AG. 221 SMALL GASOLINE ENGINES

COURSE DESCRIPTION: A course designed to develop skills in selection, operation, and maintenance of small air-cooled engines.

UNITS OF INSTRUCTION	**MINUTES OF INSTRUCTION**
Safety	235
Tool and Part Identification	940
Operating Principles	235
Overhaul Procedures	1,880
Troubleshooting and Tune Up Procedures	940
TOTAL MINUTES	4,230

A. Safety

1. Identify safety equipment necessary for agricultural power technology
2. Apply basic laboratory safety instruction
3. Describe safety practices when using electrical equipment
4. Apply safety practices when using tools and equipment

B. Tool and Parts Identification

1. Determine what information is needed for parts and mechanics manual usage
2. Identify the basic engine parts and the functions of each in the operation of an engine
3. Use the manufacturer's respective master parts manual in ordering replacement parts for an engine
4. Use a manufacturer's manuals to solve the procedural problems specific to a particular engine
5. Identify the parts of a magneto ignition system
6. Identify the major components of a carburetor
7. Identify the types of carburetors and describe the features of each of these types of carburetors
8. Identify the basic types of governors
9. Identify the parts of a valve and its accessories
10. Identify the parts of the piston, rings and rod
11. Identify the types of lubricating systems and describe how they operate
12. Identify the parts of the camshaft and tappet mechanism
13. Identify the types of crankshafts and parts thereof

14. Identify the major types and applications of tools

C. Operating Principles

1. Designate an engine as a two or four cycle
2. Identify engine by brand name and/or manufacturer
3. Determine what information is given on the nameplate
4. Identify operating conditions of small gasoline engines
5. Use horsepower terms such as indicated, friction, brake and "rated" in describing the size of an engine
6. Define and relate the following terms:
   a. stroke
   b. bore
   c. cycle
   d. crankshaft revolution
   e. camshaft revolution
   f. principle events
   g. intake
   h. compression
   i. power
   j. exhaust
   k. camshaft timing
   l. ignition timing
   m. BTDC
   n. TDC
   o. BDC
   p. power strokes per revolution of camshaft
   q. displacement
   r. compression ration
   s. clearance volume
7. List the sequential order and explain the significance of the principle events in the operation of a four-stroke cycle engine
8. Explain the relationship of the main parts of the four-stroke cycle engine to the principle events
9. Identify a four-stroke cycle engine by visual observation
10. Explain the difference in operation and construction of the two and four-stroke cycle engine
11. Recognize a two-stroke cycle engine by visual observation
12. Describe the combustion as the focal point of engine operation
13. Describe the basic operating principles of a magneto ignition system
14. Describe the operational principles of a carburetor
15. Diagram the basic principle of carburetor to governor to throttle control linkage
16. Describe the operation of each type of governor
17. Describe the purpose and operation of valves

D. Overhaul Procedures

1. Disassemble a small engine according to the procedures outlined by the manufacturer
2. Identify the wear points on a disassembled engine
3. Assemble a small engine according to the procedures outlined by the manufacturer
4. Describe the tolerance, specifications, clearance and reject size given by the manufacturer and how these terms affect engine operation
5. Identify those parts of an engine that need to be measured with a measuring device
6. Use micrometer measurements to determine if parts of a small engine are within the specifications set by the manufacturer
7. Manipulate the different micrometers and measuring devices so as to record proper measurements
8. Identify engines and machines according to model, serial, specification and type numbers when each applies
9. Use the manufacturer's specifications and torque data
10. Reface valves
11. Reface valve seats
12. Adjust valve tappet clearance
13. Install the piston rings
14. Install the piston rod assembly
15. Install the camshaft and tappets

E. Troubleshooting and Tune up Procedures

1. Clean and inspect the exhaust system of a two-cycle engine
2. Identify and service the different types of air cleaners
3. Identify and service the different types of breathers
4. Prepare a fuel and oil mixture for a two-stroke cycle engine
5. Identify and service the different types of spark plugs
6. Start an engine and adjust it for speed and load
7. Check and service the magneto and its parts for proper operation
8. Time the point opening to the piston position
9. Check each of the different types of carburetors for proper operation
10. Check and adjust the governors for proper operation
11. Find and use manufacturer's recommendations for troubleshooting problems in a small engine

AG-221

Small Gasoline Engines

FOR

IDAHO

SECONDARY AGRICULTURAL INSTRUCTORS

Developed and written by:

Cody J. Echevarria

Written through a grant from the

State Division of Professional-Technical Education

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Administered through the

Department of Biological Systems and Agricultural Engineering

University of Idaho

Jack McHargue, Project Supervisor

ACKNOWLEDGEMENTS

Many individuals have made substantial contributions to the development and publication of this curriculum. While all of them cannot be recognized, we do extend our sincere thanks for their contributions and efforts. The following people were especially influential in the development of this curriculum guide.

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  - Change oil

R. Trouble Shooting

S. Interchanging Engine Parts

Introduction:

This curriculum guide is prepared for four stroke Briggs and Stratton combustion engines. In general most of the material included will apply to any small 4 stroke engine, however, some parts and tools may be specific to Briggs and Stratton engines.

Unit Objective:

After completion of this unit, students will be able to explain the general operation theories of 2 stroke and 4 stroke engines. This knowledge will be demonstrated by completion of a quiz and a unit test with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

- Identify basic terms and definitions associated with small engines
- List tools required to work on small engines
- Compare and contrast the advantages and disadvantages of 2 stroke and 4 stroke engines
- Describe the differences in operation between 2 stroke and 4 stroke engines
- Identify the functions of each engine stroke
- Calculate and compare engine displacement (Standard 349.01)
- Identify the required elements to make an engine run
- Describe each element required to make an engine run (Standard 648.01)

Terms and Definitions

Carburetion – supplying an air/fuel mixture to the combustion chamber of a combustion engine

Combustion – an instance of burning

Combustion chamber - space inside an engine block where combustion occurs, otherwise known as an engine cylinder

Compression – to create pressure in the combustion chamber by condensing the size of the chamber

Compression ratio – Difference in volume created in the combustion chamber as the piston moves up and down, shown as a ratio of maximum volume to minimum volume.

Displacement – The volume displaced by a piston as it moves up the combustion chamber; commonly expressed in cubic inches, cubic centimeters, or liters.

Engine – A machine for converting various forms of energy into mechanical force and motion

Fuel – A material used to produce heat or power by burning; gasoline and diesel are common fuels

Horsepower – a unit of power equivalent to 746 watts in the U.S.

Ignition System – The electrical components of an engine that produce a high voltage arc or spark across the air gap on the spark plug to ignite combustible mixtures of fuel and air

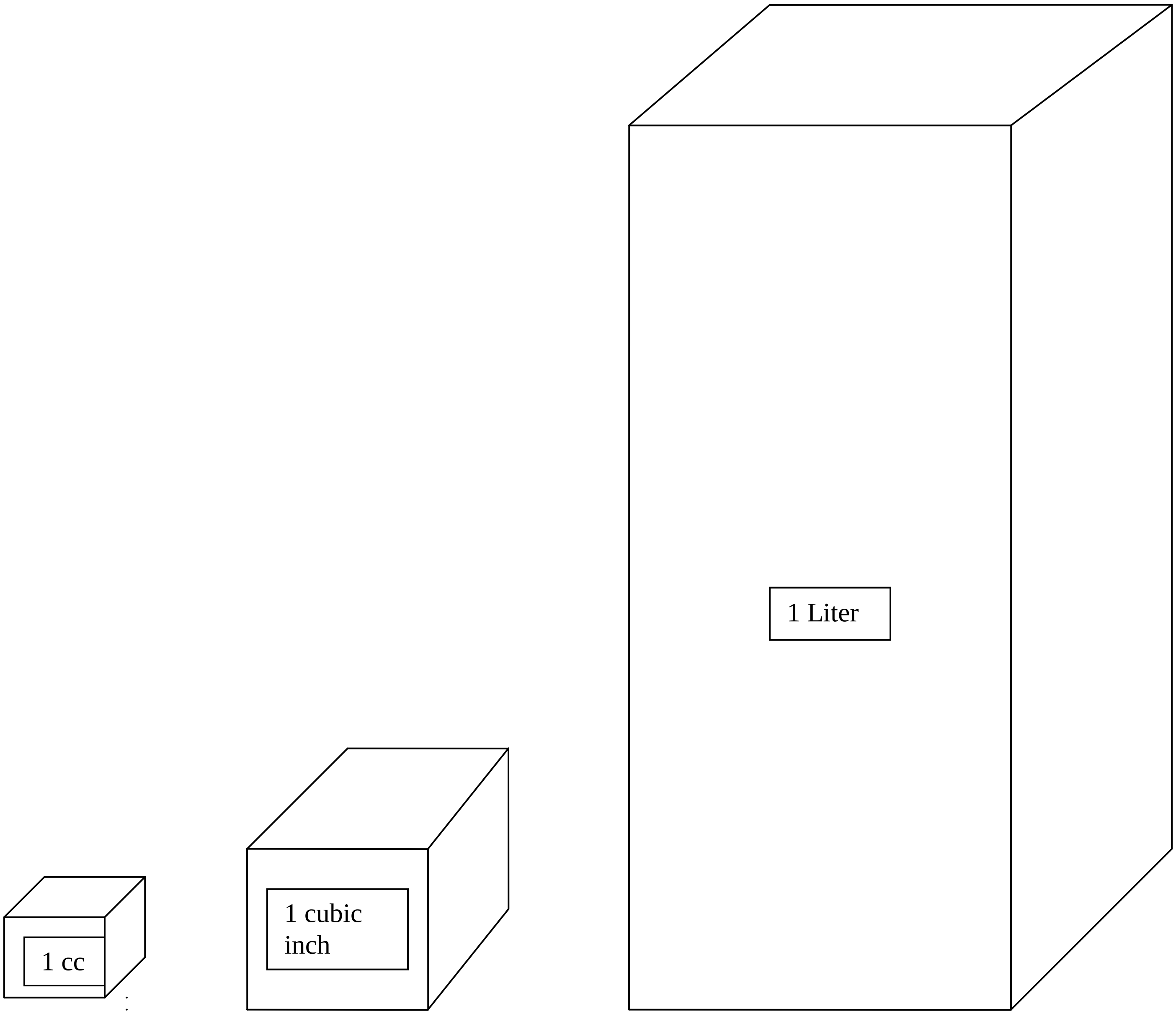
Lubricant – a substance used to reduce friction, heat, and wear when applied as a thin film between solid surfaces

Piston – cylindrical shaped engine part that moves up and down in the combustion chamber to displace volume and create compression

Power – A means of supplying energy; the time rate at which work is done

Watts – Unit of power equal to 1/746 horsepower

Engine Displacement



1 cc = 1 ml
1 cc = .061 cu. In.

1 cu. In. = 16.39 cc
1 cu. In. = 1 gal

1 liter = 1000 ml
1 liter = 1.0567 qt.
1 liter = 61.023 cu. In.

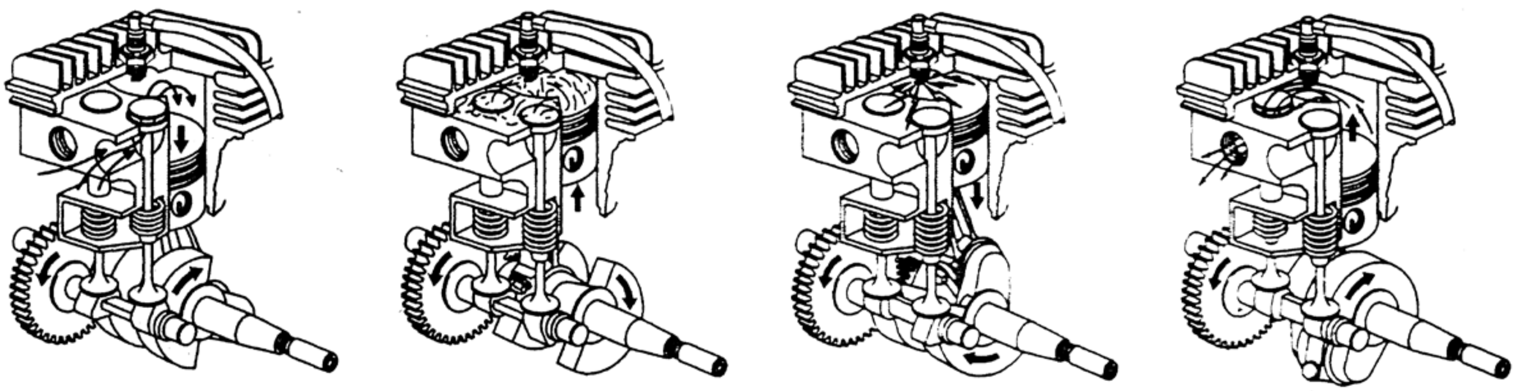
500 cc motorcycle = 30.5 cu. In = 0.5 liter

460 cu. in Ford V-8 = 7538 cc = 7.53 liters

5.9 Liter Cummins = 360 cu. In. = 5900 cc

4 Engine Strokes

As the name indicates there are four strokes necessary to complete one power cycle in a four stroke engine.



1. INTAKE STROKE 2. COMPRESSION STROKE 3. POWER STROKE 4. EXHAUST STROKE

1. Intake Stroke:	As piston moves down, a vacuum occurs in the cylinder. The intake valve opens. Atmospheric pressure pushes the air/fuel mixture through the open intake valve into the cylinder above the piston. At the bottom of the stroke the intake valve closes. The exhaust valve stays closed.
2. Compression Stroke	As the piston moves up with both valves closed, the air/fuel mixture becomes highly compressed in the space left between the top of the piston and the top of the compression chamber.
3. Power Stroke	Just before the compression stroke ends, the ignition system produces a voltage arc across the spark plug gap igniting the air/fuel mixture. The rapidly burning mixture produces very high pressure which pushes the piston down to the bottom of the combustion chamber.
4. Exhaust Stroke	As the piston begins to go up, the exhaust valve opens and the piston pushes out the burned gases completing the cycle and begins the first stroke again.

2 Engine Strokes

In a two cycle engine only two piston strokes are necessary to complete one power cycle. Power and exhaust occur simultaneously in one stroke and intake and compression occur in the other stroke. Most two stroke engines have ports which are opened and closed as the piston moves past them. Whereas, four stroke engines have valves that are opened and closed by a camshaft.

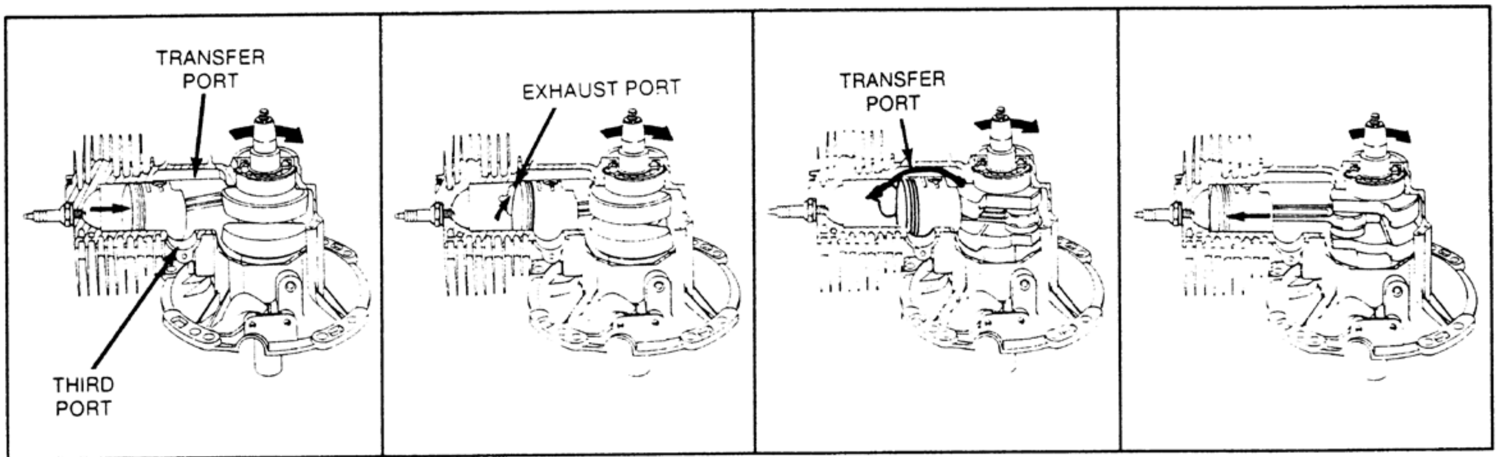


Fig. 1 – Power **Fig. 2 – Exhaust** **Fig. 3 – Intake** **Fig. 4 – Compression**

1st Stroke

1. Power — The burning air/fuel mixture expands, pushing the piston down, until the piston opens the exhaust port, power will continue. The transfer (intake port has closed.

2. Exhaust — When the piston moves past the exhaust port it allows exhaust gasses to flow out. As the piston moves down the combustion chamber the volume in the crankcase is decreased, therefore the pressure is increased to aid in moving the air fuel mixture into the combustion chamber.

2nd Stroke

1. Intake — Near the bottom of the down stroke and during the beginning of the up stroke, the transfer (intake) port opens. Because the pressure in the crankcase is higher than the pressure in the combustion chamber, the air/fuel mixture in the crankcase moves into the combustion chamber. At the same time the remaining exhaust gasses are purge out of the combustion chamber.

2. Compression — As the piston continues to move up, it closes the transfer port and the exhaust port. With both ports closed, the air/fuel mixture is being compressed in the combustion chamber. Because the volume is increasing in the crankcase, the pressure is dropping to less than atmospheric pressure. As the piston approaches the top of the combustion chamber, the third port opens. With pressure higher in the carburetor than in the crankcase, the air mixes with fuel in the carburetor and pushes into the crankcase. Just before the piston reaches the top, ignition of the air/fuel mixture occurs to begin the next complete cycle.

Advantages and Disadvantages of 2 stroke engines versus 4 stroke engines:

Two stroke engines require that the lubricant be mixed in with the fuel since the air/fuel mixture travels through the crankcase (where the lubricant is in a four stroke engine). Two stroke engines can be used in any position because of the lubrication system. Four stroke engines must be kept in one position to keep the lubricant where it is necessary. However, this can also be a disadvantage to two stroke engines. If the fuel and lubricant are mixed improperly it can effect engine performance or cause excess wear. Check manufacturer specifications for mixing. Two stroke engines have less moving parts, therefore, should require less repairs. Two stroke engines also have a higher horsepower to weight ratio.

3 Requirements for an Engine to Run

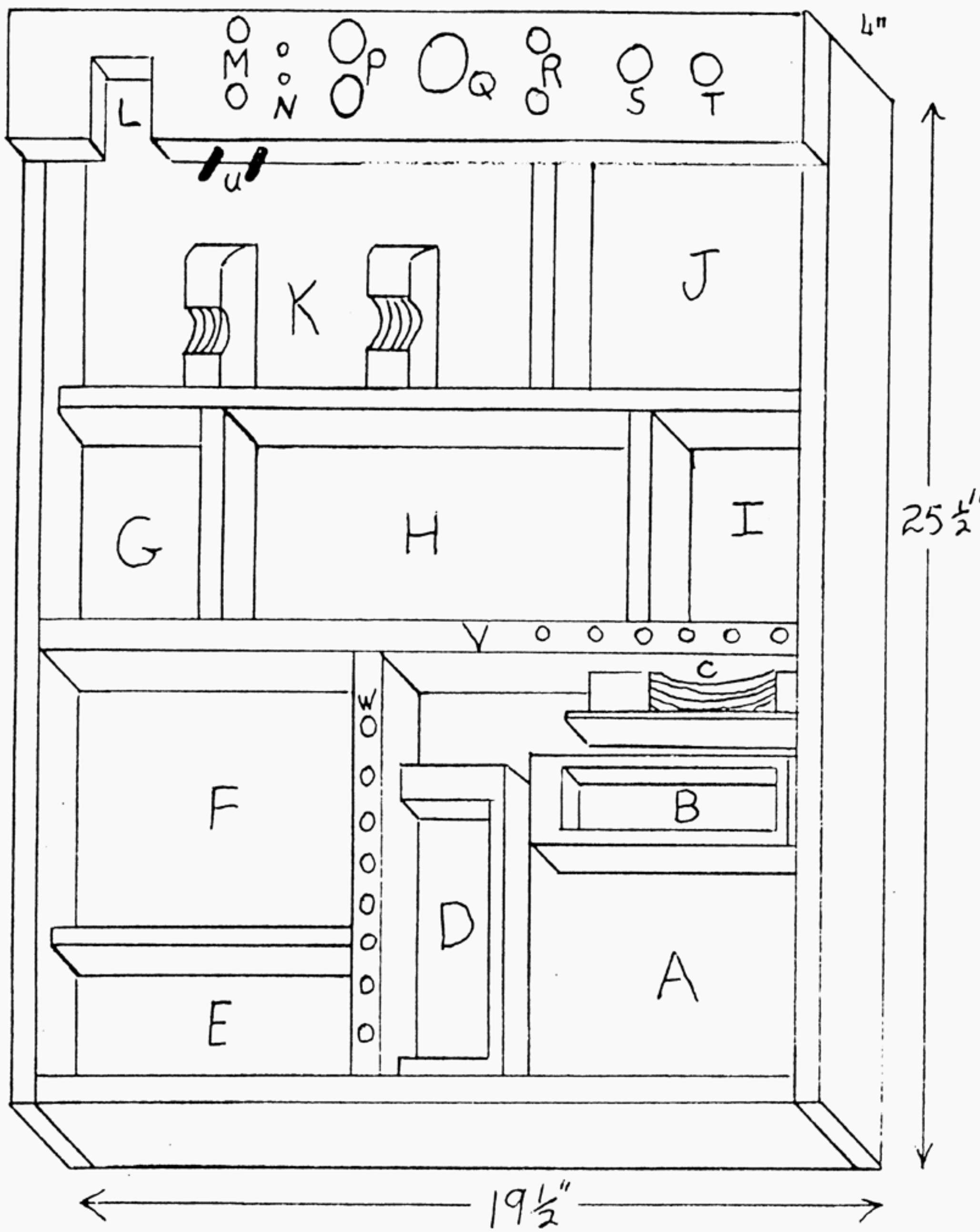
All three of the following are required for an engine to run. Problems with any one of the three systems or any combination of the three will prevent an engine from running.

Compression: The combustion chamber must be capable of compressing the air/fuel mixture in order to create the explosion necessary to complete the power stroke. The air/fuel mixture must be under pressure to explode. If the combustion chamber is not capable of pressurizing the mixture, the mixture may burn without enough exploding force to move the piston down the chamber.

Carburetion: The carburetion system of the engine supplies the correct air/fuel mixture necessary for combustion inside the combustion chamber. The air to fuel ratio is regulated by the carburetor. Timing of the air/fuel mixture entering the combustion chamber is controlled by the cam gear as it opens the intake valve on the intake stroke. Fuel quality is also important. In small amounts such as the size of fuel tanks used on small engines it is common for fuel to become stale in as little as 30 days. Dirt, water, or rust in fuels is also a common problem in carburetion systems.

Ignition: The ignition system of the engine must provide a spark or arc across the spark plug air gap at the correct time to ignite the air/fuel mixture. Timing should be such that the spark occurs when the piston is about ¼" below the top of the compression stroke.

SMALL ENGINE PARTS BOX



Bin	Parts	Inside Dimension
A	Block	5" x 8"
B	Crankcase Cover	5½" x 1½"
C	Flywheel	6" x 2¼"
D	Head	4½" x 1¼"
E	Blower Housing	3" x 7¼"
F	Gas Tank	7¼" x 6¼"
G	Air Cleaner	4½" x 5"
H	Carburetor	8¼" x 5"
I	Coil, Points	3½" x 5"
J	Misc.	5-3/4" x 7-1/4"
K	Crankshaft	11½" x 7¼"
L	Piston	1½" x 3/4"
M	Valves	5/16"
N	Valve Pins	3/16"
P	Springs	7/8" Bottom Covered
Q	Camshaft	1"
R	Cam Followers	1/4"
S	Condenser	3/4" Bottom Covered
T	Spark Plug	5/8"
U	Spring Retainer	3/16" x 1/2"
V	Crankcase Cover Bolts	1/4"D x 1" Deep
W	Head Bolts	5/16" x 2"

Tool Inventory List for Small Engine Tool Boxes

The following set of tools should be provided for each student or pair of students in the class:

1 – 10" Adjustable End Wrench

1 – 13/16" Spark Plug Socket

1 – ¾" Spark Plug Socket

12 – 3/8" – 15/16" Combination End Wrench

1 - 3/8" Drive Socket Set, Includes:
- 7 – 12 Pt. Sockets 3/8" – 3/4"
- 1 – 7" Reversible Ratchet
- 2 – Extension Bars 3 ½" & 12"
- 1 – Hinge Handle 7 3/8"
- 1 – Universal Joint
- 1 – Speed Handle 16 7/8"

5 - Regular Bit Screwdrivers:
- 1/8", 3/16", 5/16", 3/8"
- 1/4" stubby

2 - Phillips Screwdrivers:
- #1 & #2

1 - Diagonal Cutting Pliers

1 - Needle Nose Side Cutting Pliers

1 - Feeler Gauge Set:
- .0015" - .040" thickness

1 - Sparkplug Gauge Set, Gauges:
- .022" - .040"

1 - Punch & Chisel Set:
- 1/8" Pin Punch
- 3/16" Pin Punch
- 3/8" Center Punch
- 5/16" Starting Punch
- 1/2" Cold Chisel

1 - 1/4" Drive Socket Set, Includes:
- 9 – 12 Pt. Sockets 3/16" – 1/2"
- 1 – Reversible Ratchet
- 2 – Extension Bars 3 ½" & 6"
- 1 – Hinge Handle 7 3/8"
- 1 – Universal Joint
- 1 – Nut Driver Handle

Small Engine Tools

The following tools will be necessary for engine overhauls:

Bar, Rolling Head Pry
Bearing Support Jack
Carburetor Screwdriver
Coil and Condenser Tester
Compression Tester
Compressors, Piston Ring
Compressors, Valve Spring
Condenser Wire Remover
Cutter, Valve Seat
Cylinder resizing hone set
Dial Gauge
Drill Electric
Driver, Valve Guide
Drivers, Bushing
Flywheel Holders
Flywheel Weight
Grinder, Valve
Guide, Valve Seat Reamer
Hammer, Ball Peen
Hammer, Blacksmiths Cross Peen
Handle, Nut Driver
Knife, Putty
Knife, Utility
Mallet, leather
Mallet, Rubber
Micrometer, Standards
Micrometers, Inside
Micrometers, Outside
Oil Seal Protector Sleeves
Plates to Secure Engine Block to Vise
Point Plunger Hole Gauge
Puller, Valve Guide
Puller, Valve Seat
Pullers, Gear
Reamers, Bushing
Reamers, Valve Guide
Rewind Starter Tool
Ring Expanders
Rope Insertion Tool
Scraper, Carbon
Screwdriver, Offset
Small Hole Gauges
Socket Set ¼” drive
Spark Tester
Starter Clutch Sockets
Telescoping Gauges
Torque Wrench, Ft. Lb.
Torque Wrench, In. Lb.
Valve Guide Cleaning Brushes

Sample of Engine Registration Card

Name (student) ____________________

Owner's Name ____________________

Owner's Address ____________________

Owner's Phone ____________________

Make of Engine ____________________

Model ____________________

Type No. ____________________

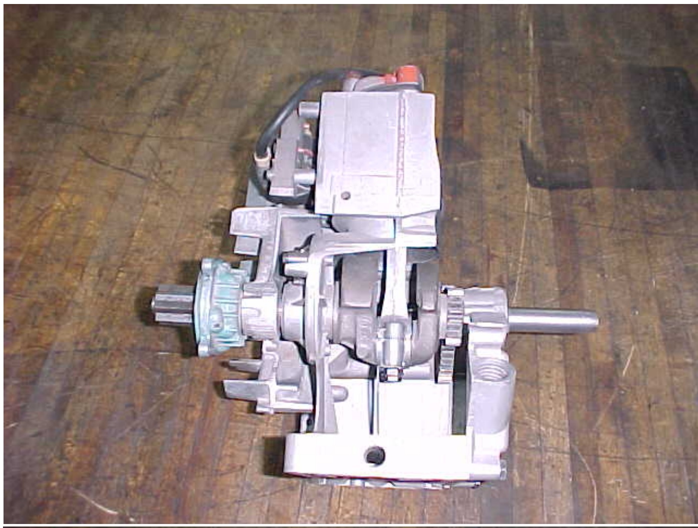
Serial No. ____________________

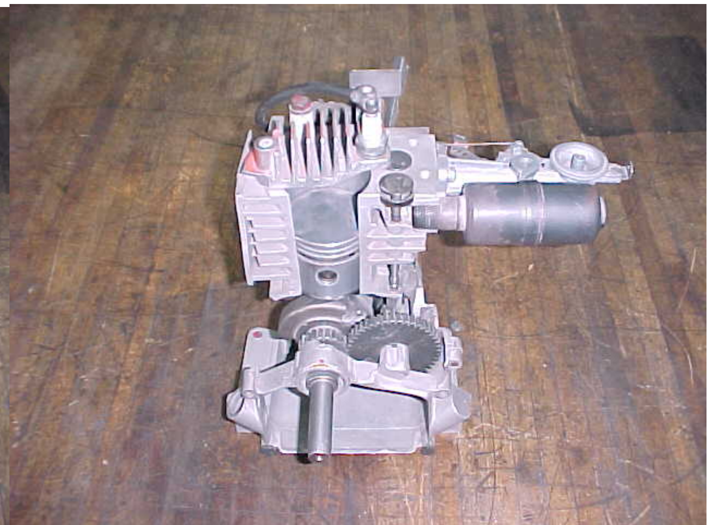
Maximum Spending Limit ____________________

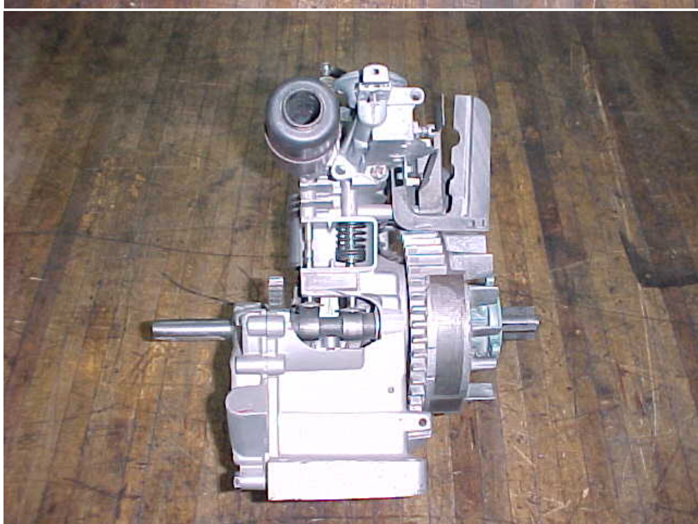
This card is made out in duplicate. One copy is placed in the teachers file and the other copy is attached to the engine storage box for use by the student. These cards enable the student to have a record of the owner's name, and engine model for ordering parts and looking up tolerance measurements. The card which is placed on the engine box also enables the instructor to know who is working on each engine for grading and measuring purposes.

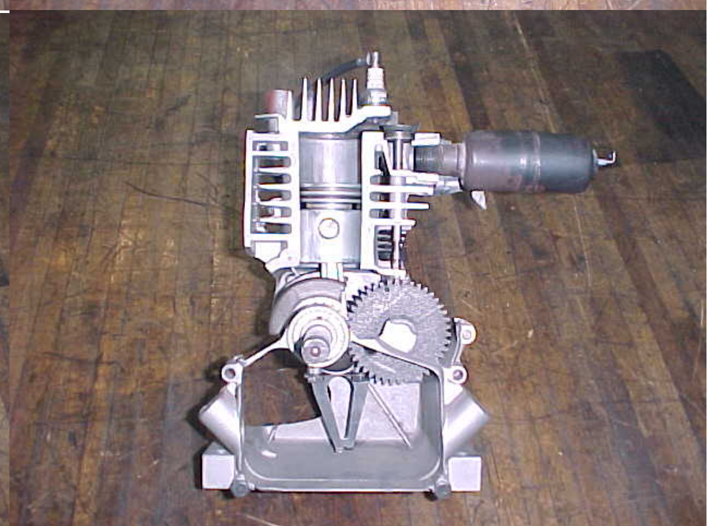
Model Engine

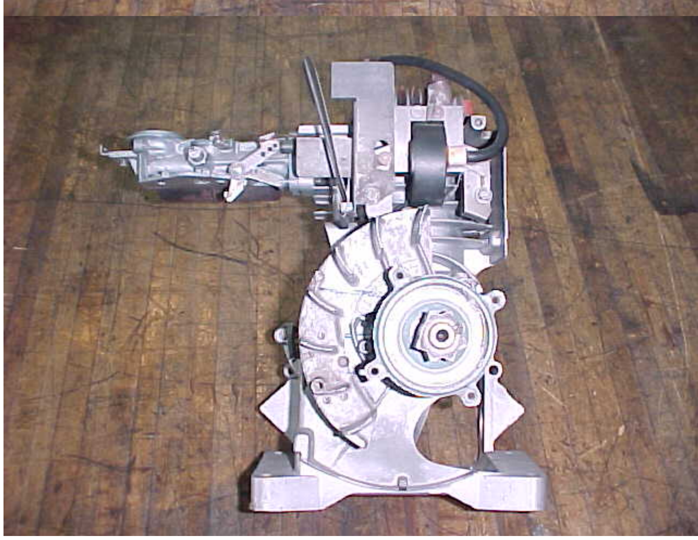
Cut-outs in an engine can be made as in the pictures below to make a visual aid to demonstrate theories of operation.











Vocabulary Quiz

Match the following terms with the correct definition.

