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A study of the need for and an outline of a radio theory course for the public schools of Indiana

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A STUDY OF THE NEED FOR AND AN OUTLINE OF A RADIO THEORY COURSE FOR THE PUBLIC SCHOOLS OF INDIANA

A Thesis

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Master of Science

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CHAPTER I

THE PROBLEM AND METHOD OF STUDY USED

Industry has become increasingly more technical and is constantly in need of more highly trained personnel. The high schools may not be able to provide highly trained personnel but they can do much to give the necessary background for later training in highly technical skills needed in industry. This study is concerned with the task of providing part of that necessary background.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to find the extent of the need for and feasibility of a course in radio theory in the high schools of Indiana; (2) to outline a course which could be used by the high school teachers of the state in the teaching of radio theory.

Method of study used. The first part of this study consisted of a questionnaire which was sent to the larger high schools in Indiana. This questionnaire was composed of a list of suggested units for a course of study in radio theory. The high school principals were asked to check the items in that suggested course of study which

they thought to be practical and desirable for high school students. In many cases the principals were assisted in this task by the science and shop instructors who may have been more familiar with this particular subject and better qualified to answer the questionnaire. The results of this questionnaire are given in a later chapter.

II. ORGANIZATION OF THE REMAINDER OF THE THESIS

The results of the questionnaire. The results of the questionnaire are given in a series of tables. Each table deals with one certain phase of the questionnaire. Explanations of the results of each table are also given.

The course of study. The course of study consists of twenty units which were deemed most important by the survey mentioned above. These units are divided into several parts. The major parts are "Fundamental concepts to be developed", "Specific objectives", "Student experiments", and "Teacher demonstrations". A supplementary section entitled "Enrichment" consists of a suggested list of films to be shown with each unit, special work projects, and exhibits. This supplementary section could be used if time were available; or if the teacher were a little weak in the knowledge of subject matter, it might

be possible to build the course around the use of basic films.

CHAPTER II

THE QUESTIONNAIRE RESULTS

This questionnaire was sent to thirty-three of the larger high schools in Indiana. A total of thirty-one replies was received. Many of these replies gave enthusiastic comments about the need and desirability of such a course in high school. Most of these replies were written on the back of the questionnaire sheet, but some school officials enclosed letters with the returning questionnaires. One such letter was composed of five full pages of comments. The writer is very grateful for the hearty cooperation received in this respect.

TABLE I

NUMBER AND PERCENTAGE OF SCHOOLS HAVING COURSES IN RADIO THEORY

Schools	Number	Percentage
Do have.	16	51.80
Do not have.	14	45.20
Night classes.	1*	3.23
Have had.	2	6.45

*This school was not counted as one of these having regular courses in radio theory.

The first question was designed to obtain an idea about the prevalence of radio theory courses in the high schools of Indiana. The results are shown in Table I. Of the 31 schools who sent a reply, 16 had regular courses in radio theory and one had a night course. The other 14 did not have courses in radio at the time the questionnaire was received, but two had offered such courses during the War.

TABLE II

NUMBER OF HOURS PER WEEK DEVOTED BY SCHOOLS TO LECTURES IN RADIO THEORY

Hours	Number of schools	Percent of schools*
0	1	5.88
1	1	5.88
2	9	52.90
3	4	23.50
4	1	5.88
10	1	5.88

*This figure is based on the schools listed as having courses in radio theory.

TABLE III

NUMBER OF HOURS PER WEEK DEVOTED BY SCHOOLS TO STUDENT EXPERIMENTS

Hours	Number of schools	Percent of schools*
1	2	11.76
2	2	11.76
3	1	5.88
5	1	5.88
7	1	5.88

*This figure is based on the schools listed as having courses in radio theory.

Table VII gives the number of qualified radio theory teachers which each school principal believed that his school had. The number per school ran as high as four. On the other hand, one letter voiced the opinion that there were only a very few teachers in the entire state really qualified to teach such a course. The person who voiced this opinion was himself a radio repairman, as well as a radio theory teacher. This would lead us to believe that most of the qualified teachers listed in the questionnaire were really science teachers who could teach radio theory, but who might have some trouble with the building of radio receivers and other equipment. This is not a reflection upon the teachers themselves since they were really trained for some phase of science teaching and not for building radio sets. Some additional training for these teachers might be necessary for them to do an excellent job in the field of radio theory and radio shop. Colleges could remedy this situation by giving more courses in practical radio.

TABLE IV

NUMBER OF HOURS PER WEEK DEVOTED BY SCHOOLS TO BUILDING SMALL RADIO SETS AND SIMILAR EQUIPMENT

Hours	Number of schools	Percent of schools*
1	2	11.76
2	1	5.88
3	1	5.88
5	1	5.88
15	1	5.88
16	1	5.88

*This figure is based on the schools listed as having courses in radio theory.

TABLE V

NUMBER OF HOURS PER WEEK DEVOTED BY SCHOOLS TO EXPERIMENTS AND BUILDING RADIO EQUIPMENT

Hours	Number of schools	Percent of schools*
1	2	11.76
2	3	17.64
3	7	41.18
4	1	5.88
5	1	5.88
12	1	5.88
16	1	5.88
20	1	5.88

*This figure is based on the schools listed as having courses in radio theory.

Since several schools did not distinguish between students and the building of equipment, it was necessary to have Table V. This table combines the data in tables III and IV with the data which was not specified as belonging in either of these tables.

TABLE VI

WHICH OF THE FOLLOWING SHOULD BE PLACED IN A RADIO THEORY COURSE?

Item	Number yes	Percent yes	Number no	Percent no	Number no ans.	Percent no ans.
Magnetism	28	90.32	2	6.45	1	3.23
Batteries	23	74.20	2	6.45	6	19.35
Ohm's Law	29	93.55	0	0.00	2	6.45
Meters	29	93.55	0	0.00	2	6.45
Capacitance	28	90.32	0	0.00	3	9.68
AC Circuits	29	93.55	0	0.00	2	6.45
Tubes	30	96.77	0	0.00	1	3.23
Power supply	30	96.77	0	0.00	1	3.23
Receivers	28	90.32	0	0.00	3	9.68
Transmitters	26	83.87	2	6.45	3	9.68
Modulation	28	90.32	0	0.00	5	16.13
Antennas	25	80.64	2	6.45	4	12.91
Oscilloscope	25	80.64	3	9.68	3	9.68

Table VI gives the replies concerning the items which should be included in a radio theory course. Since some officials did not check either "yes" or "no" on the questionnaires, it was necessary to have the "no answer" column.

TABLE VII

NUMBER OF TEACHERS IN INDIANA HIGH SCHOOLS QUALIFIED TO TEACH RADIO THEORY

Number of teachers	Number of schools	Percent of schools
1	15	48.40
2	8	25.80
3	3	9.68
4	1	3.23
no ans.	1	3.23

CHAPTER III

UNITS FOR A RADIO THEORY COURSE

The units for this course of study consist of five parts: First, the fundamental concepts to be developed in the unit; second, a list of specific objectives such as appreciation, knowledges, and skills to be gained; third, a group of experiments for the entire class; fourth, teacher demonstrations; fifth, enrichment consisting of films, special projects, charts, and exhibits.

Many instructors will find more material in these units than they can cover in the allotted time. The author has supplied enough so that instructors can choose that which they believe best to use. The charts, special projects, and other enrichment materials will add understanding to the course and could be used if time is available or if the instructor has difficulty getting certain points clear in the minds of the students. Many of these may prove to be a most important part of the course.

The distinction between student experiments and teacher demonstrations is not clearly cut. Some of these may be interchanged depending upon the equipment available and the amount of time that can be spent on each unit.

UNIT I

MAGNETISM

Fundamental concepts to be developed

A. Magnets induce a field of force about themselves.
B. Only certain substances can be attracted by magnets.
C. Magnets are useful tools as well as interesting toys.

