VISUAL AIDS AND UNIT INSTRUCTION SHEETS FOR A COURSE IN AUTOMOBILE BATTERY IGNITION

by

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CHAPTER I

INTRODUCTION

VISUAL AIDS AND UNIT INSTRUCTION SHEETS
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The present crisis in education, brought about by the depression, has necessitated overcrowded classes and curtailment of funds for equipment. This has placed upon the teacher an added responsibility for planning and organizing his subject matter in a more efficient manner. This is especially true in trade and industrial arts classes where exact information and manipulation are necessary for efficient production work. It is for such classes that this course of instruction is intended.

The teacher is confronted with two important considerations:

1. What to teach.
2. How to teach it.

A common and accepted method of deciding what to teach is by means of a trade analysis. Stated briefly, the analysis is a systematic method of dividing a trade into its elements, and listing all things the worker should know and be able to do in order to become proficient in the trade.

The second consideration, "how to teach it", concerns the selection and use of instructional aids.

Visual aids have been used for educational purposes from primitive times. Boys learned to hunt and girls learned to cook by observation, imitation and participation.

As the motion picture developed, a rather narrow interpretation of visual aids came into use. The term included motion pictures, glass and film slides, etc. A more modern and logical interpretation is visual-sensory aids. Thus the other senses come to the aid of the instructor, especially the sense of touch, which is very important to the skilled mechanic.

The early advocates of visual aids were rather extravagant in their claims for the use of these aids as teaching devices. Some went so far as to claim that they would supplant textbooks and verbal instruction.

It was due to the work of twelve men prominent in the field of educational research, with Frank N. Freeman as chairman, that visual education came into its rightful place as a teaching aid. In his report Freeman states:

> ".....no support to a belief that pictures may be substituted for language. It does indicate, however, that they have a definite function to perform. This function is determined by the nature and purpose of the instruction. The purpose of instruction at one time is to lay the foundation for thought, reflection, generalization, application. This foundation consists in direct experience with material objects. At another time the purpose is to build upon this foundation the superstructure of thought..... The evidence is that pictures are an invaluable means of getting certain kinds of experience of a concrete sort....." 1

1. Freeman, Frank N. Visual Education. p. 70.

Large classes and need for individual instruction have led to the development of unit instruction sheets. As the name implies, this is a method of presenting detailed written and illustrated information necessary to do an operation or a job. The use of the job sheet as applied to production methods in industry led to its adoption for instructional purposes.

Many writers have contributed to the field of instruction sheets, chief among whom are Charles A. Allen, Educational Advisor of the Federal Board for Vocational Education, and Robert W. Selvidge, Professor of Industrial Education, University of Missouri.

The former developed the job sheet which is adapted to doing a specific and complete job. The latter developed the operation sheet, which gives definite and specific instruction for performing an operation. The two types ought not to be confused, for each has its place as an instructional aid.

As jobs are made up of certain fundamental operations, it is obvious that, as far as possible, the units of instruction should be based on operations. There are certain trades, however, which cannot be readily separated into operations. Certain jobs in automechanics are served more satisfactorily by the job sheet.

A number of theses have been written on courses of study, using unit instruction sheets which are based on an analysis of the trade, but apparently none have been written in this particular field.

The following analysis and course of instruction is based on the writer's seven years of practical automobile experience and ten years of teaching automechanics in a trade school. An attempt is made to give instructions for the construction of simple and inexpensive testing equipment and visual aids. The unit instruction sheets are based on the use and operation of this equipment.

It is not intended that the following instructional aids will supplant the teacher demonstrations, textbooks, or other instructional methods, but, as the name implies, will be used only as aids.

As a means of diagnosing and checking individual progress, a series of objective tests, covering the course, is presented.

As prerequisites for this course, the student should have completed the following courses:

1. Principles of Engine Operation.
2. Function of Engine Parts.
3. Fundamental Principles of Electricity and Magnetism.
4. Starting, Lighting and Generating Systems.

CHAPTER II

ANALYSIS

ANALYSIS

In order to know what to teach in a course of instruction, a careful analysis of the trade must be made. This requires a thorough knowledge of the trade, as well as an analytical type of mind.

The following analysis, "Graphic Analysis of Automobile Battery Ignition", is limited to the field with which this course is concerned. The first divisions, "Public Garage" and "Fleet Owners Shop", show where automechanics work.

Under the heading, "What Men Do", are listed the two divisions, "Primary Circuit" and "Secondary Circuit", into which all battery ignition systems may be divided. These divisions are separated again into blocks, such as "Battery", "Interrupter", etc. which lead directly to the skilled manipulative operations under that heading.

There are listed several typical jobs which may be performed by one or more of the operations. For example, to service a battery, it may be necessary to use all the operations listed under "Battery". The spaces to the left of the job are numbered to show the sequence of operations necessary to do the job.

Under the heading, "What Men Should Know", are listed "Science", "Mathematics", "Trade Knowledge", and "Trade Judgment". Under these headings is grouped all the technical information necessary for performance of the job.

Numbers may be placed in the squares opposite the job to indicate the sequence of acquiring this information. All new information and new operations may be listed opposite the job under their respective headings.

The graphic analysis shows the relationship of the related information to the job and the operations furnish the basis for the unit instruction sheets. It gives the instructor and student a comprehensive view of the things a skilled worker must be able to do and the things he must know.

A job analysis can never be considered complete, as conditions in the industry are constantly changing. As new operations come into use, they should be added to the list. It is not necessary to list all the operations of a trade, but only those which require skill for their performance. From this list have been selected the operations for the instruction sheets presented in Appendix I.

GRAPHIC ANALYSIS CHART

OF

AUTOMOBILE BATTERY IGNITION

CHAPTER III

VISUAL AIDS

VISUAL AIDS

The importance of visual presentations in forming impressions is very obvious. We remember unusual things which have been seen clearly.

Ellsworth C. Dent, Secretary of the Bureau of Visual Education, University of Kansas, and special consultant in Visual Instruction, Brigham Young University, says:

> ".....The magazine, book or newspaper which does not use pertinent and abundant illustrations is limited in circulation. Industry has found the motion picture, the slide, the photograph and the chart to be highly successful in the training of men; in showing manufacturing processes; and in encouraging the public to purchase. The motion picture industry, itself, has been accused of affecting our daily life with a force exceeded only by the combined influence of the press and the radio....." 1

There are many types of visual-sensory aids for use in educational work, but not all of them are adapted to ignition instruction.

Among the devices best adapted for this course are the following:

1. Blackboard demonstrations and illustrations.
2. Charts, blueprints and drawings.
3. Automobile instruction books and wiring diagrams.
4. Pictures from trade magazines, from books and pamphlets.
5. Classroom or shop experiments.

1. Dent, Ellsworth C. <u>A Handbook of Visual Instruction</u>, p. 4.

6. Sections and models of ignition parts and engines.

7. Testing equipment.

8. Visits to garages and repair shops.

9. Moving pictures.

The usefulness of each visual aid varies with the subject or unit of instruction being presented. Perhaps all the aids listed will not be available to every instructor, but he should select from the list the aids that are available and best suited to the instruction.

Experience has shown that there are a few simple rules to be observed in connection with all visual aids to instruction. "They should be directly related to or part of the information and instruction to be imparted to the pupils at that time. They should be accurate and purposeful, well-planned in advance and executed with care".[2]

To hand out a group of illustrations or models for inspection without any particular preparation beforehand is bad practice. On the other hand, these same materials, properly used in a well-organized instruction sheet, will enable the student to learn more quickly and to remember the instruction longer.

In this connection it is well to keep in mind certain simple rules of learning:

".....1. Interest must be stimulated.....

2. Loc. cit. p. 13.

2. Effective response is necessary.....

3. Self-expression is essential....."[3]

Blackboard demonstrations and illustrations: It is desirable to give short demonstrations and blackboard illustrations whenever the whole class can profit by the result. The material and illustrations should be carefully planned and organized beforehand and be directly related to the instruction being given. Permanent illustrations of the various ignition circuits may be made up and used in place of blackboard illustrations. They are inexpensive and may be duplicated by blueprinting.

Charts, blueprints and drawings: Many valuable charts and drawings may be made up by the mechanical drawing department of the school. Simple charts or drawings to show Ohm's Law, alternating current, technical wiring diagrams and electrical symbols are useful.

Automobile instruction books and wiring diagrams: Garages and automobile-manufacturing companies are glad to furnish literature and pamphlets for the asking. Such materials are put out for advertising purposes but that need not detract from their useful purposes. Instruction books and wiring diagrams for the particular engine models in use are especially valuable.

3. Dorris, Anna Verona Visual Instruction in the Public Schools. pp. 41-42.

Pictures from trade magazines, books and pamphlets: There are many trade magazines which contain pictures and diagrams. If funds are not available for a subscription, the local garage will be glad to furnish back issues. A bulletin board for display of new and unusual ideas will stimulate interest. Books and pamphlets should be available for reference. These materials should be selected for their picture and diagram content.

Classroom or shop experiments: Many interesting experiments on induction and magnetism can be performed by the instructor and students. Special equipment can be constructed from old ignition coils to demonstrate the principles of magnetism and induction.

Sections and models of ignition parts and engines: No doubt most instructors have availed themselves of discarded automobile parts as teaching aids. They can be had for the asking in most cases and, while the cars may be out-of-date, the principles are the same. There have been no outstanding changes in battery ignition systems in recent years, but it is advisable to secure as late models as possible. The engines and parts may be used for experiments, demonstrations and models.

A cross section of an engine showing the operation of valves, pistons and gears should be available. A running model of a four cylinder and a six cylinder engine may be set up very easily. These models can be used for timing and trouble shooting operations.

Parts of various types of ignition systems should be available for inspection and demonstration. A complete ignition system can be set up and operated as described in Construction Sheet EI-1, "Construction of an Ignition Tester", Appendix I.

Testing equipment: When funds are not procurable for standard ignition testing equipment, a simple and efficient tester may be made up according to Construction Sheet EI-1, "Construction of an Ignition Tester", Appendix I. Very practical work may be done on this tester, both for practice and practical production work. It is made up almost entirely from old ignition parts. It can be constructed by students at very little cost.

A simple condenser tester is described in Construction Sheet EI-2, "Construction of a Condenser Tester", Appendix I. The writer has used one of these testers a number of years for class instruction and has found it to be very useful.

Visits to garages and repair shops: The instructor should plan and organize these trips in advance. The shops visited should be the ones equipped to best realize the aims of the trip. The students should be prepared beforehand concerning the objectives of the trip and cautioned to observe all types of test equipment. A discussion on the objectives of the trip should be held after the group returns.

Moving pictures: The writer has been able to secure very little information about moving picture films for ignition instruction. Silent and sound-synchronized moving pictures are available on the manufacture of automobiles, but little is available for instruction on ignition.

It is not intended that the visual aids described will take the place of practical manipulative work. They are offered as suggestions to aid practical and theoretical instruction. The following chapter concerns the method of incorporating some of these visual aids with unit instruction sheets.

UNIT INSTRUCTION SHEETS

The analysis of automobile battery ignition set forth in Chapter I gives definite and specific subject matter to be taught. This chapter will be concerned with the methods of teaching it.

According to Professor R. W. Selvidge, skill is established by correct habit formation and we should consider the following steps in teaching the operations:[1]

1. That the individual have a clear notion of what he is trying to do.
2. That he perform the operation correctly the first time.
3. That he give close and critical attention.
4. That he repeat the operation with the least possible variation until the habit is thoroughly established.

Instruction sheets have been developed in order to insure the correct performance of the operation the first time, with the least waste of time and energy. Professor Selvidge classifies instruction sheets as follows:[2]

1. Instruction Units
   a. Operation Sheets. The instruction sheets that tell how to perform manipulative operations are called operation sheets.
   b. Information Sheets. Instruction sheets that deal with items of information are called information sheets.
   c. Assignment Sheets. Instruction sheets composed largely of questions, designed to direct observation, reading and drill, are called assignment sheets.

1. Selvidge, R. W. <u>How to Teach a Trade</u>. pp. 84-85.

2. Selvidge, R. W. <u>Individual Instruction Sheets</u>. p. 9.

2. Jobs
   a. Job Sheets. Instruction sheets that tell how to do complete jobs which may involve a number of operations are called job sheets. They are especially designed to secure production. They also may be used for small unrelated jobs requiring little skill, such as home mechanics.

The essential elements of good operation or job sheets are the following:

1. Clear statement of the operation or job.
2. Information:
   a. Immediately related to and necessary to do the operation.
   b. Definition of technical terms necessary to understand the operation.
   c. New tools and materials necessary to do the operation.
3. Procedure: a statement of the steps within the operation in order of performance.
4. Illustrations: to supplement information and operations, when necessary.
5. Cautions about personal safety and damage to work.
6. Suggestions for application of work to other situations.
7. Questions for diagnostic purposes and to make the pupils think.

8. References: specific and directly related to the operation.

Objection is often made to instruction sheets because it is claimed that they take away student initiative. If we are to follow the steps of economical and correct habit formation in the performance of an operation, initiative is not essential. The steps in the operation have been determined, by years of practical experience, as being the most economical in time, material and energy. A student could not be expected to arrive at the same result without the expenditure of a great deal of time, energy and material.

> ".....Whatever the methods adopted, the measure of the effectiveness of the instruction is determined by--
> (a) The fact that at the completion of the instructional process the learner has completely grasped the new ideas, or can do the new piece of work.
> (b) The degree to which this result was obtained with the least expenditure of time.
> (c) The degree to which this result was obtained with the least expenditure of energy and effort on the part of both learner and instructor". 3

Opportunity for initiative will come in the application of the operations to the various jobs. The unit operations are the building materials of the trade. The fact that bricks are all the same shape and size does not curtail the initiative of the bricklayer. On the contrary,

3. Allen, Charles R. The Instructor, the Man and the Job. p. 122.

he is free to construct a garage, a church, or an office building according to various plans or designs. In the same way a student may plan and do any job by the proper use of the unit operations of a trade.

The progress that a student makes on unit instruction sheets may be recorded on a progress chart, a sample of which is presented in Appendix I. A diagonal line drawn thru the square indicates that the student has started the operation. Two diagonals indicate that the operation has been finished. The numbers show the number of times the operation has been repeated. A black square indicates an expert.

The chief advantage of instruction sheets lies in the fact that, if well written, they meet the requirements for efficiency.

It is not intended that the unit instruction sheets will take the place of the instructor, nor will they give him more leisure time. On the contrary, it will take more time to prepare the instruction sheets and properly conduct his class. However, he will be compensated by more efficient use of his time in rendering individual help where it is most needed. The student will have an opportunity for initiative and responsibility and each individual will be able to progress according to his own ability.

CHAPTER V

OBJECTIVE TESTS

OBJECTIVE TESTS

In order to check the progress of students and for diagnostic purposes the objective tests shown in Appendix II have been constructed.

Objective tests are superior to the traditional examination for the following reasons:

1. They require specific, unequivocal answers.
2. They provide a wide range of sampling.
3. The responses require little or no writing.
4. Scoring is entirely objective.
5. The results provide guidance for further instruction.
6. They provide economy of time for teacher and pupil.

The objective test may take many forms, among which the true-false, multiple choice, completion, matching and identification are the most common.

In Appendix II is presented a sample progress chart, upon which may be kept the objective test record of each student.

CHAPTER VI

CONCLUSIONS

CONCLUSIONS

In conclusion, the writer has combined visual aids with unit instruction sheets for a course in Automobile Battery Ignition. The units for instruction are based upon an analysis of the trade, made possible by long experience in practical work.

The analysis presents a comprehensive view of the whole field to both student and instructor.