1. _____ Carburetion
2. _____ Combustion
3. _____ Combustion Chamber
4. _____ Compression
5. _____ Compression Ratio
6. _____ Displacement
7. _____ Engine
8. _____ Fuel
9. _____ Horsepower
10. _____ Ignition System
11. _____ Lubricant
12. _____ Piston
13. _____ Power
14. _____ Watt

A. the time rate at which work is done

B. Difference in volume in the combustion chamber as the piston moves from bottom to top

C. material used to produce heat or power by burning

D. substance used to reduce friction and heat

E. space inside an engine block commonly referred to as a cylinder

F. machine that converts energy into mechanical motion

G. cylindrical shaped engine part that is inside the combustion chamber

H. unit of power equal to 1/746 horsepower

I. electrical components of an engine that create the necessary spark to ignite the air/fuel mixture in the combustion chamber

J. instance of burning

K. supplying an air/fuel mixture to the combustion chamber

L. a unit of power equal to 746 watts

M. commonly measured as cubic centimeters, cubic inches, and liters

N. pressure that is created in the combustion chamber as the piston reduces the amount of volume within the combustion chamber

Vocabulary Quiz Key

Match the following terms with the correct definition.

1. K____ Carburetion
2. J____ Combustion
3. E____ Combustion Chamber
4. N____ Compression
5. B____ Compression Ratio
6. M____ Displacement
7. F____ Engine
8. C____ Fuel
9. L____ Horsepower
10. I____ Ignition System
11. D____ Lubricant
12. G____ Piston
13. A____ Power
14. H____ Watt

A. the time rate at which work is done

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Unit Exam

Match the following terms with the correct definition:

1. _____ Carburetion
2. _____ Combustion
3. _____ Compression
4. _____ Displacement
5. _____ Engine
6. _____ Fuel
7. _____ Horsepower
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I. commonly measured as cubic centimeters, cubic inches, and liters

J. pressure that is created in the combustion chamber as the piston reduces the amount of volume within the combustion chamber

Multiple Choice – Choose the best answer

11. What is the name of the stroke in a 4 stroke engine, if the piston is moving down and the intake valve is open?
    A. Intake Stroke
    B. Compression Stroke
    C. Power Stroke
    D. Exhaust stroke

12. In a 2 stroke engine, what two things occur in the same stroke?
    A. Intake and Exhaust
    B. Power and Intake
    C. Intake and Compression
    D. Compression and Exhaust

13. What other two things occur in the other stroke of a two stroke engine?
    A. Intake and Exhaust
    B. Compression and Power
    C. Intake and Power
    D. Power and Exhaust

14. What is the name of the stroke in a 4 stroke engine for the stroke in which both valves are closed and the piston is moving upward?
    A. Intake
    B. Compression
    C. Power
    D. Exhaust

15. Which of the following is an advantage of 2 stroke engines versus 4 stroke engines?
    A. Lubricant must be mixed with fuel
    B. Less pollution from 2 stroke engines
    C. The engine can be used in any position
    D. More moving parts in a 2 stroke engine

Short Answer – Write 1 to 4 sentences to answer each of the following questions:

16. Why is compression necessary for an engine to run?

17. Explain how compression is created in a 4 stroke engine.

18. The spark plug should spark on which stroke of a 4 stroke engine; and what position should the piston be in on the stroke when the spark occurs.

19. Which engine has more displacement, an 800 cc engine or a 282 cu. In. engine? (show all calculations)

20. How many cubic inches are in a 5.7 liter engine? (show all calculations)

Unit Exam Key

Match the following terms with the correct definition:

1. G____ Carburetion
2. F____ Combustion
3. J____ Compression
4. I____ Displacement
5. C____ Engine
6. A____ Fuel
7. H____ Horsepower
8. E____ Ignition System
9. B____ Lubricant
10. D____ Piston

A. material used to produce heat or power by burning

B. substance used to reduce friction and heat

C. machine that converts energy into mechanical motion

D. cylindrical shaped engine part that is inside the combustion chamber

E. electrical components of an engine that create the necessary spark to ignite the air/fuel mixture in the combustion chamber

F. instance of burning

G. supplying an air/fuel mixture to the combustion chamber

H. a unit of power equal to 746 watts

I. commonly measured as cubic centimeters, cubic inches, and liters

J. pressure that is created in the combustion chamber as the piston reduces the amount of volume within the combustion chamber

Multiple Choice – Choose the best answer

11. What is the name of the stroke in a 4 stroke engine, if the piston is moving down and the intake valve is open?
    - **a. Intake Stroke**
    - b. Compression Stroke
    - c. Power Stroke
    - d. Exhaust stroke

12. In a 2 stroke engine, what two things occur in the same stroke?
    a. Intake and Exhaust
    b. Power and Intake
    c. Intake and Compression
    d. Compression and Exhaust

13. What other two things occur in the other stroke of a two stroke engine?
    a. Intake and Exhaust
    b. Compression and Power
    c. Intake and Power
    d. Power and Exhaust

14. What is the name of the stroke in a 4 stroke engine for the stroke in which both valves are closed and the piston is moving upward?
    a. Intake
    b. Compression
    c. Power
    d. Exhaust

15. Which of the following is an advantage of 2 stroke engines versus 4 stroke engines?
    a. Lubricant must be mixed with fuel
    b. Less pollution from 2 stroke engines
    c. The engine can be used in any position
    d. More moving parts in a 2 stroke engine

Short Answer – Write 1 to 4 sentences to answer each of the following questions:

16. Why is compression necessary for an engine to run?
Compression of the air/fuel mixture is necessary to create an explosion with enough force to move the piston down. The air/fuel mixture will burn without explosion if there is inadequate compression.

17. Explain how compression is created in a 4 stroke engine.
Compression is created as the piston move up the combustion chamber reducing the volume between the top of the chamber and the top of the piston. Both valves are closed during the compression stroke.

18. The spark plug should spark on which stroke of a 4 stroke engine; and what position should the piston be in on the stroke when the spark occurs.
The spark occurs on the compression stroke when the piston is about ¼" below the top of the stroke still moving upward.

19. Which engine has more displacement, a 1000 cc engine or a 100 cu. In. engine? (show all calculations)
1000 cc * .061 cu. In./cc = 61 cu. In.   100 cu. In * 16.39 cc/cu. In. = 1639 cc
100 cu. In has more displacement

20. How many cubic inches are in a 5.7 liter engine? (show all calculations)
5.7L * 61.023 cu. In./L = 347.83 cu. in

Operational Theory of Compression

This unit should be taught prior to or in conjunction with the unit of Major Engine Parts Disassembly.

Unit Objective:

After completion of this unit, students will be able to explain the principles and theories of compression as it is related to small combustion engines. This knowledge will be demonstrated by completion of a quiz 85 percent accuracy.

Specific Objectives and Competencies

- Identify basic terms and definitions associated with compression
- List individual engine parts related to compression
- Describe, compare, and contrast compression ratios (Standard 349.03)
- Calculate engine displacement (Standard 351.01)
- Test engine compression

Teaching Time

This Unit should take 2 hours to complete.

Teaching Materials:

Tools:

- 7/16" socket with nut driver handle
- 13/16" or ¾" Socket with ratchet
- Compression Tester
- C-clamps
- ½" Electric Drill

Parts:

- Cut-away model engine
- Fully assembled engine
- Sample parts related to compression

Resources:

- Briggs & Stratton Repair Manual
- Projections of pictures in this unit

Teaching Activities:

Use actual parts to aid in teaching.

Use a 13/16" or ¾" socket to remove the spark plug of an assembled engine. Install a compression tester in the spark plug hole (hand tight). Securely clamp the engine to a table. Pull the starting rope while a student(s) attempt to read the compression gauge. It will be difficult to read the compression gauge in such a short duration and the reading will likely be low due to insufficient RPM. This is why compression recommendations are not published by Briggs & Stratton.

Remove the blower housing using a 7/16" socket. With the blower housing removed quickly spin the flywheel backward (counter clockwise) on the compression stroke to see if it rebounds.

Modification of the crankshaft (sized small enough to fit into an electric drill) of an extra engine will allow the use of a compression tester. An electric drill can be attached to the crankshaft to rotate the crankshaft in a clockwise direction at sufficient RPM to read a compression gauge installed in the spark plug hole.

Test the compression of any automotive engine. Remove the spark plug wires. Mark the wires or make a note of which wire goes to each spark plug. Remove one spark plug and install a compression tester. Turn the key and engage the starter momentarily to read the compression gauge on each compression stroke. This is the proper procedure for testing compression of multi-cylinder engines. Each cylinder is tested individually in this manner.

Terms and Definitions

Ambient Temperature	-The surrounding temperature
Clearance	-The distance by which one object clears another
Octane	-
Tolerance	-The range of variation permitted in maintaining a specified dimension in machining a piece

Parts Related to Compression

Piston
Rings
Cylinder
Valve Stem
Valve Seat
Valve Face
Spark Plug
Head
Head Gasket

Compression

The subject of compression is familiar to most individuals with any engine experience. There is nothing difficult or mysterious about engine compression. However, in single cylinder engines that are air cooled, as most small engines are, the principles of compression are different. Air cooled engines do have several advantages over liquid cooled engines. Air cooled engines are lighter weight, occupy less space, and require less maintenance.

In multi-cylinder engines, which are commonly liquid cooled, the operating temperature remains constant. With air cooled engines the operating temperature varies greatly as the ambient temperature changes. Operating temperature also varies depending on the operating speed of the engine and the load put on the engine.

Metals expand as temperature increases and contract as temperature decreases. Therefore, tolerances and clearances of parts in a single cylinder air cooled engine must compensate for the entire range of operating temperatures.

There are no compression measurements published by Briggs and Stratton for their engines. It is difficult to accurately measure compression on a single cylinder engine. Briggs and Stratton recommends a simple compression test: Spin the flywheel backwards quickly. If the flywheel rebounds on the compression stroke, the engine has enough compression.

Valves are often the most important factor in compression. In order to maintain compression the valves must seal. The valves operate under the most severe conditions within an engine. Especially the exhaust valve as it is subject to extreme heat. The valves open and close in less than one complete revolution. When the engine is operating at 3000 RPM (revolutions per minute) each valve opens and closes in approximately 1/50 of a second.

Valves must seal well enough to withstand pressures of up to 500 psi, (pounds per square inch) from combustion. Under full load the exhaust valve is exposed to temperatures high enough to cause it to operate at red hot temperatures. The temperature of the exhaust valve under these conditions may reach 1200° F or more. The intake valve is cooled by the incoming air/fuel mixture. The cylinder head, the cylinder, and the top of the piston are exposed to the same heat but are cooled by air from the flywheel fan and oil in the crankcase. Specialized steel is used for the exhaust valve in order to withstand the corrosive action and high temperature of exhaust gases.

Single cylinder engines typically only have two valves whereas, multi-cylinder engines have multiple valves. Therefore, a problem with one valve in a single cylinder engine is much more significant than a problem with one valve in a multi-cylinder engine. One bad valve in a single cylinder engine may be enough to prevent the engine from running or at least significantly reduce the horsepower. In a multi-cylinder engine one bad valve will only contribute to a fractional reduction of horsepower.

Displacement

Displacement is the space that is the volume that is displaced by the piston, Fig. 1. The longer the stroke and the greater the bore diameter, the greater the displacement. Displacement is calculated by the following formula:

$$\text{Displacement} = (\text{Bore diameter}^2 / 4) * \pi * \text{stroke length}$$

Displacement indicates the relative size of the engine. Horsepower is usually directly proportional to displacement.

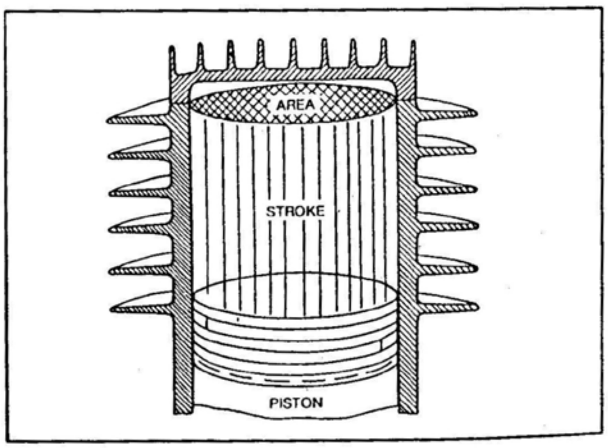


Figure 1

Compression ratio

Compression ratios give an efficiency measurement of engines. If an engine is said to have a compression ration of 8 to 1 that means that the volume in the cylinder is 8 times larger when the piston is at the bottom of the compression chamber than it is when the piston is at the top of the compression chamber, Fig. 2.

Higher compression ratios generally indicate higher efficiencies. However, as compression ratios are increased, loads and stresses on engine parts become more severe. Premium (higher octane) fuels are required for engines with higher compression ratios. Briggs and Stratton engines have compression ratios from 5:1 to 6:1. Premium fuel is not recommended for such engines.

Premium (higher octane) fuels are more difficult to ignite. Therefore, higher compression engines require premium fuels. The higher compression ratio makes it easier for the spark to ignite premium fuels. A higher octane number does not mean that the fuel is more efficient. Higher compression ratios which use higher octane fuels are more efficient, but higher octane fuel alone is not efficient. If a high octane fuel is used in an engine with a relatively low compression ratio the pressure in the combustion chamber will be insufficient to completely burn the fuel.

However, if lower octane fuels are used in a high compression ratio engine knocking will occur. The compression alone is enough to ignite the fuel and start the piston down on the power stroke. Such ignition occurs prior to the spark from the spark plug. When the spark occurs in the spark plug any fuel in the cylinder that was not burned as a result of high pressure, will ignite, causing a knocking sound.

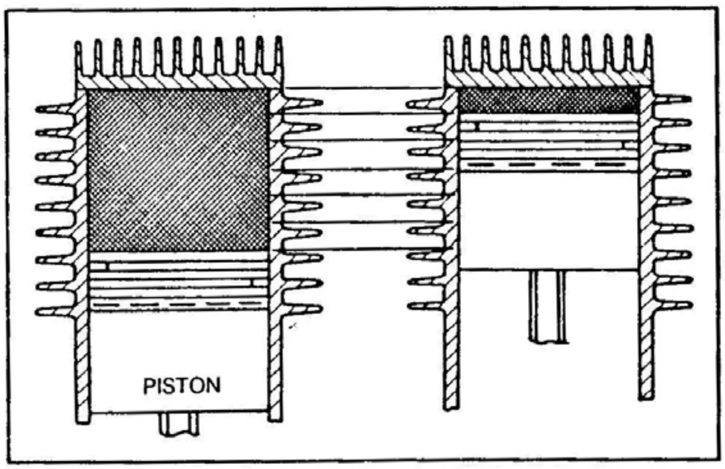


Figure 2

Compression Quiz

1. Premium grade fuel (higher octane) is used in engines with higher/lower (choose one) compression ratios?

2. Will a single cylinder engine still run if one of the valves is stuck open?

3. Will an eight cylinder engine still run if one of the valves is stuck open?

4. What is the correct procedure for testing compression on a Briggs & Stratton engine?

5. Fuel efficiency increases with a higher/lower (choose one) compression ratio.

6. Will premium (higher octane) fuel create more power in an engine with a lower compression ratio?

7. What does engine displacement indicate or measure?

8. What is the typical compression ratio of Briggs & Stratton engines?

9. Describe what the compression ratio in your answer to question 8 means.

10. Which valve is subject to more stress during engine operation, intake/exhaust (choose 1)?

Compression Quiz

1. Premium grade fuel (higher octane) is used in engines with higher/lower (choose one) compression ratios?

   Higher

2. Will a single cylinder engine still run if one of the valves is stuck open?

   No

3. Will an eight cylinder engine still run if one of the valves is stuck open?

   Yes

4. What is the correct procedure for testing compression on a Briggs & Stratton engine?

   Spin the flywheel backwards and it should rebound sharply

5. Fuel efficiency increases with a higher/lower (choose one) compression ratio.

   Higher

6. Will premium (higher octane) fuel create more power in an engine with a lower compression ratio?

   No

7. What does engine displacement indicate or measure?

   Volume of the compression chambers

8. What is the typical compression ratio of Briggs & Stratton engines?

   5:1 to 6:1

9. Describe what the compression ratio in your answer to question 8 means.

   The volume in the cylinder when the piston is at the bottom of the stroke is 5 to 6 times greater then when the piston is at the top of the stoke.

10. Which valve is subject to more stress during engine operation, intake/exhaust (choose 1)?

    Exhaust

Parts and Tool Identification

The parts and tools in this unit should be taught over an extended period of time as the engine is being disassembled.

Unit Objective:

After completion of this unit, students will be able to identify engine parts and tools and describe the function of each part or tool. It is important for students to know the correct names of parts and tools so they can communicate effectively when ordering new parts. This knowledge will be demonstrated by completion of a unit test with a minimum of 85 percent accuracy.

Teaching Activities:

Identify individual parts and their function as engine disassembly is demonstrated.

After student engines are completely disassembled, test by laying out numbered sample parts and have students identify the parts. Individual questions relating to the function of each part can also be asked.


Crankshaft


Engine Block


Connecting Rod, with Rod Cap and Oil Dipper


Piston


Piston Ring


Sump


Head


Starter Clutch


Head Gasket


Valve


Camshaft


Valve Spring


Tappet


Condenser


Connecting Rod Cap


Armature and Coil


Oil Slinger


Flywheel Washer


Breaker Points


Flywheel


Rod Cap Bolt Lock


Vertical Pull Starter


Valve Spring Retainer


Oil Seal


Vacu-Jet Carburetor


Diaphragm and Spring for Pulsa-Jet Carburetor


Flow-Jet Carburetor


Fuel Tube-1 on Pulsa-Jet Carb.; 2 on Vacu-Jet Carb.


Pulsa-Jet Carburetor


Upper Carburetor Body (Flow-Jet)


Lower Carburetor Body (Flow-Jet)


Breather Tube


Air Cleaner (Paper Cartridge Type)


Intake Tube


Air Cleaner (Foam Type)


Breather

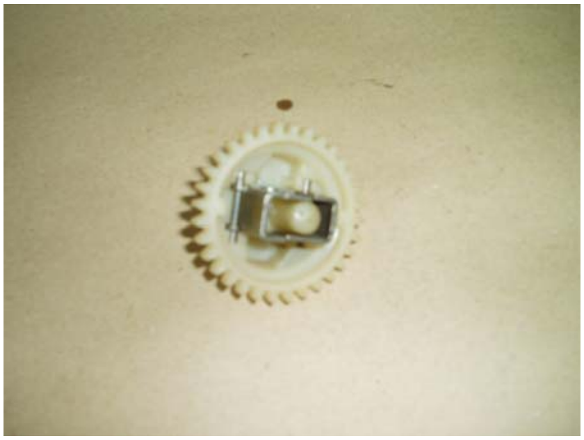

Muffler

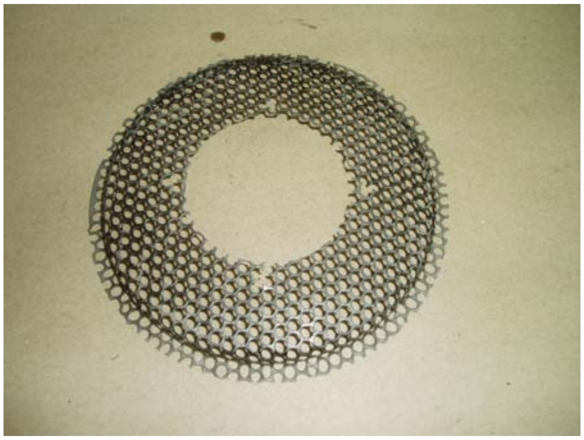

Kill Switch


Air Cleaner Grommet


Crankshaft Bearing


Cylinder Shield


Mechanical Governor


Flywheel Screen


Venturi (Flow-Jet)


Throttle Shaft


Main Jet


Main Needle (High Speed Needle)


Blower Housing


Electronic Ignition Module


Rewind Starter


Spark Plug


Rewind Starter Spring


Carburetor Float (Flow-Jet)


Valve Spring Compressor


Flywheel Puller


Flywheel Holder


Valve Spring Compressor


Flywheel Holder


Piston Ring Expander


Piston Ring Compressor


Compression Tester


Spark Plug Gauge

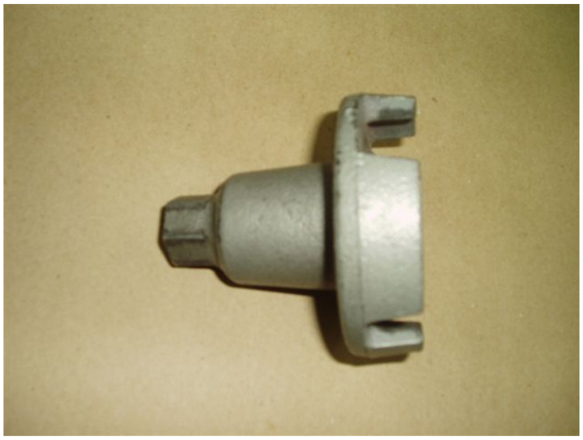

Bushing Driver


Outside Micrometer

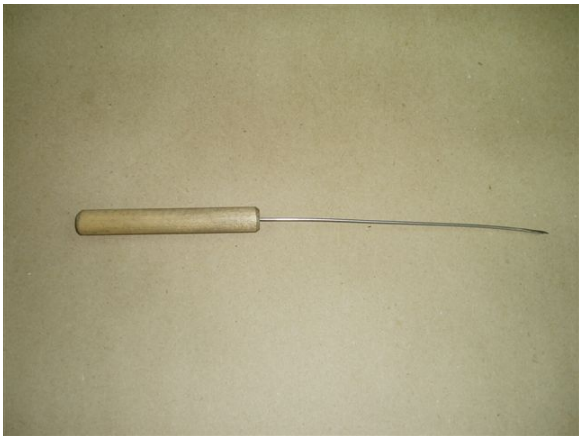

Filter Wrench


Inside Micrometer


Telescoping Gauges


Starter Clutch Wrench


Small Hole Gauges


Rope Insertion Tool


Spark Tester


Thickness Gauge

Parts and Tool Identification

The parts and tools in this unit should be taught over an extended period of time as the engine is being disassembled.

Unit Objective:

After completion of this unit, students will be able to identify engine parts and tools and describe the function of each part or tool. It is important for students to know the correct names of parts and tools so they can communicate effectively when ordering new parts. This knowledge will be demonstrated by completion of a unit test with a minimum of 85 percent accuracy.

Teaching Activities:

Identify individual parts and their function as engine disassembly is demonstrated.

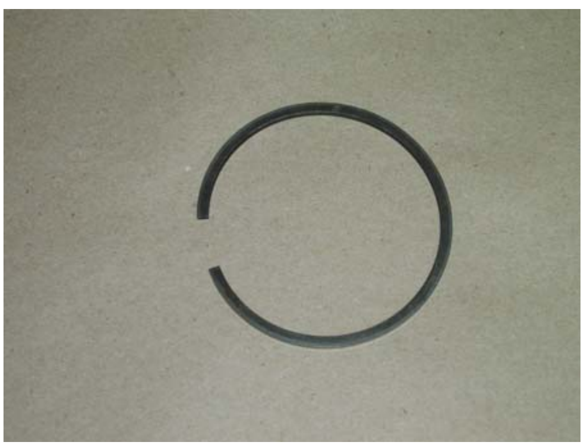
After student engines are completely disassembled, test by laying out numbered sample parts and have students identify the parts. Individual questions relating to the function of each part can also be asked.


Crankshaft


Engine Block


Connecting Rod, with Rod Cap and Oil Dipper


Piston


Piston Ring


Sump


Head


Starter Clutch


Head Gasket


Valve


Camshaft


Valve Spring


Tappet


Condenser


Connecting Rod Cap


Armature and Coil


Oil Slinger


Flywheel Washer

Breaker Points

Flywheel

Rod Cap Bolt Lock

Vertical Pull Starter

Valve Spring Retainer

Oil Seal

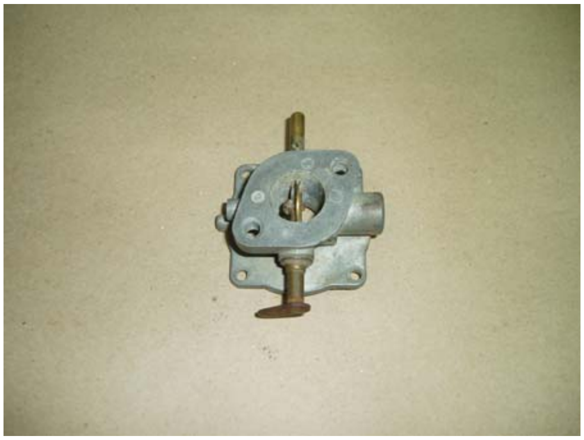

Vacu-Jet Carburetor


Diaphragm and Spring for Pulsa-Jet Carburetor


Flow-Jet Carburetor


Fuel Tube-1 on Pulsa-Jet Carb.; 2 on Vacu-Jet Carb.


Pulsa-Jet Carburetor


Upper Carburetor Body (Flow-Jet)


Lower Carburetor Body (Flow-Jet)


Breather Tube


Air Cleaner (Paper Cartridge Type)


Intake Tube


Air Cleaner (Foam Type)


Breather

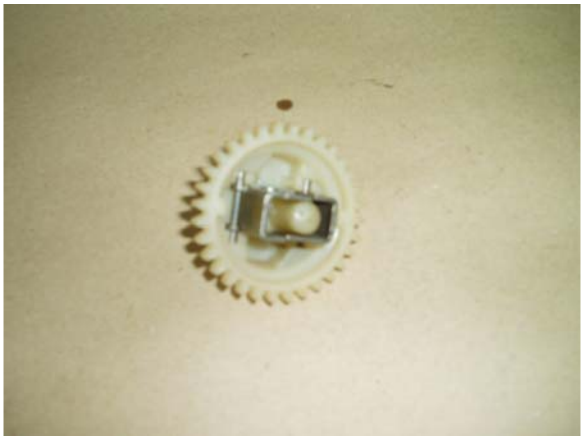

Muffler

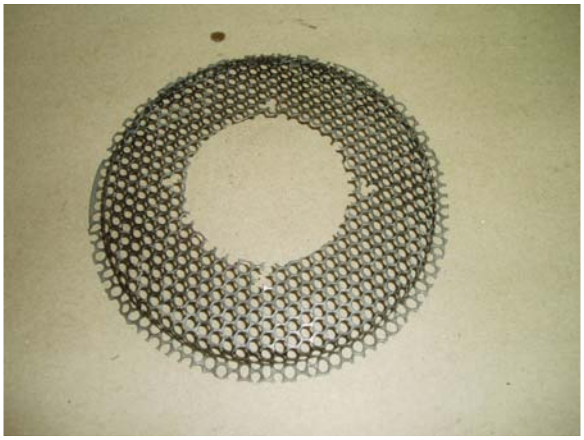

Kill Switch


Air Cleaner Grommet


Crankshaft Bearing


Cylinder Shield


Mechanical Governor


Flywheel Screen


Venturi (Flow-Jet)


Throttle Shaft


Main Jet


Main Needle (High Speed Needle)


Blower Housing

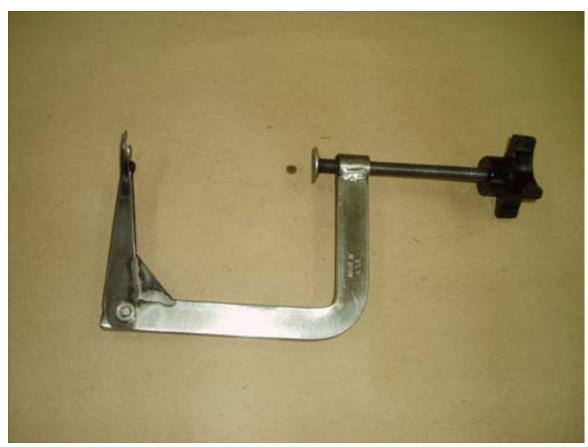

Electronic Ignition Module


Rewind Starter


Spark Plug


Rewind Starter Spring


Carburetor Float (Flow-Jet)


Valve Spring Compressor


Flywheel Puller


Flywheel Holder


Valve Spring Compressor


Flywheel Holder


Piston Ring Expander


Piston Ring Compressor


Compression Tester


Spark Plug Gauge

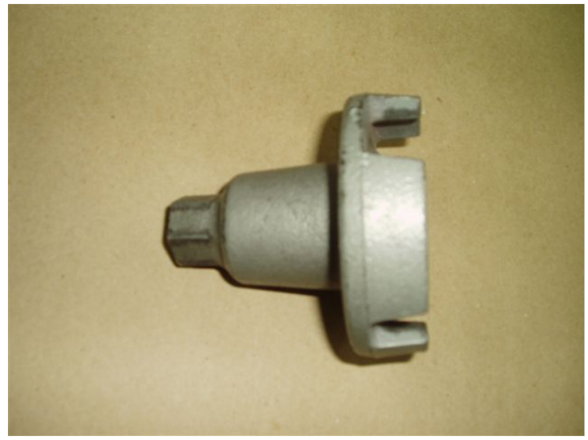

Bushing Driver


Outside Micrometer

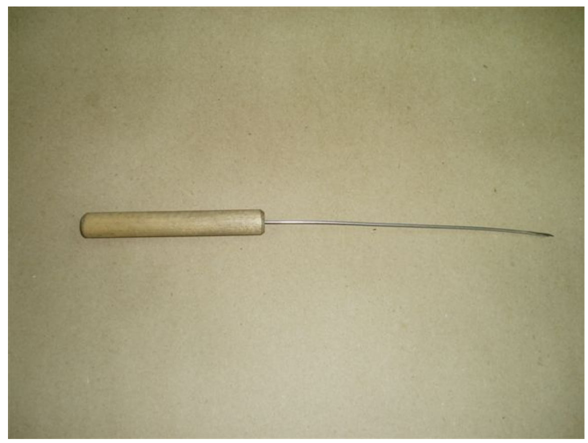

Filter Wrench


Inside Micrometer


Telescoping Gauges


Starter Clutch Wrench


Small Hole Gauges


Rope Insertion Tool


Spark Tester


Thickness Gauge

Initial Engine Assessments

Unit Objective:

After completion of this unit, students will be able to perform simple tests and observations to determine if it will be economically feasible to overhaul an engine. This knowledge will be demonstrated by completion of a quiz with 85 percent accuracy.

Specific Objectives and Competencies

- Identify engine parts that are known to wear given certain conditions

- Associate engine conditions with cause worn parts or improper operation

Teaching Time:
This unit should take 3 to 5 hours to complete (1 hour lecture and 2 to 4 hours for students to work)

Steps for students to complete before the next lesson:
Inventory individual student tool boxes
Record Engine Model, Type, and Code numbers, Student Name, Owner's Name on
    Engine ID Card
Wash Engine
Wash engine again after blower housing is removed
Take pictures or draw diagrams of carburetor linkages
Complete "Checklist to Determine Engine Wear"
    Make notes of each part

Steps for teacher to complete before next lesson:
Determine if engine is economically feasible for overhaul and if parts are available before more work is completed on the engine.
Order electronic ignition modules so they are available before Ignition lesson

Teaching Materials:
Tools:
- Flat screwdriver to remove air cleaner stud
- Glass Jar
- Spark plug socket and ratchet
- Spark tester
- Socket, and ratchet to remove blower housing (normally 7/16")
- Pressure washer
- Tool to hold blade brake off

Parts:
- Complete engine to demonstrate engine repair checklist in this section
- New spark plug

Resources:
- Briggs & Stratton Repair Manual section 1
- Copies of "Checklist to Determine Engine Repair" in this section

Teaching Activities:
Demonstrate pressure washer
Demonstrate each step on "Checklist to Determine Engine Repair"

Is the engine worth rebuilding?

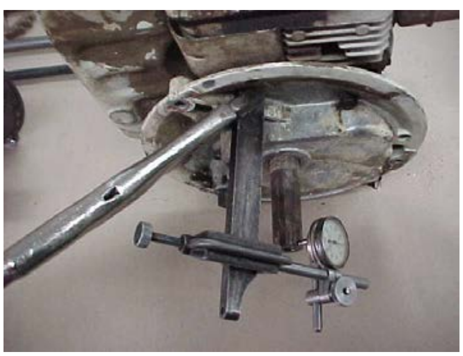
Consider the cost of an overhaul versus the cost of a new engine. An overhaul should not cost more than about half the cost of a new engine. See the checklist in this section to determine engine repair.

Are parts available for the engine. Briggs & Stratton has quit producing a lot of parts for older engines.

Bent Crank Shafts - Vertical Shaft VS. Horizontal Shaft Engines:

Vertical shaft engines are typically less expensive than horizontal shaft engines. Vertical shaft engines are most commonly used on lawn mowers. It's common for vertical shaft engines to have a bent crankshaft caused by the lawn mower blade hitting a solid object. Crankshafts are about $30 to $40. A new lawn mower can be purchased for as little as $100, therefore if a vertical shaft engine has a bent crank shaft it's probably not worth fixing.

Horizontal shaft engines have multiple applications and are more expensive. Bent crankshafts are not as common in horizontal shaft engines. A bent crankshaft in a horizontal shaft engine is probably worth replacing.

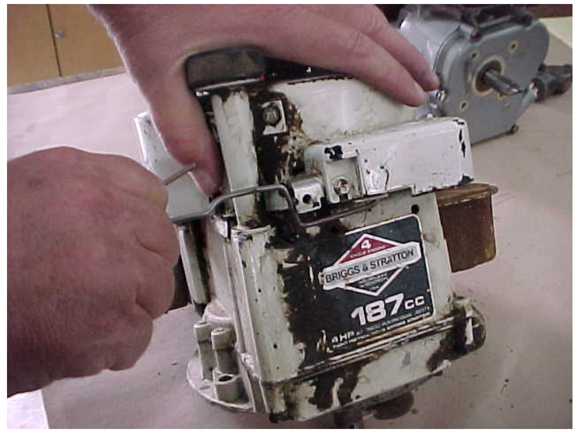


If the engine is cranked bent crankshafts are often easy to observe. If it is questionable whether a crankshaft is bent a dial indicator can be used as shown above. Do not let the needle of the dial indicator fall into the keyway. Crank shafts should be no more than 0.003" off.