Specific Objectives

A. Appreciation
   1. Learn to appreciate the use of magnets and magnetism in modern life.

B. Knowledges
   1. Magnets always have two unlike poles.
   2. The earth acts like a magnet.
   3. Only certain substances are attracted by magnets.
   4. Know the materials used to make magnets, (temporary and permanent).
   5. Know how magnetic shields function.
   6. Know the shape of magnetic fields about magnets.
   7. Know how field intensity varies at various distances from the magnetic poles.
   8. Know how a compass acts.
   9. Know the theory of magnetism. How molecules are arranged in a magnetized substance.
   10. Unlike poles attract.
   11. Know how to find force between two magnets.
   12. Know the effect of breaking a magnet into smaller magnets.
   13. Know the reason for compass declination from true North.
   14. Know how dipping needles work.
   15. Know the uses of magnets in industry.
   16. Know the following terms:
       a. poles of a magnet, b. lines of flux,
       c. magnetic flux, d. magnetic induction,
       e. magnetic substance, f. retentivity,
       g. magnetic field, h. reluctance,
       i. magnetic saturation, j. permeability,
       k. polarity, l. induced magnetism,
       m. magnetic declination.

C. Skills
   1. Develop the ability to calculate the force between two magnets.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Make temporary magnet.	Williard p. 5
B. Make permanent magnet.	Beauchamp & Mayfield p. 129
C. See how poles act on like and unlike poles.	Williard p. 9
D. Make dipping needle.	Beauchamp & Mayfield p. 131
E. Find shape of field using iron filings and magnets.	Beauchamp & Mayfield p. 129
F. Magnetize iron by induction.	Williard p. 21
G. Construct compass from knitting needle.	Williard p. 15

TEACHER DEMONSTRATIONS	
A. Make small magnets from a large magnet. This will show how new poles are formed.	Beauchamp & Mayfield p. 131
B. Magnetize a rod by holding it in the plane of the earth's field and striking it with a hammer.	Millikan, Gale and Coyle p. 309
C. Show how lines of force pass through glass and are shielded by iron or steel.	Williard p. 25
D. Show evidences of different values of permeability for different materials.	Williard p. 27
E. Suspend a magnet by a string some distance above a small compass and twist the string. As the magnet revolves the compass needle will follow precisely. This will show how a stirring device used in industry functions.	

ENRICHMENT

A. Films
   1. The Magnet — Edited Pictures System (for sale only)

B. Slides
   1. Magnetism — Society For Visual Education, Inc. (for Sale)

UNIT II

STATIC ELECTRICITY

Fundamental concepts to be developed

A. Static electricity is divided into positive and negative charges.
B. Current electricity consists of negatively charged particles in motion.
C. Like charges repel each other, unlike charges attract each other.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the relationship between static and current electricity.

B. Knowledges
   1. Know the difference between positive and negative charges.
   2. Like charges repel each other, unlike charges attract each other.
   3. Know how to calculate force between two charges.
   4. Know the difference between conductors and non-conductors.
   5. Know which materials are good conductors and which materials are good insulators.
   6. Know how the electroscope works.
   7. Know the nature of electrostatic induction.
   8. Know the electron theory of electricity.
   9. Plus and minus charges always appear in equal amounts.
   10. Know how charges distribute themselves on conductors.
   11. Know the discharge effect of points, why points do discharge more rapidly than flat surfaces.
   12. Know the causes of lightning.
   13. Know the value of lightning rods.
   14. Know the methods of measuring potential
   15. Know the action of electric condensers.
   16. Know how steel frames shield buildings from lightning.
   17. Know the meaning of 'dielectric field'.
   18. Know the following terms:
       a. static electricity, b. negative charge, c. positive charge, d. charging by induction, e. condenser, f. fixed condenser, g. variable condenser, h. conductors

i. insulator, j. lightning rods,
k. lightning arrestors, l. electrons,
m. Leyden jars, n. electroscope.

C. Skills
1. Develop the ability to calculate the force between two electricially charged bodies.
2. Develop the ability to find the kind of charge on a moving belt or other charged body.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Study the methods of producing positive and negative charges	Williard p. 35
B. Study nature of positive and negative charges.	Williard p. 36
C. Charge pith balls by contact.	Williard p. 40
D. Charge pith balls by induction.	Millikan, Gale and Coyle p. 317
E. Examine and note the action of a Leyden jar.	Williard p. 62
F. Examine and note the construction of a variable radio condenser.	Williard p. 51
G. Take apart and note the construction of a discarded tin-foil condenser.	Williard p. 51

TEACHER DEMONSTRATIONS	
A. Illustrate difference between conductors and non-conductors.	Millikan, Gale and Coyle p. 314
B. Show results of electro-static induction.	Millikan, Gale and Coyle p. 315
C. Show how charges distribute themselves upon the surface of differently shaped bodies.	Millikan, Gale and Coyle p. 322
D. Demonstrate an electric whirl.	Millikan, Gale and Coyle p. 324
E. Demonstrate an electric wind.	Millikan, Gale and Coyle p. 324
F. Demonstrate the effects of shielding.	Williard p. 58

G.	Demonstrate the effects of lightning.	Williard p. 56
H.	Show how lightning rods protect property.	Williard p. 56
I.	Demonstrate the action of condensers.	Williard p. 49

ENRICHMENT

A.	Films	
	1. Electrostatics	Indiana State Teachers College (rent) Indiana University (rent) Encyclopedia Britannica Films Inc. (for sale)
	2. Principles of Electricity	General Electric (free)

UNIT III

CURRENT ELECTRICITY AND ELECTROMAGNETISM

Fundamental concepts to be developed

A. Current electricity is static electricity in motion.
B. Positive and negative charges attract each other.
C. An electric current induces a magnetic field about a conductor.
D. Electromagnets have magnetic fields about themselves.
E. Electromagnets are more powerful and more useful than permanent magnets.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the wide range of uses of electromagnets in home and industry.
   2. Learn to appreciate the importance of current electricity in home and industry.

B. Knowledges
   1. Know how to find the direction of the field about a wire carrying a current.
   2. Know how to find the direction of the field about an electromagnet.
   3. Know how to find the field strength about an electromagnet by knowing the amount of current and the number of turns in the coil.
   4. Know the shape of the field about an electromagnet.
   5. Know how the current-carrying loop reacts when placed in a magnetic field.
   6. Electromagnets are more powerful than permanent magnets.
   7. Electromagnets are more useful than permanent magnets.
   8. Know why electromagnets are used more often than permanent magnets.
   9. Know the symbols for different types of electromagnetic cores.
   10. Know how an electric door bell works.

