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Title of Study: A PROPOSED JUNIOR HIGH SCHOOL SHOP PROGRAM FOR SMALL GAS ENGINE REPAIR AND MAINTENANCE

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Under Direction of What Department: Department of Industrial Arts Education

Scope of Study: This study presents a brief history of the gas engine and its development in the United States. Samples of instructor's guide sheets are included. They consist of information pertaining to the proper maintenance and repair of small engines that provide power for lawn mowers, motor-cycles, scooters and other small machines. Proper procedures and uses of tools are recommended along with safety rules with each lesson. The guide sheets may be used as a complete course of study or individually if special units are to be taught. Review and test questions are included with each lesson. This course of instruction is designed to fit the needs of the Junior high school students.

Findings and Conclusions: Much information regarding small engines may be gained from reading books and magazines that are available. Brochures, parts lists, and cut-away models and pictures may be secured from manufacturers of such equipment. Engines are sometimes furnished to the schools for classroom use. Motion picture films and film strips are also available. This course could be expanded to include major overhaul and be extended to one or two semesters of instruction as a unit course.

ADVISOR'S APPROVAL: L. H. Bengtson

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BY

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BACHELOR OF SCIENCE

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CHAPTER I

AN INTRODUCTORY STATEMENT

The writer of this report recognizes the need for information concerning small gas engines. Hand powered equipment is becoming a part of the past. Today many high school students use power lawn mowers which replace the hand mowers, motor scooters which replace the bicycles, and an ever-increasing number of students own or have access to an automobile.

Purpose of the Study. There is an increasing need for a course concerning the use and maintenance of small gas engines. The writer has been interested in this problem in his own experiences with engines. This study is intended to broaden the student's knowledge in the repair and maintenance of small gas engines. The writer hopes that this report will be an aid in the improvement of this phase of the industrial arts program.

The Problem Stated. The scope of this problem is to develop a program for small gas engines' repair that would be applicable to the general shop program. This must be accomplished without destroying any of the underlying principles of industrial arts.

Research Techniques Used. Books were obtained from the library of Oklahoma State University and from the Briggs and Stratton Company.

Definition of Terms. The following definitions of terms are common nomenclature used in discussing the air-cooled engine. These terms are taken from several books and pamphlets on small gas engines.

Air Cleaner: A device for filtering, cleaning, and removing dust from the air admitted to a unit, such as an engine or air compressor. (15, page 277)

Air Gap: The space between spark plug electrodes, motor and generator armatures. (15, page 277)

Carburetor: A device for automatically mixing fuel in the proper proportion with air to produce a combustible gas. (15, page 280)

Combustion: The process of burning. (15, page 281)

Crankcase: The housing within which the crankshaft and many other parts of the engine operate. (15, page 282)

Crankshaft: The main shaft of an engine which in conjunction with the connecting rods changes the reciprocating motion of the pistons into rotary motion. (15, page 282)

Engine: The term applies to the prime source of power generation. (15, page 285)

Filter: (Oil, Water, Gasoline, etc.) A unit containing an element, such as a screen of varying degrees of fineness. The screen or filtering element is made of various materials depending upon the size of the foreign particles to be eliminated from the fluid being filtered. (15, page 285)

Four-Cycle Engine: Also known as Otto Cycle, wherein an explosion occurs every other revolution of the crankshaft; a cycle being considered as one half revolution of the crankshaft. These strokes are (1) suction stroke; (2) compression stroke; (3) power stroke; (4) exhaust stroke. (2, page 1)

Spark Gap: The space between the electrodes of a spark plug through which the spark jumps. Also a safety device in a magnet to provide an alternate path for the current when it exceeds a safe valve. (15, page 299)

The Plan of the Report: The plan of presentation will include other Chapters. Chapter II will be the history and evolution of the engine. Chapter III will be concerned with the adjusting and repairing of small gas engines and possible jobs to be done on the engine. The last chapter will be composed of a summary of the program, conclusions and recommendations.

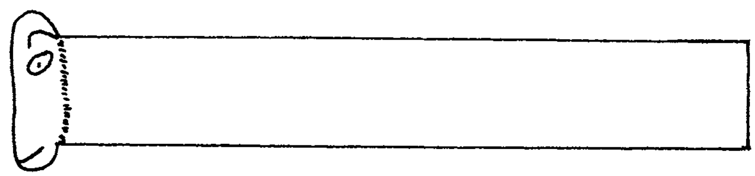
CHAPTER II

HISTORY AND EVOLUTION OF THE ENGINE

The earliest practical application of the engine was made in Biblical times. In the early stages of development needs were simple and could be supplied with no greater expenditure than that of human strength. In ancient times, human strength was used to move and operate catapults, slings, and other types of engines of war.

