of the set box and allow the front to

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drop. Remove the leads from the binding posts marked "Key" at the lower right-hand side of the panel. Release the latches at the top and pull the panel out, then with an outward and upward motion remove the panel and the attached parts from the box. This leaves all of the parts exposed as in Fig. 86. From the diagram (Fig. 87) and the set box itself answer the following questions:

Questions.

(6) *Where is the antenna tuning variometer? How is it constructed? Is it in the circuit when receiving?*

(7) *Where is the wave-length change variometer? What is its use?*

(8) *Where is the transformer which couples the antenna circuit with the power amplifier? Does it use fixed or variable coupling? Is it inductively or directly coupled?*

(9) *Which is the oscillator tube socket?*

(10) *What is the purpose of the switch in parallel with the resistance* R_3? (*See Fig. 87.*)

(11) *How many of the transmitting tubes are used as amplifiers?*

(12) *Which of the transmitting tubes have their plates in parallel?*

(13) *In what circuit is the key?*

(14) *In what circuit is the ammeter?*

(15) *Is the frame of the set grounded?*

(16) *Is there a grid leak in the transmitting tube circuit?*

(17) *How is the change from transmit to receive made?*

Information.

The power supplied for transmission is obtained from storage batteries. Three 4-volt batteries, type BB–14 or BB–28, are connected in series thus forming a 12-volt battery. This 12-volt battery is used for two purposes: (1) To light the filaments of the transmitting tubes and (2) to run the dynamotor, which supplies 350 volts to the plates of the transmitting tubes. The circuit is so arranged that when the "Transmit-Receive" switch is placed in the transmit position the dynamotor will start running and the filaments of the VT–2 tube will light. Since the VT–2 tube requires approximately 8 volts across its filament and the storage battery supplies 12 volts, it is necessary to place in series with the filament a resistance of such value that when the normal filament current is flowing the

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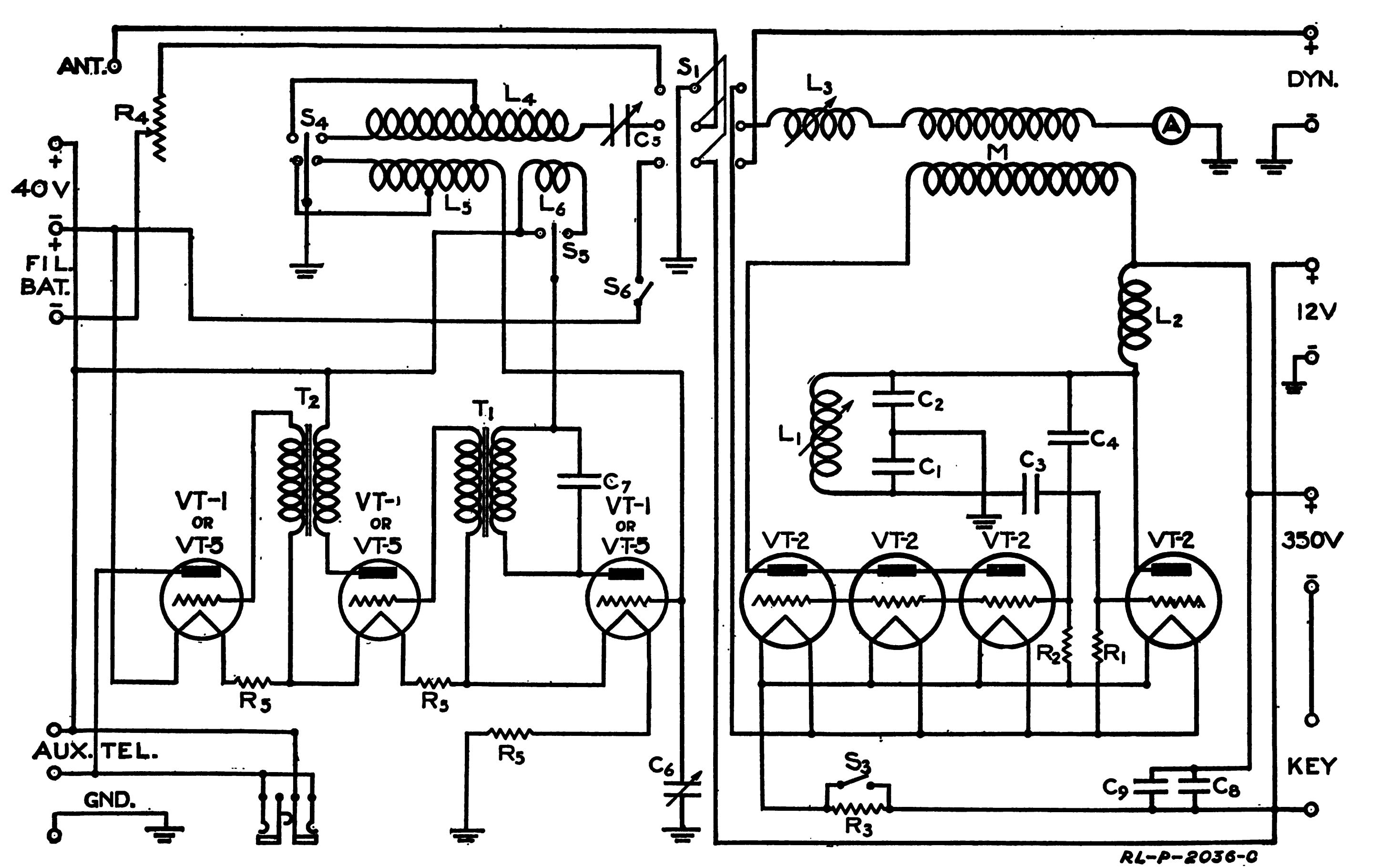

Fig. 87.—Schematic diagram of transmitting and receiver connections in set box BC-7.

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voltage will be reduced to about 8 volts. The resistance, R_8. (Fig. 87) serves this purpose. The switch S_3, which is so arranged as to throw out the resistance, must be open. The switch is closed only when 8 volts is supplied to the filament circuit, as is done when the set box is used in the SCR–127 set.

Questions.

(18) *To which binding posts are the motor terminals of the dynamotor connected?*

(19) *To which binding posts are the generator terminals of the dynamotor connected?*

(20) *To what is the 12-volt storage battery connected?*

(21) *If the storage battery had a capacity of 100 ampere-hours and the dynamotor drew 8 amperes, how long would the battery allow the operator to transmit with the set?*

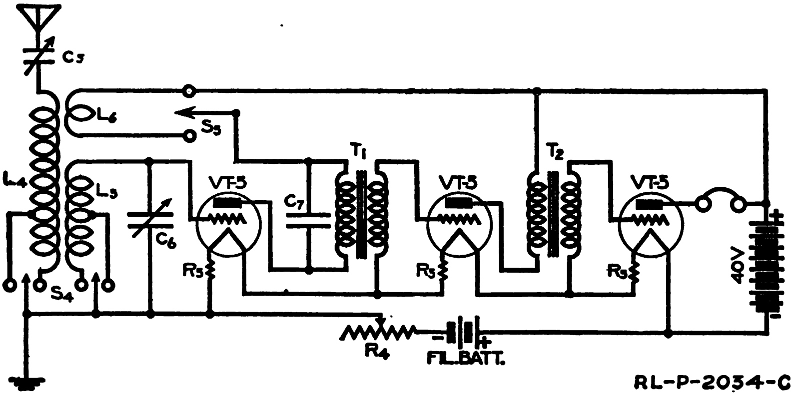

Fig. 88.—Wiring diagram of receiver connections in the SCR–130 set.

THE RECEIVER OF THE SCR–130.

Information.

The receiver of the SCR–130 is of the inductively coupled type. In addition to the primary and secondary receiving coils a third coil is provided in the plate circuit of the detector for the reception of continuous wave signals. This third coil is the *tickler coil.* When it is desired to receive spark signals the tickler coil is cut out of the circuit by means of a switch marked "Spk.-Het." located on the panel of the set box. The abbreviation "Het." stands for "Heterodyne," meaning that the circuit is adjusted for continuous wave reception. (See Fig. 88.)

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The primary circuit is tuned by adjusting the variable condenser, which is in series with the primary coil, and by adjusting the amount of inductance in the primary coil. The primary coil has one tap, which is connected to a switch on the panel of the set box. (See S_4, Fig. 88.) When the switch is thrown to "SW" (short wave) only part of the coil is in use, and when thrown to "LW" (long wave) the entire coil is in use. The secondary circuit is tuned by adjusting the variable condenser, connected across the secondary coil. In a later model of this set box the secondary coil also has one tap, which is connected to the same switch provided for the primary coil. (See S_4, Fig. 88.) This is so arranged that when the switch is in the position "S. W" only parts of each of the primary and secondary coils are in use. When it is in the "LW" position the entire circuits of the primary and secondary coils are in use.

Questions.

(22) *Locate the primary and secondary condenser controls. How are the scales marked?*

(23) *What is the purpose of the small knob located beneath the large condenser control knob?*

(24) *To which side must the large three-pole switch be thrown when using the set as a receiver?*

(25) *Locate the "SW–LW" switch. What is the purpose of this switch?*

(26) *Locate the "SP–HET" switch. What is the purpose of this switch?*

(27) *For what are the binding posts located at the left of the panel used?*

Information.

Two stages of audio frequency amplification are provided in the receiver, the coupling between stages being provided by audio frequency transformers. The filaments of the three receiving tubes are connected in series. In the SCR–130 set, VT–1 tubes are used for receiving. Since the filament voltage required by the VT–1 tube is 4 volts, the three tubes in series will require 12 volts which is just the amount furnished by the storage batteries which supply power for transmitting. It is therefore possible to use the 12 volts from the storage battery directly on the receiving tube filaments. The plate voltage is supplied by two batteries, type BD–8, connected in series, thus giving 45 volts for the plate. In field operations the

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BA–8 batteries are carried in a battery box, type BC–102. (See Fig. 89.) Connections are made from the battery box terminals to the terminals on the BC–7 set box by means of a cord and receptacle.

The filament circuit of the receiving tubes is completed through the "Transmit-Receive" switch so that the tubes are only lit when the switch is on the receive position. Since the BC–7 set box is used both in the 127 and 130 sets, and when used in the 127 set receiving filament current is supplied from a separate source, it becomes necessary to have a switch which will connect or disconnect the receive tube filament from the source which supplies the transmitting tube filament. This is accomplished by the switch S_6. (See Fig.

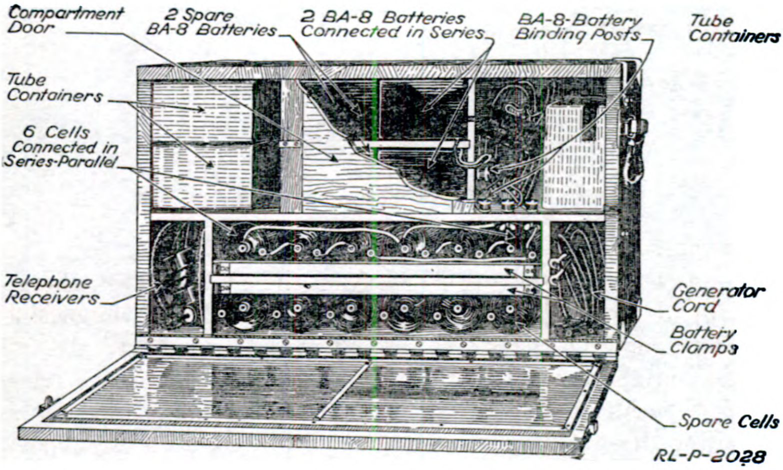

Fig. 89.—Battery and spare parts box, type BC–102 of the SCR–130 set.

87.) This switch must be closed when the set box is used in the SCR–130 set.

Directions.

3. Observe the various receiver parts mounted back of the set box panel. As far as possible trace the wiring of the receiver, using the wiring diagram shown in Fig. 88.

Questions.

(28) *Locate the receiving tube sockets. Which is the detector tube socket? Which are the amplifier tube sockets?*

(29) *Where are the fixed resistances that are in series with the receiving tube filaments?*

(30) *Where is the primary receiving inductance? How many taps are taken from it? To what do they go on the panels?*

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(31) *Where is the secondary receiving inductance? Is it coupled inductively or conductively with the primary? Is the coupling variable or fixed?*

(32) *Where is the tickler coil? Where are its terminals? Is it fixed in position with respect to the secondary?*

(33) *How many headsets can be connected to this set?*

(34) *What is the plate potential of the receiving tubes? Of the transmitting tubes?*

(35) *How are the filaments of the receiving tubes connected? Of the transmitting tubes?*

(36) *Where are the audio frequency transformers?*

EXPERIMENT No. 1.

TO CONNECT UP AND TUNE THE SCR–130 SET.

Information.

In connecting up, ready for operation the SCR–130 set, there are two main divisions of the work; namely, (1) the set connected as a receiver, and (2) the set connected as a transmitter. In either case this may be done without fully connecting it up as a receiver or as a transmitter. In a like manner the tuning of the set as a transmitter differs from the tuning of the set as a receiver. A definite method should be followed in doing all of these things.

Directions.

4. *To connect up the set as a transmitter.*—Erect the set box on its legs. The set box should be so placed that the antenna and ground leads will easily reach the proper binding posts on the panel. (See Fig. 90.) Place the dynamotor and storage batteries under the set.

a. Open up the front cover of the set box, pull down on the catches which hold the panel closed, and open the panel.

b. Insert four VT–2 tubes in the four transmitting tube sockets in the set. Open switch "S_8" (Fig. 87).

c. Close the panel, being sure that the catches are properly locked, and open the "Trans.-Rec." switch so that it does not make contact on either side.

d. Connect the high voltage dynamotor leads (with the proper polarity) to the binding posts marked "+350" and "−350."

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e. Connect the low voltage dynamotor leads to the two binding posts marked " + Dyn " and " — Dyn " with the correct polarity.

f. Connect the antenna lead-in wire to the post marked " Ant."

g. Connect the wire from the counterpoise or other ground system used to the post marked " Gnd."

h. Connect the receptacle of the cord, type CD–90, to the two plugs on the side of the set box marked " + 12 V." " — 12 V." (It will only go on with the correct polarity.)

i. Connect the three 4-volt storage batteries in series.

j. Check all connections to see that they are correct.

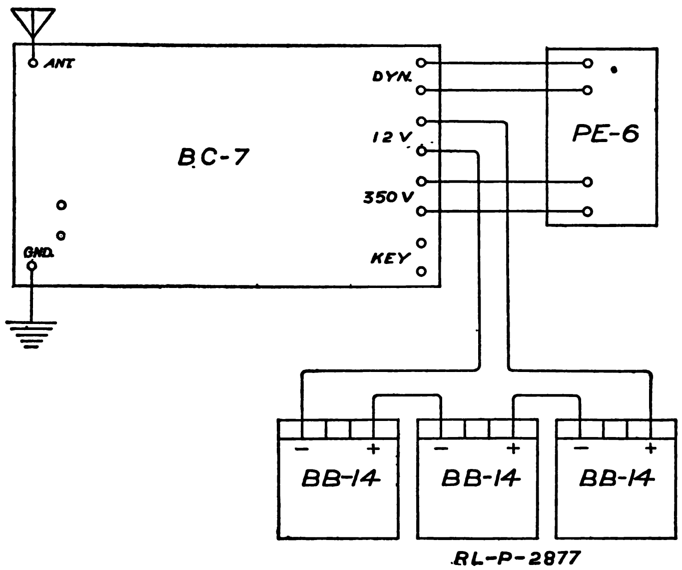

Fig. 90.—Cording diagram of transmitter connections in the SCR–130 set.

k. Connect the red terminal of the cord, type CD–90, to the positive terminal of the 12-volt battery formed by the three 4-volt batteries in series and the black terminal of the cord to the negative terminal of the 12-volt battery.

l. See that the double-pole, single-throw switch on the dynamotor panel is closed.

Questions.

(37) *Why is it necessary to follow certain steps in their proper order when connecting up the SCR–130 set?*

(38) *Why is it important to have the connecting leads connected with proper polarity?*

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Directions.

5. *To tune the transmitter.*—The next step after having made all of the connections as previously given is to tune the transmitting side to the desired or specified wave length. In order to do this properly the following steps are gone through:

a. Turn the "Transmit Wave Length" pointer to *exactly* the desired wave length and lock it in that position by means of the small lever under the knob.

b. Throw the "Trans.-Rec." switch to the "Trans." side. The dynamotor should now start running and the filaments of the VT–2 tubes should glow a dull red.

c. Close the key.

d. Turn the "Antenna tuning" knob slowly and watch the antenna ammeter. As the knob is turned the ammeter will start indicating and will gradually increase in reading up to a certain point. As the knob is turned still further the reading of the ammeter will decrease. That position of the "Antenna tuning" knob which gives the greatest reading on the antenna ammeter is the correct adjustment. The final adjustment to obtain the greatest reading should be made with the small knob just under the "Antenna tuning" knob. This small knob is a vernier or fine adjustment of the larger knob.

e. Open the key.

f. Open the "Trans.-Rec." switch. The set is now adjusted for transmitting on the wave length to which the pointer of the "Transmit wave length" adjustment is set.

Questions.

(39) *Why is the "Transmit Wave Length" pointer locked after it is set to the desired wave length?*

(40) *If, when the "Trans.-Rec." switch is thrown to "Trans." the vacuum tubes light but the dynamotor fails to start, what is the probable trouble?*

(41) *Why is it necessary to adjust the "Antenna tuning" knob so that a maximum reading occurs on the ammeter?*

Directions.

6. *To connect up the receiver side of the set.*—After having made all of the connections given under connecting up the transmitter side of the set, the following additional connections will be needed in order that the receiving side of the set be ready for operation. (See Fig. 91.)

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a. Open the panel to the set and insert 3 VT–1 tubes in the receiving tube sockets. (Be sure that the "Trans.-Rec." switch is open.)

b. Close the switch S_6 (Fig. 87) and close the panel, being sure that it locks into place.

c. Connect two batteries, type BA–8, in series and connect the positive terminal of the 45-volt battery thus formed to the binding post on the edge of the panel marked "+40." Connect the negative terminal to the post marked "—40."

NOTE.—If the battery box, type BC–102, is used, then the BA–8 batteries will be placed in that box and connections made from batteries by means of the cord, type CD–88, to the two plugs on the side of the panel marked "+40 volts" and "—40 volts."

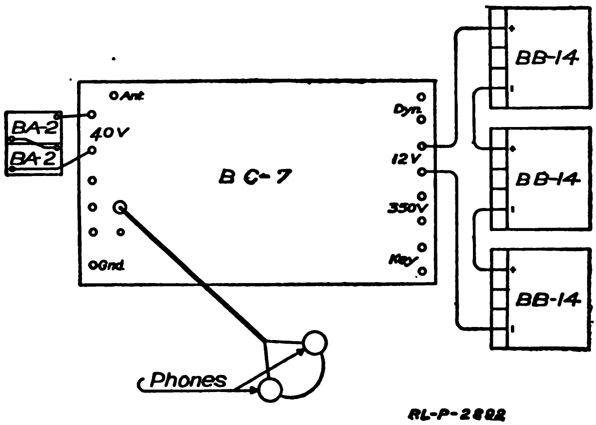

Fig. 91.—Cording diagram of receiver connections in the SCR–130 set.

d. Plug one or two head sets, type P–11, into the jacks provided on the left side of the panel. (If available head sets are not provided with cord plugs, the cord tips may be connected to the two binding posts marked "Aux. Tel.").

e. Put on one of the head sets and adjust it to fit the head comfortably.

f. If the receiving side only of the set is to be used, omit the items given under *b.*, *c.*, *d.*, and *e.* in direction 1.

7. *To connect up both as a transmitter and as a receiver.*—After the set has been properly erected:

a. Open up the front cover of the set box, pull down on the catches holding the panel closed, and open the panel.

b. Insert four VT–2 tubes in the transmitting sockets and three VT–1 tubes in the receiving sockets. Open switch S_8 and close switch S_6. (Fig. 87.)

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c. Close panel, being sure that the catches are properly locked, and open the "Trans.-Rec." switch so that it does not make contact on either side.

d. Connect the high voltage dynamotor leads (with the proper polarity) to the binding posts marked "+ 350" and "— 350." (See Fig. 92.)

e. Connect the low voltage dynamotor leads to the two binding posts marked "+ Dyn" and "— Dyn" with the correct polarity.

f. Connect the antenna lead-in wire to the post marked "Ant."

g. Connect the wire from the counterpoise or other ground system used to the post marked "Gnd."

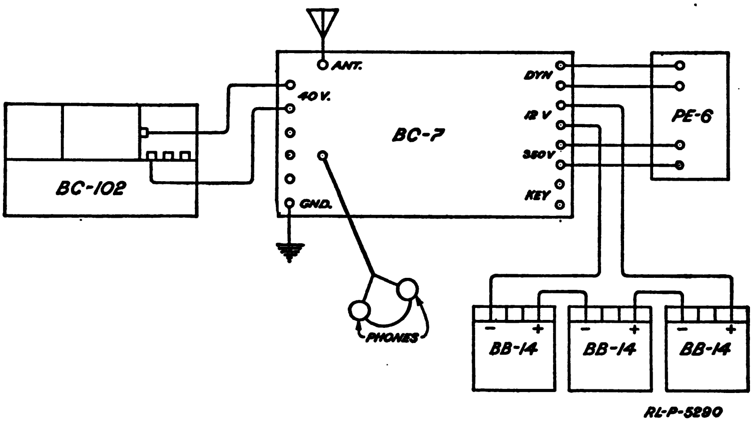

Fig. 92.—Cording diagram of complete transmitter and receiver connections in the SCR–130 set.

h. Connect the receptacle of the cord, type CD–90, to the two plugs on the side of the set box marked "+ 12" and "— 12" volts. (It will only go on with the correct polarity.)

i. Connect two batteries, type BA–2 or type BA–8, in series and connect the positive terminal of the 45-volt battery thus formed to the binding post on the edge of the panel marked "+ 40." Connect the negative terminal to the post marked "— 40."

NOTE.—If the battery box, type BC–102, is used, then the BA–8 batteries will be placed in that box and connection made from them to the two plugs on the side of the panel marked "+ 40" and "— 40" volts by means of the cord, type CD–88.

j. Plug one or two head sets, type P–11, into the jacks provided on the left side of the panel. (If head sets are to be used that do not have plugs on the ends of their cords, they may be connected to the two binding posts marked "Aux. Tel.")

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k. Connect the three 4-volt storage batteries in series.

l. Check all connections to see that they are correct.

m. Connect the red terminal of the cord, type CD–90, to the positive terminal of the 12-volt battery formed by the three 4-volt batteries in series and the black terminal of the cord to the negative terminal of the 12-volt battery.

n. See that the double-pole, single-throw switch on the dynamotor panel is closed.

o. Put on one of the head sets and adjust it to fit the head comfortably.

Question.

(42) *Why is it necessary to have the "Trans.-Rec." switch open as in Direction 3, a?*

Information.

To tune the receiver.—In tuning the receiver several different cases will occur. They are as follows:

a. Tuning in a C. W. signal of known wave length.
b. Tuning in a damped wave signal of known wave length.
c. Tuning in a C. W. signal of unknown wave length.
d. Tuning in a damped wave signal of unknown wave length.

8. To tune the receiver of the set to a C. W. signal of known wave length proceed as follows. After the receiving side has been connected up as directed above:

a. Throw the "Trans.-Rec." switch to the "Rec." side.

b. Place the "Spk.-Het." switch on "Het."

c. Set the "LW–SW" switch and the secondary condenser to the desired wave length as given by the calibration of the set.

d. Vary the primary condenser until a distinct double click is heard, and set the primary condenser about 5° to either side of the point where this double click is heard.

e. The receiving side of the set should now be in tune on the desired wave length, but due to inaccuracies which may occur the setting may not be exact enough to pick up the signal sought. It is therefore advisable to swing slowly the secondary condenser over an arc of about 10° (the middle point of which is the setting given by the set's calibration, until the sought-for signal is heard.

f. Upon hearing the desired signal, stop turning the secondary condenser by its knob and make the final accurate adjustment by means of the small vernier knob located just under the secondary condenser knob.

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g. A small further adjustment of the primary condenser may now be made in order to increase the loudness of the signal.

9. To tune the receiver to a damped wave signal of known wave length proceed as follows:

a. Same as *a* above.

b. Same as *b* above.

c. Same as *c* above.

d. Same as *d* above.

e. Place the "Spk.-Het." switch on "Spk."

f. Same as *e* above.

g. Same as *f* above.

h. Same as *g* above.

10. To tune the receiver to a C. W. signal of unknown wave length proceed as follows:

a. Same as *a* under Direction 4.

b. Same as *b* under Direction 4.

c. Set the "LW–SW" switch on "SW." Set the secondary condenser at about 5° and vary the primary condenser until the double click is heard, indicating the primary circuit is in tune with the secondary circuit.

NOTE.—For every position of the secondary condenser there should be a corresponding position of the primary condenser at which the primary or antenna circuit is in tune with the secondary circuit. In searching for a signal of unknown wave length the method should be to vary both condensers at the same time, attempting at all times to keep the primary condenser close to that point where its circuit is in tune with the secondary.

d. Starting with the secondary condenser at about 5° and the primary condenser at the point where it is in tune, slowly turn both condensers as outlined above, over their entire scale. Repeat this several times until you are sure that the signal is not obtainable. (The primary condenser should increase as the secondary is increased.)

e. Set the "LW–SW" switch on "LW" and repeat *d*.

f. When the desired signal is found under either *d* or *e*, engage the vernier knobs of the primary and secondary condensers and make the final adjustments for a loud, clear signal for a readable pitch with these knobs.

11. To tune the receiver to a damped wave signal of unknown wave length for Direction 4, proceed as follows:

a. Follow exactly the procedure outlined under Direction 3 until the desired signal is found. When found, the natural tone of the damped wave will be badly distorted.

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b. Throw the "Spk.-Het." switch to "Spk." and if necessary retune slightly both the primary and secondary condensers. The damped wave signal should now be heard with its natural tone but much weaker than when heard under *d*.

NOTE.—Damped waves may be received with the "Spk.-Het." switch on "Het." if the change in tone is not objectionable. The receiver will be far more sensitive than with the switch on "Spk."

EXPERIMENT No. 2.

CALIBRATION OF THE RECEIVER SECONDARY.

Directions.

12. Erect two complete antenna systems, separated by about 300 yards, for the SCR–130 set. On the first antenna (set A) connect up, ready for transmission, one SCR–130 set, and on the other antenna another SCR–130 set (set B) which is to have its receiver secondary calibrated.

13. Start transmitting with set A on 500 meters. Tune set B to receive the signal. Set B is now tuned to receive 500 meters. Read, in degrees, the setting of the secondary receiving condenser and put it down in a table similar to the one shown below.

Wave length.	Secondary condenser setting.	Settings of SW–LW switch.
500		
525		
550		
575		
600		
625		
650		
675		
700		
725		
750		
775		
800		
825		
850		
875		
900		
925		
950		
975		
1,000		
1,025		
1,050		
1,075		
1,100		

Transmit with set "A" on 525 meters and again tune in with set "B" and record the reading in the table. Continue this process in steps of 25 meters until the entire wave length range has been covered.

Information.

The SCR–130 set must primarily receive from another SCR–130 set; therefore it is desirable that its receiving side be calibrated with an SCR–130 transmitter. It would be easier to calibrate it by the use

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of a wave meter, but in that case the wave meter calibrations and those of other SCR–130 transmitters might not be identical. As a variation of about 1° on the secondary condenser is sufficient to tune out the desired signal it may be seen that accuracy is very important.

EXPERIMENT No. 3.

CHECKING THE CALIBRATIONS OF THE TRANSMITTER OF SEVERAL SETS.

Information.

When three or more sets are to operate in a net it is very important that the transmitting wave length calibrations of all of the sets be identical; that is, any one set should receive all other sets operating on the same wave length, on the same setting of the secondary receiving condenser. In order to accomplish this it is sometimes necessary to check or recalibrate all of the sets involved. Although the oscillator of the SCR–130 set is originally quite accurately calibrated, sometimes due to rough handling, or to other causes, the calibrations may be thrown off.

Directions.

14. Set up two antenna systems. Pick out one set to be known as the "master set" and connect it up ready for transmitting to one antenna. To the other antenna connect another set ready for receiving. With the master set transmit successively on wave lengths from 500 to 1,100 meters in steps of 25 meters.

15. Receive each of these transmissions on the other sets and fill out accurately a table similar to the one shown below, showing all receiving adjustments on which each of the transmissions is received.

Wave length.	Primary condenser.	Secondary condenser.	Setting of SW-LW switch.
500			
525			
550			
575			
600			
625			
650			
675			
700			
725			
750			
775			
800			
825			
850			
875			
900			
925			
950			
975			
1,000			
1,025			
1,050			
1,075			
1,100			

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Disconnect the master set and place it aside. Connect to the antenna of the master set one of the sets whose calibrations have been checked and start it transmitting on 500 meters according to its new calibration. Tune in the transmitted signal with the remaining receiving set. If it is received on the same adjustments used for the master set when it was transmitting on 500 meters, then the 500-meter calibration of the set under test is correct. If it is received on a different adjustment the calibration is inaccurate and must be corrected.

16. To do this, adjust the receiving sets to the settings on which the master set was received on 500 meters. Gradually vary the transmitted wave length of the set under test until it is heard by the adjusted receiving sets. It will then be transmitting on 500 meters by the calibrations of the master set. A piece of paper should be pasted over the scale of the master oscillator and a mark made on the paper exactly opposite the end of the pointer, this mark being labeled " 500 ". The above process is repeated in steps of 25 meters until the entire wave length range of the set has been covered. The next set to be checked is then put through the same process.

EXPERIMENT No. 4.

TUNING A SET HAVING A BURNT OUT ANTENNA AMMETER.

Directions.

17. Connect up the set properly for transmitting, and if the burnt out antenna ammeter has not been short-circuited, do so with a piece of fairly heavy copper wire. Throw the " Trans.-Rec." switch to the " Trans." and hold down the key.

METHOD " A."

Slowly turn the antenna variometer (with the wave length variometer set at the desired wave length) until on listening to the dynamotor a very perceptible slowing up is noticed. As the antenna variometer is still further turned the dynamotor will again increase its speed. At the position of the antenna variometer half way between the points where the slowing up is first noticed and where the dynamotor again speeds up, the antenna circuit is approximately in tune with the master oscillator circuit. The set is then transmitting fairly well on the desired wave length.

METHOD " B."

Light and adjust the lamp on an SCR–95 wave meter and couple the wave meter to the master oscillator circuit of the set by holding

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the side of the wave meter marked "Plane of coil" against the knob of the wave length variometer. Start the set transmitting and close the key. Set the wave meter to the desired wave length and vary the wave length variometer until the wave meter lamp burns brightest. Then, without disturbing the adjustments of either the wave meter or the wave length variometer, move the wave meter over and couple it to the antenna circuit by wrapping one or two turns of the lead-in wire around it. Slowly turn the "Antenna tuning" variometer until the wave meter lamp again indicates that the circuits are in tune. The set is then transmitting on the desired wave length with all circuits in tune.

Information.

With the SCR 127 and 130 sets, tuning the set to transmit on a given wave length is entirely dependent on readings of the antenna ammeter. Accordingly some method becomes necessary to tune the set when this meter is out of service. Of the two methods given, the first may be employed with no additional apparatus and will give fairly good results. The second method is dependent on the availability of an SCR–125–A wave meter, but when properly used will give excellent results. Sometimes, in using the second method, trouble is experienced in getting an indication that the circuits are in tune with the wave meter coupled to the wave length variometer. This is due to weak oscillations in the oscillator tube of the set and may be overcome by tuning the set by the first method and then coupling the wave meter to the antenna circuit for the final adjustment. It is to be remembered that the calibrations on the SCR–125–A wave meter and the master oscillator variometer may not be the same, due to inaccuracies in manufacture, and therefore a set transmitting on, say, 800 meters by the wave meter may not be on exactly the same wave length as one which was set by the calibrations on the set. It will be noticed that in both of the above methods the calibrations on the set are used in determining the wave length. In general, the calibrations on the set are more accurate than those on the SCR–125–A wave meter.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. Show the class, during the preliminary assembly, a type BC–7 set box with the front panel lowered. Point out the important parts of the transmitting side of the set and name each part clearly and distinctly. Draw on the blackboard a circuit diagram similar to the one shown in Fig. 85 in the Students Manual. As each part of the set is discussed point out its location in the circuit.

2. In the same manner proceed with the receiving side of the set, using a diagram similar to Fig. 88 in the Students Manual.

3. Exhibit a type PE–6 dynamotor to the class. Point out the terminals used for connections to the set box.

4. Show the class a type BC–102 battery box and explain its use with the set box BC–7.

5. The important new words in this Unit Operation are as follows:

Antenna tuning variometer.
Wave-length change variometer.
Power amplifier.

6. When the students have completed this Unit Operation, they should know the names and symbols of the important parts of the SCR–130 set. They should be able to prepare a list of the complete equipment necessary to install and operate an SCR–130 set.

7. From the experiments performed in this Unit Operation the students should know:

a. How to connect up the SCR–130 set completely ready for operation.

b. How to tune the transmitter and receiver to designated wave. lengths.

c. How to tune the receiver to unknown wave lengths.

d. How to calibrate the secondary circuit of the receiver.

e. How to check the calibration of the transmitter of several nets.

f. How to tune a set having a burnt out antenna ammeter

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SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 17-A (PERFORMANCE).

Directions to the instructor.

Equipment.

1 antenna, type A-1-A.
1 set box, type BC-7.
4 legs for set box, BC-7.
3 vacuum tubes, type VT-1.
4 vacuum tubes, type VT-2.
3 storage batteries, type BB-14 or BB-28
1 set box, type BC-102, with BA-8 batteries.
1 dynamotor, type PE-6.
1 head set, type P-11.
1 cord, type CD-88.
1 cord, type CD-90.
1 cord, type CD-91.
1 cord, type CD-92.
1 wave meter, type SCR-125-A.