11. Know the uses of electromagnets in the home.
12. Know the uses of electromagnets in industry.
13. Know how the telegraph works.
14. Know how a magnetic circuit breaker works.
15. Know how relays work.
16. Know the construction of a telephone receiver.
17. Know the types of cores for electromagnets.
18. Know how a galvanometer works.
19. Know the construction of a commercial ammeter.
20. Know the electron theory of electricity.
21. Know the construction of a telephone transmitter.
22. Know how to install a door bell.
23. Know how to install a simple telephone circuit.
24. Know the following terms:
    a. relay, b. solenoid, c. core
    d. armature, f. ampere-turn,
    g. magnetic circuit breaker,
    h. right-hand rule for a wire carrying a current
    i. electromagnet, j. ampere
    k. field strength

C. Skills

1. Develop the ability to install a door bell circuit.
2. Develop the ability to repair door bells.
3. Develop the ability to make simple repairs on battery telephones.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Note reaction of a small compass to a current-carrying wire. Place the wire in the plane of the compass needle.	Williard p. 156
B. Note the reaction of a compass to a current-carrying wire when the wire is perpendicular to the plane of the compass needle.	Williard p. 157
C. Plot the magnetic field about a current-carrying coil.	Beauchamp and Mayfield p. 148
D. Find the polarity of an electromagnetic coil using a compass of a permanent magnet.	Williard p. 164
E. Find the relative strength of electromagnets using different cores.	Williard p. 161
F. Find the relative strength of electromagnets using different number of turns and different amounts of current.	Williard p. 161
G. Find the polarity of an electromagnet using the right-hand rule.	Williard p. 165

TEACHER DEMONSTRATIONS	
A. Demonstrate the action of a fixed-coil galvanometer.	Millikan, Gale and Coyle p. 347
B. Demonstrate and diagram the action of a door bell.	Beauchamp & Mayfield p. 141
C. Demonstrate the action of a telegraph sounder and key.	Beauchamp & Mayfield p. 143
D. Demonstrate and diagram the action of a simple telephone.	Beauchamp & Mayfield p. 142

ENRICHMENT

A.	Films:	
	1. Electrons on Parade	Indiana University (rent) RCA (free loan)
	2. Electromagnetism	Indiana State Teachers College (rent) Herman DeVry Inc. (for sale)
	3. Electrodynamics	Indiana State Teachers College (rent) Encyclopedia Britannica Films Inc. (for sale)
	4. The Electron	Indiana University (rent) U.S.Office of Education (for sale)
	5. Electrons	Indiana State Teachers College (rent) Indiana University (rent) Encyclopedia Britannica Films Inc. (for sale)
B.	Special Projects	
	1. Group of students construct a simple circuit breaker and demonstrate it to the class.	Williard p. 170
	2. Group of students construct a simple telegraph sounder and demonstrate to class.	Williard p. 172
	3. Group of students construct a simple electric bell and demonstrate to class.	Williard p. 175
	4. Group of students draw a large diagram of standard electric door bell.	Williard p. 175
	5. Group of students draw a large diagram of a simple one-way telephone circuit.	Beauchamp & Mayfield p. 142
	6. Group of students draw a large diagram of a solenoid-plunger type of electromagnet used in an electric door chime.	Beauchamp & Mayfield p. 145

C. Exhibits

1. Chart showing the construction of a door bell	Made by students
2. Chart showing the construction of telephone transmitter and headphones	Made by students

UNIT IV

THE ELECTRIC CIRCUIT

Fundamental concepts to be developed

A. There must be a completed circuit from negative to positive before electric current will flow.
B. An electric circuit must be properly fused and controlled by switches and regulators.
C. There must be a difference in potential between two points before a current will flow.
D. Certain materials, known as conductors, must be used to carry the current.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the importance of the electric circuit in modern life.
   2. Learn to appreciate the importance of proper control of electric currents.

B. Knowledges
   1. Each circuit must have a source of power.
   2. Conductors must lead from the source of power through electrical appliances and return to the other terminal of the same source.
   3. Know materials that make good conductors.
   4. Know materials that make good insulators.
   5. Know how to properly fuse a circuit.
   6. Know the construction of fuses.
   7. Know the proper switches for electrical circuits.
   8. Know the uses of rheostats.
   9. Know the uses of circuit breakers.
   10. Know the symbols used to show parts of circuits.
   11. Know how to read drawings of circuits.
   12. Electrons move from the negative terminal to the positive terminal in a circuit.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Construct a simple circuit using dry cell batteries and a light socket with a bulb.	Beauchamp & Mayfield p. 13
B. Construct circuit as above adding a fuse, plug, switch and receptacle.	Beauchamp & Mayfield p. 15
C. Inspect an electric plug and the attached cord to see correct methods of wiring.	Beauchamp & Mayfield p. 7

TEACHER DEMONSTRATIONS

A. Show effects of a short-circuit.	Beauchamp & Mayfield p. 13 and 15

ENRICHMENT

A. Films	
1. Elements of Electrical Circuits	Indiana University (rent)

UNIT V

ELECTRICITY BY CHEMICAL ACTION

Fundamental concepts to be developed

A. A storage battery does not store electrical energy.
B. A storage battery does store chemical energy which liberates electrical energy.
C. Electrical current from a storage battery is an expensive form of electrical energy.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the role of storage batteries in modern transportation.
   2. Learn to appreciate the convenience of storage batteries as used in modern life.

B. Knowledges
   1. Know the construction of a dry cell.
   2. Know why each part must be used in a dry cell.
   3. Know the uses of dry cells.
   4. Know the limitations of dry cells.
   5. Know how to test dry cells.
   6. Know how to connect dry cells for a desired voltage.
   7. Know how to connect dry cells for a desired amperage.
   8. Know how to prolong the life of dry cells by proper use.
   9. Know the construction of storage batteries.
   10. Know why each part must be used in a storage battery.
   11. Know the uses of storage batteries.
   12. Know the two methods of testing storage batteries.
   13. Know the proper care of storage batteries.
   14. Know the proper method of recharging storage batteries.
   15. Know the causes of local action in a cell.
   16. Know the causes of polarization in a cell.
   17. Know the following terms:
       a. electrode, b. depolarizer,
       c. hydrometer, d. ampere-hour,
       e. internal resistance, f. sulphation,
       g. electrolyte, h. separator,
       i. polarization, j. specific gravity,
       k. charge, l. discharge.

C. Skills

1. Develop the ability to test a dry-cell battery by testing the voltage of the cell under load.
2. Develop the ability to test a storage battery by testing the voltage of the battery under load.
3. Develop the ability to test the condition of a storage battery by using a hydrometer to find the specific gravity of the electrolyte.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Test the condition of dry cells by testing the voltage under load.	Beauchamp & Mayfield p. 93
B. Test wet cell batteries by reading the specific gravity of the electrolyte as given by a hydrometer.	Beauchamp & Mayfield p. 102
C. Construct a simple wet cell and observe its action.	Williard p. 73
D. Examine the cross-section of a storage battery noting the construction and the color of the plates.	Exide Storage Model from The Electric Storage Battery Company
E. Examine the cross-section of a dry cell noting the electrodes and electrolyte.	National Carbon Co. or cut old cell in half lengthwise.
F. Find the internal resistance of a dry cell.	Beauchamp & Mayfield p. 93

TEACHER DEMONSTRATIONS	
A. Demonstrate the method of reducing the effect of local action by amalgamation.	Williard p. 71
B. Demonstrate how to test dry cells.	Beauchamp & Mayfield p. 71
C. Demonstrate the two methods of testing lead storage batteries.	Williard p. 99

ENRICHMENT

A.	Films	
	1. Primary Cell	Indiana University (rent) Encyclopedia Britannica Films Inc. (for sale)
	2. Storage Battery Power	Iowa State College (rent)
	3. The Story of a Storage Battery	Willard Storage Battery Company (free loan)
B.	Special Projects	
	1. Group of students construct a simple Voltaic cell and demonstrate its action to the class. Show evidences of polarization.	Williard p. 66
	2. Group of students construct a wet cell and demonstrate its action to the class.	Williard p. 74
	3. Group of students experiment with and demonstrate to the class several methods of determining the polarity of a storage battery. Also show how to determine whether a given source of electricity is direct current or alternating current.	Williard p. 103
C.	Booklets	
	1. The Inside Story of Dry Batteries	National Carbon Co. Inc.
	2. The Storage Battery	The Electric Storage Battery Company
	3. Monograph III of the Nickel-Iron-Alkaline Storage Battery.	Thomas A. Edison Inc.

D. Charts

1.	Easy Lesson on Batteries	The Electric Storage Battery Co.
2.	Construction of Edison-Iron-Alkaline Storage Cell	Thomas A. Edison Inc.

E. Exhibits

1.	Cutaway view of a dry cell	National Carbon Company
2.	Cutaway view of a storage battery	The Electric Storage Battery Co.
3.	Cutaway model of a dry cell	National Carbon Company
4.	Cutaway model of a storage battery	The Electric Storage Battery Co.