Engines of War. In Biblical times engines of war were catapults, or bullistas, slings and scaling equipment. The term catapult meant "to throw" as used by the Romans and Greeks in ancient times. Catapults or bullistas were in the form of an upright rectangular frame with two inner vertical supports dividing it into three equal parts. A grooved slide was attached at right angles to the bottom of the frame in the middle opening. Human strength was used to pull back the bow arm and as the tension increased the men would release the rope, throwing stones or other objects at the enemy. One man could carry and operate the catapults or bullistas, but the larger catapults needed about ten men to operate them. The sizes of the shot were from 2 to 4 pound stones on the one man catapult and 20 to30 pound stones on the larger ones. The range of the hurling engine was from 100 to 800 yards.

The breaching engine was the earliest and one of the simplest of the engines of war. The ram is an example of the breaching engine, named after Aries of the Greek and Cancer of the Romans. The ram was from 6 to 60 feet long. At the head of the ram there was a mass of metal, to prevent the beam from splitting. The beam was a long log or a tree cut down to use as a breaching engine.



ram

The larger ram required 20 men to carry and operate it, while the small rams could be operated by one man.

Scaling Engines. The ladder was the simplest of all scaling engines. The ladder in Biblical times could have been a small tree with the branches cut about a foot away from the trunk to make footholds for the men to climb on. As time passed the Romans developed the ladder into towers. The towers were used to enable men of war to go over the top of the enemy's wall. First the tower was moved to the wall of the enemy and then the men on the first floor would use a small ram on the base of the wall, trying to cave it in. At the same time men on the second or third floor would try to fight their way into the fort. The towers made by the Romans were called belfries, for they were like church bell towers of that period. Since Biblical times many different types of engines of war have been developed. In 1680 gunpowder was suggested as a source of power.

Huygens. Huygens, a Dutch savant, published a work describing an apparatus, suitably arranged with cylinders and valves, in which the explosion of gunpowder was made to force a volume of heated air into the cylinder, after which the valve having closed, the gas became cool and soon fell to a pressure less than that of the atmospheric pressure. The apparatus as well as the operation was exceedingly crude and no very flattering results were obtained from its use.

Papin. About 1690, Papin continued the experiment with gunpowder, improving upon the design, and actually constructed an engine that worked, but the engine was crude and of poor workmanship. Papin's gunpowder engine was used to some extent but without success.

Robert Street. In 1794 Robert Street obtained a patent on the use of a mixture of liquid and air. The engine contained a motor cylinder, piston, and pump. The bottom of the motor cylinder was heated by a fire; a few drops of spirits of turpentine were evaporated by the heat; the piston was drawn up; and air entering mixed with the inflammable vapor as the piston was being driven, forcing the pump piston down, so performing work in raising water. Street's idea on gas engines was not improved upon in practice until later.

Samuel Brown. In the year 1823 Samuel Brown obtained a patent on the principle as well as the construction of an engine using gas-vacuum. Brown's engine is important as being the first gas engine to work. Boats and road carriages used Brown's engines for power in London.

W. L. Wright. In 1833 Wright developed a governor to vary the mixture of the gas to make it proportional to the work being done and to regulate the compression. The engine was double-acting, the piston receiving two impulses for every revolution of the crankshaft. The explosion of a mixture of gas and air acted directly upon the piston which acted through a connecting rod upon a crankshaft. Separate pumps supplied the gas and air to the motor cylinder at a pressure a few pounds above atmospheric pressure and the gases were ignited while the piston was crossing the dead center. The explosion pushed the piston down or up through its whole stroke, and as the piston was at the end of the stroke the exhaust valve opened and the products of combustion were discharged during the return, except for the portions remaining in the spaces not entered by the piston. Both cylinder and piston were water-jacketed, as would have been necessary in a double-acting gas engine to preserve the working parts from damage from the intense heat of the explosion.

William Barnett. In the year 1838 William Barnett obtained a patent on the principle as well as the construction of igniting arrangement, as the flame method most widely used at the present time. The compression system now so largely used in gas engines was also Barnett's invention.