Procedure.

Problem No. 1.

a. Place the equipment listed above in a suitable location for conducting the test and direct the student to connect this equipment so that it will transmit and receive signals. As each student finishes record the time taken to do the work and check the connections.

b. Point out any errors made by the student and allow time for him to make corrections.

Problem No. 2.

a. Direct the student to tune the transmitter for maximum radiation on a given wave length. As each student finishes record the time and check the tuning of the transmitter.

Problem No. 3.

a. Start the SCR-125-A wave meter transmitting on some wave length unknown to the student. Direct the student to tune the receiver of the set to the signal of the wave meter. As each student finishes record the time taken to do the work and check the tuning of the receiver.

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INSTRUCTION TEST NO. 17–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   - 1 antenna, type A–1–A.
   - 1 set box, type BC–7.
   - 4 legs for set box, BC–7.
   - 3 vacuum tubes, type VT–1.
   - 4 vacuum tubes, type VT–2.
   - 3 storage batteries, type BB–14 or BB–28.
   - 1 set box, type BC–102, with BA–8 batteries.
   - 1 dynamotor, type PE–6.
   - 1 head set, type P–11.
   - 1 cord, type CD–88.
   - 1 cord, type CD–90.
   - 1 cord, type CD–91.
   - 1 cord, type CD–92.
   - 1 wave meter, type SCR–125–A.

2. When the instructor directs "Begin," start work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

a. Connect up the SCR–130 equipment completely, ready for transmission and reception.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will check the connections.

Problem No. 2.

a. When the instructor again directs "Begin," proceed to tune the transmitter of the set to a wave length designated by the instructor. Tune the transmitter so as to obtain maximum radiation on this wave length.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

Problem No. 3.

a. When the instructor again directs "Begin," tune the receiver of the set to the signal of the wave meter, being careful to obtain maximum signal strength in the receivers.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

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Scoring.

1. The maximum score for this test is 16 points
2. The score required to pass this test is 12 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
If the SCR-130 equipment is properly connected	8

PROBLEM NO. 2.

If the transmitter is properly tuned to the wave length designated	4

PROBLEM NO. 3.

If the receiver is properly tuned to the signal of the wave meter	4

4. Where the student has failed to complete this test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or parts incorrectly performed.

INSTRUCTION TEST NO. 17-B (INFORMATION).

Directions to the student.—Below are a number of questions and unfinished sentences. Following each one are several words, numbers, or statements. Select the one which best fits or which makes the best sense. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Only one of the answers given in each case is correct.

1. The transmitting wave-length range of the SCR-130 set is from
   (1) 600 to 1,200 meters. (2) 550 to 1,100 meters.
   (3) 900 to 2,000 meters. (4) 50 to 250 meters. ------
2. The SCR-130 set is known as
   (1) a damped wave set. (2) a continuous set.
   (3) a radio telephone set. (4) a 1,000-watt set. ------
3. The transmitting range of the SCR-130 set is approximately
   (1) 100 to 150 miles. (2) 10 to 12 miles.
   (3) 30 to 60 miles. (4) 250 miles. ------
4. The transmitting circuit of the SCR-130 set includes
   (1) two oscillator tubes and three amplifier tubes.
   (2) three VT-1 tubes and two VT-2 tubes.
   (3) one oscillator tube and three amplifier tubes.
   (4) three oscillator tubes and one amplifier tube. ------
5. The oscillator circuit of the SCR-130 transmitter is tuned by
   (1) a variable condenser. (2) a variable resistance.
   (3) a variometer. (4) a rheostat. ------

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6. The plate current for the transmitting tubes of the SCR–130 set is supplied by
(1) "B" batteries. (2) a motor generator.
(3) a dynamotor. (4) a hand generator. ------

7. The receiving wave-length range of the SCR–130 set is from
(1) 300 to 600 meters. (2) 100 to 1,500 meters.
(3) 600 to 1,000 meters. (4) 550 to 1,100 meters. ------

8. The plate current for the receiving tubes of the SCR–130 set is supplied by
(1) two type BA–8 batteries. (2) 22½-volt batteries.
(3) a dynamotor. (4) thirty type BA–10 cells. ------

9. The receiving circuit of the SCR–130 set includes
(1) two type VT–1 tubes. (2) three type VT–5 tubes.
(3) three type VT–1 tubes. (4) four type VT–2 tubes. ------

10. The primary circuit of the SCR–130 receiver
(1) can not be tuned. (2) is aperiodic.
(3) is tuned by a condenser.
(4) is tuned by a condenser and switch. ------

Directions to the student.—Below are a number of sentences. Read each sentence carefully, and if what it says is true (correct), place a (+) plus sign on the *short dotted line* in the right margin. If what it says is not true (incorrect), place a minus (–) sign on the dotted line.

11. The antenna system used with the SCR–130 set is known as type A–1–A. ------

12. The tuning of the oscillator circuit of the SCR–130 transmitter is independent of the antenna circuit. ------

13. The antenna circuit of the SCR–130 transmitter is tuned by a variable condenser. ------

14. The filaments of the transmitter tubes in the SCR–130 set are connected in series. ------

15. Type VT–5 vacuum tubes are not used in the receiver of the SCR–130 set. ------

16. The secondary of the SCR–130 receiver is tuned by a variometer. ------

17. Provisions are made for connecting three head sets to the SCR–130 receiver. --------

18. All binding posts for connecting up the receiver of the SCR–130 set are located on the left side of the set-box panel. ------

19. When type VT–1 tubes are used in the BC–7 receiver, the filament switch inside the set box must be closed. ------

20. The current to the filaments of the receiving tubes in the SCR–130 set is controlled by a rheostat. ------

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THE SCR-127 SET.

Equipment.

1 set, type SCR-127 less the following equipment:
- 3 cincha bands, type ST-7.
- 1 equipment, type LE-1.
- 3 frames, type M-1.
- 6 straps, with snap hooks at each end.

1 wave meter, type SCR-125-A.
1 head set, type P-11.

GENERAL CONSTRUCTION OF THE SCR-127 SET.

Information.

The SCR-127 set is designed to transmit and to receive continuous wave radio telegraph signals. It is intended for communication between cavalry organizations and is built to be packed and transported on mules. The wave length range for both transmitting and receiving is from 550 to 1,100 meters.

The transmitting and receiving circuits are connected to the antenna, as desired, by a triple-pole, double-throw switch, mounted on the front of the set box panel. (See Fig. 84.)

Directions.

1. Place the set box type BC-7 on some convenient support. Unfasten the three latches and lower the front door. (See Fig. 84.) Study the various controls on the panel and their markings. Notice the four large tuning knobs on the lower edge of the panel.

Questions.

(1) *Which current does the ammeter on the panel read?*

(2) *Locate the "antenna tuning" and the "transmit" wave length control knobs. What is the purpose of the small knob located beneath the "antenna tuning" knob?*

(3) *What is the purpose of the lever located beneath the transmit wave length knob?*

(4) *Locate the antenna and ground binding posts.*

(5) *For what are the binding posts on the right-hand side of the panel used?*

Information.

Four VT-2 vacuum tubes are used in the transmitter of the SCR-127. One of the tubes is used as an oscillator or generator of electrical impulses. The other three tubes, connected in parallel, are

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used to amplify the impulses generated by the oscillator tube. In this way the power supplied to the antenna is more than that generated by one tube. In addition, the antenna in no way affects the frequency of the impulses generated by the oscillator tube so that the wave length on which the set transmits is entirely independent of the antenna used.

The vacuum tube circuit of the transmitter is inductively coupled to the antenna circuit. (See Fig. 85.)

The wave length of the transmitter is controlled by a variometer which is located in the right of the set box. The antenna circuit is tuned by a variometer located at the left of the set box. When the " Transmit Wave length " variometer is adjusted to a certain wave length, it is necessary to tune the antenna circuit to this wave length. When the two circuits are in tune the " Antenna Current " meter will give the highest reading.

Directions.

2. Remove the four screws holding the two brackets to the operating table formed by the front of the set box and allow the front to drop. Remove the leads from the binding posts marked " Key " at the lower right-hand side of the panel. Release the latches at the top and pull the panel out; then with an outward and upward motion remove the panel and the attached parts from the box. This leaves all the parts exposed as in Fig. 86. From the diagram (Fig. 87) and the set box itself answer the following questions.

Questions.

(6) *Where is the antenna tuning variometer? How is it constructed? Is it in the circuit when receiving?*

(7) *Where is the wave-length change variometer? What is its use?*

(8) *Where is the transformer which couples the antenna circuit with the power amplifier? Does it use fixed or variable coupling? Is it inductively or directly coupled?*

(9) *Which is the oscillator tube socket?*

(10) *What is the purpose of the switch in parallel with the resistance R_3?* (See Fig. 87.)

(11) *How many of the transmitting tubes are used as amplifiers?*

(12) *Which of the transmitting tubes have their plates in parallel?*

(13) *In what circuit is the key?*

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(14) *In what circuit is the ammeter?*

(15) *Is the frame of the set grounded?*

(16) *Is there any grid leak in the transmitting tube circuit?*

(17) *How is the change from transmit to receive made?*

Information.

Power is supplied to the transmitter of the set by the hand-driven generator, type GN–29. (See Fig. 93.) This unit consists of

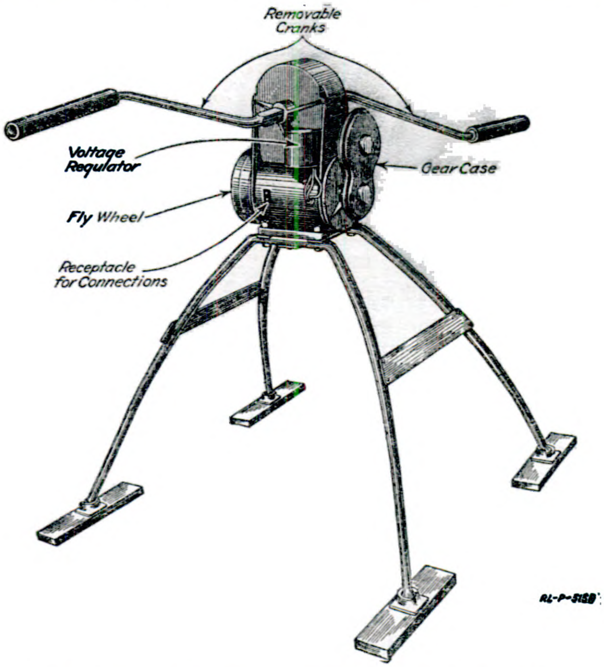

Fig. 93.—Hand-driven generator, type GN–29.

a double current generator supplying direct current at 8 volts and at 350 volts pressure. The 8-volt side of the generator is used to light the filaments of the transmitting tubes, while the 350-volt side supplies the plate current for the same tubes. When the set box, type BC–7, is used in the SCR–130 set, 12 volts are supplied to the transmitting tube filaments; while as stated above, only 8 volts are supplied when used in the SCR–127 set. To make up for this difference in voltage the switch S_3 (Fig. 87) must be closed when the set box is used with the hand generator and opened when used in the

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SCR-130 set. The generator is driven through a train of gears at high speed. The gear train is turned by two cranks which are slipped on the squared shaft protruding from the sides at the top of the gear box. The cranks should be placed on this shaft so that they are opposite each other as shown in Fig. 93. Two men standing beside the generator, but facing in opposite directions, operate the cranks, one man at each crank. Marked on the top of the gear box of the generator is an arrow which shows the direction in which the cranks are to be turned. For the proper operation of the generator the cranks should be turned at a steady speed of not less than 35 revolutions per minute. Mounted on the side of the generator is a voltage regulator. The purpose of this regulator is to hold the voltage of the generator constant over a wide range of speed. It will do very well at crank speeds from 35 to 60 revolutions per minute, but at speeds under 35 revolutions per minute the voltage of the generator is too low and can not be brought up by the regulator. The high and low voltage sides of the hand generator are connected to the set box by two cords having plugs which are not interchangeable and can be inserted only with the correct polarity. It is therefore impossible to make wrong connections. The jacks in which these plugs fit are mounted in the frame of the generator and properly marked. The remaining plugs on the two cords contain two holes which fit the connecting pins on the edge of the set box. In operating the set the generator should be brought up to proper speed before any load is placed on it.

Directions.

3. Set up the hand generator on its stand and using the proper cords connect it to the set box. Open the panel of the set box and insert four tubes, type VT-2, in the transmitting tube sockets. Connect a voltmeter, type I-10, to the two binding posts corresponding to the two pins on the edge of the panel on which the plug of the low voltage lead of the generator fits. Be sure that the connections are correct in polarity.

4. Open the "Trans.-Rec." switch on the panel and have two men turn the hand generator cranks at 25 revolutions per minute. Read the voltage as indicated by the type I-10 voltmeter. Close the "Trans.-Rec." switch to the "Trans." side of the switch. Press the key and again read the voltage.

5. Repeat the above for each of the following crank speeds, putting down your results in a rough table: 30, 35, 40, 45, and 50.

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Questions.

(18) *Was the voltage high enough to light the tube filaments properly at a crank speed of 25 revolutions per minute?*

(19) *What change took place in the voltage reading when the "Trans.-Rec." switch and the key were closed?*

(20) *With the "Trans.-Rec." switch and the key closed when the crank speed was changed from 35 to 50 revolutions ver minute, was there much change in the voltage?*

(21) *Did the generator turn much harder when the "Trans.-Rec." switch and key were closed than when they were open? Why?*

(22) *Should the "Trans.-Rec." switch be closed before or after the generator has reached full speed? Why?*

(23) *How many revolutions does the generator make for a complete revolution of the crank?*

THE RECEIVER OF THE SCR–127.

Information.

The receiver of the SCR–127 is of the inductively coupled type. In a later model, however, conductive coupling as well as the secondary receiving coil, is provided in the plate circuit of the detector tube for the reception of continuous wave signals. When it is desired to receive spark signals the tickler coil is cut out of the circuit by means of a switch marked "Spk–Het" located on the panel of the set box. The abbreviation "Het." stands for "Heterodyne," meaning that the circuit is adjusted for continuous wave reception. (See Fig. 88.)

The primary circuit is tuned by adjusting the variable condenser which is in series with the primary coil and by adjusting the amount of inductance in the primary coil. The primary coil has one tap which is connected to a switch on the panel of the set box. When the switch is thrown to "SW" (short wave) only part of the coil is in use, and when thrown to "LW" (long wave) the entire coil is in use. The secondary circuit is tuned by adjusting the variable condenser, connected across the secondary coil. In a later model of the SCR–127 set the secondary coil also has one tap which is connected to the same switch provided for the primary coil. This is so arranged that when the switch is in the position "SW" only parts of each of the primary and secondary coils are in use. When it is in the "LW" position the entire circuits of the primary and secondarv coils are in use.

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Directions.

6. Note carefully all of the receiver controls on the panel of the set box.

Questions.

(24) *Locate the primary and secondary condenser controls. How are the scales marked?*

(25) *What is the purpose of the small knobs located beneath the large condenser control knobs?*

(26) *To which side must the large three-pole switch be thrown when using the set as a receiver?*

(27) *Locate the "SW–LW" switch. What is the purpose of this switch?*

(28) *Locate the "SP–Het" switch. What is the purpose of this switch?*

(29) *For what are the binding posts located at the left of the panel used?*

Information.

Two stages of audio frequency amplification are provided in the receiver, the coupling between stages being provided by audio frequency transformers. The receiving tube sockets are for the standard base receiving tubes, but adapters are provided and VT–5 tubes are used. (See Fig. 94.)

The VT–5 tube is used on account of the fact that its filament may be lighted for a long time on one battery, type BA–10, and therefore do away with storage batteries for lighting the receiving tube filaments. In this set the three receiving tubes used have their filaments in series so that three batteries, type BA–10, connected in series, are required to light the filaments of the receiving tubes.

Set box, BC–7, is used both in the SCR–127 and 130 set. In the latter set the voltage supplied to the receiving tubes is 12 volts, while in the former it is only 4.5 volts. Accordingly, some means must be provided to keep the filament circuit of the receiving tubes separate from any higher voltage circuit when the set box is used in the SCR–127 set. This is accomplished by opening the switch S_6. (Fig. 87.)

Directions.

7. Observe the various receiver parts mounted back of the set box panel. As far as possible, trace the wiring of the receiver using the wiring diagram shown in Fig. 88.

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Questions.

(30) *Locate the receiving tube sockets. Which is the detector tube socket? Which are the amplifier tube sockets?*

(31) *Where are the fixed resistances that are in series with the receiving tube filaments?*

(32) *Where is the primary receiving inductance? How many taps are taken from it? To what do they go on the panel?*

(33) *Where is the secondary receiving inductance? Is it coupled inductively or conductively with the primary? Is the coupling variable or fixed?*

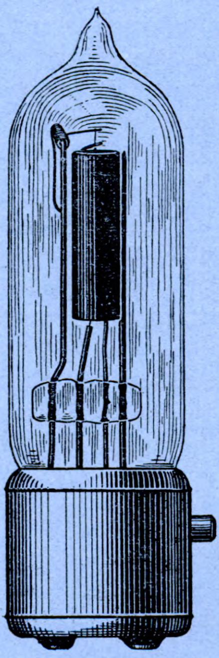

Fig. 94.—The type VT–5 vacuum tube.

(34) *Where is the tickler coil? Where are its terminals? Is it fixed in position with respect to the secondary?*

(35) *How many head sets can be connected to this set?*

(36) *What is the plate potential of the receiving tubes? Of the transmitting tubes?*

(37) *How are the filaments of the receiving tubes connected? Of the transmitting tubes?*

(38) *Where are the audio frequency transformers?*

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Information.

Power for the receiver is supplied entirely by dry cells so that no storage batteries are needed. This is made possible by the fact that the normal filament current of the VT–5 tube is 0.2 of an ampere, and that this amount of current can be supplied by the dry cell for some length of time. The battery box, type BC–102 (see Fig. 89) is designed to carry 12 batteries, type BA–10. Three of these batteries are connected in series and used to supply the filament current to the VT–5 tubes. The remaining nine batteries are spares and are used as needed. The plate current for the receiving tubes is supplied by two batteries, type BA–8 in series. Space is provided in the battery box for carrying type BA–8 batteries, the two in use and two spares. The negative side of the 45-volt plate battery is connected to the negative side of the filament battery so that only one lead is needed to connect this point to the set box. The cord provided for connecting the battery box to the set box consists of three braid-covered wires, one for the common lead mentioned above, one for the positive 45-volt connection, and one for the positive filament connection. This cord has a plug on one end which fits on three pins extending out from the edge of the set box. Terminals are provided on the other end of the cord for connecting to terminals in the battery box. A small groove is provided in the end of the battery box through which this cord may be laid when the lid of the battery box is closed. The compartments of the battery box not used for batteries are to be used for carrying tubes, head sets, etc.

Directions.

8. Place the battery box type BC–102 on some convenient support. Release the catches on the sides of the box and drop down the front cover. Notice the positions of the batteries and parts (including spare parts).

Questions.

(39). *Where are the terminals to which the BA–10 batteries are connected?*

(40) *Where are the terminals to which the BA–8 batteries are connected?*

(41) *How are the BA–10 cells held in place?*

(42) *Where are spare vacuum tubes kept?*

(43) *Is it possible to close the cover of the battery box when the battery cord is connected from the box to the receiver? Explain your answer.*

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EXPERIMENT No. 1.

TO CONNECT UP AND TUNE THE SCR-127 SET.

Information.

In connecting up the SCR-127 set, ready for operation, there are two main divisions of the work; namely, connecting the set as a receiver and connecting the set as a transmitter. The set may be connected up as a transmitter without fully connecting it up as a receiver and vice versa. In like manner the tuning of the set as a transmitter differs from the tuning of the set as a receiver. A definite method should be followed in doing all these things.

Directions.

9. *To connect up the set as a transmitter.*—Erect the set box on its legs. The set box should be so placed that the antenna and ground leads will easily reach the proper binding posts on the panel. Place the hand generator on the right side of the set box and the battery box on the left.

a. Open up the front cover of the set box, pull down on the catches which hold the panel closed, and open the panel.

b. Insert four VT-2 tubes in the four transmitting tube sockets in the set. Close switch "S_2." (Fig. 87.)

c. Close the panel, being sure that the catches are properly locked, and open the "Trans.-Rec." switch so that it does not make contact on either side.

d. Connect the high voltage generator lead to the two pins marked "+350" and "—350."

e. Connect the low voltage generator lead to the two pins marked "+12" and "—12" volts.

f. Connect the antenna lead-in wire to the post marked "Ant."

g. Connect the wire from the counterpoise or other ground system used to the post marked "Gnd."

Questions.

(*44*) *Why is it necessary to follow certain steps in their proper order when connecting up the SCR-127 set?*

(*45*) *Why is it important to have the connecting leads connected with proper polarity? Can this be done incorrectly? If so, how?*

Directions.

(10) *To tune the transmitter.*—The next step, after having made all of the connections as previously given, is to tune the transmitting

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side to the desired or specified wave length. In order to do this properly the following steps are gone through:

a. Turn the "Transmit Wave Length" pointer to *exactly* the desired wave length and lock it in that position by means of the small lever under the knob.

b. Have the generator cranks turned at 35 to 40 revolutions per minute.

c. Throw the "Trans.-Rec." switch to the "Trans." side. The filaments of the VT-2 tubes should glow a dull red.

d. Close the key.

e. Turn the "Antenna Tuning" knob slowly and watch the antenna ammeter. As the knob is turned the ammeter will start indicating and will gradually increase in reading up to a certain point. As the knob is turned still further the reading of the ammeter will decrease. That position of the "Antenna Tuning" knob which gives the greatest reading on the antenna ammeter is the correct adjustment. The final adjustment to obtain the greatest reading should be made with the small knob just under the "Antenna Tuning" knob. This small knob is a vernier or fine adjustment of the larger knob.

f. Open the key.

g. Open the "Trans.-Rec." switch and have the generator stopped. The set is now adjusted for transmitting on the wave length to which the pointer of the "Transmit Wave Length" adjustment is set.

Questions.

(46) *Why is the "Transmit Wave Length" pointer locked after it is set to the desired wave length?*

(47) *How long did it take the men turning the generator to bring it up to the required speed?*

(48) *Why is it necessary to adjust the "Antenna Tuning" knob so that a maximum reading occurs on the ammeter?*

Directions.

11. *To connect up the set as a receiver.*—After having made all of the connections given under the paragraphs entitled "To Connect Up the Set as a Transmitter," the following additional connections will be needed in order that the receiving side of the set may be ready for operation:

a. Open the panel to the set and insert three VT-5 tubes and adapters in the receiving tube sockets. (Be sure that the "Trans.-Rec." switch is open.)

b. Open the switch S_6 (Fig. 87) and close the panel, being sure that it locks into place.

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c. Open the battery box, type BC–102, and then remove the lid of the " B " battery compartment, placing the box so that it appears as in Fig. 89. Insert a battery, type BA–8, in the lower of the " B " battery compartments. The battery should be inserted with its top up and with the negative lead toward the back of the box. Guide the negative lead through the hole in the bottom of the right side of the compartment and pull the battery up aganst that side. Insert another battery, type BA–8, in the upper "B " battery compartment with its top down and with the positive lead toward the back of the box. Guide the positive lead through the hole in the bottom of the right side of the compartment and pull the battery up against that side of the compartment. Connect the positive and negative leads coming through the holes to the binding post marked " Black —" " Red +." Connect the remaining red lead to the post marked "+ 40 V Red " and the remaining black lead to the post marked "— 40 V Black." When spare batteries, type BA–8, are carried, they are placed alongside the two just connected in the " B " battery compartment. Replace the cover to the " B " battery compartment.

d. After having prepared six cells, type BA–10, for service, place them in the upper long narrow compartment in the battery box. Numbering the six cells from left to right, connect them in series-parallel as follows, using pieces of insulated wire cut to the necessary lengths:

(1) Carbon of No. 1 to carbon of No. 4.
(2) Zinc of No. 1 to carbon of No. 2.
(3) Zinc of No. 2 to carbon of No. 3.
(4) Zinc of No. 3 to zinc of No. 6.
(5) Carbon of No. 4 to wing nut back of binding post marked " Carbon +."
(6) Zinc of No. 4 to carbon of No. 5.
(7) Zinc of No. 5 to carbon of No. 6.
(8) Zinc of No. 6 wing nut back of binding post marked " Zinc —."

NOTE.—If only three cells are used, connect them in series and make connections to the wing nut terminals with proper polarity. The remaining cells should be left disconnected as spares.

When the six cells, type BA–10, have been connected as described above clamp them in place by means of the wooden rod which fits over their tops. If spare batteries, type BA–10, are to be carried, they should be placed in the lower compartment and clamped in place with the wooden rod provided.

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e. The cord, type CD–88, has a connecting block on one end and three leads of different colors on the other end. Connect the red and white lead to the binding post marked "+ 40 V Red," the white lead to the post marked "Carbon +," and the black lead to the post marked "Zinc —." Lay the cord in the groove in the upper edge of the right side of the battery box and close the lid of the box, clamping it shut.

f. Plug the connecting block of the cord, type CD–88, on the three pins marked "+40 V," "+Fil.," and "—Fil." into the receptacle on the left edge of the panel of the set box.

g. Plug one or two head sets, type P–11, into the jacks provided on the left side of the panel. (If available head sets are not provided with cord plugs, the cord clips may be connected to the two binding posts marked "Aux. Tel.")

h. Put on one of the head sets and adjust it to fit the head comfortably.

i. If the receiving side only of the set is to be used, omit the items given under *b*, *c*, *d*, and *e*, in Direction 9.

12. *To connect up the set both as a transmitter and as a receiver.*—After the set has been properly erected:

a. Open up the front cover of the set box, pull down on the catches holding the panel closed, and open the panel.

b. Insert four VT–2 tubes in the transmitting tube sockets and three VT–5 tubes and adapters in the receiving tube sockets. Close switch S_8 and open switch S_6. (Fig. 87.)

c. Close the panel, being sure that the catches are properly locked, and open the "Trans.-Rec." switch so that it does not make contact on either side.

d. Connect the high voltage generator lead to the pins marked "+350" and "—350."

e. Connect the low voltage generator lead to the two pins marked "+ 12" and "— 12" volts.

f. Connect the antenna lead-in wire to the post marked "Ant."

g. Connect the wire from the counterpoise, or other ground system used, to the post marked "Gnd."

h. Open the battery box, type BC–102, and then remove the lid of the "B" battery compartment, placing the box so that it appears as in Fig. 89. Insert a battery, type BA–8, in the lower of the "B" battery compartments. The battery should be inserted with its top up and with the negative lead toward the back of the box. Guide the negative lead through the hole in the bottom of the right side of the

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compartment and pull the battery up against that side. Insert another battery, type BA–8, in the upper "B" battery compartment with its top down and with the positive lead toward the back of the box. Guide the positive lead through the hole in the bottom of the right side of the compartment and pull the battery up against that side of the compartment. Connect the positive and negative leads coming through the holes to the binding post marked "Black—" "Red +". Connect the remaining red lead to the post marked "+ 40 V Red" and the remaining black lead to the post marked "—40 V Black." When spare batteries, type BA–8, are carried, they are placed alongside the two just connected in the "B" battery compartment. Replace the cover to the "B" battery compartment.

i. After having prepared six cells, type BA–10, for service, place them in the upper long narrow compartment in the battery box. Numbering the six cells from left to right connect them in series-parallel as follows, using pieces of insulated wire cut to the necessary lengths:

(1) Carbon of No. 1 to carbon of No. 4.
(2) Zinc of No. 1 to carbon of No. 2.
(3) Zinc of No. 2 to carbon of No. 3.
(4) Zinc of No. 3 to zinc of No. 6.
(5) Carbon of No. 4 to wing nut back of binding post marked "Carbon +."
(6) Zinc of No. 4 to carbon of No. 5.
(7) Zinc of No. 5 to carbon of No. 6.
(8) Zinc of No. 6 wing nut back of binding post marked "Zinc —."

NOTE.—If only three cells are used, connect them in series and make connections to the wing-nut terminals with proper polarity. The remaining cells should be left disconnected as spares.

When the six cells, type BA–10, have been connected as described above, clamp them in place by means of the wooden rod which fits over their tops. If spare batteries, type BA–10, are to be carried, they are placed in the lower compartment and clamped in place with the wooden rod provided.

j. The cord, type CD-88, has a connecting block on one end and three leads of different colors on the other end. Connect the red and white lead to the binding post marked "+ 40 V Red.", the white lead to the post marked "Carbon +," and the black lead to the post marked "Zinc —." Lay the cord in the groove in the upper edge of the right side of the battery box and close the lid of the box, clamping it shut.

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k. Plug the connecting block of the cord, type CD–88, on the three pins marked "+40 V", "+Fil.," and "–Fill." into the receptacle on the left edge of the panel of the set box.

l. Plug one or two head sets, type P–11, into the jacks provided on the left side of the panel. (If head sets are to be used not having plugs on the end of their cords they may be connected to the two binding posts marked "Aux. Tel.")

m. Check all connections to see that they are correct.

n. Put on one of the head sets and adjust it to fit the head comfortably.

Question.

(49) *Why is it necessary to have the "Trans.-Rec." switch open as in Direction 11, a?*

Information.

To tune the receiver.—In tuning the receiver several different cases will occur. They are as follows:

a. Tuning in a C. W. signal of known wave length.

b. Tuning in a damped wave signal of known wave length.

c. Tuning in a C. W. signal of unknown wave length.

d. Tuning in a damped wave signal of unknown wave length.

Directions.

13. To tune the receiver of the set to a C. W. signal of known wave length proceed as follows. After the receiving side has been connected up as directed above:

a. Throw the "Trans.-Rec." switch to the "Rec." side.

b. Place the "Spk.-Het." switch on "Het."

c. Set the "LW–SW" switch and the secondary condenser to the desired wave length as given by the calibration of the set.

d. Vary the primary condenser until a distinct double click is heard, and set the primary condenser about 5° to either side of the point where this click is heard.

e. The receiving side of the set should now be in tune on the desired wave length, but due to inaccuracies which may occur, the setting may not be exact enough to pick up the signal sought. It is therefore advisable to swing the secondary condenser slowly over an arc of about 10° (the middle point of which is the setting given by the calibration of the set) until the sought-for signal is heard.

f. Upon hearing the desired signal, stop turning the secondary condenser by its knob and make the final accurate adjustment by means of the small vernier knob located just under the secondary condenser knob.

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g. A small further adjustment of the primary condenser may now be made in order to increase the loudness of the signal.

14. To tune the receiver to a damped wave signal of known wave length proceed as follows:

a. Same as *a* above.

b. Same as *b* above.

c. Same as *c* above.

d. Same as *d* above.

e. Place the "Spk.-Het." switch on "Spk."

f. Same as *e* above.

g. Same as *f* above.

h. Same as *g* above.

15. To tune the receiver to a C. W. signal of unknown wave length proceed as follows:

a. Same as *a* under Direction 12.

b. Same as *b* under Direction 12.

c. Set the "LW–SW" switch on "SW." Set the secondary condenser on about 5° and vary the primary condenser until the double click is heard, indicating that the circuits are in tune.

NOTE.—For every position of the secondary condenser there should be a corresponding position of the primary condenser at which the primary or antenna circuit is in tune with the secondary circuit. In searching for a signal of unknown wave length, the method should be to vary both condensers at the same time, attempting at all times to keep the primary condenser close to that point where its circuit is in tune with the secondary.

d. Starting with the secondary condenser at about 5° and the primary condenser at the point where it is in tune, slowly turn both condensers, as outlined above, over their entire scale. Repeat this several times until you are sure that the signal is not obtainable. (The primary condenser should increase as the secondary is increased.)

e. Set the "LW–SW" switch on "LW" and repeat *d.*

f. When the desired signal is found under either *d* or *e*, engage the vernier knobs of the primary and secondary condensers and make the final adjustments for a loud, clear signal of a readable pitch with these knobs.

16. To tune the receiver to a damped wave signal of unknown wave length, proceed as follows:

a. Follow exactly the procedure outlined under Direction 11 until the desired signal is found. When found, the natural tone of the damped wave will be badly distorted.

b. Throw the "Spk.-Het." switch to "Spk.", and, if necessary, retune slightly both the primary and secondary condensers. The

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damped wave signal should now be heard with its natural tone, but much weaker than when heard under *a*.

NOTE.—Damped waves may be received with the "Spk.-Het." switch on "Het.", if the change in tone is not objectionable. The receiver will be far more sensitive than with the switch on "Spk."

EXPERIMENT No. 2.

CALIBRATION OF THE RECEIVER SECONDARY.

Directions.

17. Erect two complete antenna systems, separated by about 300 yards, for the SCR–127 set. On the first antenna (set A) connect up, ready for transmission, one SCR–127 set, and on the other antenna another SCR–127 set (set B) which is to have its receiver secondary calibrated.

18. Start transmitting with set A on 500 meters. Tune set B to receive the signal. Set B is now tuned to receive 500 meters. Read in degrees the setting of the secondary receiving condenser and put it down in a table similar to the one shown below.

Wave length.	Secondary condenser setting.	Setting of SW-LW switch.
500		
525		
550		
575		
600		
625		
650		
675		
700		
725		
750		
775		
800		
825		
850		
875		
900		
925		
950		
975		
1,000		
1,025		
1,050		
1,075		
1,100		

Transmit with set "A" on 525 meters and again tune in with set "B." Record the reading in the table. Continue this process in steps of 25 meters until the entire wave length range has been covered.

Information.