UNIT VI

POTENTIAL, RESISTANCE, OHM'S LAW

Fundamental concepts to be developed

A. A difference of potential, which is measured in volts, must exist between two points before a current will flow.
B. The amount of current flowing between two points can be measured and is given in units called amperes.
C. The amount of resistance to the flow of electric current between two points in an electrical circuit is measured in ohms.
D. There are three factors present in all electrical circuits, namely: voltage, current and resistance.

Specific Objectives

A. Knowledges
   1. Each circuit must have a source of power.
   2. The quantity of electrons flowing between two points in a circuit is measured in amperes.
   3. The amount of difference in potential between two points in an electrical circuit is measured in volts.
   4. The resistance to the flow of current through an electrical circuit is measured in ohms.
   5. The ampere is the amount of current that will flow through a resistance of one ohm under a pressure of one volt.
   6. Know the relationship of the following terms: micro, milli, kilo, meg.
   7. Know Ohm's law.
   8. Know some of the factors affecting resistance.
   9. Know how to calculate resistance of series circuits.
   10. Know how to calculate resistance of parallel circuits.
   11. Know how to calculate the resistance of combinations of series and parallel circuits.
   12. Know how a rheostat works.
   13. Know how a thermostat works.
   14. Know the uses of rheostats.
   15. Know the uses of thermostats.
   16. Know how to compute the number of watts of power by measuring the voltage and amperage of an electrical circuit.

17. Know how to calculate the cost of electricity.
18. Know the following terms:
    a. resistance, b. specific resistance
    c. volt, d. ampere, e. E.M.F.,
    f. electromotive force, g. voltmeter,
    h. ammeter, i. Ohm's law,
    j. series resistance circuit, k. shunt,
    l. parallel circuit, m. watt,
    n. circular mil, o. mil-foot,
    p. thermostat, q. rheostat.

C. Skills
    1. Develop the ability to read a light meter and calculate the cost of electricity for a given period of time.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Find how the voltage and current values are related in various parts of a series resistance circuit.	Williard p. 131
B. Find how the voltage and current values are related in various parts of a parallel circuit.	Williard p. 133
C. Experiment with and note the action of a rheostat placed in a series circuit.	Williard p. 139
D. Examine and note the action of a compound bar type of thermostat.	Williard p. 140
E. Find the resistance of several electrical appliances by using an ammeter and a voltmeter.	Williard p. 152
F. Find the relationship between the voltage and the amount of current through a given resistance.	Beauchamp & Mayfield p. 70

TEACHER DEMONSTRATIONS	MATERIALS
A. Demonstrate the water analogy of electricity using drawings and actual water flowing from a pipe.	Williard p. 117 and Beauchamp & Mayfield p. 45
B. Demonstrate some of the factors affecting the resistance of a piece of wire, including: kind of material, length, size of diameter, and temperature.	Williard p. 125
C. Show the heating effect of an electric current.	Beauchamp & Mayfield p. 71

ENRICHMENT

A. Films	
1. Principles of Electricity	Iowa University (rent) General Electric (free loan)
2. Series and Parallel Circuits	Indiana University (rent) Encyclopedia Britannica Films Inc. (for sale)
B. Strip Film	
1. Resistance	Society for Visual Education (for sale)

UNIT VII

ELECTROMAGNETIC INDUCTION

Fundamental concepts to be developed

A. Moving a wire through a magnetic field gives an electric current and is the basis for all electric generators.
B. The amount of voltage developed in a wire moving through a magnetic field is determined by the strength of the field and the speed of the moving wire.
C. An understanding of the action of transformers in inducing voltages in the secondary windings.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the importance of electric generators, transformers and other apparatus which employ electromagnetic induction, in the modern world.
   2. Learn to appreciate the economy of the electromagnetic method of producing electric current as compared with the chemical method.

B. Knowledges
   1. Whenever magnetic lines of force are cut by a moving conductor, electric current is produced.
   2. The voltage induced by a moving wire is determined by the speed of the moving wire and the strength of the magnetic field being cut by the wire.
   3. Know the right-hand rule for generators.
   4. Know Lentz's law.
   5. Know the definition of a volt in terms of the number of lines of force cut per unit of time.
   6. Know the conditions necessary to induce a voltage.
   7. Know how electric generators work.
   8. Know the difference between alternating current and direct current generators.
   9. Know the nature of alternating currents.

10. Know how a multi-coil direct current generator smoothes out the pulsating current.
11. Know the basic theory behind the construction of a series-wound electric generator.
12. Know the advantages and disadvantages of a series-wound generator.
13. Know the basic theory behind the construction of a shunt-wound generator.
14. Know the advantages and disadvantages of a shunt-wound generator.
15. Know the basic theory behind the construction of a compound-wound generator.
16. Know the advantages and disadvantages of a compound-wound generator.
17. Know the advantages of a multipole generator over a bipole generator.
18. Know why Eddy currents are not desirable in a transformer.
19. Know how to keep Eddy currents to a minimum.
20. Know the shape of an alternating voltage curve.
21. Know the shape of a commutated voltage curve.
22. Know how a commutator works.
23. Know how induction coils act.
24. Know the action of a transformer.
25. Know why we have self-induction in a coil.
26. Know the uses of transformers.
27. Know how to find the voltage in the secondary of a transformer by knowing the turns ratio and the voltage in the primary.
28. Know how hystersis losses affect transformer action.
29. Know how to reduce the hystersis losses in a transformer.
30. Know the applications of induced currents in telephone, telegraph and radio.
31. Know the following terms:
    a. cycle, b. induction coil,
    c. induced current, d. alternating current,
    e. primary, f. turns ratio,
    g. secondary, h. transformer,
    i. induced E.M.F., j. step-up,
    k. self-induction, l. frequency,
    m. step-down, series-wound,
    o. shunt-wound, p. compound-wound,
    q. field magnets, r. commutator,
    s. slip rings, t. multi-pole,
    u. armature.

C. Skills
   1. Develop the ability to calculate the efficiency of electrical transformers.
   2. Develop the ability to find the number of turns necessary to produce a given voltage in the secondary of a transformer if the primary voltage and number of turns are known.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Experiment to show the principle of magnetic induction using magnets, wire, and a galvanometer.	Williard p. 258
B. Construct a simple alternating current generator.	Williard p. 263
C. Study the construction and action of a direct current generator.	Williard p. 272
D. Find the effect of using several magnetic poles in a generator as compared to a two pole generator.	Beauchamp & Mayfield p. 228

TEACHER DEMONSTRATIONS	
A. Demonstrate the action of alternating current when a condenser is placed in series with an electric bulb.	Williard p. 268
B. Demonstrate the action of shunt and series-wound generators.	Williard p. 276
C. Show the effects of Eddy currents.	Williard p. 279
D. Demonstrate the inductive action of different size coils when a magnet is moved into and out of each coil. Compare the amounts of galvanometer deflection in relation to the number of turns in each coil.	Williard p. 282
E. Show the action of mutual induction using two coils of wire, one inserted inside the other.	Williard p. 302

TEACHER DEMONSTRATIONS	MATERIALS
F. Demonstrate the action of an automobile coil in stepping up voltages.	Williard p. 304
G. Show how an ordinary bell transformer changes the voltages.	Williard p. 309
H. Show how to find the efficiency of a transformer by measuring the voltages and amperages in primary and secondary.	Williard p. 310
I. Demonstrate the action of self-induction in a coil.	Williard p. 320
J. Demonstrate the reactance of an electromagnetic coil by placing a coil in series with an electric lamp and inserting an iron core.	Williard p. 321

ENRICHMENT

A. Strip Films	
1. Current Generation	Society for Visual Education (for sale)
2. Transformers	Society for Visual Education (for sale)
3. A.C. and D.C. Generators	Society for Visual Education (for sale)
B. Special Projects	
1. Group of students construct a small alternating current generator.	Williard p. 264
2. Group of students construct a small direct current generator.	Williard p. 272
3. Group of students draw a large chart showing an automobile ignition system.	Marine Electrical Equipment Handbook, by Delco-Remy.