Blade or band brakes

Lawn mower engines will have a brake around the flywheel to stop the blade from turning when the safety handle is released. A tool (shown below) can be made from

3/16" round stock to hold the brake off the flywheel while testing for spark or bent crankshaft.



Fuel Problems:

As of January 1, 1996 no more lead is added to gasoline. The primary reason lead was added to gasoline was to protect valves and valve seats. The development of harder seats and valves in about 1976 has eliminated the need for lead in gasoline. Using unleaded fuel in older engines can cause premature wear of valves and valve seats when engines are put under heavy loads. Hard seats and valves are available replacements which enable older engines to burn unleaded fuels.

Old Fuel:

Modern gasoline seems to turn sour faster than it did even 10 years ago. Most small engine manufacturers recommend keeping fuel stored no longer than 30 days before it is used. Storing fuel in warm places seems to hasten its deterioration. Using stale fuel in an engine causes gum deposits in the carburetor, causes valve stem deposits that will cause the valve to stick open and causes deposits on pistons that greatly hastens the wear of cylinders.

Water in Fuel:

Water may get in gasoline from condensation (keeping fuel tanks full in winter helps avoid this problem), leaving engines which have holes in fuel caps outdoors, not shielding engines mounted on wheel lines, or from kids playing gas station attendant. Water is heavier than fuel and goes to the bottom of the tank which is the source of use by the engine. Since water doesn't burn, the engine immediately dies and will not start until the water is drained form the tank and carburetor. A turkey baster is a handy tool to take a fuel sample from the bottom of the tank. When the sample is squirted into a glass jar, there will be an immediate separation of the water to the bottom and gas on top.

Foreign Material in Fuel:

Dirt, rust and liquids other than gasoline are generally the biggest problems. These problems are often caused by a poor choice of gas containers. The "any old can will do" theory often backfires because of the previous contents of the can. For example, the can could contain diesel. Most of the time the can is not cleaned and gas is added to whatever the can contained. A rust problem usually occurs when gas tanks are not drained winter (lawn mowers are a good example). Condensation causes the zinc coating inside the can to deteriorate, thereby encouraging the rusting of the steel gas tank. Simply cleaning the rust out of the tank is only a temporary fix. The correct repair would be to either install a new tank or to use a slushing compound that coats the inside of the tank to prevent further rusting.

Alcohol in Fuel:

Alcohol is a common additive in gasoline to boost octane rating. Most newer engines are designed to tolerate gasohol as long as the fuel is fresh and it is not stored for extended periods or left in the engine's carburetor. Since alcohol absorbs water, that water can cause corrosion of the carburetor and cause clogged jets. Some forms of rubber fuel lines and seals, which are found in the older 2-cycle engines outboard boat engines and chainsaws, may be dissolved by the alcohol. Most manufacturers of 2-cycle engines recommend that gasohol not be used in their engines because 2-cycle oil does not always mix well and stay mixed when it is added to gasoline.

Checklist to Determine Engine Repair

With blower housing on check:

Lawn mower blade – properly mounted	If bent or chipped, check for sheared flywheel key and bent crankshaft
Bent crankshaft	Crank engine and observe drive end, bent cranks should be easy to observe if questionable use a dial indicator. Expensive repair, will also cause worn drive end bearings
Oil level	Low oil indicates scored or worn parts – may be expensive repair
Oil condition	Very dirty or thick oil indicates worn parts (crankshaft bearings and journals, camshaft bearings and journals, rod bearing)
Air Cleaner	Dry foam air cleaners let dirt into engine (may need new intake valve, valve guide, valve seat, could cause cylinder wear); plugged air cleaner will not allow engine to start; check wear of throttle shaft.
Carburetor	If dirty; dirt has gone into engine - Some newer engines have no replacement parts or adjustments for the carb. A new carb can be purchased for as little as $15
Proper operation of choke or primer	If inoperative engine will be hard starting – may be inexpensive repair
Gas – smell	Old gas can cause plugged jets – pour gas from tank into glass jar and check for water

Spark	Use ignition tester – make sure kill switch is not engaged
Spark Plug	If spark plug tester is not available, try a new spark plug.
Muffler	If plugged with carbon build up engine will not run – feel for exhaust coming out while cranking engine

Remove blower housing and check:

Flywheel key	if sheared, spark will not occur at proper time. Engines with electronic ignition will still produce spark even if flywheel key is sheared. A sheared key indicates a bent crankshaft
cylinder fins	If clogged, cylinder could have overheated and caused wear or warpage
compression	If low - hard starting - check by spinning flywheel counter clockwise - should rebound
valves - carbon build up	excess carbon can keep valves from closing
cylinder measurements	if .003" wear - new piston, expensive repair

Initial Engine Assessment Quiz

1. What parts may be worn if an engine has very thick or dirty oil?

2. If a foam type air cleaner is not oiled dirt and abrasive grit could have gotten inside the engine and likely caused wear of what parts?

3. How can an engine be tested for a bent crankshaft?

4. What engines are most likely to have a bent crankshaft?

5. If an engine has a bent crankshaft what other part is probably also worn?

6. How can fuel be tested to see if it has water in it?

7. What problems can be caused in an engine if gasoline is left in the engine for a long period of time?

8. How can a muffler be checked to see if it is plugged?

9. What is the procedure to check compression on a Briggs & Stratton engine?

10. How would a sheared or partially sheared flywheel key prevent an engine from running?

Initial Engine Assessment Quiz

1. What parts may be worn if an engine has very thick or dirty oil?
   Crankshaft bearings and journals, camshaft bearings and journals, rod bearing

2. If a foam type air cleaner is not oiled dirt and abrasive grit could have gotten inside the engine and likely caused wear of what parts?
   Valve, valve guide, valve seat, possibly cylinder

3. How can an engine be tested for a bent crankshaft?
   Crank engine and observe drive end of crankshaft

4. What engines are most likely to have a bent crankshaft?
   Vertical shaft lawn mower engines

5. If an engine has a bent crankshaft what other part is probably also worn?
   Drive end bearing

6. How can fuel be tested to see if it has water in it?
   Pour a sample into a glass jar, water will separate to bottom

7. What problems can be caused in an engine if gasoline is left in the engine for a long period of time?
   Plugged jets

8. How can a muffler be checked to see if it is plugged?
   Crank engine while holding a hand over the muffler, should be able to feel air coming out of the muffler

9. What is the procedure to check compression on a Briggs & Stratton engine?
   Spin the flywheel backward (counter clockwise), the flywheel should rebound

10. How would a sheared or partially sheared flywheel key prevent an engine from running?
    Spark occurs at the wrong time

Engine Condition

With Blower Housing On:

Test compression ________psi?

Test ignition ________ have spark?

With Blower Housing Off:

Spin flywheel backwards ________Does flywheel rebound sharply?

Test spark plug _____good _____bad

Carburetion _____old gas _____water _____choke/primer operational?

Air Cleaner: Foam Type _____Oiled _____Dry _____Clean _____Dirty
Paper Cartridge _____Oily _____Dry _____Clean _____Dirty

Cooling fins ________ clogged ________open

Tappet Clearance ________ Intake ________Exhaust

Armature Air Gap ________"

Crankshaft End Play ________"

Crankshaft bent _____yes _____no _____"

Carbon Build up on Cylinder________(normal or excess?)

Valve to Valve Guide clearance (shake with fingers) _____loose _____tight

Cylinder: _____scratched or scored _____honing marks

Student Progress Chart

Name	Crankshaft straightness drive end	Engine Parts Quiz	Date measurements completed	Grind Valves	Reface Valve Seats	Break Cylinder Glaze	Resize Cylinder	Bush point plunger hole	Bush intake guide	Bush exhaust guide	Bush Magneto bearing	Bush drive end bearing	Test Coil	Adjust tappet clearance	Install Fuel Pipe	Paint Engine	All work complete	Instructor signature before sump cover install

Key:

- Requires that step
+ Indicates Repair has been completed

*** Repair step must be completed before valve seat is replaced**

Blank indicates step is not necessary

Disassemble to Valves (external parts)

Unit Objective:

After completion of this unit, students will be able to disassemble the internal parts of an engine. This knowledge will be demonstrated by complete disassembly of student engines.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Demonstrate correct use of tools
- Disassemble external engine parts in a logical order
- Follow written directions (Standard 752.05)
- Listen for information (Standard 754.01)

Teaching Time:
This unit should take 3 to 5 hours to complete (1 hour lecture and 2 to 4 hours for students to work)

Steps for students to complete before the next lesson:
Drain oil and gasoline from engine
Remove all pulleys, blade adapters, blade brake, throttle cables, etc.
(repair manual section 4)
Remove engine from mower, tiller, etc.
Remove vertical pull starters (repair manual 7A-16)
Remove gas tank (repair manual section 3)
Remove air cleaner (repair manual section 1)
Remove carburetor from block (leave carb assembled as much as possible)
(repair manual section 3 & 4)
Remove muffler from block
Remove cylinder or head shields
Remove breather from block
Remove coil and governor air vane (repair manual section 2)
Remove starter clutch and flywheel (repair manual section 2)
Remove cylinder head (repair manual section 6)
Remove valves (repair manual section 6)
Make a note of any missing parts
Clean, oil and re-assemble starter clutch (repair manual section 7A)
Clean engine parts in parts washer

Teaching Materials:
Tools:
- Tools to disassemble engine down to valves
- Gear Pullers
- Bearing Splitter
- Fly wheel puller
- Plug tap ¼" – 20
- Inertial flywheel puller
- Rawhide mallet
- Diagonal cutting pliers
- Flat Screwdriver
- Valve spring compressor

Parts:
- Complete engine to demonstrate disassembly
- Example of pneumatic and mechanical governors
- Example of a blade brake on engine

Carburetor	Flywheel Screen
Muffler	Head or cylinder shields
Coil or armature	Starter Clutch
Flywheel	Blade Brake

Intake Tube	Air Cleaner
Starter	Blower Housing
Kill Switch	Valves
Valve springs	valve spring retainers

Resources:

Briggs & Stratton Repair Manual

Teaching Activities:

Explain 3 types of air cleaners (repair manual section 1)
Demonstrate how governors work (repair manual section 5)
Demonstrate how blade brake works with kill wire (repair manual section 5)
Demonstrate how vertical pull starter works (repair manual section 7A)
Explain function of breather
Demonstrate engine disassembly
Demonstrate parts washer

Air Cleaners

3 types – paper cartridge, oil foam, dual element

Governors

The function of a governor is to maintain a constant engine speed under varying engine loads. Briggs & Stratton has two different types of governors, mechanical and pneumatic.

Pneumatic governors use air from the flywheel to maintain a constant speed. The governor spring tends to keep the throttle open while air pressure against the air vane tends to close the throttle. The engine speed at which the two forces balance out is called the governed speed. This speed can be changed by changing springs or some engines have multiple positions to attach the spring to change the tension.

Mechanical governors use centrifugal force to maintain a constant speed. The governor spring tends to pull the throttle open, while the centrifugal force of the counterweights tends to close the throttle. The engine speed at which the two forces balance is called the governed speed. This speed can also be changed by changing governor springs or spring tension.

Breathers

The function of the breather is to maintain a vacuum in the crankcase. The breather has a fiber disc valve, which operates as a check valve. The breather allows air to flow out of the crankcase as the piston moves down but it does not allow air to be drawn into the crankcase as the piston moves up. A vacuum must be maintained in the crankcase to prevent extra air pressure from forcing oil out of the engine at the rings, oil seals, point plunger, and gaskets.

Breathers should be tested to ensure that air is only allowed to pass in one direction (from the engine side to the outside). If air flows in both directions the breather should be replaced. It is not common for breathers to operate incorrectly.

Valves

Repair manual 6-3 shows three different valve spring retainers and page 6-4 shows gives instructions for removal of the retainers. The valve spring retainer that is labeled C in figure 5 on page 6-3 can be removed without using a valve spring compressor.

A flat screwdriver can be used to remove the retainer. If the screwdriver is used to pry upward on the retainer, it can be moved so the larger opening is around the valve and the retainer will be pushed from the end of the valve stem. Note that the retainer has a notch on the outside of it. The notch is to identify the location of the larger hole that will allow the retainer to slide down the valve stem. The larger hole is on the opposite side of the notch.

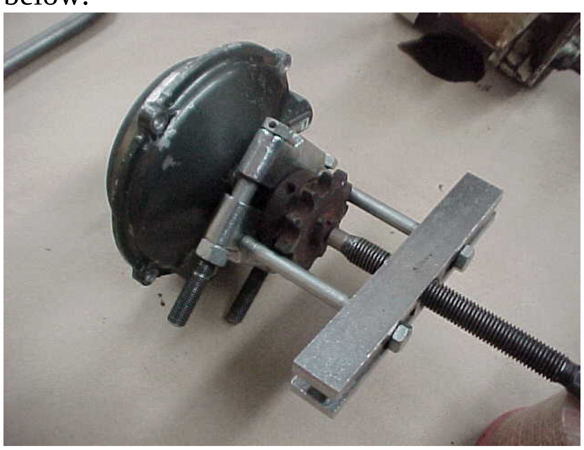
In some engines the exhaust valve and the intake valve are identical. If the valves are different, it is common for the exhaust valve to have a smaller diameter. The spring of the exhaust valve may also be heavier than the intake valve spring. Some valves may be faced at 45 degrees and others at 30 degrees, make a note of the valve face angle during removal to avoid costly mistakes later. If both valves are faced at 45 degrees the valve stems should be parallel when the faces of the two valves are placed together.

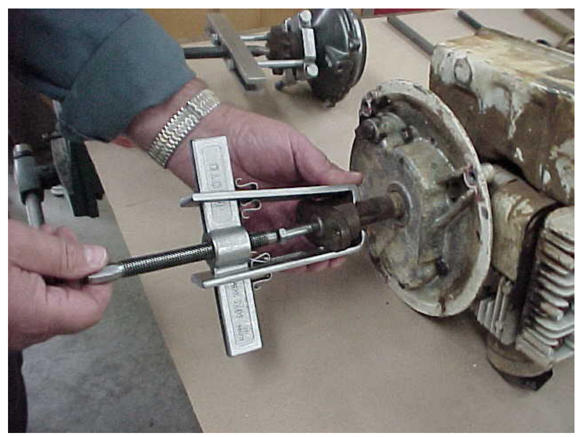
Tips for removing pulleys and blade adapters

Before removing any pulleys or blade adapters mark the location on the shaft with a hacksaw. Take caution not to bend pulleys by pulling too hard. On thin pulleys used a metal plate with a slot cut in it to fit around the crankshaft as a backing plate.

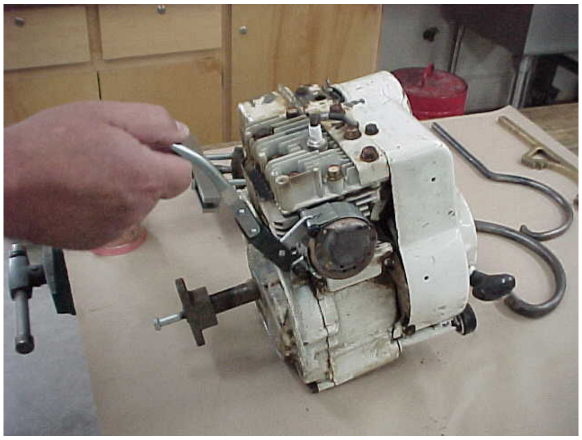
If the shaft is rusted use emery cloth to remove any rust on the shaft. Feel around the shaft especially around the keyway and on the end for burrs. Use a file to remove any burrs that may hang up the pulley.

Use a bearing splitter behind the pulley and a gear puller to remove pulleys. As shown below.





An oil filter wrench can be used to remove mufflers as shown below.



Flywheels

Briggs & Stratton engines have three different types of flywheels, aluminum flywheels and cast iron flywheels are the most common. The model series 280000 and model series 100700 have a different style of flywheel and require a special Briggs & Stratton flywheel holder.

Remove the screws that hold the flywheel screen to the starter clutch and carefully remove the flywheel screen without pulling the cover from the starter clutch. Once the flywheel screen is removed place the screws back in the starter clutch to hold the cover on.

Aluminum and cast iron flywheels can be removed by holding the flywheel with a flywheel holder (pictured below) and turning the starter clutch with a starter clutch wrench. The flywheel holder should be placed as close as possible to the base of the fins and on thickest fins to avoid breaking fins. If a flywheel fin is broke off break off a fin on the opposite side to balance the flywheel.

Clean up any burrs on the crankshaft with a file, be sure to check for burrs around the keyway and on the end of the shaft. Clean rust and corrosion from the shaft with emery cloth before attempting to pull the flywheel.

To remove aluminum flywheels use a flywheel puller as shown below. The holes in the flywheel will need to be threaded if the flywheel has never been pulled before. Use a ¼" – 20 tap to thread the holes for the flywheel puller.

To remove cast iron flywheels apply outward pressure with one hand while hitting the outside of the flywheel with a rawhide mallet. Do not hit the flywheel magnets. This will remove most flywheels, if it does not work then use an inertia puller (shown below). The inertia puller has 5/8" NF thread and is threaded onto the end of the crankshaft. Hit the inertia puller with a hammer to loosen the flywheel.

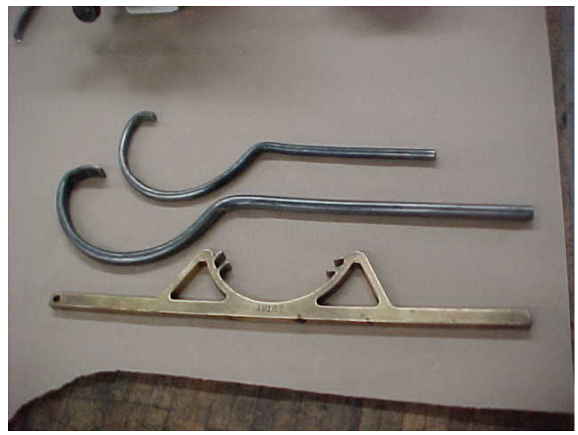
Do not use a gear puller to pull flywheels off. Gear pullers will bend the flywheel.

Remove the flywheel key using diagonal cutting pliers and prying against the shaft with the pliers to lift the key upward.

Once the flywheel is removed finish cleaning the shaft using emery cloth or a wire wheel.

Inertia Puller

Inertia Puller



Flywheel Holders

Starter Clutch

Once removed from the crankshaft the cover of the starter clutch should be taken apart cleaned up and re-assembled. Lay the clutch housing down flat and place ratchet in the center of the housing, place one ball in each slot and then place the cover over the top. There is a felt washer or wick that goes in the end of the starter clutch housing, add a few drops of oil to the felt before re-assembling. If the engine makes a loud whining noise while running the starter clutch was not oiled properly.

Engine Disassembly (internal parts)

Unit Objective:

After completion of this unit, students will be able to disassemble the internal parts of an engine.   This knowledge will be demonstrated by complete disassembly of student engines.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Demonstrate correct use of tools
- Disassemble internal engine parts in a logical order
- Follow written directions (Standard 752.05)
- Listen for information (Standard 754.01)

Teaching Time:
This unit should take 5 to 7 hours to complete (2 hour lecture and 3 to 5 hours for students to work)

Steps for students to complete before the next lesson:
Remove breaker point cover, points, and condenser if equipped
    (Repair manual section 2)
Remove sump cover
Remove governor gear and arm (mechanical governor)
Remove cam gear (repair manual section 10)
Remove piston and rod (repair manual section 9)
Remove crankshaft (repair manual section 10)
Remove rings (repair manual section 9)
Remove oil seals
Scrape off old gaskets
Clean valves and top of piston w/wire wheel
Remove oil plugs
Clean all parts with solvent
Record any broken bolts, parts, stripped threads, missing parts, or bolts
Clean engine parts with parts washer

Steps for teacher to complete before next lesson:
Measure each engine

Teaching Materials:
Tools: Tools for engine disassembly
    Flat Screwdriver
    ¼" and 3/8" Sockets
    Rolling head pry bar
    Ring Expander
    Putty knife

Parts: Complete engine to demonstrate engine disassembly
    Sump cover
    Camshaft
    Crankshaft
    Piston
    Rings
    Connecting Rod
    Rod Cap
    Mechanical Governor
    Oil Seals
Resources:
    Briggs & Stratton Repair Manual

Teaching Activities:

Demonstrate each step of engine disassembly
Demonstrate use of parts washer
Demonstrate use of wire wheel

Remove Sump Cover

Place a rag under the engine to collect oil that will drain after sump cover is removed. Most Briggs & Stratton engines use 6 bolts in the sump cover. After the bolts are removed a rawhide mallet may be necessary to break the sump cover away from the gasket.

Remove Governor (mechanical governor)

Carefully pull the center cap from the governor gear, do not lose the metal ring. Loosen the bolt on the outside of the engine that attaches the linkage to the governor arm, pry the linkage away from the block and off the governor arm. There should be a washer and a pin behind the linkage. Remove the pin and pull the governor arm out from the inside of the block.

Remove Cam Gear

If the crankshaft has a ball bearing, the camshaft cannot be removed until the piston is removed. The camshaft and the crankshaft must be removed together if there is a ball bearing on the crankshaft.

If the engine is equipped with a compression release, check the condition of the spring on the camshaft.

Remove Rod Cap

Use a chisel or punch with a hammer to flatten the rod bolt locks. Note the position of the rod cap and oil dipper. Some rods and caps have assembly marks that must line up. Most rod caps are positioned closest to the cam gear side of the block. Remove rod cap bolts with a socket and ratchet and remove rod cap. Rotate crankshaft as necessary to access bolts. Be careful of sharp edges around the block.

Remove Crankshaft

Rotate the crankshaft until the piston is at top dead center and then rotate the crankshaft away from the rod until the crankshaft can be pulled out.

Remove Piston

Push the piston through the top of the cylinder.

Remove Rings

Use a ring expander to remove the rings from the piston. Note the position of the rings and the bevel around the rings. In most Briggs & Stratton engines there will be 3 rings on the piston. The top ring (compression ring) has a bevel on the inside that goes toward the top of the piston. The middle ring (scraper ring) has a bevel on the outside that goes toward the bottom of the piston. The bottom ring (oil ring) has holes to collect oil.

Remove Oil Seals

Use a rolling head pry bar to remove oil seals. Do not re-use oil seals, throw them away.

Scrape Off Gaskets

Use a putty knife to remove old gaskets, be careful of sharp edges around the engine block.

Clean Valves and Piston Top

Use a wire wheel to clean off any carbon build up on the valves. Only clean the top of the piston with a wire wheel, do not clean the sides with the wire wheel.

Clean up parts

Scrape off excess grease and dirt with a putty knife. Solvent is expensive, to make it last longer keep a bucket of old dirty solvent available. Initially clean parts in old solvent in a stainless steel dishpan. Then clean parts again in the parts cleaner with newer solvent. Solvent in the parts cleaner should last for about three years if used correctly. Have rubber gloves available, some students may be allergic to solvent.

Use a rag with solvent on it to clean out the engine parts boxes before putting clean parts back into it.

When parts are clean do not put bolts back into the holes. The threads still contain and can collect abrasive grit. The engine will have to be cleaned again before re-assembly.

Engine Measuring

Unit Objective:

After completion of this unit, students will be able to perform engine measurements necessary to identify engine wear. This knowledge will be demonstrated by completion of a engine measuring sheet with 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Identify the parts of a micrometer

- Identify and properly use gauges used to measure engine parts

- Read a micrometer

- Measure engine parts within 0.0005"

- Understand and use decimals to describe engine wear (Standard 347.01)

- Understand and use U.S. customary measurements (Standard 349.01)

- Perform addition of decimals to obtain precise measurements (Standard 347.02)

- Judge reasonableness of measurements (Standard 347.03)

- Communicate measurement results using appropriate terminology and methods (Standard 348.04

Teaching Time:
This unit should take 8 to 12 hours to complete (2 hour lecture and 6 to 10 hours for students to work)

Steps for students to complete before the next lesson:
Measure Engine
Complete Engine Measuring sheet
Once measuring is completed begin removing paint

Steps for teacher to complete before next lesson:
Measure each student engine and complete measuring sheet
Compare your measurements to student measurements

Teaching Materials:
Tools:
- Feeler gauges
- Inside micrometers
- Outside micrometers
- Point plunger hole gauge
- Small hole gauges ¼" and 5/16"
- Telescoping gauges
- Micrometer standards
- Valve guide cleaning brush (rifle boring brush)

Parts:

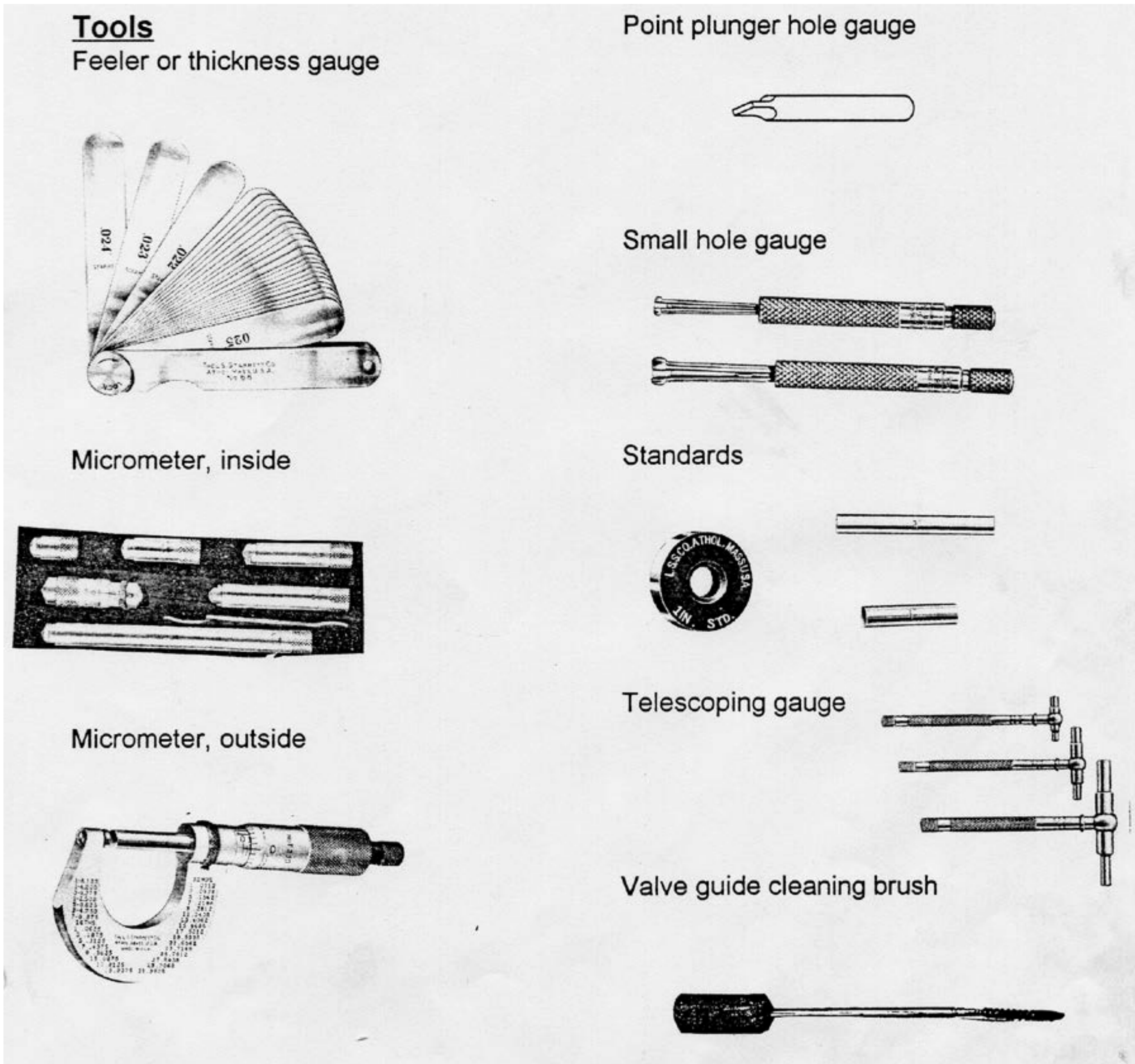
Cylinder	Valve guides
Cam lobes and journals	Crank pin bearing
Crank journals	Point plunger hole
Main bearings	Piston pin
Valve stems	Piston pin retainer
Piston pin bearing	Ring end gaps

Resources:
- Briggs & Stratton Repair Manual
- Projections in this section
- Copies of "Engine Measuring Sheet" this section
- Copies of "Instructions for Engine Measuring" this section

Teaching Activities:
Demonstrate micrometer reading – use bushing drivers or shafts of a known size for students to practice measuring in class.

Prepare a sample set of all engine parts. Have a key of measurements for students to practice measuring and compare their results.

Demonstrate how to measure each engine part. A clear plastic cylinder or beaker works well for demonstrating how to measure the cylinder of an engine.



Importance of Measuring Engines

It is the only accurate way to assess wear of engine parts
As little as 0.002" is significant wear in an engine

It explains engine problems such as noises, smoking, and oil consumption

Reading Micrometers

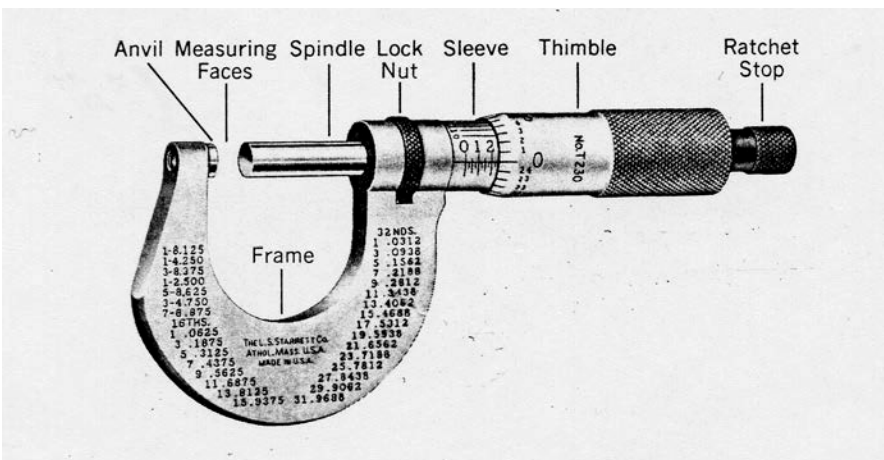
Micrometer readings are pronounced as thousandths or ten thousandths only. Not as point 00…..

Write down numbers and have students read them out loud, for example:

0.001 = one thousandth 0.003 = three thousandths
0.010 = ten thousandths 0.030 = thirty thousandths
0.100 = one hundred thousandths 0.300 = three hundred thousandths
0.0015 = one and a half thousandths or fifteen ten thousandths
0.0417 = four hundred seventeen ten thousandths

Say measurements out loud and have students write down the number.

Parts of a micrometer



Mechanical operation of a micrometer

A micrometer has a screw which has 40 threads per inch. These threads are on the spindle and are concealed by the sleeve. One complete turn of the thimble, which is threaded on the inside with 40 threads per inch, moves the spindle one thread which is 1/40th of an inch. Or, converted into thousandths of and inch (1.000 divided by 40) moves the spindle 0.025 or 25 thousandths of an inch.

The sleeve or barrel divisions are marked off along a line with 40 spaces to the inch with each space equaling 0.025 inch. Thus, one complete turn of the thimble, in a counter clockwise direction, will retract the spindle 0.025 inch and the space between the spindle and the anvil will be 0.025 inch. For distances less than 0.025 inch, readings are taken from the thimble.

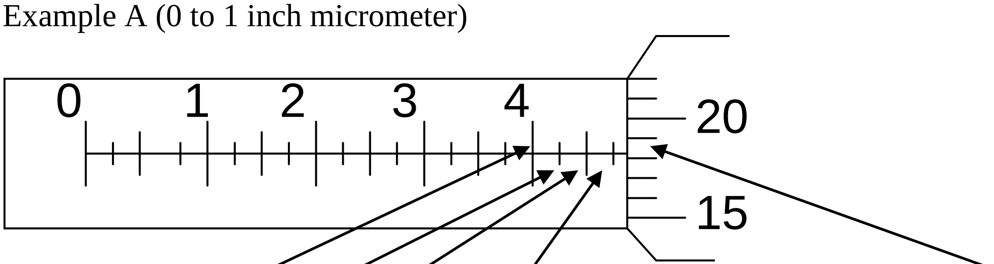
The circumference of the beveled end of the thimble is divided and marked off into 25 equal segments or spaces with each space equaling one one-thousandth (0.001) of and inch. One complete revolution of the thimble equals 0.025 inch and since this distance is divided into 25 equal parts, each space or division equals 0.001 inch. Reading the value of the mark, on the thimble, which coincides with the line marked along the sleeve gives the number of thousandths of an inch for distances less than those marked on the sleeve.

The above explanation is for the simplest micrometer. Other models may have a lock nut, ratchet stop, or a vernier scale for measuring to the ten thousandths of an inch.