The visual aids have been described and special units have been presented for construction and operation of equipment. They take advantage of steps in learning by

1. Stimulating interest
2. Securing effective response
3. Stimulating self expression.

The instruction sheets have been presented as aids in teaching and the following advantages are claimed for them:

1. They provide for larger classes without imparing efficiency of instruction.
2. They provide a more economical use of the instructor's time.
3. They give the instructor more time for individual instruction.
4. They enable each student to progress at his own rate of speed.
5. They place responsibility and initiative on the student.

6. They insure correct habit formation by directing the steps in the operation so that it is performed correctly the first time.

Objective tests for diagnostic and grading purposes have been worked out for the course. The results of these tests provide guidance for further instruction.

There is presented a sample progress chart, upon which may be kept objective test records and also the progress record of each student on unit instruction sheets.

The course has been planned specifically for trade training but it can be adapted to classes in industrial arts and in technical high schools. Although it has been limited to ignition, the idea can be extended to other divisions of automechanics and to other trades. Its use is limited only by the ingenuity and resourcefulness of the instructor.

The writer does not claim to have discovered new principles or methods of teaching, but it is hoped that some of the suggestions may be helpful to other instructors.

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APPENDIX I

UNIT INSTRUCTION SHEETS

19c

CONTENTS OF APPENDIX I

CONTENTS OF APPENDIX I
(continued)

BATTERY IGNITION

Construction of an Ignition Tester

INFORMATION:

A test bench is desirable for accurate testing of ignition equipment. However, when funds are not available for standard equipment, a simple tester may be made from old ignition parts. Such a tester is described on pages 157 and 158 of the January, 1935, issue of "Popular Mechanics Magazine". A similar tester, modified to meet instruction needs, is described here. A picture of the tester is shown in Fig. 1 and the wiring diagram is shown in Fig. 2, but no attempt is made to give detailed instructions for the construction of each part. The details will have to be modified to conform with the equipment and materials available. For operation of this tester, see Operation Sheet EI-6, "Operating the Ignition Tester".

PROCEDURE:

1. Construct a suitable base board for the tester, the size of which should be $\frac{3}{4}$" x 8" x 12".

2. The upright is a piece of board, $\frac{3}{4}$" x 5" x 16". Notch into the back of the base board and fasten with screws.

3. Secure a complete ignition system such as is used on a Ford or Chevrolet.

4. Mount the ammeter on the upright by boring a hole slightly larger than the diameter of the meter body.

5. Mount the switch in like manner.

6. Remove the small gear at the bottom of the distributor shaft.

7. Mount the distributor shaft on the upright, about 8" above the base board. Use a suitable clamp bracket, made of wood or metal, so that the distributor head may be removed.

8. Mount a small 1/8 H. P. motor upright on the base board so that its shaft lines up with the distributor shaft. Leave a space of at least 2" for the flexible coupling. (A sewing machine motor with rheostat control is suitable.)

9. Turn a disk 6" in diameter from ½" stock. In the center of it cut a grooved circle 1.16" wide, ¼" deep, and 4" in diameter. Bore a hole 2" in diameter in the center.

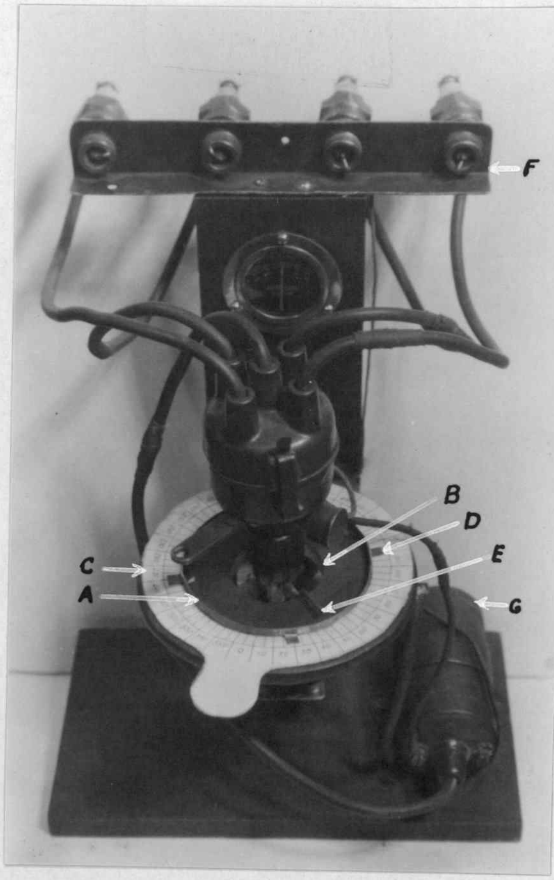


Fig. 1

10. From 3/32" brass or copper make a band 4" in diameter and ½" in width. This is the spark ring. Insert this ring tightly in the groove of the wooden disk, as shown at A in Fig. 1.

11. Mount the wooden disk on the upright so that the top is just flush with the bottom of the distributor shaft, as shown at B, Fig. 1. Small metal brackets made for the purpose are suitable for mounting the disk. Adjust the wooden disk so that the distributor shaft is centered in the hole.

12. Make a cardboard disk, calibrate it into degrees and fit it over the spark ring, as shown at C, Fig. 1. A piece of cellophane or celluloid may be used to cover the dial and protect it from dirt. Small lugs may be

soldered to the ring to hold down the disk, as shown at D, Fig. 1.

13. Connect the motor to the distributor shaft with a piece of flexible hose of suitable size. If the hose fits tightly enough there will be no need for clamps.

14. The rotor arm, shown at E in Fig. 1, is made from a piece of heavy copper wire about 2½" long. Insert it in the hole which held the gear on the bottom of the distributor shaft. The rotor arm may be made adjustable by soldering a brass screw to the copper wire and using a nut on each side of the shaft for adjustment.

15. Adjust the gap between the rotor arm and the spark ring to approximately ¼".

16. Mount the spark plugs on top of the upright by means of an angle iron which has threaded holes to take the plugs. See F, Fig. 1.

17. Mount the ignition coil, shown at G in Fig. 1, in a convenient place.

18. Wire the tester according to the ignition tester circuit diagram shown in Fig. 2.

CAUTIONS:

1. For best results the motor should be controlled by a rheostat of some kind. A water rheostat may be constructed if a wire-wound one is not available.

2. The top speed should be at least 1800 R. P. M. This corresponds to an engine speed of 3600 R. P. M. The spark disappears on most systems at 1500 to 2000 R. P. M. distributor speed.

SUGGESTIONS:

1. Many variations of this tester may be made for instructional purposes. A series of these testers may be set up and run by a counter shaft and ¼ H. P. motor. Cone step pulleys and round belts can be used to vary the speed of each individual tester.

IGNITION TESTER CIRCUIT

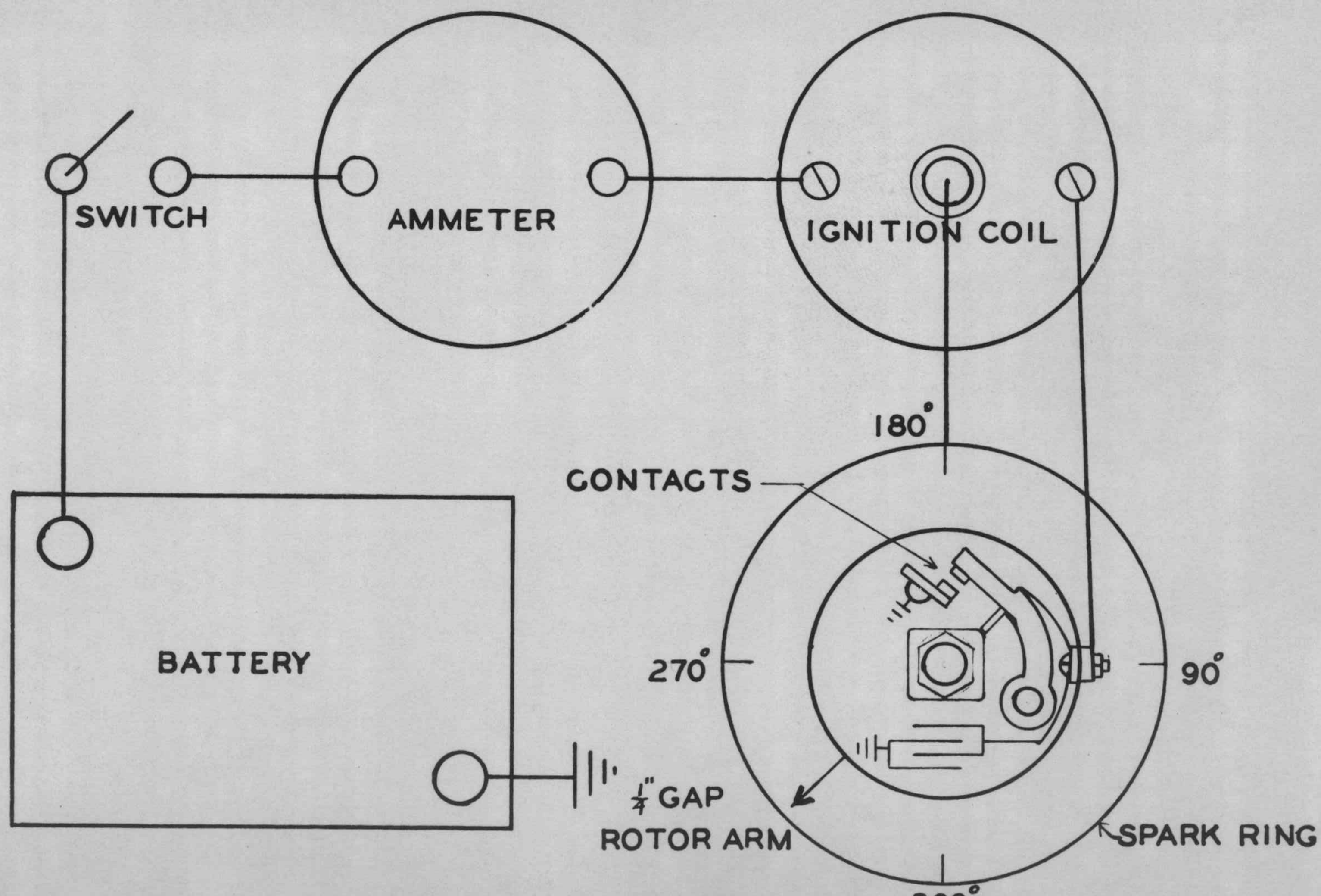


FIG. 2

Each tester may be arranged to test some special part of the ignition system or some particular make of ignition system.

2. Old parts of ignition systems may be secured from junk yards and wrecking companies at low prices. Very often old cars and parts are donated to schools by private owners and garages.

3. Students can do most of the construction work under the guidance of the instructor. The usefulness of the tester is limited only by the ingenuity and the resourcefulness of instructor and students.

REFERENCES:

"Popular Mechanics Magazine", Vol. 63, No. 1, January, 1935. pp. 157, 158.

BATTERY IGNITION

Construction of a Condenser Tester

INFORMATION:

A source of direct current is necessary for testing condensers. A simple and efficient testing device may be made up as follows:

Material Required

1 step down transformer, 110 to 5 volts
1 four-prong tube socket
1 '01A radio tube
1 standard electric lamp socket
1 Neon Glow tube, $\frac{1}{2}$ watt, standard base
1 base board, $\frac{3}{4}$" x 6" x 10"
1 pair test leads
1 test point
1 test clip
5 ft. double flexible lamp cord and plug
Supply of screws and No. 16 hook up wire

PROCEDURE:

1. Mount the transformer, tube socket and light socket on the base board in the order shown in the diagram. It is not necessary to leave a space for the condenser shown in the diagram, as that is the one to be tested. Space the instruments evenly and neatly on the base and fasten securely with screws.

2. Wire the transformer secondary, supplying 5 volts, to the filament terminals of the tube socket.

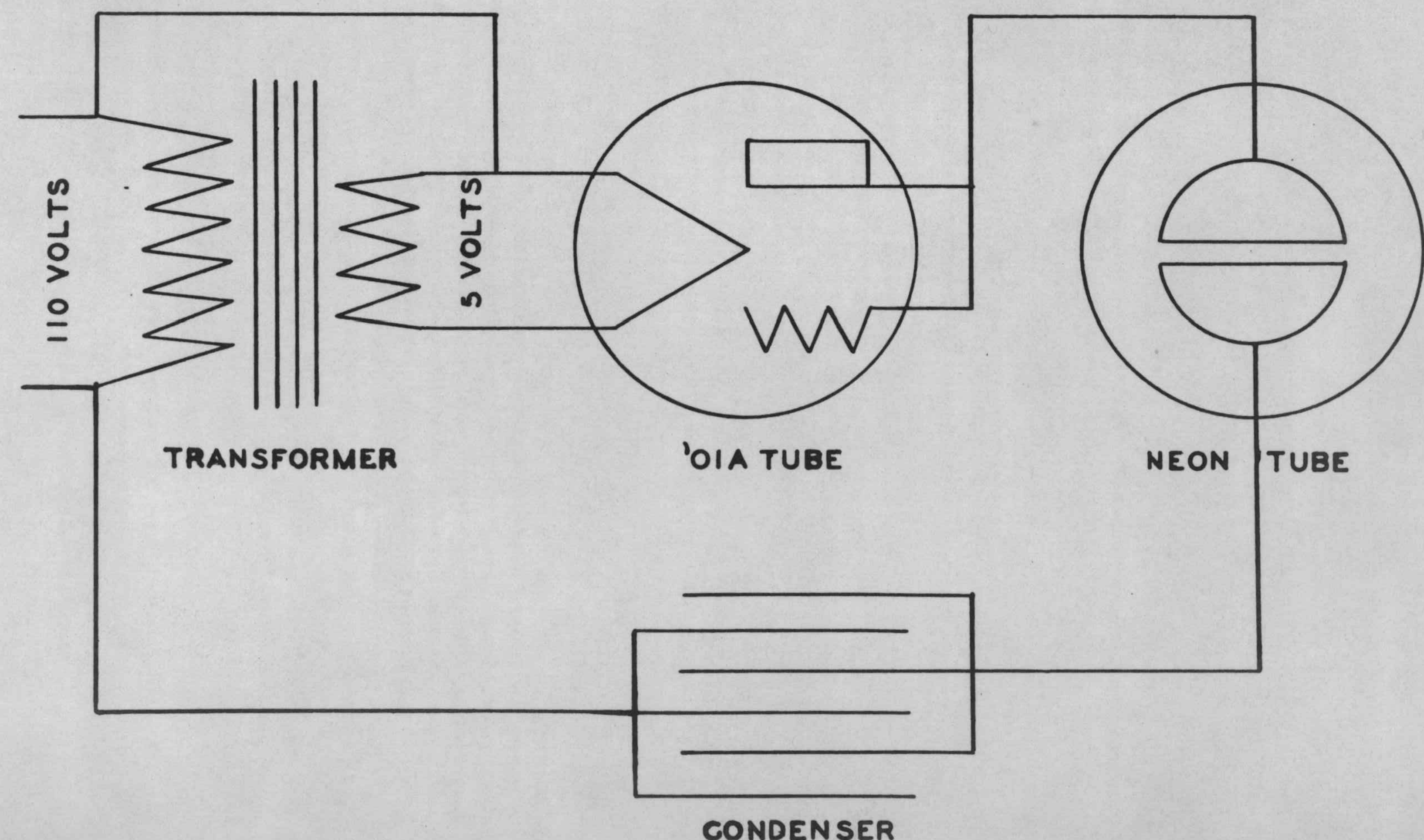
3. Wire the grid and plate of the tube socket together, as shown in the diagram, and connect to one side of the neon tube.

4. Connect a flexible test lead, with point attached, to the other side of the neon tube.

5. Connect the other flexible test lead, with clip attached, to one side of 110 volt supply.

6. Connect the opposite side of the supply line to one

CONDENSER TESTER



side of the filament of the '01A tube socket.