The SCR–127 set must primarily receive from another SCR–127 set; therefore it is desirable that its receiving side be calibrated with an SCR–127 transmitter. It would be easier to calibrate it by the

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use of a wave meter, but in that case the wave meter calibrations and those of other SCR-127 transmitters might not be identical. As a variation of about 1° on the secondary condenser is sufficient to tune out the desired signal it will be seen that accuracy is very important.

EXPERIMENT No. 3.

CHECKING THE CALIBRATION OF THE TRANSMITTERS OF SEVERAL SETS.

Information.

When three or more sets are to operate in a net it is very important that the transmitting wave-length calibrations of all of the sets shall be identical; that is, any one set should receive all other sets operating on the same wave length, on the same setting of the secondary receiving condenser. In order to accomplish this it is sometimes necessary to check or recalibrate all of the sets involved. Although the oscillator of the SCR-127 set is originally quite accurately calibrated, sometimes, due to rough handling, or to other causes, the calibrations may be thrown off.

Directions.

19. Set up two antenna systems. Pick out one set, to be known as the "master set," and connect it up to one antenna ready for transmitting. To the other antenna connect another set ready for receiving. With the master set transmit successively on wave lengths from 500 to 1,100 meters in steps of 25 meters.

20. Receive each of these transmissions on the other sets and fill out accurately a table similar to the one given below, showing all receiving adjustments on which each of the transmissions is received.

Wave length.	Primary condenser.	Secondary condenser.	Setting of SW-LW switch.
500			
525			
550			
575			
600			
625			
650			
675			
700			
725			
750			
775			
800			
825			
850			
875			
900			
925			
950			
975			
1,000			
1,025			
1,050			
1,075			
1,100			

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Disconnect the master set and place it aside. Connect to the antenna of the master set one of the sets whose calibrations have been checked and start it to transmitting on 500 meters according to its new calibration. Tune in the transmitted signal with the remaining receiving set. If it is received on the same adjustments used for the master set when it was transmitting on 500 meters, then the 500-meter calibration of the set under test is correct. If it is received on a different adjustment, the calibration is inaccurate and must be corrected.

21. To do this, adjust the receiving sets to the settings on which the master set was received on 500 meters. Gradually vary the transmitted wave length of the set under test until it is heard by the adjusted receiving sets. It will then be transmitting on 500 meters by the calibrations of the master set. A piece of paper should be pasted over the scale of the master oscillator and a mark made on the paper exactly opposite the end of the pointer, this mark being labeled " 500 ". The above process is repeated in steps of 25 meters until the entire wave length range of the set has been covered. The next set to be checked is then put through the same process.

EXPERIMENT No. 4.

TUNING A SET HAVING A BURNED OUT ANTENNA AMMETER.

Directions.

22. Connect up the set properly for transmitting, and if the burned out antenna ammeter has not been short-circuited, do so with a piece of fairly heavy copper wire. Throw the " Trans.-Rec." switch to " Trans.", have the generator turned, and hold down the key.

METHOD "A".

Slowly turn the antenna variometer (with the wave length variometer set at the desired wave length) until the men turning the generator notice a very perceptible increase in the load. As the antenna variometer is still further turned the generator load will again become lighter. At the position of the antenna variometer half way between the points where the increased load is first noticed and where the load again becomes lighter, the antenna circuit is approximately in tune with the master oscillator circuit. The set is then transmitting fairly well on the desired wave length.

METHOD "B".

Light and adjust the lamp on an SCR-125-A wave meter and couple the wave meter to the master oscillator circuit of the set by

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holding the side of the wave meter marked " Plane of Coil " against the knob of the wave length variometer. Start the set to transmitting and close the key. Set the wave meter to the desired wave length and vary the wave length variometer until the wave meter lamp indicates that the circuits are in tune. Then, without disturbing the adjustments of either the wave meter or the wave length variometer, move the wave meter over and couple it to the antenna circuit by wrapping one or two turns of the lead-in wire around it. Slowly turn the "Antenna Tuning" variometer until the wave meter lamp again indicates that the circuits are in tune. The set is then transmitting on the desired wave length with all circuits in tune.

Information.

With the SCR-127 and 130 sets, tuning the set to transmit on a given wave length is entirely dependent on readings of the antenna ammeter. Accordingly, some method becomes necessary to tune the set when this meter is out of service. Of the two methods given, the first may be employed with no additional apparatus and will give fairly good results. The second method is dependent on the availability of an SCR–125–A wave meter, but when properly used will give excellent results. Sometimes, in using the second method, trouble is experienced in getting an indication that the circuits are in tune, with the wave meter coupled to the wave length variometer. This is due to weak oscillations in the oscillator tube of the set and may be overcome by tuning the set by the first method and then coupling the wave meter to the antenna circuit for the final adjustment. It is to be remembered that the calibrations on the SCR–125–A wave meter and the master oscillator variometer may not be the same, due to inaccuracies in manufacture, and therefore a set transmitting on, say, 860 meters by the wave meter, may not be on exactly the same wave length as one which was set by the calibrations on the set. It will be noticed that in both of the above methods the calibrations on the set are used in determining the wave length. In general, the calibrations on the set are more accurate than those on the SCR–125–A wave meter.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. During the preliminary assembly show the class the SCR–127 set, including hand generator, set-box (type BC–102), and the various connecting cords. Open the set box BC–7 and point out the important parts of the transmitting circuit, showing how the movable parts are actuated by the dials on the panel. Draw on the blackboard a circuit diagram similar to the one shown in Fig. 85 of the Students Manual. As each part on the set is discussed point out its location in the diagram.

2. In the same manner proceed with the receiving side of the set, using a diagram similar to Fig. 88 of the Students Manual. Show the class the type VT–5 vacuum tube and explain how it differs from the other types of tubes used. Explain the use of the switches S_3 and S_6 shown in the diagram in Fig. 87 of the Students Manual.

3. Exhibit the BC–102 set box and explain its use in connection with the SCR–130 set.

4. Exhibit the hand generator, type GN–29, and explain its functioning. (If the BC–7 has been modified, substitute the new hand generator, type GN–29–A, described in Information Topic No. 5 of the Students Manual.)

5. Show how each of the cords, type CD–86, 87 (type CD–97 if GN–29–A is used), and 88 are used in making connections between the various parts of the equipment.

6. Review with the class the information given in the Students Manual regarding the functioning of the transmitting and receiving circuits.

7. When the students have completed this Unit Operation, they should know the names and symbols of the important parts of the SCR–127 set. They should be able to prepare a list of the complete equipment necessary to install and operate an SCR–127 set. From the experiments performed in this Unit Operation the students should know:

a. How to connect up the SCR–127 set completely, ready for operation.

b. How to tune the transmitter and receiver to designated wave lengths.

c. How to calibrate the secondary circuit of the receiver.

d. How to tune a set having a burned-out antenna ammeter.

e. How to check the transmitter calibration of several sets.

8. When the class work has been completed, give the following Instruction Test (or devise one similar to it). This test should be conducted in the same manner as in previous Unit Operations.

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Suggestions for Conducting Instruction Test No. 18–A (Performance).

Directions to the instructor.

Equipment.

1 SCR–127 (set box BC–7 only).
4 legs for set box, type BC–7.
3 vacuum tubes, type VT–5.
4 vacuum tubes, type VT–2.
1 set box, type BC–102, complete, with batteries.
1 hand generator, type GN–29 (or GN–29–A).
1 head set, type P–11.
1 cord, type CD–86.
1 cord, type CD–87 (CD–97 if GN–29–A is used).
1 cord, type CD–88.
1 antenna system A–1–A or substitute.
1 wave meter, type SCR–95 or SCR–125–A.

Procedure.

Problem No. 1.

a. Place the equipment listed above in a suitable location for conducting the test and direct the students to connect this equipment so that it will transmit and receive signals. As each student finishes record the time taken to do the work and check the connections.

b. Point out any errors made by the student and allow him time to make corrections.

Problem No. 2.

a. Assign two assistants to operate the hand generator for this part of the test.

b. Direct the student to tune the transmitter for maximum radiation on a given wave length. As each student finishes record the time and check the tuning of the transmitter.

Problem No. 3.

1. Start the wave meter, transmitting on some wave length unknown to the student. Direct the student to tune the receiver of the set to the signal of the wave meter. As each student finishes record the time taken to do the work and check the tuning of the receiver.

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INSTRUCTION TEST NO. 18–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   - 1 SCR–127 (set box BC–7 only).
   - 4 legs for set box, type BC–7.
   - 3 vacuum tubes, type VT–5.
   - 4 vacuum tubes, type VT–2.
   - 1 set box, type BC–102, complete, with batteries.
   - 1 hand generator, type GN–29 (or GN–29–A).
   - 1 head set, type P–11.
   - 1 cord, type CD–86.
   - 1 cord, type CD–87 (CD–97 if GN–29–A is used).
   - 1 cord, type CD–88.
   - 1 antenna system A–1–A or substitute.
   - 1 wave meter, type SCR–95 or SCR–125–A.

2. When the instructor directs "Begin," start work promptly; perform the following operations carefully and quickly:

Problem No. 1.

a. Connect up the SCR–127 equipment completely, ready for transmission and reception.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will check the connections.

Problem No. 2.

a. When the instructor again directs "Begin," proceed to tune the transmitter of the set to a wave length designated by the instructor. Tune the transmitter so as to obtain maximum radiation on this wave length.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

Problem No. 3.

a. When the instructor again directs "Begin," tune the receiver of the set to the signal of the wave meter, being careful to obtain maximum signal strength in the receivers.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

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Scoring.

1. The maximum score for this test is 16 points.
2. The score required to pass this test is 16 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
If the SCR–127 equipment is properly connected	8

PROBLEM NO. 2.

If the transmitter is properly tuned to the wave length designated	4

PROBLEM NO. 3.

If the receiver is properly tuned to the signal of the wave meter	4

4. When the student has failed to complete the test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or parts incorrectly performed.

INSTRUCTION TEST NO. 18–B (INFORMATION).

Directions to the Student.—There are listed below a number of questions and unfinished statements. After each question or statement are several words or phrases, preceded by a *number*. Only one of these is correct. Write the *number* of the correct word or phrase on the *dotted line* at the right of each question. Take plenty of time. *Do not rush.*

1. The SCR–127 set is a
   (1) spark set. (2) transmitting set only.
   (3) transmitting and receiving set combined.
   (4) stationary set. ------
2. The SCR–127 set is designed for the
   (1) Infantry. (2) Cavalry.
   (3) Field Artillery. (4) Aviation. ------
3. In transit the SCR–127 set is carried by
   (1) hand. (2) motor vehicles.
   (3) airplanes. (4) mules. ------
4. The power supply for the SCR–127 transmitter is secured from
   (1) a gasoline motor geared to a generator.
   (2) a hand driven generator.
   (3) a motor generator operated from an electric power line.
   (4) a motor generator operated by storage batteries. ------
5. The transmitter of the SCR–127 requires
   (1) two VT–2 tubes. (2) four VT–2 tubes.
   (3) four VT–1 tubes. (4) two VT–5 tubes. ------

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6. The signal sent out by the transmitter of the SCR–127 set
   (1) can be received only with a crystal detector set.
   (2) can be received only with careful and close tuning.
   (3) interferes with signals from nearly all other transmitters.
   (4) Is heard by most every receiving set. ------

7. The wave-length range of the SCR–127 transmitter is from
   (1) 150 to 550 meters. (2) 1,000 to 3,000 meters.
   (3) 550 to 1,100 meters. (4) 250 to 2,600 meters. ------

8. The total number of tubes used in the SCR–127 set is
   (1) four. (2) three. (3) seven. (4) five. ------

9. The receiving set of the SCR–127 uses
   (1) VT–1 tubes. (2) VT–2 tubes.
   (3) VT–4 tubes. (4) VT–5 tubes. ------

10. The total filament voltage for all the tubes used on the receiving set of the SCR–127 is
   (1) 12 volts. (2) 8½ volts.
   (3) 4½ volts. (4) 10 volts. ------

11. The filaments of the receiving tubes in the SCR–127 set are
   (1) Connected in parallel. (2) Connected in series.
   (3) Connected in series-parallel.
   (4) Not connected together. ------

12. The current required to light the filaments of the SCR–127 receiving tubes is supplied by
   (1) dry cells. (2) one storage battery.
   (3) a generator. (4) two storage batteries. ------

13. The normal filament current of each of the tubes used in the SCR–127 receiver is
   (1) 0.06 ampere. (2) 0.2 ampere.
   (3) 1.1 amperes. (4) 1.35 amperes. ------

14. The normal plate voltage used on the SCR–127 receiver is
   (1) 20 to 22½ volts. (2) 40 to 45 volts.
   (3) 60 to 67½ volts. (4) 90 volts. ------

15. If the power supply for the SCR–127 transmitter was destroyed, the receiving set
   (1) Would still work.
   (2) Would be put out of commission.
   (3) Would not work as well.
   (4) Would be without plate voltage. ------

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Directions to the student.—Below are several sentences and just after each one is a short dotted line (------). Read each sentence carefully, and if what it says is true write a plus sign (+) *on the line*. If what it says is not true, write a minus sign (–) *on the line*.

16. Speech is received on the SCR–127 when the tickler coil switch is set on tap marked "H E T." ------

17. Slow-motion or Vernier knobs are provided on all receiver and transmitter controls on the SCR–127 set. ------

18. A double-pole, double-throw switch is used to change from "Receive" to "Transmit." ------

19. Speech and C. W. signals can both be transmitted by the SCR–127 set. ------

20. An inductance switch is provided for shifting from short to long waves, or vice versa, in the SCR–127 receiver. ------

21. Two types BA–8 batteries are connected to the binding posts marked "40V" and "–40V." ------

22. If the antenna ammeter on the SCR–127 burns out while a message is being sent, the receiving operator will not hear the rest of the message. ------

23. The high voltage for the transmitting tubes is connected to binding posts at the left of the SCR–127 set. ------

24. The transmitting key is connected to binding posts at the left of the SCR–127 set. ------

25. The speed of the generator used in the SCR–127 transmitting set should not exceed 25 revolutions per minute. ------

26. The "Wave-length change" variometer of the SCR–127 set is used to vary the plate current of the transmitting tubes. ------

27. The transmitter of the SCR–127 set uses one oscillator tube, one modulator tube, and two amplifier tubes. ------

28. The telegraph key of the SCR–127 set is in the high-voltage circuit. ------

29. A condenser is used in the key circuit of the SCR–127 set to keep the tubes burning at a constant temperature. ------

30. The circuit employed in the SCR–127 set is known as the "master oscillator" circuit, because there is only one oscillator whose output is amplified by the other tubes used in the transmitter. ------

31. In the SCR–127 set there is no filament rheostat for the transmitting tubes. ------

32. In the SCR–127 set there is no filament rheostat for the receiving tubes. ------

33. A head set without a plug on the end of the cord can be connected to the 127 receiver. ------

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34. In order to make sure that the tubes of an SCR–127 set are lighted, it is necessary for the operator to move the panel forward and look inside. ------

35. The wave-length control knob of the SCR–127 set can be locked in position. ------

36. If the SCR–127 transmitting variometer in the antenna circuit is changed, the length of the transmitted wave will be changed. ------

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THE SCR-77-A LOOP SET.

Equipment.

1 set box, type BC-9.
1 equipment box, type BE-48.
1 loop, type LP.
1 battery case, type CS-17.
1 head set, type P-11.
6 tubes, type VT-1 (two good oscillators).
9 batteries, type BA-2.
1 battery, type BB-41.

Information.

The SCR-77-A set (see Fig. 95) provides undamped or continuous wave, two way, telegraph communication over the distances ordinarily separating regiments and battalions. The wave length range of the set, both transmitting and receiving, is from 74 to 76 meters. Within this range of two meters it is possible to work on nine different wave lengths without interference.

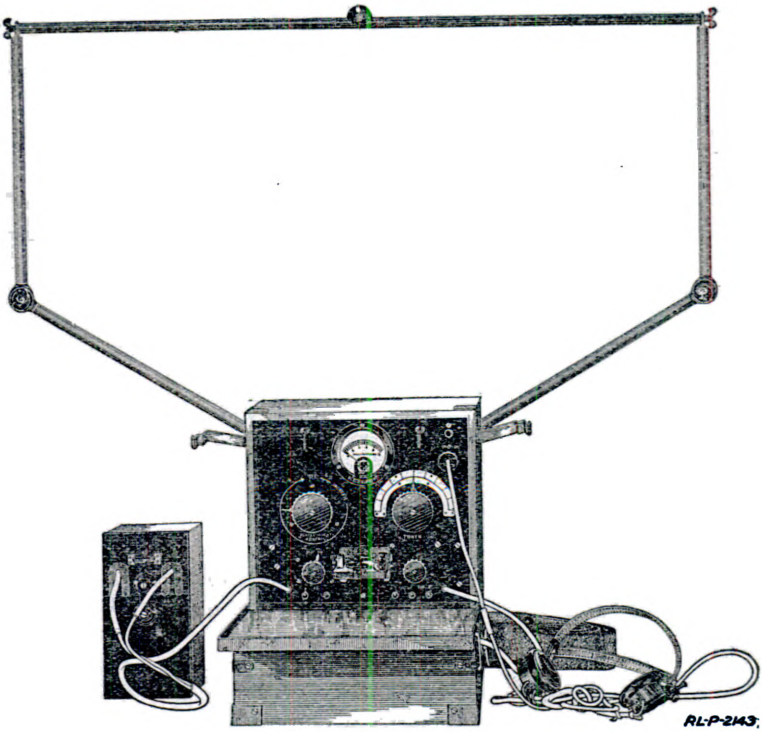

Fig. 95.—The SCR-77-A loop set.

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The type of antenna used with the SCR-77-A set is called a *loop antenna.* This consists of a single turn of metallic tubing the ends of which are provided with suitable connection lugs for mounting the loop on the set box and making contact to the circuits in the box. The loop is assembled in three sections which are joined together by bolts and wing nuts. Each section is hinged so that it may be folded for packing.

Directions.

1. Look at the front, top, and rear of the set box. Note carefully how the various controls are marked, how the ammeter is marked, how the key is constructed, and how the sockets for the loop antenna in the rear are constructed.

Questions.

(1) *Into how many positions is the tuner scale divided?*

(2) *How is the filament lighting current connection made?*

(3) *How many pair of telephones can be connected to this set?*

(4) *Why are the luminous paint lines placed on the ammeter scale?*

(5) *Why are these lines placed at the scale markings 4, 5, and 6?*

(6) *Where is the loop connection made to the inside of the set box?*

Directions.

2. Look at the loop antenna of this set. Note the construction and the method of attachment to the set box.

Questions.

(7) *Of how many distinct parts does the loop consist?*

(8) *Why is this type of construction preferred in this case?*

(9) *How is the loop fastened on to the set box proper?*

(10) *Why are wing nuts used on this antenna instead of ordinary hexagonal nuts?*

(11) *Where is the antenna carried during transportation of the set?*

(12) *Why is the antenna given a black finish?*

Information.

In the SCR-77-A the same circuit is used for both transmitting and receiving. (See Fig. 96.) In other words, the oscillator tube which furnishes power for transmitting serves as a detector when

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receiving signals. These two functions may operate at the same time. The receiving circuit is provided with two additional tubes which are used as audio-frequency amplifiers. These tubes, combined with audio-frequency transformers amplify the signals from the detector-oscillator. When the set is operating, a special filter circuit prevents high frequency currents from entering the amplifier tubes or the potentiometer circuit, but allows the direct and audio-frequency currents to flow.

The oscillator tube circuit consists of an inductance (the loop), several fixed condensers, and two variable condensers. The plate and grid circuits of the oscillator tube are coupled by the two fixed con-

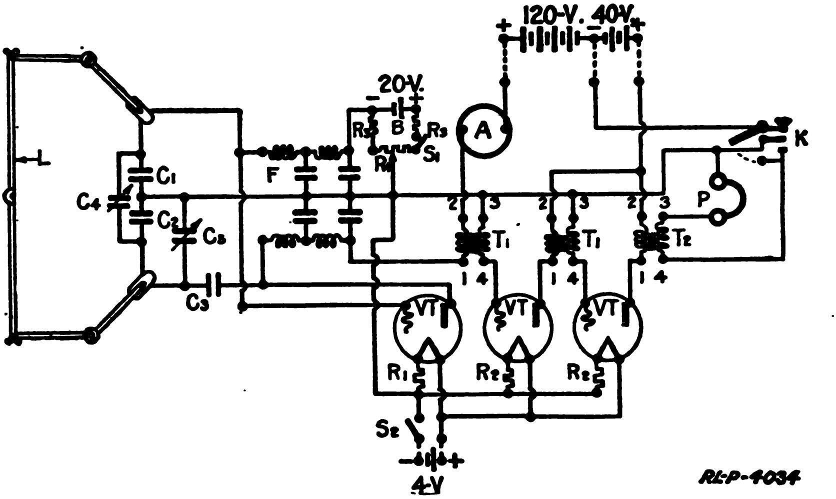

Fig. 96.—Schematic diagram of connections in the SCR–77–A set.

densers connected in series across the loop antenna terminals. A single moveable-plate variable condenser is connected across one of the fixed coupling condensers and enables the oscillator tube circuit to be tuned over a narrow band of wave lengths. A specially constructed two-plate variable condenser is connected directly across the loop terminals. This condenser, called the "screw driver" condenser, is mounted on the inside of the back of the set box with a large slotted head machine screw projecting through the back of the box, so that the condenser may be adjusted or varied without opening the panel of the set. The object of the "screw driver" condenser is to make the calibration of several sets agree at one point on their respective tuner scales.

A 4-volt storage battery supplies the necessary current for lighting the filaments of the 3 VT–1 tubes used in the SCR–77–A set. The

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necessary plate potential for the detector-oscillator tube is supplied by the 120-volt battery (6 BA-2 batteries in series) carried in the equipment box, type CS-17. The plate potential for the amplifier tubes is supplied by a 40-volt battery (2 BA-2 batteries in series), which is also contained in the equipment box. (See Fig. 97.) In order to operate the set it is also necessary to supply the grid of the detector-oscillator tube with a potential. This voltage is obtained

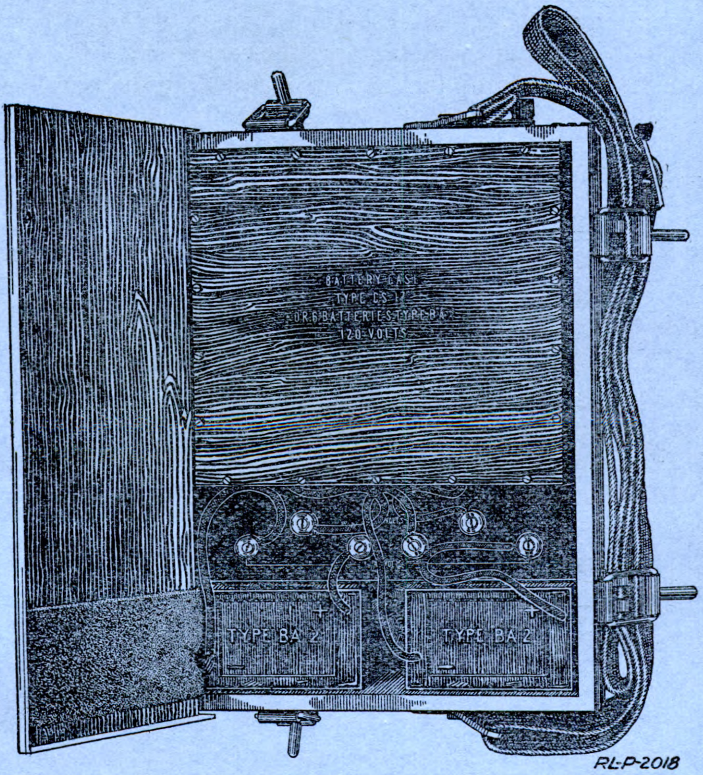

Fig. 97.—Battery compartment of equipment case, type CS-17.

from 1 BA-2 battery which is mounted in a special container on the rear of the panel of the set. As this voltage must be closely regulated or controlled, a variable resistance called a "Potentiometer" or "Controller" is connected across the grid battery. By careful adjustment of this controller the proper potential is supplied to the grid. A switch, used for turning the filament current on and off, also provides a means for opening the controller circuit, so that the grid battery will not have current drawn from it when the set is not

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in use. The battery box also contains compartments for 3 spare VT–1 vacuum tubes and a head set. (See Fig. 98.)

In the circuit diagram of the SCR–77–A set (see Fig. 96) it will be noticed that the phones are in series with the secondary winding of a special transformer the primary of which is in the plate circuit of

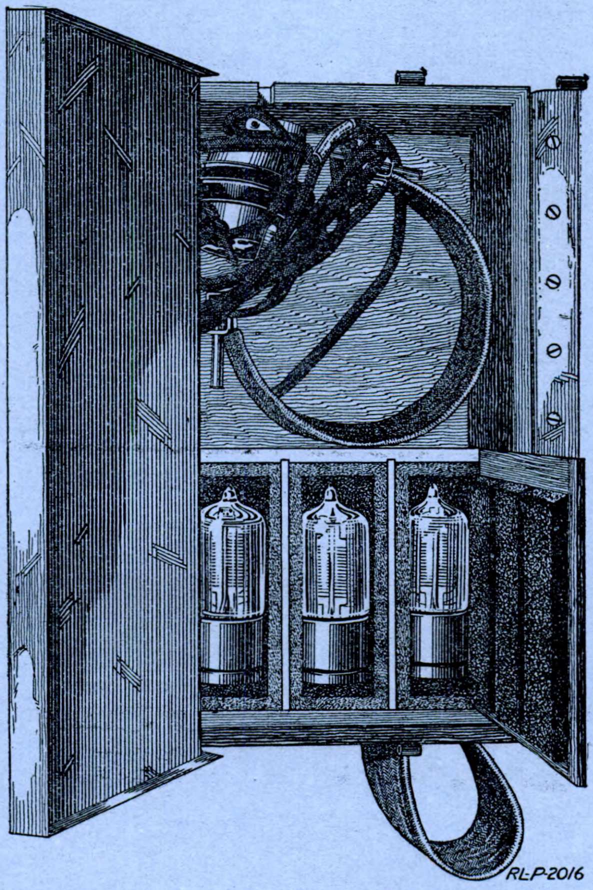

Fig. 98.—Head set and spare vacuum tube compartment of equipment case, type CS–17.

the last amplifier tube. The phones and the secondary of this transformer are across the lower contact and a special middle contact of the telegraph key. The middle contact is also connected to the negative filament terminal. The contact in the key arm is connected to the negative side of the 120-volt and 40-volt "B" batteries. The purpose of this arrangement is to eliminate the loud noise that other-

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wise would be produced in the phones whenever the telegraph key is operated.

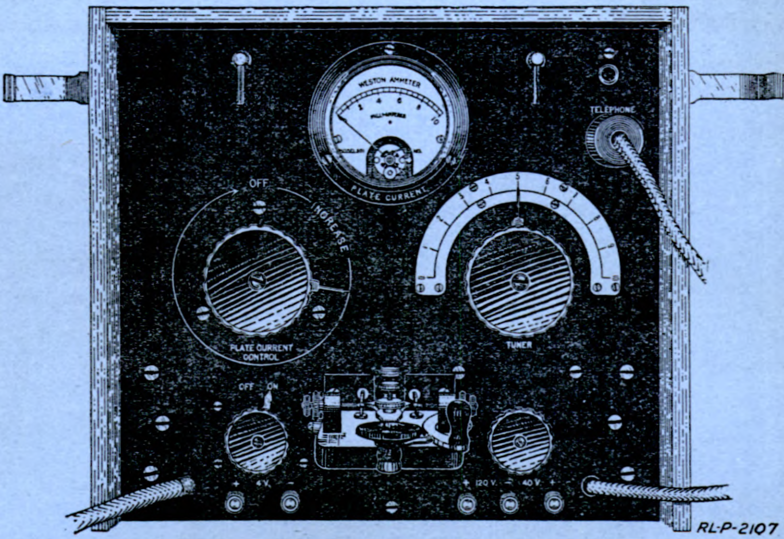

Fig. 99.—Set box, type BC-9 with front cover removed.

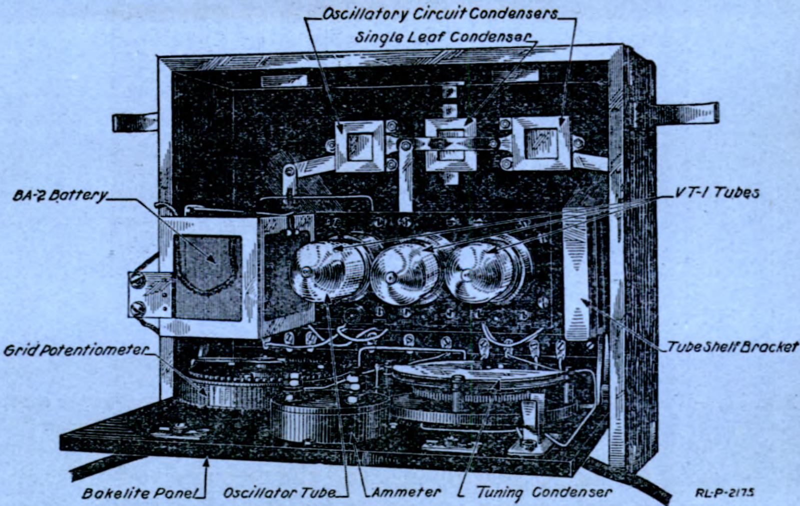

Fig. 100.—Front panel of set box, BC-9, lowered to show interior parts.

Directions.

3. Turn the two catches on the upper edge of the panel and swing the panel forward. (See Figs. 99 and 100.) Reach inside the set box and on the bottom will be found three thumb nuts. Remove these

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thumb nuts and lift off the wires connected to the bolts. The panel may now be lifted up and forward and removed from the box. Note the construction of the various parts mounted on the panel and those mounted on the inside of the back of the set box.

Questions.

(13) *How is the loop antenna connected into the circuit?*

(14) *How is the key connected to the circuits which it controls?*

(15) *In which circuits is the key?*

(16) *In what circuit is the milliammeter?*

(17) *What current does the milliammeter read?*

(18) *Locate the "screw driver" condenser. What is its use in this set?*

(19) *What kind of coupling is used between the grid and plate of the oscillator tube?*

(20) *Locate the coupling condensers of the oscillator circuit.*

(21) *How is the transmitting wave length of the set varied?*

(22) *How is the receiving wave length of the set varied?*

(23) *Where are the plate voltage supply batteries carried in this set?*

(24) *Where is the grid voltage supply battery carried in this set?*

(25) *How are the plate voltage supply batteries connected to the circuits of the set?*

(26) *How many volts are used on the plate of the detector-oscillator tube in this set?*

(27) *What batteries supply this voltage?*

(28) *How many volts are used on the plate of each amplifier tube?*

(29) *If one tube is removed from its socket, will the others still burn? Explain.*

(30) *Locate the potentiometer and the fixed resistances in series with it.*

(31) *Why are the fixed resistances used?*

(32) *What kind of coupling is used between the different stages of the amplifier?*

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(33) *Locate the audio frequency transformers?*

(34) *Which is the oscillator tube socket?*

(35) *Which are the amplifier tube sockets?*

(36) *Are the amplifier tubes being used when the set is transmitting? Explain.*

(37) *In general, what circuit is mounted on the inside of the back of the set box?*

(38) *How should the contacts of the key be adjusted?*

(39) *Should the joints of the loop be kept tight? Why?*

(40) *Where are the "B" batteries carried in this set?*

(41) *How are the "B" batteries connected to the circuits of the set?*

(42) *Which binding posts are positive and which are negative, as the student looks from the front of the set?*

(43) *How many volts are used on the plate of the oscillator tube in this set?*

(44) *Which "B" batteries in the set supply this?*

(45) *How many volts are used on the plate of each amplifier tube? Which batteries supply this?*

(46) *If one amplifier tube is removed from its socket will the set still function? Explain.*

(47) *Locate the grid resistances and the potentiometer. Why are they provided in this set?*

(48) *Why is the piece of varnished cambric placed between the bottom choke coil and the aluminum of the battery container?*

(49) *How is the receiving wave length of this set varied?*

Information.

A brief description of the operation of the SCR-77-A set follows: When an SCR-77-A set, which is called "A," for example, is set up and properly connected and the key is closed, the set will transmit and receive at the same time. In other words, the oscillator tube is generating impulses which leave the the loop antenna in the form of continuous waves, while at the same time, the tube is acting as a detector of incoming waves. If another SCR-77-A set, "B," is erected

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and put in operation at a suitable distance from set A and its key closed, it will send out continuous waves and detect incoming signals at the same time.

If set B is now tuned to almost the same wave length as set A, a musical or whistling note, called a "beat" note, will be heard in the telephone receivers of both sets. The action taking place in set B is as follows: The impulses generated by the oscillator tube of set B are combined with the impulses received from set A. This combination of impulses is detected by the oscillator tube of set B and causes a musical beat note to be heard in the telephone receivers of the set. The action in set A takes place in the same way. The impulses generated by the oscillator tube of set A are combined with the impulses received from set B and a beat note is heard in the receivers of set A due to the detector action of the oscillator tube in this set. When the two sets are operating as described above a beat note will be heard in the telephone receivers of both sets at the same time. If the key of either set is opened the beat note in the telephone receivers of both sets will cease.

If communication is to be established between the two sets, the levers on the sides of the keys of both sets are first closed. The tuner knob of one set is adjusted to any given setting on the dial and is left in that position. The tuner knob of the other set is adjusted until a strong beat note is heard. This beat note should be heard in the telephone receivers of both sets except under certain conditions which will be described later. If the operator of set A desires to send a message, he opens his key lever and proceeds to transmit. When he has finished, he closes the key lever and is ready for receiving. The operator at set B opens his key lever as soon as the operator at set A has finished and proceeds to answer. In this way it may be seen that in order to transmit the key lever must be open and to receive, it must be closed.