Barnett's first engine was single-acting while the second and third were double-acting engines. In all three engines the ignition took place when the crankshaft was crossing the dead center, so that the piston received the impulse during the whole forward stroke.

Barnett's first engine had three pistons, motor piston, air pump piston, and gas pump piston. The motor piston was suitably connected to the crankshaft, and the other two were also connected by levers in such manner that all three moved up or down. On the upward stroke air and gas were forced into the cylinders, and on the downward stroke the gases were forced through an automatic lift valve into the receiver and there mixed. When the receiver was fully charged with the explosive mixture, the pressure had risen to about 25 pounds per square inch above atmospheric pressure.

Barnett's second engine was like his first, but it was a double-acting engine, working in the same way but requiring a greater number of parts.

Barnett's third engine, a double-acting engine, had three cylinders; motor, air-pump and gas pump. All the pumps were single-acting except the motor piston which was double-acting. Barnett's third engine was not as satisfactory as his first machine, because of the difficulty of obtaining a sufficient amount of expansion.

Barsanti and Matteucci. In 1857 Barsanti and Matteucci developed an engine with a free piston instead of using the principle of allowing the explosion to act directly upon the power shaft through a connecting rod at the moment of the explosion. Three advantages were gained by the Barsanti and Matteucci engine: (1) rapid expansion; (2) considerable expansion; and (3) condensor.

M. Lenoir. In 1860 M. Lenoir made the first practical gas engine. It was constructed along the lines of a double-acting steam engine. The electric ignition was obtained by a battery and Ruhmkorff coil producing a jump shank. It was a decided advance over all existing forms of gas engines. Lenoir's gas engine was much more economical than the steam engine, and since the gas engine was a small compact power plant it became popular. Lenoir engines required about 100 Cubic feet of gas per horsepower-hour and four times as much water for cooling as was used in a steam engine of like power. The troubles of a new idea were realized although there were some hundreds of Lenoir gas engines in practical use. The new gas engine was successful because it was small in size and compact in design which made it a much more desirable mechanism than the steam engine which had heavy boilers and cumbersome equipment and was expensive to operate. Several other ideas on the gas engine were advanced about this time, all of them being either of minor importance or repetitions of previous attempts.

M. A. Otto. In 1867 Messrs. Otto and Langen designed an engine that would consume only 44 cubic feet of gas horsepower per hour as compared to Lenoir's engine which consumed 112 cubic feet. The Otto and Langen engine was noisy, unreliable in action and, on account of the free piston rod which it employed, was subject to much vibration. Otto and Langen gas engines were sold because of the lower gas consumption compared with the first Lenoir engines. In 1867 Mr. Otto superseded his former invention by the production of the "Otto Silent" engine. Mr. Otto sold over 15,000 engines of this type, putting the gas engine on a firm commercial basis. The Otto gas engine was the first to be offered as a practical and reliable engine.

Dugald Clerk. The Clerk cycle engine was first introduced in 1879, and was the first of the compression engines built. This two-stroke-cycle engine utilized the engine crankcase to introduce fuel into the cylinders. While this engine contained fewer moving parts, it developed less power than a comparable four-stroke-cycle engine. The Clerk engine which is now called a two-cycle engine affected in one revolution what the Otto engine took two to do. As the working cylinder fired, forcing the piston down by the explosion at the bottom of the stroke, the burnt gases were allowed to escape. The automatic inlet valve opened and fresh gas filled the working cylinder, and as the piston moved upward the exhaust gas port was closed. At this point there was a tendency for a state of stratification existing between the fresh and the residual exhaust gases, but there was very little intermixing and fouling of the fresh charge. The two-cycle engine was just as economical in gas consumption as the Otto engine.

Rudolph Diesel. In 1895 Dr. Rudolph Diesel developed a new type of internal-combustion engine requiring no ignition system. The high temperature generated by the compression of air was utilized to ignite the fuel charge. With some improvements, this engine has found wide acceptance in the forms of heavy-oil diesel-type engines in both two-cycle and four-cycle forms.

Summary. Over three hundred years ago Huggens thought of the idea of using gunpowder as a source of power. In 1794 Street developed an engine that operated on liquid and air. Many attempts were made to invent the gas engine, but none of the inventors sufficiently overcame the practical difficulties to make any of their engines commercially successful.