7. Connect the lamp cord to the primary of the transformer and attach the plug.

8. Plug the '01A tube into its socket.

9. Plug the transformer into a base plug or light socket.

10. Touch the test leads together and watch for the neon tube to glow. This indicates that the tester is working properly. See Operation Sheet EI-14, "Testing a Condenser with Direct Current".

CAUTIONS:

When the line voltage is below 100 volts, the tester does not work well. It may be necessary to substitute a transformer with two secondary windings, one supplying 150 volts and the other, 5 volts. The 5-volt secondary is connected to the filament of the tube. One side of the 150 volt secondary is connected to the filament winding and the other, to the flexible test lead.

SUGGESTIONS:

1. The '01A tube acts as a rectifier to supply direct current to the neon tube. When direct current flows, only one element of the neon tube glows. When alternating current flows, both elements glow. Check the tester to verify this. The tube will work in a standard socket, using 110 volts, A. C.

2. The neon tube will operate with a fraction of a milliampere of current. The tester may be used to make continuity tests on the secondary of ignition coils and other circuits.

3. The filament of the '01A tube will stand 6 volts and a transformer supplying 6 volts may be used.

4. A milliameter reading 0-1 may be used in place of the neon tube. Capacity tests may be made by observing the amount of deflection of the needle.

BATTERY IGNITION

Testing a Battery with a Hydrometer

INFORMATION:

All cells in a battery should be tested at least once a month. If any cell reads below 1.200 points on several successive test dates, the battery should be removed from the car and charged on the bench until each cell reads from 1.280 to 1.300. The hydrometer readings indicate the state of charge and are of vital importance in battery care. The test should be made before filling up with distilled water. If the water is supplied first, it weakens the electrolyte and will give no reading until the battery has been charged for some time. Charging causes the water to mix thoroughly with the electrolyte, producing uniform density. If the electrolyte is below the level of the plates, a test cannot be made. Distilled water must be supplied and the battery charged or the car allowed to run for some time before testing.

PROCEDURE:

1. Carefully remove all dirt and foreign substance from the top of the battery.

2. Remove the filling plugs in the top of each cell.

3. Deflate the hydrometer bulb.

4. Insert the rubber tube in the vent and lower into the electrolyte.

5. Slowly release the bulb, allowing the electrolyte to flow into the body of the instrument.

6. Hold the syringe body perpendicular, so that the hydrometer proper will float clear of the sides.

7. See that the hydrometer really floats and does not touch top or bottom.

8. When the hydrometer is floating nicely, give the bulb a little pressure to relieve the vacuum, otherwise the reading may be too high.

9. Read the graduation number which coincides with the level of the liquid.

10. Deflate the bulb to expel all the electrolyte from the instrument. Take care not to spill electrolyte on top of the battery.

11. Replace all filler plugs.

CAUTIONS:

1. Take care not to drop any of the electrolyte on top of the battery.

2. Allow the rubber tube to remain in the electrolyte if the hydrometer can be read in this position. This will prevent spilling electrolyte when tube is removed.

3. Any electrolyte accidentally spilled on the battery or car should be carefully wiped off.

4. Take care not to spill electrolyte on clothing. It will eat holes in clothing as it contains sulphuric acid.

5. If electrolyte is accidentally spilled on clothing or upholstery, rub some common soda into the spot or rinse in soda water. This will counteract the action of the acid.

SUGGESTIONS:

A small bristle brush may be used to clean the dirt from the top of the battery.

QUESTIONS:

1. What is the purpose of the hydrometer?

2. What reading indicates a fully charged battery? A discharged battery?

3. Should distilled water be added before the hydrometer test? Why?

4. Why should the hydrometer "float"?

5. Will the electrolyte affect clothing?

6. What will counteract acid?

7. What is meant by specific gravity?

8. Should acid be added to the battery?

9. Why is it necessary to have the electrolyte at a certain level?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. p. 59.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 293-296.

BATTERY IGNITION

Adding Distilled Water to a Battery

INFORMATION:

There is a continual evaporation of water from the battery and it is necessary to keep all cells filled with distilled water to a depth of 3/8 to $\frac{1}{2}$ inch above the separators between the plates. Nothing but distilled water should be used because it contains no foreign substances detrimental to the action of the battery. The electrolyte level should be tested at least every two weeks to insure having the plates covered at all times. Exposure of plates to air has a deteriorating effect on them. Do not fill the cells too full or they will spill over when the battery is being charged and thus cause the loss of electrolyte.

PROCEDURE:

1. Remove all dust, dirt and foreign material from the top of the battery.

2. Remove the filler plugs.

3. Observe the depth of the liquid above the separators by looking straight down thru the filler hole. A short glass tube with a short rubber tube attached to one end may be used for this purpose. (a) Insert the glass tube in the electrolyte and push it down until it strikes the separators. (b) Place your finger tightly over the rubber tube and remove the glass tube from the battery. A small amount of electrolyte will remain in the glass tube, held up by the vacuum. (c) The height of this column of liquid above the separators indicates the height of the liquid in the battery.

4. Compress the bulb of the syringe battery filler to force out the air.

5. Insert hard rubber tube in distilled water jar.

6. Release the bulb slowly to allow the water to be drawn into the bulb.

7. Insert hard rubber tube in the battery filler hole.

8. Compress the bulb slowly, allowing the water to run into the cell.

9. Watch the level of the liquid above the separators and do not overfill. Check depth with the glass rod at frequent intervals. Proper level is 3/8 to ½ in. above the separators.

10. Replace filler plugs.

11. Wipe all surplus water from top of the battery.

CAUTION:

Do not use metal in handling distilled water.

SUGGESTIONS:

1. A small bristle brush may be used to remove dirt and foreign substance from the top of the battery.

2. The battery should be tested with the hydrometer before filling with water. See Operation Sheet EI-1, "Testing a Battery with a Hydrometer".

QUESTIONS:

1. Why is it necessary to use distilled water?

2. Why keep the level of electrolyte above separators?

3. Why avoid metals in handling distilled water?

4. Does spilling electrolyte affect the battery? How?

5. Why is the hole placed in the top of the filler plug?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 60-62.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. p. 293.

BATTERY IGNITION

Removing the Battery from the Car

INFORMATION:

When any cell of the battery tests less than 1.200 for several consecutive monthly tests, the battery should be removed from the car and charged on the bench until each cell reads 1.280 to 1.300. See Operation Sheet EI-1, "Testing a Battery with a Hydrometer". The battery is usually located under the floor boards just back of the engine on the starting motor side. A glance under the car will determine its location. Sometimes it is necessary to remove the floor boards but nearly all new cars have provision for removing the battery without disturbing the floor boards. All that is necessary is to lift the floor mat and a special cover over the battery. Special battery-carrying devices are used to lift the battery out of the car and to carry it to the charging bench. These devices are of two kinds, depending on the type of battery. One is a strap with hooks on each end to be hooked into the handles of the battery. Another kind is made of a heavy metal rod bent into the shape of a bail, which fits into holes in each end of the battery. Make sure that the carrier is secure to the battery so that there will be no danger of dropping it. Use a 6" crescent or open end wrench to loosen the battery cable terminal.

PROCEDURE:

1. Locate and uncover the battery.

2. Note whether the negative or positive terminal is grounded.

3. Loosen the nut on the inside battery cable terminal.

4. Remove the clamp carefully by moving it upward so that it will slip off the battery terminal.

5. Drop the loose cable down out of the way.

6. Remove the ground cable terminal in the same manner.

7. Loosen battery clamps that hold battery in brackets.

8. Insert the battery-carrying device in the holes or handles at each end of the battery.

9. Carefully lift the battery straight up out of its brackets.

CAUTIONS:

1. Do not hammer the battery terminals in removing the cables because this may injure the cells.

2. Do not use pliers on battery cable terminal nuts. Always use proper wrench.

3. Be careful about "shorting" the battery or any of the cells with your tools when you are working on it. Disconnect the inside terminal first so that it can be dropped down out of the way.

SUGGESTIONS:

1. Sometimes the terminals become corroded due to the action of the sulphuric acid on the metal. This should be carefully removed before loosing the terminal, if possible.

2. Sometimes the terminals stick tightly because of corrosion. They can often be started loose by a very gentle twisting motion of the cable terminal around the battery terminal.

3. When lifting the battery out of the brackets, stand with one foot on each side of the battery and pull straight up.

QUESTIONS:

1. Why is it necessary to remove a battery from the car?

2. What special tools are necessary to remove a battery?

3. Why does corrosion form on the battery cable terminals?

4. Should any precaution be taken for the protection of the cells? If so, what?

5. Why remove the battery cable first?

REFERENCES:

Dyke, A. L. Automobile and Gasoline Engine Encyclopedia, The Goodheart-Willcox Company, Inc., Chicago, Ill., 1923. pp. 521-528.

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. p. 52.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. p. 292.

BATTERY IGNITION

Charging a Battery with the Tungar Rectifier

INFORMATION:

Storage batteries must be charged with direct current. If no direct current is convenient, some device must be used to change alternating current to direct current. A common and economical method of changing A. C. to D. C. is by means of a Tungar Rectifier. It is best to make a record of hydrometer readings of each cell before starting the charge.

PROCEDURE:

1. See that the electrolyte level in each cell is correct. If not, bring it to the proper level by adding distilled water. See Operation Sheet EI-2, "Adding Distilled Water to a Battery".

2. Remove the filler plugs from the battery to allow free escape of gases.

3. Connect the positive terminal of the charger to the positive terminal of the battery.

4. Connect the negative terminal of the charger to the negative terminal of the battery.

5. Turn the current on the rectifier and see that the tube is lighted.

6. Note the ammeter reading and turn the rheostat so that the reading is less than seven.

7. Observe the battery occasionally during the charge and make hydrometer readings of each cell.

8. If the battery heats or gases too freely, cut down the rate of charge.

9. When all cells have a hydrometer reading between 1.280 and 1.300, stop the charger and disconnect the battery.

10. Replace filler plugs and wipe top of battery clean.

CAUTIONS:

1. Avoid heating the battery above 110 degrees Fahrenheit. Reduce the charging rate if it goes above that point.

2. Do not bring a naked flame near the gassing battery, as hydrogen and oxygen are being produced which are highly explosive.

SUGGESTIONS:

1. Charge at the rate recommended by the particular battery being charged, if it is possible to secure that information.

2. Read article 148 and 149 on constant potential charging in <u>Automotive Electrical Practice</u> by Ray F. Kuns, pp. 123-124.

QUESTIONS:

1. What kind of current should be used for charging storage batteries?

2. What charging rate should be used?

3. How is the battery connected to the charger?

4. How can you tell when the battery is fully charged?

5. What gases are generated during the charge?

6. Is there danger of overheating the battery? What is the remedy?

REFERENCES:

Kuns, Ray F. <u>Automotive Electrical Practice</u>, Bruce Publishing Company, 1926. pp. 123-126.

Kuns, Ray F. <u>Automotive Trade Training</u>, Bruce Publishing Company, 1922-1926. pp. 321-323.

BATTERY IGNITION

Replacing the Battery in the Car

INFORMATION:

After the battery has been charged, it should be carefully checked for proper level of electrolyte and hydrometer reading. In order to counteract the action of acid spilled on top and terminals, clean with a cloth dampened with a saturated solution of baking soda and water. The battery has posts of different sizes; the positive is larger than the negative. The battery cable terminals are of different size also, the positive being larger to fit over the positive battery post. This fact makes it much easier to replace the battery in the car. Many new cars have the positive terminal grounded; some of the older ones have the negative side grounded.

PROCEDURE:

1. With an old knife or similar tool scrape the corrosion from the cable terminals. Be sure to get the inside of the hole bright and clean. A piece of emery or sandpaper may be used and the whole terminal may be washed in a saturated solution of soda and water.

2. Clean and oil the threads of the bolt in the terminal clamp.

3. Rub a little vaseline over the battery post and cable terminal.

4. Insert the battery carrier in the battery and lift it into its proper place. Be sure to put it in so that the proper terminal is grounded. The battery post and cable terminal must be matched in size.

5. Replace battery cable terminals and securely tighten clamp bolts, using proper size wrench.

6. If the clamps are badly corroded or do not fit the posts of the battery, they should be replaced. Sometimes sheet lead used as a bushing around the inside of the clamp will remedy a loose connection.

7. Turn on the lights and note the ammeter. It should show discharge. If it shows charge, the terminals of the battery are reversed.

8. If the ammeter shows discharge, step on the starter and start the motor.

9. Speed up the motor to a moderate speed and watch the ammeter. It should show charge, which indicates that the battery is charging in the proper manner.

10. Stop the engine and replace battery "hold down" clamps.

11. Remove all tools and replace battery cover, floor boards, and mat.

12. See that there is no dirt or grease left on the car.

CAUTIONS:

1. Acid spilled on the clothing can be counteracted by the application of a saturated solution of soda and water. Acid will rapidly deteriorate clothing.

2. A loose battery terminal may cause all the lights on the car to burn out. The battery acts as a reservoir for the generator and, if disconnected, the voltage to the lights goes too high. A sudden jar may cause a temporary broken connection between battery and generator.

3. The battery terminals may be tight enough for the passage of current required for the lights and ignition, but still not pass the current necessary for starting the car. The starter requires several hundred amperes for a short interval and all connections and cables must have such carrying capacity.

SUGGESTIONS:

Corroded terminals making poor contact may lead you to think that the battery is dead. Check this before condemning the battery.

QUESTIONS:

1. What is the cause of corrosion on the battery terminals?

2. What will counteract acid?

3. Why is it necessary to replace the battery with proper terminal connections? How can you check your connections?

4. Is it advisable to use pliers on the terminal clamp bolts? Why?

5. Why does a loose battery connection burn out the lights?

6. Why is a large cable used for the starter and only a small one for lights and ignition?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 62, 65.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 288, 292.

BATTERY IGNITION

Operating the Ignition Tester

INFORMATION:

Special equipment is necessary for the accurate testing of the parts of an ignition system. The best equipment for this purpose is a standard test bench, but it is rather expensive for the average small commercial or school shop. Construction Sheet EI-1, "Construction of an Ignition Tester", gives the details for the construction of an inexpensive home made ignition tester. A similar tester is described on pages 157 and 158 of the January, 1935, issue of "Popular Mechanics Magazine". It consists of a variable speed motor which drives a distributor connected in a regular ignition circuit with battery, interrupter, condenser and transformer. A special spark ring, which has been calibrated in degrees, permits observation of the regularity and heat of the spark. Tests may be made by comparing the action of the suspected part with a part of the same type that is known to be good. Tests may be made on this tester, as described in the following unit instruction sheets:

1. Operation Sheet EI-7, "Testing an Interrupter on the Ignition Tester".

2. Operation Sheet EI-8, "Testing a Condenser on the Ignition Tester".

3. Operation Sheet EI-9, "Testing an Ignition Coil".

4. Operation Sheet EI-10, "Testing a Distributor".

5. Operation Sheet EI-11, "Testing Spark Plugs".

6. Operation Sheet EI-12, "Testing Automatic Spark Control".

7. Operation Sheet EI-15, "Synchronizing Dual Sets of Breaker Points".

General directions for operation of the tester are given below.

PROCEDURE:

1. Plug the tester with rheostat connected into the 110-volt line.

2. Connect a 6-volt storage battery to the tester, as shown in the illustration.

3. Turn on the ignition switch and observe the reading of the ammeter. If no current is indicated, turn the distributor shaft by hand until the contact points close and meter registers. If there is still no reading, carefully check the connections and wiring.