This method of operation of the SCR-77-A set makes possible the "break-in" system. Either operator, when two sets are in communication, may interrupt or "break-in" on the sending of the other. For instance, if the operator of set A is sending a message and the operator of set B misses a word, the operator of set B immediately opens his key lever and after waiting a few seconds advises the operator at set A of that fact. As the operator of set A can not hear his own transmitted signals when the key switch of set B is opened, he will thus know that the operator of set B is breaking in, and will accordingly close the key switch of set A and stand by for signals from set B. In the same way the operator of set A can break-in when set B is transmitting.

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In order to obtain maximum efficiency in the operation of the SCR–77–A set it is necessary to use a VT–1 tube in the oscillator socket which has been especially selected for this purpose. Since this tube must fulfill two functions, i. e., as an oscillator and as a detector, two sets of conditions will be given for selecting the tube. These two sets of conditions are opposed to each other so that the best that can be done is to compromise between the two in the final selection.

The best oscillator tube, that is, the one which will transmit the best, is the tube which, when placed in the oscillator socket and with the set in operation can be made (by adjusting the controller) to draw the greatest plate current and at the same time to show the greatest drop in plate current when the loop is touched with the bare hand. If one tube can be made to draw 8 milliamperes and drops to 6 milliamperes when the loop is touched, it is a better oscillator than a second tube which will draw 6 milliamperes and drops to 4 milliamperes when the loop is touched. However, if the second tube drew 6 milliamperes and dropped to 3 milliamperes when the loop was touched it would probably be a better transmitter tube than the first tube.

The best detector tube, that is, the one which will receive the best, is the tube which, when placed in the oscillator tube socket and with all connections properly arranged, can be made (by adjusting the controller) to draw the least plate current and still show a slight drop when the loop is touched. Thus a certain tube may draw only one milliampere. The meter needle indicates a slight decrease in reading when the loop is touched and returns to the one milliampere reading when the hand is removed from the loop. Another tube can not be made to draw less than 2 milliamperes. The meter needle indicates a slight decrease in reading when the loop is touched and returns to the 2 milliampere reading when the hand is removed from the loop. The first tube is the better detector of the two and since it is a poorer oscillator than the second tube it will cause less interference on any tuner setting when listening in on the transmission of another station.

The tube, therefore, finally selected for the oscillator should be one which will best fulfill both the oscillator and detector conditions with different settings of the controller.

Due to the fact that the plate current is supplied by BA-2 batteries and that these batteries will not supply over 6 milliamperes without greatly shortening their life, it is best to use in transmitting not more than the above value of plate current. Occasionally,

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when a distant station can not be reached with signals loud enough to read, the plate current can be increased for that transmission only, to 8 or 9 milliamperes, provided that the tube used is a better oscillator at that value of plate current.

To place the set in operation, insert and connect the necessary batteries in the equipment box. (See Fig. 95.) Place the set box on top of the equipment box and clamp the two together; and connect, with the proper polarity, a 4-volt storage battery to the battery leads from the set. Open the panel and insert a selected oscillator tube in the oscillator tube socket, insert two amplifier tubes in the amplifier tube sockets. Close the panel. Insert the plug of the plate-battery connecting cord in the jack provided in the equipment box and plug in a headset. With the key lever closed, turn the filament switch to the " On " position and adjust the controller until the tube is oscillating strongly as shown by touching the loop and noting the meter deflection. Turn the tuner over its scale slowly, and if there is another SCR-77A set transmitting within range, a beat note will be heard in the headset.

EXPERIMENT No. 1.

THE SELECTION OF OSCILLATOR TUBES FOR THE SCR-77-A.

Information.

Oscillator tubes for the SCR-77-A must be selected before the set is sent into the field for operation. At the most, only one out of every ten or fifteen tubes tested will prove satisfactory for use in the oscillator tube socket of this set. Every SCR-77-A set going into the field should have with it at least two and, if possible, three or four selected oscillator tubes.

The selection of the oscillator tubes should be based on the information given on this subject earlier in this Unit Operation, and should be carried out in the following manner:

Directions.

4. To connect up the set ready for operation proceed as follows:

a. Open up the rear compartment of the equipment box, type BE-48, and insert a battery case, type CS-17, which shows a reading of at least 110 volts when tested with a voltmeter. Connect the positive and negative leads to the two binding posts marked "+ 120" and "— 120" volts, with the proper polarity. Place two BA-2 batteries in the small compartment and connect their leads with the correct polarity to the four binding posts marked "40 volts." Close the compartment.

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b. Place the set box on top of the equipment box in the correct position and clamp the two together.

c. Remove the loop from its carrying bag, straighten out the three pieces to their correct shape, and clamp their hinged joints tightly. Place the two sides of the loop in their respective sockets on the back of the set box and put the top bar in place, at the same time tightening up the wing nuts which hold it. Go over the entire loop and see that all joints are tight.

d. Open up the front cover of the set box sufficiently to pull out the plate battery connecting cord and plug and lay it to the right of the set. Open up the front compartment of the equipment box, remove the tubes and head sets which are to be used in operating the set, and plug in the plate battery connecting plug into the jack provided. Lay the cord in the little notch on the right side of the compartment and close the compartment.

e. Let down the front cover of the set box all the way and open the panel. (See Fig. 100.) Place a BA–2 battery in the compartment attached to the panel and connect the leads from this battery to the two binding posts on the side of the compartment with the polarity as marked. Place two VT–1 tubes in the two amplifier tube sockets.

f. Connect the red terminal of the storage battery cord which extends from the panel to the positive terminal of a 4-volt storage battery and the black terminal of the cord to the negative terminal of the battery.

g. See that the filament current switch is in the "On" position.

h. The set is now ready to operate with the exception of placing a selected oscillator tube in the oscillator tube socket, closing the panel, and plugging in a head set.

5. The student will be supplied with 20 VT–1 tubes out of which the tubes suitable for use in the SCR–77–A set must be selected. Each tube has a number written on a small piece of paper pasted on the glass of the tube. Refer to the tubes by their number in stating the qualifications of each tube in this experiment.

6. Insert one of the tubes in the oscillator tube socket of the set, close the panel and see that the key lever is closed. Vary the controller and determine if the tube will oscillate at any value of plate current within the range of the set. If it does oscillate (as shown by the decrease in plate current when the loop is touched) determine the points at which it is the best oscillator and the best detecor. Re-

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peat the above for each of the 20 tubes given you and fill out a table similar to the one shown below.

Tube No.	For best oscillations.		For best detection.	
	Plate current.	Deflection.	Plate current.	Deflection.
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	....	....	....

NOTE.—If a tube can not be made to oscillate with any adjustment, write down its number and put an x in each of the columns opposite that number.

Questions.

Study carefully the table which has been filled out and answer the following questions:

(50) *State by number, in the order of your choice, the three tubes which are the best oscillators.*

(51) *State by number, in the order of your choice, the four tubes which are the best detectors.*

(52) *State by number, in the order of your choice, the three tubes which best fulfill both qualifications as a detector and an oscillator.*

(53) *State your reasons for choosing the tubes selected in response to question 52.*

(54) *If all of the stations which are to be communicated with are very close to each other, which tube would you use? State the number of the tube.*

(55) *Which tube would you use in order to cover the extreme range of an SCR–77–A set? State the number of the tube.*

(56) *Suppose that the plate current milliammeter shows no reading, but that otherwise the set is working, could you tell by listening in the headset whether or not a tube was oscillating? If so, how?*

(57) *Out of the 100 VT–1 tubes, how many would you expect to be suitable for use in the SCR–77–A set as oscillators?*

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Experiment No. 2.

CHOOSING A "MASTER" SET AND CALIBRATING ALL SETS.

Information.

With the SCR–77–A set the different wave lengths are referred to as "tuner settings." Due to the fact that these tuner settings are very close together and that the set always works on a tuner setting which is not assigned to any other set within range, it is of extreme importance that the tuner settings of all sets within range check together. Whenever intercommunicating radio sets are working on different wave lengths it becomes very important that the different wave length settings on all of the sets be exactly alike, so that when one of the sets tunes to the wave length of another it is really on the wave length desired.

As mentioned before, the SCR–77–A set covers a wave length range of 2 meters, but due to slight and unavoidable differences which arise in manufacture, some sets will cover a slightly greater and some a smaller wave length range. Therefore it is necessary when selecting a set as the "master set," with which all other sets are to be oscillated, to choose the one which covers the smallest or shortest wave length range. This is necessary, for the reason that, if some of the sets to be checked cover a smaller range than the master set, it would be impossible to check them on all of the calibrations of the scale of the master set. After the master set has once been chosen the same set should be kept as the master set as long as it operates or does not become damaged in any way which affects its calibration.

Directions.

7. *To choose the "master set."*—1. Set up any one set as a temporary master set and place it in operation. Turn the adjustment screw of the screw driver condenser in a clockwise direction as far as it will go and then give the screw exactly four complete turns in a counterclockwise direction. With the screw in this position the screw driver condenser is adjusted at one-half its total capacity, which is the correct adjustment for the master set.

8. Set up one of the sets to be tested about 200 yards from the master set and place it in operation. Turn the tuner knob of the master set to tuner setting No. 5. Slowly turn the tuner knob of the set being calibrated until the beat note is heard. If the beat note is

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heard on a setting below the No. 5 setting, the adjustment screw of the screw driver condenser of the set under test must be turned in a counterclockwise direction. If the beat note occurs above the No. 5 setting, the adjustment screw of the screw driver condenser must be turned in a clockwise direction. The adjustment screw of the screw driver condenser must be turned in the directions stated until a "zero" beat note is obtained with the tuner knob set on exactly the No. 5 setting. The explanation of the term "zero beat note" is as follows:

9. When one set is being tuned to another the beat note is at first heard in the form of a very high pitched whistle as the tuner dial is slowly turned. If the operator continues turning the dial in the same direction, the whistle will become lower and lower in pitch until a point is reached where no sound is heard at all in the receivers. When the beat note disappears at this point, it is at zero value and is known, therefore, as the "zero beat note." If the dial is turned beyond this point, the whistle or beat note will again be heard, first as a very low whistle, and then gradually going higher in pitch until it is inaudible.

10. When the set under test has been adjusted to a zero beat note on tuner setting No. 5, turn the tuner knob of the master set to the No. 1 setting and vary the tuner knob of the set under test until a zero beat note is again obtained. Note whether the zero beat note is obtained above or below the No. 1 setting on the scale of the set under test.

11. Repeat Direction 10 with the tuner of the master set on setting No. 9.

Questio

(58) *If in Direction 10 and 11 the zero beat note settings were below setting No. 1 and above setting No. 9, has the set under test a smaller wave-length range than the set selected for the temporary master set or greater?*

(59) *If the zero beat note settings were above setting No. 1 and below setting No. 9, has the set under test a smaller or greater wave length than the temporary master set?*

(60) *If both zero beat note settings of the set under test were either above or below Nos. 1 and 9, has the set under test a smaller or greater wave-length range than the temporary master set?*

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Directions.

12. If settings are obtained as outlined under either Question 59 or Question 60 above, place the set tested to one side. Proceed to test another set, following the instructions as given in Directions 7, 8, and 9.

13. If settings are obtained as outlined under Question 58 above, take the set tested and substitute it in place of the temporary master set. Adjust the new temporary master set as explained in Direction 7, and continue the testing of sets.

14. If, while testing the remaining sets, another set is found which has a shorter wave-length range than the sets which have already been tested, substitute this set as before in place of the temporary master set. This process should be repeated until a set is found which has the shortest wave-length range of all the sets tested. The set having the shortest wave-length range should be chosen as the permanent master set.

15. *To calibrate all sets.*—Set up the master set and place it in operation. Adjust the screw-driver condenser of the master set as explained in Direction 1 above.

16. About 200 yards away set up and place in operation one of the sets to be calibrated. No sets other than the two already mentioned should be in operation.

17. Adjust the tuner knobs of both the master set and the set to be calibrated to setting No. 5 and vary the screw-driver condenser of the set to be calibrated until a zero beat note is obtained.

18. Adjust the tuner knob of the master set to setting No. 1 and turn the tuner knob of the set under calibration until a zero beat note is obtained. When adjusting the tuner knob of the set under calibration, the zero beat note may not occur exactly on the No. 1 setting. If this happens, mark the exact position of the tuner pointer where the beat note does occur by drawing a single pencil mark on the scale of the tuner extending from the black line in the center of the scale to the inner edge of the scale. Opposite the outer end of this mark place the figure "1."

19. Repeat Direction 18 above, with the tuner of the master set adjusted successively set on tuner settings Nos. 2, 3, 4, 6, 7, 8, and 9. The result should show that the set being calibrated checks with the master set setting on No. 5 and either checks or has a pencil calibration which does check with all other settings on the master set.

NOTE.—SCR–77–A sets are never calibrated on settings Nos. 0 and 10, due to the fact that at these positions of the tuner the amount of change obtained by turning the tuner is very little and quite erratic.

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20. Repeat directions 15 to 19 above for all sets which have to be calibrated, taking one set at a time and completing its calibration before going to the next.

Questions.

(61) *Why is it necessary to select a set as the master set?*

(62) *What should be the qualifications of the set to be used as the master set?*

(63) *If the movable plate of the master set tuner condenser should become bent, would a new master set have to be selected?*

(64) *Does the position of the controller affect the tuner settings of a set?*

(65) *In selecting a master set, why are the sets first made to agree on the No. 5 setting?*

(66) *As the screw-driver condenser adjustment is turned clockwise does the capacity of the condenser increase or decrease?*

(67) *In checking calibrations by means of the screw-driver condenser, why is it necessary to turn the screw-driver condenser adjustment in a clockwise direction if the position of the tuner pointer of the set being calibrated is too high?*

(68) *Why can only one set be calibrated at a time?*

(69) *If only a few of the tuner settings were to be used, would it be necessary to calibrate all of them?*

(70) *Why are the sets separated by several hundred yards while calibration is going on?*

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THE SCR–77–B SET.

Equipment.

1 set box, type BC–9–A.
1 equipment box, type BE–48.
1 loop type LP–2.
1 battery case, type CS–17.
1 head set, type P–11.
3 tubes, type VT–1.
9 batteries, type BA–2.
1 battery, type BB–41.

Information.

Purpose of Set.—The SCR–77–B set is a modification of the SCR–77–A set. It was designed to furnish radio telegraph communication between units whose headquarters are usually from three to five miles apart. Reliable communication may be maintained up to three miles. Under favorable conditions, such as open terrain, etc., this distance is increased to approximately five miles. The average working wave length of this set is about 65 meters (about 4,600 kilocycles) and the set is so arranged that there are nine different wave-length settings available. It will be noted that the working wave length has been changed, and that the modified sets will therefore not work with the original SCR–77–A set which use the 74 to 76 meter band.

Reasons for Modification.—The original SCR–77–A set has been modified in order to remedy certain faults. As the sets were transmitting at full power at the time they were receiving, only nine sets (corresponding to nine available tuner settings) could be operated at one time within the distance range of the set, without setting up excessive interference. Due to the constants of the circuits the sets were very critical in operation and only a small percentage of tubes would operate satisfactorily as oscillators. Also trouble was experienced with the mechanical adjustment of the key. The modified sets have been developed overcoming these difficulties and are now being issued for service trial.

Special Features of the Set.—Similar to the SCR–77–A set the SCR–77–B set is very portable and is quickly set up. A moving unit furnished with the SCR–77–B set can keep in constant communication within its transmitting range, with every unit furnished with a like set. The break-in system of the SCR–77–B set is more efficient and reliable than the SCR–77–A set, especially at maximum distances. This greatly facilitates communication. There is no change in adjustment needed to reverse the direction of communication. The

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set is oscillating weakly with the key up and strongly when the key is pressed. This reduces interference while receiving. Consequently it is possible to operate all stations in a net on a common tuner setting. As an entire net requires only one tuner setting it is possible to operate a number of sets simultaneously.

Questions.

(1) *What is the purpose of the SCR–77–B set?*

(2) *For what reasons was the SCR–77–A set modified?*

(3) *State the two most important features of the SCR–77–B set.*

Information.

Principles of operation.—Similar to the SCR–77–A set the SCR–77–B set uses three type VT–1 vacuum tubes. One of these is connected as an oscillator, using capacity coupling between the plate and grid. The other two tubes are used as audio frequency amplifiers. The oscillating circuit is so designed that when receiving it is oscillating weakly, consequently the oscillator tube will act as a detector. It is evident from this that the SCR–77–B set does not emit strong continuous waves at all times but only when the key is pressed.

Connected across the loop is the grid condenser and the plate condenser, which supply the coupling between the plate and grid. A condenser of large capacity is connected in the lead from the plate to the oscillating circuit. This condenser prevents the 120-volt direct current potential from passing through the loop to the grid. A small, single leaf or screw-driver condenser is connected across the loop to permit an adjustment for calibration. A variable condenser is also connected across the plate coupling condenser. This condenser, controlled by the tuner knob on the front of the panel, is used to vary the wave-length adjustment of the set.

The plate voltage of the oscillator tube is supplied by a 120-volt battery which is also connected to the filament. When the transmitting key is up for receiving the plate current passes through a 100,000 ohm resistance. This greatly reduces the voltage on the plate so that very weak oscillations will be obtained. The small plate current thus obtained passes through the transformer primary and the milliammeter. Across the resistance is connected a fixed condenser which acts as a by-pass for the audio frequency current. When the transmitting key is pressed the circuit, including the 100,000 ohm resistance, the primary and the milliammeter becomes short-circuited. The full plate voltage is then impressed on the plate. The short-circuiting of the transformer primary avoids passing the large current through the winding which might cause the

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winding to become open-circuited in time. It is necessary to short-circuit the milliammeter when transmitting because of the low range of the meter.

A potentiometer or controller on the panel of the set box controls the grid potential of the oscillator tube. A change in this grid potential will produce a change in the plate current of the oscillator tube. This adjustment is needed so that the plate current in the oscillator tube, when receiving, will be as weak as possible. When transmitting the potentiometer has very little effect on the power.

A single-pole knife switch is mounted on the face of the panel. When closed the switch short-circuits the 0.5 ohm resistance in series with the oscillator tube. This has very slight effect on the receiving adjustment but greatly influences the transmitted signal. This is particularly helpful when the storage battery is nearly discharged as the switch may be closed in order to make use of the additional current. However, with the filament resistance short-circuited when using a fully-charged battery, the filament current is high and as a consequence the life of the tube filament will be considerably shortened. The switch should therefore only be closed when it is necessary, as in working with a distant station.

The SCR-77-B set is operated in much the same manner as the SCR-77-A set, the beat note method of reception being used. It is not necessary, however, to close the lever on the side of the key for reception. To establish communication it is only necessary to set the wave-length control to the allocated tuner setting and to begin sending. If for any reason it is desired to interrupt or "Break" the sending operator, simply send a series of dots with the key. The sending operator will hear the dots during the intervals when his key is up. He then immediately stops sending to receive the message from the interrupting station.

SETTING UP THE SCR-77-B SET.

Directions.

1. *Preparing the Equipment Box.—a.* Place the battery case (type CS-17) containing the 120-volt unit in its compartment in the equipment box. Connect the terminals of the binding post marked "—120 volts+," being sure to observe the correct polarity and make firm connections.

b. Place two BA-2 batteries in the smaller compartment on the same side of the equipment box. Connect the terminals of one battery to the left-hand pair of binding posts marked "—20 volts+," and the terminals of the other battery to the right-hand pair of con-

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nectors. Close and fasten the cover of this side of the equipment box.

c. Open the other side of the equipment box, remove the telephone headset and also the vacuum tube (if same are not already in the operating chest). Plug in the plate battery cord (the one attached to the lower right side of the operating chest). Having run the cord through the slot provided in the cover of the equipment box, close and fasten it. Place the box on a level spot of ground with its fasteners up.

2. *Preparing the Operating Chest.—a.* Place the operating chest on the top of the equipment box and fasten it in place by means of the catches provided. If the operating chest is not absolutely firm it will rock when the key is operated, causing an unsteady beat note. Open the cover of the operating chest, allowing it to rest on the end of the equipment box. Turn the "Off-On" switch to the "Off" position. Turn the handles of the two fasteners at the top of the box to a horizontal position and pull the panel forward. Place a BA–2 battery in its holder alongside of the vacuum tube. Connect its terminal to the binding posts located alongside the holder. Observe the correct polarity and make tight connections. Secure the battery in place by means of the clamp. Place a VT–1 vacuum tube in each of the three sockets. Close the front panel and lock it in place by turning the handles of the fasteners downward. Pull the top of the telegraph key downward to its operating position. Plug in the telephone headset.

b. Place the storage battery carrying case near the operating chest and connect to one of the storage batteries the terminals of the cord which extend from the left-hand side of the operating chest. Observe the correct polarity as marked. The cover of the operating chest should then be closed.

c. Remove the loop from its case and unfold it. Jam the ends of the loop firmly into the sockets in the end of the operating chest. Tighten up all wing nuts on the loop. The set is now ready for operation.

3. *Adjustment For Reception.*—Turn the filament circuit switch to the "On" position. Slowly turn the potentiometer adjustment in a clockwise direction from the "Off" position until the circuit starts oscillating. When the circuit is oscillating a click is heard in the head set when the loop is touched with the bare finger and an equally loud click is heard when the finger is removed. If the circuit is oscillating strongly a slight decrease in reading of the plate current milliammeter is obtained when the loop is touched. If the circuit is oscillating weakly the decrease of plate current obtained when the

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loop is touched is too small to be perceptible. Even this weak oscillation will be radiated and will cause interference over a considerable distance and it is therefore desirable that the oscillation be made as weak as possible. If necessary, while receiving signals, the potentiometer can be turned back until the signal just begins to weaken. This precaution is necessary only when one station is located near another station in the same net and consequently uses the same tuner setting. The set should now be in proper adjustment for receiving. Turning the tuner adjustment slowly will bring in the signals transmitted from other modified SCR–77–A sets within the distance range of the sets. Slight readjustment of the potentiometer is necessary from time to time as the storage battery is discharged.

4. *Adjustment for Transmission.*—The only operating adjustment of the set is that required for receiving, described in Direction 3. In order to transmit after this adjustment has been obtained it is simply necessary to press the key.

Questions.

(4) *Why is it necessary to have the oscillator tube oscillating very weakly when receiving?*

(5) *Has the adjustment of the controller, any effect on the transmitted signal?*

Information.

Operation of a Single Net.—When only one net is to be operated no special tuner calibration is required. All stations in a net work on the same tuner setting. The Net Control Station operator should adjust his tuner to the number 5 setting and should then send a series of long dashes. All other station operators should adjust their tuners until the signal from the NCS is picked up and a beat note of readable pitch obtained. This adjustment can be marked on the white celluloid dial by means of a lead pencil. Each station then reports in regular order to the NCS and the net is ready for traffic, which is carried on in accordance with specified net regulations. Any station can then work with the NCS without readjustment of the tuner. When working a station other than the NCS it may be desirable to slightly readjust the tuner in order to obtain a beat note of readable pitch. Only one message at a time is handled in the net.

Operation of a number of nets.—When a number of nets are required to operate at the same time each net is assigned an individual tuner setting. All stations in each net are then to be tuned to the same tuner setting. All sets to be used as Net Control Stations

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should be brought together for calibrations. One set should be placed in operation, oscillating weakly with the key up. The tuner pointer should be adjusted to the number 5 position. The other sets should be operated, one at a time, not less than 20 feet from the master set and with the loop at right angles to the loop of the master set. Each of these sets, as they are operated, should also be adjusted to oscillate weakly with the key up. The tuner of each set should be adjusted carefully until a very low beat note or zero beat adjustment is obtained. The single plate condenser should then be adjusted by means of the screw provided in the back of the set, until beat adjustment is obtained as near as possible to the number 5 mark on the scale. The exact point located should be marked by a pencil on the white celluloid dial. The tuner of the master set can then be placed on points 1 to 4 and 6 to 9 in turn and corresponding points marked in pencil on the tuner dial of the set being calibrated. It will be noted that a total of nine nets can be operated at once, all operating on different tuner settings. Use of a greater number of nets than nine makes necessary the use of more than one net having a certain tuner setting. Care must then be taken that two nets using the same tuner setting are not located sufficiently close to each other to cause mutual interference. It may be found by experience that some other set is more satisfactory for use as a master set than the one first selected. This would be true if most of the sets tune in with the master set when their tuners are either above or below the number 5 mark. All sets in each net can be calibrated by the NCS to operate at the tuner setting assigned the net as described previously. If it is required that any set in a net other than the NCS be able to communicate with a set in a different net, the additional calibration required can be obtained by comparison with the NCS.

Trial Operation.—After all sets that may be required to work have been calibrated it is well to try out intercommunication between the different sets while the sets are all in the same vicinity. Any faulty calibration can then be checked up and corrected without the confusion that would result if the sets were taken into the field before the faulty calibration were discovered.

Permanency and Limits of Calibration.—The calibration of the set, as described above, is quite permanent and reliable. However, any heavy jar or shaking up of the set is liable to disarrange the adjustment. If the set is operated at a station where the surroundings or earth conditions are different from those under which the set was calibrated the wave length adjustment of the set will probably be slightly altered. This is most apt to occur when the loop of the set is near some object. The position of the set should be changed if

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practicable. In some cases it will be necessary to recalibrate the set in the location at which it is to be used. This should be done under the direction of the officer in charge of the net. In extended operations the calibration of the sets should be checked up at least every day by comparison with the master set. This may be done by the operator transmitting for a definite length of time with his tuner upon each position. The other stations should then, one at a time, make any corrections to the markings on their scale that may be necessary.

Questions.

(6) *How many SCR–77–B sets can be operated, each with a different tuner setting?*

(7) *Is it possible to operate more than one set in the same net on the same tuner setting? Explain.*

(8) *Is it possible to have more nets in operation than there are tuner settings on the tuner dial? Explain.*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. Show the class during the preliminary assembly an SCR–77–A loop set, complete, with loop, storage battery, and plate-battery case. Open the front cover and point out the controls on the panel, naming each one. Lower the front panel so as to expose the interior of the set box. Using a blackboard diagram similar to the one shown in Fig. 96 of the Students Manual, point out and name each interior part as it appears in the set box.

2. Explain how the same circuit functions both as a transmitter and a receiver. Also explain that the loop replaces the wire type of antenna in this set.

3. Review carefully with the class the information given in the Students Manual regarding the operation of the set.

4. The important new words in this Unit Operation are as follows:

Loop antenna.	Break-in.	Zero beat note.
Milliampere.	Controller.	

5. In the event that a type 77–B set is available proceed with instructions on this set in the same manner as outlined in the above suggestions.

If the 77–B set is not available, review carefully with the class the information given on this set in the Students Manual.

6. When the students have completed this Unit Operation, they should know the names and symbols of the important parts of the SCR–77–A and 77–B sets. They should know how the two sets differ in construction and operation. They should be able to prepare a list of equipment necessary to install and operate either set. From the experiments performed in this Unit Operation the students should be able to:

a. Connect up both the SCR–77–A and 77–B sets.
b. Select an efficient detector-oscillator tube for the SCR–77–A set.
c. Select a master set.
d. Calibrate all sets.

7. When the students have finished the study of this Unit Operation, the following Instruction Test should be given. In the event that the SCR–77–B set is available, the instructor should devise a similar Performance Test covering this set.

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Suggestions for Conducting Instruction Test No. 19–A (Performance).

Directions to the instructor.

Equipment.

2 set boxes, type BC–9.
2 equipment boxes, type BE–48.
2 loops, type LP.
2 battery cases, type CS–17.
2 head sets, type P–11.
6 tubes, type VT–1 (2 good oscillators).
12 batteries, type BA–2.
2 batteries, type BB–41.

Procedure.

Problem No. 1.

a. The equipment listed above provides for two complete set-ups. Place one set of equipment in a suitable location for conducting the test and direct the student to connect this equipment completely, ready for transmission and reception. As each student finishes record the time taken to do the work and check the connections.

b. Point out any errors made by the student and allow time for him to make corrections.

Problem No. 2.

a. Set up the other SCR–77–A set in a room adjoining the one in which the test is being conducted. Direct an assistant to operate this set on a given tuner setting. The assistant should keep the key switch closed until he hears the signal from the set operated by the student. He should then operate the key until the instructor breaks in and indicates by a prearranged signal that the next student is to be tested. Direct the student to start the test set and tune it to the signal of the other set. When the student indicates that he has located the signal of the other set, record the time taken and check the tuning. Break-in and signal the assistant instructor that the next student is to be tested.

INSTRUCTION TEST NO. 19–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:

1 set box, type BC–9.
1 equipment box, type BE–48.
1 loop, type L. P.
1 battery case, type CS–17.
1 head set, type P–11.
3 tubes, type VT–1.
8 batteries, type BA–2.
1 battery, type BB–41.

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2. When the instructor directs "Begin," start the work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

a. Set up and connect the equipment laid out at your position completely, ready for transmission and reception.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will record the time taken to do the work and will check the connections.

Problem No. 2.

a. When the instructor again directs "Begin," proceed to tune the set to the signal of another set which is operating within range of your set.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

Scoring.

1. The maximum score for this test is 8 points.
2. The score required to pass this test is 8 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
If the SCR–77–A equipment is properly connected	4

PROBLEM NO. 2.

If the set is properly tuned to the signal of the second set	4

4. Where the student has failed to complete the test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or parts incorrectly performed.

INSTRUCTION TEST NO. 19–B (INFORMATION)

Directions to the student.—There are listed below a number of questions and unfinished statements. After each question or statement are several words or phrases preceded by a *number*. Only one of these is correct. Write the *number* of the correct word or phrase *on the dotted line at* the right of each question.

1. The SCR–77–A set provides communication by means of
   (1) damped-wave telegraphy.
   (2) continuous-wave telegraphy.
   (3) buzzer modulated telegraphy.
   (4) radio telephony. ......
2. Its wave-length range is from
   (1) 200 to 500 meters. (2) 56 to 58 meters.
   (3) 74 to 76 meters. (4) 90 to 120 meters. ......

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3. Its approximate range is about
(1) 20 miles. (2) 60 miles.
(3) one-quarter mile. (4) 3 miles. ------

4. The tuner scale is divided into the following number of positions:
(1) Ten. (2) Six. (3) Twelve. (4) Twenty. ------

5. The loop consists of the following number of sections:
(1) Two. (2) One. (3) Four. (4) Three. ------

6. The set employs the following number of tubes:
(1) One. (2) Three. (3) Two. (4) Four. ------

7. The "screw-driver" condenser is used
(1) to make one point on the tuner scales of several sets agree.
(2) as a vernier adjustment in tuning the set.
(3) as a lightning arrestor.
(4) as a safety gap to protect the tube. ------

8. The current necessary for lighting the filaments is obtained from
(1) a 12-volt storage battery. (2) a dynamotor.
(3) dry cells. (4) a 4-volt storage battery. ------

9. The plate potential for the detector-oscillator is supplied by
(1) a dynamotor. (2) dry cells.
(3) hand generator. (4) storage battery. ------

10. The amplifier has the following type of coupling:
(1) Transformer. (2) Choke coil.
(3) Resistance. (4) Capacity. ------

11. The following type of tube is used throughout in the SCR-77-A:
(1) VT-2. (2) VT-5. (3) VT-1. (4) VT-4. ------

12. If while the operator is sending a message he suddenly fails to hear his own signals in his phones, he should first
(1) Check all connections.
(2) See if his tubes are lighted.
(3) Close his key. (4) Adjust his controls. ------

13. In adjusting the "screw-driver" condenser for a "master set" the screw on this condenser is turned clockwise as far as it will go, and then turned counterclockwise
(1) one turn. (2) two turns.
(3) three turns. (4) four turns. ------

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Directions to the student.—Below are several sentences, and just after each one is a short dotted line (------). Read each sentence carefully, and if what it says is true write a plus sign (+) *on the line.* If what it says is not true write a minus sign (−) *on the line.*

14. Luminous paint lines are placed on the ammeter scale of the BC–9 set box so that it can be read at night. ------
15. Luminous paint lines are placed on all the scale markings. ------
16. The loop antenna makes connection with the set box, on top of the box. ------
17. The loop antenna requires a wrench for tightening at the joints. ------
18. The loop antenna is given a black finish so that it is not easily seen by the enemy. ------
19. The same circuit is used for both receiving and transmitting. ------
20. Only one pair of head phones can be connected to this set. ------
21. The loop is made in sections so that it can be made to assume different shapes. ------
22. One tube is used for an oscillator and also a detector. ------
23. One tube is used as a modulator. ------
24. The audio frequency amplifiers are used to increase the transmitting range. ------
25. All the tubes have their filaments connected in parallel. ------
26. The amplifier tubes use a plate voltage of 120. ------
27. One BA–2 battery is used for the proper grid potential. ------
28. The "plate current control" is a potentiometer in the grid circuit of the oscillator. ------
29. When two SCR–77–A sets are in operation, no signal is heard at either set, unless the keys on both sets are closed. ------
30. If the receiving operator misses a word, he can "break in" on the transmitting operator by opening his key. ------
31. The milliammeter reads from 0 to 8 milliamperes. ------
32. The grid and plate of the oscillator tube are inductively coupled. ------
33. If one tube is removed from its socket, the remaining tubes will not burn. ------
34. The oscillator tube socket is located at the left, looking at the set from the front. ------

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35. The SCR–77–A set actually transmits and receives at the same time. ------

36. Tube A draws 8 milliamperes and falls to 6 milliamperes when the loop is touched, while tube B draws 7 milliamperes and drops to 4 milliamperes when the loop is touched. Tube A is the best tube to use for transmitting. ------

37. Tube C draws 8 milliamperes and falls to 6 milliamperes when the loop is touched. Tube D draws 6 milliamperes and falls to 4 milliamperes when the loop is touched. Tube C would be better for a transmitting tube than tube D. ------

38. A tube that can be made to draw the least plate current by adjusting the controller and still show a slight drop when the loop is touched is a poor detector. ------

39. Several SCR–77–A sets can be calibrated from a master set at the same time. ------

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THE SCR-109-A AND SCR-159-A SETS.