It was not until the internal-combustion engine was invented that man tried to make a motor car. It seems that the first fairly successful internal-combustion engine was made by a German, Dr. Nicholas Otto, who lived near Cologne. He was assisted By Gottlieb Daimler who about ten years later made an engine and attached it to a bicycle. No one man can be given credit for the engine. It is not certain who first thought of the idea, but the gas engine like all great inventions, is the result of great minds like James Watt, who ran his first steam engine at SoHo Works, Birmingham.

While the internal-combustion engine has undergone numerous changes in design and construction, its basic principle of poeration has not changed. Many engines operate on the four-stroke-cycle principle patented by Dr. Otto in 1876. Others operate on the two-stroke-cycle principle.

CHAPTER III

SUGGESTED TEACHING OUTLINE

This chapter is composed of guide sheets which are to be used by the instructor. The instructor's guide sheets are planned to "put the lesson across", and to give the instructor a detailed plan to organize his work. After a definite aim has been established for a lesson the next step is to carefully plan the procedure for attaining the air or objective. The instructor's guide sheet consists of a plan of instruction comprised of four steps: (1) introduction or preparation (2) presentation, (3) application, (4) test or check-up. These sheets may be used separately from the rest of the study if desired.

The Instructor's Guide Sheet. The instructor's guide sheet is just what the name implies, a guide for the instructor. It serves as a map to guide him to a successful conclusion in teaching a particular lesson. The guide sheet is a convenient form for the instructor to use in making notes on how to approach the lesson and proceed through to its completion. The parts of the instructor's guide sheet will be discussed in the succeeding paragraphs.

Job or Subject. The instructor selects a certain job or subject to be taught at a certain time, beginning with the least difficult and leading to more and more difficult aspects of the work. This new job should have some key points that were covered in the previous lesson and new information which have not been covered before. Now the instructor can select the aims or objectives of the lesson.

Objectives. The aims and objectives for discussing a particular job should be presented. They should all pertain to the job. The objectives are short sentences listing what the teacher plans to have the learner accomplish in the lesson. The methods and materials may change from lesson to lesson but the pattern will stay the same. The first part of the pattern will be the introduction or preparation.

1. Introduction or Preparation. The introduction or preparation deals with the preparation by the instructor. The instructor plans the time for the job, training aids, tools and equipment, and what room or shops to teach in. The purpose of the introduction or preparation is to present to the student what is expected, and arouse his curiosity so as to develop interest. D. M. Kidd stated that:

> "Another kind of preparing is necessary during the teaching of the lesson. This consists of preparing the mind of the learner to receive the instruction. The best laid plans of the teacher may fail to result in successful learning unless the learners are physically and mentally ready to learn. They must be in a state of readiness to learn. This state of readiness cannot be created by the teacher at will. It must develop in the learner from within. The teacher merely takes advantage of such a state when it is present." (13, page 23)

To keep alive the desire to learn will be up to the instructor and student. If the instructor can make the student feel pride in workmanship or show to the learner that the job will be useful then the desire to learn will stay alive. Now the learner is ready to receive instruction in the new job. The presentation will follow.

2. Presentation. In this step the instructor presents the new ideas, information, techniques, and procedures, step by step. There are several methods by which information can be presented. The instructor may present the new experience by demonstration, pictures, diagrams, models, motion picture, film strips or glass slides.

The demonstration method shows the learner how the new techniques should be performed while the learner observes. Difficult points may be clarified in the demonstration by the use of pictures, diagrams, and models or mock-ups of the job. A suitable film can often be used as a preview for a lesson or a series of lessons to be followed by demonstrations. The instructor must be prepared to present each lesson in such a way that it will be interesting and effective.

In the demonstration the instructor will stress safety. The instructor will present only the safe methods of doing work, and should also tell the learner that there are short cuts to the job but they are dangerous for a beginner. Such methods should be carefully avoided in the demonstration. Safety precautions should not be placed at the beginning or at the end of the demonstration, but utilized all the way through it. The instructor should organize personal safety for the learner, general rules of safety in the shop, fire drill and other types of safety rules. In the application step the instructor can check to see if the student uses safe methods.

3. Application. The pupil has the best opportunity to learn by doing the job. The application step is most important, because it will be the learner's first time working at a new operation. The learner is free to call upon the instructor for assistance in the application step.