4. Start the motor by pressing the foot pedal of the rheostat.

5. Speed up the motor to a moderate speed and observe the spark on the spark ring.

6. Note the intensity and regularity of the spark.

7. Move the calibrated dial until the zero mark coincides with the nearest spark.

8. Note the number of degrees between sparks. The correct angle is ninety degrees.

9. Speed up the motor to its highest speed by stepping on the rheostat.

10. Note the approximate speed at which spark disappears.

11. These operations are to make you familiar with the tester. Have the instructor check your work.

12. Turn off the ignition switch.

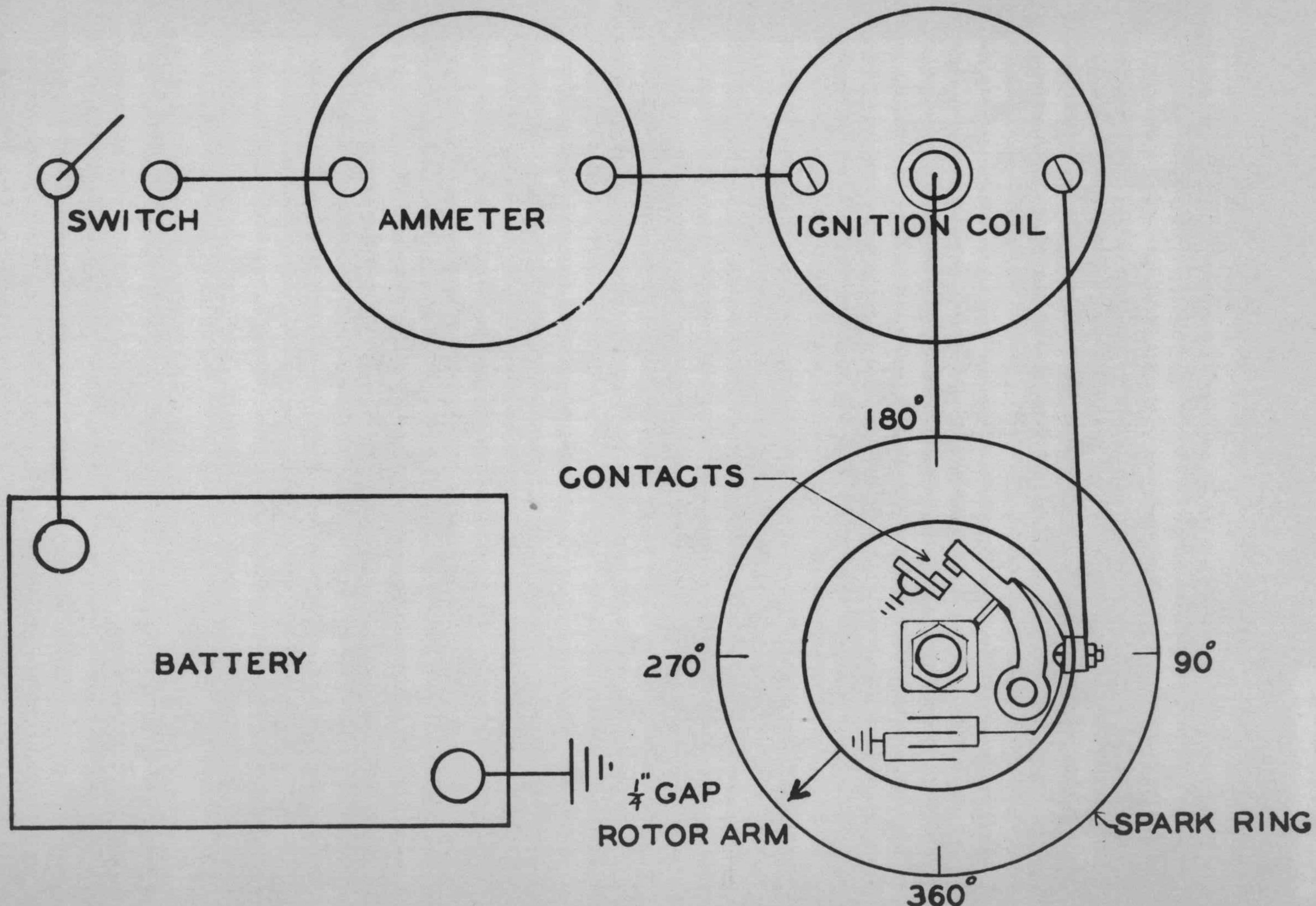
13. Disconnect battery.

14. Pull the plug, disconnecting motor from line.

CAUTIONS:

1. Keep hands clear of spark ring as this carries high tension current.

IGNITION TESTER CIRCUIT



2. Be sure that the battery is furnishing the necessary current and that contacts are well made.

3. Do not forget to turn off the switch. It will run down the battery and damage the coil.

SUGGESTIONS:

1. Test only one part at a time with all other parts known to be in good condition.

2. Refer to proper operation sheet when testing the suspected part.

3. Study and become familiar with symptoms that indicate trouble and be able to diagnose the cause of them.

4. Have the instructor check the spark of the standard equipment before you proceed with a test.

QUESTIONS:

1. Why is it necessary to have an indication of current on the ammeter before proceeding with the test?

2. Why are the sparks ninety degrees apart?

3. What will happen if the battery switch is left on?

4. If no current is indicated, what should you do?

5. If there is no reading on the ammeter, does it indicate a discharged battery?

6. What controls the speed of the motor?

REFERENCES:

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 360-363.

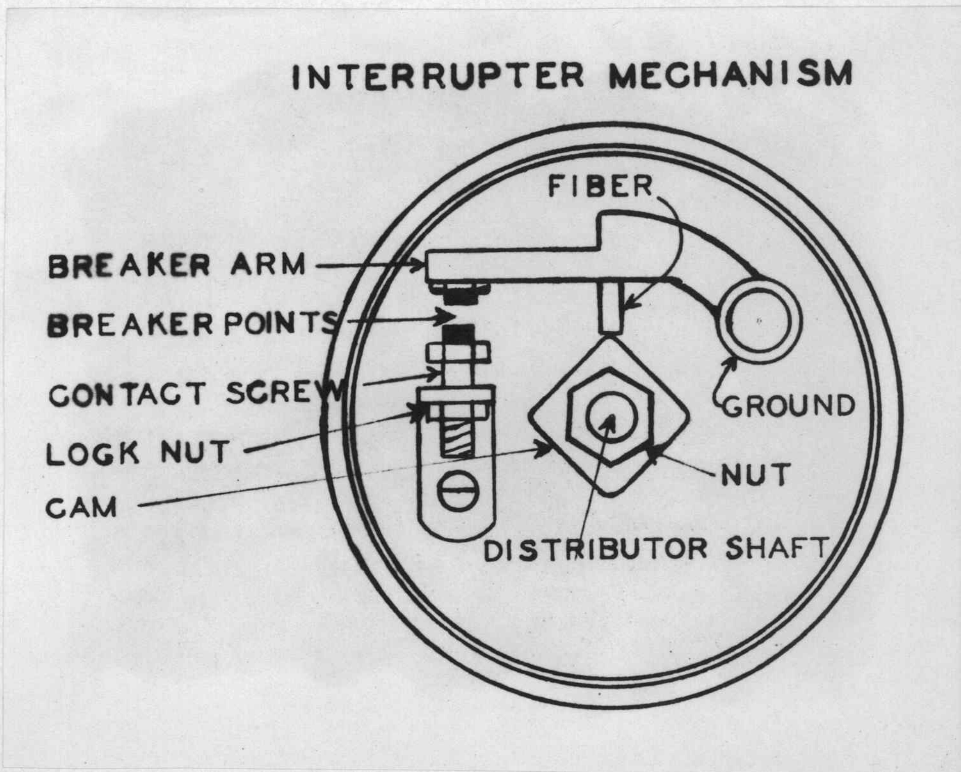
"Popular Mechanics Magazine", Vol. 63, No. 1, January, 1935. pp. 157-158.

BATTERY IGNITION

Testing an Interrupter on the Ignition Tester

INFORMATION:

The interrupter is a mechanical device for breaking the primary circuit at the proper time. See Information Sheet EI-1, "Transformer". It is sometimes spoken of as the circuit breaker, contact points and similar terms. It is located in the ignition head which also contains the distributor, and both are operated by the same shaft. For the purpose of this



test, we will include all parts necessary for its operation as part of the interrupter mechanism. See illustration. It is a vital part of the ignition system and a good spark is dependent on its proper operation. It is necessary for every trouble shooter to be able to recognize symptoms and to diagnose cause of trouble.

PROCEDURE:

1. Test the standard interrupter already in the ignition tester and observe the heat and regularity of the spark on the spark ring.

2. Remove the standard interrupter and substitute the interrupter to be tested.

3. Turn on the ignition switch and follow instructions in Operation Sheet EI-6, "Operating the Ignition Tester".

4. Check the degrees between sparks. If sparks do not occur ninety degrees apart, it indicates:

    a. Worn distributor shaft bearing.
    b. Worn and uneven interrupter cam.

5. If a double spark occurs, it indicates "point bounce", caused by weak interrupter arm spring.

6. Compare the heat of spark on the spark ring with the spark you observed on the standard coil. If spark is weak, it indicates:

    a. Improper adjustment of contact points.
    b. Poor contact of points. See Operation Sheet EI-13, "Adjusting and Caring for Breaker Points".
    c. Other causes of weak spark are defective coil and condenser, but these causes are eliminated because the parts are standard and known to be good.

7. Trim the contact points, if necessary, and adjust according to instructions given in Operation Sheet EI-13, "Adjusting and Caring for Breaker Points".

8. Give the interrupter a final test.

9. Speed up the motor and observe the approximate speed at which the spark weakens and disappears.

10. If the interrupter compares favorably with the standard interrupter, it is satisfactory.

11. Remove the interrupter and replace standard part.

12. Have the instructor check your work.

CAUTIONS:

1. Turn off ignition switch while making adjustments.

2. Beware of high tension circuit.

SUGGESTIONS:

Make nothing but interrupter tests and become familiar with symptoms and causes. Keep all standard parts in circuit except part being tested.

QUESTIONS:

1. Why do bad contact points cause a weak spark?

2. What results are caused by improper contact point adjustment?

3. What causes "point bounce"?

4. What causes a double spark?

5. What causes irregularity of the spark?

6. How many degrees apart should the sparks occur on the spark ring?

REFERENCES:

Dyke, A. L. Automobile and Gasoline Engine Encyclopedia, The Goodheart-Willcox Company, Inc., Chicago, Ill., 1923. p. 200.

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 364-366.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 328-329.

"Popular Mechanics Magazine", Vol. 63, No. 1, January, 1935. pp. 157-158.

BATTERY IGNITION

Testing a Condenser on the Ignition Tester

INFORMATION:

In Operation Sheet EI-14, "Testing a Condenser with Direct Current", is described the method of testing a condenser by the use of direct current. Another way is to place the condenser in the ignition tester and compare its action with that of a condenser of the same type which is known to be good. This can be done on a test bench or on the ignition tester described in Operation Sheet EI-6, "Operating the Ignition Tester". This is the best way to find out how well a condenser works with a certain type of coil. Condensers which are sealed in the coil may be tested in this way. Before starting on the operations, read Information Sheet EI-2, "Condenser", and follow Operation Sheet EI-6, "Operating the Ignition Tester".

PROCEDURE:

1. Test the standard condenser already in the ignition tester and observe the heat and regularity of the spark on the spark ring.

2. Remove the standard condenser already in the ignition tester and substitute the condenser to be tested.

3. Follow the operations in Operation Sheet EI-6, "Operating the Ignition Tester", and compare the spark on the ring with the spark observed when the standard condenser was in place.

4. A weak spark indicates a defective condenser.

5. A dead "short" causes complete failure of the spark.

6. A leaking condenser causes irregular ignition.

7. Excessive sparking at the points indicates a faulty condenser.

8. If the condenser is faulty, replace with new condenser and give final test.

9. Replace the standard condenser in the tester.

10. Turn off the ignition switch and disconnect battery and motor.

CAUTIONS:

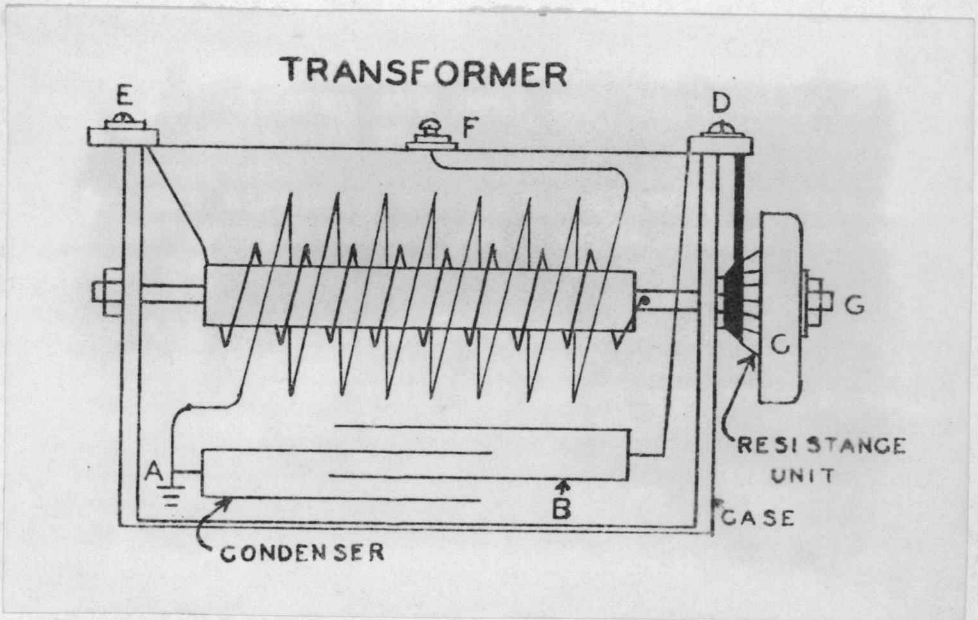
1. Be sure that all connections are made properly.

2. Do not replace condenser until you are certain that it is defective.

3. Make a test with direct current before discarding the condenser. See Operation Sheet EI-14, "Testing a Condenser with Direct Current".

SUGGESTIONS:

1. It is a good precaution to test a suspected condenser by the condenser tester as well as on the test bench, before discarding.



2. The type of condenser sealed in a coil case may be tested by both methods. A careful study of the technical diagram will enable you to make the test. See illustration. For the D. C. test, connect to points A and D.

3. Remember that the condenser is always shunted across the contact points in parallel.

QUESTIONS:

1. What causes excessive sparking at the points?

2. What effect does a "shorted" condenser have on the spark?

3. What are the two functions of the condenser?

4. How is the condenser connected in the circuit?

5. Where is the condenser located?

6. What is the result of a leaking condenser?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 28, 377.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. p. 357, Fig. 417; p. 353, Fig. 407.

BATTERY IGNITION

Testing an Ignition Coil

INFORMATION:

The ignition coil is essentially a transformer for stepping up the voltage from six to about eighteen thousand volts. This high voltage is required to jump the gap between the spark plug points. See Information Sheet EI-1, "Transformer". There must be an intense, hot spark at the spark plug in order to ignite the gas under pressure in the cylinders. The ignition coil is the heart of the ignition system and the trouble shooter must be able to diagnose symptoms of a faulty coil.

PROCEDURE:

1. Test the standard coil, (already in the testing machine), noting the intensity and regularity of the spark.

2. Remove the standard coil and substitute the coil to be tested.

3. Throw the ignition switch to allow current to flow into the primary circuit.

4. Observe the ammeter and note its reading. It should read approximately the same as the standard coil. If no current is indicated, examine all connections and be sure that the contact points of the interrupter are closed. If there is still no reading on the meter, it indicates an open circuit in the primary. If the reading is too high, it indicates a "short" in the primary. If the reading compares favorably with the standard coil which is known to be good, the secondary winding should be all right.