Equipment.

1 transmitter, type BC-86-A.
1 receiver, type BC-98-A.
1 antenna equipment type A-9-A.
1 dynamotor, type DM-13.
3 batteries, type BB-14.
4 batteries, type BA-2.
1 headset, type P-11.
3 tubes, type VT-1.
1 tube, type VT-2.
2 tubes, type VT-4.
1 microphone transmitter, type T-3.
1 key, type J-12 or J-2.
1 cord, type CD-48.
2 cords, type CD-38.
3 cords, type CD-49.
1 wave meter, type SCR-125-A.
1 wave meter type SCR-61.

GENERAL CONSTRUCTION OF THE SCR-109-A AND SCR-159 SETS.

Information.

The SCR-109-A and SCR-159 are ground radio sending and receiving vacuum tube sets providing three means of communication; undamped or continuous wave radio telegraphy, buzzer modulated radio telegraphy and radio telephony. The two sets are identically the same, differing only in the antenna equipment. Their transmitting wave-length range is from 300 to 500 meters and the receiving wave-length range is frome 300 to 1,100 meters. The SCR-109-A set will furnish reliable communication with a similar set over a distance of 60 miles by undamped wave telegraphy; over a distance of 30 miles by buzzer modulated telegraphy; and over a distance of 20 miles by telephony.

NOTE.—As the SCR-109-A set and the SCR-159 set differ only in antenna equipment only one of the sets, the SCR-109-A will be referred to in this Unit Operation.

TRANSMITTER SET BOX, TYPE BC-86-A.

Three 4-volt storage batteries, connected in series, are required to furnish the necessary power to operate the BC-86-A transmitter. In practice two groups of batteries are connected in parallel, there

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being three batteries in series in each group. This grouping of batteries is necessary if the sets are to be operated any length of time, as a considerable amount of current is consumed by the vacuum tubes and dynamotor in the set. A dynamotor is provided for changing the 12-volt direct current furnished by the storage batteries to a 750–800-volt direct current. The motor takes about 27 amperes at 12 volts, while the output of the generator is approximately 0.2 of an ampere at 750 volts.

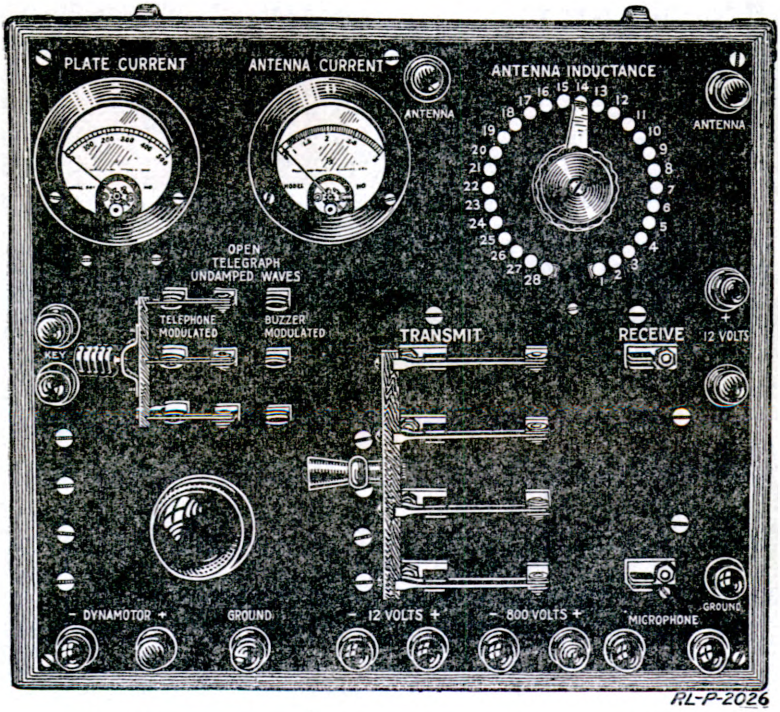

Fig. 101.—Front panel of transmitter set box, type BC–86A.

The BD–86–A set box (see Fig. 101) contains the necessary apparatus for the three methods of transmission. At the upper left-hand corner of the front panel is a milliammeter which indicates the plate current of the vacuum tubes used in the transmitter. To the right of this meter is a thermoammeter, which indicates the antenna current. In the upper right-hand corner is a 28-point dial switch controlling the number of turns of inductance included in the antenna circuit and hence controlling the transmitted wave length. Below this dial switch is a large four-pole, double-switch

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marked "Transmit-Receive." When thrown to "Transmit," the upper blade connects the antenna to the transmitting apparatus; the second blade closes the 800-volt plate circuit; the third blade closes the circuit of the 12-volt supply to the dynamotor, thus causing it to start up; and the bottom blade closes the filament circuit of the transmitting tubes. When thrown to "Receive," the upper

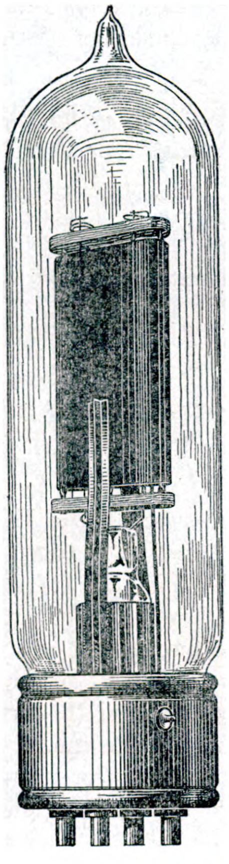

Fig. 102.—Type VT–4 vacuum tube.

blade connects the antenna to the receiving apparatus (in the BD–98–A set box), and the lower blade closes the filament circuit of the receiver vacuum tubes.

Beneath the two ammeters is a small three-pole double-throw switch which must be considered as having three positions—closed to the left, closed to the right, and open. This switch controls the three methods of transmission which are properly marked on the

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switch positions. The buzzer used in buzzer modulated telegraphy is mounted just below the three-pole switch. The necessary binding posts for connections are mounted along the edges of the panel and are plainly marked.

Directions.

1. Examine the panel of the BC–86–A (see Fig. 101), and note the marking of the various switches, knobs, and controls. Also observe carefully the positions and markings of the various binding posts.

Questions.

(1) *What is the range of the meter marked "Plate Current"? Of the meter marked "Antenna Current"?*

(2) *What connections are made to the four binding posts on the right-hand side of the panel?*

(3) *Where is the key connected to the set?*

(4) *For what purpose are the two binding posts marked "+ and Dynamotor?"*

(5) *Where are the filament current connections made for the transmitting tubes?*

Information.

Three vacuum tubes are used in the BC–86–A transmitter—two type VT–4 tubes and one type VT–2 tube. The VT–4 vacuum tube is a high-power tube. (See Fig. 102.)

Its output is rated at 50 watts. One of the VT–4 tubes is used as an oscillator while the other is used as a modulator. The purpose of the VT–2 tube in this circuit is to amplify the voice or buzzer currents which are impressed upon the grid of the oscillator tube. The proper grid potential for the modulator and VT–2 amplifier tubes in the transmitter is obtained from a 40-volt battery (two type BA–2 batteries in series), which is placed in a container inside the set box.

Capacity coupling is used between the grid and plate circuits of the oscillator tube. The antenna circuit acts as part of the capacity coupling, and therefore is a factor in determining the wave length of the transmitter. The plate circuit of the oscillator tube is directly coupled to the antenna circuit through the antenna inductance. The coupling is varied by means of an 8-point switch. This switch is located at the rear of the antenna inductance inside the set box. The coupling between the oscillator, modulator, and amplifier tubes is obtained by the use of audio frequency transformers.

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When the large three-position switch on the front of the panel is thrown to "Open," the proper connections are made for transmitting undamped wave signals. (See Fig. 103.) In this case the VT–4 modulator tube and the VT–2 amplifier tube are not connected in the transmitting circuit. The impulses delivered to the antenna circuit by the oscillator tube are controlled by the telegraph key. For instance, when the key is depressed the impulses are being generated by the VT–4 and radiated from the antenna in the form of continuous waves. When the key is released the generating

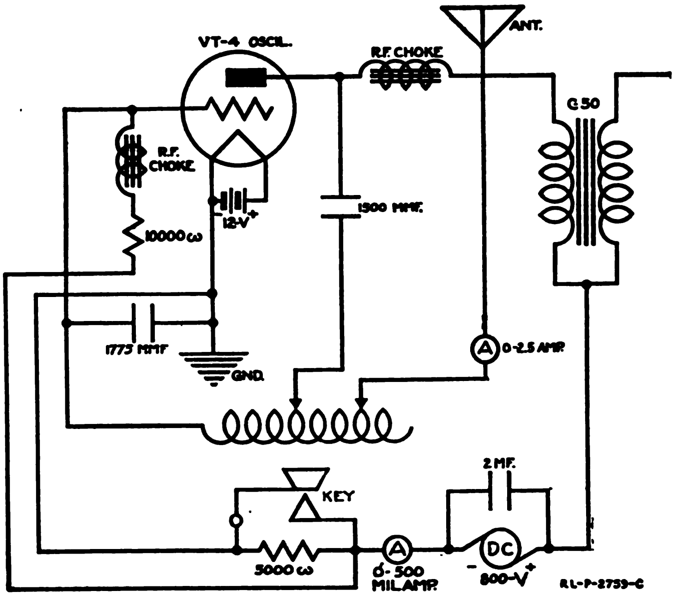

Fig. 103.—Schematic diagram of connections when the BC–86–A transmitter is being used for the transmission of undamped-wave signals.

action ceases. In this way signals are sent by the usual manipulation of the key.

When the three-position switch is thrown to the "Telephone Modulated" position, all three transmitting tubes are connected in the circuit. (See Fig. No. 104.) A microphone is connected to the proper terminals, and when spoken into it conducts the voice currents to the coupling transformer which is connected to the grid circuit of the VT–2 amplifier tube. Here the voice currents are amplified and then impressed upon the grid of the modulator tube through the second coupling transformer. The modulator tube in turn amplifies the voice currents again and impresses them upon the impulses generated by the oscillator tube through the third amplifying transformer.

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The result is that the continuous waves radiated from the antenna are modulated to conform to the voice currents of the microphone.

With the three-position switch thrown to the "Buzzer Modulated" position, the proper connections are made for transmitting buzzer modulated radio telegraph signals. (See Fig. 105.) The three tubes of the transmitter are again in use, the same as for radio telephony. The small buzzer is connected across a small resistance and, therefore, obtains enough current to operate steadily. The interrupted currents from the buzzer are amplified in the same manner as the voice currents from the microphone and are impressed upon the impulses generated by the oscillator tube. The oscillator tube, however, is connected the same as it is when transmitting undamped wave telegraph

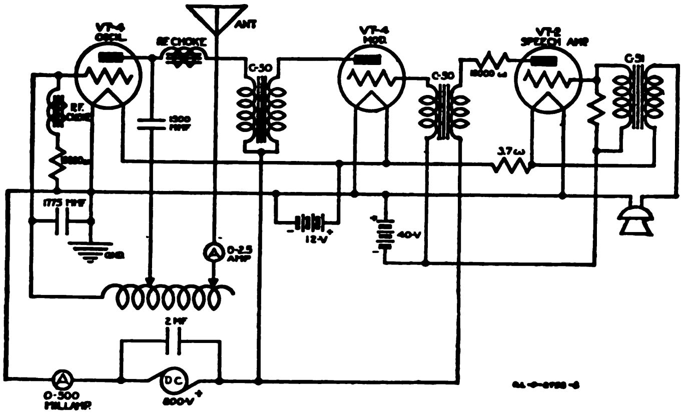

Fig. 104.—Schematic diagram of connections when the BC-86-A is being used as a radio telephone transmitter.

signals. In other words the oscillator tube generates impulses only when the key is depressed. When the key is held down the impulses generated by the oscillator tube are modulated by the buzzer currents. When the transmitter is used as a radio telephone, the oscillator tube is generating impulses continuously, and these impulses are modulated only when the microphone is spoken into. When buzzer modulated signals are transmitted, the reverse of this is true, as the modulator is operating continuously and the oscillator generates only when the key is depressed. The buzzer modulated wave radiated by the antenna may be received by any receiving set which uses a crystal detector or a simple vacuum tube detector circuit. The note heard in the telephone receivers will be exactly the same as the original note of the buzzer in the transmitter.

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Directions.

2. Remove the four screws in the corners of panel and the screws in the center of the horizontal edges of the panel. This allows the

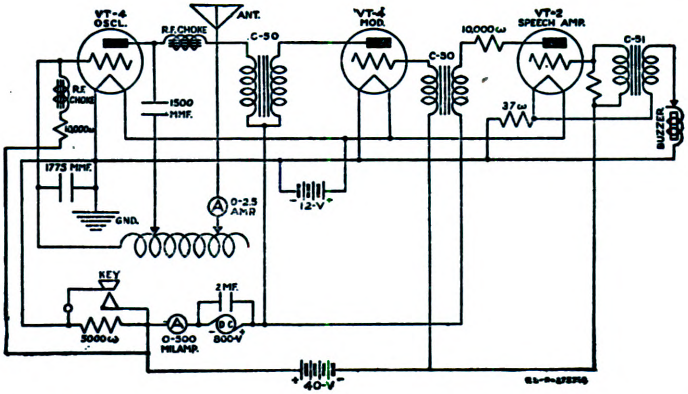

Fig. 105.—Schematic diagram of connections when the BC–86–A is being used as a transmitter of buzzer modulated signals.

panel to be removed from the wooden box frame. Using Fig. 106, locate the various parts of the apparatus on the rear of the panel.

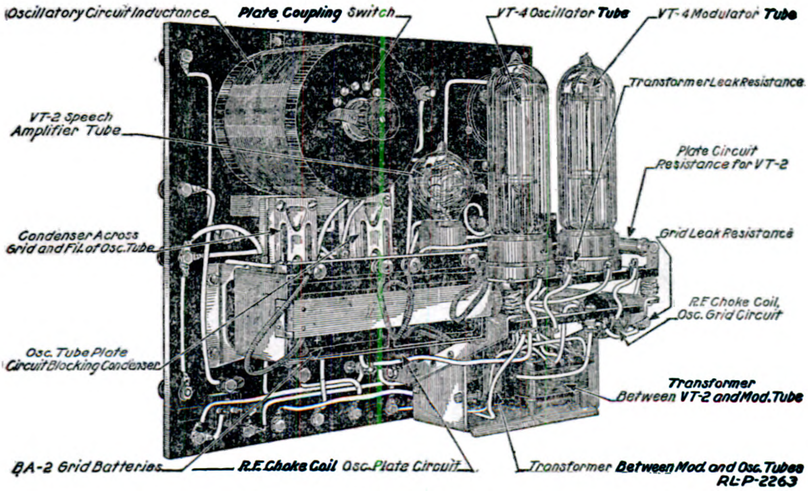

Fig. 106.—Rear view of BC–86–A transmitter panel.

Questions.

(6) *Locate the antenna inductance. How is it varied?*

(7) *Does this variation affect the wave length of the transmitter?*

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(8) *How is the coupling between the antenna current and the oscillator circuit varied? What kind of coupling is used?*

(9) *Locate the oscillator, modulator, and VT–2 tube sockets. What difference is there in the sockets?*

(10) *Where is the container for the grid battery located?*

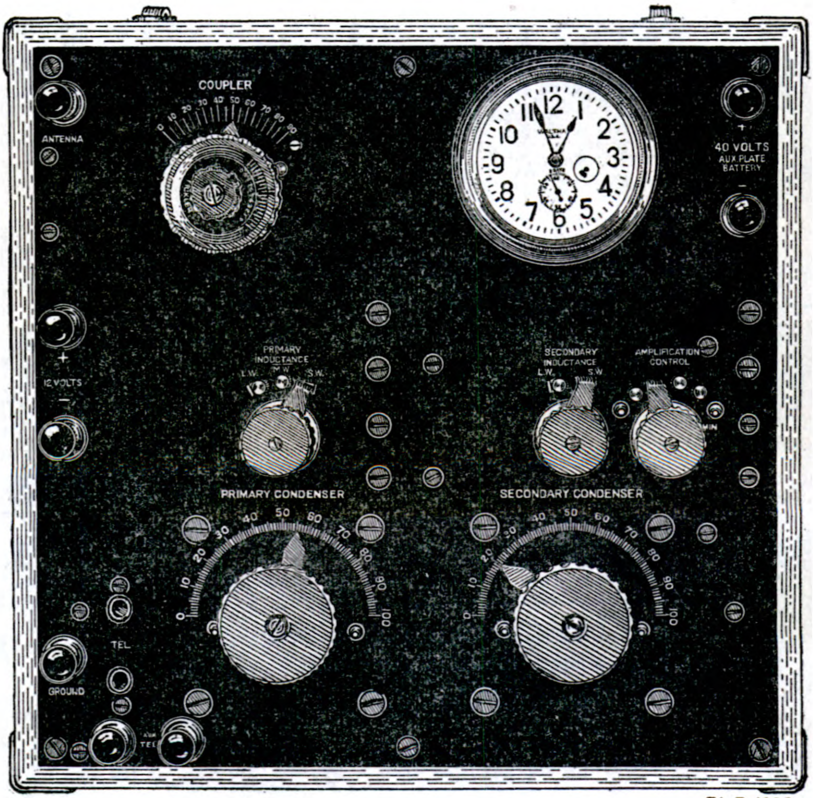

Fig. 107.—Front panel of BC–98–A receiver set box.

(11) *Locate the transformer used for coupling the oscillator and modulator tubes.*

(12) *What is the use of the buzzer in this set?*

(13) *Does the buzzer operate continuously when buzzer modulated telegraph signals are being transmitted?*

Information.

The receiving apparatus of the SCR–109–A is contained in the BC–98–A set box. (See Fig. 107.) It is similar in size to the trans-

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mitter set box. The necessary controls for operating the receiver are mounted on the front panel. The receiver is equipped with a vacuum tube detector and two stages of audio frequency amplification. Along the left-hand edge of the panel are four binding posts marked "Antenna," "+ 12 Volts," "— Volts," and "Ground," respectively.

These binding posts, when the set is used in the field, are connected to the corresponding binding posts on the right-hand edge of the transmitter panel. As the three VT-1 tubes are connected in series, the voltage required for the filaments is the same as that supplied to the filaments of the transmitting tubes. The two binding posts on the upper right edge of the receiver panel marked "+ 40 Volts Aux. Plate Battery" are provided in case it is necessary to use an external 40-volt plate battery instead of the one that fits the compartment provided in the inside of the set box.

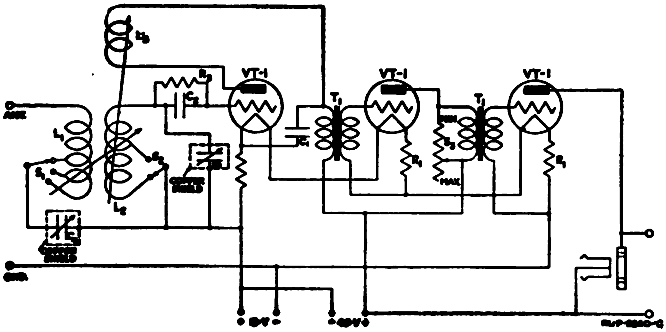

Fig. 108.—Schematic diagram of connections in set box BC-98-A.

The antenna circuit of the receiver (see Fig. 108) consists of a primary inductance having three taps and a primary variable condenser. The primary inductance is inductively coupled to the secondary which consists of a secondary inductance having two taps and a secondary variable condenser. The coupling between the primary and secondary inductances is varied by turning the larger of the two knobs mounted together on the upper left-hand corner of the panel.

The plate circuit of the detector tube (see Fig. 108) contains a tickler coil which is coupled to the secondary inductance coil. This coupling is varied by means of the knob marked "Tickler" which is mounted, together with the secondary coupler knob, on the upper left-hand corner of the panel.

The adjustment of the tickler is especially important in the BC-98-A receiver. The tickler in this set provides a means for ad-

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justing the receiving circuit so that C. W. signals as well as damped wave signals may be received. The proper adjustment of the tickler also makes possible an increase in signal strength and greater selectivity when receiving damped wave signals.

Directions.

3. Release the two latches at the top of the BC–98–A set box and remove the back. This leaves the back of the panel and attached part exposed to view. (See Fig. 109.) Turn the various controls and the parts on the rear of the panel that move. Check wiring diagram as far as possible.

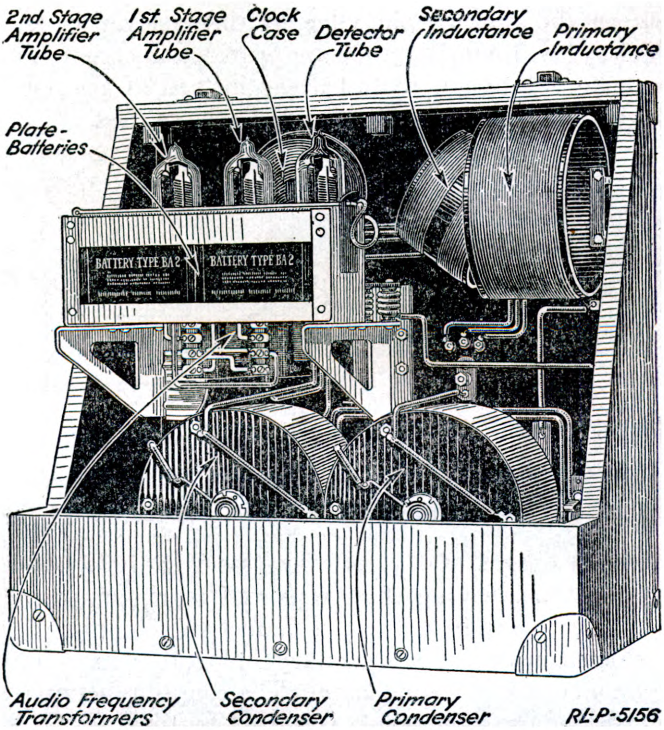

Fig. 109.—Rear of BC–98–A receiver panel.

Questions.

(14) Note how the primary, secondary, and tickler inductance coils are mounted. Which is the secondary? Which the tickler?

(15) What is the purpose of the switch marked "Amplification Control"?

(16) How is the wave length of the primary circuit varied? Of the secondary circuit?

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(17) Locate the "B" battery container. How many terminals are provided on it?

(18) How many pairs of phones can be plugged into this set?

(19) What connections are made to the binding posts marked "Aerial" and "Ground"?

EXPERIMENT No. 1.

TO CONNECT UP AND TUNE THE SCR–109–A.

Information.

The SCR–109–A set differs from other sets such as the SCR–79–A, the SCR–130, and the SCR–77–A sets in that the transmitting and

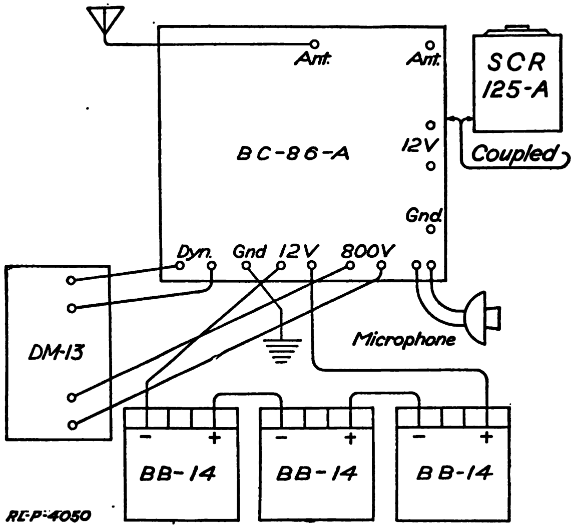

Fig. 110.—Cording diagram of transmitter connections of SCR–109–A set and method of coupling the SCR–125–A wave meter to transmitter circuit.

receiving apparatus are contained in separate boxes. Either set box may be connected up and operated independently of the other. Also the receiver set box may be connected up in conjunction with the transmitter set box so that the receiver may be placed in operation when desired by manipulating the proper switches on the transmitter panel. The transmitter and receiver are tuned separately.

Directions.

4. To connect up the transmitter. (See Fig. No. 110.)

a. Place the BC–86–A set box on the surface on which it is to be operated. Remove the cover of the set box.

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b. Insert two VT–4 tubes in the two large sockets on the tube shelf and insert a VT–2 tube in the small socket.

c. Place two BA–2 batteries in the compartment back of the tube shelf and connect the leads from the batteries to the four binding posts provided in the correct order indicated. Make sure that the connections are correct in polarity.

d. Open the "Trans.-Rec." switch.

e. Connect three 4-volt storage batteries in series and using the cord, type CD–48, connect the 12-volt battery thus formed to the two binding posts on the lower edge of the panel marked "— 12 volts +." Do not complete the circuit, but leave the negative lead disconnected at the battery.

f. Connect the antenna lead-in to the binding post in the center of the top of the panel marked "Ant."

g. Connect the wire from the counterpoise or other ground system used to the binding post on the lower edge of the panel marked "Gnd."

h. With the proper cord connect the motor (or low voltage side of the dynamotor) to the two binding posts on the panel marked "— Dynamotor +," with the correct polarity.

i. With the proper cord connect the generator (or high voltage side of the dynamotor) to the two posts on the panel marked "— 800 volts +" with the correct polarity.

j. Connect the key to the proper binding posts on the panel and plug the microphone in the jack provided.

k. Check all connections to see that they are correct.

l. Connect the negative lead of the cord, type CD–48, to the negative terminal of the 12-volt battery. The transmitter should now be ready for operation.

Information.

The transmitter of the SCR–109–A besides having an adjustment for wave length, also has one for coupling. This coupling adjustment is made by the 8-point switch located on the rear of the antenna inductance. Its position has some influence on the transmitting wave length, so that, it is necessary to note its position if it is desired to return to any given wave length.

The wave length on which the BC–86–A set box transmits is dependent on the type of antenna used and it is, therefore, impossible to calibrate it for use with any antenna. It is necessary to make a table of settings corresponding to the wave lengths on which the set will be required to transmit for each antenna system used. The settings for each of these wave lengths should be obtained in the manner explained below.

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Directions.

5. To tune the transmitter to a given wave length.

a. Set the antenna inductance switch approximately at the wave length desired. (Suppose that the wave length desired is 400 meters. Four hundred meters is halfway along the wave-length range of the set. Therefore, as a trial setting, place the antenna inductance switch halfway around "Max.")

b. Throw the small double-pole switch on the panel to the "C. W." position and the "Trans.-Rec." switch to the "Trans." position. The dynamotor should now start running and the filament of the oscillator tube should light with a dull red glow.

c. Close the key and vary the coupling switch (on the back of the antenna inductance) until the plate milliammeter on the panel reads about 125 milliamperes.

d. Light the lamp of the SCR–125–A wave meter and adjust it to a dull red glow.

e. Couple the SCR–125–A wave meter to the antenna inductance and vary the wave meter dial until the lamp glows brightly. If this occurs at a wave length greater than that desired, reduce the antenna inductance. If it occurs at a wave length less than the wave length desired, increase the antenna inductance.

f. After adjusting the antenna inductance, measure the wave length again and continue this process until the inductance tap is found which gives the wave length nearest that desired.

g. If the plate milliammeter does not indicate a reading of about 125 milliamperes, readjust the coupling until this value is obtained. If the coupling switch is adjusted in order to get the correct plate current, the antenna inductance switch may require readjustment in order to maintain the correct wave length.

h. After the above adjustments have been made the transmitter should be sending continuous waves on the desired wave length. If it is desired to send buzzer or telephone modulated waves, the small double-pole switch on the panel is thrown to the proper position for the type of modulation desired and the wave length again checked and adjusted if necessary.

Questions.

(20) *Why is the "Trans.-Rec." switch left open until all connections have been made?*

(21) *Would the set transmit any kind of signal without the key being connected?*

(22) *What is the range of the antenna current ammeter?*

(23) *Why can not the transmitter be permanently calibrated?*

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(24) *What is the wave length range of the SCR–125–A wave meter?*

(25) *What is the purpose of the coupling switch?*

(26) *What plate current does the oscillator tube normally draw?*

(27) *Does the plate milliammeter read only the plate current of the oscillator tube?*

(28) *How much difference in wave length does one tap of the antenna inductance make?*

(29) *When the coupling switch is varied, does it vary the transmitting wave length?*

(30) *When transmitting continuous waves, do the filaments of all three tubes light?*

(31) *What value of antenna current did you obtain in tuning the transmitter?*

Information.

The receiver of the SCR–109–A is contained in a separate box known as set box, type BC–98–A. It may be used either separately or with its transmitter. When connected up with the transmitter it forms a complete unit for transmission and reception. The transmitter is provided with the necessary binding post for connecting the receiver. In the following directions it is assumed that the transmitter has already been connected up and that it is desired to complete the set by connecting up the receiver.

Directions.

6. To connect up the receiver. (See Fig. 111.)

a. Place the set box, type BC–98–A on the right side of the transmitter and with their panels in line. Open up the cover to the receiver.

b. Place two BA-2 batteries in the compartment back of the panel and connect the leads of the batteries to the binding posts provided in the correct order and with the proper polarity. Insert three VT-2 tubes in the three sockets and close the cover of the receiver.

c. On the left edge of the panel of the receiver are four binding posts marked "Antenna," "+ 12 volts", "— 12 volts," and "Ground." On the right edge of the transmitter panel are four binding posts corresponding to the first four. After making sure that the "Trans.-Rec." switch is open, connect the corresponding binding posts to-

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gether, that is, the "Antenna" post on the receiver to the "Antenna" post on the transmitter and so on.

d. Insert the plugs of one or two head sets, type P-11, in the jacks provided on the receiver panel and adjust one of the head sets to fit the head comfortably. (If the head sets available have no plugs, they may be connected to the two binding posts on the receiver panel marked "Aux. Tel.") The receiver is now completely connected and ready for operation.

e. If it is desired to connect up the receiver only, and not the transmitter, the four binding posts on the left edge of the receiver panel are

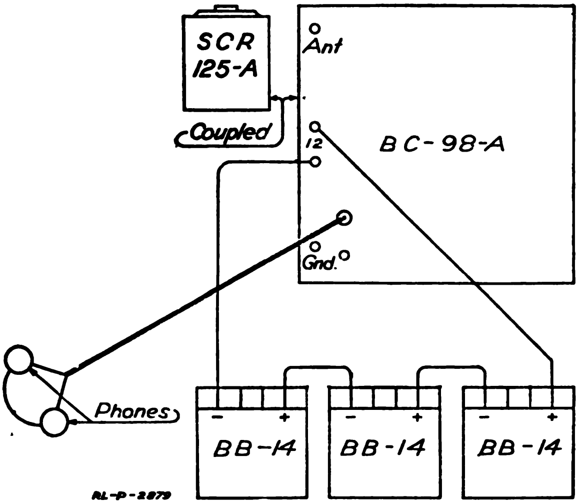

Fig. 111.—Cording diagram of receiver connections of SCR–109–A set and method of coupling the SCR–125–A wave meter to the receiver circuit.

connected directly to the "Antenna", "Ground," and "+ and − 12-volt" leads from the storage battery and *not* to the corresponding posts on the transmitter panel.

Questions.

(32) *Why do the antenna, ground, and filament battery connections for the receiver go through the transmitter when both units are connected up?*

(33) *For what reason are the two binding posts on the receiver panel marked "+ and − 40 volts Aux. plate battery"?*

(34) *When the receiver alone is used, how can you turn off the filament current?*

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(35) *What kind of connectors did you use between the corresponding binding posts on the receiver and transmitter panels?*

(36) *What is the advantage of having the transmitter in a separate box?*

(37) *What is the disadvantage of having the receiver in a separate box?*

Directions.

7. To connect up the complete set.

a. Connect up the transmitter as previously given.

b. When the transmitter has been completely connected up, connect up the receiver as given above and the complete set will be ready for operation.

Information.

In tuning the receiver, several different cases will occur. They are as follows:

a. Tuning in a C.W. signal of known wave length.

b. Tuning in a damped wave signal of known wave length.

c. Tuning in a C.W. signal of unknown wave length.

d. Tuning in a damped wave signal of unknown wave length.

Directions.

8. To tune the receiver to a C.W. signal of known wave length.

a. Throw the "Trans.-Rec." switch to the "Rec." position (if the transmitter is connected up).

b. Set the secondary coupling on the 20° mark.

c. Set the secondary "LW-SW" switch and the secondary condenser to the desired wave length as given by the calibration of the set.

d. Beginning at "0" on the scale, increase the tickler coupling until a distinct double click is heard in the head set, and then set the coupling adjustment two scale divisions beyond the point where the click is heard.

e. Vary the primary inductance switch and the primary condenser at the same time until a distinct double click is heard. Without moving the secondary condenser, set the primary condenser about 5° to either side of the point where this click was heard.

f. The receiver should now be in tune on the desired wave length, but due to inaccuracies which may occur, the tuning may not be exact enough to pick up the signal desired. If the signal is not heard, the secondary condenser control should be slowly rotated, covering

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an arc of 10°, about 5° either side of the setting given by the calibration of the set.

g. A small further adjustment of the primary condenser, the secondary coupling, and the tickler coupling should now be made in order to increase the loudness of the signal.

9. To tune the receiver to a damped wave signal of known wave length:

a. Same as *a* above.

b. Same as *b* above.

c. Same as *c* above.

d. Same as *d* above.

e. Same as *e* above.

f. Decrease the tickler coupling to a point just below where the double click is heard.

g. Same as *f* above.

h. Same as *g* above.

10. To tune the receiver to a C.W. signal of unknown wave length:

a. Same as *a* under Direction 8.

b. Same as *b* under Direction 8.

c. Set the primary inductance switch on "SW."

d. Set the secondary inductance switch on "SW."

e. Set the secondary condenser on about 5° and increase the tickler coupling until a click is heard.

f. Vary the primary inductance switch and the primary condenser until the double click indicating resonance is heard.