Helping the pupil over his difficulties in this way is not the same thing as doing his work for him. The learner should practice the new information as soon as possible after the demonstration. If there is a lapse of time between the presentation and application the pupil may not recall all of the important details of the job. Some of the reasons for delay are work stations, tools, equipment and other teaching aids not being completely ready. The application is the first point in the lesson where the learner has a chance to try out what is in the presentation. At this point the instructor will assist, suggest and even help the learner. The purpose of the application is to see if the learner applies the new ideas, information and techniques. To test or check this the instructor can use a test.

4. Test or Check-up. The purpose of the test or check-up is to determine whether or not the pupil has acquired the information or skill intended. The test will help both the learner and teacher to determine whether the objectives of the lesson have been achieved. The important part of the test is not the mark or rating the pupil receives but the test helps to determine at what points, if any, the learner is weak and requires more instruction. Other purposes are:

1. pre-teaching measure of achievement
2. to diagnose learning difficulties
3. teaching success
4. standards of achievement
5. rating
6. teaching device

Tools and Materials. In planning, the machines, tools, drawings, charts, instruction sheets and working materials should be at hand and properly arranged for the student and teacher. All tools that the student will use on the job should be checked by the instructor before the class starts.

Reference Books. There is a book listed to be used as a reference with every guide sheet. Many books, pamphlets and instructional aids may be obtained from manufacturers of gas engines. Most popular mechanical magazines have articles about the maintenance and repair of engines and a list of safety precautions to be observed by the operator.

Assignments. With every guide sheet there is an assignment after each demonstration. This assignment is for the next lesson for the pupil to read or to study. This helps to prepare the student for the following lesson. These assignments may be made from any available text book, pamphlet, cutaway, picture, or parts list.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Starting an Engine

Objectives: To teach the student how to start an engine.

I. Introduction or preparation: Have a student try to start the engine, with a rope type starter. (develop interest)

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Starting an engine with a rope starter.	Models
a. turn pulley counter-clockwise	
b. wind rope counter-clockwise	
c. pull clockwise	Demonstration
2. Starting an engine with rewind starter.	Models
a. pull rope (compression is felt)	
b. allow rope to rewind	
c. pull rope	Demonstration
3. Starting an engine with electric starter.	Models
a. cord to engine	
b. cord to receptacle	
c. remove plug (from wall receptacle)	Demonstration

III. Application: Have the learner start all three types of engines.

IV. Test or Check-up: Questions
1. What are the three types of starters?
2. Why turn the pulley backward on the rope starter?
3. How long can the electric starter run at one time?

Tools and Materials: three types of starters

Reference: Briggs and Stratton, Operation Instruction, page 3 to 4

Assignment: Read pages 3 to 4 on changing oil.
Briggs and Stratton, Operation Instruction.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Change Oil (Oil Sump)

Objectives: To remove old oil from the engine

I. Introduction or preparation: It is always best to drain the oil immediately after stopping the engine.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Drain the oil from the engine.	Demonstration
a. different positions	
b. remove oil drain plug	
c. drain oil	
2. Replace plug in drain plug hole.	Demonstration
3. Fill oil sump.	Demonstration
a. remove oil filler plug	
b. pour oil in	
c. to what level	
d. replace oil filler plug	

III. Application: Have the learner go over the steps on changing oil.

IV. Test and Check-up: Inspect learner's work and check it with him.

Tools and Materials: screwdriver, oil, engine, wrench

Reference: Briggs and Stratton, Operating Instruction, page 3 to 4

Assignment: Read page 5 on changing oil (air cleaner)
Briggs and Stratton, Operating Instruction.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: <u>Changing Oil in The Air Cleaner:</u>

Objectives: To clean the air that will go to the carburetor.

I. Introduction or preparation: Inspect air cleaner to see if it has been serviced regularly or is full of dirt or clippings.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Remove wing nut on top of cleaner. a. remove cover	Demonstration
2. Lift out oil element. a. wash element	Demonstration
3. Lift off bowl. a. pour out oil b. clean bowl	Demonstration
4. Replace bowl to cleaner.	Demonstration
5. Pour in oil to ''oil level'' mark.	Demonstration
6. Replace filter element.	Demonstration
7. Replace cover and wing nut.	Demonstration

III. Application: Have the learner change oil in air cleaner.

IV. Test or Check-up: Questions
1. What are the functions of the air cleaner?
2. Is the oil put in after the filter element?
3. Clean and refill the air cleaner every _____ hours?