UNIT VIII

ELECTRIC MOTORS

Fundamental concepts to be developed

A. A wire carrying a current in a magnetic field tends to move in a direction at right angles to both the direction of the magnetic field and to the direction of the current.
B. A current in a magnetic field tends to move away from the side on which the lines caused by the current are added to the lines of the field.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the role played by electric motors in making life easier and in making difficult jobs into simple ones.

B. Knowledges
   1. Know the relation between direct current generators and direct current motors.
   2. Know how the efficiency of an engine is calculated.
   3. The action of a commutator in a direct current motor.
   4. Know the basic theory behind the action of a simple motor, such as the St. Louis motor.
   5. Know how to find the direction of forces acting within a direct current motor by use of the left-hand motor rule.
   6. Know the basic theory behind the construction of a series-wound motor.
   7. Know the advantages and disadvantages of a series-wound motor.
   8. Know the basic theory behind the construction of a shunt-wound electric motor.
   9. Know the advantages and disadvantages of a shunt-wound electric motor.
   10. Know the basic theory behind the construction of a compound-wound motor.
   11. Know the advantages and disadvantages of a compound-wound motor.
   12. Know the advantages of a multipole motor over a simple bipole motor.

13. Know the action of back Electromotive Force in an electric motor.
14. Know why starting boxes are used in the circuit of an electric motor.
15. Know the uses of electric motors.
16. Know how motor speed affects the amount of current being used by the motor.
17. Know the different types of alternating current motors, such as the synchronous and squirrel-cage motors.
18. Know how to reverse the rotation of a direct current motor.
19. Know the following terms:
    a. starting box, b. back E.M. F.,
    c. rotor, d. induction motor,
    e. stator, f. counter E.M.F.,
    g. synchronous motor, h. slip.

C. Skills
    1. Develop the ability to construct a simple direct current motor of the St. Louis type.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Note the reaction of a current carrying wire in a magnetic field.	Beauchamp & Mayfield p. 250
B. Note the reaction of an electromagnet when placed in a magnetic field. Also note the reaction when the current is reversed in the coil.	Beauchamp & Mayfield p. 251
C. Observe the action of back E.M.F. and its relation to the speed of the electric motor. Note how current varies as motor speed varies.	Beauchamp & Mayfield p. 251

TEACHER DEMONSTRATIONS	MATERIALS
A. Show the relation of a direct current motor to a direct current generator by using a small generator as a motor.	Williard p. 286
B. Demonstrate the action of a simple direct current motor, such as the St. Louis motor. Show the effect of using electromagnets as compared to permanent magnets. Also show how to reverse the direction of rotation.	Williard p. 288
C. Show the action of a shunt-wound motor as compared to a series-wound motor.	Williard p. 293

ENRICHMENT

A. Films 1. Alternating Current Motor	Otis Elevator Company (free loan)
B. Strip Films 1. Motors	Society For Visual Education (for sale)
C. Special Projects 1. Group of students construct a simple direct current motor and demonstrate its action to the class.	Williard p. 298

UNIT IX

METERS AND ELECTRICAL MEASUREMENT

Fundamental concepts to be developed

A. Electrical currents flow between two points of an electrical circuit in definite amounts and can be measured as to quantity in a given unit of time.
B. Electrical pressure between any two points of an electrical circuit has a definite value which can be measured.
C. The four common effects of an electric current are electrostatic attraction or repulsion, heating effect, chemical effect, and magnetic effect.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the delicateness of electrical measuring instruments and the need for care in handling them.
   2. Learn to appreciate the convenience of our modern measuring instruments in reading values of electric current and voltage.

B. Knowledges
   1. Know the construction and action of a fixed-coil galvanometer.
   2. Know the construction and action of the moving-coil type of galvanometer.
   3. Know the construction and action of the plunger-vane type of galvanometer.
   4. Know the construction and action of the double-iron type of galvanometer.
   5. Know the construction and action of the dynamometer type of galvanometer movement.
   6. Know the principle of the construction of an ammeter from a galvanometer.
   7. Know the principle of the construction of a multi-range voltmeter from a galvanometer.
   8. Know the principle of the construction of an ohmmeter from a galvanometer.

9. Know the action of alternating current meters as compared to direct current meters.
10. Know the uses of range multipliers with electric meters.
11. Know the uses of a rectifier to change a direct current meter and enable it to read alternating current.
12. Know how a wattmeter operates.
13. Know how to measure electrical resistance by use of a voltmeter and ammeter.
14. Know the uses of a Wheatstone Bridge in measuring resistance.
15. Know the following:
    a. ohmmeter, b. voltmeter, c. shunt,
    d. plunger-vane, e. ammeter,
    f. multiplier, g. hot-wire meter,
    h. repulsion vane, i. galvanometer,
    j. moving-vane meter, k. wattmeter,
    l. watt-hour, m. coulomb, n. ampere.

C. Skills

1. Develop the ability to calculate the amount of electrical power consumed during any interval of time by reading the meter.
2. Develop the ability to use an ohmmeter.
3. Develop the ability to find electrical resistance by using the ammeter-volemeter method.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Construct and note the action of the iron-vane type of galvanometer.	Williard p. 183
TEACHER DEMONSTRATIONS	
A. Demonstrate the action of the moving-coil dynamometer. Note the effects of different amounts of current upon the amount of deflection.	Williard p. 183
B. Demonstrate the action of the moving-coil dynamometer using an electromagnetic field instead of a permanent magnet.	Williard p. 185
ENRICHMENT	
A. Special Projects	
1. Group of students construct a simple iron-vane type of galvanometer and demonstrate its action to the class.	Williard p. 184
2. Group of students construct a simple double iron-vane type of galvanometer and demonstrate to class.	Williard p. 184
3. Group of students construct a simple dynamometer movement.	Williard p. 185
4. Group of students construct an ohmmeter from a milliammeter movement.	Williard p. 199
5. Construct a moving-coil type of galvanometer using a permanent magnet for a field.	Beauchamp & Mayfield p. 274

C. Films		
	1. Electrical Measurement	Society for Visual Education (for sale)
D. Strip Films		
	1. D.C. Voltmeters and Ammeters	Society for Visual Education (for sale)
	2. A.C. Voltmeters and Ammeters	Society for Visual Education (for sale)
E. Exhibits		
	1. Chart showing internal construction of moving-vane type of meter.	Weston Electrical Instrument Corp. (free)
	2. Chart showing internal construction of the Electrodynamometer type of instrument.	Weston Electrical Instrument Corp. (free)
	3. Chart showing internal construction of moving-coil type of meter.	Weston Electrical Instrument Corp. (free)

UNIT X

CAPACITANCE AND RESISTANCE-CAPACITANCE CONSTANTS

Fundamental concepts to be developed

A. Capacitance is a measure of the ability of a capacitor to store an electric charge. The greater the capacitance the greater the charge that can be stored when the capacitor has a given voltage applied.
B. Capacitors are very useful in blocking direct current while allowing alternating current to "pass" through.
C. RC time constants are important considerations in radio work.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the role played by capacitors in radio and other electrical circuits.

B. Knowledges
   1. Know how to calculate the capacitance of a given physical size capacitor.
   2. Know how to calculate the quantity of electricity which can be stored in a given capacitor under a given voltage.
   3. Know how to calculate the time required to charge a given condenser to a given voltage if the resistance of the circuit, the size of the capacitor and the voltage of the source are known.
   4. Know the importance of RC time constants in a radio circuit.
   5. Know how a capacitor can be used to block direct current voltages from certain parts of the circuit and still allow the alternating voltage to pass.
   6. Know how to calculate capacitance of capacitors in series.
   7. Know how to calculate capacitance of capacitors in parallel.