5. Start the motor and control with the rheostat to a moderate speed.

6. Observe the heat and regularity of the spark on the spark ring.

7. Speed up the motor until the spark disappears. Compare this speed with that of the standard coil.

8. Cut out the rheostat and let the tester run full speed for twenty minutes. If there is any decrease in the spark, the coil will probably cause the car to miss at high speed or when it is pulling hard.

CAUTIONS:

1. Check the original circuit from which the coil came and determine the location of the condenser. Sometimes the condenser is sealed in the coil case, (see Information Sheet EI-1, "Transformer",), in which case remove the lead from the regular condenser on the ignition tester.

2. Examine the coil to determine if it has a safety coil. If this coil is burned out it may lead you to think that the primary winding is open. See Information Sheet EI-1, "Transformer".

SUGGESTIONS:

1. If the coil stands all these tests and compares favorably with the standard coil known to be in good condition, it should operate satisfactorily.

2. Study the references and become familiar with the different types of coils.

3. Ask the instructor to check your results for final approval.

QUESTIONS:

1. How much current flows thru the primary circuit?

2. What is the purpose of the primary winding?

3. Is the primary current D. C. or A. C.?

4. How is the current transferred from the primary to the secondary?

5. Is there a metallic contact between the primary and the secondary?

6. How is the voltage raised to eighteen thousand volts?

7. Is the current in the secondary A. D. or D. C.?

8. What kind of insulation is used on secondary leads? Why?

9. Of what material is the core made?

10. What indicates a "short" in the primary winding?

11. What is the result of a "short" in the secondary winding?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 375-403.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 325-327.

BATTERY IGNITION

Testing a Distributor

INFORMATION:

The distributor is a device for distributing the spark from the ignition coil to the cylinders in the correct firing order. See Information Sheet EI-4, "Charging a Battery with the Tungar Rectifier". The

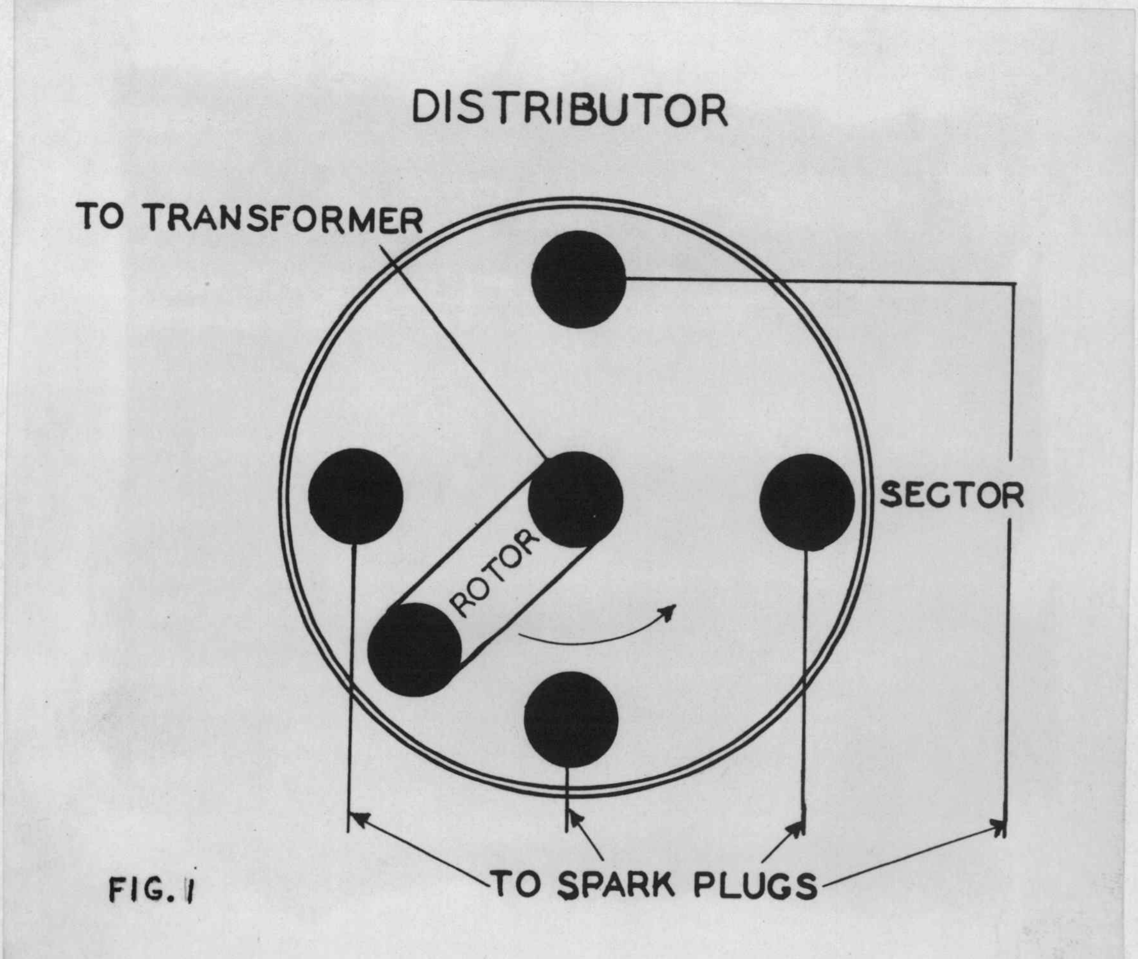


FIG. 1

distributor cap is composed of high insulating material, in which is imbedded a metal sector for each cylinder. To these sectors are attached the high tension wires leading to the spark plugs. A metal sector in the center of the cap is attached to a high tension wire from the secondary of the ignition coil. A rotor carries the current from this center cap to the other sectors. See Fig. 1. Examine the distributor cap on the ignition tester and become familiar with its operation. Sometimes the insulating material in the distributor cap becomes broken down, causing a short circuit. This will cause irregular running of the engine if the condition is bad and the engine will appear to be out of time. It is difficult to locate this trouble without the proper equipment but it can be done on the ignition tester.

PROCEDURE:

1. See that the ignition tester is in working order by following the directions in Operation Sheet EI-7, "Testing an Interrupter on the Ignition Tester".

2. Connect the insulated test leads, as shown in Fig. 2.

3. Start the motor and hold the test points about one fourth inch apart to test the spark.

4. Test the suspected distributor cap from center sector to each outside sector.

5. Test between each outside sector, and every other one, in like manner.

6. If the insulation is broken down, a spark will jump between points.

7. If a spark occurs between any two points, the distributor cap should be replaced.

8. If the distributor does not show a spark between any two points, it should operate satisfactorily.

9. To test the distributor under actual running conditions, remove the standard distributor cap and rotor from the ignition tester and replace them with the distributor to be tested.

10. Run the tester at a moderate speed and observe the sparks at the spark plugs.

TESTING DISTRIBUTOR CAP

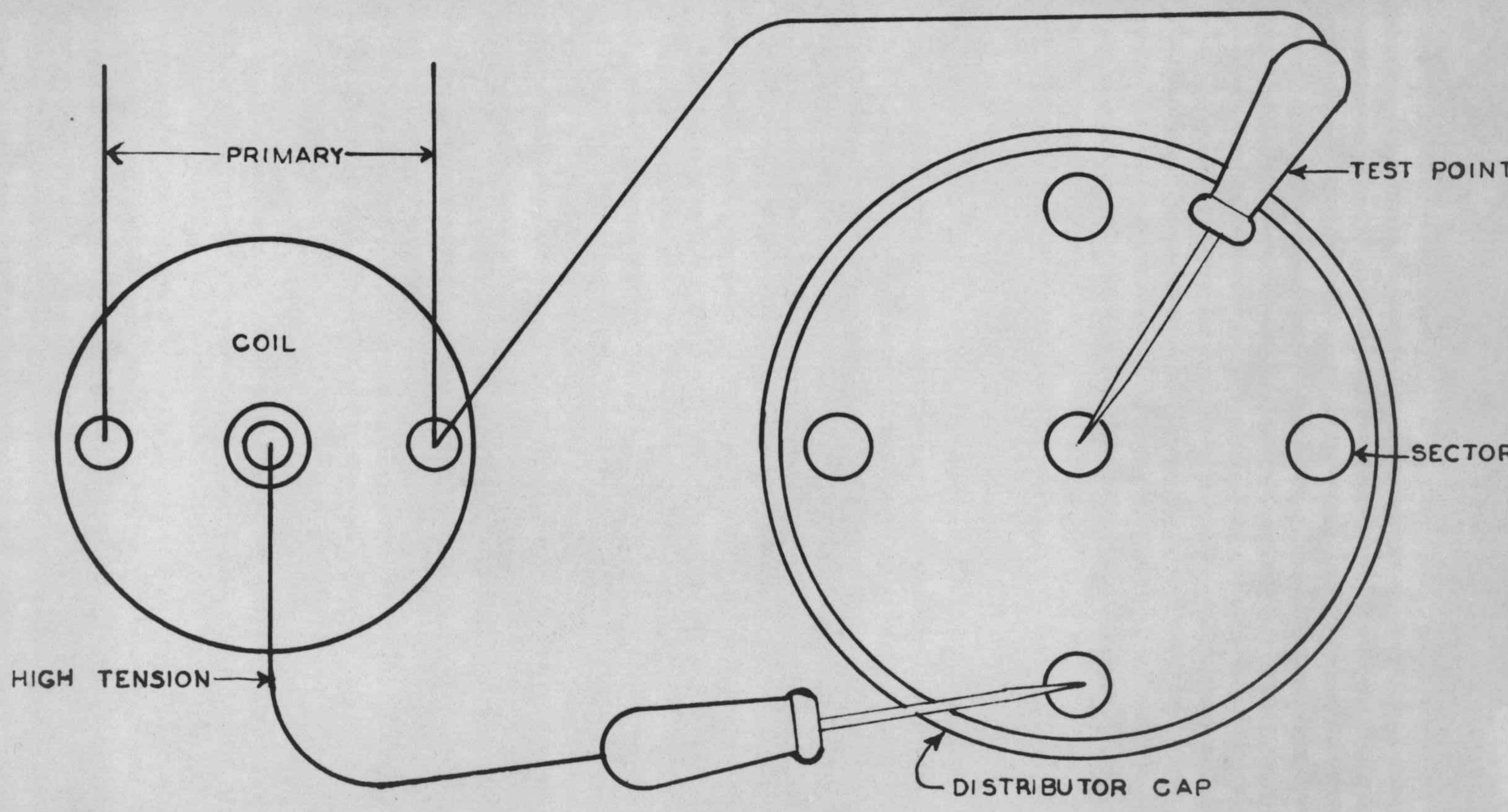


FIG. 2

11. Any irregularity in the firing order will indicate trouble. If a spark fails to appear at the plugs, examine the rotor for proper adjustment. See Information Sheet EI-4, "Types of Distributors".

12. Replace standard parts in the ignition tester circuit.

CAUTIONS:

1. Be careful to hold the test leads by the insulated handles to avoid a shock.

2. Clean the distributor cap thoroughly before testing, as fine particles of dirt may cause a "short".

SUGGESTIONS:

Read the references on the jump-spark-type and wipe-type of distributor and become familiar with the advantages and disadvantages of each type.

QUESTIONS:

1. Why does the distributor cap require a high insulation material?

2. Name two types of distributor. What are the advantages and disadvantages of each?

3. What is the purpose of the rotor?

4. What are the two possible firing orders on a four cylinder engine? What governs the firing order?

5. How can you determine the firing order of an engine?

6. What symptom indicates a "shorted" distributor?

REFERENCES:

Kuns, Ray F. _Automotive Electrical Practice_, Bruce Publishing Company, 1926. pp. 371-372.

Kuns, Ray F. _Automotive Trade Training_, Bruce Publishing Company, 1922-1926. pp. 329-330, 343-344.

BATTERY IGNITION

Testing Spark Plugs

INFORMATION:

The spark plug is a device for producing a spark inside the cylinder, for the purpose of igniting the explosive mixture. Because of the oil and carbon which collect on the points of the plugs, it is necessary to give them an occasional cleaning. The plugs are subjected to extreme heat and cold and this often causes breaks in the insulating core, resulting in a "short". Under working conditions the plug must fire under a pressure of about sixty pounds or more. A plug that fires satisfactorily at atmospheric pressure may not produce good results under a pressure of sixty pounds. There are special spark plug testing devices which test the plug under pressure and the intensity of the spark can be observed thru a heavy glass. If this apparatus is not at hand, the plugs may be tested in the ignition tester. However, the operator should bear in mind that a plug giving only a weak spark on the ignition tester may not fire at all under pressure in the cylinder.

PROCEDURE:

1. Clean the plugs and be sure that they are free from oil and carbon. If they are of the type that can be taken apart, grip the body in a vise and take the plugs apart with a wrench. Be careful that you do not break the porcelain core. Do not scratch the glaze.

2. Examine the porcelain core for breaks.

3. Adjust the spark gap to a distance of .03" between points, testing with a thickness gauge. Do not bend the center point. Adjust by bending the point attached to the plug body.

4. Connect the ignition tester for operation of the distributor and plugs. See Operation Sheet EI-6, "Operating the Ignition Tester".

5. Operate the tester at a moderate speed and observe

the intensity and regularity of each spark.

6. Replace standard plugs with the plugs to be tested and operate tester at same speed.

7. Observe regularity and intensity of spark at each gap and compare with the spark you observed on the standard plugs. A "shorted" plug is indicated by a weak spark or by irregularity of the spark. Plugs comparing favorably with standard plugs should operate satisfactorily.

CAUTIONS:

1. Be sure to adjust points to correct distance.

2. Do not bend center point, as it may crack porcelain.

SUGGESTIONS:

1. Become familiar with the appearance of a satisfactory spark by watching the performance of standard plugs in the tester.

2. Watch for cracked plugs and replace them.

QUESTIONS:

1. What material is used for insulation in a spark plug?

2. What causes a plug to get fouled?

3. How wide is the spark plug gap? How measured?

4. Why should you watch for cracked plugs?

5. Why should the glaze on porcelain not be scratched?

6. What kinds of threads are used on spark plugs?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 346-349, 389.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. p. 387.

BATTERY IGNITION

Testing Automatic Spark Control

INFORMATION:

Combustion does not take place at the instant that the spark occurs. A short interval of time is needed for the gas to ignite. Some mechanism must be provided to take care of the lag between the spark and combustion. Sometimes this is done by means of the manual spark advance. The spark can be made to take place several degrees before the piston reaches top dead center. By the time the piston reaches top dead center the gas will be ignited. The amount of spark advance depends upon the engine speed. The higher the speed, the more spark advance is required. The automatic spark advance is centrifugally operated and takes care of the spark advance in accordance with the engine speed. It is built into the distributor head in accordance with the operating characteristics of the engine, and it is not adjustable. If it needs repair, it is best to replace the entire assembly. The following procedure is intended to test the operation of the mechanism.

PROCEDURE:

1. Replace the standard distributor head with the distributor head to be tested.

2. Operate the tester at slow speed. See Operation Sheet EI-6, "Operating the Ignition Tester".

3. Set the calibrated dial so that the zero mark coincides with the nearest spark.

4. Gradually speed up the motor to top speed and observe the spark on the ring.

5. Read the amount of spark advance on the calibrated scale. The maximum advance for top speed should be approximately 23 degrees.

6. Decrease the speed and watch the spark drop back to zero. The spark should shift about the ring in accordance with the speed.

7. Replace the standard distributor in the tester.

8. See that the ignition tester is left as directed in Operation Sheet EI-6, "Operating the Ignition Tester".

CAUTION:

Sometimes the spark advance mechanism fails because of corrosion and lack of oil. See that it is oiled properly and that the centrifugal mechanism is free.