Micrometers are available in various sizes typically in one inch increments. Common sizes for measuring small engines include: 0 to 1 inch, 1 to 2 inch, 2 to 3 inch, 3 to 4 inch

Micrometer Reading Illustrations

Example A (0 to 1 inch micrometer)

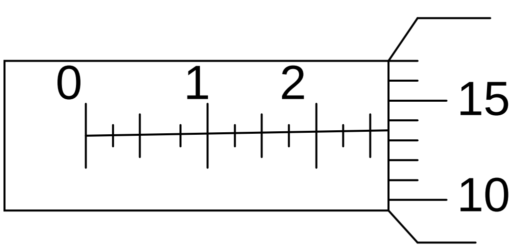


Sleeve Readings: Thimble Reading:

0.400 + 0.025 + 0.025 + 0.025 = 0.475 inch 0.018 inch

Total Reading = sleeve readings + thimble reading or 0.475 + 0.018 = 0.493 inch or four hundred ninety three thousandths

Example B (1 to 2 inch micrometer)



Micrometer size (1 to 2 inch) 1.000 inch

Sleeve reading:	0.250 inch
Thimble reading:	+0.014 inch
Total Reading:	1.264 inch

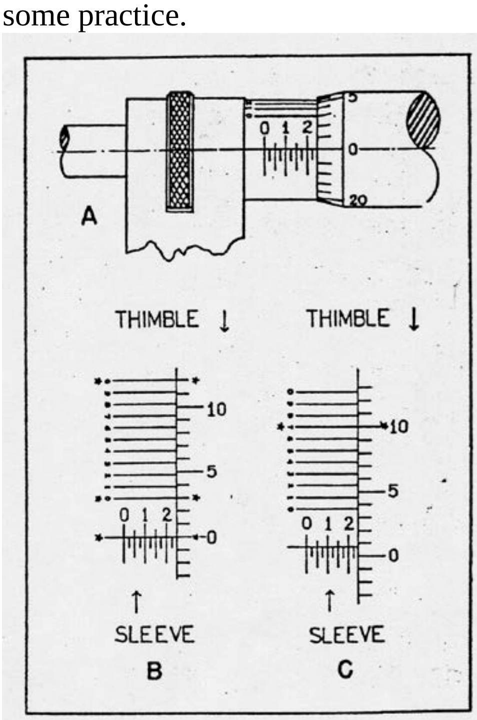
Reading Vernier Scales for ten thousandths of an inch measurements

Starrett micrometers graduated in the thousandths of an inch are used like micrometers graduated in thousandths as described above, except that an additional reading in ten thousandths which is obtained from a vernier is added to the thousandth reading. The vernier consists of ten divisions on the sleeve, shown in figure B below, which occupy the same space as nine divisions on the thimble. Therefore, the difference between the width of one of the ten spaces on the vernier and one of the nine spaces on the thimble is on tenth of a division on the thimble, or one tenth of one thousandth, which is one ten thousandth.

To read a ten thousandths micrometer, first obtain the thousandths reading, then see which of the lines on the vernier coincides with a line on the thimble. If it is the line marked “1” add one ten thousandth, if it is the line marked “2” add two ten thousandths, if it is the line marked “3” add three ten thousandths, etc.

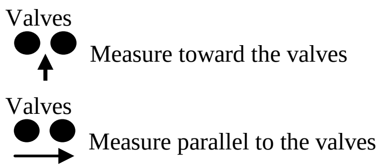
Ten thousandths of an inch can be estimated on micrometers without a vernier scale. Once the reading is taken from the thimble, if the lines on the thimble do not line up perfectly with the lines on the thimble. The space between two lines on the thimble can be divided into ten thousandths of an inch to give a more precise measurement.

Outside micrometers should be held in one hand using the thumb and forefinger to turn the thimble while the other hand holds and rotates the part being measured. This takes some practice.



Instructions for Engine Measuring

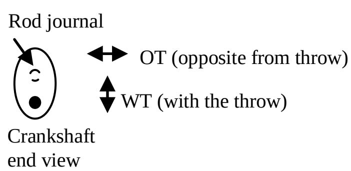
Cylinder bore size: Measure in 2 directions



An inside micrometer may be used to measure cylinders, however, it must be re-calibrated and checked every time the anvil is changed. To avoid re-calibrating inside micrometers, it is easier to use an inside micrometer, then measure the inside micrometer with an outside micrometer. The repair manual suggests using a telescoping gauge to measure cylinders, but an inside micrometer is more accurate. Cylinder measurements should be made ¼" down from the top of the cylinder and ½" up from the bottom of the cylinder.

A total of 4 cylinder measurements should be taken. Measure in 2 directions at the top of the cylinder and the same 2 directions at the bottom of the cylinder. Cylinders will often be tapered; larger at the top and smaller at the bottom.

Crankshaft: Measure in 2 directions (with throw and opposite throw) at 3 locations (magneto end, pto end, and rod journal). Measure the smallest part of the journal in both directions. Use an outside micrometer.



Bearings: Measure bearings in 2 directions OT and WT similar to the crankshaft. Use a telescoping gauge. Insert the telescoping gauge at an angle into the bearing, loosen the gauge, then tighten it, then move the gauge so it is straight. Pull the telescoping gauge straight out and measure it with an outside micrometer. Bearing measurements should be taken ¼" from the outside edge. Be sure to avoid measuring in oil grooves.

Valve Stems: Using an outside micrometer, take a “minimum” measurement on the smallest or most worn part of the stem. Take a “maximum” measurement on the unworn portion of the stem (about ¼" above the valve spring retainer). Discard any valve that has more than 0.0015" difference between the minimum and maximum measurements.

Valve Guides: Clean the valve guides with a wire brush type rifle bore cleaner before measuring. Insert a small hole gauge into the valve guide ¼" from the top of the guide. Rotate the gauge to find the largest diameter (valve guides wear oblong). Pull the gauge straight out of the guide and measure it with an outside micrometer. Valve guide clearance is obtained by subtracting the valve stem size from the valve guide size. Use the worn stem measurement if the valve will not be replaced. Use unworn valve stem measurement if the valve will be replaced.

Connecting Rod: Before measuring the crankpin bearing (connecting rod bearing), assemble rod cap (be sure rod cap is on correctly use alignment marks). Tighten the rod cap bolts to the torque found in the Repair Manual chart on page II. Check the tightness of the piston pin with the instructor before disassembling the piston from the connecting rod. If it is tight, there is no reason to remove the pin from the piston and measure it. Use a telescoping gauge and the same method as described above for measuring bearings, measure the telescoping gauge with an outside micrometer. Measure the connecting rod in 2 different directions (WT & OT).

Piston Pin: Check the tightness of the piston pin with the instructor before disassembling the piston from the connecting rod. If it is tight, there is no reason to remove the pin from the piston and measure it. Measure the worn part of piston pin with an outside micrometer, rotate the pin to find the smallest diameter. Measure 3 locations on the pin, both sides of the piston and the center where the connecting rod attaches. Measure the bearings using a telescoping gauge and measure the telescoping gauge with an outside micrometer.

Camshaft: Measure 4 places on the camshaft with an outside micrometer. Measure the smallest part of the 2 journals on each end and the largest part of the 2 lobes.

Ring Gap: Measure each of the three rings. Insert each ring one at a time into the top of the cylinder. Use the top of the piston to push the ring down the cylinder to it's approximate location if it were on the piston at top dead center. Use a feeler gauge to measure the gap between the ends of the rings.

Point Plunger Hole: Later model engines with electronic ignition will not have a point plunger hole. If electronic ignition is used to replace points and condenser this measurement is not necessary. Insert the flat end of a point plunger gauge into the hole. Rotate the gauge to seek out the largest diameter.

Reject Sizes:

Most reject sizes are found in the "Check Chart" on pages II and III of the repair manual.

Cylinder Bore: The "Check Chart" gives a maximum and minimum diameter of a new cylinder. If the cylinder measurement is more than 0.003" larger than the maximum measurement the cylinder should be re-sized by 0.010" and have an oversized piston installed. If a cast iron cylinder is out of round by more than 0.0015" or if an aluminum cylinder is out of round by more than 0.0025" the cylinder should be re-sized by 0.010".

Crankshaft: Crankshaft reject sizes are listed in the "Check Chart". If any of the measurements on the crankshaft are equal to or less than the size listed in the chart the crankshaft should be replaced. If the rod journal is too small, the journal can be undersized by a machine shop and an undersized connecting rod can be ordered. This may be less expensive than a new crankshaft.

Bearings: Table No. 2 of the Cylinder and Bearing section (section 11) gives reject sizes for bearings. If the bearing measurements are larger than the sizes listed in the table then the bearing needs to be replaced. Replacement bearings may not be available for some older engine models, therefore a used block or sump must be found.

Valve Stems: The Repair manual does not list reject sizes for valves. To determine if valves can be re-used compare the measurements from the worn part (shiny) of the valve to the measurement of the unworn part of the valve. If the difference is more than 0.0015" the valve should be replaced. Additionally, if the valve margin is less than ½ the thickness of a new valve (1/32") the valve must be replaced.

Valve Guides: Valve guide clearance is obtained by subtracting the valve stem size from the valve guide size. Use the worn stem measurement if the valve will not be replaced. Use unworn valve stem measurement if the valve will be replaced. If the difference between the exhaust valve guide and the exhaust valve stem is equal to or greater than 0.007" then the valve guide needs to be replaced. If the difference is equal to or greater than 0.005" on the intake valve, the valve guide needs replaced. Valve guide part numbers are found in the compression section (section 6) of the repair manual.

Connecting Rod: Connecting rod reject sizes are found in the Piston, Rings, and Rods section (section 9) of the Repair Manual. Table No. 2 gives connecting rod reject sizes. If the crankpin bearing of the connecting rod measurement is equal to or greater than the reject size, the connecting rod must be replaced.

Piston Pin: Table No. 3 of the Piston, Rings, and Rods section (section 9) of the Repair Manual gives reject sizes for the piston pin and the piston pin bearings. If the piston pin measurement is equal to or less than the reject size the pin must be replaced. If the pin bore measurement is equal to or larger than the reject size the piston must be replaced.

Camshaft: Reject sizes are listed in Table No. 3 in the Crankshafts and Cam Gear section (section 10) of the repair manual. If the cam gear measurements are equal to or smaller than the reject sizes in the table the camshaft must be replaced.

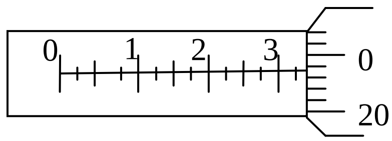
Ring Gap: Reject sizes are listed in Table No. 1 in the Pistons, Rings, and Rods section (section 9) of the Repair Manual. If the ring gap measurement is equal to or greater than the reject sizes in the table then the rings must be replaced.

Ring Land Clearance: Ring land clearance can be measured by using a feeler gauge between the rings and the ring lands on the piston. The rings that will be installed should be used to measure ring land clearance. Briggs & Stratton does not give specifications for ring land clearance. Therefore, it is not commonly measured in small engines.

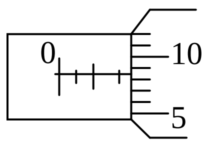
MICROMETER READING WORKSHEET

Micrometer Size	Reading

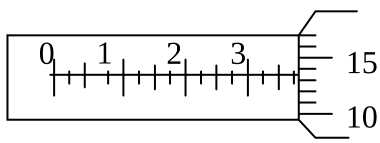
0 to 1 inch ______________________



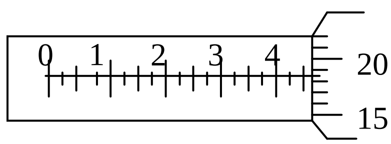
2 to 3 inch ______________________



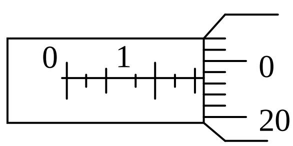
0 to 1 inch ______________________



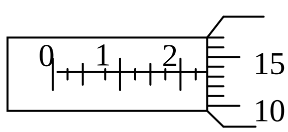
4 to 5 inch ______________________



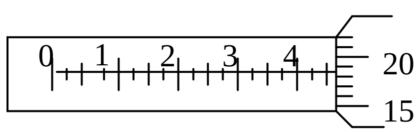
3 to 4 inch ______________________



10 to 11 inch ______________________

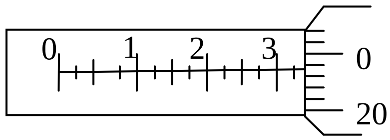


1 to 2 inch ______________________

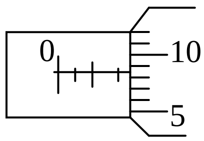


MICROMETER READING WORKSHEET KEY

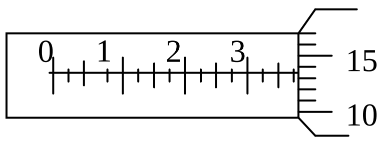
Micrometer Size	Reading
0 to 1 inch	____**0.349**__________



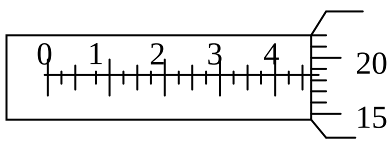
2 to 3 inch	___**2.084**____________



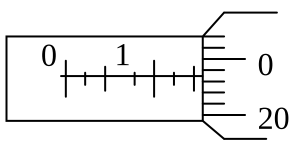
0 to 1 inch	___**0.388**____________



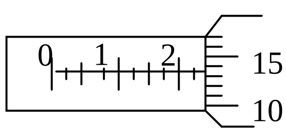
4 to 5 inch	__**4.468**______________



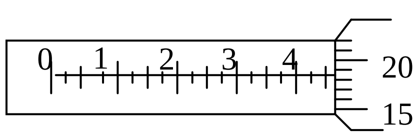
3 to 4 inch	___**3.169**_____________



10 to 11 inch	___**10.238**___________



1 to 2 inch	___**1.468**____________



MEASUREMENTS

Engine Model________________
Type No.___________________ **Make**______________________ **Name**___________________
Serial No.____

	Your Engines	Measurements	Manufacturer's	Measurements	Reuse	Replace
I Cylinder Bore Size	**O ↑ O**	**O → O**	**New Cylinder Measurements**			
	↑		**Max**	**Min**		
Top						
Bottom						
II Crankshaft	**WT**	**OT**	**Reject**	**Reject**		
Magneto End			XXXXXX			
Drive End			XXXXXX			
Rod Journal			XXXXXX			
III Bearings	**WT**	**OT**				
Magneto End				XXXXXX		
Drive End				XXXXXX		
IV Valve Stems	**Max = (unworn)**	**Min = (worn)**	**Taper Your Engine**	**Reject**		
Exhaust				0.0015		
Intake				0.0015		
V Valve Guides			*Use worn stem size if valve is to be reused. Use unworn stem size if valve is to be replaced.			
Exhaust Guide			**Reject**			
*Stem -			0.007			
Clearance =						
Intake Guide						
Stem -						
Clearance =			0.005			
VI Connecting Rod	**WT**	**OT**		XXXXXX		
Crankpin Bearing						
**Piston Pin Bearing			**Max Rod Max**	**Max**		
**Piston Pin			**Max**	**Min**		
VII Camshaft	Gear End		**Reject**	**Reject**		
Journal			XXXXXX			
Lobe			XXXXXX			
VIII Ring Gap						
Top Compression				XXXXXX		
2nd Compression				XXXXXX		Bush
Oil Ring				XXXXXX		
IX Point Plunger Hole	No Go	1/4"	Go 1/4"	Reassemble		
****Check with instructor for looseness before disassembling. If Loose, it should be disassembled and measured**						

Theory of Operation Ignition System

This lesson should be taught prior to or in conjunction with the unit on Ignition Disassembly and Reassembly.

Unit Objective:

After completion of this unit, students will be able to explain the general theories and principles of magneto ignition systems. This knowledge will be demonstrated by completion of a quiz with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

- Identify basic terms and definitions associated with magneto ignition systems

- Test and diagnose ignition problems

- List and identify the parts related to a magneto ignition system

- Describe the principles of magneto ignition systems (Standard 650.04)

- Identify the functions of individual parts related to ignition systems

Teaching Time
This Unit should take 2 hours to complete.

Teaching Materials:
Tools:

13/16" or ¾" Socket with ratchet (for spark plug)
Spark tester
Spark plug tester (optional)
Coil tester (may be made from an engine with vertical pull starter, see ?)
C-clamps

Parts:

Cut-away model engine
Fully assembled engine
Varnish insulate copper wire (can be unwound from primary winding of old coil)
Steel Nail
12 Volt Battery
Short 14 gauge jumper wires (2)

Resources:

Briggs & Stratton Repair Manual
Projections of pictures in this unit

Teaching Activities:
Make an electromagnet to demonstrate the magnetic field that surrounds a wire as a current flow on the wire. An electromagnet can be made by coiling the varnished insulated tightly around a steel nail. Use a jumper wire to connect one end of the varnish insulated wire to the positive pole of a 12 volt battery and another wire to connect the other end of the varnish insulated wire. When energized the nail and coil of wire around it should be magnetic and pick up ferrous metals. The inverse of this is the principle of magneto ignition systems. In other words if the magnet passes through the coil of wire electrical current is created.

Electrically charge a condenser to demonstrate how a condenser holds or collects current. Use a jumper wire connected to the negative terminal of a 12 volt battery and another wire connected to the positive terminal of the battery. Simultaneously touch the end of the negative wire anywhere on the outer shell of the condenser and the positive wire to the terminal end of the condenser. The condenser should be charged now. To remove the charge touch the outer shell to a conductive surface and rock the end of the condenser up so that the terminal end almost touches the same surface at the same time. Students should be able to observe a spark between the terminal end and the conductive surface.

Secure an assembled engine to a table with C-Clamps. Install a spark tester. Pull the rope starter and observe the spark tester for spark or arcing. If arcing in the spark tester is present, it is known that the engine has spark at least to the spark plug. Test the spark plug if a tester is available. Spark plug testers are expensive so if one is not available just purchase a new spark plug or use a spark plug that is known to be good. Spark plugs are inexpensive; $1 or $2. If there is not spark in the spark tester, test the coil in the coil tester.

Terms and Definitions

Amperage (I)	-A unit for measuring the rate of current flow (electron flow) through wires. It can be compared to the flow of water in pipes.
Circuit	-The complete path of electric current; An assembly of electronic elements
Ignition	-A process or means of igniting a fuel mixture
Magneto	-An alternator with permanent magnets used to generate current for the ignition of an internal combustion engine
Ohm (R)	-Measure of the resistance to current flow through a wire or other current carrying material.
Primary Circuit	-Current generated from flywheel magnet and armature carried through the breaker points and condenser
Secondary Circuit	-Current generated from the primary circuit carried through the coil and spark plug wire (secondary wire) to the spark plug
Voltage (E)	-A unit of electrical force or pressure. It may be compared to water pressure.

Parts Related to Ignition

Armature
Breaker Points
Crankshaft
Coil
Condenser
Electronic Ignition Module
Flywheel
Flywheel Key
Point Plunger
Spark Plug

Ohms Law

Before attempting to understand the ignition system of an engine it is important to have an understanding of basic electricity principles.

Ohms law says that a pressure of one volt (E) will force a current (I) of one amp through a resistance of one ohm (R). In other words:

$$E = I*R$$

Amperage (I) and resistance (R) are directly proportional to voltage (E). If amperage or resistance increase then voltage will also increase.

An ignition system of an engine requires 10,000 to 12,000 volts to create a sufficient arc across the spark plug air gap which ignites the air/fuel mixture.

To obtain that high of voltage a coil of wire is used to increase resistance which directly increases voltage.

How Electricity is Produced

If a wire is passed through a magnetic field an electrical current will flow on the wire. A larger wire or a larger number of wires that are passed through a magnetic field will increase the amount of current.

If current flows on a wire a magnetic field is produced around the outside of the wire.

Resistance (R) can be used to reduce the current (I) and increase the pressure or voltage (E).

In a small engine the magnet is located on the outer edge of the flywheel and the coil of wires is in a stationary position outside of the flywheel. The magnet passes by the coil with each revolution of the flywheel creating electricity on every revolution.

Magneto Ignition (Simplified Explanation)

The ignition system consists of two circuits, a primary circuit and a secondary circuit. The primary circuit is consists of larger gauge wire windings in the coil, the primary coil wire, breaker points, and condenser (breaker points and condenser may be replaced by an electronic ignition module). The secondary circuit consists of smaller gauge wire windings in the coil, secondary wire from the coil, and the spark plug. The ratio of windings in the coil uses Ohm's law to multiply the voltage. The ratio of secondary windings to primary windings is 60 to 1. Figure 1 diagrams both circuits. The coil only has two wires inside it, the primary wire and the secondary wire. Both wires are wound or coiled several times to increase resistance. The two wires are insulated from one another. One end of the primary wire is grounded to the engine block and the other end carries current to the breaker points and condenser. One end of the secondary wire is also grounded to the engine block and the other end carries current to the spark plug.

Current is produced in the primary circuit from the flywheel magnet passing through the primary windings of the coil. If the primary windings are carrying a current that produces a magnetic field around them which produces electricity on the secondary windings when the breaker points open and suddenly stop the flow of electricity on the primary circuit. The voltage is much higher on the secondary circuit due to the ratio of windings. The voltage produced on the secondary circuit is carried by the secondary wire to the spark plug. An arc is created between the contact points of the spark plug to ignite the air/fuel mixture.

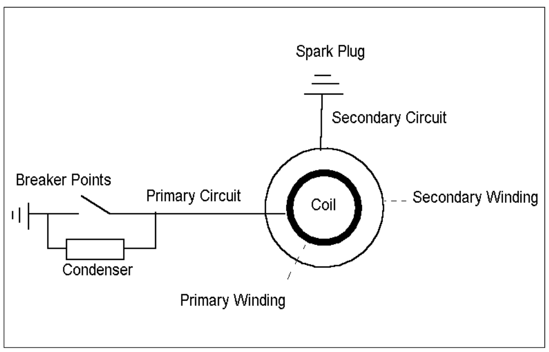
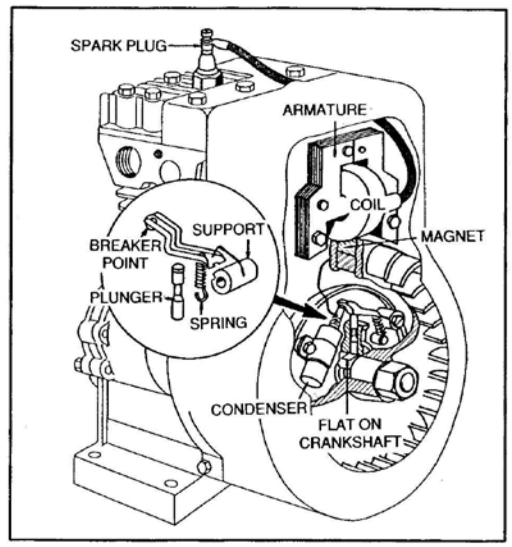


Figure 1



Magneto Ignition

Magneto Ignition

A magneto in a sense consists of two simple circuits, one called the primary circuit and the other the secondary circuit. Both Circuits have windings or coils which surround the same iron core and the magnets in the flywheel or rotor act on both circuits. Current can be induced in each by changing the magnetism in or around the coils of the circuit.

The primary circuit has relatively few turns of heavy wire (low resistance) and the circuit includes a set of breaker points and a condenser, or an electronic switch.

The secondary circuit has a coil with many turns of lighter wire (high resistance) which are wound around the outside of the primary winding, and includes a spark plug. There are about 60 turns in the secondary to each turn in the primary.

A permanent magnet is mounted in the flywheel or rotor. As the flywheel rotates, the magnet is brought into proximity with the coil and core.

Fig. 3 Shows the flow of magnetism through the iron core of the coil as the magnet in the flywheel approaches the armature. The arrows indicate the direction of flow of the magnetic field. Notice that there is no (or very little) magnetism flowing through the upper part of the core. This is because of the air gap at the top which causes a resistance. In this position the breaker points close.

The flywheel continues to rotate to the position shown in Fig. 4. The magnetism continues to flow in the same direction and magnitude through the center of the core because of primary current. However, the magnetism flows in an opposite direction through the outer portion of the core and through the top air gap because of the change of flywheel position. Since the shunt air gap provides a path for the flux from the armature legs and the core, the required current flow through the primary circuit is low, assuring long breaker point life.

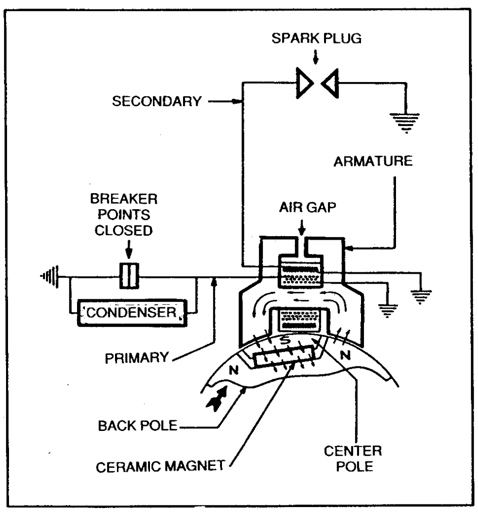


Figure 3

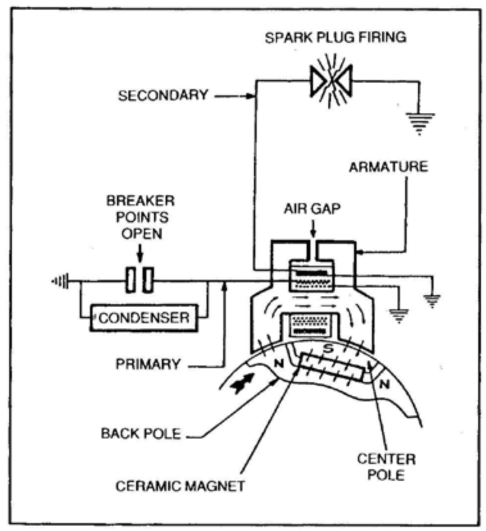


Figure 5

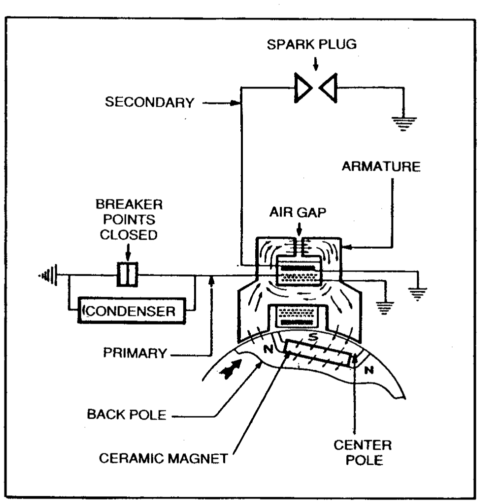


Figure 4

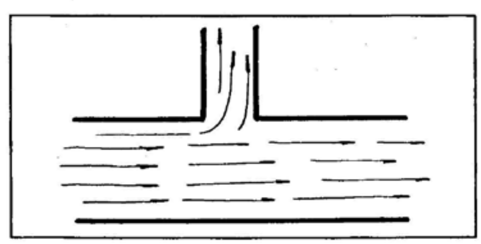


Figure 6

At this position our breaker points open, the current stops flowing in the primary circuit and therefore the electromagnetic effect ceases. The magnetism instantaneously changes from the flow shown in Fig. 5. Note the opposite direction of the arrows indicating a complete reversal of magnetism which has happened so fast that the flywheel magnet has not had a chance to move any noticeable amount.

The rapid change in magnetism produces 170 volts in the primary winding. A voltage is also induced in the secondary but it is proportional to the turns ratio, i.e., 60 to 1 or 10,000 volts. This voltage is more than ample to fire across the spark plug electrodes. This rapid magnetism change is very short and therefore the flow of current across the spark plug gap is as long as necessary, but short enough to afford long electrode life. This assures full power plus long life dependability.

The condenser is a sort of safety valve on the primary circuit. It is connected across the breaker points to prevent the circuit from jumping the breaker point gap (normally referred to as arcing).

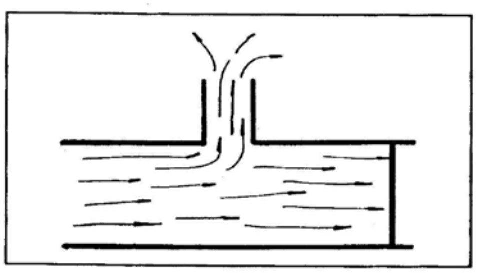


Figure 7

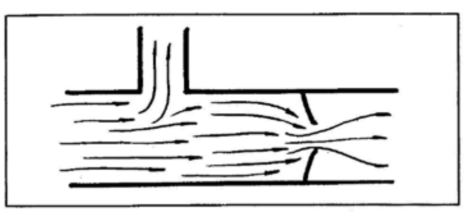


Figure 8

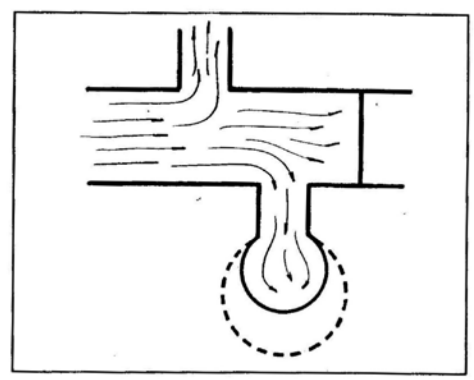


Figure 9

Suppose water is forced through a large pipe at a high rate of speed (Fig. 6). This represents the primary circuit. A much smaller pipe is joined to the large pipe, to represent the secondary circuit. As long as the large pipe is unobstructed, the water is free to flow and very little will flow out through the small pipe.

If a valve in the large pipe suddenly stops the flow (Fig. 7). The inertia of the water in the large pipe will force the water out through the small pipe at a much higher velocity. This represents the high voltage in the secondary circuit.

However, the valve cannot stand the pressure or it will break (Fig. 8). This represents arcing across the breaker points. The flow would continue through the large pipe, and very little would flow through the small pipe.

If another small pipe is added near the valve with a rubber collection bag over the end, (Fig. 9), this represents a condenser. Therefore, when the valve is closed the excess pressure on the valve is absorbed by the rubber bag, the valve does not break and water is forced out the small pipe.

In later model engines the breaker points and condenser are replaced with an electronic ignition switch to control the flow of current on the primary circuit.

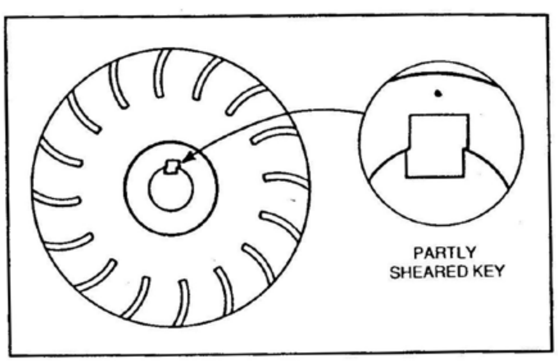
Electronic Ignition

Later model engines are equipped with an electronic ignition module on the armature. Electronic ignition modules may be retrofitted onto early model engines. The electronic ignition module replaces points and condenser. Ignition systems with electronic ignition still operate under the same principles as points and condenser. The opening of the primary circuit that is done mechanically with breaker points in done electronically with a switch inside the electronic ignition module. Breaker points require adjustment at various intervals as the contact points wear down. The advantage to electronic ignition is that it requires no adjustments, it is maintenance free.

Ignition Timing

The ignition system must be in time with the engine such that the arcing across the spark plug gap occurs when the engine is just below top dead center of the compression stroke. The flywheel key is installed to keep the ignition in time with the engine.

The flywheel key should not be partially sheared as this can cause the timing to be off enough to result in hard starting. Do not use a steel flywheel key. The soft metal key is used so that if the flywheel should become loose the key will be sheared, allowing the flywheel to shift and stop the engine before any further damage occurs. The flywheel key is a locator not a driver.



Partially Sheared Flywheel Key

Ignition Quiz

1. If an engine has an electronic ignition module, will it also have breaker points and a condenser?

2. How many wires are there in an ignition coil?

3. Is the spark plug a part of the primary circuit or the secondary circuit?

4. Is the condenser a part of the primary circuit or the secondary circuit?

5. What is the advantage of electronic ignition?

6. What is the function of a spark plug in an ignition system?

7. What is the function of the secondary wire in an ignition system?

8. What is the function of a condenser in an ignition system?

9. Voltage is increased by increasing/decreasing (choose one) resistance.

10. The flywheel key is made of soft/hard (choose one) metal.

Ignition System

Unit Objective:

After completion of this unit, students will be able to test and repair engine ignition systems. This knowledge will be demonstrated by completion student engines.

Specific Objectives and Competencies

After completion of this unit students will be able to:

- Identify basic terms and definitions associated with magneto ignition systems

- Test and diagnose ignition problems

- List and identify the parts related to a magneto ignition system

- Describe the principles of magneto ignition systems (Standard 650.04)

- Identify the functions of individual parts related to ignition systems

- Convert engine ignition systems to electronic ignition

Teaching Time:
This unit should take 3 to 4 hours to complete (1 hour lecture and 2 to 3 hours for students to work)

Steps for students to complete before the next lesson:
Install electronic ignition module
Test coil

Steps for teacher to complete before next lesson:
Schedule a computer lab for parts ordering

Teaching Materials:
Tools:
- Coil tester
- Condenser
- Pocket knife
- Diagonal cutting pliers
- Tin snips

Parts:
- Coils
- Electronic ignition modules
- Flywheel
- Spark Plug
- Points and condenser
- Kill switches

Resources:
- Briggs & Stratton Repair Manual (section 2)
- "Operational Theory of Ignition" this curriculum guide

Teaching Activities:
Demonstrate "Operational Theory of Ignition" It may be easier to explain the function of points and condenser and then relate those principles to how an electronic ignition module functions.

Demonstrate how to retro-fit magnetron electronic ignition modules on early model point and condenser engines.

Demonstrate use of coil tester

Testing Coils:

Coils with electronic ignition need to have the flywheel spun at least 350 rpm to be properly tested. A Briggs & Stratton model 92908 engine with a vertical pull starter can be easily made into a coil tester as shown below. Remove the blower housing, camshaft, piston, rod, valves, tappets, etc. All that is needed for the coil tester is the block crankshaft, sump cover, flywheel and nut, and the vertical pull starter.

Cut the clamping surface from two 1" C-clamps and weld a 5/16" nut onto the ends to replace the clamping surface. Insert an 8-32 flat head machine screw through the nuts that are welded to the C-clamps into the holes where a coil would normally bolt on the block.