8. Know the meaning of leakage in a capacitor.
9. Know the importance of the type of dielectric used.
10. Know the uses of condensers in radio circuits.
11. Know the types of condensers used.
12. Know how to test condensers.
13. Know the following terms:
    a. capacitance, b. capacitor,
    c. RC Time, d. condenser,
    e. condenser action, f. charge,
    g. microfarad, h. series,
    i. parallel, j. blocking condenser,
    k. dielectric, l. electrolytic condenser,
    m. variable condenser, n. fixed condenser.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Examine variable tuning condenser from an old radio and observe how capacitance is varied as different stations are tuned into the circuit.	Any old radio
B. Examine mica and paper condensers and note the construction of each type.	Any old radio

TEACHER DEMONSTRATIONS	
A. Show how different types of condensers hold their charge by charging each and observing sparks as each is discharged after a given period of time.	Henney p. 114

UNIT XI

A.C. CIRCUITS

Fundamental concepts to be developed

A. Alternating current is similar to direct current except for the fact that the current changes the direction of travel each half cycle.
B. Alternating current has several advantages over direct current.
C. Alternating current can have a very wide range of frequencies.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the advantages of the use of alternating current in home and industry.

B. Knowledges
   1. Alternating current is current which reverses direction each half cycle of flow.
   2. Know the advantages of alternating current in industry and for use in sending electrical power over long distrances.
   3. Know the advantages of alternating current in operating electrical equipment such as radios.
   4. Know the uses of condensers with alternating and direct currents.
   5. Know how voltage varies in an alternating current generator.
   6. Know the range of frequencies of alternating currents.
   7. Know how to find instantaneous values of voltage and current in an alternating current circuit.
   8. Know the meaning of phase angle.
   9. Know the meaning of effective value of alternating current or voltage.
   10. Know how to find effective values of a voltage.
   11. Know how to find peak values of a voltage.
   12. Know how to add values of alternating current or voltage.
   13. Know how the phase relation between current and voltage varies with the type of circuit.

14. Know the meaning of inductive reactance and how to calculate inductive reactance.
15. Know how to calculate capacitive reactance.
16. Know the use of by-pass condensers in alternating current circuits.
17. Know how to find impedance in a series circuit.
18. Know how to calculate impedance in parallel circuits.
19. Know how to calculate power expended in an alternating current circuit.
20. Know the meaning of the term "Power Factor".
21. Know the following terms:
    a. alternating current, b. cycle,
    c. frequency, d. sine wave,
    e. instantaneous voltage, f. peak power,
    g. effective voltage, h. average power,
    i. phase angle, j. by-pass condenser,
    k. capacitive reactance, l. inductive reactance,
    m. impedance, n. power factor,
    o. true power, p. apparent power.

TEACHER DEMONSTRATIONS	MATERIALS
A. Show the effect of placing a condenser in a series direct current circuit as compared to placing the same condenser in an alternating current circuit.	Williard p. 268
B. Show the effect of placing a choke coil in a series direct current circuit as compared to placing the same coil in an alternating current circuit.	Williard p. 268

ENRICHMENT

A. Strip Film	
1. Condensers and Choke Coils	Society for Visual Education (for sale)

UNIT XII

RESONANT CIRCUITS

Fundamental concepts to be developed

A. Resonant circuits are used in all types of radio and television circuits.
B. Without resonant circuits it would be impossible to tune or receive on a radio.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the importance of resonant circuits in modern radio and electrical wiring circuits.

B. Knowledges
   1. Know how current increases in a series resonant circuit as resonance is approached.
   2. Know how capacitive and inductive circuits react.
   3. Know how to plot reactance diagrams.
   4. Know how to calculate the resonant frequency of a series circuit.
   5. Know how to find wave length if the frequency is known.
   6. Know how to calculate the resonant frequency of a parallel circuit.
   7. Know what constitutes a resonant circuit.
   8. Know the applications of resonance circuits.
   9. Know the conditions which determine the sharpness of resonance.
   10. Know the uses of LR circuits in radio.
   11. Know the uses of RC circuits in radio.
   12. Know how the tuning circuit of a receiver works.
   13. Know the uses of filters in radio circuits.
   14. Know the following terms:
       a. acceptor circuit, b. rejector circuit, c. series resonant, d. parallel resonant, e. high pass filter, f. low pass filter, g. band pass filter, h. wave length, i. vector sum, j. resonant frequency.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Determine the effects of changing the capacitance in a series-resonant circuit. plot a graph to show how the amount of current varies as the capacitance is changed if the frequency of the oscillator remains constant.	Henney p. 168
B. Using the equipment mentioned in the above experiment, determine how reactance changes with frequency if the coil and condenser values are not changed. Plot graph to show results.	Henney p. 174
C. Determine the effects of changing the capacitance in a parallel resonant circuit.	Henney p. 181

UNIT XIII

RADIO TUBES

Fundamental concepts to be developed

A. The electron tube is the heart of radio and electronic circuits.
B. The electron tube is a very delicate and sensitive device which must be used carefully.
C. The electron tube gives almost instantaneous control over electron flow in a circuit.

Specific Objectives

A. Appreciations

1. Learn to appreciate the delicate and sensitive control which the electron tube has over the flow of electric current.
2. Learn to appreciate the many uses of electron tubes in modern radio and electronic circuits.

B. Knowledges

1. Know the importance of the Edison effect.
2. Know the types of electron emission.
3. Know the action of thermionic emission.
4. Know the action of secondary emission.
5. Know the action of field emission.
6. Know the action of photoelectric emission.
7. Know the types of electron emitters.
8. Know the types of emitter materials.
9. Know the action of a diode tube.
10. Know the meaning of plate resistance.
11. Know the effect of introducing gas inside the tube.
12. Know the shape of a diode characteristic curve.
13. Know the action of the grid in an electron tube.
14. Know the shape of a triode characteristic curve.
15. Know the action of a basic triode circuit.
16. Know the names of the parts of electron tubes.
17. Know how to determine load resistance needed for a given tube.
18. Know how to calculate the amplification of a tube.

19. Know the importance of operating the electron tube at the proper point on the characteristic curve.
20. Know the causes of distortion.
21. Know the proper load resistance for maximum power output from electron tubes
22. Make a comparison of the phase of a voltage at the grid of the tube and the voltage swing at the plate.
23. Know the advantages of adding a screen grid to an electron tube.
24. Make the comparison of a tetrode with a triode as an electron tube.
25. Be able to recognize a typical tetrode circuit and explain how it works.
26. Be able to recognize a typical pentode circuit and explain how it works.
27. Know the advantages of pentode tubes.
28. Know the shape of a characteristic curve for a pentode.
29. Know the shape of a characteristic curve for a tetrode.
30. Know the action of a variable-mu tube.
31. Know the advantages of a variable-mu tube. Uses of variable-mu tubes.
32. Know about the construction of a beam power tube.
33. Know the advantages of a beam power tube.
34. Know the shape of a characteristic curve for a beam power tube.
35. Know the shape of a characteristic curve for a variable-mu tube.
36. Know the methods of providing grid bias in an electron tube circuit.
37. Know the following terms:
    a. space charge, b. cathode, c. plate,
    d. diode, e. triode, f. tetrode,
    g. Edison effect, h. thermionic emission,
    i. pentode, j. secondary emission,
    k. photoelectric emission, l. mho,
    m. field emission, n. directly heated cathode,
    o. indirectly heated cathode, p. emitter,
    q. plate resistance, r. gaseous tube,
    s. inverse peak voltage, t. distortion,
    u. amplification factor, v. transconductance,
    w. operating point, x. grid bias,
    y. variable-mu, z. rectifier.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Determine how plate current of a diode is controlled by the value of plate voltage and filament voltage. Plot curve to show results.	Henney p. 224
B. Determine the effects of grid bias upon plate current by using several values of grid bias. Plot this against the flow current.	Henney p. 229
C. Show how the plate current of a triode is affected by the value of plate voltage.	Henney p. 231
D. Determine the effects of a change in plate voltage of a tetrode upon the plate current and draw the characteristic curves.	Henney p. 262
E. Determine the effects of a change in plate voltage of a pentode upon plate current and draw the characteristic curves.	Henney p. 264
F. Determine the effects of a change in grid voltage upon the change in plate current of a variable-mu tube and draw the curves.	Henney p. 266
G. Determine the effects of a change in plate voltage of a beam power tube upon the plate current and draw the curves.	Henney p. 267'

UNIT XIV

POWER SUPPLIES

Fundamental concepts to be developed

A. Power supplies are essential to the operation of radios and other devices where direct current is essential.
B. Rectifiers are used to change alternating current into direct current.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the essential part played by power supplies in modern electronics.