Tools and Materials: oil, engine, air cleaner

Reference: Briggs and Stratton, Operating Instructions, page 5

Assignment: Read page 6 on draining and cleaning fuel tank, Briggs and Stratton, Operating Instructions.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Draining Fuel Tank and Cleaning Fuel Filter.

Objectives: The object is to remove all dirt and sediment.

I. Introduction or preparation: Alcohol or acetone should be used to clean the parts of a fuel tank.

II. Presentation:

Teaching Outline	T eaching Techniques, Aids and Devices
1. Close fuel valve. a. what direction	Demonstration
2. Remove fuel tank drain plug. a. what direction	Demonstration
3. Detach fuel pipe. a. what end first b. what direction	Demonstration
4. Remove fuel filter from fuel tank. a. what direction	Demonstration
5. Clean with alcohol or acetone. a. safety (tell about gasoline) b. screen not removable	Demonstration
6. Replace fuel filter, pipe plug, and fuel line.	Demonstration

III. Application: Have learner go through the step of draining fuel filter.

IV. Test or Check-up: Questions
1. What is used to clean the screen?

Tools and Materials: engine, alcohol or acetone, wrench

Reference: Briggs and Stratton, Operating Instructions, Page 6

Assignment: Read setting air gap on armature; page 13
Briggs and Stratton, Repair Instructions.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Armature Air Gap Adjusting.

Objective: To teach the student how to check air gap (Armature to Flywheel)

I. Introduction or preparation: The purpose for checking the air gap is to have the strong spark.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. The air gap should be: (aluminum flywheel) a. weight b. gap	Diagrams
2. The air gap should be: (zinc flywheel) a. weight b. gap	Diagrams
3. Turn flywheel until magnets are directly beneath the flywheel.	Demonstration
4. Magnets should pull the armature down firmly against feeler gauge.	Demonstration
5. Tighten the mounted screws.	Demonstration

III. Application: Have the learner check air gap.

IV. Test or Check-up Questions:
1. What are the two types of flywheel?
2. Where should the magnets be located?
3. What is used to check the air gap?

Tools: Feeler gauges, diagram, screwdriver

Reference: Implement and Tractor Publication, Inc., Small Engine Service Manual, page 53

Assignment: Work on armature air gap adjusting.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Carburetor Adjustments

Objectives: To teach the student how to adjust a carburetor.

I. Introduction or preparation: The purpose of adjusting a carburetor is to make the engine run as smoothly as possible.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Close the needle valve.	Demonstration
a. location of needle valve	
b. what direction	Question
2. Open the needle valve.	Demonstration
a. what direction	
b. how far	Question
3. Close the idle valve.	Demonstration
a. location of idle valve	
b. what direction	Question
4. Open the idle valve.	Demonstration
a. what direction	
b. how far	Question
5. Start the engine.	Refer to starting an engine
6. Adjusting the needle valve. (engine running)	Demonstration
7. Adjusting the idle valve. (engine running)	Demonstration

III. Application: Have the learner adjust carburetor.

IV. Test and Check-up: Questions
1. What direction is the needle valve turned to stop engine?
2. What direction is the idle valve turned to make the engine run smoothly?

Tools and Materials: engine, screwdriver

Reference: Briggs and Stratton, Operation Instruction Book, page 6

Assignment: Read page 7 on governor adjustment, Briggs and Stratton, Operation Instruction.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Governor Adjustments

Objectives: To be able to change the speed of an engine.

I. Introduction or preparation: To maintain the desired speed even though the load on the engine may vary.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. There are three different types of speed controls,	Show diagrams of all three
a. control lever mounted on cylinder	
b. hand governor control	
c. remote governor control	
2. The correct operating speed	Charts
a. type of engine	Rating scales
b. the load on engine	Rating Scales
3. Control lever mounted on cylinder.	Models
4. The hand type governor control.	Models
5. The remote governor control.	Models

III. Application: Experiment with the governor while the engine is still running.

IV. Test or Check-up: Questions
1. What are the three types of control on a governor?
2. What is ''No Load''?
3. What is R. P. M.?

Tools and Materials: Models, diagrams, charts, test, rating scales and engine.

Reference: Briggs and Stratton Operating Instruction Book, page 7

Assignment: Read part 80 on repairing carburetor. page 34, Implement and Tractor Publication, Inc., Small Engine Service Manual

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Repair Carburetor

Objectives: Replace worn parts and repair carburetor.