Weld a short piece (3" or 4") of aluminum angle to the bottom of the block. Or bolt on a piece of angle iron to enable the coil tester to be clamped into a vise.

Use the correct shim stock to obtain the air gap between the flywheel and coil. Make sure that the electronic ignition module is assembled on the opposite side of the coil from the secondary wire (spark plug wire). Insert the coil into the tester with the secondary wire facing away from the block and secure it with the C-clamps. Make sure that the ground wire for of electronic ignition module and the ground wire of the coil are grounded between the coil and the C-clamp. Connect the secondary coil wire to a spark tester and ground the tester to the block of the coil tester. Pull the vertical pull starter and watch for spark in the spark tester. If there is spark then the coil is good.

Installing Electronic Ignition Modules

Section 2 of the Repair Manual describes most of the steps for removing and installing magnetron electronic ignition modules.

Be sure to remove the varnish insulation from the primary wire before inserting it under the clip of the electronic ignition module. There is a plastic insulation that must be stripped from the outside of the wire and there is also a varnish coating on the wire. The varnish must be scraped off with a knife to all good contact.

When retro-fitting early model engines with electronic ignition modules a corner of the air vane governor may need to be trimmed off to fit over the module. Use tin snips.

Kill Switch Operation:

A kill switch operates by grounding out the primary circuit, thus terminating the flow of electricity to the spark plug. Kill switch wires are connected to the primary circuit under the hook of the electronic ignition module. The kill switch runs to a grounding wire somewhere on the engine. Lawn mowers typically have the kill switch connected to the blade brake, some engines have a kill switch connected to the throttle cable, other engines may have a toggle switch for a kill switch. When the engine is running the kill switch is open which cuts off the flow of electricity from the primary wire to ground. When the kill switch is engaged or closed by the blade brake, throttle cable, or toggle switch voltage travels from the primary circuit to ground, terminating the voltage to the spark plug.

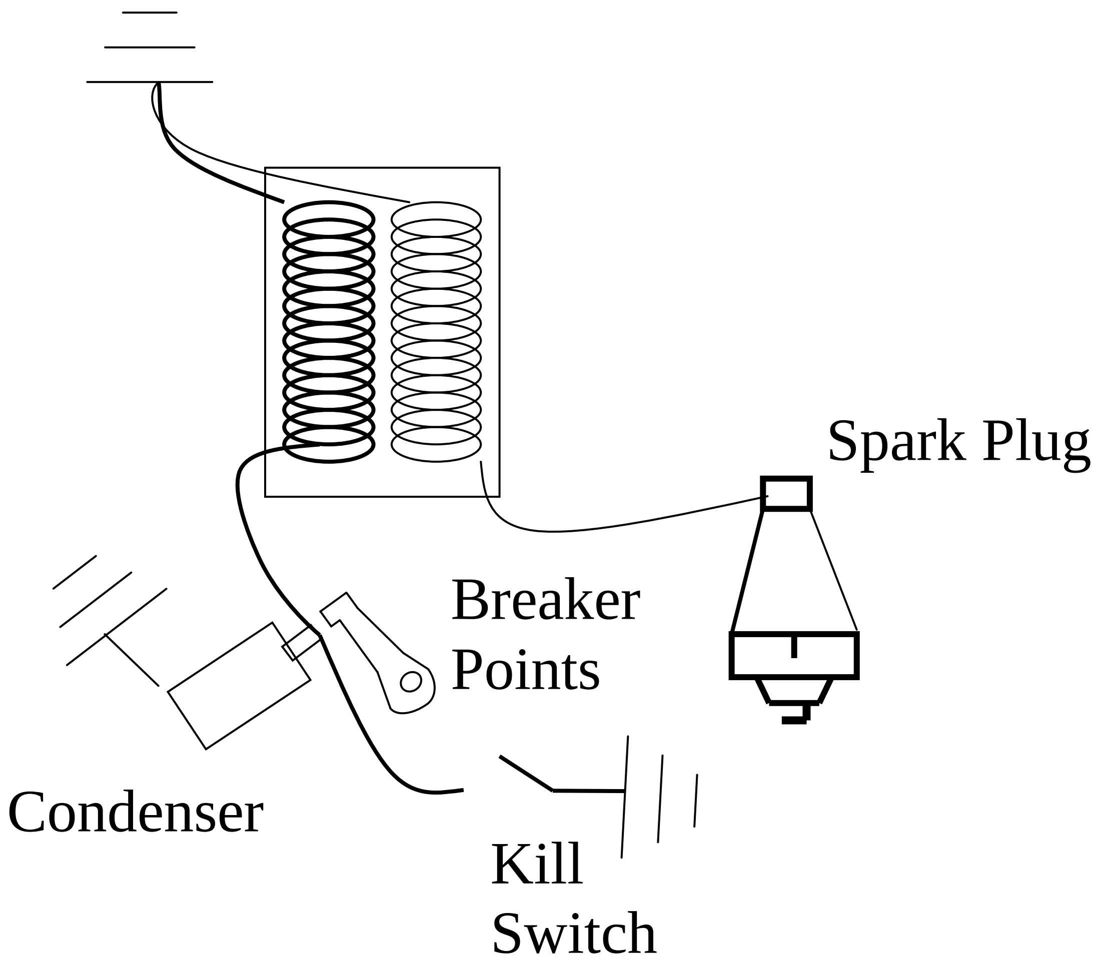
Some type of electronic kill switch should always be used to stop an engine. Closing the choke valve is a common way to stop an engine if the kill switch is not functional. However, closing the choke valve allows raw fuel to enter the cylinder and could cause cylinder damage.

Ignition System Diagram

Primary Circuit
Primary coil winding
Points
Condenser

Secondary Circuit
Secondary coil winding
Spark Plug

Ratio = 1 turn : 60 turns
170 volts : 10,000 volts



Operational Theory of Carburetion

This lesson should be taught prior to or in conjunction with the unit on Carburetor Disassembly and Reassembly.

Unit Objective:

After completion of this unit, students will be able to explain principles and theories of carburetion in small engines. This knowledge will be demonstrated by completion of a quiz with a minimum of 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Identify basic terms and definitions associated with carburetion
- List and identify individual engine parts related to carburetion
- Describe the operation of 3 different types of carburetors (Flo-Jet, Pulsa-Jet, and Vacu-Jet)
- Describe the function(s) of individual carburetor parts
- Adjust carburetors to proper air/fuel mixtures and speeds
- Understand diaphragm pumps
- Understand concepts of motion and forces such as Bernoulli's principle, gravity, venturi, air foil (Standard 648.04)

Teaching Time
This unit should take 2.5 hours to complete

Teaching Materials

Tools:
- Small Engines Tool Box
- Carburetor Screwdriver
- Glass Beaker
- Air Nozzle

Parts:
- Samples of each type of carburetor
- Samples of each carburetor part

Resources:
- Briggs & Stratton Repair Manual
- Video "Carburetor Theory" by Briggs & Stratton
- Projections of pictures in this unit

Teaching Activities

Use actual parts to aid in teaching.

Use an overhead or projection of Figure 3. Have students imagine they are a drop of gas trying to find their way through the carburetor maze. Use actual carburetors and parts to explain the path that fuel must take from the inlet, through the carburetor, and into the compression chamber.

Use a glass beaker, water, and compressed air to demonstrate how a carburetor venturi works. Fill a glass beaker about ½ full of water. Position an air nozzle to blow air across the top of the beaker. If the position of the air stream is on the correct plane (parallel to the plane across the top of the beaker) and at the correct height (approximately 1/32" above the beaker) a mist of water will mix with the air stream and spray out on the opposite side of the beaker. The same principle applied to lift water from the beaker is used to lift fuel from the bowl in the lower body of a Flo-Jet carburetor. The water can also be said to be vaporized under the same principles that fuel in a carburetor is vaporized.

Terms and Definitions

Carburetion	-To enrich fuel by mixing with air and transfer the mixture into the combustion chamber
Diaphragm	-A thin flexible disc that vibrates
Idle	-To run disconnected so that power is not used for useful work
Lean Mixture	-An air/fuel mixture with excess air
Rich Mixture	-An air/fuel mixture with excess fuel
Tachometer	-A device used to indicate speed of rotation (RPM)
Vaporization	-The act of mixing liquid fuel with air such that the liquid fuel is suspended by air to form an explosive mixture
Velocity	-Quickness of motion

Parts Related to Carburetion

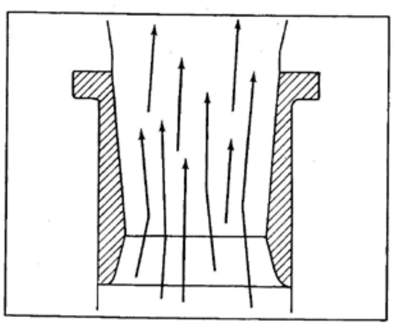
Air Cleaner
Air Foil
Choke Plate
Choke Shaft
Float
Float Needle
Float Seat
Fuel Cap
Fuel Line
Fuel Tank
Fuel Tube or Pipe
Idle Mixture Screw
Idle Speed Screw
Intake Tube
Intake Valve
High Speed Mixture Screw
High Speed, Speed Screw
Main Jet
Throttle Plate
Throttle Shaft
Venturi

The purpose of a carburetor is to produce a mixture of fuel and air on which an engine will operate; to do so is relatively easy. However, producing economical fuel consumption and smooth engine operation over a wide range of speeds creates the need for a more complicated mechanism than a mixing valve. There is an additional problem in that the price of such a carburetor must be proportional to the price of the engine.

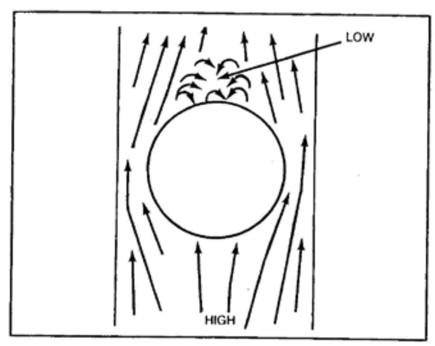
The force of atmospheric pressure and the principles of the venturi and airfoil are applied in carburetors. Atmospheric pressure, although it changes with altitude, is a constant force that tends to equalize itself in any given area. Atmospheric pressure is commonly between 13 and 15 psi. Air moves from high pressure areas to areas of lower pressure to equalize pressure. Carburetors create areas of low pressure to utilize the force of atmospheric pressure. The terms "vacuum" or "suction" are used to describe carburetor operation. These terms actually mean the difference in pressures in carburetor principles.

Venturi

A venturi is used in a carburetor to artificially produce desired flow rates. The term wind tunnel is sometimes used to describe the space between two buildings or structures in which the wind or air pressure is greater than that in an open area. Similarly, a river flows faster through a narrow channel than it does where the channel is wider. These are examples of venturis. The great volume of air or water has to accelerate in order to maintain a constant volume flow. This same principle is used in a carburetor to produce desired air flow patterns.



Venturi



Airfoil

Airfoil

Similar to a venturi an airfoil is used in carburetion to form desired airflow patterns. Airfoils can be compared to a rock in a river. On the upstream side of the rock and around the sides of the rock the velocity of water is high on the downstream side of the rock the velocity is reduced.

Gravity Feed (Flo-Jet) Carburetors

In a gravity feed system the tank is above the carburetor and fuel flows by gravity. An air vent hole in the tank cap allows air to flow in as fuel flows out and a vent hole in the carburetor bowl allows air to flow out as fuel flows in. If one or both of these holes are plugged, the flow of fuel would cease and stop the engine.

As the fuel enters the bowl, it raises the float. The float in turn raises the needle in the float valve. When the needle touches the seat, it shuts off the fuel flow. The position of the float at this time is called the float level.

The float level in general should be high enough to afford an ample supply of fuel at full throttle and low enough to prevent flooding or leaking.

To set the level on the carburetor, the upper body is inverted. In this position the float and the upper carburetor body should be parallel (Fig. 1). If not, bend the tang on the float to obtain this position. There should be one gasket between the float valve seat and the upper carburetor body.

With the float level properly set and the float valve properly operating fuel will fill the carburetor bowl. The fuel in the bowl seeks its own level, which is well below the discharge holes. The discharge holes are in the venturi, the place of greatest air velocity. As the piston in the cylinder moves down with the intake valve open, it creates a low pressure area that extends down into the carburetor throat and venturi. Two things then occur. First the air pressure above the fuel in the bowl pushes the fuel down in the bowl and up in the nozzle (often referred to as the main jet) to the discharge holes. At the same time the air rushes into the carburetor air horn and through the venturi where its velocity is greatly increased.

The nozzle (main jet) extending through this air stream acts as an air foil, creating an even lower pressure area on the upper side. This allows the fuel to stream out of the nozzle through the discharge holes into the venturi where it mixes with the air and becomes a combustible mixture ready for firing in the cylinder.

A small amount of air is allowed to enter the nozzle through the bleeder. This air compensates for the difference in engine speed and prevents too rich of a mixture at high speed.

If engines always ran under optimal conditions and a constant speed then carburetion would be as simple as it is described above. However, we know that engines run under a number of conditions, loads, and speeds.

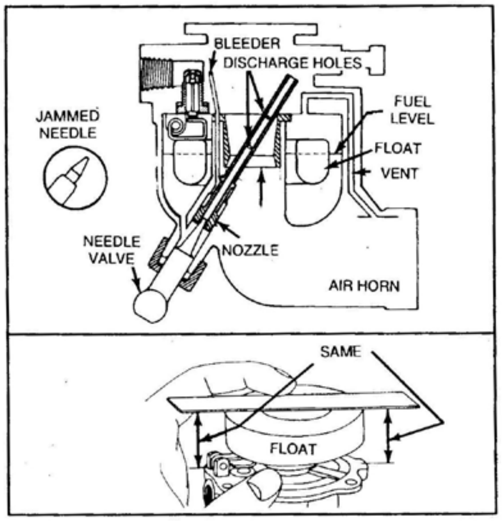


Figure 1 Flo-Jet Carburetor

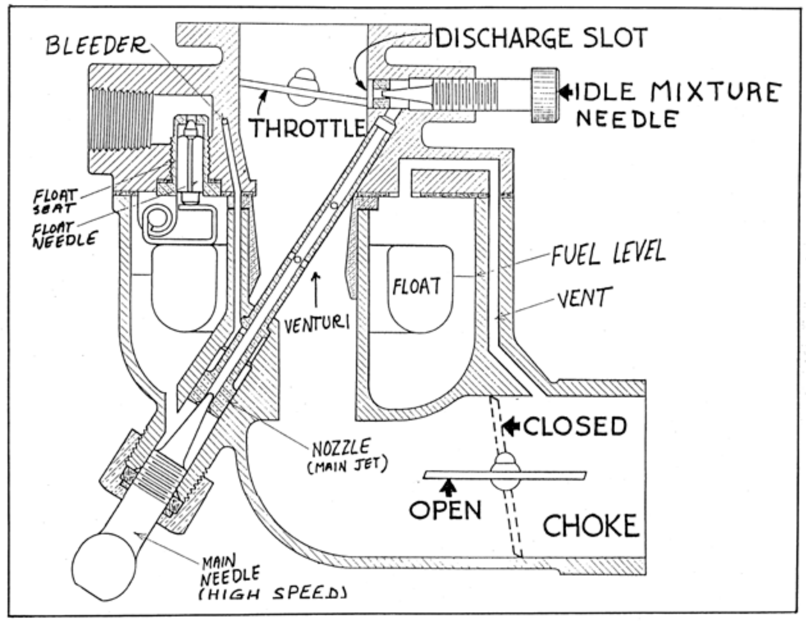


Figure 2 Flo-Jet Carburetor

Flo-Jet Carburetors (Simplified)

Fuel enters the carburetor through the threaded inlet nipple above the float needle (Fig. 2). As the fuel level in the bowl drops the float drops and opens the float needle to allow more fuel to fill the bowl. Fuel from the bowl is then regulated by the main needle as it flows into the nozzle (main jet) (Fig. 2). High pressure air flowing through the venturi (Fig. 2) draws fuel from the fuel bowl through the main jet into the air horn to operate the engine at high speeds.

To operate the engine at an idle the throttle plate closes the air horn which forces fuel through the main jet to the idle mixture needle. Fuel that reaches the idle mixture needle enters the air horn above the throttle plate to enter the intake valve.

Needle Valve

The ideal combustion mixture is 14 or 15 pounds of air in weight to 1 pound of gasoline. An engine operating under heavy load requires a richer mixture than under light load. In order to regulate the mixture, a threaded needle valve with a tapered point which projects into the end of the nozzle (Fig. 1) is used. This needle valve is called the main needle or the high speed needle.

To adjust the carburetor for maximum power the engine is ran at the desired operating speed. The needle valve is turned until the engine slows down, indicating a lean mixture. Noting the position of the needle valve, turn the needle valve out until the engine speeds up and then slows down, indicating a rich mixture. Noting this position of the needle valve, then the needle valve is turned to midway between the lean and rich position. The mixture must be adjusted to the requirement for each engine. Too lean of a mixture is not economical, it causes overheating, detonation, and short valve life. Also, since there is no accelerator pump, the mixture should be rich enough so that the engine will not stop when the throttle is suddenly opened. Engines which run at constant speeds can be slightly leaner than those that require changes in speed.

The above picture shows what happens when the needle valve is turned too far. A square shoulder is produced on the taper. It is possible, of course, to adjust the carburetor with the needle valve in this condition, but it is quite difficult, because a small movement of the needle makes a big difference in the amount of fuel that can enter the nozzle. If is adjusted properly a slight vibration can throw it off.

Throttle

To allow for different speeds, a flat disc called a butterfly, mounted on a shaft, is place in the carburetor throat above the venturi (Fig. 3). This is called the throttle.

The throttle in the wide open position does not affect the air flow to any extent. However, as the throttle starts to close, it restricts the flow of air to the cylinder and this decreases the power and speed of the engine. At the same time it allows the pressure in the area below the butterfly to increase. This means that the difference between the air pressure in the carburetor bowl and the air pressure in the venturi is decreased, the movement of the fuel through the nozzle is slowed down; thus the proportion of fuel and air remain approximately the same. As the engine speed slows down to idle, this changes.

At idle speed the throttle is practically closed, very little air is passing through the venturi and the pressure in the venturi and in the float bowl are about the same. The fuel is not forced through the discharge holes, and the mixture tends to become too lean.

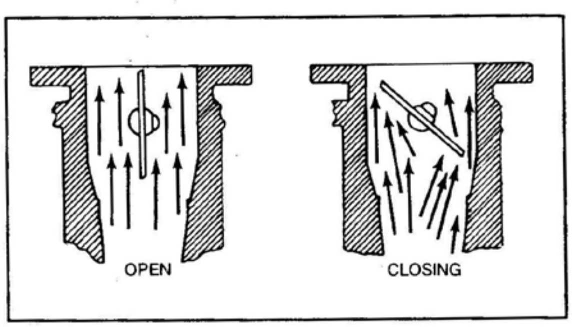


Figure 3 Throttle

Idle mixture valve

To supply fuel for the idle, the nozzle (main jet) is extended up into the idle valve chamber (Fig. 2). It fits snugly in the upper body to prevent leaks. Because of this tight fit, the nozzle must be removed before the upper and lower bodies are separated, or the nozzle will be bent.

The idle valve chamber leads into the carburetor throat above the throttle. Here the pressure is low, and the fuel rises in the nozzle past the idle valve and into the carburetor throat through the discharge slot. The amount of fuel is metered by turning the idle mixture valve in or out until the proper mixture is obtained. A damaged idle valve can be the result of over-tightening the idle valve.

Adjustment of the idle valve is similar to that of the needle valve but should be made after the needle valve has been adjusted. The idle speed is not the slowest speed at which the engine will run. On smaller engines it is 1750 RPM. On larger engines the idle speed may be as low as 1200 RPM. A vibration tachometer can be used to set the speed.

To obtain the desired idle speed, the idle speed adjusting screw (located on the throttle shaft) is turned until the desired idle speed is obtained while the throttle is closed. The idle mixture is adjusted in the same manner as the high speed mixture while the engine is at idle. The idle mixture valve is turned in until speed decreases, and then out until speed increases and again decreases. The final position of the idle mixture screw is at a point midway between these two settings. Usually the idle speed adjusting screw will have to be reset to the desired idle speed.

Choke

Starting the engine in different temperatures and with different fuels can present a problem. A butterfly mounted on a shaft similar to the throttle, called a choke is placed in the air horn. With this choke the air inlet flow can be closed, or almost closed to create low pressure in the venturi and throat (Fig. 2).

Thus, a rush of fuel is obtained from the nozzle with a relatively small amount of air (rich mixture). Even with low vaporization the extra rich mixture allows easy starting. Only a portion of the fuel will be consumed while choking, a large portion will remain in the cylinder. This raw gasoline will dilute the crankcase oil and may even cause scuffing due to washing away of the oil film from between the piston rings and the cylinder wall. For this reason prolonged choking should be avoided.

Vacu-Jet Carburetors

In a Vacu-Jet carburetion system the fuel tank is below the carburetor so fuel does not flow into the carburetor by gravity. Therefore, the force of atmospheric pressure must be applied.

A vent hole in the fuel cap allows the pressure in the fuel tank to remain constant. As the piston goes down in the cylinder with both the intake valve and the throttle open, a low pressure area is created in the carburetor throat. A slight restriction is places between the air horn and the carburetor throat at the choke. This helps to maintain low pressure. The difference in pressure between the tank and the carburetor throat forces the fuel up the fuel pipe, past the needle valve, through the two discharge holes. The throttle is relatively thick, so in effect a venturi is created at this point, thus aiding vaporization. A spiral is placed in the throat to help acceleration and also to help keep the engine from dying when the throttle is opened suddenly.

The amount of fuel at operating speed is metered by the needle valve and seat. Turning the needle valve in or out changes the setting until the proper mixture is obtained. This adjustment must always be done while the engine is running at operating speed, not at idle speed. While the needle valve may look like and idle valve due to its position, it is a true high speed mixture adjusting valve.

Since no accelerator pump is used on this carburetor and since many of these engines are used on lawn mowers where rapid acceleration is needed, the mixture should be rich. The needle valve should be turned in until the engine begins to lose speed, indicating a lean mixture. Then, the needle valve should be opened past the point of smooth operation until the engine just begins to run unevenly. Since this setting is made without load, the mixture should operate the engine satisfactorily under load.

These carburetors do not have an idle valve, but the mixture at idle speed is controlled in a different way. As the throttle closes to idle, the leading edge takes a position between the two discharge holes. The larger of the discharge holes is now in the high pressure area, and the flow of fuel through it will cease. The small hole will continue to discharge fuel but the amount will be metered by the hole size and will be in proportion to the reduced air flow. For this reason it is important that the small discharge hole be of the proper size. The needle valve will allow much more fuel to pass than should go through the small discharge hole. A number 68 drill can be used as a plug gauge to check the small hole. A number 56 drill can be used to check the larger hole. This can be done with the needle valve and seat removed.

A small section is milled out of the throttle where it meets the discharge hole. This concentrates the flow of air past the hole and assures good vaporization.

The idle speed adjusting screw should be set to obtain an idle speed of 1750 RPM. This may seem fast when compared to automotive engines, but it is necessary in order to have fast acceleration. It also helps cooling and lubrication. A slight unevenness may be noticed at idle speed, but this is normal and no readjustments of the needle valve should be made.

The choke is the sliding plate mounted at the outer end of the carburetor. The choke is pushed in to close the air intake for starting but should be pulled out as soon as the engine starts. The use of this choke should be understood clearly. Many complaints of engine trouble, upon investigation prove to be nothing more than failure to properly use the choke, especially where the choke is operated by remote control. The choke must fully close.

Prior to making any adjustments to a Vacu-Jet carburetor, make sure the fuel tank is half full. The distance the fuel has to be lifted will affect the adjustment. At half full we have an average operating condition, and the adjustment will be satisfactory if the engine is run with the tank full or nearly empty. Later model engines with Vacu-Jet carburetors incorporate a ball check in the fuel pipe which assures a steady flow of fuel to the needle valve and discharge holes.

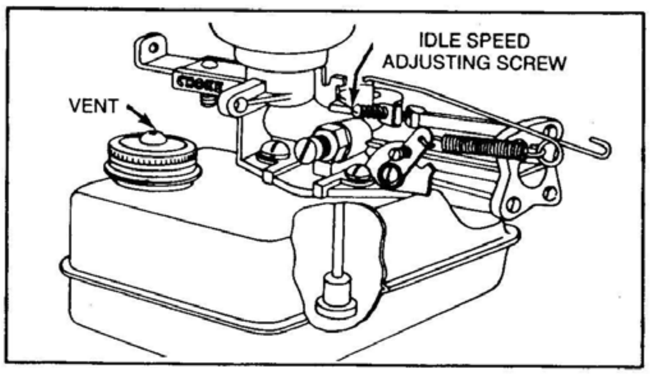


Figure 4 Vacu-Jet Carburetor

Pulsa-Jet Carburetors

The pulsa-Jet is a full carburetor incorporating a diaphragm type fuel pump and a constant level fuel chamber. The fuel tank, the fuel pump and the constant level fuel chamber serve the same functions as the gravity feed tank, the float and the float chamber of conventional “float type” carburetors.

This design makes it possible to obtain just as much horsepower from the Pulsa-Jet carburetor as is obtained form more complex “float type” carburetors. This is due to the fact that the Pulsa-Jet provides a constant fuel level directly below the venturi. With this design, very little fuel lift is required to draw gasoline into the venturi. The venturi can be made larger, permitting a greater volume of fuel/air mixture to flow into the engine with a consequent increase in horsepower.

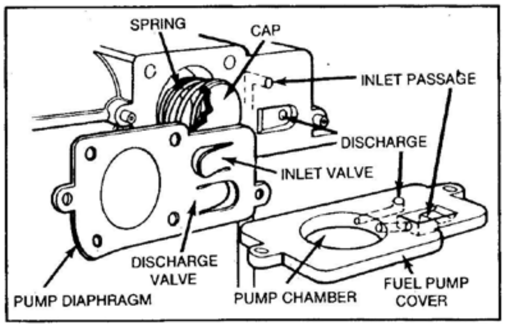


Figure 5 Pulsa-Jet Carburetor

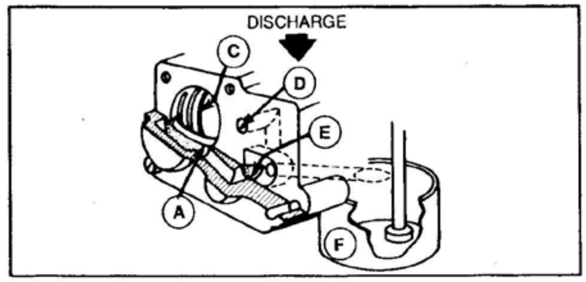


Figure 7

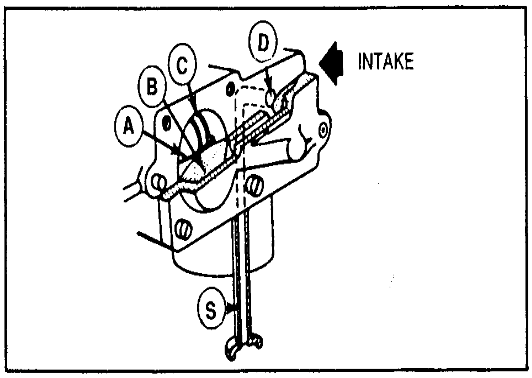


Figure 6

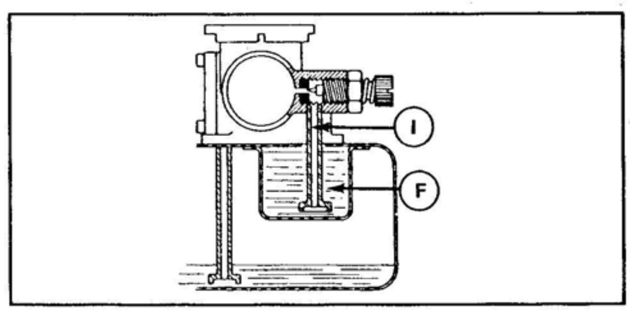


Figure 8

Vacuum created in the carburetor elbow by the intake stroke of the piston pulls cap A and pump diaphragm B inward and compresses spring C (Fig. 6). The vacuum thus created on the cover side of the diaphragm pulls gasoline up suction pipe S and under intake valve D into the pocket created by the diaphragm moving inward.

When engine intake stroke is completed, spring C pushes plunger A outward. This causes gasoline in the pocket above the diaphragm to close inlet valve D and open discharge valve E. The fuel is then pumped into fuel cup F (Fig. 7).

On the next intake stroke the cycle is repeated and this pulsation of the diaphragm keeps the fuel cup full. Excess fuel flows back into the tank. The venturi of the carburetor is connected to intake pipe I which draws gasoline from the fuel cup F (Fig 8). Since a constant level is maintained in the fuel cup, the engine gets a constant air/fuel ratio no matter what fuel level exists in the main tank.

From this point on, the carburetor operates and is adjusted in the same manner as is the Vacu-Jet carburetor except that the fuel tank does not have to be half full as in the Vacu-Jet. It can be full or almost empty and the adjustment will be the same since the fuel level in the small cup is always the same. There are no valve checks in the fuel pipes. The flaps on the diaphragm serve as valves.

Carburetion Quiz

1. List the three types of Briggs & Stratton carburetors.
2. Which type of carburetor has a float?
3. Which type of carburetor has a diaphragm?
4. Which type of carburetor must be adjusted with the fuel tank half full to obtain average operating conditions?
5. As air passes through a venturi it flows faster/slower (choose 1) than air entering the venturi.
6. A closed choke increases/decreases (choose 1) the air flow through the carburetor.
7. A closed throttle plate or throttle butterfly increases/decreases (choose 1) the air flow through the carburetor.
8. A lean mixture has too much air/fuel (choose 1).
9. Choking an engine causes the air fuel mixture to be rich/lean (choose 1).
10. What is the function of needle valves or mixture screws in a carburetor?

Carburetion Quiz KEY

1. List the three types of Briggs & Stratton carburetors.
   Pulsa-jet, vacu-jet, and flo-jet

2. Which type of carburetor has a float?
   Flo-jet

3. Which type of carburetor has a diaphragm?
   Pulsa-jet

4. Which type of carburetor must be adjusted with the fuel tank half full to obtain average operating conditions?
   Vacu-jet

5. As air passes through a venturi it flows faster/slower (choose 1) than air entering the venturi.
   Faster

6. A closed choke increases/decreases (choose 1) the air flow through the carburetor.
   Decreases

7. A closed throttle plate or throttle butterfly increases/decreases (choose 1) the air flow through the carburetor.
   Decreases

8. A lean mixture has too much air/fuel (choose 1).
   Air

9. Choking an engine causes the air fuel mixture to be rich/lean (choose 1).
   Rich

10. What is the function of needle valves or mixture screws in a carburetor?
    Adjusts the flow of fuel

Carburetor Disassembly and Re-assembly

This lesson should be taught prior to or in conjunction with the unit on Carburetor Theory.

Unit Objective:

After completion of this unit, students will be able to disassemble, clean, repair, and re-assemble a carburetor. This knowledge will be demonstrated by completion of a carburetor overhaul.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- List and identify individual engine parts related to carburetion
- Describe the operation of 3 different types of carburetors (Flo-Jet, Pulsa-Jet, and Vacu-Jet)
- Describe the function(s) of individual carburetor parts
- Adjust carburetors to proper air/fuel mixtures and speeds
- Understand diaphragm pumps
- Understand concepts of motion and forces such as Bernoulli's principle, gravity, venturi, air foil (Standard 648.04)

Teaching Time:
This unit should take 10 hours to complete (2 hour disassembly lecture 3 hr. student working time, 2 hr. re-assembly lecture and 3 hour student working time).
Plan for at least a week to order parts between disassembly and re-assembly

Steps for students to complete before the next lesson: (repair manual section 3)
Disassemble carburetor,
Order carburetor parts
Flatten carburetors
Clean carburetor
Wrap clean carburetor parts in a clean rag and store
Memorize model number of their engine
Re-assemble carburetor when parts arrive

Teaching Materials:
Tools: Flat Screwdrivers
- End wrenches 3/8", ½", 9/16"
- Needle nose pliers
- Diagonal cutting pliers
- Carburetor Cleaner

Parts: Examples of three different types of carburetors
Class set of carburetors (2 students per carburetor)

Bowl type (flo-jet) Carburetor
- Float
- Float needle & seat
- Choke butterfly
- Main Jet
- Main adjusting screw
- Idle mixture screw
- Idle speed screw
- Throttle butterfly
- Throttle shaft bushings
- Venturi

Suction type (vacu-jet) carburetor
- Choke butterfly
- Fuel pipe (has check ball)
- Idle speed screw
- Throttle shaft
- Main adjusting screw
- Needle seat

Pulsa-jet carburetor
- Choke butterfly
- Diaphragm
- Fuel pipes (1 long, 1 short)
- Idle speed screw
- Throttle Shaft
- Main adjusting screw
- Needle seat

Resources:
- Briggs & Stratton Repair Manual section 3
- Video “Carburetor Theory” by Briggs & Stratton
- Projections of pictures and diagrams in this section
- “Operational Theory of Carburetion” section of this curriculum guide

Teaching Activities:
Show Carburetor video

Explain 3 types of carburetors
Identify parts on 3 types of carburetors
Use class set of carburetors to have students (2 students per carb.) disassemble and re-assemble for practice. Lay a rag on the table below where the carburetor is held, the rag will keep small parts from rolling off the table.

Flo-jet carburetors

Disassembly

-Observe bleeder hole in upper body-clean hole with a wire or oxy-acetylene tip cleaner

-Observe drain in bottom of bowl – should be covered with a felt filter

-Check space between upper and lower bodies – should be less than 0.002" with feeler gauge.

-Check throttle and choke shafts and bushings for wear – if more than 0.010" of play then bushings need to be replaced. Loose throttle shaft allows dirt into cylinder

Disassembly:
-Remove packing nut on main needle and remove main needle from lower body

-Use a carburetor screwdriver to remove main jet (careful not to damage brass screw head)

The main jet goes through the lower body and screws into the upper body. The main jet must be removed before the upper and lower bodies can be separated.