SUGGESTIONS:

1. Study references and all information on spark efficiency and its effect on economy of fuel.

2. Always retard manual spark before starting the motor. Neglecting this precaution may result in a back fire of motor and damage to starter mechanism. In case of hand cranking, it may result in a broken arm or jaw.

QUESTIONS:

1. Why is spark advance necessary?

2. What is the effect of a late spark? Early spark?

3. What are the advantages of the automatic spark advance?

4. What is meant by the "lag" between the spark and the ignition of the gas?

5. What is the principle upon which the automatic spark advance mechanism is based?

6. What is meant by a spark "knock"?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. p. 388.

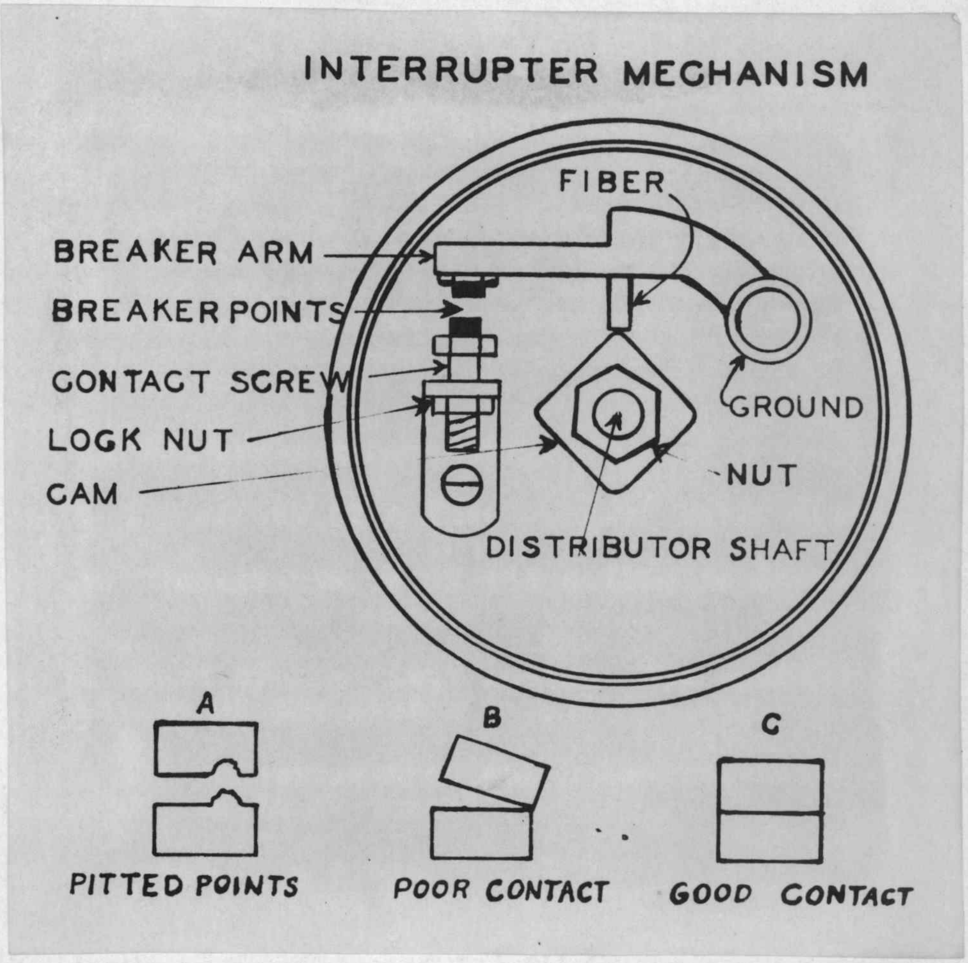
Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. p. 395.

BATTERY IGNITION

Adjusting and Caring for Breaker Points

INFORMATION:

All battery systems use tungsten points. This metal is very hard and durable and cannot be filed satisfactorily. Direct current flowing through the primary winding carries small particles of metal



from one point and deposits them on the other point. This is called "pitting of the points". See A in illustration. This condition continues so that the points do not make contact over their entire surfaces. This makes a high resistance contact and current in the primary circuit is slow in building up to its maximum. Consequently the ignition spark is weak and the engine runs sluggishly or not at all. If the points are only slightly uneven or dirty, a piece of 00 sandpaper may be folded and placed between them so that the sanded surfaces are in contact with the points. By moving the sandpaper back and forth, the points may be cleaned and irregularities removed. When the points are badly pitted, they should be removed and redressed on an oilstone. The tungsten is very thin, about 3/32" thick, and no more metal than necessary should be removed. Do not try to remove a deep pit as this will waste too much material. When the tungsten becomes too thin, the points should be replaced.

PROCEDURE:

1. Remove the distributor cap.

2. Remove rotor arm.

3. Take out cotter pins or clips. Loosen any clamping screws or nuts which may hold the breaker arm spring in place.

4. Remove breaker arm by lifting it from the post on which it operates. See illustration.

5. Remove the lock nut from the contact screw.

6. Remove the contact screw.

7. Rub contacts lightly over an oilstone. Be careful to hold the surface flat on the stone. It is not necessary to remove all small pits. Brighten the surface of the pitted contact and remove the raised portion of metal from the other contact.

8. Replace points in distributor head.

9. Adjust points to correct opening by means of contact screw wrench and feeler gauge. The contact separation varies from .015" to .025" for the various types of interrupters. If the exact data is not known, a safe setting is .018".

10. Inspect the points to see if they make contact over their entire surfaces. Turn the screw slightly, if necessary. Contact as shown at B of illustration is incorrect and should be redressed on oilstone until it appears as at C.

11. Securely tighten the lock nut and replace all nuts and screws in their proper places.

12. Check the ignition timing. When material has been removed from the points, changing the distance between them, it is necessary to retime the ignition with the engine. See Job Sheet EI-1, "Timing a Reamy Battery Ignition System to the Engine".

CAUTIONS:

1. When a new breaker arm is put into use, the fiber contact will wear considerably during the first thousand miles and the points should be inspected and adjusted, if necessary.

2. When working properly, the breaker points have a white, frosty appearance. Black or burned points, with excessive arcing between them, indicate a faulty condenser.

SUGGESTIONS:

1. Study the references and become familiar with as many types of distributors as possible.

2. Most manufacturers have very definite and exact information as to care and repair of their equipment. Follow their directions whenever possible.

QUESTIONS:

1. What causes "pitting of the points"?

2. What is the result of improper contact of points?

3. What happens when the opening of the breaker points is not wide enough?

4. Of what material are the breaker points composed? Why?

5. What is a "safe" setting for breaker point opening?

6. What keeps the breaker points closed?

7. Why is the surge of a higher voltage than the battery voltage?

8. Why does excessive "arcing" indicate a faulty condenser?

9. Why is the condenser placed in parallel with the points?

10. Why not use a file to dress the contact points?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 373, 387, 395.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 328, 337-338, 343, 345, 352, 358.

BATTERY IGNITION

Testing a Condenser with Direct Current

INFORMATION:

There are several methods of testing a condenser for "opens" and "shorts" but a simple way is by means of the condenser tester described in Construction Sheet EI-2, "Construction of a Condenser Tester". Direct current must be used and this device will furnish a suitable supply. See Information Sheet EI-2, "Condenser" and Operation Sheet EI-8, "Testing a Condenser on the Ignition Tester".

PROCEDURE:

1. Plug the condenser tester into the 110 volt line.

2. Touch the test leads together. If the neon tube lights, the tester is ready for operation.

3. Touch the test leads to the leads of the condenser to be tested. Do not touch condenser or leads with hands.

   a. A <u>short flash</u> of the neon tube, when contact is made, indicates that the condenser has taken a charge and is working properly. <u>Discharge the condenser</u> by shorting its terminals and try it again to be sure of the <u>short flash</u>!

   b. No flash at all indicates an open circuit.

   c. A continuous glow of the neon tube indicates a "short". Try it several times, keeping hands clear of condenser and leads.

   d. Intermittent flashing of the tube indicates leaking. If it flashes more than once per second, the condenser is useless.

4. Have the instructor check your results.

5. Disconnect the condenser tester.

CAUTIONS:

1. Keep hands free from leads and condenser as the body will pass enough current to make the neon tube glow. This may cause an error in the test.

2. A good condenser will hold a charge for some time and will not show a flash when tested. This may lead to the false conclusion that the condenser has an open circuit. Discharge the condenser before testing a second time.

SUGGESTIONS:

A capacity test may be made by following directions given in Article 569, p. 377, Automotive Electrical Practice, by Kuns.

QUESTIONS:

1. How is the condenser constructed?

2. What is the purpose of the condenser?

3. What trouble may develop in the condenser?

4. Why is it necessary to use direct current to test a condenser for a "short"?

5. Where is the condenser located?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 372, 384, 377-378.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 332-333, 363.

BATTERY IGNITION

Synchronizing Dual Sets of Breaker Points

INFORMATION:

There are two types of distributors using dual sets of synchronized points:

1. Dual sets of points operating two separate primary ignition circuits.

2. Dual sets of points connected in parallel operating a single primary circuit.

In either case the points must be adjusted so that the two sets open at exactly the same time. This operation is called "synchronizing the points". The student should not attempt it until he is thoroughly familiar with the ignition tester.

PROCEDURE:

1. Replace the standard distributor head of the ignition tester with the distributor head containing the points to be synchronized. (In type No. 1, two ignition coils must be used.)

2. Operate the ignition tester at a moderate speed and observe the sparks on the ring.

3. Loosen the clamp screws and shift one set of points until only one intense, hot spark occurs at each 90 degree angle. This may be done while the tester is running.

4. Tighten the clamp screws and recheck the sparks for intensity and heat. They should be 90 degrees apart.

5. Replace the standard distributor head.

6. Check the ignition tester to see that it is left in order.

CAUTIONS:

1. Keep hands clear of spark ring while making tests on distributor head when tester is running.

2. Do not confuse synchronized points with dual sets used on 60-120 degree engines. See reference on page 379 of Automotive Electrical Practice, by Ray F. Kuns.

SUGGESTIONS:

1. Consult the instructor in regard to wiring the two ignition coils for type No. 1.

2. Study all references on dual ignition systems and dual sets of points. Ask the instructor to explain anything you do not understand.

QUESTIONS:

1. Name the types of ignition systems that use dual sets of synchronized points.

2. What are the advantages of dual sets of synchronized points?

3. What are the advantages of dual ignition?

4. What cars use dual ignition?

5. What is meant by "60-120 degree engines"?

6. Where are the spark plugs placed in dual ignition engines?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 379-381.

BATTERY IGNITION

Timing a Reamy Battery Ignition System to the Engine

GENERAL DIRECTIONS:

1. Read the directions and examine the Reamy System on the ignition tester. Try to locate all the parts mentioned in the job sheet.

2. Select the proper tools required for the job.

SPECIFICATIONS:

Time the system to the engine and completely rewire or check all high tension leads from the distributor to the cylinders. See that they are in the right firing order.

INFORMATION:

An auto mechanic must be able to time the ignition system and to replace all wires in their proper order. This is necessary after a complete overhaul job and on numerous other occasions. It should be done quickly and efficiently. It is important to remember that when the contact points open a spark takes place at the plug points, and the piston for that particular cylinder must be on top, dead center, ready to fire. The following directions are for timing the ignition on a retarded spark. Some manufacturers give specific directions for timing their engines on an advanced spark. Follow the directions of the manufacturer, whenever possible.

DIRECTIONS:

1. Turn the engine over with the crank until No. 1 piston is on top, dead center, of the firing stroke. This may be done by a gauge in the spark plug hole and by working the piston to the top of the compression stroke. Note the fly wheel mark for top dead center, if it has one.

2. Move the hand spark lever to full retard.

3. Remove the distributor cap.

4. Remove the rotor.

5. Unscrew the nut on top of cam.

6. Loosen cam on its taper shaft. Lift it up with screw driver. Tap gently, if necessary. Take care not to damage the parts.

7. Move the cam on the shaft in the direction in which it rotates until the contact points are just opening. Do not move the engine.

8. Tighten the nut on top of the cam.

9. Replace the rotor.

10. Replace the distributor cap.

11. Attach the high tension lead from cylinder No. 1 to the distributor cap terminal immediately over the rotor inside the cap.

12. Note the direction in which the rotor travels.

13. Determine the firing order of the engine. See Assignment Sheet EI-1, "Determining the Firing Order of an Engine".

14. Take the next high tension lead in order of rotation on the distributor cap and run it to the proper cylinder according to the firing order. If the order is 1-2-4-3 for a four cylinder engine, it will go to No. 2 cylinder.

15. Take the next high tension lead in order of rotation on the distributor cap and run it to the next cylinder on the firing order. With the above firing order it will go to No. 4 cylinder.

16. Follow the same procedure for all the leads. A six cylinder engine may be timed in the same way. Study the wiring diagram in Information Sheet EI-3, "Theory of Induction".

CHECKING:

1. Start the engine and check its running condition.

2. Advance the spark and note whether the engine picks up speed. There should be a noticeable pick-up.

3. Have the instructor check your results.

QUESTIONS:

1. Why do you retard the spark before timing the engine?

2. Why is "spark advance" necessary?

3. How many lobes on the cam of a six cylinder system?

4. What is the ratio of the distributor shaft speed to engine speed? Why?

5. Can an engine fire 1-2-3-4? Why?

6. What happens when the contact points break?

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 381-403.

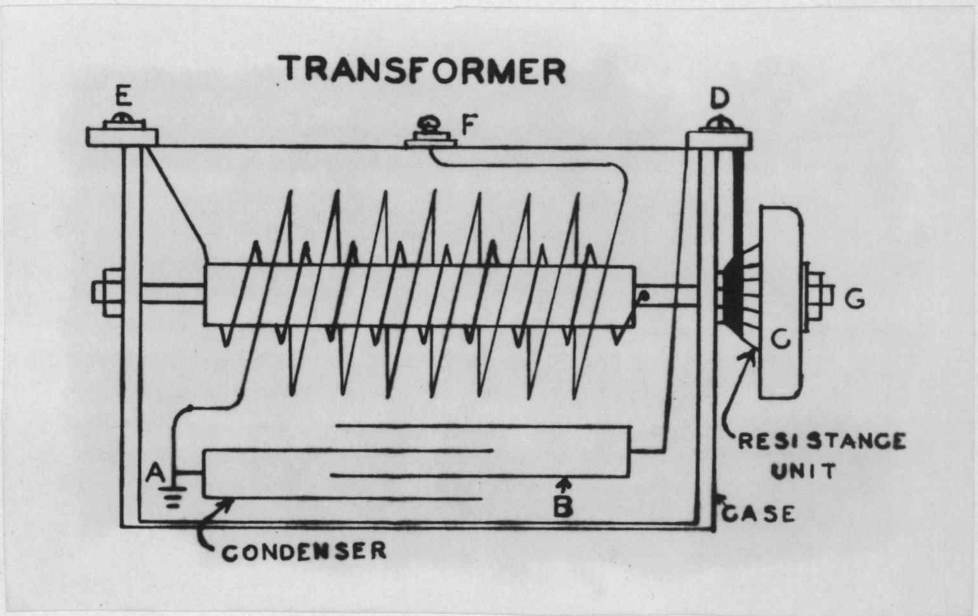
Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 350-359.