B. Knowledges
   1. Know the types of circuits which would use a high-vacuum type of rectifier.
   2. Know the types of circuits which would use a mercury-vapor type of rectifier.
   3. Know the types of circuits which would use a thyratron tube.
   4. Know several typical circuits using thyratron tubes.
   5. Know the action of a thyratron tube.
   6. Know the typical half-wave rectifier circuit.
   7. Know the type of current put out by a half-wave rectifier.
   8. Know a typical full-wave rectifier circuit.
   9. Know the type of current put out by a full-wave rectifier.
   10. Know the uses of voltage-doubler circuits.
   11. Know the action of voltage-doubler circuits.
   12. Know the uses of dry metal rectifiers.
   13. Know several typical circuits using dry metal rectifiers.
   14. Know the use of filter circuits in the power supply.
   15. Know the types of filter circuits.
   16. Know the advantages of the different types of filter circuits.
   17. Know the uses of swinging chokes in a filter system.
   18. Know the uses of a bleeder in the power supply.
   19. Know the uses of voltage dividers in the power supply.
   20. Know how to calculate the resistance and power rating needed in a voltage divider.
   21. Know the uses of ballast tubes.
   22. Know the uses of voltage regulator tubes.

23. Know the use of vibrators in a power supply.
24. Know several typical vibrator circuits.
25. Know the following terms:
    a. rectifier, b. mercury-vapor tube,
    c. thyratron, d. deionization,
    e. half-wave rectifier, f. filter,
    g. full-wave rectifier, h. choke,
    i. voltage-doubler, j. bleeder,
    k. peak inverse voltage, l. grid bias,
    m. peak plate current, n. metal rectifier,
    o. voltage divider, p. swinging choke,
    q. self-bias, r. voltage regulator tube,
    s. ballast tube.

UNIT XV

AUDIO AMPLIFIERS

Fundamental concepts to be developed

A. Audio amplifiers are amplifiers which are designed to amplify all the frequencies present in the audio range.
B. Audio amplifiers may be classified as to type of voltage or power amplifier and as to class of operation just as other amplifiers are classified.
C. Audio amplifiers may vary in the type of circuit connections just as other amplifiers do.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the relative simplicity of the operation of a simple audio amplifier.
   2. Learn to appreciate the wide range of uses of audio amplifiers in home and industry.

B. Knowledges
   1. Know the difference between a voltage amplifier and a power amplifier.
   2. Know the different classes of amplifiers according to the operating point on the characteristic curve.
   3. Know the advantages of the various classes of amplifiers.
   4. Know some of the problems involved in construction of audio amplifiers.
   5. Know the types of tubes used in an audio amplifier.
   6. Know the general wiring diagram of an audio amplifier.
   7. Know how to wire a resistance coupled amplifier.
   8. Know how to calculate gain at low, middle, and high frequency.
   9. Know how to calculate over-all amplification of an audio amplifier.
   10. Know how to wire an impedance coupled amplifier.
   11. Know the results of the Miller effect.
   12. Know how to wire a tuned-inductance amplifier to give a narrow frequency amplification.
   13. Know a typical amplifier circuits using pentode tubes.
   14. Know the importance of proper RC values in an audio amplifier.
   15. Know how to wire a transformer-coupled amplifier.
   16. Know how to wire a push-pull amplifier.

17. Know the advantages of each type of coupling in an audio amplifier.
18. Know how a phase inverter works.
19. Know the role of feedback in amplifiers.
20. Know how to wire and use a cathode follower.
21. Know why decoupling networks are necessary in amplifiers.
22. Know how to boost the bass frequencies in an amplifier.
23. Know how to boost the high frequencies in an amplifier.
24. Know the following terms:
    a. voltage amplifier, b. power amplifier
    c. operating point, d. class A amplifier,
    e. resistance coupled, f. multistage,
    g. impedance-coupled, h. push-pull,
    i. tuned impedance, j. feedback,
    k. transformer coupled, l. Miller effect,
    m. low frequency gain, n. amplification,
    o. high frequency gain, p. decibel,
    q. phase inverter, r. negative feedback,
    s. cathode follower, t. bass-boost circuit.

UNIT XVI

MODULATION AND DETECTION

Fundamental concepts to be developed

A. Audio frequencies must be used to modulate high frequencies so that they can be radiated.
B. Detection is the process of separating the audio frequencies from the high frequency carrier waves.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the method used to send audio frequencies over the air by the means of carrier waves.
   2. Learn to appreciate the circuits used to separate the audio frequencies from the carrier waves.

B. Knowledges
   1. Know the basic principles of amplitude modulation.
   2. Know the basic wiring circuits used in amplitude modulation.
   3. Know how to find the percentage of modulation.
   4. Know the steps used in detection.
   5. Know where rectifiers are used in the detector circuit.
   6. Know how wiring is used in the filter circuit to smooth the output current.
   7. Know the wiring circuits that are used with a simple diode detector.
   8. Know the advantages of a diode detector.
   9. Know the wiring circuit used for a plate detector.
   10. Know the advantages of a plate detector.
   11. Know the wiring circuit for a grid-leak detector.
   12. Know the advantages of a grid-leak detector.
   13. Know the uses of automatic volume control.
   14. Know the use of delayed automatic volume control.
   15. Know the following terms:

       a. modulation, b. carrier wave,
       c. percentage of modulation, d. filter,
       e. detection, f. rectification,
       g. envelope, h. detector, i. AVC
       j. crystal detector, k. plate detector,
       l. grid-leak, m. delayed AVC.

UNIT XVII

RADIO RECEIVERS

Fundamental concepts to be developed

A. There are several basic radio circuits which can be used to give different qualities of reception.
B. A desirable radio signal is one having a high signal to noise ratio.
C. It is desirable to have a receiver that will give nearly equal amplification on all audio frequencies present in a modulated wave.

Specific Objectives

A. Appreciations

1. Learn to appreciate the importance of each basic type of radio receiver circuit.
2. Learn to appreciate the engineering behind the building of a modern radio receiver.

B. Knowledges

1. Know the basic qualities desired in a radio receiver and of the extent that these qualities are present in each type of receiver.
2. Know how the field strength varies as distance from the transmitting station varies.
3. Know the factors that influence the signal to noise ratio in a radio receiver.
4. Know the factors that limit the amount of gain that is practical in a radio receiver.
5. Know the importance of selectivity in a receiver.
6. Know the importance of fidelity in a receiver.
7. Know the types of radio receiver circuits.
8. Know how a simple crystal detector works.
9. Know the advantages and disadvantages of a crystal detector.
10. Know the theory of operation of a regenerative detector.
11. Know the advantages and disadvantages of a regenerative circuit.
12. Know how to wire a tuned-radio-frequency receiver.
13. Know the advantages and disadvantages of a tuned-radio-frequency receiver.
14. Know the theory of operation of a superregenerative receiver.