-Note the position of the upper body in relation to the lower body. Also note the position of the hook for the fuel line under one of the screws.

-Remove 4 screws holding the upper and lower bodies together. Do not separate yet, only remove screws.

-Point the fuel inlet nipple on the upper body upward and separate the upper and lower bodies. Damage to the float is possible if the carburetor is not positioned correctly before the bodies are separated.

-The purpose of the float is to maintain a full bowl of fuel to be used by the engine, similar to a float in a toilet tank.

-The float should be attached to the upper body. Turn the upper body so it is upside down, in this position the float should be parallel with the plane of the upper body. If it is not parallel bend the tang on the float where it contacts the float needle to adjust it to parallel.

-Use needle nose pliers to remove the float pin, lift gently on the float and remove the float needle. Remove the bowl gasket.

-Unscrew the float seat with a big flat screwdriver. Make sure that there is a gasket (small round washer) under the float seat. Remove that gasket.

-Pull the venturi and gasket (round washer) from the lower body.

-Unscrew idle mixture needle – inspect all needle tips for burrs or flattened ends.

-Use the information in the carburetion theory section to explain how gas flow is adjusted, how it gets from the fuel inlet nipple to the cylinder.

Re-assembly

Re-assemble the carburetor by using the above steps in the opposite order.

Note: If there is excess corrosion between the seating surfaces of the main jet and the lower body the carburetor will leak gas from the bowl. A main jet can be made into a tool to grind the surface inside the lower body. Grind the threads off around the outside of a bad main jet so it will easily fit into the hole in the lower body. Use some valve grinding compound on the seating surface of this main jet and insert it into the lower body. Turn the main jet about 1/8 of a turn back and forth repeatedly to clean any corrosion inside the lower body. Be sure to clean out all valve grinding compound before re-assembly.

Pulsa-jet carburetors

Disassembly

-Remove tank from carburetor – turn tank and carb. upside down to separate

-Remove fuel tubes – plastic tubes will be threaded, brass tubes are pressed in – note position of long and short fuel tubes – remove pressed in tubes with diagonal cutting pliers by prying upward against the bottom of the carburetor while gently squeezing the tube. See picture below.

-Check condition of fuel screens in ends of tubes – clean if necessary

-Remove diaphragm cover – explain operation as explained in "operational theory of carburetion" section

-Remove diaphragm spring and cap – note positions (cap protects diaphragm)

-Remove air cleaner gasket

-Remove high speed mixture screw – do not put in carburetor cleaner, the rubber o-ring will be damaged by the cleaner.
-Remove high speed screw

-Remove main jet and seat note washer (main jet looks like the float seat of a flo-jet carburetor)

-Check tightness of throttle shaft

-Check tightness of manual choke – can be tightened by hitting rivet

-Order new intake tube seal and new diaphragm

Reassembly

Re-assemble the carburetor by using the above steps in the opposite order.

Plastic tubes will be fine in the carburetor cleaner but do not put any rubber parts in the carburetor cleaner.

Fuel Tube Removal

Vacu-jet carburetors

-Observe and discuss operation of automatic choke housing on the outside of the carburetor (thermostatic choke spring) – see "Operational Theory of Carburetion"

-Remove 5 tank to carb. Screws (model series 110000 may have a screw inside the air horn) and separate tank from carb. – turn tank and carb upside down to separate.

-Note position of springs – the larger spring goes on the carburetor side of the gasket

-Remove main adjusting needle and seat – note washer

-Remove fuel tube – check screen

-Check operation of check valve

-Check throttle shaft for wear.

-Check tightness of choke shaft – can be tightened by hitting rivet

-Remove choke housing cover

-Unhook choke spring and remove diaphragm

Reassembly

Re-assemble the carburetor by using the above steps in the opposite order.

Later model Vacu-jet carburetors have few or no adjustments or replacement parts. These carburetors are inexpensive to replace.

Cleaning Carburetors

-Disassemble all carburetor parts except throttle and choke – unless throttle and choke are worn

-Separate all rubber parts (intake tube seal, diaphragm, o-rings on main needle, main needle packing)

- It is important that all mating surfaces be flat to prevent air from entering the carburetion system from anywhere other than the air cleaner. Bend corners of surfaces slightly upward with a crescent wrench and a vise. Flatten the bottoms of pulsa-jet and vacu-jet carburetors. Also flatten engine mounting surface of bolt on carburetors. Use a disc sander if available or a piece of glass covered with a sheet of emery paper (220 grit). Flatten the tops of tanks where carburetors mount only if they are non-magnetic (aluminum). Use a flat piece of steel wrapped with 220 grit emery cloth for tank tops. See pictures below.

-Place all metal parts and fuel tubes in a parts basket and soak in carburetor cleaner for 15 to 30 minutes. Use a 5 gallon metal bucket with a lid to hold carburetor cleaner. Napa has a good carburetor cleaner. If the cleaner doesn't stink and remove paint then it's not very good.

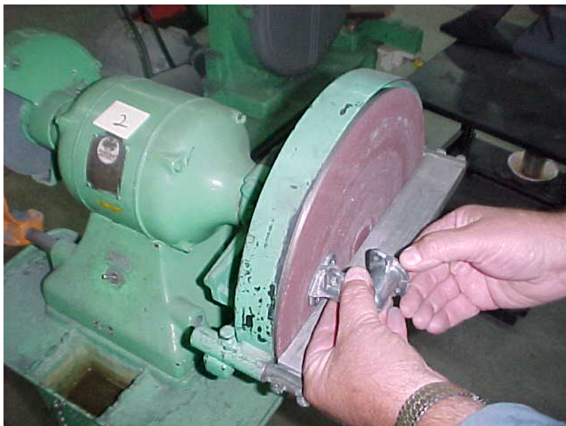
-Wear safety glasses and rubber gloves when using carburetor cleaner

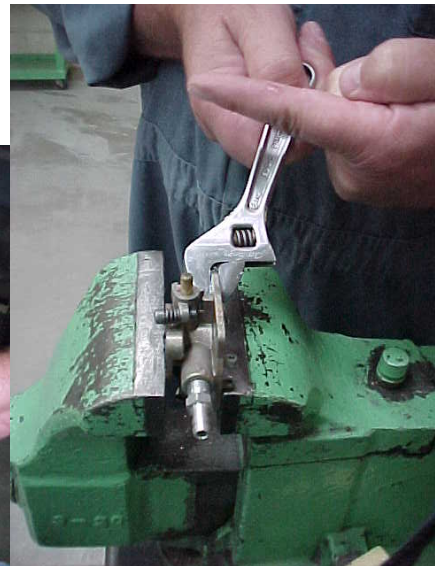
-At the end of the soak hold parts over the bucket and allow carburetor cleaner to drain from parts into the bucket

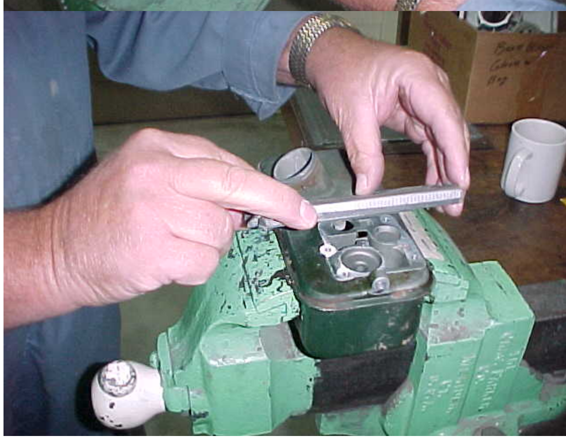
-Wash parts and basket with hot water and bushes

-Use compressed air to blow through all passages of the carburetor

-Wrap all parts in a clean shop rag until new parts arrive for re-assembly







Repairing gas tanks:

Rust in a gas tank will cause plugged jets in the carburetor. If a gas tank is rusted on the inside, get as much rust as possible broken loose and out with a pressure washer. Then use a bead blaster to remove more rust. Clean tank with water and blow dry with compressed air after bead blasting to remove all abrasives.

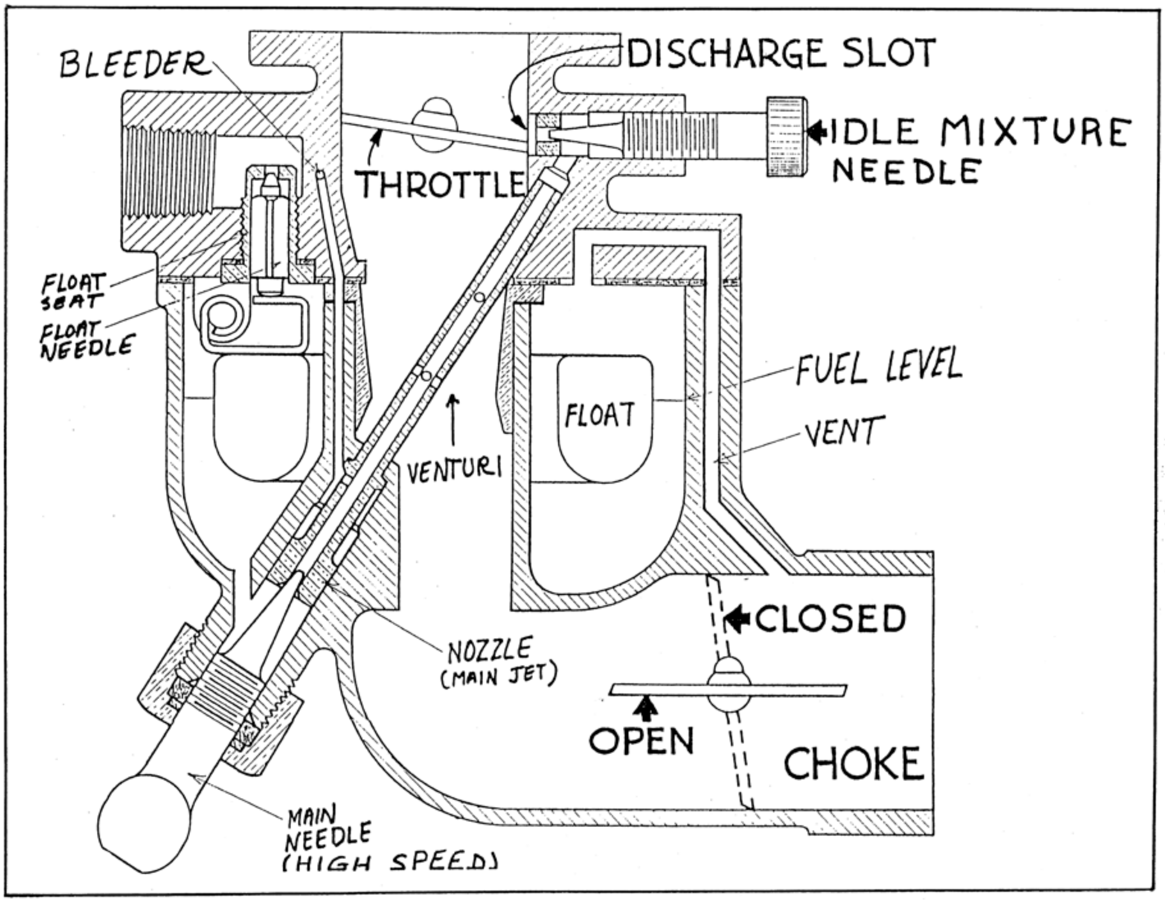
A tank sealer can be sloshed around the inside of the tank to seal the rust from the inside. A good tank sealer is "U.S. Standard Fuel Tank Sealer" from the makers of POR 15. Some auto parts dealers may have it in stock or be able to order it. Or it can be ordered online at http://www.por15.com/.

Cover any holes (carburetor mounting holes) in the tank with tape and pour enough of the slushing compound into the tank to coat all sides. Turn the tank over and slosh the compound around enough to coat interior tank surfaces. Pour any excess compound from the tank back into the tank, remove what won't pour out with a turkey baster. The slushing compound does not wash off, cover working area with paper.

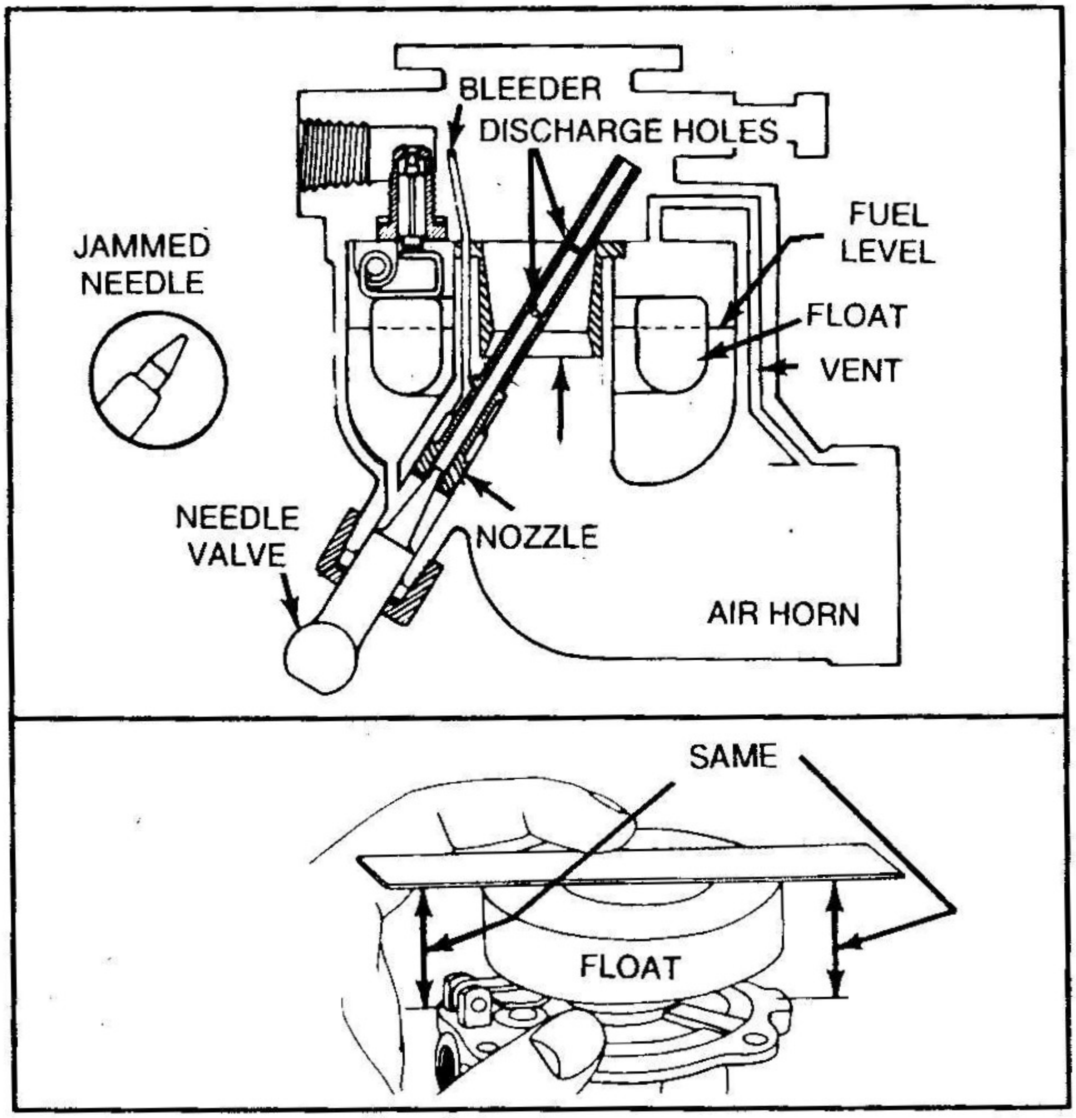
The compound requires at least 72 hours to dry. Position the tank so any excess compound will not clog fuel holes in the tank while drying.

If a tank has a relatively small hole in it, the best way to fix it is with JB Weld. Attempts to weld tank holes normally fail because welding, brazing, or soldering usually requires enough heat that the factory soldered tank joints melt and then leak.

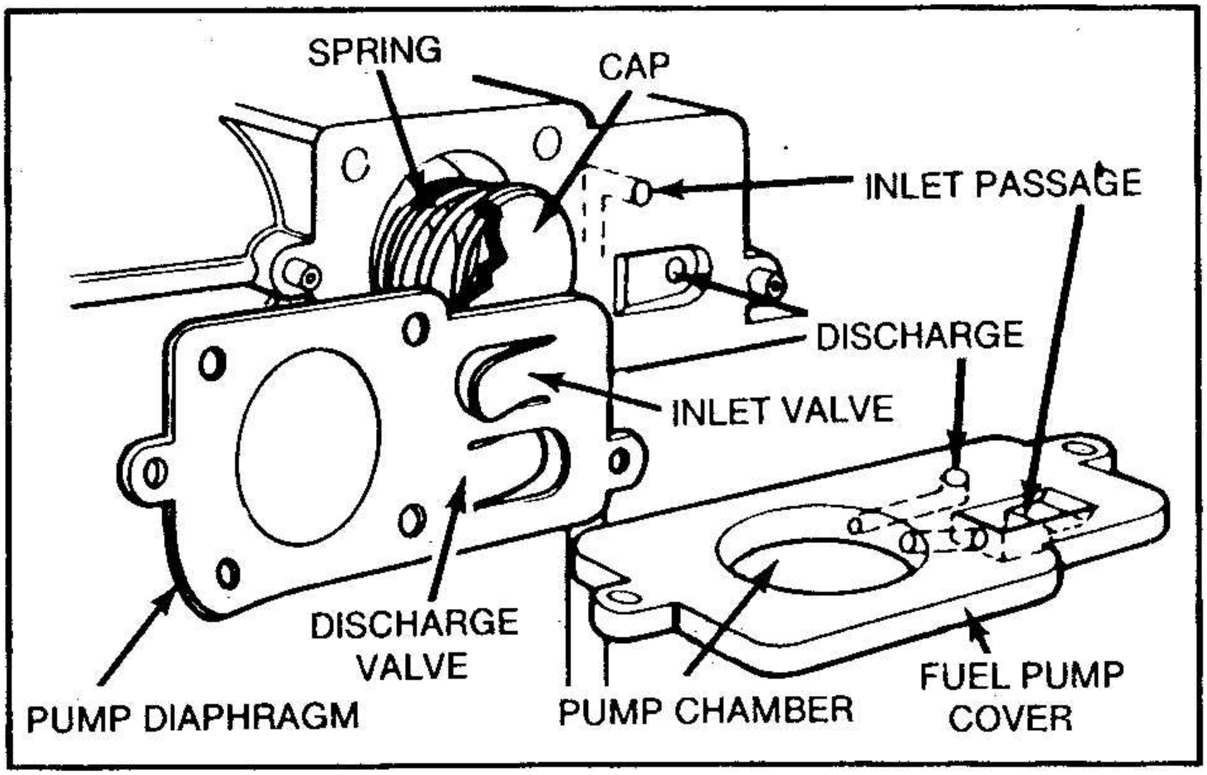
Tank slushing tools



Flo-jet carburetor



Float Level of Flo-jet Carburetor



Pulsa-jet Carburetor

Parts Ordering

Unit Objective:

After completion of this unit, students will be able to obtain part numbers and order engine parts. This knowledge will be demonstrated by completion of a assignments with 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Identify engine parts from an exploded view
- Associate reference numbers with part numbers and prices
- Communicate technical information (Standard 658.02)

Teaching Time:
This unit should take 3 to 5 hours to complete (1 hour lecture and 2 to 4 hours for students to work)

Steps for students to complete before the next lesson:
List all necessary parts
Look up part numbers
Look up prices

Steps for teacher to complete before next lesson:
Check each parts order
Deliver parts to be machined (valves if no grinder is available, crankshaft if it is to be undersized on the rod journal)

Teaching Materials:

Resources:

- Briggs & Stratton Repair Manual
- Briggs & Stratton Service and Parts Manuals
- Briggs & Stratton Master Price List
- Briggs & Stratton Microfiche
- Engine Measuring Sheet
- http://www.briggsandstratton.com

Teaching Activities:
Demonstrate parts ordering
Hand out practice ordering worksheet in this section
Have students complete parts order sheets in this section for their engine.

Part Numbers:

Briggs & Stratton Service and Parts Manuals are no longer available for ordering parts. All parts manuals are available online or on CD. Microfiche is still available however it is only updated quarterly. Hard copies of the master price list can still be ordered from Briggs & Stratton.

The Briggs & Stratton web site has illustrated parts lists (IPL) available to find part numbers. Go to http://www.briggsandstratton.com, click on "select your region and language" under Briggs & Stratton engines. Click on English under North America, click on "Owner's manual and illustrated parts list", click on "Engine IPLs", enter the engine model number and type number in the text boxes and click the search button. Scroll down to the search results and click on "View PDF" of the best match to your search. This will bring up a list of parts for the selected engine model in Adobe.

When the IPL appears be certain that the engine model and type number falls within the range of models listed on the first page. For example for a Model number 130252 type 1540 the first page of the IPL is for models 130200 to 130299 and type numbers 1535 through 1543.

Scroll down through the exploded views of engine parts until the necessary part is found. There is a reference number (picture number) with each part. Make a note of the reference number (picture number) and then scroll further down to the parts description and parts number page. The reference numbers are in numerical order on these pages. Find the correct reference number and then write down the corresponding part number.

Parts that are shown inside a box come as a complete assembly. For example, to order for a model 130252 type 1540 engine a complete connecting rod assembly (with rod, rod cap, oil dipper, rod bolt lock, and rod cap bolts) is listed as reference number 29. Or a single part such as the rod bolt lock would be reference number 31.

Pay attention to the notes listed on the part number pages. For example the part number for a standard connecting rod assembly is 299430 but the number for a connecting rod with an undersized crankpin bore is 390459 for a model 130252 type 1540 engine.

Hard to find Part Numbers:

Part numbers for valve guide bushings are listed in the Repair manual in the tables of the compression section (section 6). To order new valve guide bushings the old valve guide bushings will have to be pulled out. To select the correct part number for valve guide bushings the old bushings must be compared to the pictures and descriptions in section 6. See instructions for pulling valve guide bushings later in this section.

Not all engines have factory installed valve guide bushings. Factory installed bushings are only on the exhaust side. If the engine has been overhauled before it may have valve guide bushings for both valves.

Rivets to plug the point plunger hole can be ordered from http://www.mcmaster.com. The rivets are #7 X ½" copper belt rivets (part number **97537A170)**. A one pound box is $11.44.

The part number for a retro-fit magnetron electronic ignition module is 394970.

Part numbers for short blocks and decal kits are typically found on microfiche. If microfiche is not available call a dealer or call Briggs & Stratton.

Part Pricing:

To find prices for parts, once all of the part numbers have been found, go back to the Briggs & Stratton home page and click on "Shop for Briggs & Stratton Parts". Enter the part number in the appropriate text box for part numbers and click search.

The hard copy of the price list has the part numbers listed in numerical order. Part numbers may change in the parts list. For example, when it is found in the price list, part number 262306 (governor spring) has a note to use part number 262323. Be sure to record the latest part number from the price list.

Part numbers also change when looked up online. The online parts pricing system does not bring number changes to attention. Therefore, double check each part number after the price has been displayed. If the part number listed with the price is different than the part number entered, use the latest part number (the number listed with the price).

Ordering Parts:

Parts can be ordered online or the Briggs & Stratton web site has a dealer locator. It is often easier to have the dealer order parts when ordering multiple parts for the entire class.

If parts are ordered over the phone or in any case where part numbers are given verbally Briggs & Stratton has a specific system for communicating part numbers. If the part number is 5 digits such as 23513 the number is pronounced as twenty three, five thirteen. If the part number is 6 digits such as 293538 it is pronounced as two ninety three, five thirty eight.

After Market Parts:

After market parts can be ordered from Stens Corporation. Parts from Stens are considerably less expensive than original Briggs & Stratton parts. Common parts that can be ordered from Stens include but are not limited to:

- Air cleaners
- Ring sets
- Carburetor diaphragms
- Fuel tank shut-off valves
- Speed control cables
- Fuel line
- Connecting rods
- Valves
- Gasket sets

The Stens Corporation has a website for online ordering at http://www.stens.com/ or call 800-628-5827. http://www.stens.com/

Common Parts:

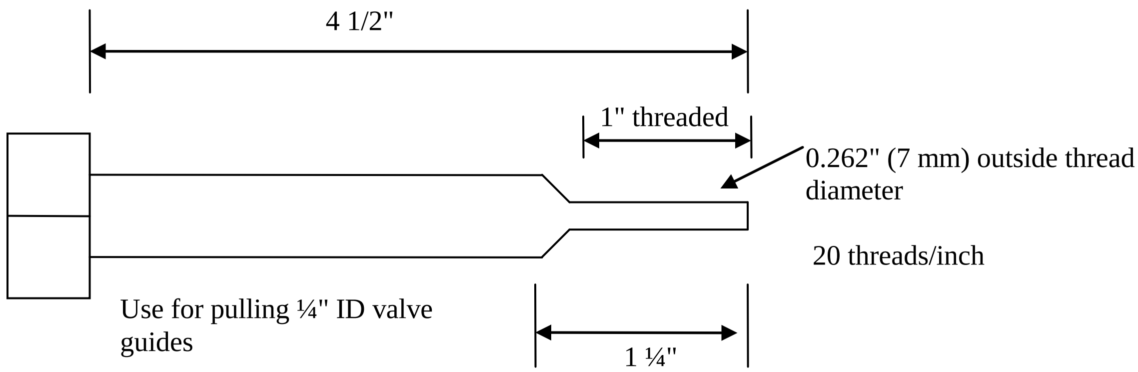
The following is a list of parts that are common on any engine model and can be purchased in quantities rather than on separate student orders:

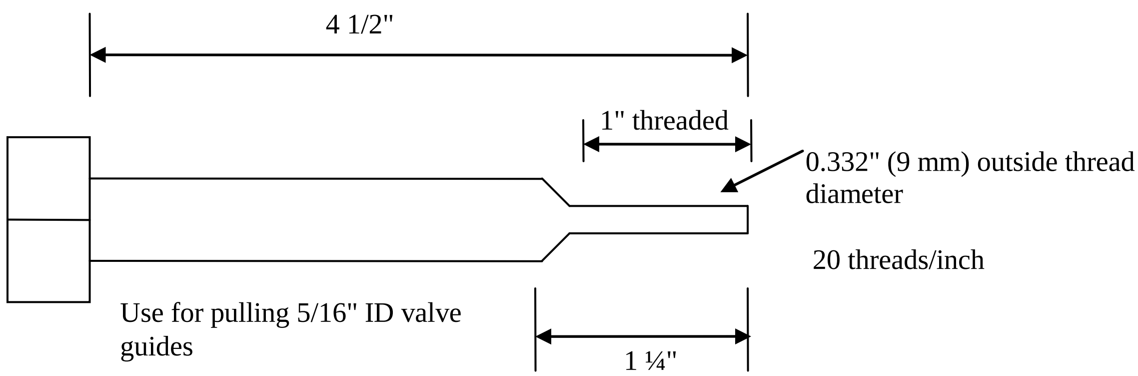
Spool of starter rope
Spool of fuel line ¼"
Hose clamps 5/16"
Spark plugs
Electronic ignition modules
Flywheel keys
Case of engine oil

Pulling Valve Guides:

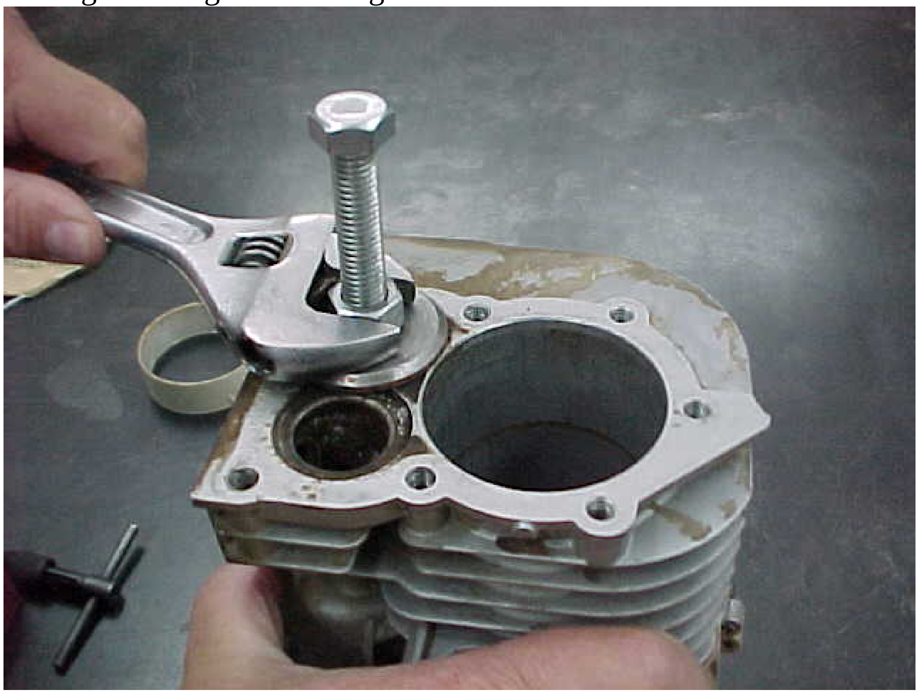
Pulling valve guides requires a special tool, Briggs & Stratton tool #19239 for 5/16" valve guides or Briggs & Stratton tool #19272 for ¼" valve guides. The ¼" valve guide tool requires the valve guide to be tapped with a 7 mm tap and the 5/16" tool requires the guides to be tapped with a 9 mm tap. Thread the valve guides with the correct tap no more than ¾" from the top of the valve guide. Thread the correct puller into the valve guide and tighten the nut and washer against the valve seat to pull the valve guide. The compression section (section 6) gives detailed instructions and illustrations for pulling valve guides.

The valve guide pulling tools can be made on a lathe as shown in the drawings below. A ½" X 4 ½" bolt can be turned down to the proper diameter on the end and threaded with a die.

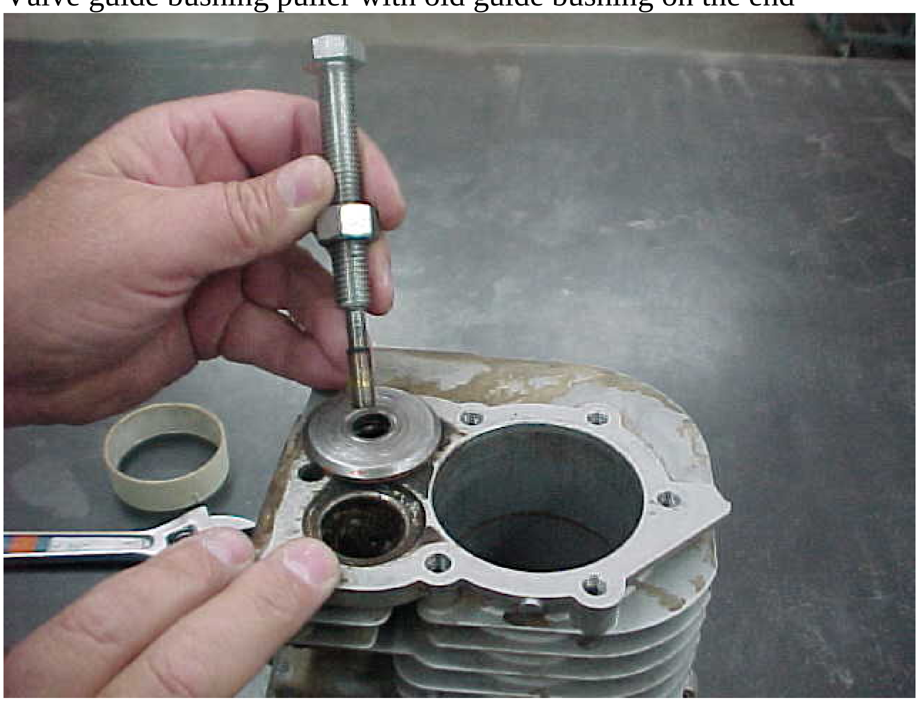




Pulling a valve guide bushing



Valve guide bushing puller with old guide bushing on the end



PARTS ORDERING WORKSHEET

Model 130252 Name______________________________
Type 1540-01
Serial No. 70100971

Part Description	Picture No.	B&S No.	Price	*Check
Crankshaft				
0.020 Under Rod				
Mag. End bushing (includes oil seal)				
Intake Valve				
Valve guide - exhaust				
0.020 over piston				
Throttle shaft				
Piston Pin				
Gasket Set				
Breather Grommet (attaches to breather)				
Electronic Ignition Module				
Point plunger plug				
Spark Plug (1 1/2") Non-Resist				
Governor spring				
Governor link spring				
Cam Gear				
Throttle shaft felt washer				
Carburetor Diaphragm				
Decal Kit				
	Total cost			4 hrs. labor $144
	Cost of a new engine			
	Cost of a short block			
	Total cost if short block is used			1 hr. labor $36

*Parts that still need to be ordered if short block is used

PARTS ORDERING WORKSHEET

Model 130252 Name______________________________

Type 1540-01

Serial No. 70100971

Part Description	Picture No.	B&S No.	Price	*Check
Crankshaft	16	492090	$95.35	
0.020 Under Rod	29	390459	$22.85	
Mag. End bushing (includes oil seal)	2	297565	$12.85	
Intake Valve	34	261044-s	$8.50	
Valve guide - intake	RM 6-11	63709	$3.30	
Valve guide - exhaust	RM 6-11	231348	$3.70	
0.020 over piston	25	298906	$47.50	
Throttle shaft	97	691946	$8.80	X
Piston Pin	28	298909	$2.70	
Gasket Set	358	495603	$16.85	
Breather Grommet (attaches to breather)	11	692187	$1.35	X
Electronic Ignition Module	Find on newer engine IPL	394970	$12.10	X
Point plunger plug		692882	$2.50	
Spark Plug (1 1/2") Non-Resist	337	492167-s	$3.60	X
Governor spring	209	692208	$3.40	X
Governor link spring	232	690545	$3.90	X
Cam Gear	46	6911164	$36.65	
Throttle shaft felt washer	634	270167	$1.20	X
Carburetor Diaphragm	394	270026	$1.25	X
Decal Kit	Microfiche white 18	491100	$12.30	X
		Total cost	$300.65	4 hrs. labor $144
		Cost of a new engine	$323.30	
		Cost of a short block (use microfiche yellow 6C or call dealer)	No longer available	
		Total cost if short block is used		1 hr. labor $36

*Parts that still need to be ordered if short block is used

PARTS ORDER SHEET

Model__________________________ Student Name______________________________

Type ____________________________
Serial
No.________________________ Owner Name___________________________________

Part Description	Picture No.	B&S No.	Price	*Check
	Total cost		$0.00	4 hrs. labor $144
	Cost of a new engine			
	Cost of a short block (use microfiche yellow 6C or call dealer)			
	Total cost if short block is used			1 hr. labor $36

Major Engine Failure Analysis

Unit Objective:

After completion of this unit, students will be able to associate causes with effects of major engine failure. This knowledge will be demonstrated by completion of a quiz with 85 percent accuracy.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Identify engine parts that are obviously worn
- Associate worn parts with the cause of wear
- Understand constancy , change, and measurement (Standard 648.03)

Teaching Time:
This unit should take 2 hours to complete

Steps for students to complete before the next lesson:
Major engine failure analysis quiz
Work on removing paint

Steps for teacher to complete before next lesson:
Check status of parts orders

Teaching Materials:
Parts:
Examples of worn, scored, discolored, or broken parts

Resources:
"Major Engine Failure Analysis" video by Briggs & Stratton
Briggs & Stratton Repair Manual

Teaching Activities:
Show "Major Engine Failure Analysis" video by Briggs & Stratton
Display examples of engine parts and explain the signs of failure related to each part.
Give written quiz included in this section
Prepare a quiz on engine failure analysis, use actual parts or pictures in this section

Knowing the causes of engine failures can save you time and allows discussion of the failure reasons with the engine owner.