BATTERY IGNITION

Transformer

CONSTRUCTION:

The transformer, sometimes called induction coil, is made up of a core of soft iron wire or laminations, upon which are wound a primary and a secondary winding. The primary winding consists of a few hundred turns of magnet wire. This wire is usually number sixteen or eighteen gage, cotton covered. The secondary winding is composed of many thousand turns of fine enameled wire. The layers are insulated from each other to prevent "shorts" in the high tension current. The primary and secondary windings



are insulated from each other. One terminal of the secondary is usually fastened to the ground terminal of the primary. See A in illustration. The entire transformer is sealed in a metal case in order to make it moisture proof. In some makes of transformers the condenser also is sealed in the case. See B in illustration. This is a distinct disadvantage because, if anything happens to the condenser, the whole transformer must be discarded. Some transformers have a safety coil mounted on the outside of the case. See C in illustration. This is made of resistance wire and protects the primary circuit in case the switch is not turned off. The resistance of the coil increases with the temperature and, as it heats, very little current is allowed to flow thru the primary winding. When the safety coil is cool, under normal intermittent operation, it does not affect the flow of current thru the primary winding.

PURPOSE:

The transformer is a device to step up the voltage of the battery from six volts to approximately eighteen thousand volts. This high voltage is required to produce the necessary heat and intensity at the spark plug points. The efficiency of the spark is very important in economic gas consumption and in the proper running of the engine. See Information Sheet EI-3, "Theory of Induction".

TYPES OF COILS:

Ignition coils may be designed for high speed engines with many cylinders, or for slow speed engines with few cylinders. This is done by varying the length, diameter, and number of turns of primary winding to meet the required conditions. It is necessary to have the right coil to meet the needs of a particular engine.

TRANSFORMER TROUBLES:

The transformer may have either an "open" or a "short", in either the primary or the secondary circuit. In either case the coil should be discarded, as nothing can be done about it. A "short" in the primary is indicated by:

1. High ammeter reading of primary current.
2. No spark on secondary circuit.

An open circuit in the primary is indicated by no reading on the ammeter. (Be sure that other parts of circuit are not causing the trouble.) A "short" or "open" in the secondary is indicated by a weak spark or by no spark at all.

SUGGESTIONS:

Trouble shooting in ignition work is done by a process of elimination. List all possible causes of the trouble and eliminate one at a time, beginning with the most probable one.

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. p. 375.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 326-327.

BATTERY IGNITION

Condensers

CONSTRUCTION:

The condenser consists of two long strips of tinfoil separated by strips of paraffine paper. This is rolled or folded into a compact form. It is all enclosed in a moisture proof case, to which one tinfoil strip is grounded. The condenser is always connected in parallel with the contact points.

PURPOSE:

The condenser acts as a shock absorber for the contact points. As the points open, it absorbs the surge of the back electromotive force, caused by self induction in the primary winding. See Information Sheet EI-1, "Transformer". The condenser serves two purposes:

1. Decreases amount of arcing or sparking across the contact points by absorbing the surge.

2. Causes magnetic field to collapse quickly, thus increasing the secondary voltage and the intensity of the spark at the plugs.

CONDENSER TROUBLES:

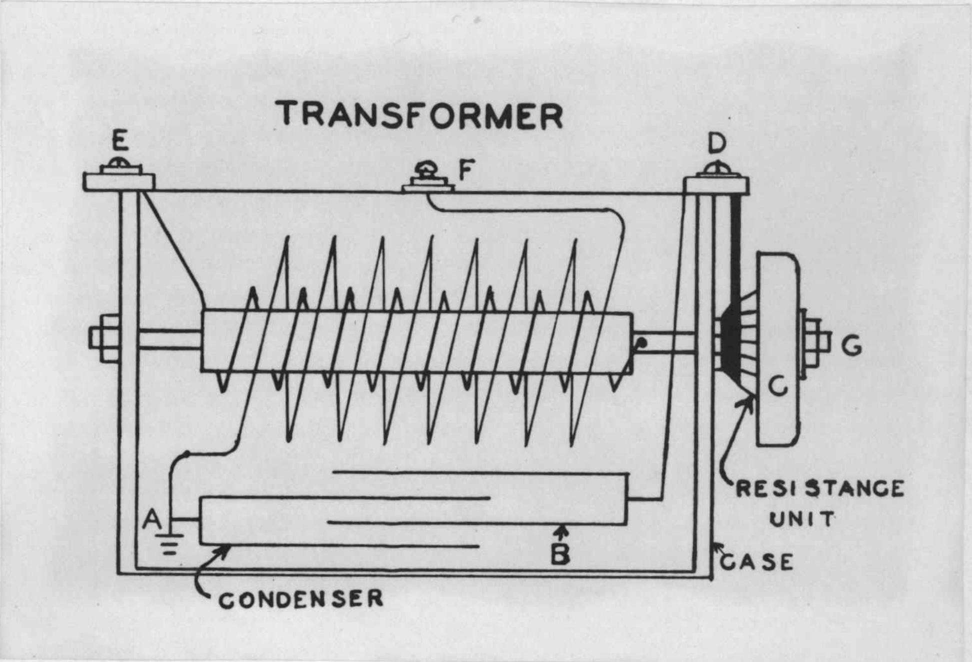
Two things cause condenser troubles:

1. The paraffine paper may become punctured or moisture soaked, causing a short circuit.

2. The leads from the strips of tinfoil may become broken or deteriorated, causing an open circuit.

REMEDIES:

An internal "short" in a condenser cannot be repaired but sometimes an external "short" can be located and repaired. If an "open" occurs in the leads from the condenser, it may be repaired. Whenever there is internal trouble the condenser should be replaced. In some makes of ignition coil, the condenser is sealed in the coil case and cannot be removed. See illustration. In case of a defective condenser in such coils, the whole unit must be replaced. This type of condenser can be tested on the ignition tester or test bench. See Operation Sheet EI-8, "Testing a Condenser on the Ignition Tester".



SUGGESTIONS:

1. Be sure that you understand the construction of the condenser.

2. Study the two main purposes of the condenser.

3. Study the condenser troubles and know the remedies.

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. p. 377.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 332-334, 363, 28-31.

BATTERY IGNITION

Theory of Induction

INFORMATION:

For information concerning the construction and purpose of the transformer, see Information Sheet EI-1, "Transformer". The technical wiring diagram is shown on the following page and frequent reference will be made to it.

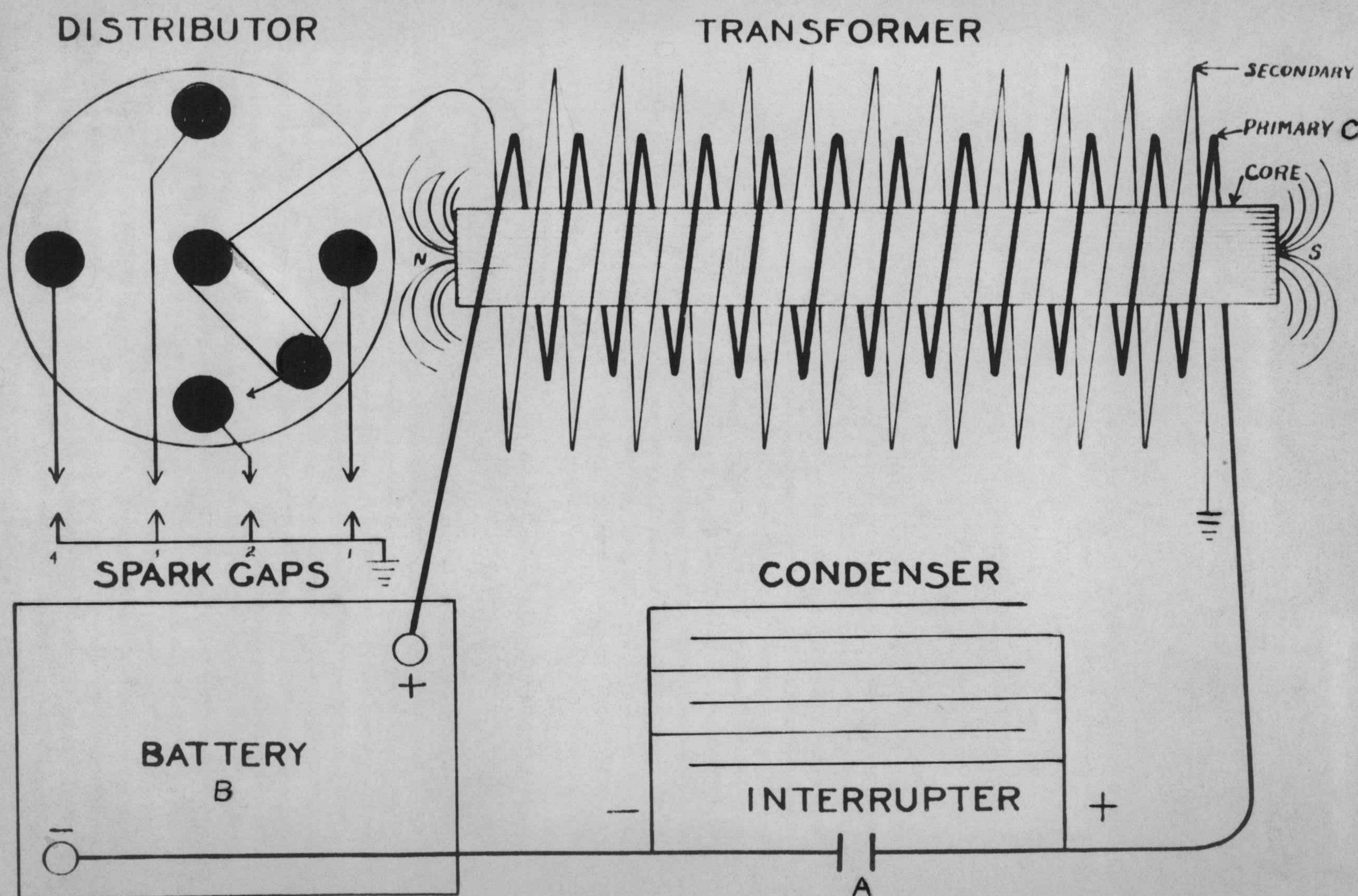
ACTION OF PRIMARY CIRCUIT:

As the contact points of the interrupter (A) close, current flows from the battery (B) thru the primary circuit (C). A well-known law of magnetism states that, whenever a current flows thru a conductor, a magnetic field is set up around that conductor. A magnetic field is set up around the primary winding (C) with poles concentrated in the soft iron core (N) and (S). The law of induction states that, whenever the lines of force passing thru a conducting circuit either increase or decrease, a current is induced in that circuit. The current induced is such that its magnetic field opposes the motion which produced it. The magnetic lines of force increase as soon as the contact points are closed and they cut thru both primary and secondary circuits.

EFFECT OF INDUCTION ON THE PRIMARY CIRCUIT:

The direction of the induced current in the primary circuit is such that the magnetic field opposes the flow of the original current from the battery. This back electromotive force causes the current in the primary to lag and the magnetic field is slow in building up. Once the magnetic field has reached its maximum and remains steady, the inductive effect ceases and offers no opposition to the flow of current in the primary winding. When a cylinder is ready to fire, the contact points open and the magnetic lines of force cutting the primary circuit start to decrease. This produces self induction and this time the current is in the same direction as the original battery current. This pressure may amount to several hundred volts, depending on the

TECHNICAL WIRING DIAGRAM



number of turns in the primary circuit. It is evident that this voltage may jump the gap at the points, causing an arc. This is prevented by a condenser shunted across the points. See Information Sheet EI-2, "Condenser". The absorption of current by this shunted condenser causes the current to be quickly drained out of the primary and the magnetic field suddenly collapses. A defective condenser will prevent this sudden collapse and a poor spark at the spark plug gap will result.

ACTION OF THE SECONDARY CIRCUIT:

When the contact points close, some induction takes place in the secondary but the voltage is low and it does not jump the spark plug gap. The low voltage is due to the opposition of the induced current in the primary winding, causing a lag and slow building up of the magnetic field. As the points open, there is a quick collapse of the magnetic field which cuts the secondary circuit. The sudden collapse causes a very high voltage in the secondary winding. The voltage in the secondary circuit is governed by the following conditions:

1. Ratio of turns between primary and secondary.
2. Voltage of primary.
3. Number of lines of force cutting secondary.
4. Speed at which magnetic lines of force cut the secondary circuit.

SUGGESTIONS:

Try to master the theory of induction and you will have less difficulty in diagnosing ignition troubles. It is a rather difficult principle to master, so do not become discouraged. Ask the instructor to explain points you do not understand.

REFERENCES:

Dyke, A. L. Automobile and Gasoline Engine Encyclopedia, The Goodheart-Willcox Company, Inc., Chicago, Ill., 1923. pp. 196-202.

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 18-21.

BATTERY IGNITION

Types of Distributors

INFORMATION:

There are two types of distributors in general use:

1. The jump type
2. The wipe type

The jump type has a small gap, approximately .01 of an inch, between the rotor and contacts. As the rotor passes this point, a spark jumps to the contact. In this type of distributor nitric oxide is formed by the spark thru the air. To prevent deterioration of points caused by the acid, a small hole is placed in the side of the distributor cap to cause free circulation of air and to dilute the nitric oxide which forms. This hole should be kept open. In the wipe type distributor the rotor makes contact with the sector by means of a contact button held by a small spring. This button and spring are subject to wear and should be replaced when worn too thin. Examine both types of distributors and become familiar with their operations. The standard distributors on the ignition tester furnish good examples. In either type of distributor the high tension current coming from the ignition coil goes to the center contact on the distributor. The rotor leads the current across to the sector and the high tension wire delivers it to the spark plug. Study the diagram in Information Sheet EI-3, "Theory of Induction". The rotor is carried on the same shaft as that which operates the breaker cam and is so arranged that when the points open and a spark occurs in the secondary, the rotor is opposite one of the sectors. The leads from the distributor to the plugs must be connected according to the firing order of the engine. For firing order, see Assignment Sheet EI-1, "Determining the Firing Order of an Engine".

SUGGESTIONS:

1. Connect the wires from the distributor on the ignition tester to the spark plugs, so that the firing

order will be 1-2-4-3. Have the instructor check your work.

2. Examine all distributors to which you have access and determine the type.

REFERENCES:

Kuns, Ray F. Automotive Electrical Practice, Bruce Publishing Company, 1926. pp. 371-372.

Kuns, Ray F. Automotive Trade Training, Bruce Publishing Company, 1922-1926. pp. 329-331.

Assignment EI-1

BATTERY IGNITION

Determining the Firing Order of an Engine

DIRECTIONS:

Read The Four Stroke Cycle, page 107 in Automotive Trade Training by Ray F. Kuns and To Determine the Firing Order, page 79 in Automobile and Gasoline Engine Encyclopedia by A. L. Dyke.

YOUR JOB:

To determine the firing order of any four cylinder engine available in the shop. Have the instructor check your method and results.

QUESTIONS:

1. How many different firing orders for a four cylinder engine are there? What are they?

2. What governs the firing order of an engine?

3. What is the easiest way to find the firing order?

4. Can No. 4 cylinder fire immediately after No. 1? Why?

5. What two pistons are up at the same time?

6. What is meant by the four stroke cycle?

Assignment EI-2

BATTERY IGNITION

Rewiring the Ignition System

DIRECTIONS:

Study the circuit diagram in Fig. 395, page 344 of Automotive Trade Training by Ray F. Kuns.

YOUR JOB:

Ask the instructor to assign you to a running model engine from which all ignition wires have been removed.

1. Replace all wires and retime the engine.
2. Start the motor and check its running condition.
3. Call the instructor to check your work.

If you feel that you do not have sufficient knowledge to carry out this assignment, be honest about it and tell the instructor. He will be glad to let you have more time for practice and study.

QUESTIONS:

1. Under what conditions is it necessary to rewire a motor?
2. What advantages may result in having the diagram of the car ignition circuit when rewiring?
3. How long did it take you to rewire the engine and get the motor started?
4. Was your first attempt successful?
5. Compare your time with the class average.