I. Introduction or preparation: A hand spray gun is an example of a carburetor.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Disassemble the old carburetor.	Demonstration
a. loosen needle packing nut	
b. remove packing nut and needle valve	Check
c. remove nozzle, screws, upper and lower body	
d. remove idle valve, float, float needle valve	
2. Clean, check and replace all worn parts.	Check
a. use new gaskets	
b. use new parts	
c. clean old parts	
3. Assemble the carburetor after instructor checks parts.	Demonstration
a. replace float needle valve, float, idle valve	
b. replace upper and lower body, nozzle	Check
c. replace needle valve and packing nut	
d. screw in packing nut	

III. Application: Have learner disassemble and assemble the carburetor and check his work.

IV. Test or Check-up: Questions
1. What is the purpose of a carburetor on an engine?
2. Describe the purpose of a carburetor float.
3. Describe the purpose of the upper and the lower body.

Tools and Materials: carburetor, screwdriver, wrench, and carburetor repair kit.

Reference: Implement and Tractor Publication, Inc., Small Engines page 12 to 17

Assignment: Disassemble and assemble the carburetor.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Function of a Spark Plug

Objectives: To become familiar with a spark plug and its parts.

I. Introduction or preparation: The function of spark plug is to provide the means for igniting the compressed charge of air and fuel in the engine cylinder.

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. What are some of the types of spark plugs? a. cold plug b. normal plug c. hot plug	Charts
2. Explain the parts of the spark plug. a. terminal b. insulator c. metal shell d. center electrode e. ground electrode	Cut-away of spark plug
3. Plugs with long paths for the heat to travel are ''hot plugs''.	Models
4. Plugs with shorter paths for the heat to travel are ''cold plugs''	Models

III. Application: By testing.

IV. Test or Check-up: Questions
1. What is the function of a spark plug?
2. Plugs with long paths for heat to travel are?
3. Plugs with short paths for heat to travel are?

Tools and Materials: Models, cut-away of plug, charts

Reference: Implement and Tractor Publications, Inc., Small Engines Service Manual page 11 to 12

Assignment: Read how to set and check the air gap of a spark plug. page 23

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Setting and Checking Air Gap (spark plug)

Objectives: To have the correct gap so that the high voltage will jump across the gap.

I. Introduction or preparation: Where does ignition occur on a spark plug? (try to develop interest)

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Remove spark plug from engine.	Demonstration
a. check open end	
b. clean open end	
2. Check and reset the air gap.	Demonstration
a. gap .025''	
b. Resistor type plugs	Question
3. Assemble plug in the engine	Demonstration
a. gap .025''	
b. new gasket	

III. Application: Have learner clean and check gap on plug and check his work.

IV. Test or Check-up: Questions
1. Are all spark plugs gapped at .025''?
2. What can a plug do to the engine if the gap is too long?
3. What is the material called that forms around the spark plug gap?

Tools and Materials: feeler gauge, spark plugs, diagram and cleaner.

Reference: Implement and Tractor Publications, Inc., Small Engines Service Manual, page 23

Assignment: Read pages 4 to 6 on distributor.

INSTRUCTOR'S GUIDE SHEET

Job or Subject: Check Piston Rings, Connecting Rod and Piston Pin

Objectives: To see if parts show sign of wear or scoring.

I. Introduction of preparation: How much more does an engine with worn parts cost to operate than one with new parts? (trying to develop interest)

II. Presentation:

Teaching Outline	Teaching Techniques, Aids and Devices
1. Check the piston for wear or scoring.	Charts
a. resized	Models
b. old piston	
c. new piston	
2. Check all three types of rings.	Diagrams
a. top compression	Models
b. center compression	''
c. oil	''
3. Check the connecting rod.	Demonstration
a. bearing scored	
b. ''file'' or ''fit'' rod	
4. Check the piston pin.	Demonstration
a. pin	

III. Application: Have the learner check old piston, rings, connecting rod, and piston pin.

IV. Test or Check-up: Inspect learner's work and have learner inspect his own work.

Tools and Materials: Piston, rings, connecting rod, piston pin, feeler gauge, rings remover, charts, models and diagrams.

Reference: Briggs and Stratton, Maintenance Book, page 23 to 24

Assignment: Work on the above parts.

SUMMARY. The instructor's guide sheet is a guide for the teacher. After a definite aim or objective has been established for a lesson, the next thing to do is arouse curiosity, develop interest and create a desire to learn the lesson. The instructor's way to do this is by explaining what the lesson is about or by past experience.