Four most probable causes of major engine failure:

Abrasive grit
Lack of lubrication
Overheating
Over speeding

<u>Abrasive Grit:</u> Abrasive grit can enter the engine in a number of ways, such as:

Through an improperly serviced or missing air cleaner
Through loose throttle or choke shaft
When the oil plug or dipstick is removed
Insufficient cleaning during overhaul

Abrasive grit can enter an engine at almost 25 MPH through the air cleaner. When this occurs, an examination of the air cleaner assembly will reveal the presence of abrasives around the air cleaner stud and on the engine side of the air cleaner.

From the air cleaner, abrasives travel through the carburetor and accumulate on carburetor parts. This can cause excess wear of the throttle and choke shafts and bushings.

One of the most distinctive signs of abrasives passing through the carburetor is a unique wear pattern found on the intake valve. Each time the valve opens and closes some of the abrasives are caught between the valve face and seat. Soon the valve seat wears wider, toward the cylinder and a groove develops on the valve face. Some of the abrasives are dragged down into the valve guide to eventually wear the valve guide.

Once through the intake valve the abrasives are drawn into the cylinder. At 3600 rpm the piston changes its direction of travel 120 times each second. While abrasives are present, the rings wear rapidly resulting in excessive ring end gaps. In addition, the cylinder also becomes worn. The cylinder's crosshatch pattern is erased, and at the top of ring travel in the cylinder, a ridge is developed. An engine which receives regular and proper maintenance will continue to show crosshatch patterns even after hundreds of hours of rugged use.

Abrasive grit can cause additional destruction on all internal parts such as, crankshaft journals and main bearings.

The main symptom of failure from abrasive grit is scratched or pitted parts and wear beyond reject sizes.

Lack of Lubrication: Operating an engine with an insufficient amount of lubrication causes temperatures to increase beyond what the engine can tolerate. Excessive temperatures cause discoloration of internal parts. Parts most commonly found discolored are the connecting rod, crankshaft journals, main bearings, piston pin, piston skirt, and the cylinder.

Besides discoloring parts, the increased operating temperatures also change the working clearances between the crankshaft journals and their respective mating bearings, resulting in more scored bearing surfaces. When two or more crankshaft journal bearing surfaces are scored, the engine has usually been run, at sometime, with an insufficient amount of lubrication.

When scoring is isolated to a single crankshaft journal bearing surface, the cause can usually be attributed to: a manufacturing defect involving that bearing surface, or the manner in which the engine had been mounted to the application. For example, excessive belt tension, misalignment between engine and equipment, etc.

The main symptom of failure from lack of lubrication is discoloration of parts that require lubrication.

Overheating: An accumulation of debris within the cylinder fins prevents the circulation of air and the cooling of critical engine areas. A partial restriction of the cylinder fins is sufficient to increase the operating temperatures of the engine above normal. When this condition occurs, damage can result.

Excessive engine operating temperatures produce "Hot Spots" within the cylinder. These same higher temperatures can also cause the cylinder to fluctuate in size, preventing proper conforming and sealing of the piston rings. Excessive oil consumption and smoking result. Since metal expands with increased temperatures, the excessive heat generated from plugged cylinder fins, especially in the valve area, can produce sufficient expansion to loosen the exhaust valve seat. In some extreme instances, the exhaust valve corner of the cylinder may warp. This condition can be detected by placing a straight edge across the head gasket mounting surface on the cylinder. Loss of compression and a blown head gasket result.

When the engine continues to run in an "overheated" condition, crankcase oil loses it's viscosity because of the continuous "cooking" it experiences at the higher temperatures. Besides losing effective lubrication, the "cooked" oil is reduced to a tar like substance within the crankcase.

The main symptoms of failure from overheating are discoloration and warping of parts.

Over speeding: A connecting rod that breaks as a result of over speeding may not necessarily show signs of discoloration, scoring or seizure. However, it is very typical of a rod which has failed due to over speeding to break very close to the piston pin.

The real potential dander of an over speeding condition is the flywheel exploding. This occurrence is not usually considered by most individuals, even those with many years of engine experience. As engine speed increases, centrifugal forces working upon the flywheel also rapidly increase. Sufficient forces can be obtained causing the flywheel to explode. Removing a flywheel by striking it with a hammer, or prying underneath it with a screwdriver, increases someone's chances of experiencing a flywheel exploding.

Major Engine Failure Cause and Effect Relationships

<table>
<tr><th>Cause</th><th>Effect</th></tr>
<tr><td>Improper or Infrequent air cleaner service. Damage air cleaner mounting gaskets or bent air cleaner stud.

A & B</td><td rowspan="5">A. Premature Wear
B. Seizure
C. Breakage
D. Scoring
E. Over speeding
F. Overheating
G. Excessive Oil Consumption/Smoking</td></tr>
<tr><td>Insufficient amount of lubrication.
B, C, D, & F</td></tr>
<tr><td>Misadjusted Governor/Bypassing Governor
E, C, B</td></tr>
<tr><td>Plugged cooling fins
F, E, C, & G</td></tr>
<tr><td>Loss of crankcase vacuum
G, B, C, D, & F</td></tr>
</table>

Major Engine Failure Analysis Quiz

Name_______________

1. Engine wear is normally associated with:

   a. dirt or similar abrasive
   b. insufficient amount of oil
   c. Over speeding
   d. Over heating

2. A cylinder measures 0.002" over standard at the top and 0.005" at the bottom. Abrasive grit most likely entered the engine through the:

   a. Air cleaner
   b. PTO oil seal
   c. Oil inlet when oil was added
   d. Carburetor throttle shaft

3. When an engine becomes worn from abrasive grit, the complaint that usually comes from the engine owner is:

   a. the engine lacks power, smokes and uses too much oil
   b. runs too fast
   c. seizes
   d. hunts and surges

4. An engine which has consumed and excessive amount of abrasive grit it will normally have:

   a. scored and discolored bearing surfaces
   b. a warped head
   c. no cross hatching in the cylinder
   d. a worn exhaust valve face

5. An engine that has run with and insufficient amount of oil will:

   a. always break a rod
   b. score only the cylinder
   c. cause internal discoloration and scoring of two or more bearing surfaces
   d. cause cylinder discoloration

6. If an engine has scoring at only one bearing surface the cause was likely:
    a. Over speeding
    b. Overheating
    c. Improper engine mounting
    d. Insufficient lubrication

7. When a connecting rod breaks due to over speeding, it most likely:
    a. will score and turn black
    b. was partially broken or fractured prior to the over speeding
    c. not discolor and break close to the crankshaft
    d. not discolor and break close to the piston pin

8. Plugged cooling fins will cause:
    a. over speeding
    b. over heating
    c. excessive oil consumption
    d. broken connecting rod

9. If an engine is suspected of over speeding, which should be considered:
    a. insufficient oil level
    b. plugged cooling fins
    c. misadjusted governor
    d. abrasive grit entering an improperly service air cleaner

10. Warping and discoloration from over heating will most likely occur on the:
    a. crank shaft
    b. cam shaft
    c. connecting rod
    d. head

Major Engine Failure Analysis Quiz

Name_____KEY__________

1. Engine wear is most often associated with:

   a. dirt or similar abrasive
   b. insufficient amount of oil
   c. Over speeding
   d. Over heating

2. A cylinder measures 0.002" over standard at the top and 0.005" at the bottom. Abrasive grit most likely entered the engine through the:

   a. Air cleaner
   b. PTO oil seal
   c. Oil inlet when oil was added
   d. Carburetor throttle shaft

3. When an engine becomes worn from abrasive grit, the complaint that usually comes from the engine owner is:

   a. **the engine lacks power, smokes and uses too much oil**
   b. runs too fast
   c. seizes
   d. hunts and surges

4. An engine which has consumed and excessive amount of abrasive grit it will normally have:

   a. scored and discolored bearing surfaces
   b. a warped head
   c. no cross hatching in the cylinder
   d. a worn exhaust valve face

5. An engine that has run with and insufficient amount of oil will:

   a. always break a rod
   b. score only the cylinder
   c. cause internal discoloration and scoring of two or more bearing surfaces
   d. cause cylinder discoloration

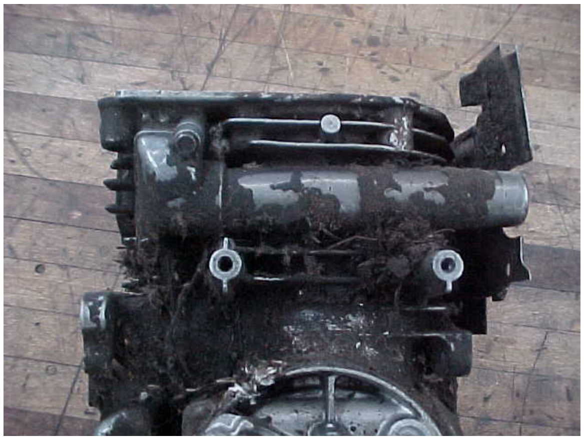
6. If an engine has scoring at only one bearing surface the cause was likely:
    a. Over speeding
    b. Overheating
    c. Improper engine mounting
    d. Insufficient lubrication

7. When a connecting rod breaks due to over speeding, it most likely:
    a. will score and turn black
    b. was partially broken or fractured prior to the over speeding
    c. not discolor and break close to the crankshaft
    d. **not discolor and break close to the piston pin**

8. Plugged cooling fins will cause:
    a. over speeding
    b. **over heating**
    c. excessive oil consumption
    d. broken connecting rod

9. If an engine is suspected of over speeding, which should be considered:
    a. insufficient oil level
    b. plugged cooling fins
    c. **misadjusted governor**
    d. abrasive grit entering an improperly service air cleaner

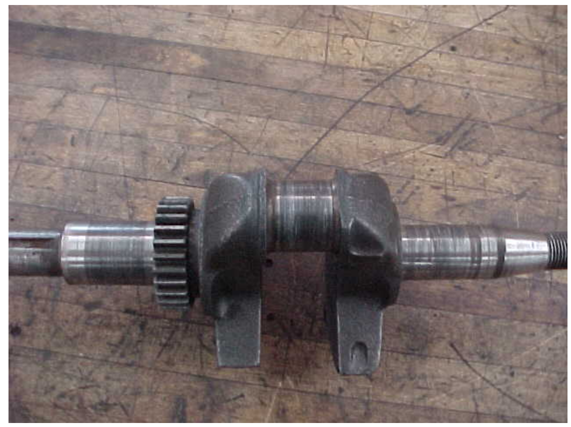
10. Warping and discoloration from over heating will most likely occur on the:
    a. crank shaft
    b. cam shaft
    c. connecting rod
    d. **head**

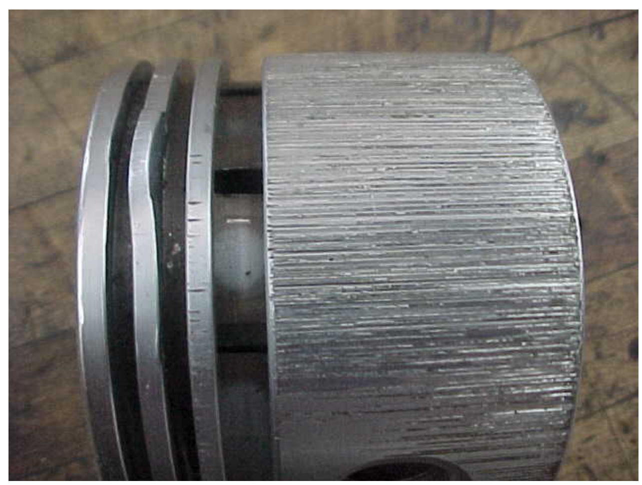

Clogged Cooling Fins


Discolored and warped head surface from overheating, caused by clogged cooling fins in above picture.


Loose valve seat caused by expansion and contraction from over heating


Discolored piston pin and damaged piston caused from overheating


Scored and discolored crankshaft journals from insufficient lubrication


Worn piston from abrasive grit


Bent air cleaner screw allows abrasive grit to enter engine


Cracked breather grommet allows abrasive grit into engine.


Cracked air cleaner grommet allows abrasive grit into engine.


Broken connecting rod near piston pin from over speeding


Broken block from broken connecting rod


Scored crankpin bearing from insufficient lubrication.

Rewind Starters

Unit Objective:

After completion of this unit, students will be able to disassemble, clean, repair and re-assemble rewind starters. This knowledge will be demonstrated by completion of student engines.

Specific Objectives and Competencies

After completion of this unit students will be able to:

- Identify the parts of a rewind starter
- Properly use tools for assembling rewind starters
- Listen for information (Standard 754.01)
- Read for technical information (Standard 658.02)

Teaching Time:
This unit should take 2 to 3 hours to complete (1 hour lecture and 1 to 2 hours for students to work)

Steps for students to complete before the next lesson:
Clean spring and housing
Rewind starter with new rope

Steps for teacher to complete before next lesson:
Pick up parts orders

Teaching Materials:
Tools:

- Diagonal cutting pliers
- Matches
- Bench grinder
- Flat Screwdriver
- Rope inserting tool
- Rewind starter tool
- Tang bending tool
- Locking pliers

Parts:

- Blower housing
- Rewind Starter or vertical pull starter
- Starter Rope
- Rope handle

Resources:

- Briggs & Stratton Repair Manual (section 7A)

Teaching Activities:

Demonstrate disassembly, cleaning, and re-assembly of rewind starter and/or vertical pull starter.

Have students write down steps for disassembly, cleaning and re-assembly

Starter Rewinding

The Starters and Charging Systems section (section) of the Repair Manual explains the steps for starter rewinding. A few helpful tips are listed below:

Only one tang needs to be bent up on the back of the blower housing to remove the rewind starter.

When re-assembling the starter there should be 1/16" clearance between the pulley and the tangs holding it in.

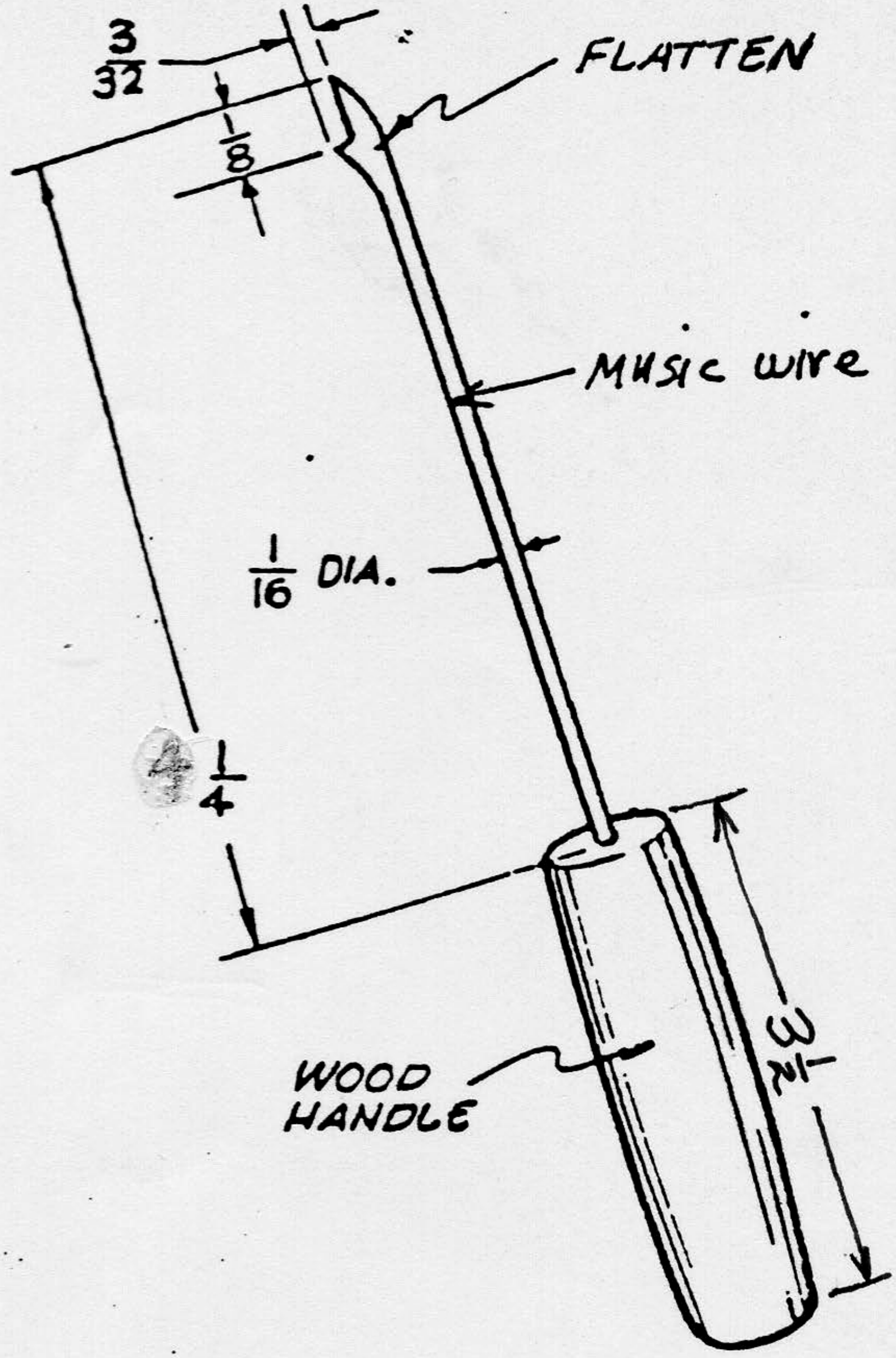
Use diagonal cutting pliers to cut rope.

Use a bench grinder to remove old knots from starter handles.

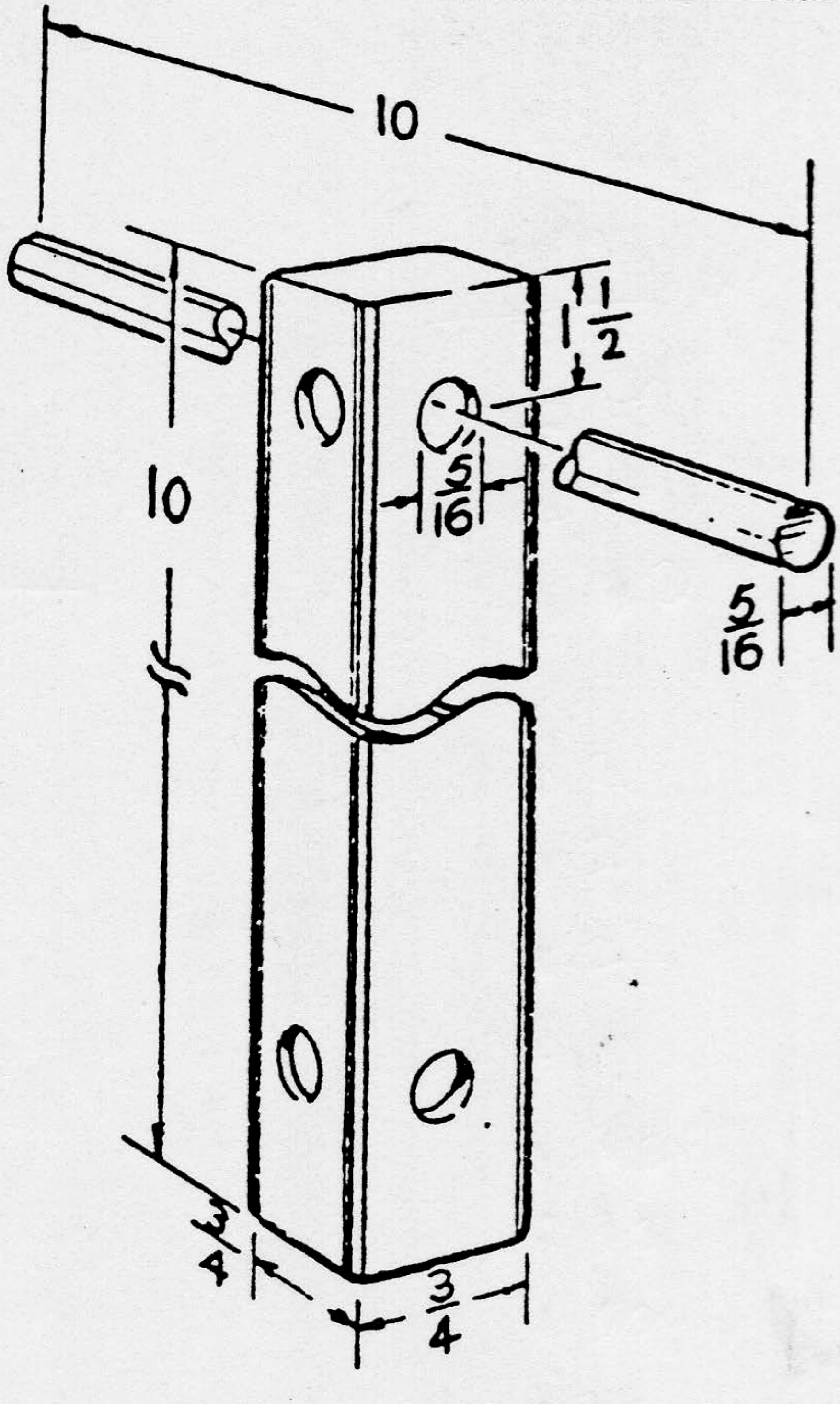
The illustrated parts lists from http://www.briggsandstratton.com will give rope lengths for each engine model

Clamp a pair of locking pliers to the end of the spring when rewinding to prevent the spring from going all the way into the housing.

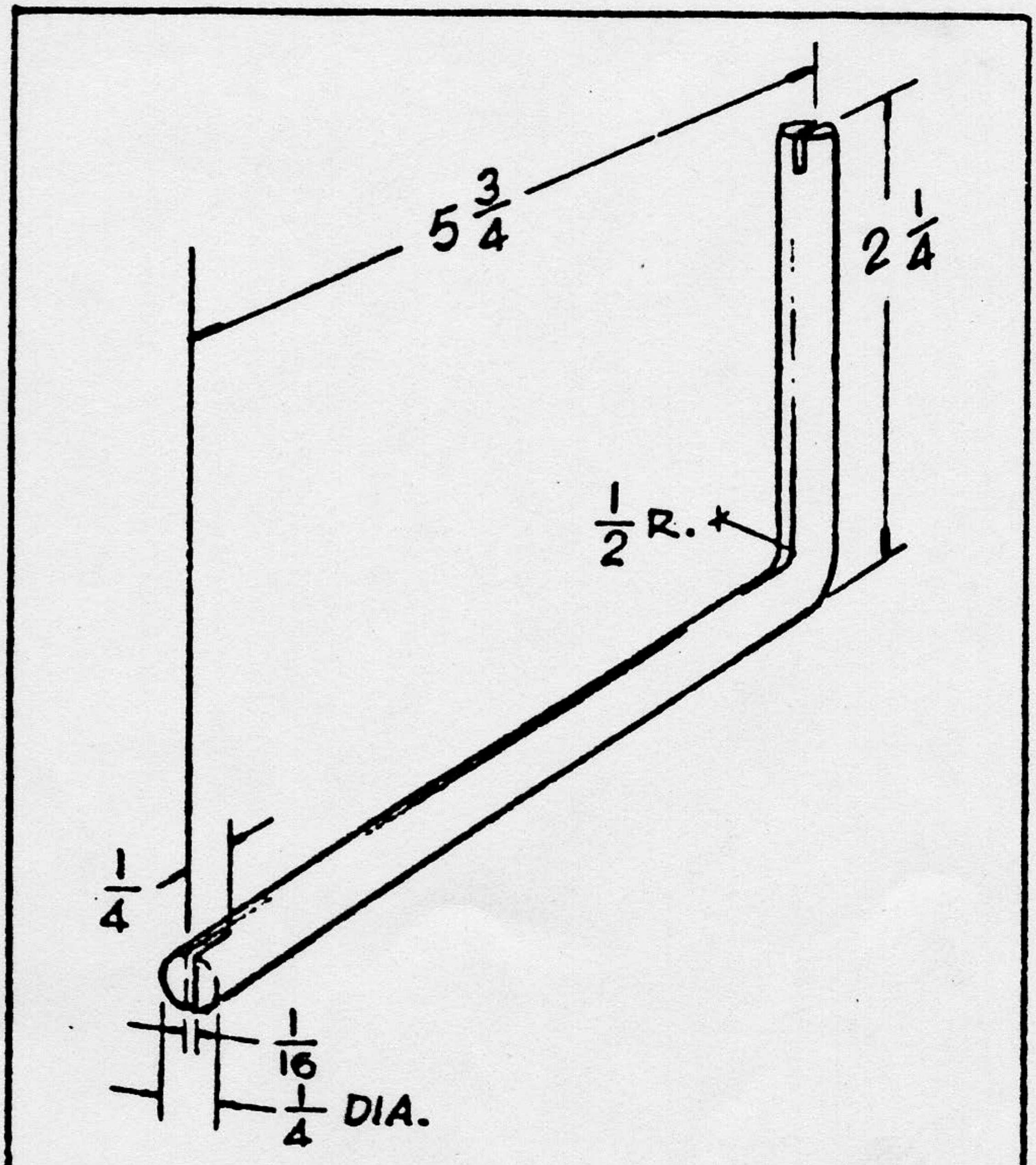
The rope inserting tool, rewind starter tool, tang bending tool, and quantum starter tools, can all easily be made in the shop. See the drawings below.



ROPE INSERTER



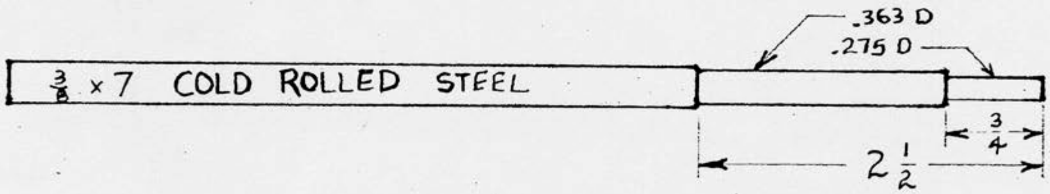
REWIND STARTER TOOL



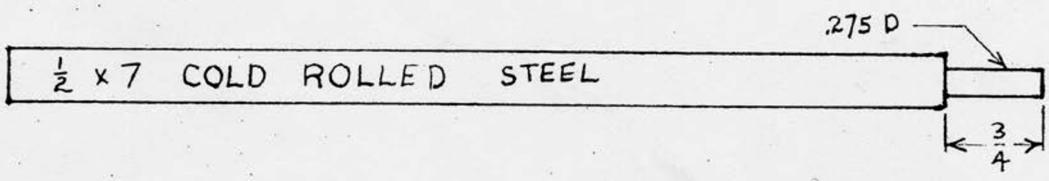
TANG BENDING TOOL

QUANTUM STARTER TOOLS

PIN REMOVER



PIN INSTALLER



USE 1" PIPE 4" LONG FOR ANVIL

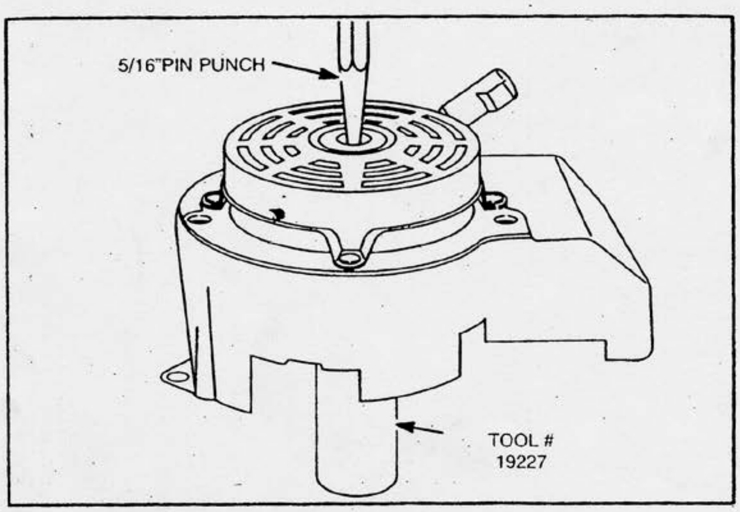


Fig. 37 – Removing Center Pin

REFER TO BRIGGS REPAIR MANUAL
FOR COMPLETE INSTRUCTIONS

Machine Work

Unit Objective:

After completion of this unit, students will be able to perform machine work necessary to bring worn engine parts back to factory specifications. This knowledge will be demonstrated by completion student engines.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Install point plunger bushing or plug
- Install new valve guide bushings
- Replace valve seats
- Replace main bearings
- Grind valve faces
- Cut valve seats
- Resize cylinder or break glaze
- Listen for information (Standard 754.01)
- Read for technical information (Standard 658.02)

Teaching Time:
This unit should take 10 to 12 hours to complete (2 hours for lecture and 8 to 10 hours for students to work)

Steps for students to complete before the next lesson:
If required for their engine:

- Install point plunger bushing or plug
- Install new valve guide bushings – repair manual section 6
- Replace valve seats – repair manual section 6
- Replace main bearings – repair manual section 11
- Grind valve faces
- Cut valve seats
- Resize cylinder or break glaze – repair manual section 11
- Clean all engine parts

Steps for teacher to complete before next lesson:
Check on any back ordered parts
Order parts that didn't get ordered with the first order
Check each engine to make sure all machine work is complete

Teaching Materials:
Tools:

- Point plunger reamer and driver set
- Valve guide reamer and driver set
- Valve seat drivers, pilots, and staking chisel
- Main bearing reamer and driver set
- Valve grinder
- Valve seat cutters
- Cylinder hones
- ½" electric drill
- Hammer
- Soap brushes to clean engines
- Parts Cleaner

Parts:

- Block
- Sump cover
- Valves
- Bearings
- Valve guides
- Valve seats

Resources:

- Briggs & Stratton Repair Manual

Teaching Activities:

Demonstrate all steps of machine work. Not all student engines will require every step. Use different student engines for each step so all students can see each process.

Complete Engine Overhaul:

A complete engine overhaul means that every part of the engine was replace or repaired back to factory specifications.

Cause and Effect of Worn Parts

Part	Effect if worn	How to repair	Tools used for repair
Point plunger	oil gets on points - loss of ignition spark	Install new bushings	Center bore reamer, finish reamer, pilot guides
Valve guides	Blow-by - loss of crankcase vacuum and smoking	Install new bushings	Counter bore reamer, pilot guides, finish reamer
Main bearings	Damages oil seals, can effect spark timing, low oil pressure	Install new bearings	Counter bore reamer, pilot guides, finish reamer
Rusty fuel tanks	Rust in carburetor jets	Clean tank and coat with slushing compound	pressure washer, bead blaster, turkey baster

Special Tools:

Machine work requires special reamers, guides, pilots, and cutters. Many of these tools can be purchased online at http://www.ezbore.net/index.html or from Briggs & Stratton.

Vise mounting plates:

Vise mounting plates can be made to bolt onto the engine block where the sump or head would normally bolt on to allow the block to be held in a vise. Patterns for vise mounting plates are at the end of this section.

Reamer and Cutter Care and Use:

Reamers and valve cutters are expensive. Blade life can be prolonged by making sure that they are not laid on steel tables. Use a rag or a rubber mat between steel tables or use wood surfaces for machine work.

Reamers should always be turned clockwise. Do not turn them backwards.

Always use a lubricant with reamers. Kerosene is a good lubricant for aluminum.

Reamer pilot guides should always be used to ensure that the bore is straight.

Installing point plunger bushings:

If engine is converted to electronic ignition, drive a #7 X ½" copper belt rivet into the point plunger hole and skip this step.