15. Know the theory of operation of a superhetrodyne receiver.
16. Know how tone control is accomplished.
17. Know the theory of automatic volume control.
18. Know the theory of noise suppressor circuits.
19. Know how push button receivers work.
20. Know the theory of tuning indicators.
21 Know the types of loud speakers.
22. Know the theory of operation of loud speakers.
23. Know the following terms:
    a. sensitivity, b. selectivity,
    c. fidelity, d. field strength,
    e. signal to noise ratio, f. T.R.F.,
    g. regenerative circuit, h. mixer,
    i. superhetrodyne, j. IF frequency,
    k. superregenerative circuit,
    l. oscillator, m. 2nd detector,
    n. 1st detector, o. heterodyne,
    p. frequency conversion, q. AVC
    r. electron-ray tube, s. dynamic speaker.

SCIENCE EXPERIMENTS FOR ENTIRE GROUP	MATERIALS
A. Inspect different types of speakers noting construction of each type.	Any old radio
B. Inspect an IF coil to determine construction.	From an old radio

ENRICHMENT

A. Films

1.	Radio Receivers Principles of Radio Receivers	Iowa State (for rent)
2.	Receiver Radio Messages	Iowa State (for rent)

UNIT XVIII

OSCILLATORS AND TRANSMITTERS

Fundamental concepts to be developed

A. Oscillators are used to generate alternating currents ranging from zero to hundreds of millions of cycles per second.
B. Oscillators are used in radio circuits to send out carrier waves from transmitters.
C. Oscillators are important in certain types of radio receivers and are used to change the radio frequency present.
D. Oscillators are self-excited and need no outside source of alternating current to cause them to generate an alternating voltage.
E. A transmitter consists of an oscillator, equipment to modulate the carrier wave and amplifiers to increase the output.

Specific Objectives

A. Appreciations

1. Learn to appreciate the importance of oscillators in radio transmitters, receivers and service equipment.

B. Knowledges

1. Know the basic operation of a tickler feedback oscillator.
2. Know the basic operation of a Hartley oscillator.
3. Know the basic operation of a Colpotts oscillator.
4. Know the basic operation of a Electron-coupled oscillator.
5. Know the basic operation of a crystal oscillator.
6. Know the uses of frequency multipliers.
7. Know the types of transmission lines.
8. Know the methods of keying a transmitter.
9. Know the basic principles of audio modulation of a carrier wave.
10. Know the types of microphones and microphone circuits.
11. Know the advantages and disadvantages of the above types of microphones.

12. Know the types of modulation systems.
13. Know how to calculate percent of modulation.
14. Know the following terms:
    a. Hartley oscillator, b. tickler,
    c. Colpitts oscillator, d. feedback,
    e. negative resistance, f. keying,
    g. frequency stability, h. piezoelectric
    i. neutralization, j. flywheel effect,
    k. frequency multiplier, l. coaxial cable,
    m. modulation.

ENRICHMENT

A. Films

1. Sending Radio Messages	Iowa State (rent) Encyclopaedia Britannica Films Inc. (for sale)

UNIT XIX

ANTENNAS AND ELECTROMAGNETIC RADIATION

Fundamental concepts to be developed

A. High-frequency energy is transmitted from the sending to the receiving station by means of electromagnetic radiation.
B. Antennas are used to propagate these fields of electromagnetic energy into space.
C. Different arrangements of antennas give different field patterns of radiation.

Specific Objectives

A. Appreciations

1. Learn to appreciate the efficiency of the different antenna arrays.

B. Knowledges

1. Know the basic action of an electromagnetic field about an antenna.
2. Know the influence of L and C of the antenna upon the tuning of the output circuit.
3. Know the action of ground waves.
4. Know the action of sky waves.
5. Know the causes of fading.
6. Know the influence of frequency upon distance of transmission.
7. Know the types of antennas.
8. Know the effects of the various heights of antennas.
9. Know the uses of direction-finding antennas.
10. Know the types of transmission lines.
11. Know how to match line impedances.
12. Know the uses of resonant and non-resonant lines.
13. Know how to calculate characteristic impedance.
14. Know the following terms:
    a. radiation, b. electromagnetic field,
    c. radiation field, d. induction field,
    e. radiation resistance, f. sky wave,
    g. ground wave, h. ionosphere,
    i. half-wave antenna, j. fading,
    k. dipole, l. Marconi antenna,
    m. directional antenna, n. array,
    o. characteristic impedance, p. coaxial cable,
    q. resonant line, r. concentric line.

UNIT XX

ELECTRONIC INSTRUMENTS

Fundamental concepts to be developed

A. Vacuum-tube voltmeters have the advantage of high input impedance and do not load down the radio circuits being checked.
B. Vacuum-tube voltmeters have a higher sensitivity than regular meter movements and can be used to read lower voltages.
C. Vacuum-tube voltmeters are usually more rugged than other sensitive meters.
D. Oscillographs are especially useful in the study of wave forms of current and to find distortion in electronic circuits.

Specific Objectives

A. Appreciations
   1. Learn to appreciate the basic oscillograph circuits and the importance of their applications.
   2. Learn to appreciate the wide range of uses of vacuum-tube voltmeters.

B. Knowledges
   1. Know the construction of a cathode-ray tube.
   2. Know the methods of deflection used in a cathode-ray tube.
   3. Know how sweep frequencies are obtained.
   4. Know how to use the controls of an oscillograph.
   5. Know the uses of the signal generator.
   6. Know the advantages and disadvantages of vacuum-tube voltmeters.
   7. Know the uses of vacuum-tube voltmeters.
   8. Know the uses of an oscillograph.
   9. Know the following terms:
      a. oscillograph, b. sweep frequency,
      c. deflection, d. electron beam,
      e. oscilloscope, f. electron gun,
      g. vacuum-tube voltmeter, h. VTVM,
      i. slide-back voltmeter, j. calibration,
      k. sawtooth wave.

Department of Science
Indiana State Teachers College
Terre Haute, Indiana

Dear Sir:

We, at Indiana State Teachers College, are conducting a survey among the larger high schools of Indiana to try to ascertain the feasibility of a course in "Electricity and Radio Theory" in the schools of Indiana. We would be grateful for your opinions on a few questions.

Yes ___ No ___ 1. Does your high school now have a course in "Radio Theory" or "Radio Shop"?

___ hrs. 2a. If so, how many hours per week are devoted to radio theory lectures?

___ hrs. 2b. How many hours to student experiments?

___ hrs. 2c. How many hours to building small radio sets and similar equipment?

3. Which of the following would you place in a radio theory course?

Yes ___ No ___ a. Magnetism and electromagnetism.
Yes ___ No ___ b. Batteries and generators.
Yes ___ No ___ c. Ohms Law.
Yes ___ No ___ d. Electric meters (ammeters, voltmeters, and ohmmeters).
Yes ___ No ___ e. Capacitance.
Yes ___ No ___ f. A. C. Circuits and resonance.
Yes ___ No ___ g. Radio tubes.
Yes ___ No ___ h. Power supplies.
Yes ___ No ___ i. Types of radio receivers.
Yes ___ No ___ j. Radio transmitters.
Yes ___ No ___ k. Modulation.
Yes ___ No ___ l. Antennas.
Yes ___ No ___ m. Oscilloscopes and vacuum-tube voltmeters.

4. How many instructors in your school are qualified to teach such a course?

We wish to thank you for your help in making this survey possible.

Sincerely yours,

Lloyd B. Sherman

This study is sponsored by the Department of Science, Indiana State Teachers College, and any help rendered will be appreciated.

J. F. Mackell
Chairman

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