A few of the many possible jobs that could be carried out in a program of this type have been presented. A program of this type would not require many tools or equipment.

Listed below are some of the manufacturers of small gas engines.

Briggs and Stratton	Lawn Boy
Clinton	Lycoming
Continental	McCulloch
Cushman	Onan
Gladden	Power Products
Gravely	Reo
I. E. L.	Titan
Jacobsen	Vespa
J. A. P.	West Bend
Kohler	Wisconsin
Lawson	Wright

The following chapter is composed of the summary and conclusions of the study of small gas engines.

CHAPTER IV

SUMMARY AND CONCLUSION

Although air-cooled engines find little use in American-made automobiles they are being used on both two-cycle and four-cycle engines employed to propel some European cars. They are also used on motorcycles, scooters, lawnmowers, garden tractors, airplanes and on some makes of diesel engines.

Summary. Air-cooled engines have fins or ribs on the outer surfaces of the cylinders and cylinder heads. The fins are cast integrally with the cylinder and cylinder head and serve to increase the amount of radiation surface presented to the air stream. The heat produced by combustion passes through the walls of the cylinder and cylinder head to the fins, where it is dissipated into the passing air. Individual cylinders are generally employed to provide ample cooling area.

The air-cooled engine requires the circulation of large volumes of air over and past the fin area. In motorcycles and airplanes, the required amount of air is supplied by the forward motion of the vehicle. In cases where air-cooled engines are used in automobiles, the required volume of air is supplied by a fan or a blower sometimes built into the engine flywheel. A cowling or shroud often encloses the engine to control the flow of air over the engine. Baffles are located near or between the cylinders to deflect the air through the fin area around the rear of the cylinders.

Air-cooled engines operate at a higher operating temperature than other types of engines. Normal cylinder head temperatures for such engines vary between 300 degrees and 500 degrees Fahrenheit. As a result, greater clearances must be provided between the moving parts to allow for their greater expansion. Because of the higher operating temperatures, a heavier grade of lubricating oil is usually used in air-cooled engines.

In 1794, a Mr. R. Street of England proposed an internal-combustion engine to be operated by a flame-ignited mixture composed of spirits of turpentine and air. Near the end of the eighteenth century, Murdock discovered that a combustible gas could be produced by burning coal, opening the way for the development of internal-combustion engines. Some engines were built using this gas for fuel. In 1860, Lenoir produced a practical internal-combustion engine using electricity for ignition. While many of these engines were built and used, they developed little power since the fuel charge was not compressed at the time it was ignited.

It was not until 1862 that Beau-de-Rochas of France proposed the basic principle of the four-stroke-cycle engine. He proposed that the fuel taken into the cylinders be compressed to take full advantage of its expansive power. However, fourteen years elapsed before his suggestions were followed.

In 1876 Dr. Otto of Germany produced the Otto cycle gas engine operating on the four-stroke-cycle. This development made possible the internal-combustion engine as we know it today. A short time later Dugal Clerk of England constructed the first two-stroke-cycle engine, utilizing the engine crankcase to introduce fuel into the cylinders. While this engine contained fewer moving parts, it developed less power than a comparable four-stroke-cycle engine.

In 1895 Dr. Rudolph Diesel developed a new type of internal-combustion engine requiring no ignition system. The high temperature generated by the compression of air was utilized to ignite the fuel charge. With some improvements, this engine has found wide acceptance in the form of heavy-oil, diesel-type engines in both two-cycle and four-cycle engines.

Conclusions. While the internal-combustion engine has undergone numerous changes in design and construction its basic principle of operation has not changed. Many engines operate on the four-stroke-cycle principle patented by Dr. Otto in 1876. Others operate on the two-stroke-cycle principle. Aside from improvements in materials and methods, the chief changes that have been made in these engines are:

1. increased compression ratios
2. improved valve timing
3. better balance of moving parts
4. better mixing and distribution of fuel
5. more accurate timing of fuel charge ignition

These changes have resulted in compact, powerful, highly efficient engines of light weight that can operate at extremely high speeds. The weight per horsepower developed has been reduced to but a fraction of the weight of early engines. Nevertheless, in principle, the modern internal-combustion engine is the same as originally conceived.

APPENDICES

A. A Selected Bibliography

A SELECTED BIBLIOGRAPHY

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