APPENDIX II

OBJECTIVE TESTS

CONTENTS OF APPENDIX II

PROGRESS CHART

LESSON SHEETS	NAMES
Operation EI-1	
Operation EI-2	
Operation EI-3	
Operation EI-4	
Operation EI-5	
Operation EI-6	
Operation EI-7	
Operation EI-8	
Operation EI-9	
Operation EI-10	
Operation EI-11	
Operation EI-12	
Operation EI-13	
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Job EI-1	
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Information EI-3	
Information EI-4	
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Test EI-1	
Test EI-2	
Test EI-3	
Test EI-4	
Test EI-5	
Test EI-6	
Test EI-7	

/ Operation started ☒ Operation finished ☒ Operation repeated ■ Expert

Objective Test EI-1
Possible Score 20

BATTERY IGNITION

Interrupter

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; if it is false, place a circle around the F.

T F 1. The interrupter is a device to break the secondary circuit.

T F 2. The contact points are made of tungsten.

T F 3. When the points break, a high tension current is induced in the secondary.

T F 4. The interrupter points should be adjusted to .002 to prevent "arcing" at the points.

T F 5. The interrupter is connected in parallel with the battery and coil.

T F 6. The points should be trimmed by grinding on the emery wheel.

T F 7. The interrupter cam has a lobe for each cylinder.

T F 8. The distributor shaft drives the interrupter cam.

T F 9. The distributor shaft turns at engine speed.

T F 10. A worn distributor shaft bearing may cause irregular firing.

T F 11. A weak contact arm spring may cause point bounce.

T F 12. A spark occurs at the plug points at the instant the interrupter points close.

T F 13. "Arcing" means that a spark jumps the interrupter points when they are open.

Objective Test EI-1

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ "Pitting" is a source of trouble on (1) contact points, (2) interrupter cam, (3) distributor.

2. _____ Points may be cleaned with (1) fine sandpaper, (2) emery wheel, (3) coarse file.

3. _____ A white frosty appearance on surface of points indicates (1) trouble, (2) good condition, (3) "shorted" condenser.

4. _____ It is necessary to dress the points to insure (1) correct opening, (2) proper contact, (3) good clearance.

5. _____ The flow of direct current carries small particles of metal from one point to another, causing (1) "shorts", (2) "opens", (3) "pitts".

6. _____ One of the interrupter points is connected to the (1) ground, (2) rotor, (3) distributor.

7. _____ The interrupter is part of the (1) secondary circuit, (2) primary circuit, (3) transformer.

Objective Test EI-2
Possible Score 20

BATTERY IGNITION

Condenser

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; if it is false, place a circle around the F.

T F 1. The condenser is connected across the points in parallel.

T F 2. A condenser is composed of two conductors separated by an insulator.

T F 3. The condenser stores up a charge of electricity.

T F 4. It is the purpose of the condenser to prevent a high voltage in the secondary circuit.

T F 5. The condenser prevents "arcing" at the points.

T F 6. A condenser will hold a charge indefinitely.

T F 7. To test a condenser for a "short", direct current should be used.

T F 8. An open circuit in a condenser will produce excessive "arcing" at the points.

T F 9. A "shorted" condenser has no effect on the secondary voltage.

T F 10. The condenser is sometimes sealed in the transformer case.

Objective Test EI-2

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ The condenser is a part of the (1) primary circuit, (2) secondary circuit, (3) high tension circuit.

2. _____ The condenser may be tested by (1) direct current, (2) alternating current, (3) high tension current.

3. _____ Excessive "arcing" at the points is caused by (1) poor condenser, (2) pitted points, (3) worn contacts.

4. _____ The condenser is necessary to absorb the surge in the (1) primary circuit, (2) distributor, (3) rotor.

5. _____ The elements of the condenser are (1) tin, (2) zinc, (3) tin foil.

Completion

DIRECTIONS:

Place in the blank space the best word to make the statement true.

1. The condenser causes a quick collapse of ______________.

2. The insulating material between the plates of a condenser is ______________.

3. The insulating material of a condenser is dipped in ______________.

4. The condenser is located near the ____________.

5. When direct current passes thru a condenser, it has a ______________.

Objective Test EI-3
Possible Score 20

BATTERY IGNITION

Distributor

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; if it is false, place a circle around the F.

T F 1. The distributor is in the secondary circuit.

T F 2. The distributor must be well insulated.

T F 3. The current flows from the primary of the coil to the center of the distributor.

T F 4. The rotor turns at one half engine speed.

T F 5. A common firing order for a four cylinder engine is 1-4-3-2.

T F 6. There is a sector on the distributor cap for every cylinder.

T F 7. The spark jumps from the rotor to the sector in the wipe type distributor.

T F 8. The interrupter points must open just as the rotor is opposite the sector.

T F 9. Nitrous oxide is produced by the jump spark type distributor.

T F 10. The distributor head contains the interrupter.

Objective Test EI-3

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ The rotor is composed of (1) metal, (2) insulation, (3) insulation and metal.

2. _____ The wire running to the center of the distributor carries (1) high tension current, (2) low tension current, (3) direct current.

3. _____ The small hole in the side of the jump type distributor cap is for (1) evaporation, (2) condensation, (3) ventilation.

4. _____ The right way to test the distributor cap is with (1) a storage battery, (2) voltmeter, (3) high tension current.

5. _____ When the distributor cap is "shorted", it should be (1) insulated, (2) repaired, (3) replaced.

Completion

DIRECTIONS:

Place in the blank space the best word to make the statement true.

1. A one cylinder engine does not need a ________.
2. The function of the distributor is to distribute the sparks to the ________________.
3. The distributor rotor is driven by the _______.
4. The wires leading to the spark plugs are heavily insulated with ___________________.
5. The firing order of an engine is governed by the ________________.

Objective Test EI-4
Possible Score 20

BATTERY IGNITION

Transformer

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; it it is false, place a circle around the F.

T F 1. The transformer is a device to step up the voltage.

T F 2. The primary voltage of an ignition coil should be about 20 volts.

T F 3. The core is made of soft iron.

T F 4. A solid iron core in a transformer gives best results.

T F 5. Whenever a current flows in a conductor, a magnetic field is set up around that conductor.

T F 6. The greatest intensity of magnetism is at the poles.

T F 7. The primary is wound with fine wire.

T F 8. The primary winding is insulated from the secondary winding.

T F 9. A potential of 200 volts is required to jump the spark plug gap.

T F 10. A "short" in the primary causes more current to be indicated on the ammeter.

Objective Test EI-4

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ The transformer is based on the principle of (1) generation, (2) transmission, (3) induction.

2. _____ Potential is measured in (1) amperes, (2) ohms, (3) volts.

3. _____ Self induction takes place in the (1) secondary circuit, (2) core, (3) primary circuit.

4. _____ When the primary circuit is "shorted" there will be no (1) primary current, (2) magnetism, (3) spark at the plugs.

5. _____ The surge is absorbed by the (1) core, (2) condenser, (3) interrupter.

Completion

DIRECTIONS:

Place in the blank space the best word to make the statement true.

1. The voltage required to jump the spark plug gap is approximately _______________.

2. One terminal of the secondary winding goes to the _______________.

3. The ohm is a measure of _______________.

4. The ampere is a measure of _______________.

5. The volt is a measure of _______________.

Objective Test EI-5
Possible Score 20

BATTERY IGNITION

Spark Plugs

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; it it is false, place a circle around the F.

T F 1. The correct distance of spark plug gap is approximately 1/16".

T F 2. The pressure inside the cylinder is approximately 20 lbs.

T F 3. It is easier for the spark to jump a gap at atmospheric pressure than to jump the same gap inside the cylinder under compression.

T F 4. All spark plugs use standard threads.

T F 5. Porcelain is a good insulation material for spark plugs.

T F 6. Spark plugs must stand extreme heat, cold and pressure.

T F 7. Carbon is a product of combustion.

T F 8. It is better practice in design to place the spark plug over the intake valve.

T F 9. A small crack in the porcelain does no particular harm.

T F 10. The spark plug gasket prevents the escape of oil.

Objective Test EI-5

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ It is best to adjust the points by bending the (1) center point, (2) outside point, (3) moving the core.

2. _____ To measure the gap, use a (1) ruler, (2) steel scale, (3) gauge.

3. _____ The proper tool to use in removing spark plugs is (1) crescent wrench, (2) pliers, (3) spark plug wrench.

4. _____ The greatest cause of trouble with spark plugs is (1) heat, (2) pressure, (3) carbon.

5. _____ A "shorted" plug causes the cylinder to (1) backfire, (2) miss, (3) heat.

Completion

DIRECTIONS:

Place in the blank space the best word to make the statement true.

1. The abbreviation, "S. A. E.", means __________.
2. The greatest cause of carbon is ____________.
3. The approximate voltage required to jump the gap is __________.
4. The approximate pressure necessary for combustion is __________.
5. A common size of spark plug is ____________.

Objective Test EI-6
Possible Score 20

BATTERY IGNITION

Battery

True-False

DIRECTIONS:

If the statement is true, place a circle around the T; if it is false, place a circle around the F.

T F 1. Electrolyte is a mixture of water and nitric acid.

T F 2. The electrolyte may be tested with an hydrometer.

T F 3. A dead battery is indicated by a reading of 1.280.

T F 4. The level of electrolyte should be ½" below the top of the plates.

T F 5. The filler plugs should be removed when charging.

T F 6. Connect in parallel when charging more than one battery at a time.

T F 7. The positive terminal of the battery should be connected to the positive terminal of the charger.

T F 8. The rate of charge depends on the kind of battery.

T F 9. Alternating current is used to charge a battery.

T F 10. The capacity of a battery is indicated by volts.

Objective Test EI-6

Multiple Choice

DIRECTIONS:

Place in the space at the left the number of the correct word or words which make the statement true.

1. _____ Automobile batteries are (1) six-volt, (2) eight-volt, (3) ten-volt.

2. _____ The starter draws from the battery approximately (1) 10 amperes, (2) 50 amperes, (3) 250 amperes.

3. _____ The cells of a battery are connected in (1) series, (2) parallel, (3) series parallel.

4. _____ Each cell of a battery has a potential of approximately (1) 3 volts, (2) $1\frac{1}{2}$ volts, (3) 6 volts.

5. _____ The electrolyte is composed of distilled water and (1) nitric acid, (2) hydrochloric acid, (3) sulphuric acid.

Completion

DIRECTIONS:

Place in the blank space the best word to make the statement true.

1. The vents in the top of the filler cap are for the purpose of _______________.

2. A substance which will counteract acid is _________________.

3. The unit for rating the capacity of a battery is _______________.

4. The largest battery terminal is the _________.

5. The corrosion on the positive terminal of the battery is ________________.

Objective Test EI-7
Possible Score 20

BATTERY IGNITION

Miscellaneous

DIRECTIONS:

Indicate the location of each of the following ignition parts by placing its number under the proper heading.

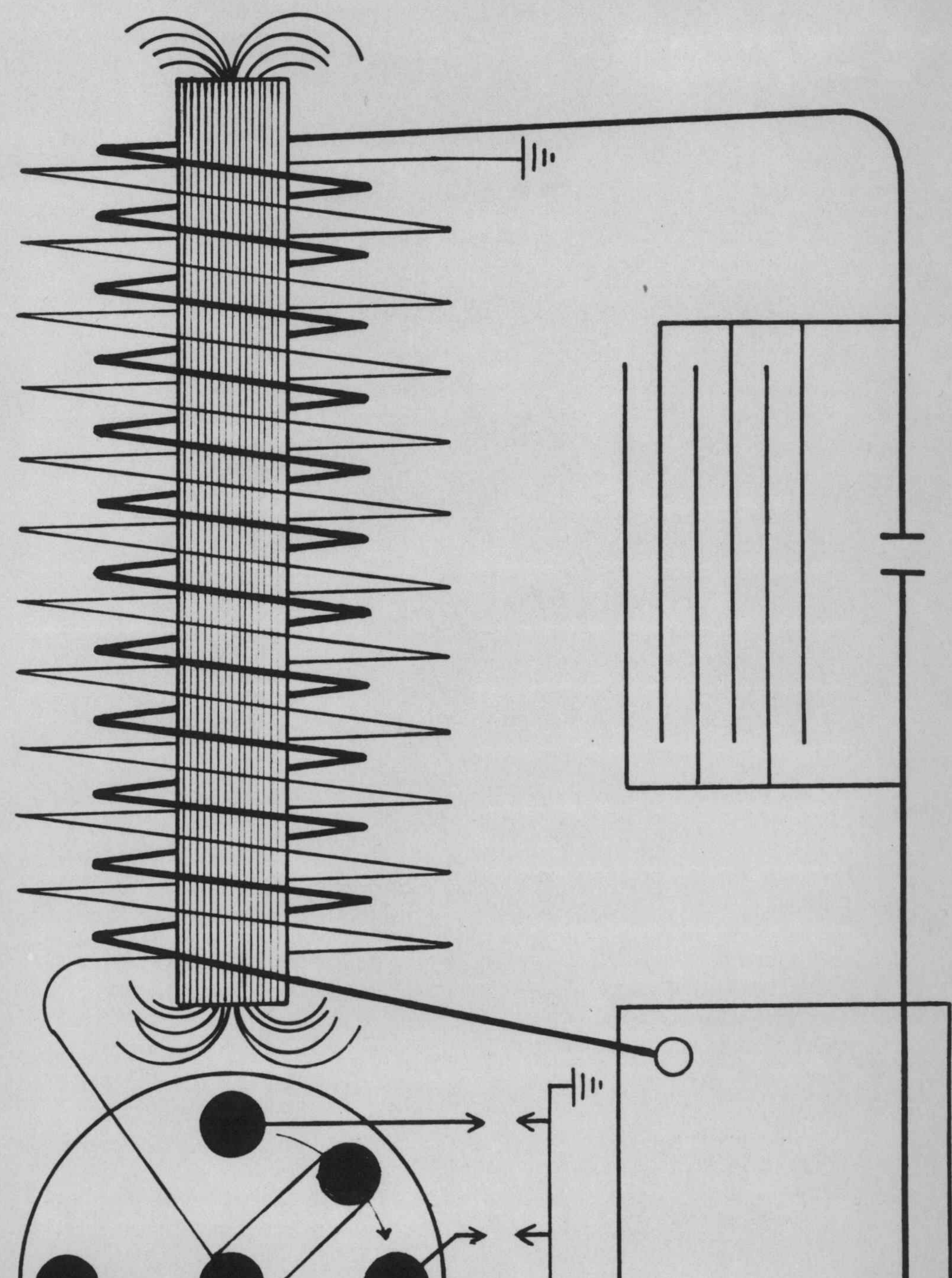
Primary Circuit	Secondary Circuit
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________
______________	______________

1. Spark plugs	5. Interrupter
2. Battery	6. Transformer
3. Rotor	7. Condenser
4. Distributor	8. Contact points

DIRECTIONS:

Place the number of the ignition part under each symbol in the illustration.

1. Spark gap	7. Primary winding
2. Distributor	8. Secondary winding
3. Rotor	9. Core
4. Ground	10. Poles
5. Interrupter	11. Magnetic field
6. Battery	12. Condenser



PROGRESS CHART

LESSON SHEETS	NAMES
Operation EI-1	
Operation EI-2	
Operation EI-3	
Operation EI-4	
Operation EI-5	
Operation EI-6	
Operation EI-7	
Operation EI-8	
Operation EI-9	
Operation EI-10	
Operation EI-11	
Operation EI-12	
Operation EI-13	
Operation EI-14	
Operation EI-15	
Job EI-1	
Information EI-1	
Information EI-2	
Information EI-3	
Information EI-4	
Assignment EI-1	
Assignment EI-2	
Test EI-1	
Test EI-2	
Test EI-3	
Test EI-4	
Test EI-5	
Test EI-6	
Test EI-7	

/ Operation started ☒ Operation finished ⊠ Operation repeated ■ Expert