NOTE.—For every adjustment of the secondary circuit there should be a corresponding adjustment of the primary circuit at which the two are in tune. In searching for a signal of unknown wave length, both condensers should be varied at the same time, attempting always to keep the primary condenser close to that point where its circuit is in tune with the secondary.

g. Starting with the secondary condenser at about 5° and the primary condenser at the point where it is in tune, slowly turn both condensers as outlined in the note above, over their entire scale. It may be necessary to increase the primary inductance as the secondary condenser reaches the higher part of its scale in order that the primary circuit may remain in tune with the secondary.

h. If the desired signal is not heard as under Direction *g* above, set the secondary inductance switch on "LW" and repeat Direction *g*, being sure that at all times the primary circuit is in tune.

i. When the desired signal is found, adjust very carefully the primary and secondary condensers, and the secondary and tickler couplings for a loud clear signal of good readable pitch.

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11. To tune the receiver to a damped wave signal of unknown wave length:

a. Follow exactly the procedure outlined under Direction 10 above until the desired signal is found. When found the natural tone of the damped wave will be very badly distorted.

b. Decrease the tickler coupling until the natural tone of the damped wave appears and if necessary readjust the primary and secondary condensers and the secondary coupling.

NOTE.—Damped waves may be received with the tickler coupling adjusted so that the receiver is oscillating, if the change in tone is not objectionable. In receiving telephone signals the tickler coupling must be reduced until the distortion of signals is eliminated.

Questions.

(38) *Why is a different method of tuning followed when looking for a signal of unknown wave length than when looking for one of known wave length?*

(39) *If your receiver were not calibrated how would you tune in a signal of known wave length?*

(40) *Which condenser has the greatest effect on the tuning?*

(41) *When you tune in a telephone signal with the tickler coupling to near maximum, what happens?*

(42) *Is the adjustment of the secondary condenser as critical when tuning in a telephone signal as when tuning in a C. W. signal?*

EXPERIMENT No. 2.

OPERATION OF TRANSMITTER.

Directions.

12. Place the BC–86–A transmitter in operation as given in Experiment No. 1. (See Fig. No. 110.)

a. Pull open the small 3-pole switch. Throw the large switch to the "Transmit" position. The dynamotor should start and the oscillator tube should light up. Turn the "Antenna Inductance" switch to stud No. 1 (Min.). Close the key of the transmitter and adjust the 8-point coupling switch until the "Plate Current" ammeter shows a reading of 125 milliamperes or as near this value as can be obtained. With this adjustment the "Antenna Current" meter should show a reading of over one ampere.

b. Throw the small switch to the "Buzzer Modulated" position and note any changes in the reading of the two meters on the panel when the telegraph key is alternately opened and closed.

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c. Throw the small switch to the "Telephone Modulated" position and note any further changes in the reading of the two ammeters. Speak and whistle into the microphone and note variation of the plate current reading, if any.

Questions.

(43) *Is there any difference between the readings of the two meters when using the modulated methods of transmission and when using the continuous wave method?*

(44) *Do the readings of the meters change when the key is opened and closed while using "Buzzer Modulation"?*

(45) *Does any change take place in the reading of the "Plate Current" ammeter when using telephone modulation?*

(46) *Which method of transmission would cover the greatest distance?*

EXPERIMENT No. 3.

DETERMINING THE WAVE LENGTH RANGE OF THE TRANSMITTER.

Information.

The transmitter of the SCR-109-A, like that of the SCR-79-A, is dependent on its antenna system for the wave length on which it transmits. It is accordingly impossible to calibrate permanently the transmitter, and it is therefore necessary to calibrate it each time the antenna is erected and the set put in operation. This calibration will hold only so long as no change is made in the antenna or ground systems. In actual operation in the field it will not be necessary to calibrate the set for all possible wave lengths but only for those upon which it may be necessary to communicate. It is to be noted with this set that it is impossible to set the transmitting wave length exactly on any given wave length within its range unless the given wave length happens to fall on one of the taps of the antenna inductance.

Directions.

13. Throw "Transmit-Receive" switch to "Transmit" and open the small three-pole switch. Adjust the coupling switch so that the plate current meter shows a reading of about 125 milliamperes. Turn the "Antenna Inductance" switch to the No. 1 stud.

14. With the telegraph key closed take a reading of the wave length using the SCR-125-A wave meter.

15. Take wave length readings for the remaining adjustments of the "Antenna Inductance" switch and record in the table below.

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Also record the readings of the two meters and the plate coupling tap used for each wave length setting. Remember that the plate coupling may have to be readjusted when changing the wave length adjustment in order to keep the reading of the "plate current" meter around 125 milliamperes.

16. Throw the small three-pole switch to the "Buzzer Modulated" position. Using the SCR–61 wave meter, check a few of the wave length readings taken in the above experiment. Also check the wave length readings with the small switch thrown to the "Telephone Modulated Position."

Wave length.	Primary inductance tap.	Plate coupling tap.	Plate current.	Antenna current.
	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
	7.			
	8.			
	9.			
	10.			
	11.			
	12.			
	13.			
	14.			
	15.			
	16.			
	17.			
	18.			
	19.			
	20.			
	21.			
	22.			
	23.			
	24.			
	25.			
	26.			
	27.			
	28.			

Questions.

(47) *From Experiment No. 3, what is the wave length range of the set?*

(48) *Was there any difference in the wave length readings for the same setting of the antenna inductance when the continuous wave system was used, and when the buzzer and telephone modulated systems were used?*

(49) *If an SCR–125–A wave meter were not on hand, would it be possible to adjust the transmitter to a certain wave length for all three systems by using an SCR–61 wave meter? Explain.*

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EXPERIMENT No. 4.

CALIBRATION OF THE RECEIVER.

Information.

Where possible the receiver of any radio set should be permanently calibrated over its entire wave length range. With the receiver of the SCR–109–A this is possible only for the secondary circuit and for fixed adjustments of the secondary and tickler couplings.

Directions.

17. Connect up the receiver ready for operation as given in Experiment No. 1.

a. Set the secondary coupling on 20°.

b. Set the secondary inductance switch on "SW."

c. With an SCR–125–A wave meter measure the wave length of the secondary circuit for each 10° of the secondary condenser. For each setting of the secondary condenser set the tickler coupling 5° beyond the point where a double click is heard.

d. Record the settings obtained in table similar to the one shown below.

Secondary inductance switch on "SW."

Secondary condenser.	Wave length.
0	
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	

e. Set the secondary inductance switch on "LW."

f. Repeat *c.* above.

g. Record the settings obtained in a table similar to the one shown below.

Secondary inductance switch on "LW."

Secondary condenser.	Wave length.
0	
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	

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Questions.

(50) *From the above experiment what is the wave length range of the receiver of the SCR–109–A?*

(51) *At what wave length was the change made from "SW" to "LW" on the secondary inductance?*

(52) *Did the tickler coupling vary with the wave length?*

EXPERIMENT No. 5.

RECEIVING.

Directions.

18. Set up and connect for operation the transmitter of an SCR–109–A, using the standard antenna. Three or four hundred yards away set up and connect for operation the receiver of an SCR–109–A, using either the standard antenna supplied with the set or a 150-foot "V" type antenna.

19. The operator of the transmitter will send buzzer modulated signals on a given wave length. Tune the receiver to the transmitted signals.

Questions.

(53) *After tuning the primary and secondary circuits, did the signal strength increase with increase of the tickler coupling?*

(54) *With the tickler coupling below the point where a click is obtained, do the received sgnals sound exactly like the buzzer on the transmitter?*

(55) *As the tickler coupling was changed, did the secondary condenser need any readjustment?*

(56) *Was the sound of the signal greatly changed as the tickler coupling was increased beyond the point where the click was obtained?*

Directions.

20. The operator of the transmitter will send continuous wave signals. Tune the receiver to these signals.

Questions.

(57) *Where was the tickler coupling when the continuous wave signals were first heard?*

(58) *Can these signals be heard with the tickler coupling below the point where the click is obtained?*

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(59) *When these signals are properly tuned in, what is the effect of slight changes in the tickler coupling?*

(60) *If the tickler control is adjusted anywhere between the point where the click is heard and its maximum position, can the signals still be heard?*

Directions.

21. The operator of the transmitter will change over to telephone modulated signals. Tune the receiver to these signals.

Questions.

(61) *What is the best position of the tickler for the reception of these signals?*

(62) *Can you recognize the voice of the transmitting operator?*

(63) *Can you understand all of his words?*

(64) *With the tickler coupling beyond the point where the click is heard, what do you hear?*

(65) *Tune the set as though you were looking for a continuous wave signal. What do you hear?*

(66) *With the tuning as in Question (65) decrease the tickler coupling below the point where the click is obtained. What do you hear?*

(67) *Based on your answers to Questions (65) and (66), what would be a good method of tuning the set when trying to pick up a weak telephone signal?*

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Proceed as in former Unit Operations. Show the class during the preliminary assembly the type BC–86–A set box with the front panel removed. Point out the various controls and meters on the panel. Explain the use of the small three-position switch; also the antenna inductance switch. Show the rear of the panel. Point out and name the important parts. Explain the use of the plate coupling switch. Draw on the blackboard step by step the diagrams shown in Figs. 103, 104, and 105 of the Students Manual. Point out and name each part as it is drawn in the diagram and show its location in the set box.

2. Show the class the type DM–13 dynamotor and the type T–3 microphone transmitter. Show how they differ from those used on previous sets.

3. Review with the class the information on the transmitting circuit given in the Students Manual.

4. Show the class the type BC–98–A set box. In the same manner as outlined above for the transmitter explain the use of the various controls and parts on the front and rear of the panel, using as an aid a blackboard diagram similar to Fig. 108 of the Students Manual.

5. Review with the class the information on the receiving circuit given in the Students Manual.

6. The important new word in this Unit Operation is as follows:
Buzzer modulated.

7. When the students have completed this Unit Operation, they should know the names and symbols of the important parts of the SCR–109–A set. They should be able to prepare a list of the complete equipment necessary to install and operate the SCR–109–A and SCR–159–A sets.

8. From the experiments performed in this Unit Operation the students should know:

a. How to connect, install, and connect up the SCR–109–A set completely, ready for operation.

b. How to tune the transmitter and receiver to designated wave lengths.

c. How to tune the receiver to unknown wave lengths.

d. How to calibrate the receiver.

e. How to determine the wave-length range of the transmitter.

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SUGGESTIONS FOR CONDUCTING INSTRUCTION TEST No. 20–A (PERFORMANCE)

Directions to the instructor.

Equipment.

1 set box, type BC–86–A.
1 receiver, type BC–98–A.
1 antenna equipment, type A–9–A.
1 dynamotor, type DM–13.
3 batteries, type BB–14.
4 batteries, type BA–2.
1 head set, type P–11.
3 tubes, type VT–1.
1 tube, type VT–2.
2 tubes, type VT–4.
1 microphone transmitter, type T–3.
1 key, type J–12 or J–2.
1 cord, type CD–48.
2 cords, type CD–38.
3 cords, type CD–49.
1 wave meter, type SCR–125–A.

Procedure.

Problem No. 1.

a. Place the equipment listed above in a suitable location for conducting the test and direct the student to conduct this equipment so that it will transmit and receive signals. As each student finishes record the time taken to do the work and check the connections.

b. Point out any errors made by the student and allow time for him to make corrections.

Problem No. 2.

Direct the student to tune the transmitter for maximum radiation on a given wave length. As each student finishes record the time and check the tuning of the transmitter.

Problem No. 3.

Start the SCR–125–A wave meter, transmitting on some wave length unknown to the student Direct the student to tune the receiver of the set to the signal of the wave meter. As each student finishes record the time taken to do the work and check the tuning of the receiver.

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INSTRUCTION TEST NO. 20–A (PERFORMANCE).

Directions to the student.

1. The following equipment is laid out at your position:
   - 1 set box, type BC–86–A.
   - 1 receiver, type BC–98–A.
   - 1 antenna equipment, type A–9–A.
   - 1 dynamotor, type DM–13.
   - 3 batteries, type BB–14.
   - 4 batteries, type BA–2.
   - 1 head set, type P–11.
   - 3 tubes, type VT–1.
   - 1 tube, type VT–2.
   - 2 tubes, type VT–4.
   - 1 microphone transmitter, type T–3.
   - 1 key, type J–12 or J–2.
   - 1 cord, type CD–48.
   - 2 cords, type CD–38.
   - 3 cords, type CD–49.
   - 1 wave meter, type SCR–125–A.

2. When the instructor directs "Begin," start work promptly. Perform the following operations carefully and quickly:

Problem No. 1.

a. Connect up the SCR–109–A equipment completely, ready for undamped-wave transmission and damped-wave reception.

b. Notify the instructor when you have finished by facing about and raising your hand. The instructor will record the time taken to do the work and will check the connections.

Problem No. 2.

a. When the instructor again directs "Begin," proceed to tune the transmitter of the set to a wave length designated by the instructor. Tune the transmitter so as to obtain maximum radiation on this wave length.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

Problem No. 3.

a. When the instructor again directs "Begin," tune the receiver of the set to the signal of the wave meter, being careful to obtain a clear signal of maximum strength in the receiver.

b. Notify the instructor when you have finished by facing about and raising your right hand. The instructor will again record the time taken and will check the tuning.

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Scoring.

1. The maximum score for this test is 18 points.
2. The score required to pass this test is 16 points.
3. *Directions for scoring.*

PROBLEM NO. 1.

	Points.
If the SCR–109–A equipment is properly connected	6

PROBLEM NO. 2.

a. If the transmitter is adjusted for continuous wave transmission	2
b. If the transmitter is properly tuned to the wave length designated	4

PROBLEM NO. 3.

a. If the receiver is properly tuned to the signal of the wave meter	4
b. If the signal in the phones is clear	2

4. Where the student has failed to complete the test, or has failed to perform the experiments correctly, a grade of zero will be given for incomplete parts or parts incorrectly performed.

INSTRUCTION TEST NO. 20–B (INFORMATION).

Directions to the student.—There are listed below a number of questions and unfinished statements. After each question or statement are several words or phrases, preceded by a *number*. Only *one* of these is correct. Write the *number* of the correct word or phrase *on the dotted line* at the right of each question.

1. The transmitting wave-length range, in meters, is from
   (1) 200 to 800. (2) 300 to 500.
   (3) 300 to 1,100. (4) 200 to 350. ------
2. The receiving wave-length range, in meters, is from
   (1) 300 to 1,100. (2) 200 to 800.
   (3) 300 to 3,000. (4) 300 to 500. ------
3. The plate-current milliammeter on the transmitter reads from
   (1) 0 to 100. (2) 0 to 1,000.
   (3) 0 to 500. (4) 0 to 1,500. ------
4. The antenna-current ammeter reads from
   (1) 0 to 500. (2) 0 to 100.
   (3) 0 to 5. (4) 0 to 3. ------
5. The antenna inductance of the transmitter has the following number of taps:
   (1) Ten. (2) Fifteen.
   (3) Eighteen. (4) Twenty-eight. ------
6. The following filament voltage is used to light the transmitter tubes:
   (1) 4 volts. (2) 8 volts. (3) 12 volts. (4) 16 volts. ------

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7. The current necessary for lighting the filaments of the transmitter tubes is supplied to the tubes by
(1) a dynamotor. (2) storage batteries.
(3) dry cells. (4) hand generator. ------

8. The oscillator tube and modulator tube used in the transmitter of the SCR–109–A are known as type
(1) VT–2. (2) VT–1. (3) VT–4. (4) VT–5. ------

9. When using the set to transmit continuous waves for telegraphy, the following number of tubes is lighted:
(1) Three. (2) Two. (3) Four. (4) One. ------

10. When using buzzer-modulated telegraphy the following number of transmitter tubes is used:
(1) Two. (2) Three. (3) One. (4) Four. ------

11. A VT–2 tube is used to
(1) amplify the telegraph signals. (2) modulate.
(3) amplify the buzzer-modulated signals only.
(4) amplify both speech and buzzer-modulated signals. ------

12. The coupling between the plate circuit of the oscillator and the antenna circuit is
(1) fixed. (2) varied by a variable condenser.
(3) varied by a variocoupler.
(4) varied by a tap switch. ------

13. The following number of pairs of phones may be plugged into the receiver:
(1) Two. (2) Three. (3) One. (4) Four. ------

14. The receiver employs the following types of tubes:
(1) VT–5's. (2) VT–4's. (3) VT–2's. (4) VT–1's. ------

15. The receiver tubes are supplied with the following total voltage:
(1) 6 volts. (2) 8 volts. (3) 2 volts. (4) 12 volts. ------

16. The dynamotor draws from the power supply a current of
(1) 2 amperes. (2) 17 amperes.
(3) 27 amperes. (4) 40 amperes. ------

17. A change of one tap on the inductance switch makes a change in wave length of about
(1) 5 meters. (2) 10 meters. (3) 15 meters. (4) 1 meter. ------

18. The normal plate current for the oscillator tube is about
(1) 25 milliamperes. (2) 1.5 amperes.
(3) 175 milliamperes. (4) 125 milliamperes ------

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Directions to the student.—Below are several sentences and just after each one is a short dotted line (------). Read each sentence carefully and if what it says is true, write a plus sign (+) *on the line.* If what it says is not true, write a minus sign (−) *on the line.*

19. The SCR–109–A set is designed for continuous-wave telegraphy, radio telephone, and buzzer-modulated telegraphy. ------

20. The distance range of the SCR–109–A set is greater when using radio telephony than when using radio telegraphy. ------

21. A triple-pole, double-throw switch is used to change from "Transmit" to "Receive." ------

22. A triple-pole, double-throw switch is used to change from telephony to telegraphy, and vice versa. ------

23. The filaments of the transmitter tubes in the SCR–109–A set are connected in series. ------

24. There are three vacuum tubes used in the transmitter of the SCR–109–A set for radio telephony. ------

25. The dynamotor changes the low-voltage direct current of the storage batteries to about 800 volts direct current. ------

26. The signal switch at the left of the transmitter is thrown to the right for continuous-wave telegraphy. ------

27. The signal switch is left open for buzzer-modulated telegraphy. ------

28. The signal switch is thrown to the left for radio telephony. ------

29. The VT–2 tube used in the transmitter of the SCR–109–A set is used as a "master oscillator" and one of the larger tubes is used as a power amplifier. ------

30. The wave length of the SCR–109–A transmitter does not depend upon the length of antenna or amount of antenna inductance used. ------

31. Capacitive coupling is used between the grid and plate circuits of the oscillator tube. ------

32. The plate circuit of the oscillator tube is inductively coupled to the antenna circuit. ------

33. When using the radio telephone, a continuous wave is transmitted from the transmitting set at all times, even though the operator may not be speaking into the microphone. ------

34. The same tube that amplifies speech also amplifies the buzzer modulations when the buzzer is used. ------

35. The buzzer-modulated wave may be received on any type of receiving set. ------

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36. The buzzer operates continuously when buzzer-modulated signals are being transmitted, even though the key is not depressed. ------

37. Buzzer - modulated telegraphy is used in the SCR-109-A set in order to transmit over greater distances than would otherwise be possible. ------

38. The receiving set of the SCR-109-A can not be operated alone, but must be connected to the transmitter. ------

39. The receiver tubes of the SCR-109-A set are connected in parallel. ------

40. A coupling adjustment for the transmitter is provided by means of a tap switch mounted on the antenna inductance coil. ------

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THE INVERTED "L" ANTENNA.

Equipment.

1 inverted "L" antenna, type AN–7, consisting of 75 feet, type W–24 wire, attached insulators (IN–10), and 25 feet lead-in type W–4 wire.
4 mast sections, type MS–14.
2 guys, rope, double, type GY–4.
1 counterpoise, wire, insulated, 75 feet long, type CP–5.
2 ground mats, copper screening, type MT–5.
2 insulators, type IN–7 (for mast tops).
4 stakes, ground, type GP–8.
1 hammer, type HM–1.

GENERAL CONSTRUCTION OF THE ANTENNA.

Information.

This type antenna is used with the SCR–105 radio telegraph set. The erection of the inverted "L" antenna requires the above listed material. The mast sections are carried strapped together, while the rest of the equipment is carried in a canvas bag.

The mast sections are fastened together by using the metal clamps provided. The top of each mast section is so prepared that the mast top insulator may be screwed in place. When the mast is raised, the guy rope should make an angle of about 45° with the direction of the antenna. The antenna is made of stranded insulated wire because of its greater flexibility and less liability to become kinked as compared with single wire. Each of the type IN–10 insulators used between the antenna and masts consists of a 7 by ½ by ¼ inch micarta strip with galvanized steel clevises and harness hooks at each end.

For a ground with this antenna either the insulated counterpoise wire or the ground mats may be used. Where the ground is dry, or the installation only temporary, the counterpoise is used. In case the ground is moist, and consequently a good conductor, or where the installation is semipermanent, the ground mats may be used. When the counterpoise wire is used, care must be taken to ascertain that it is well insulated and that it will not become grounded. The counterpoise or ground mats connect to the "ground" binding post of the set which is in use. Ground mats and counterpoise wires will not both be used at the same time. The antenna and counterpoise as well as the guys are placed on hand reels for transportation.

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Questions.

(1) *What kind of wire is used with this antenna? Why?*

(2) *What insulators are used with this antenna? Where are they used?*

(3) *Where is the "lead in" and what is its purpose?*

(4) *How many mast sections are used at each end of the antenna, and how are the sections fastened together?*

(5) *Why are sectional masts used instead of one mast 20 feet long for each end of the antenna?*

(6) *Why is a copper wire screen used for the ground mat?*

(7) *What is the purpose of the insulation on the counterpoise wire?*

(8) *Explain how the counterpoise wire replaces a ground connection.*

Information.

Two men are required to erect efficiently the inverted "L" antenna. The antenna equipment is taken to the field and removed from the carrying bags. The mast sections are assembled and connected into two masts with the clamps and the mast insulators screwed into place. One guy and the lead-in end of the antenna is connected to the mast insulator of one mast. While one man (No. 1) holds this mast erect, the other man (No. 2) should stake down the guys, so that they will make an angle of about 45° with the direction of the antenna. Lean the pole so that its weight pulls against the guys. Then man No. 2 takes the reel on which the antenna is to extend, unreeling the antenna as he goes. No. 1 follows with the other mast, guys, two ground stakes, and the hammer. Connect the guys and antenna to the mast as was done at the first mast. The guys are tightened enough to take up the slack of the antenna after which the first mast is straightened up.

While the operator connects up the set and gets it adjusted, the other man should unroll the counterpoise wire, stretching it on the ground directly underneath the antenna. If the ground mats are used they should be spread out on the ground, or buried lightly, under the antenna.

A convenient method of placing the ground mats is to have them rolled up and then to start a trench about 8 inches deep and the width of the mats. The trench can be dug for about 2 feet and then a start made to unroll the mats in it. As the digging proceeds, the

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loose earth is thrown back on that portion of the mats which is unrolled. The operation is kept up until the mats are completely unrolled and covered by the loose earth. This saves handling the earth more than once. The ground mats should be connected together with wire, leaving a space about the width of one mat between them. When the antenna has been erected, the work will be inspected by the instructor, after which it will be taken down and prepared for transportation.

EXPERIMENT No. 1.

TO ERECT AN INVERTED "L" ANTENNA.

Directions.

1. Erect the inverted L antenna assigned by the instructor in accordance with the procedure outlined above. One man of the team will act as No. 1 and the other as No. 2.

2. After the work has been inspected, remove the antenna and prepare it for transportation.

3. Unpack the equipment and again erect the antenna with man No. 1 now assuming the duties of No. 2, and former No. 2 assuming the duties of No. 1.

4. Remove the antenna and pack the equipment for transportation as before.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Prepare in advance several complete sets of antenna equipment as listed in the Students Manual.

2. Indicate and name the different parts of the equipment. Demonstrate how the mast sections are clamped together, how the insulators are attached to the mast tops, and how the antenna and guy wires are attached to the mast insulators. Explain the use of the counterpoise wire and ground mats.

3. Take the class out into the field and with one group of two men go through the erection of an inverted "L" antenna. Show how to lay out the counterpoise wire and the ground mats. Demonstrate how the antenna is taken down and prepared for transportation.

4. Divide the class into groups of two men each. Direct each group to erect the antenna so that either the counterpoise wire or ground mats may be used. When all connections are made and the antenna is properly erected have the group take it down and prepare it for transportation. Have the process repeated until each group can accomplish the work quickly and correctly.

5. Personally supervise the work of the class, correct mistakes, and ask questions so that each man answers verbally at least a few of the questions given in the Students Manual.

6. Assemble the class and give the following Instruction Test or one similar to it:

NOTE.—*No performance test is supplied with this Unit Operation (also Unit Operations Nos. 22 and 23), as the data available at the writing of this Manual were insufficient to establish the procedure for conducting a group test of this type. Any suggestions or ideas regarding such a test should be sent to the Chief Signal Officer.*

INSTRUCTION TEST NO. 21-B (INFORMATION).

Directions to the student.—There are listed below a number of unfinished statements. After each statement are several words, phrases, or numbers, each preceded by a number. Only one of these is correct Write the *number* of the correct word, phrase, or number on the dotted line at the right of each question. Take plenty of time. Do not rush.

1. The length in feet of the type AN-7 antenna is
(1) 50. (2) 75. (3) 150. (4) 100. ------

2. The number of mast sections used with the type AN-7 antenna is
(1) two. (2) three. (3) one. (4) four. ------

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3. The length of the lead-in of the type AN-7 antenna is
(1) 50 feet. (2) 25 feet. (3) 75 feet. (4) 10 feet. ------

4. The number of ground stakes required for the erection of the inverted "L" type antenna is
(1) eight. (2) four. (3) six. (4) ten. ------

5. The length of the counterpoise wire used with the type AN-7 antenna is
(1) 100 feet (2) 50 feet. (3) 75 feet. (4) 60 feet. ------

6. If the mast used for the type AN-7 antenna is 20 feet high, the distance between the anchored guy stake and the bottom of the pole should be
(1) 10 feet. (2) 15 feet. (3) 20 feet. (4) 25 feet. ------

7. The counterpoise wire is insulated by
(1) type IN-10 insulators. (2) type IN-7 insulators.
(3) by a covering of insulation. (4) type IN-5 insulators. ------

8. Type IN-10 insulators are used
(1) on mast tops. (2) on the counterpoise.
(3) between the antenna and the top mast.
(4) on the guy ropes. ------

9. The total number of insulators of any type supplied with the AN-7 antenna equipment, not including spares, is
(1) Four. (2) Three. (3) Two. (4) One. ------

10. The number of men required to efficiently erect the inverted "L" antenna is
(1) One. (2) Two. (3) Four. (4) Three. ------

Directions to the student.—Below are several sentences and just after each one is a short dotted line (------). Read each sentence carefully, and if what it says is true (correct) write a plus sign (+) on the dotted line. If what it says is not true, write a minus sign (−) on the line.

11. The antenna, type AN-7, is composed of a single solid copper wire. ------

12. Type IN-10 insulators used in the AN-7 antenna are of a cone shape and screw on the top of the mast. ------

13. Copper screen is used for ground mats because it is lighter than iron. ------

14. Sectional masts are used in preference to a solid mast, chiefly because they are more easily transported. ------

15. Two men are normally required to erect the AN-7 type of antenna. ------

16. The counterpoise should be connected with the ground by connecting it to the copper screen ground mats. ------

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17. The counterpoise may be used in place of a ground by connecting it separately to the post marked ''ground'' on the equipment. ------

18. It is not necessary to insulate the counterpoise when operating a set efficiently. ------

19. The counterpoise ordinarily is used when the ground is dry and also when the installation is only a temporary one. ------

20. The ''lead-in'' makes a connection between the antenna and the radio equipment. ------

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THE "V" TYPE ANTENNA.

Equipment.

1 "V" type antenna—type A–N–8, including wire, attached insulators (IN–10), and lead-in.
6 mast sections, type MS–14.
3 guys, rope, double, type GY–4.
1 counterpoise wire, insulated, double, type CP–4.
2 ground mats, copper screening, type MT–3.
3 insulators for mast tops, type IN–7.
6 stakes, ground, type GP–3.
1 hammer, type HM–1.

GENERAL CONSTRUCTION OF THE ANTENNA.

Information.

The "V" antenna is used with SCR–79–A, SCR–99, SCR–109–A, and SCR–67–A sets. Each leg of the V is 150 feet long and requires a double counterpoise wire of the same length. Insulated stranded wire is used rather than single wire in this antenna because of its greater flexibility and its less liability to become tangled. The type IN–10 insulators used between the ends of the antenna and the masts are micarta strip 7 by ½ by ¼ inch, with galvanized steel clevises and harness hooks at each end.

The stranded "V" antenna may be erected rapidly and efficiently by two men. Generally a two-wire counterpoise is used, but sometimes three wires may be used. In this case, one wire is laid on the ground, midway between the antenna wires, while the other two are laid outside the antenna wires, making angles of about 30° with the antenna legs. When the ground mats are used they should be spread out on the ground in the space bounded by the legs of the antenna.

The two-wire "V" antenna is used with the above sets instead of the one-wire inverted "L" antenna, since due to the two wires in parallel, the antenna has greater capacity and less resistance than would one wire having a length equal to the two wires together. Therefore it radiates stronger signals in the direction of the point of the "V" than would be the case if an inverted "L" antenna were used.

Questions.

(1) *Why is stranded wire used in this antenna?*

(2) *What type of insulators are used with the "V" antenna?*

(3) *Could the antenna be used without insulators on the antenna wires?*

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(4) *Why is this type antenna used rather than the inverted "L"?*

(5) *Into how many sections is each mast divided? Why not use a single section mast 20 feet long?*

(6) *Why are counterpoise wire and ground mats both provided?*

Information.

The various parts of the equipment should first be examined and their functions understood. After this the equipment is taken into the field and the antenna is erected. A convenient method for the erection of the "V" antenna is to treat is as two inverted "L's." First the mast at the lead-in end is raised, and then each leg in turn, as was done in raising the end of the inverted "L." After the two end masts are erected, the mast at the lead-in end is straightened up, if necessary. While the operator connects up the set, the second man should lay out the counterpoise wires or the ground mats, whichever it has been decided to use.

After the antenna has been erected, the work will be inspected by the instructor. When this inspection has been completed, the equipment should be taken down and prepared for transportation.

EXPERIMENT No. 1.

TO ERECT A "V" ANTENNA.

Directions.

1. Go to the equipment assigned by the instructor and inspect it carefully, checking up the parts. Then take it into the field, unpack the equipment required, and erect the antenna. One man will act as No. 1 of the group and the other as No. 2.
2. After the work has been inspected, remove the antenna and prepare it for transportation.
3. Unpack the equipment and again erect the antenna, reversing the positions of the No. 1 and No. 2 men in the operation.
4. Remove the antenna and pack the equipment for transportation.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Prepare in advance the equipment listed in the Students Manual. Divide the class into groups of not less than four men, preferably six, and assign each group to one set of antenna equipment.

2. Indicate and name the different parts of the equipment. Demonstrate how the mast sections are joined, how the insulators are attached to the masts, and how the antenna and guys are attached. Explain by blackboard sketches the placing of the counterpoise wires or ground mats with a "V" antenna.

3. Take the class out into the field and personally direct the erection of a "V" antenna. Call attention to the steps of the erection in turn as they are arrived at. Lay out the counterpoise wires and the ground mats. Then take the antenna down and prepare it for transportation.

4. Have each group erect its antenna and lay out either the counterpoise wires or the ground mats. When the antenna is correctly erected, have it taken down and prepared for transportation. Have these operations repeated until the group can properly erect the antenna in a very short time.

5. Personally supervise the work of the class and correct mistakes Require each man to answer verbally at least a few of the questions given in the Students Manual.

6. Assemble the class and give the following Instruction Test or one similar to it:

INSTRUCTION TEST NO. 22–B (INFORMATION).

Directions to the student.—There are listed below a number of unfinished statements. After each statement are several words, phrases, or numbers, each preceded by a number. Only one of these is correct. Write the *number* of the correct word, phrase, or number on the dotted line at the right of each question. Take plenty of time. Do not rush.

1. The following number of mast sections are supplied with the type AN–8 antenna equipment:
   (1) Four. (3) Eight. (2) Six. (4) Twelve. ------

2. Each leg of the "V" type antenna is of the following length:
   (1) 75 feet. (2) 100 feet. (3) 125 feet. (4) 150 feet. ------

3. Type IN–7 insulators are used
(1) at mast tops.
(2) between antenna and mast tops.
(3) on the counterpoise. (4) on the guy ropes. ......

4. Normally the number of men required to erect the "V" type antenna is
(1) four. (2) three. (3) two. (4) one. ......

5. The antenna wires of the type AN–8 antenna equipment are
(1) Solid bare copper.
(2) Insulated stranded copper.
(3) Stranded bare copper.
(4) Insulated solid copper. ......

6. The counterpoise wires of the "V" type antenna are each
(1) 50 feet long. (3) 100 feet long.
(2) 30 feet long. (4) 150 feet long. ......

7. The type IN–10 insulators are made of
(1) glazed porcelain. (3) micarta strip.
(2) hard rubber. (4) glass. ......

8. The number of ground stakes required for the "V" type antenna is
(1) six. (2) eight. (3) five. (4) ten. ......

Directions to the student.—Below are several sentences and just after each one is a short dotted line (......). Read each sentence carefully, and if what it says is true (correct) write a plus sign (+) on the dotted line. If what it says is not true, write a minus sign (—) on the line.

9. Two solid copper wires are used to form the antenna proper of the type AN–8 antenna equipment. ......

10. Sectional masts are used in preference to solid ones because they are stronger. ......

11. The "V" type antenna has lower resistance and greater capacity than the inverted "L" type. ......

12. When using the "V" type antenna, the ground mats are connected to the counterpoise. ......

13. The counterpoise wires of the "V" type antenna are insulated. ......

14. The "V" type antenna is directional. ......

15. The lead-in wires of the "V" type antenna are connected to the midpoints of the two antenna wires. ......

16. The mast of the "V" type antenna is insulated from the ground. ......

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THE 40-FOOT UMBRELLA ANTENNA.

Equipment.

1 equipment, type A–1–A consisting of: 1 antenna, type AN–4; six 75-foot lengths and antenna cord, complete with insulators and guy ropes.
1 counterpoise, type CP–3; six 90-foot lengths of counterpoise wire.
1 cord, type CD–89; set box to counterpoise block, type BL–2 on one cord.
13 reels, type RL–3; 6 for antenna, 6 for counterpoise, 1 for antenna lead-in.
6 stakes, type CP–2.
2 hammers, engineer's, 2-pound, 2-face.
2 bags, BG–6.
1 bag, BG–7.
2 connectors, type M–6, spares for antenna wires.
1 mast section, type MS–1.
12 mast sections, type MS–2.
1 mast section, type MS–3.
1 mast cap, type MF–4; complete with 50-foot lead-in wire.

GENERAL CONSTRUCTION OF THE ANTENNA.

Information.

The umbrella antenna is used with the SCR–127, SCR–159, and SCR–130 sets. The antenna equipment consists of a 40-foot sectional mast, antenna wire, counterpoise, guy ropes, and ground stakes. The mast consists of 10 sections of wooden tubing each 4 feet 2 inches long. With the metal coupling tube this length is increased to 5 feet 2 inches over all. Of the 10 sections used for the mast there are 8 central sections, 1 bottom section, and 1 top section. The central sections have a metal coupling tube on one end and a hole in the other end. The top section has a hole in both ends. One end of the top section slips on the coupling tube of the upper central section. A mast cap (coupling block for the antenna wires) is fitted into the other end. The bottom section has a coupling tube similar to those of the central sections, while its lower end is fitted with an electrose insulator.

The antenna is of the umbrella type with six radiating wires, each 75 feet long, suitably insulated at the open ends, and held as nearly horizontal as possible by guy-rope extensions, 90 feet long, the outer ends of which are made fast to ground stakes. The standard counterpoise has six radiating insulated wires. Both antenna and

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counterpoise wires are carried on hand reels for convenience in packing for quick reeling and unreeling when setting up and taking down the mast.

Directions.

1. Examine the various parts of the antenna equipment and determine the relation of the various parts to one another.

Questions.

(1) *How many radiating wires are there in the antenna?*

(2) *What is this type of antenna called?*

(3) *How many sections are used in the 40-foot mast? How do the top and bottom sections differ from the others? How are the sections connected together?*

(4) *How are the antenna wires supported at the end away from the mast?*

(5) *How are the antenna wires fastened to the mast?*

(6) *How is the mast insulated from the ground?*

(7) *How many counterpoise wires are used? What types of wires are used for the counterpoise?*

(8) *How is the counterpoise system placed?*

(9) *How are the counterpoise and the antenna wires carried?*

(10) *How are the antenna wires insulated from the mast?*

(11) *How is the mast raised, and how are the sections added?*

(12) *How many men are needed to erect the 40-foot umbrella antenna?*

(13) *With which sets is the 40-foot umbrella antenna used?*

Information.

The antenna should be erected in a clear space at least 225 feet in diameter. The antenna wires must not touch an object such as a tree, building, etc., nor should they cross over any power lines or roads. The lead-in wires must be run as directly to the set as possible. In case of severe climatic conditions, such as strong winds, a guy plate may be placed between the fourth and fifth sections of the mast (counting from the top) and additional guy ropes attached. In rainy weather, it is advisable to loosen the guy ropes. If this is not done, the water will shrink the guy ropes, and this will cause the mast either to buckle or to break.

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The minimum number of men that can erect the 40-foot mast for the antenna is five. Six or more should be used whenever possible. Three men are stationed at the end of the antenna and guy ropes, two men raise the mast and add the sections, while one man directs the operations so that the mast will be erect and straight at all times. The procedure is as follows:

a. Before going into the field, the men are numbered from 1 to 6; No. 1 is the section chief, No. 2 the key operator, and No. 3 the log operator. The other three men may be assigned at will.

b. When the suitable location is selected, No. 1 will order the truck stopped near the point at which the mast is to be erected. All of the men will then get off the truck except No. 6 who will hand out the equipment to the others. No. 2 arranges the mast sections in the order in which they are to go up, being sure the bottom insulator is screwed on. Nos. 3, 4, and 5 open the bags and place the antenna wires, counterpoise wires, and stakes in separate piles. No. 2 takes the top section, and placing the mast cap on one end of it, puts the other end on the ground. The mast cap has eight sockets which hold the metal balls on the ends of the antenna wires. The antenna lead-in wire is permanently fastened to it. Men, Nos. 4, 5, and 6 will each attach an antenna wire to the mast cap by means of the ball and socket provided. No. 2 puts his in the second socket from the lead-in; No. 5 in the second from that of No. 4's; No. 6 two sockets from that of No. 5. Nos. 4, 5, and 6 unreel and lay out on the ground these three antenna wires and the guy ropes fastened to them. The antenna wires extend radially from the mast and should divide the circle into three equal parts, that is, they should make angles of 120° with each other. While Nos. 4, 5, and 6 are laying out the first three wires, No. 2 holds the top section and No. 3 attaches the other three antenna wires to the mast cap. There will be one vacant socket. Nos. 4, 5, and 6 lay out the last three antenna wires and remain in position at the end of their guy ropes. The last wires should go half way between the other wires, thus dividing the circle into six equal parts. Each time Nos. 4, 5, and 6 lay out an antenna wire, they will also take a stake with them and leave it at the end of the wire. The guy ropes will be fastened to these stakes after the mast is erected. All hand reels should be left at the ends of the wires.

c. It is the duty of the three men at the end of the guy ropes to keep the mast upright while the sections are being added. They do this by keeping the correct strain on the guy ropes, walking toward or away from the mast as directed by No. 1.

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d. The mast is set up by adding the sections. No. 2 raises the mast, and No. 3 adds the sections. Having added all the sections, including the bottom one, the base of the mast is permitted to rest on the ground. No. 2 now takes out both hammers, one of which he lays down for No. 4. No. 2 then drives the stake for No. 4, who ties down his attenna. No. 2 then goes toward No. 5, driving stakes and tying down, while No. 4 takes the second hammer and goes toward No. 6, driving stakes and tying down the antenna wires. Stakes should be driven at an angle slanting away from the mast. After all the stakes have been driven, No. 2 and No. 4 bring the hammers back and leave them near the base of the mast. No. 2 will then connect up the set that is to be used. No. 3 lays out the counterpoise connection block and attaches the counterpoise wires. He will then assist No. 2 in connecting up the net. Nos. 4, 5, and 6, after all the guy ropes are tied down, will lay out the counterpoise wires directly under the antenna wires which they have carried out.

e. In taking down the antenna, it is not necessary to untie the guy ropes from the stakes. Nos. 4, 5, and 6 take their positions at the ends of the guy ropes which they held before. They will steady the mast while No. 2 raises it and No. 3 withdraws the sections. No. 2 holds the top section until all antenna wires are reeled in and the connectors removed from the mast cap. The antenna wires and guy ropes are untied and reeled up by the men who laid them. Each time Nos. 4, 5, and 6 reel up an antenna wire, they will bring a stake with them. After they have completed the antenna wires, they will reel up the counterpoise wires. Nos. 2 and 3 disconnect the set and pack the equipment.

EXPERIMENT No. 1.

SETTING UP THE 40-FOOT MAST.

Directions.

2. Erect the 40-foot mast for the umbrella antenna as described in the procedure given above. The duties of each member of the group will be in accordance with this procedure.

3. Remove the mast and antenna and prepare them for transportation.

4. Repeat this experiment acting each time as a different number in the group, the particular assignment of numbers being designated by the instructor.

5. Dismantle the equipment and prepare it for transportation.

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SUGGESTIONS FOR THE INSTRUCTOR.

1. Prepare in advance the equipment listed in the Students Manual. Divide the class into groups of not less than six men each for work with the 40-foot mast. Assign each group to a set of antenna equipment. In case there is only one 40-foot umbrella antenna on hand, each group will erect the antenna as its turn comes. One man will act as chief and direct the work, while the other five perform the work of raising the mast.

2. At the preliminary meeting of the class explain the use of this type antenna and name the sets with which it is used. Demonstrate both for the 40-foot and the 80-foot mast how the antenna wires, guys, lead-in, etc., are attached. Show how the sections of the mast join and how the insulators are attached.

3. Show, if possible, by blackboard sketches the position of the members of the group while the mast is being raised.

4. Take the class into the field and direct the raising of the 40-foot antenna by one of the groups; calling attention to each step as it is arrived at. After the antenna is properly raised, lower and prepare it for transportation. Repeat the operation at least once in order for the men to become more familiar with the method of raising the 40-foot umbrella mast.

5. Personally supervise the work of all groups and require each student to answer verbally at least a few of the questions given in the Students Manual.

6. Assemble the class and give the following Instruction Test or one similar to it:

INSTRUCTION TEST NO. 23–B (INFORMATION).

Directions to the student.—There are listed below a number of unfinished statements. After each statement are several words, phrases, or numbers, each preceeded by a number. Only one of these is correct. Write the *number* of the correct word, phrase, or number on the dotted line at the right of each question. Take plenty of time. Do not rush.

1. The following number of wires are used in the umbrella antenna proper:
   (1) Two. (2) Three. (3) Four. (4) Six. ------
2. The length of each of the umbrella antenna wires is
   (1) 75 feet. (2) 90 feet. (3) 125 feet. (4) 150 feet. ------
3. The counterpoise of the umbrella antenna consists of the following number of wires:
   (1) Two. (2) Four. (3) Six. (4) Eight. ------

4. The length of each of the counterpoise wire of the umbrella is

(1) 75 feet. (2) 90 feet. (3) 125 feet. (4) 150 feet. ------

5. The lead-in wire of the umbrella antenna is of the following length:

(1) 20 feet. (2) 30 feet. (3) 50 feet. (4) 75 feet. ------

6. The following number of sections are used for the mast of the umbrella antenna:

(1) Two. (2) Four. (3) Six. (4) Ten. ------

7. The minimum number of men who are required to erect the umbrella antenna is

(1) Two. (2) Three. (3) Four. (4) Five. ------

Directions to the student.—Below are several sentences and just after each one is a short dotted line (------). Read each sentence carefully, and if what it says is true (correct), write a plus sign (+) on the dotted line. If what it says is not true, write a minus sign (−) on the line.

8. All the sections used for the umbrella-antenna mast are identically the same. ------

9. The antenna wires of the umbrella antenna are supported at the end away from the mast by small poles. ------

10. The mast of the umbrella antenna is insulated from the ground. ------

11. In taking down the umbrella antenna mast all the guy ropes must first be taken off the stakes. ------

12. The antenna wires of the umbrella antenna are attached to the pole by a ball and socket for each wire. ------

13. The counterpoise wires used with the umbrella-type antenna are of the same length as the antenna wires. ------

14. The antenna wires of the umbrella antenna, when erected, should be as nearly horizontal as possible. ------

15. In rainy weather it is advisable to tighten the guy ropes because they stretch when wet. ------

16. All men on the detail which erects the mast help out wherever they can, doing the first job they encounter. ------

17. Thirteen hand reels are used for carrying the necessary wire used in the A–1–A equipment. ------

18. The counterpoise wire is of the same type as that used for the antenna. ------

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INFORMATION TOPICS

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INFORMATION TOPICS.

DEFINITIONS.

NOTE.—The definitions given below are the common meanings of words *as used in this Manual.*

Alternating current.—An electric current which flows first in one direction, reverses, reverses again, and continues flowing in this manner regularly, first in one direction and then in the other.

Ammeter.—A device for measuring the number of amperes which are passing through a circuit and showing the same by a direct reading on a scale. Similarly a milliammeter and microammeter show the number of milliamperes and microamperes passing through the circuit. (See thermo ammeter.)

Ampere.—The practical unit of electric current; it is the current produced by an electric pressure of one volt in a circuit having a resistance of one ohm.

Amplifier.—The means by which signals are amplified. In radio sets, vacuum tubes used in connection with transformers serve this purpose.

Amplify.—To increase the strength of signals received or transmitted.

Antenna.—Usually a wire conductor or a group of wire conductors supported on masts or towers for the purpose of radiating into space or receiving the electromagnetic waves conveying the signals. Also constructed in other forms. (See Loop antenna.)

Aperiodic.—A circuit is said to be aperiodic when it can not be tuned; a receiving circuit which will respond to a number of different wave lengths at the same time.

Audible.—Capable of being heard; perceptible to the ear.

Audio frequency.—A vibration falling within the limits of audibility that is between 40 and 20,000 cycles. The average person can hear all vibrations within these limits.

Bakelite.—An insulating, moisture-proof material made of a hard-pressed, artificial composition, and which is used especially for the front panels of radio sets.

"*B*" *Battery.*—The battery placed in the plate circuit of a vacuum tube receiving set specially made up in 22½-volt units.

Battery.—Two or more primary or secondary cells connected in series or parallel, or both.

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Beat note.—The resultant audible note heard in the headset in continuous wave reception. The electrical vibrations of the incoming continuous waves are combined with the electrical vibrations produced locally by the vacuum tube detector, thereby resulting in an electrical beat vibration which is in turn converted by the detector action of the vacuum tube to an audible beat note.

Binding post.—A connection device used to secure the end of a connecting wire; usually mounted on the front panels of radio sets.

Buzzer.—An electromagnetic vibrating device. Used in radio sets for testing purposes. Also used in wave meters as producing rapidly vibrating currents.

By-pass.—An auxiliary path to provide means for the outlet of radio or audio frequency.

Calibrate.—To ascertain by special measurement, or by comparison with a standard, variations in the readings of an instrument used for electrical or radio measurements.

Capacity.—The quantity of electricity which a condenser is able to store or condense is known as its electrostatic capacity, and is measured in farads or microfarads.

Carbon pile resistance.—A variable resistance which depends for its operation on the compactness of small carbon granules or carbon disks. When the carbon granules or disks are pressed tightly together the resistance is much less than when loosely packed.

Cell.—A single element of an electric battery, either primary or secondary, usually the former. It generally consists of a container filled with a liquid or pasty electrolyte in which two electrodes, usually carbon and zinc, are inserted.

Choke coil.—A coil of wire usually provided with an iron core, used to impede the passage of high frequency currents in radio circuits.

Circuit.—The entire course traversed by an electric current. It consists usually of a source of electricity, as a battery or dynamo, the conductors for conveying the current, and the devices in which it is utilized, lamps, bell, motors, etc. When it is complete, so that current will flow, it is said to be *made* or *closed;* when interrupted, so that the current stops, it is *broken* or *open.*

Clevis.—A loop galvanized iron clasping the end of a pole, beam, etc.

Condenser.—An accumulator of electrical energy, and is always made up of two conductors separated by some nonconducting medium such as air, mica, glass, etc.

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Conductive coupling.—A means of transferring energy from one circuit to another. Two circuits are said to be conductively coupled when they have a part of each circuit common to both. or are joined together electrically.

Connection.—Two or more conductors touching each other in such manner as to close an electric circuit.

Continuous waves.—Waves which are all of the same electrical dimensions. Waves emitted by a vacuum tube radio telegraph set. Continuous waves are also called undamped waves.

Cording diagram.—A diagram which shows how the external apparatus, such as storage batteries, dynamotor, etc., are connected to the set box, by the operator.

Counterpoise.—Metallic conductors placed either on or a few feet above or below the ground, directly under and parallel to the antenna wires, and used in place of the earth as a ground.

Coupling.—The term applied to the method in which electrical energy is transferred from one circuit to another. Coupling may be direct, inductive, capacitive, or resistance.

Crystal detector.—A form of detector which uses certain kinds of crystals, as carborundum, galena, which have the property of allowing current to flow in one direction, but oppose the current flow in the opposite direction to a greater or less degree. A means of converting a high frequency current to a low or audio frequency current.

Current.—A flow of electricity usually measured in amperes.

Cycle.—The term applied to a complete vibration in an alternating current when the current starting first in one direction rises to maximum value, falls to zero value, reverses, rises again to maximum value and returns to zero value.

Damped waves.—Waves which are not all of the same electrical dimensions. Waves emitted by a spark transmitter. Also called discontinuous waves.

Detector.—A device used to convert the high frequency currents to low or audio frequency currents.

Dielectric.—Any nonconducting medium.

Direct current.—A current flowing in one direction.

Double-throw switch.—A knife switch which may be thrown over into either of two opposite sets of contacts.

Dynamotor.—A combination of dynamo and motor on the same shaft, one receiving current or voltage and the other delivering current or voltage, usually of different value.

Electrodes.—The term applied to the metal parts immersed in the active material of a primary cell, also the spark terminals of a spark gap.

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Electrose.—A trade name for a substance manufactured into high-power transmission insulators. It has a brown, smooth polished surface, is very strong, does not absorb moisture, and possesses good insulating properties.

Fahnstock clip.—A form of binding post involving a spring catch in which a wire is placed and held.

Farad.—The unit of capacity.

Filament current.—The electric current which flows in the filament circuit and which causes the filament to light up.

Filter circuit.—A circuit containing inductance and capacity in series, which serves as a trap for some certain frequency, thus "filtering" it out of the rest of the circuit.

Fixed resistance.—An electrical resistance which is of constant value and can not be varied.

Frequency.—The number of cycles per second made by an alternating current.

Grid circuit.—That part of a vacuum tube circuit which is included between the filament and grid, both internally and externally.

Grid leak.—A resistance of the order of a megohm, which allows electricity to leak away slowly, usually placed around the grid condenser, but sometimes connected between the filament and the grid lead at the point between the grid condenser and the grid of the tube.

Ground.—A connection with the earth, either intentional or accidental.

Ground telegraphy.—Exactly the same as radio telegraphy except that the ground is used as a medium which carries the waves instead of the ether, or air.

Henry.—A unit of measure of inductance.

High frequency.—Radio frequency.

Induction coil.—A coil having two separate coils wound about a common iron core. The primary consists of a few turns of coarse wire, and the secondary of many turns of fine wire, the two coils being insulated from each other. The primary is connected to a battery through a contact breaker which magnetizes and demagnetizes the core at a rate governed by a spring. The lines of force thus created cut the secondary and set up in it an induced voltage which may be great enough to cause sparks of considerable length to jump between the electrodes of a spark gap.

Inductive coupling.—Two circuits are inductively coupled when the energy of one circuit is transferred to the other by means of a magnetic field.

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Input.—The terminals of an electrical instrument which receive current from some other instrument, or the entering point for incoming current from another instrument.

Insulate.—To safeguard an instrument, wire, or other part against the escape of electricity from them or the conduction of electricity to them.

Insulation.—Material used in insulating.

Insulator.—A contrivance usually made of glass or porcelain or bakelite for supporting wires and at the same time preventing escape of current; a nonconductor.

Interference.—Noises heard in a receiving set due to several stations transmitting on the same wave length or to static or other undesirable noise which decreases the clearness of the particular incoming signal which it is desired to receive.

Interrupter.—An apparatus for producing sudden interruptions in the primary of an induction coil or similar type of step-up transformer.

Jack (telephone).—A form of metallic spring contact receptacle which is adapted to fit the plug of the telephone receiver and connects the latter in the circuit.

Lead.—A conducting wire which leads from an electric source to any instrument or circuit. The leads from a storage battery to a radio set, etc.

Lead-in.—The wire which connects the antenna to the radio set.

Long waves.—Six hundred meters and up, usually.

Loop antenna.—An antenna with two separate vertical "legs" connected at the top by a more or less horizontal wire; the lower ends of the legs are usually connected through the apparatus in the set box. These antennæ are extremely directive.

Magnetic field.—Magnetic lines of force produced about a conductor carrying current. Any change in this current, as in intensity, direction, or make and break, will cause corresponding changes in the magnetic field.

Megohm.—One million ohms.

Meter.—A measure of length; 39.37 inches.

Micarta.—An insulating composition made of paper impregnated with mica.

Microampere.—One one-millionth of an ampere.

Microfarad.—One one-millionth of a farad; the unit of capacity more commonly used.

Micro-microfarad.—One one-millionth of a microfarad; the unit of measure of very small capacities encountered in radio work.

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Microphone.—An electrical device for converting sound waves into corresponding electrical currents or waves.

Milliampere.—One one-thousandth of an ampere.

Modulation.—The process of impressing variations due to the voice, buzzer, etc., upon a continuous or carrier wave.

Modulator.—A device which serves to vary in tone, inflection, pitch, or other quality of sound; a modulator tube in a radiotelephone transmitting set.

Net.—A group of two or more radio stations, which may or may not operate on the same wave length, and which habitually intercommunicate with each other.

Ohm.—The practical unit of electrical resistance.

Oscillation.—When the frequency of an alternating current rises to the value included in radio-frequency the current is termed an *electric oscillation.*

Oscillator.—A device for creating electrical impulses or oscillations, such as a vacuum tube.

Panel.—The front side usually of a radio set, made of bakelite or some similar insulating material, and on which are mounted the knobs, switches, etc., used in the operation of the set.

Parallel.—An electric circuit is said to be connected in *parallel* when all the positive poles, terminals, etc., in the circuit are connected to one conductor, and all the negative terminals to the other.

Pitch.—The highness or lowness of a musical note; the vibration frequency of a note.

Plate battery.—See " B " battery.

Plate circuit.—The complete electric circuit from the filament to the plate, both externally and internally.

Plate potential.—See " plate voltage."

Plate voltage.—The voltage measured across filament and plate.

Plug.—A terminal, consisting of a metal tip and sleeve, insulated from each other, and connected to a flexible cord, for inserting in a spring jack, thus placing the instrument to which the plug is attached in the circuit.

Polarity.—The quality of having opposite poles. In a cell or battery the terminals from which the current flows is of positive polarity, and the other terminal is of the negative polarity.

Positive pole (of a battery).—That terminal of a battery from which the electric current flows; usually marked with a " + " sign.

Potentiometer.—A variable resistance shunted around a battery by means of which any desired voltage can be obtained within the limits of the voltage of the battery.

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Primary battery.—A group of primary cells connected in series, or parallel, or both, each of which is a device for transforming chemical energy into electric current.

Primary inductance.—The inductance placed in the antenna circuit of a receiving set, or in the closed circuit of a transmitting set which is coupled electromagnetically to the inductance in the antenna circuit.

Pulsating current.—An electric current whose intensity changes at fixed intervals, but whose direction is constant.

Quenched spark.—The result of any type of spark gap which employs some method for extinguishing the spark quickly. It can be done by providing a large cooling surface on the electrodes, or by inclosing the spark in a vacuum, etc.

Radiation (current).—The current in the antenna of a transmitting set when transmitting.

Radio frequency.—A frequency of 20,000 cycles and up.

Radio telegraphy.—A system of telegraphy in which signals are transmitted by means of electromagnetic waves set up by an instrument for generating impulses at the sending station, passing through free space, and received by a delicate detecting instrument at the receiving station.

Relay switch.—A switch which depends for its operation on an armature being attracted to a pole piece of an electromagnet when the latter is energized by current flowing through it.

Resistance.—That property of a substance which opposes the flow of an electric current, usually measured in or spoken of as ohms.

Rheostat.—A variable resistance.

Secondary inductance.—The inductance coil in the secondary circuit of a receiving set which is electromagnetically coupled to the primary inductance coil, or the inductance in the antenna circuit of a transmitting set.

Selectivity.—Property of a receiving circuit which can be tuned sharply.

Series.—An electric circuit is said to be connected in series when all the sources or utilizers of electricity in the circuit are arranged in succession. Cells are said to be in series when the positive terminal of one cell is connected to the negative terminal of the next.

Set box.—The box or container which contains the radio set, usually all the parts which are permanently connected and are not to be changed.

Sharp (in tuning).—A receiving set is said to tune sharply when a slight variation of inductance or capacity will entirely tune out a

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signal or is capable of tuning out all undersirable signals except the one which is being received.

Short waves.—Up to 600 meters, usually.

Signals.—The sound vibrations heard in the telephone receivers, radio telegraph, or telephone.

Signal strength.—The degree of audibility or loudness of signals heard in the receivers of a radio receiving set. Also in reference to the intensity of a signal before it is converted into sound waves.

Socket.—The cuplike base in which a vacuum tube is placed, and which makes contact connections with the four terminals in the base of the tube.

Spark gap.—The space between two electrodes through which a spark discharge takes place.

Spark signals.—Signals sent out by a spark transmitter.

Spark transmitter.—A radio sending set which employs the use of an electric spark discharging through inductance and capacity in series to produce electric impulses or oscillations.

Stage (of amplification).—An amplifier contains from one to six tubes, each of which, with its transformer, amplifies the signal a certain amount, and is called a *stage* of amplification.

Storage battery.—A type of battery in which electricity may be stored up in the form of chemical energy, as a secondary battery distinguished from a primary battery. A direct current must be passed through the battery for a certain length of time before the reaction of the chemicals will cause a flow of current from the battery.

Switch.—Any device by means of which an electric circuit may be opened or closed.

Tap.—A connection made to any turn of an inductance coil. By making a number of these connections any portion of a coil may be included in a circuit as desired.

Thermoammeter.—An ammeter which depends for its operation on the heating of a wire by the current passing through it.

Traffic.—Business handled in a radio net, consisting of official messages, or radio service messages necessary to the maintenance of the system.

Transformer.—An apparatus similar to the induction coil commonly used in radio sets to raise the voltage from one circuit to another, also as a means of coupling between amplifier circuits.

Tuning.—The adjusting of the receiving apparatus of one station to the sending apparatus of another, so that the detector at the receiving station shall respond only to the waves sent from that particular transmitter, without interference of waves of other frequencies; or to adjust two circuits to the same wave length.

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Untuned.—See "aperiodic."

Vacuum.—A container from which the air has been exhausted to a very high degree by means of an air pump or some other efficient device.

Variable resistance.—An electrical resistance whose value can be varied by any device which will serve to use any part as desired.

Variometer.—A variable inductance coil.

Volt.—The unit of electrical pressure.

Voltage.—The electrical pressure of circuit measured in volts.

Voltammeter.—An instrument which will measure either volts or amperes, depending on the manner in which the binding posts thereon are used.

Voltmeter.—An instrument of high resistance for measuring differences in potential in volts.

Wave length.—The distance in meters covered by one cycle, measured in a straight line.

Wave meter.—A device for measuring the wave length of transmitted waves.

Winding.—Any part of an electrical circuit which is in the form of a coil.

Wiring diagram.—A diagram which shows in detail the manner in which the parts of any circuit are connected up.

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THE SCR-79-A AND THE SCR-99 SETS.

1. *Antenna Equipment, Type A-9-A.*—The same antenna equipment is used with the SCR-79-A and SCR-99 sets. The essential component parts are the antenna, masts, counterpoise, ground mats, guys, and stakes. The antenna itself is a V with a 60-degree opening, 20 feet high, 100 feet long on each side, and with a 25-foot lead-in wire. Under some conditions, such as a limited space or for short-distance work, an inverted L may be used. This should be 20 feet high, 100 feet long, and with a 25-foot lead-in wire. The V antenna is supported on three masts, 20 feet high, each with two guys. The antenna wire is a bare stranded wire, and the lead-in is a lightly insulated wire or lamp cord. One end of both legs of the antenna wire forms the point of the V and to this is joined the lead-in wire. The two outer ends of the antenna and the point of the V are provided with strain insulators, which have a snap or harness hook for fastening them to the tops of the masts. The antenna, lead-in, etc., are wound on two hand reels for convenience in storing away in transportation. The masts are of spruce and in three sections, each about 6⅔ feet long, all sections being interchangeable. Each section is fitted at one end with a spike and at the other end with a steel tube that is tapered slightly to take the spike of the next section, and is pierced with three holes to take the snap hooks of the antenna insulators and guy ropes. The mast sections are carried in a carrying roll, which has both a handle and a shoulder strap of nonelastic webbing. The guys are of No. 5 sash cord, 40 feet long, provided at one end with a snap or harness hook, for fastening in the holes in the steel tube of the topmast section and at the other end with a tent slide for adjusting the tension on the guy after it has been passed around the ground stake. In storing away they are wound on the same type of hand reels as the antenna. The ground stakes are of galvanized pipe, 18 inches long, and are provided with a binding post that makes it possible to use them as a ground rod if desired.

The counterpoise consists of two lengths of 150 feet of heavily insulated wire which is laid out on the ground in a V shape with a 60-degree opening under the antenna. In storing away they are wound on two hand reels. As an alternative for the counterpoise, three ground mats, which are of a fine copper gauze, each 13 feet long and 3 feet wide are furnished. These have wood strips at both ends to keep the mats flat and are provided with binding posts at both ends for convenience in making quick connections. The mats

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are generally rolled up for transportation and carried in the roll with the mast sections. The antenna and counterpoise wires, guys, stakes, hammer, etc., are carried in a carrying bag. The essential electrical constants of the V antenna are approximately: Inductance, 0.04 millihenry; capacity, 0.0004 microfarad; fundamental wave length, 240 meters; and average resistance, 50 ohms.

2. *The Dynamotor, Type DM-1.*—The dynamotor, type DM-1, is a combined motor and generator that, together with certain accessories, is contained in a cast aluminum alloy case. With the motor running light—that is, with no generator load—it takes a current of about 4 amperes at 10 or 12 volts from the storage battery. At full load the motor takes about 10 amperes at 10 or 12 volts, and the generator delivers about one-sixth ampere (167 milliamperes) at 300 to 350 volts to the plate circuit of the vacuum tubes of the transmitter. The motor input is therefore about 120 watts, the generator output about 50 watts, and the over-all efficiency is between 40 and 50 per cent. The machine is a converter from a low to a high direct-current voltage. It has separate motor and generator armature windings and commutators mounted on the same shaft, revolving in a single common magnetic field. The speed of the machine is 2,550 R. P. M. (revolutions per minute). The motor end is marked but can still further be identified by the heavier wires at the brushes. Generator ends are marked on the end shield. The necessary wiring from the motor and generator is brought up onto a bakelite panel that carries a fuse block, with 15-ampere fuse wire, a switch in the motor leads extension cords, oiling holes, etc. Spare fuse wire is wound on a small spool in the cover of the box. On the panel the motor terminals are marked "10 Volts," "Plus," and "Minus." An extension cord is provided to connect them to the binding posts on the operating chest (set box) marked, respectively, "Plus 10 V" and "Minus 10 V." The generator terminals are marked "300 Volts," "Plus," and "Minus." An extension cord is provided to connect them to the binding posts on the operating chest (set box) marked, respectively, "Plus 300 V" and "Minus 300 V." In both cords the red wire is positive and the black is negative. Both cords are permanently fastened to the dynamotor terminals and are to be stored away on top of the panel. The polarity of the dynamotor terminals is marked on the panel, but in both cases they can be identified by noting that with the cover of the case opened away from the operator the right-hand post of each pair is positive. The dynamotor is secured in place in the lower part of its carrying case by two heavy machine screws through the bottom. The approximate over-all dimensions are 7 by

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11 inches by 9 inches high, its weight is about 24 pounds, and it is provided with a carrying strap.

PARTS LIST OF SETS FOR FIELD OPERATION.

Equipments in 79–A Set.—The SCR–79–A comprises the following equipment:

One equipment, Type PE–7.
One equipment, Type RE–5–A.
One equipment, Type A–9–A.

Equipments in 99 set.—The SCR–99 comprises the following equipment:

One equipment, Type PE–7.
One equipment, Type RE–7.
One equipment, Type A–9–A.

Parts Comprising Above Equipments.—These equipments are made up of parts as noted below:

Equipment, Type PE–7.
- Battery, Type BB–14 (9).
- Box, type BC–25 or BC–25–A (1).
- Dynamotor, Type DM–1 (1).

Equipment, Type A–9–A.
- Antenna, Type AN–8 (2).
- Bag, Type BG–12 (2).
- Cord, sash, No. 5, olive drab (300 feet).
- Guy, Type GY–4 (8).
- Hammer, 2-face, 2-pound (1).
- Insulator, Type IN–10 (4).
- Mast section, Type MS–14 (12) 9 in use; 3 spare.
- Mat, Type MT–5 (3).
- Pliers, combination, 6-inch (1 pair).
- Reel, Type RL–3 (8).
- Roll, Type M–15 (1).
- Stake, Type GP–8 (12).
- Tape, friction (1 roll).
- Wire, Type W–4 (50 feet).
- Wire, Type W–6 (300 feet).
- Wire, Type W–24 (750 feet).

Equipment, Type RE–5–A.
- Battery, Type BA–2 (4), 2 in use; 2 spare.
- Battery, Type BA–4 (4), 1 in use; 3 spare.
- Chest, Type BC–43 (1).
- Clock, Type I–15 (1).

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Cord, Type CD–15 (3).
Cord, Type CD–38 (5).
Cord, Type CD–47 (2).
Cord, Type CD–48 (2).
Cord, Type CD–49 (2).
Head set, Type P–11 (2).
Key, Type J–12 (1).
Lamp, Type LM–4 (4) (for wavemeter), 1 in use; 3 spare.
Pliers, combination, 6-inch (1 Pair).
Screw driver, 2½-inch blade (1).
Set box (operating chest), Type BC–32–A (1).
Set box (wavemeter), Type BD–40 (1).
Tape, friction (½ pound).
Tube, Type VT–1 (6), 3 in use; 3 spare.
Tube, Type VT–2 (4), 2 in use; 2 spare.
Voltmeter, Type I–10 (1).
Wire, Type W–7 (2 pounds).
Radio Communication Pamphlet No. 17 (1).

Equipment, Type RE–7.

Battery, Type BA–2 (4), 2 in use; 2 spare.
Battery, Type BA–4 (4), 1 in use; 3 spare.
Chest, Type BC–43 (1).
Clock, Type I–15 (1).
Cord, Type CD–15 (3).
Cord, Type CD–38 (5).
Cord, Type CD–47 (2).
Cord, Type CD–48 (2).
Cord, Type CD–49 (2).
Head set, Type P–11 (2).
Key, Type J–12 (1).
Lamp, Type LM–4 (4) (for wavemeter), 1 in use; 3 spare.
Pliers, combination, 6-inch (1 pair).
Screw driver, 2½-inch blade (1).
Set box (operating chest), Type BC–45 (1).
Set box (wavemeter), Type BC–49 (1).
Tape, friction (½ pound).
Tube, Type VT–1 (6), 3 in use; 3 spare.
Tube, Type VT–2 (4), 2 in use; 2 spare.
Voltmeter, Type I–10 (1).
Wire, Type W–7 (2 pounds).

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THE SCR-67-A RADIOTELEPHONE SET.

POSSIBLE SOURCE OF TROUBLE.

1. Frequently the set does not operate satisfactorily on account of incomplete adjustment of the transmitting circuit. In making adjustments, each setting affects all the others, and it is therefore necessary to go over all adjustments in the same order until proper conditions are obtained. Once the set is adjusted, it will therefore save time to record the settings and corresponding wave length. These settings will, of course, change if the antenna is changed.

2. With a set properly adjusted, the results are still dependent on the voice of the operator. The speech should be clear, rather slow, and in an even, moderate tone, and with the lips close to the telephone transmitter.

3. In general, it may be said that the set is operating properly when, with the switch on "Power on" and the control push button closed and the amplification switch on "Minimum," the operator hears himself distinctly in the telephone receiver while talking in the transmitter in a low tone of voice. The test is a check on the working condition of the circuits, but may not be considered as a conclusive proof that the circuits are perfectly adjusted.

4. *Noise in Receiver.*

a. Worn-out dry batteries. Voltage should not be less than 17.5 volts per battery.

b. Noisy leak resistance.

c. Loose connections in plate, filament, or grid circuits. Inspect soldered connections, especially of long wires which may vibrate loose. Inspect connection clips of grid leak and telephone jack.

d. Poor contact between vacuum tube and spring contacts in socket.

e. Broken-down grid leak condenser. Remove condenser and test for click, using telephones.

f. Noisy detector vacuum tube.

g. Sparking at dynamotor commutator, due to poor brushes or dirty commutator.

5. *Failure to Receive.*

a. Tap on the detector tube. If a loud ringing noise is heard, the trouble is probably in the antenna primary and secondary circuits. If no noise is heard, the trouble is probably between the detector and telephones.

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b. Failure of filaments to light; due to broken filament in one of the receiver tubes (VT–1) or open in filament circuit. May also be due to broken-down antenna stopping condenser.

c. Blocking of detector tube; due to too high resistance grid leak or open in grid circuit. Examine grid leak connecting clips.

d. Receiving condenser short-circuited, due to buckled plates; or antenna stopping condenser broken down.

6. *Failure of Amplifier.*

a. Amplifier resistances may be burned out, or short-circuited, or the connections may be broken.

b. Condenser terminals grounded to metal frame.

c. Loose connections. Condenser terminal connections broken off.

7. *Failure to Oscillate.*

a. Failure to have any plate current with modulator switch open may be due to a failure to impress the plate voltage on the tube. Test direct current plate circuit for an open by shunting the plate and filament terminals of the tube socket with a buzzer or receiver. Test dynamotor voltage on power board. The milliammeter circuit may be open. Inspect plate current jack and plug. The contacts on the control relay may not operate properly. Too small a plate current may be due to too small a filament current.

b. Failure to have any grid current may be due to a burned-out grid resistance. Test the latter by clicking through with the telephones. It may also be due to an imperfect grid current jack or burned-out ammeter.

c. Oscillator tube filament may not light due to an open in the filament circuit.

d. No reading on antenna ammeter, may be due to an open in the antenna circuit. Ammeter may be burned out or antenna inductance coil may be open. Test by buzzer. Antenna condenser may be shorted. Antenna switches may be faulty.

e. Test grid coupling condenser by buzzer.

f. Circuit may not be adjusted properly.

g. Antenna insulator may leak or antenna may be grounded.

8. *Overheating of Oscillator Tube.*

a. Too much plate voltage.

b. Improper adjustment of circuit.

c. Lack of grid current or excessive grid current due to improper adjustment of circuit.

d. Faulty tube.

9. *Failure to Modulate.*

a. Receiving tube filaments may not light.

b. Control relay contacts may not work.

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c. Open in modulator plate circuit. Modulator knife switch should be closed. If the latter is open, plate current ammeter should read 40 to 50 milliamps. When closed, space current should be 60 to 70 milliamps.

d. Iron core choke coil may be short-circuited.

e. Faulty or burned-out input transformer.

f. Short circuit on input transformer secondary.

g. Open circuit between transformer and grid of modulator tube.

h. Faulty telephone transmitter.

i. Faulty tube.

j. Blocking of modulator may be due to too high or too low a plate current or to improper resistance in plate circuit. A tendency of the tube to block will be evidenced by a high and unsteady reading on the plate current ammeter when blowing or whistling on the telephone transmitter. Blocking of the modulator is also evidenced by the fact that when the operator talks into the transmitter while sending he hears his speech interruptedly. A remedy, if the tube is not faulty, is to interchange the oscillator and modulator tubes.

PARTS LISTS OF SET FOR FIELD OPERATION.

SET, RADIOTELEPHONE, TYPE SCR-67-A.

1 Equipment, Type PE-2-A; power.
- 6 Batteries, Type BB-5 or Type BB-14.
- 1 Powerboard, Type BD-1-A.
- 1 Cord, Type CD-48.
- 2 Cords, Type CD-38; 1 in use, 1 spare.

1 Equipment, Type RE-2-A; radio.
- 1 Set Box, Type BC-13-A.
- 1 Cord, Type CD-23; powerboard to set box.
- 1 Cord, Type CD-25; set box to operator's cut-in switch.
- 1 Cord, Type CD-24; set box to operator's jack.
- 2 Head sets, Type P-11; 1 in use, 1 spare.
- 1 Radio Communication Pamphlet No. 22.
- 2 Transmitters, Type T-3; 1 in use, 1 spare.
- 16 Tubes, Type VT-1; 3 in use, 13 spare.
- 16 Tubes, Type VT-2; 2 in use, 14 spare.
- 8 Batteries, Type BA-2; 2 in use, 6 spare.

1 Equipment, Type A-9; antenna.
- 6 Insulators, Type IN-5.
- 6 Insulators, Type IN-7.
- 6 Couplers, Type FT-2.
- 3 Mats, Type MT-3.
- 750 feet Wire, Type W-1.
- 2 Reels, Type RL-3.
- 300 feet Wire, Type W-6.

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6 Mast Sections, Type MS-5.
2 Bags, Type BG-14.
12 Stakes, Type GP-3.
1 Bag, Type BG-8.
50 feet Wire, Type W-4.
1 Hammer, Type HM-1.
½ pound Marlin, Type RP-2.
300 feet, Cord Type RP-3.

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THE RADIO SETS SCR-77-A AND SCR-77-B.

THE SCR-77-A SET.

1. *Carrying Units of set—Weight and bulk.*—The whole set is assembled in five carrying units, each provided with a carrying strap. The loop antenna folds up and is carried in a bag, which is $28\frac{1}{2}$ inches long, $4\frac{1}{2}$ inches in diameter, and weighs 6 pounds with the loop in it. The transmitting and receiving apparatus is in an operating chest measuring $14\frac{5}{8}$ inches by $9\frac{15}{32}$ inches by $12\frac{9}{32}$ inches high and weighs $20\frac{1}{2}$ pounds complete. The four-volt storage batteries are carried in a case measuring $5\frac{5}{32}$ by $10\frac{9}{16}$ inches by $8\frac{13}{16}$ inches high and weighing 27 pounds with the batteries in it. The equipment box has two distinct compartments, one of which carries the dry batteries and the other the spare vacuum tubes and the telephone head set. Its dimensions are 13 by $4\frac{5}{8}$ inches by $15\frac{5}{16}$ inches high, and when filled it weighs $17\frac{1}{2}$ pounds. The spare transmitting dry batteries, which like those in use are contained in a wooden case, are carried in a carrying bag which measures 10 by $3\frac{1}{2}$ inches by 8 inches, and weighs $7\frac{1}{2}$ pounds with the case in it. The case containing the transmitting dry batteries in use is contained in the equipment box. There is room for two extra BA-2 dry batteries in the carrying bag in addition to the case. It is a wise precaution to carry these two extra batteries, though they are not provided in the parts list. They weigh only 15 ounces each.

2. *Troubles and remedies.*—*a.* If the set is inoperative after being installed, go over carefully all connections made in installing the set. Especially examine the loop joints to see that they are clear and bright and make electrical contact. If the set is still inoperative, pull forward the operating chest panel and see if all their filaments are lighted. If not, trace out the circuit for poor or broken connections. The tube socket contact springs sometimes make poor contact with the contact pins of the tube, due to dirty contacts or weak-spring tension. Of course, a run-down storage battery may be the cause of the failure of the tubes to light up.

b. If the instrument still fails to operate properly, as indicated by failure of meter to read as much as 5 milliamperes and by failure to obtain a marked drop in plate current when the left-hand side of the loop is touched with the bare hand, note whether the telephone click produced in this manner is louder while operating the key when the meter is shunted. If so, the meter is burned out. If the clicking is the same and quite weak, the trouble probably lies in faulty or run-down BA-2 batteries or faulty connections between the batteries or otherwhere in this circuit.

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c. If the milliameter is burned out or otherwise becomes open-circuited, it can be shunted until replaced or repaired. To shunt the meter, connect its two terminal posts together by a piece of wire. To test whether or not the set is oscillating when there is no meter, touch the left-hand side of the loop with the bare hand. A distinctive click in the telephone receiver is heard if the set is oscillating.

d. If it is impossible to cause the meter to read as low as 5 milliamperes by adjustment of the plate-control current knob, it is due either to reverse polarity of storage-battery connections or a run-down or wrongly-connected grid potentiometer battery. It may happen, however, that an exceptionally good oscillator tube will cause a plate current that can not be reduced to the proper value.

3. *General care of the set.*—The sets are made as rugged as possible with this type of apparatus. However, they should not be subject to any heavy jars or severe shaking, as this will break connection or injure the apparatus. The set should not be unnecessarily exposed to rain or dampness. If it becomes wet it should be thoroughly dried out but not exposed to intense direct heat. Care should be taken to keep all terminals bright and clean, including the joints of the loop. If the sets are stored they must be kept in a dry place.

PARTS LISTS OF SET FOR FIELD OPERATION.

4. *Equipments in the SCR–77–A set.*—There are two equipments in the set, as follows:

Power equipment, type PE–37.
Radio equipment, type RE–23.

5. *Parts lists of equipments.*—These equipments are made up of parts as noted below:

Power Equipment, Type PE–37:

3 batteries, type BB–41; 1 in use, 2 spare.
1 case, type CS–19.

Radio equipment, type RE–23, comprises:

1 bag, type BG–13; for carrying battery case, type CS–17.
1 bag, type BG–18; for carrying loop.
15 batteries, type BA–2; 9 in use, 6 spare.
2 battery cases, type CS–17; 1 in use, 1 spare.
1 equipment box, type BE–48.
2 head sets, type P–11.
1 loop, type LP–2.
1 radio transmitter and receiver, type BC–9.
6 tubes, type VT–1; 3 in use, 3 spare.

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THE SCR–77–B SET.

TROUBLES AND REMEDIES.

1. If the set is inoperative after being installed, go over carefully all connections made in installing the set. Especially examine the loop joints to see that they are clean and bright and make good electrical contact. If the set is still inoperative, pull forward the operating chest panel and see if all their filaments are lighted. If not, trace out the circuit for poor or broken connections. The tube socket contact springs sometimes make poor contact with the contact pins of the tube, due to dirty contacts or weak-spring tension. Of course, a run-down storage battery may be the cause of the failure of the tubes to light up.

2. If no reading of the milliammeter can be obtained with the key up by adjusting the potentiometer, the milliammeter or the C–21–A transformer primary may be open. Or the trouble may be due to faulty connection with the 120-volt " B " battery, or the battery may be run down. If the milliammeter is burned out or otherwise becomes open-circuited, it can be shunted until replaced or repaired. To shunt the meter, connect its two terminal posts together by a piece of wire.

3. If it is impossible to cause the meter to read as low as 0.5 milliampere by adjustment of the plate control knob, it is due either to reverse polarity of storage battery connections or a run-down or wrongly connected grid potentiometer battery.

4. When the amplifier stages are operating, a ringing sound will be heard when the oscillator tube or the panel is tapped. When the storage battery runs down, the set will usually continue oscillating even after the amplifier has ceased functioning as evidenced by the tapping test.

5. A small percentage of tubes will not oscillate with key up for any position of the potentiometer. Another tube should then be tried. Tubes which have a gas leak will ionize when the key is pressed. This is evidenced by a blue glow in the tube when the key is pressed.

6. If the set becomes noisy the following procedure is suggested as useful in locating the trouble. When the key is pressed the noise practically always stops since this shorts the primary of the first C–21 transformer. If it is still heard the noise is in the two-stage amplifier, the 40-volt amplifier plate battery, or the storage battery circuit. If the noise largely disappears when the key is closed, it is due to irregularity of the oscillator plate current passing through the C–21 primary when receiving. One side of the grid BA–2 bat-

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tery should be disconnected. If the noise is still heard, the grid potentiometer circuit is probably working normally. If the noise disappears when the oscillator tube socket plate terminal is connected to filament, the noise is then either in the tube or in the plate 1,000 mmf. R. F. by-pass condenser or the 20,000 mmf. stopping condenser. Then, removing the special connection to filament, if the noise continues when the tube is removed from the socket the noise is located in one of the two condensers mentioned. Several of the plate 1,000 mmf. condensers have been found to cause noise because of low insulation resistance due to corrosion. When the sets are working normally the most frequent source of noise is the oscillator tube. Often pressing the key momentarily will reduce the noise. Some tubes are very noisy when jarred. All tubes developing unusual noise should of course be replaced. The discarded tube will probably work satisfactorily in one of the audio amplifier sockets. The new set is found to be considerably more quiet than the BC–9, due to careful test of condensers before installation, and because the D. C. voltage impressed on the oscillator tube and condenser while receiving is much reduced.

7. The sets are made as rugged as possible with this type of apparatus. However, they should not be subjected to any heavy jars or severe shaking, as this will break connections or injure the apparatus. The set should not be unnecessarily exposed to rain or dampness. If it becomes wet it should be thoroughly dried out but not exposed to intense direct heat. Care should be taken to keep all terminals bright and clean, including the joints of the loop. If the sets are stored they must be kept in a dry place.

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HAND GENERATOR, TYPE GN-29-A.

1. *Purpose.*—The hand generator type GN–29–A (to replace the type GN–29) is designed for use with the SCR–127 set. The necessary filament and plate voltage for the transmitter is supplied by this generator. The cording diagram (Fig. 112) shows the method of connecting the type GN–29–A generator.

2. *Improvements.*—The GN–29–A generator differs from the type GN–29 in that the voltage regulator of the former is mounted in the set box instead of on the side of the generator, also the new voltage regulator, type MC–62, is an improvement over the old type. The location of the voltage regulator was changed due to the fact that when it was mounted on the generator it was subjected to vibrations which tended to disturb the contact adjustments, consequently causing an

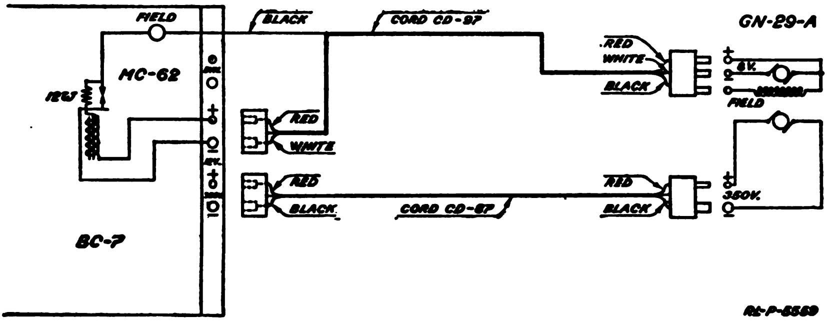

Fig. 112.—Cording diagram showing connections between the type GN–29–A hand generator and the set box of the SCR–127 set.

improper regulation of the voltage. Mounted in the set box the regulator is free from disturbances and therefore gives more satisfactory operation.

3. *Details and Operation of Regulator.*—*a.* All regulators are carefully adjusted by the manufacturer so as to maintain the generator low voltage between 8 and 9 volts. The adjustments are securely locked. The operator is cautioned against tampering with the regulator, as no readjustment is necessary. If it is found impossible to maintain the generator voltage between the limits of 8 and 9 volts, a *readjustment should be made by a radio electrician at the direction of an officer.*

b. After a set has been operated for a long period of time the regulator may need attention due to the sticking of the contacts. This trouble is made evident by the sudden brightening of the VT–2 tube filaments or by sudden increase of antenna current. Excessive

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sparking will also be caused at the same time at the telegraph sending key contacts. The transmit-receive switch should be opened momentarily, which will probably correct the trouble. If the trouble still persists and the generator fails to develop the proper voltage it is probable that the regulator contacts have become roughened. If this is the case, the contacts should be lightly smoothed with a very fine file or very fine emery paper. *The work should be done by a radio electrician at the direction of an officer.*

c. The operation of the regulator is as follows: The electromagnet winding is connected across the generator low-voltage brushes. A resistance of 12 ohms is connected across the contacts of the regulator, so that when the contacts are closed the resistance is short-circuited. The contacts are connected in series with the generator field. When the generator is turned at slow speed the voltage developed is insufficient to cause the electromagnet to pull the armature separating the contacts. When the generator speed is above a certain minimum value (about 35 revolutions per minute of the handles) the voltage developed pulls the armature closer, thus opening the contacts. This places the resistance in series with the shunt field and reduces the generated voltage sufficiently so that the electromagnet allows the armature to move back again, thus closing the contacts. This process occurs at a sufficient rate to maintain the voltage at a value practically unchanged by an increasing generator speed. The regulator, therefore, operates to maintain the generator voltage at a fixed value for all generator speeds above a certain minimum value.

4. *Voltage adjustment.—a.* The curved spring adjusts the air gap between armature and core. Decreasing the air gap will cause a lower voltage to exert the same pull on the armature as previously obtained with a higher voltage.

b. When the contact screw barely touches the armature contact, a slight pull will open the circuit. When the screw is turned in further, the pressure at the contacts is greater, consequently making greater the magnetic pull necessary to open the circuit.

c. The transmit-receiver switch of the radio set must be open during the adjustment of the regulator in order to prevent damage which may be caused by excessive filament and plate voltage. A direct-current voltmeter, having a range of not less than 0–10 volts, should be connected to the 12-volt binding posts on the radio set.

d. The adjustment screw which bears on the small curved spring should be turned in until the air gap between the armature and the core is about 1/16″; the contact screw should then be turned in (with

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the generator running at high speed) until the contact adjustment giving the highest voltage is found. It is desired that the maximum voltage thus tested be 9½ volts.

(1) If the voltage is *greater* than 9½ volts, it is necessary to turn in the screw bearing on the curved spring, about one turn, decreasing the air gap slightly. Another test should be made to see if the maximum voltage obtainable is, 9½ volts. If the maximum voltage is still above 9½ volts, it is necessary to turn in still further, the screw bearing on the adjusting spring.

(2) If the voltage is *less* than 9½ volts, it is necessary to turn out the screw bearing on the curved spring, about one turn, increasing the air gap slightly. Again a test should be made to see if the maximum voltage obtainable is 9½ volts. If the maximum voltage is still below 9½ volts, it is necessary to turn out, still further, the screw bearing on the adjusting spring.

e. The maximum voltage adjustment having been obtained at 9½ volts, the contact screw should be turned outward until the voltage has decreased to 8½ volts.

f. This process insures proper spring tension. A certain minimum tension is necessary in order to prevent sticking at the contacts. The screw adjustments should be secured by means of the lock nuts provided.

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THE SCR–109–A AND SCR–159 SETS.

DESCRIPTION OF ANTENNA EQUIPMENT.

1. *a The V antenna* (*used in the SCR–109–A set*).—This antenna is a V-shaped antenna supported on three masts, each 20 feet high. The length of each leg is 175 feet. There is a lead-in wire 25 feet long. Each mast is made of three spruce sections, which are fitted with a spike at one end and a steel tube at the other to join with the next section. Six hundred feet of heavily insulated counterpoise wire is provided, which should be made in a V-shaped counterpoise with a third leg bisecting the V. The auxiliary antenna equipment comprises spare parts and such carrying rolls, reels, guy ropes, etc., as are needed to support or pack away the antenna. Ground mats, which may be used in place of the counterpoise under favorable conditions, are also a part of the antenna equipment.

b The umbrella antenna (*used in the SCR–159 set*).—The umbrella antenna consists of six antenna wires each 50 feet long spread radially from the top of a 40-foot mast. At the end of each antenna wire there is attached a properly insulated guy rope, 95 feet long, by which the antenna wires are kept stretched out from the mast. The mast is composed of 10 spruce sections, each having a coupling tube to engage the next section. These sections are all alike except the top and bottom sections; the top section is fitted to receive the mast cap; the bottom section carries a heavy insulator on which it rests. The counterpoise system consists of six heavily insulated wires, each 90 feet long, radiating out from a central connecting block. Necessary spare parts and accessories are provided as a part of the antenna equipment.

2. *Erecting the antenna and ground system of the SCR–109–A set.*—The V antenna is used. This antenna can be installed for either of two purposes: (1) General use and (2) directional use. For the former the orientation of the wire is not important, but for the latter the point of the V should be directed toward the other station.

Measure the antenna wires to insure that each leg is 175 feet long and that the lead-in wire is 25 feet long. Correct any departure from this standard length.

Stretch out the antenna wires on the ground with an opening of about 60°. Couple three mast sections together for each mast and lay them on the ground alongside the wire and in the same straight line with it. Attach the antenna wires with their insulators to the tops of the three masts by means of the snap hooks and also attach

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two guys to each mast. Drive two ground stakes near each mast about 20 feet beyond the end of the wire, so that the guys will lie at an angle of about 45° with the line of the wire. Attach the lead-in wire to the antenna wires at the front of the V. Having raised the mast at the point of the V, raise the other mast tops gradually by using a light strain on the guys and, keeping the bottom ends of the masts on the ground, move them toward the points where they are to be when the mast is in the vertical position. Pass the guys around the ground stakes and take up the slack with the tent slides. If necessary, straighten up the masts and tighten the guys so that the antenna wires are nearly horizontal. Care should be taken in raising the masts to keep them in the prolongation of the antenna wires, as then there will be little or no stress tending to bend the masts.

For general use the three counterpoise wires should be laid out on the ground under the antenna with the point of the V-like arrangement near the radio transmitter. The counterpoise wires, each of which should be made 175 feet long, are arranged in a V with the third wire bisecting the angle made by the two legs of the V. For directional use the three wires should be laid out in the V-like arrangement with the point near the radio transmitter as before and with the free ends opening out toward the other station. The legs of the counterpoise are connected together electrically at the point of the V. Wherever possible the counterpoise wires should be supported on wood stakes about 1 foot high. This will give greater distance of transmission as well as better telephone communication.

Although ground mats are provided as a part of the antenna equipment, they are seldom used, for it is only under exceptional conditions that they will give as good results as the counterpoise. When used they should be buried under a few inches of earth, which should be well packed down on them. For general use the ground mats may be buried under the antenna wires. For directional use they should extend away from the radio transmitter toward the receiving station.

3. *Erecting the antenna and ground system of the SCR-159-set.*—At least five men are needed to erect the antenna. Three men are at the end of the antenna wires and guy ropes, two men raising the mast and adding the sections. The following directions should be observed:

Select clear space in which the antenna is to be erected. This clear space should be at least 200 feet in diameter. Place the mast

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and antenna equipment in the center of the space where the mast is to be erected. Take the top section (the one which has no iron pipe projecting from either end) and place the mast cap in one end of it. (The mast cap has eight sockets, which will hold the metal balls on the end of the antenna wires. It should have the 50-foot antenna lead-in wire permanently fastened to it.) Attach the six antenna wires to the mast cap by means of the ball and sockets provided. Unreel and lay out on the ground the six antenna wires and the guy ropes fastened to them. They should extend out radially from the mast, dividing the circle in equal parts—that is, they should make angles of 60° with each other.

Place a man at every other guy rope at the end of the guy rope. It is the duty of these three men to keep the mast upright as the sections are added. They do this by keeping the correct strain on the guy ropes, walking toward the mast as necessary. Select the eight other sections to be added (all alike) and the bottom section. (This has an insulator screwed on the bottom of it. If it is not screwed on, this should be done before adding the sections to the mast.) The mast will contain, when erected, 10 sections in all, 8 besides the top and bottom sections.

Add the sections, one man raising the mast directly upward and the other man adding the sections. Keep the mast upright, giving any directions that may be necessary to the men at the end of the guy ropes to do this. Having added all the sections, including the bottom one, allow the mast to rest on the ground. The two men at the mast then go out to the end of a guy rope and drive a stake in the ground and by means of the metal tent slide tighten the guy to the proper tension. This is done for each of the six guy ropes. Be careful that the mast is upright and that it is not bent. Make any changes in the strain on the guys necessary to insure this.

It is to be noted that on each guy rope there is an insulator between it and the antenna wire to which it is fastened. The rope is also divided by insulators. It is absolutely necessary that the antenna wires be well insulated. The antenna wires must not touch an object such as a tree, building, etc. The lead-in wire hangs down beside the mast.

Having erected the antenna, place the counterpoise connecting block on the ground near the mast. (This is fitted with holes in which the ends of the counterpoise wire are plugged.) A short wire leading to the set box is attached to it. Reel out the six counterpoise wires to their full extent—90 feet. Each rests directly under an antenna wire. The counterpoise connecting block should be raised

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off the ground to properly insulate it. Wherever possible the counterpoise wires should be supported on wood stakes about 1 foot high. This will give greater distance of transmission as well as better telephone transmission.

4. *Notes on operation.*—For efficient operation, the SCR–109–A and SCR–159 sets require experienced operators who are familiar with the sets. If the operators are not familiar with the sets, it may be expected that at first only poor results will be obtained. The sets should be studied and their adjustments and peculiarities learned. The sets are capable of excellent transmission and reception. If a set fails to operate satisfactorily the following points should be noted:

Carefully go over all connections made when installing the set. Check up as to correct connections, including correct polarity, and as to clean and tight connections.

Test the voltage of all batteries—both storage and dry.

See that the dynamotor is running properly and easily. See that it is properly oiled. The end covers of the dynamotor may be removed for ventilation if conditions are such that dirt, etc., will not get into the dynamotor.

Note that all switches make good contact. Press the double-throw switches firmly in their positions. Clean their contacts frequently.

Inspect the antenna. Check it as to correct length of legs and lead-in wire. See that the antenna wires are properly insulated. Improve the ground system if it admits of improvement.

When using the microphone, speak distinctly and directly into the transmitter. It is well to tap the transmitter smartly with the heel of the hand to make sure that its microphone element is not stuck.

Do not overlook the fact that the tickler adjustment is very critical, especially in receiving undamped wave radio telegraphy.

In transmitting, if any of the three tubes fail to light, it may be due to a bad connection in the socket or a dirty contact pin. Clean the contact pin and replace the tube properly in the socket. If this does not remedy the defect, try a new tube. In exchanging tubes always pull the "Transmit–Receive" switch so that it makes no contact.

In receiving, all three of the tubes will light or none of them will, because their filaments are connected in series. Examine and clean the tube contact pins.

Sometimes a tube is defective. Find the defective one by trial of other tubes known to be in good condition.

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Interchange the receiving tube until you have found the combination that works the best. Some tubes are better detectors than others. One of the receiving sockets is connected so that its tube is a detector.

Be careful not to touch any of the metal parts of the transmitter when transmitting, as a shock will result. This applies particularly to the ammeters, the double-throw switches, and the various inductance taps. Even when not transmitting, if the dynamotor is running, a shock is likely to be received. Thus it is well to open the "Transmit-Receive" switch if it is necessary to make any adjustments other than by the control handles.

In transmitting radio telephony, the plate current should continually vary. If it does not, the set is not working properly.

During a thunderstorm or other severe electrical disturbance, disconnect the antenna and ground wires from their binding posts and connect them directly to each other. This should always be done if the set is left installed without an operator being present.

5. *Care of sets.*—*a* The radio equipment must be handled with great care. The various parts are of delicate construction and rough handling will make the set inoperative. The transmitter and receiver boxes contain many parts closely packed together and with a great many connections. These are liable to become dislodged and the connection broken. The set should not be stored in a damp place nor unnecessarily exposed to rain. If the set becomes wet it should be carefully dried out but never exposed to intense heat.

b The storage batteries must receive proper attention and care. The dynamotor panel should be kept clean and the dynamotor properly oiled. Use a good grade of oil and apply one or two drops after two hours' operation. It is important that not too much oil be used. It is much better to oil frequently with a small amount than to oil less frequently using a larger amount of oil.

c The clock needs no attention other than winding and setting. It is wound by a key fastened at the top of the clock, access to which is gained by turning the rim counterclockwise about 45° and pulling outward. The clock is set in the usual manner by pulling the key up until a click is heard.

d Great accuracy has been observed in assembling the telephones and the microphone. There is a right and wrong polarity in connecting the cords of the telephones. If the cords are removed for any reason this must be taken into account in replacing them. The microphone must be carefully handled and packed. It should need no other attention.

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PARTS LISTS OF SETS FOR FIELD OPERATION.

6. *Equipments in the SCR–109–A set.*—The SCR–109–A set comprises the following equipments:

One power equipment, type PE–36.
One radio equipment, type RE–19–A.
One antenna equipment, type A–9–B.

7. *Equipments in the SCR–159 set.*—The SCR–159 set comprises the following equipments:

One power equipment, type PE–36.
One radio equipment, type RE–19–A.
One antenna equipment, type A–14.

8. *Parts lists of above equipment.*—These equipments are made up of parts as noted below:

Power equipment, type PE–36:

Battery, type BB–28; 12, 6 in use, 6 spare.
Dynamotor, type DM–13; 1.

Radio Equipment, type RE–19–A:

Battery, type BA–2; 8, 4 in use, 4 spare.
Chest, carrying, type BE–49; 1, for radio transmitter and receiver.
Chest, carrying, type BE–50; 1, for spare parts and accessories including dynamotor.
Cord, type CD–15; 1, transmitter to high-voltage side of dynamotor.
Cord, type CD–38; 8, for storage-battery connections.
Cord, type CD–47; 1, transmitter to low-voltage side of dynamotor.
Cord, type CD–48; 1, transmitter to storage batteries.
Cord, type CD–49; 1, transmitter to key.
Head sets, type P–11; 2.
Key, type J–12 or J–2; 1, telegraph sending.
Pliers, side cutting, 6-inch; 1 pair.
Radio receiver, type BC–98–A; 1.
Radio transmitter, type BC–86–A; 1.
Screw driver, electrician's 3-inch blade; 1.
Tape, friction, $\frac{3}{4}$-inch; 1 pound.
Transmitter, type T–3; 1, microphone.
Tube, type VT–1; 6, 3 in use, 3 spare.
Tube, type VT–2; 2, 1 in use, 1 spare.
Tube, type VT–4; 4, 2 in use, 2 spare.
Wire, type W–7; 2 pounds.

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9. ANTENNA EQUIPMENT, TYPE A–9–B (V ANTENNA):

Antenna, type AN–8–A; 2, on 2 reels, 1 in use, 1 spare.
Bag, type BG–12; 2, carrying.
Cord, type RP–3; sash No. 5, olive drab, 300 feet.
Guy, type GY–4; 8, complete on 4 reels, 6 in use, 2 spare.
Hammer, 2-pound crosspein; 1.
Insulator, type IN–10; 4 spare.
Mast section, type MS–14; 12, 9 in use, 3 spare.
Mat, type M–5; 3, ground.
Pliers, combination, 6-inch; 1 pair.
Reel, type RL–3; 10 hand, 4 for counterpoise, 4 for guys, 2 for antenna E.
Roll, type M–15; 1, carrying.
Stake, type GP–8; 12 ground, 6 in use, 6 spare.
Tape, friction; 1 roll.
Wire, type W–4; 50 feet, lead-in.
Wire, type W–24; 750 feet on a spool, antenna.
Wire, type W–30; 600 feet, on 4 reels, counterpoise.

10. ANTENNA EQUIPMENT, TYPE A–14, 40–FOOT UMBRELLA:

Antenna, type AN–12; 1, six 50–foot wires with insulators and cords attached.
Bag, type BG–6; 2, carrying.
Bag, type BG–7; 1, carrying.
Connector, type M–6; 2 spares for antenna wires.
Cord, type CD–94; 1, to counterpoise. Insulator block BL–2 on one end.
Counterpoise, type CP–3; 1, six 90-foot wires.
Hammer, 2-pound crosspein; 2.
Insulator, type IN–4; 1, for bottom of mast.
Mast cap, type MP–4; 1, with 50 feet lead-in wire.
Mast section, type MS–1; 1, top.
Mast section, type MS–2; 8, intermediate.
Mast section, type MS–3; 1, bottom.
Reels, type RL–3; 13, 6 for antenna, 6 for counterpoise, 1 for lead-in.
Stakes, type GP–2; 6, ground.
Straps, type ST–5; 6, for bundling mast sections.

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(Corrected to June, 1925.)

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*Part II, Vol. II—Tactical Radio Procedure.	
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