1. Install a vise mounting plate on the engine block.
2. Check to see if a brass bushing has previously been installed. If a brass bushing is worn, it must be driven through with a special bushing driver.
3. Install correct reaming guide on armature mounting surface.
4. Counter bore ream all the way thru the point plunger hole using kerosene-hone oil mix for lubricant.
5. Blow out chips.
6. Take reaming guide off.
7. Drive a new bushing in until flush with the top of point plunger hole using a bushing driver.
8. Reinstall reaming guide.
9. Finish ream using kerosene-hone oil mix as lubricant. Ream all the way through the bushing.

Installing Valve Guide Bushings:

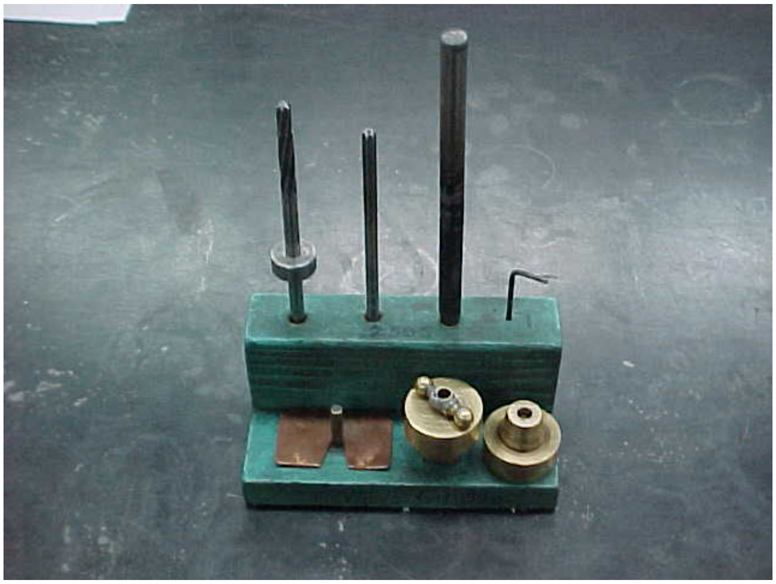
1. Install a vise mounting plate on the engine block.
2. Check to see if a brass bushing has previously been installed. If brass bushing is worn, it must be pulled and identified so that a new bushing can be ordered (this should have been done with the parts ordering lesson).
3. Place reamer guide on valve seat and place counter bore through reamer guide and into valve guide to the depth that the reamer will begin cutting. Set depth control stop so that counter boring will be 1/16" deeper than new bushing.

    Caution: Reset depth gauge for each guide – intake and exhaust may be at different depths.

4. Counter bore using kerosene as lubricant. Hold guide firmly and keep drill straight. Do not turn drill off until reamer is out of valve guide.
5. Blow out chips.
6. Drive in new bushing flush with top of guide. If the valve guide bushing has grooves around the outside, install it with the grooves toward the bottom of the guide.
7. Install small guide bushing into main reamer guide.
8. Place a small steel plate over tappet holes so that reamer does not enter tappet holes. Hold guide firmly and keep finish reamer straight. Finish ream all the way through valve guide using kerosene as a lubricant.

Some valves may have a burr on the end of them that will not allow them to fit into new valve guide bushings. Remove the burr with a file.

Valve guide bushings can be replaced without removing the sump cover and internal parts. Remove the head and valves cover the tappet holes and be careful not to get any shavings or grit into the cylinder or crankcase.


Valve guide bushing reamers, and pilot guides

Replacing Main Bearings:

1. Install a vise mounting plate on the head surface of engine block.
2. Pry out oil seal with rolling head pry bar if not already out.
3. Insert reamer guide bushing in oil seal housing of bearing to be replaced.
4. Insert pilot guide in opposite bearing and assemble base on engine block with 4 bolts.
5. Counter bore using kerosene.
6. When counter boring is completed, disassemble base from block and clean everything with compressed air. Remove reamer guide bushing (not necessary for finish reaming).
7. Determine where split in bushing will be when bushing is installed. Notch bushing housing opposite the split on outside edge of housing. Dress off notch with knife.

    Caution: Use a bearing support jack to keep from bending the cylinder housing.

8. Drive in new bushing.
9. Stake bushing with staking chisel. Dress off stakes with knife.
10. Reassemble base with pilot guide and finish ream (make sure base is clean)

Caution: Use light pressure and plenty of kerosene

11. Do not install oil seal at this time.

Do not finish ream DU bearings.

Grinding Valves:

Problems with valves: Valves must fully seat for two reasons. First compression, if the valves are not fully seated there will be a loss of compression. Second, the only time valves have to cool is when they are seated. The larger surface area surrounding the seated valves draws heat from the valves. Valves need to be properly ground to ensure prolonged engine life.

New valves have a margin width of 1/32", if valves are ground there should be at least ½ of the margin left surface left. If the margin width is less the 1/64" of an inch after grinding, a new valve should be installed. The surface area of the margin is necessary to dissipate heat away from the valve every time it seats.

If a valve grinder is not available there are a couple of options. New valves can be purchased. New valves will fully seat without being ground. Or some engine machine shops will grind outside valves for a reasonable cost.

Valve grinders are several thousand dollars to purchase new. However, a valve grinder can occasionally be purchased inexpensively at an auction.

Burned valves will not seat.
Improperly ground valves will not seat.
If all of the pitting in the valve face is not ground out the valve will not fully seat.
Oil can blow by the valve stem if it is worn down.

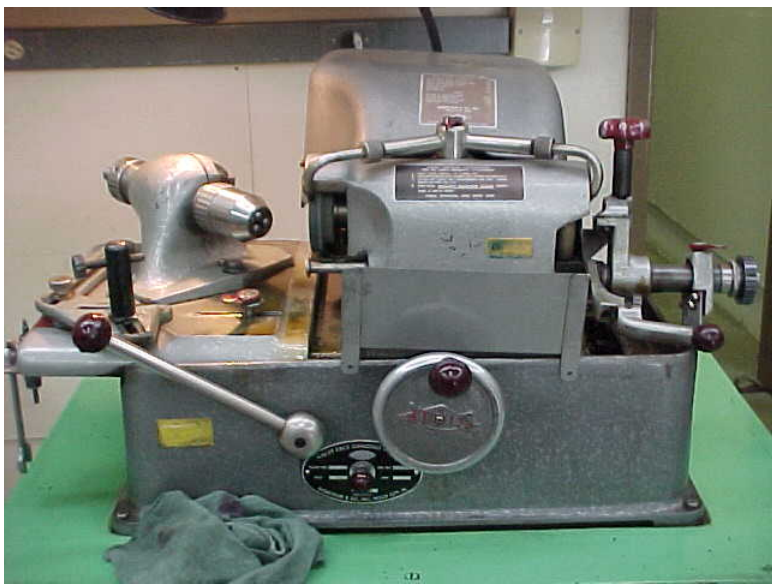
Some Briggs & Stratton engines have ¼" diameter valve stems and others have 5/16" diameter valve stems.

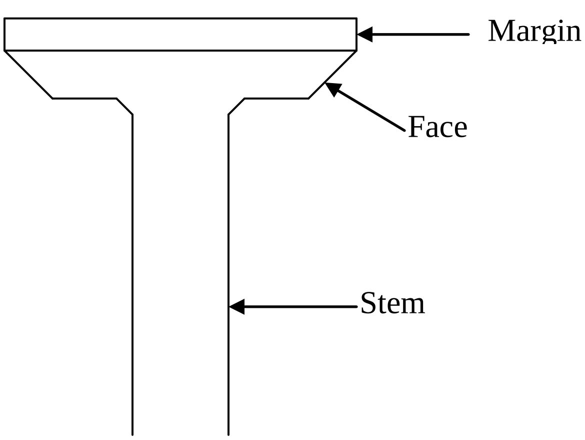
Some Briggs & Stratton valve faces are ground at 30 degrees and others are 45 degrees. If the faces of the two valves from the engine are matched together the stems of the valves will be parallel if both faces are 45 degrees. Model series 100000, 130000, 190000, use 30 degree intake valve faces on later model engines – early model engines use 45 degrees for both valves.

The instructions below are for a Sioux valve grinder. Other valve grinders will be similar.

1. Dress the grinding stone after every 4th valve.

2. Set the depth of the chuck so the valve is held by the un-worn portion of the stem. (Just above the worn portion).
3. Chuck the valve while holding it firmly against the inside of the tapered shaft.
4. Check the face angle of the valve.
5. Set the table stop nut so the stems of the valve and the chuck will stop before hitting the grinding wheel.
6. With the valve face close to and in front of the stone, turn on the valve grinder. Adjust the oil flow.
7. Slowly move the stone to the valve and move the table back and forth until the entire face of the valve is ground clean (no more grinding noise).
8. **Never** remove valve from stone sideways while stone is turning.
9. When valve is finished, back stone away from valve and turn off oil and then turn off machine.


Sioux Valve Grinder

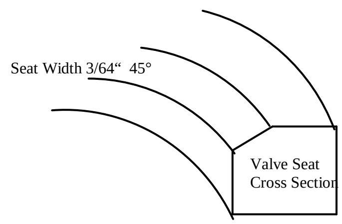


Valve parts

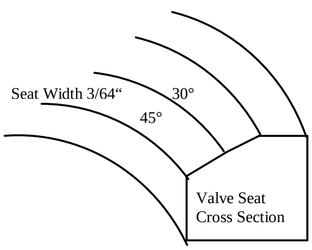
Valve Seat Cutting:

Valve seat cutting is just as important as grinding valves to ensure valve cooling and good compression. The instructions listed below are for a Neway Valve Seat Cutter Kit. The kit can be purchased for about $170 at http://www.ezbore.net/index.html. Other valve seat cutter kits will have similar instructions.

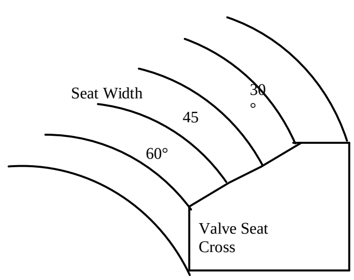
1. Clean valve guide. Use black felt tip marker to color seat.
2. Insert proper pilot into valve guide and tighten
3. Check angle of desired seat and place proper cutter on pilot.
4. Use speed wrench to turn cutter and cut seat to width of 3/64".



5. If seat is too wide, but is equal width all the way around, cut the top of the seat down with the next shallower cutter i.e., if a 45° seat is being reconditioned, use a 30° cutter to narrow it.



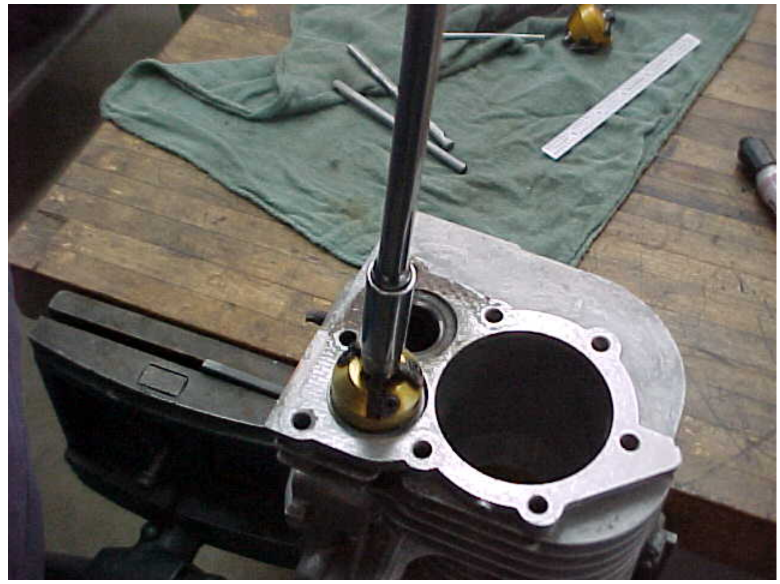
6. If seat width is not the same all the way around, use steeper cutter than shallower cutter to trim original seat to proper width. Then use original cutter to remove burrs.



7. Apply a small amount of valve grinding compound to valve face and lap the seat. Only rotate 15°.

8. Check finished job by applying small amount of bluing to valve and rotate it against the seat.

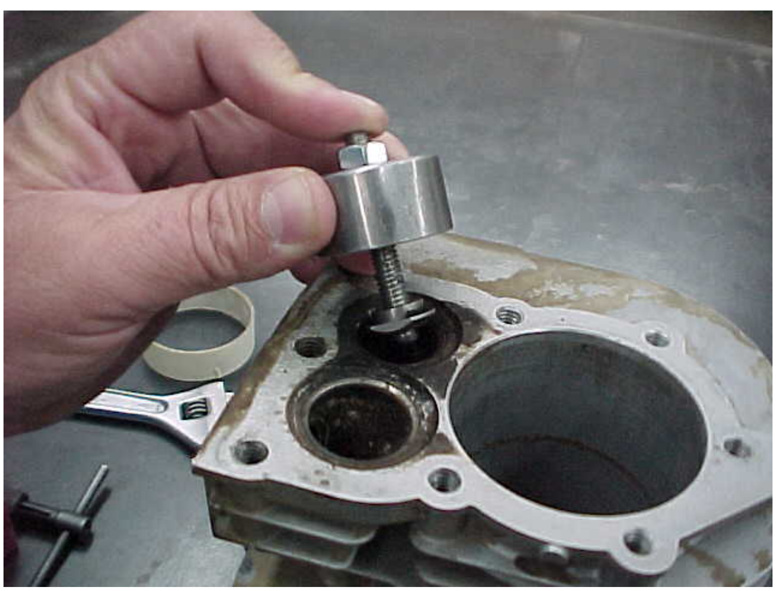
Valve seat cutter kit, valve lapping compound, engine block with vise mounting plate.



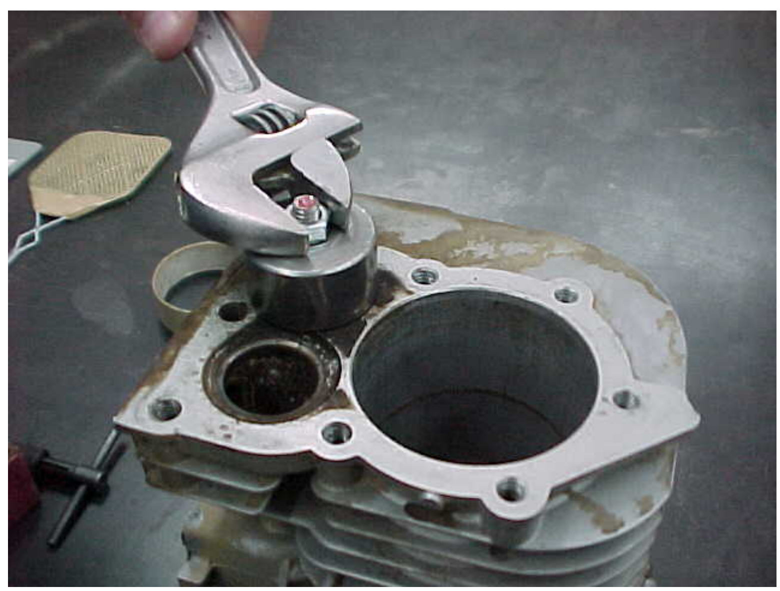
Cutting valve seats

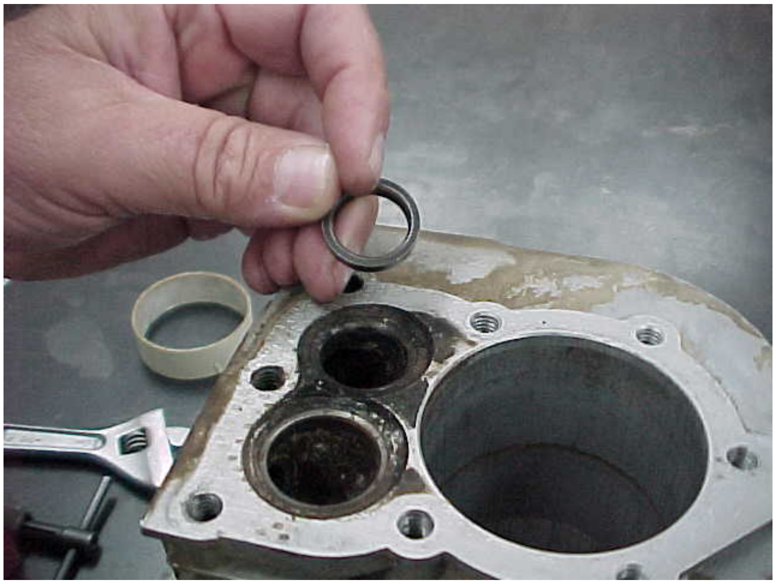
Replacing Valve Seats:

1. Pull out the original seat using a valve seat puller as shown below.
2. Clean out carbon with a knife around valve seat housing.
3. Using a valve seat driver (shown below) drive the new seat in.
4. Stake valve seat with staking chisel. Dress off stakes with knife.

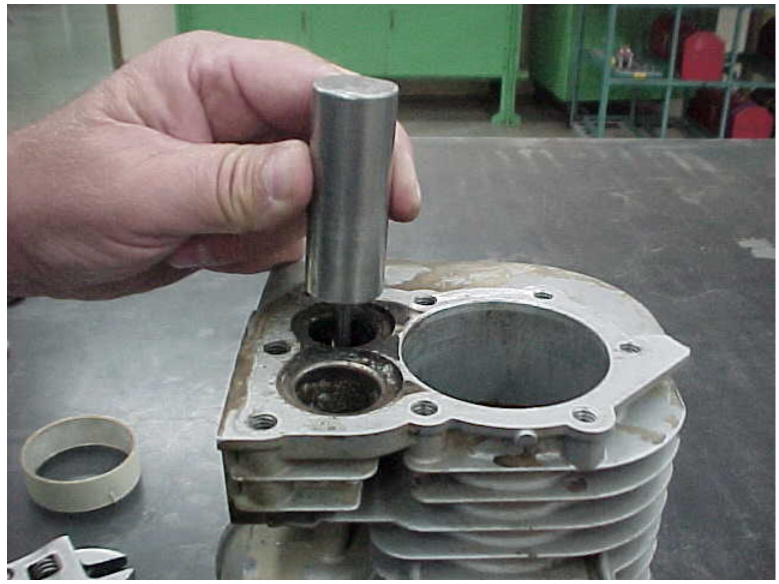


Valve Seat Puller





Valve Seat Removed



Valve Seat Driver

Breaking Glaze and Resizing Cylinders:

1. If cylinder is worn 0.003" or more over factory size, it must be resized. If cast iron cylinder has less than 0.003" wear, you will need to break glaze. Do not deglaze aluminum cylinders.
2. Place mounting plate on block so valve ports are up.
3. Remove carbon from top of cylinder with emery paper.
4. Determine bore size and select proper stones from chart.

    <u>For resizing cast iron cylinders:</u>

    a. Use 60 grit stones to within 0.0025" of finished size.
    b. Use 150 grit stones to within 0.0005" of finished size.
    c. Use 280 grit stones with oil to finished size.

    <u>For resizing aluminum cylinders:</u>

    a. Use 150 grit stones to within 0.002" of finished size.
    b. Use 280 grit stones to finished size.

    <u>For breaking glaze in cast iron cylinders:</u>

    a. Use 280 grit stones

Cylinder Hones	Cylinder Diameter Range (inches)	Roughing Stone Set (60 grit)	Coarse Finishing Stone Set (150 grit)	Polishing Stone Set (280 grit)
JN-89 & JN-90	2.0 to 2.2	JN-100	JN-200	JN-500
Junior Cylinder Hones	2.2 to 2.4	JN-101	JN-201	JN-501
	2.4 to 2.6	JN-102	JN-202	JN-502
AN-110	2.7 to 4.2	AN-100	AN-200	AN-500
AN111	3.7 to 5.5	AN-101	AN-201	AN-501

5. Stone sets should be dressed with truing sleeve before honing aluminum cylinder. Tighten the stone set until the hone can just barely be turned by hand. Use a rapid

in and out motion while the stones are turning and don't extend the stones more than ¾" from ends of truing sleeve.

6. Hone the cylinder using rapid strokes so that a cross hatch pattern is attained. Use plenty of hone oil for aluminum cylinders and for 280 grit stones when honing cast iron cylinders. 60 grit and 150 grit stones should be used dry with cast iron. There is a dry (no oil) and a wet (with oil) set of stones to use for cast iron and aluminum cylinders. If a set of stones is used with oil it will have to be used with oil every time it is used.
7. When over sizing, measure cylinder frequently checking both the top and bottom of the cylinder to avoid taper. When breaking glaze, hone until the cylinder walls show the cross hatch pattern. Check frequently to avoid over sizing the cylinder.
8. It may be necessary to re-bevel the top of the cylinder if the over sizing is 0.020" or 0.030". The slight bevel at the top of the cylinder aids in installing rings. If a new bevel is needed on aluminum cylinders, cut it with a knife before the finish honing.
9. Caution – Honing produces sharp edges at the bottom of the cylinder. Use care to not cut hands while cleaning the cylinder.

Use an electric or air drill to turn the cylinder hones. The hones must be turned clockwise. Turn the hones at 250 to 450 rpms.

When re-sizing cylinders the cylinder hones should be tightened enough to make the drill sound as if it is working hard to turn the hones. Once the drill is able to operate easily the hones need to be tightened against the cylinder again.

When stopping the drill, keep it moving back and forth until it completely stops.

Cylinder hone set.

Over sizing a cylinder-tightening the hones, buckets cut to catch oil.

Honing oil


Hone truing sleeves

Cleaning Engine Blocks after Honing:

The abrasive grit left in an engine block can wear an overhauled engine out in a matter of hours if it is not thoroughly cleaned out.

1. Use clean, oily rags until no more hone dust shows on them.
2. Wash engine block with hot soapy water. Use small brushes in corners.
3. Retest for hone dust with white oily rags.
4. Wash engine block and internal parts with pressurizes solvent gun.

Clean engine after honing.

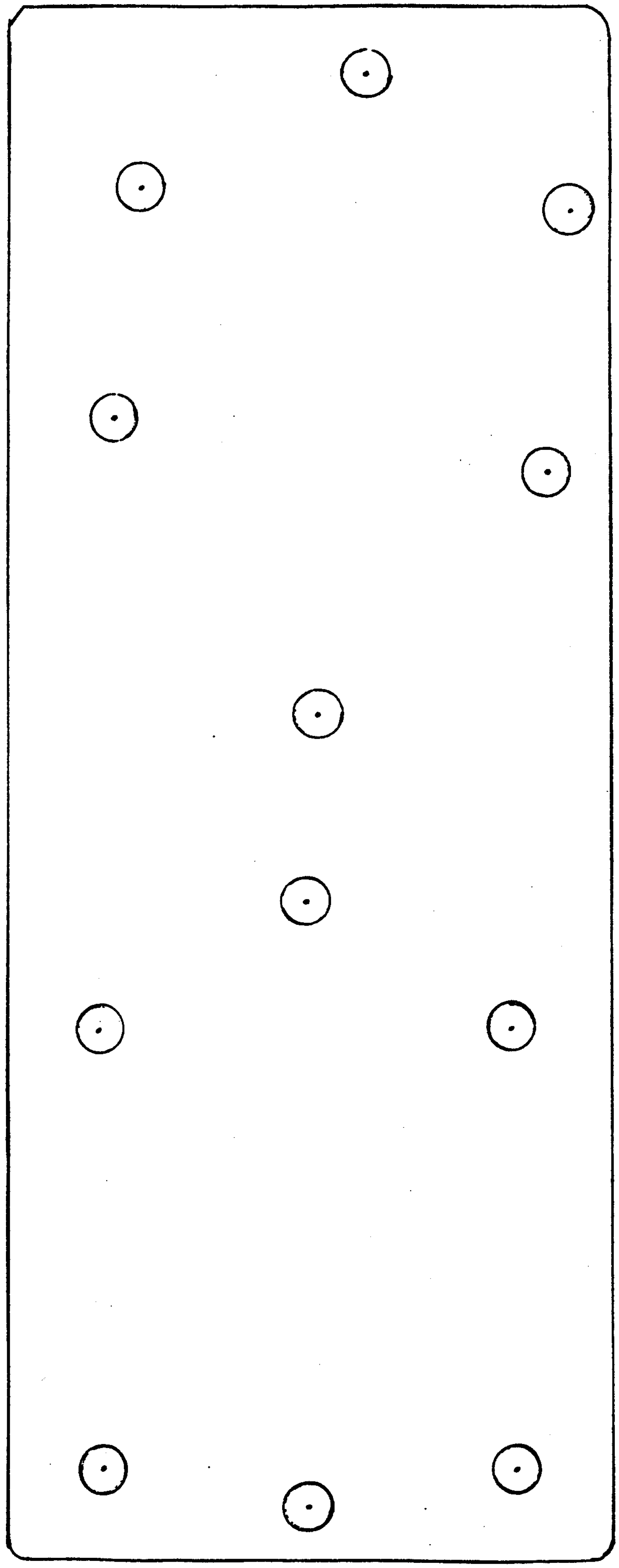


PLATE TO SECURE HEAD SECTION OF CY- LINDER BLOCK TO VISE

1/2" plate

11/32" holes

Use head of various models of engines for pattern:

60000, 80000
92000
100000,130000
110000
170000, 190000

PLATE TO SECURE ENGINE BLOCK TO VISE

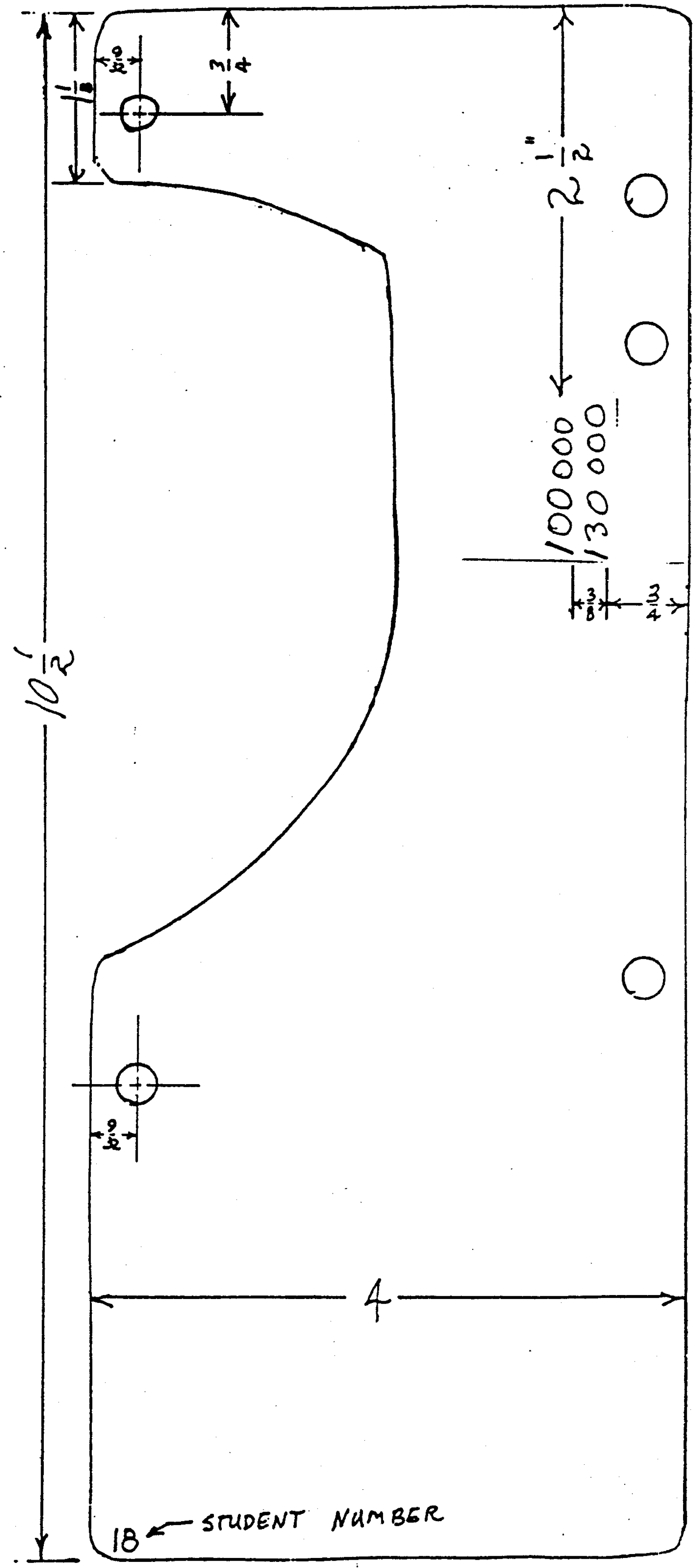
1/4" Plate

5/16" Holes

Holes in plate should be centered over holes in engine block

Use 5/32" number stamps

100,000; 130,000 plate will require 5 holes so that it can be used on both vertical and horizontal shaft engines



8-5

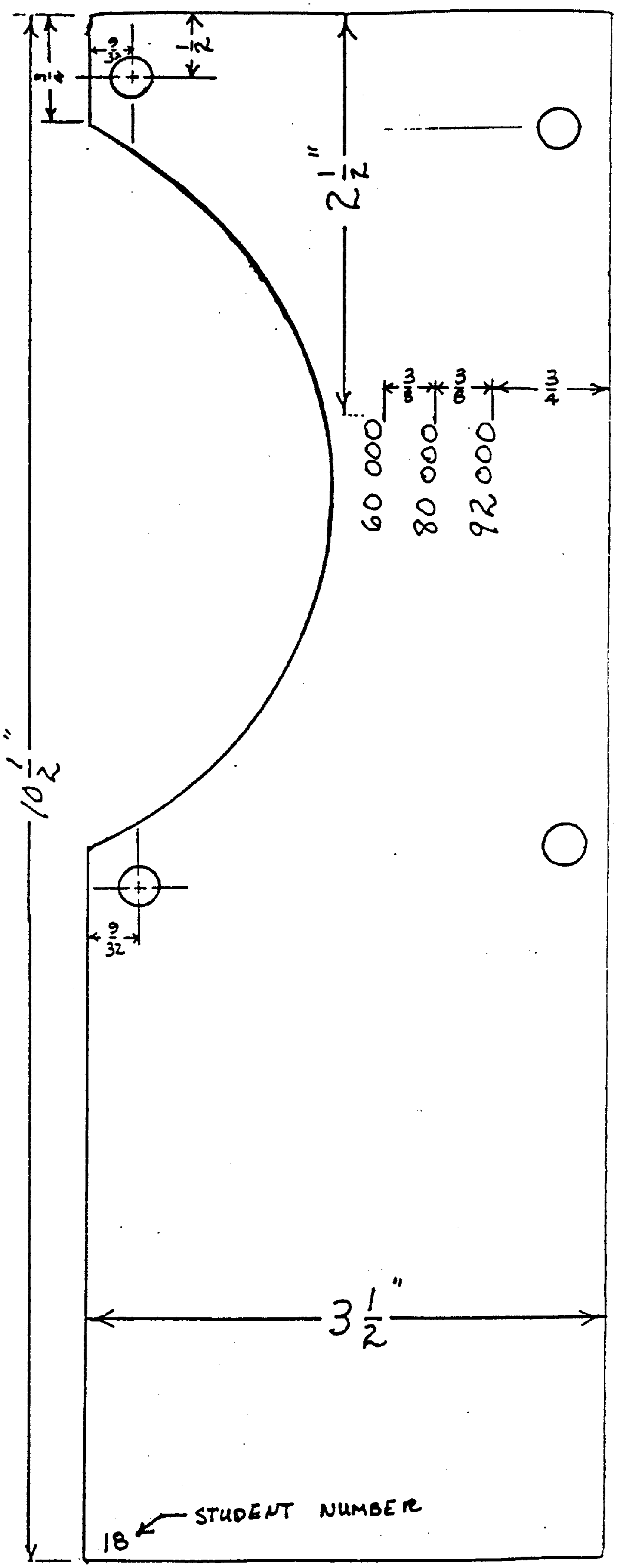
PLATE TO SECURE ENGINE BLOCK TO VISE

1/4" Plate

5/16" Holes

Holes in plate should be centered over holes in engine block

Use 5/32" number stamps



Re-Assembly

Unit Objective:

After completion of this unit, students will be able to assemble an engine. This knowledge will be demonstrated by assembly of student engines.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Read for technical information and follow written directions (Standard 752.05)

- Listen for information (Standard 754.01)

- Follow sequential steps to correctly assemble an engine.

Teaching Time:
This unit should take 12 to 16 hours to complete (3 hours for lecture and 9 to 13 hours for students to work)

Steps for students to complete before the next lesson:
Clean engine again!
Install rings on piston
Assemble block, crankshaft, & sump cover to check crankshaft end play
Disassemble block, crankshaft, & sump after checking end play
Install piston in cylinder
Install crankshaft
Install rod cap
Assemble tappets and cam gear
Have teacher check assembly and install sump cover
Re-check crankshaft end play
Grind valves for tappet clearance
Install valves and springs
Assemble head & shield
Install breather
Install armature
Install flywheel
Install flywheel screen
Adjust armature gap
Install muffler
Install cylinder shield
Clean gas tank
Assemble carburetor
Install Carburetor
Adjust governor
Check spark

Steps for teacher to complete before next lesson:
Check assembly of each engine before sump cover is installed, check for:
- Proper oiling during assembly
- Proper timing
- Rod cap assembled correctly
- Rod cap lock bent against bolts
- Tappets and oil slinger installed
- Mechanical governor installed

Check crankshaft end play

Teaching Materials:
Tools:
- Student tool boxes

Resources:
- Briggs & Stratton Repair Manual

Teaching Activities:
Demonstrate carburetor re-assembly
Demonstrate gas tank cleaning & tank slushing compound
Demonstrate engine re-assembly

Re-Assembly Tips

Do it right the first time, the faster you go the slower you go. Take your time putting engines back together. If you forget even the smallest step before moving on to other steps it can cost a lot of time to go back and complete the step.

The rule of implied guarantee – by putting this engine back together, you guarantee it is clean. If not, you will disassemble, pay for worn parts and re-assemble.

Make sure all parts and tools are clean and free of abrasive grit before beginning re-assembly. Common places for abrasive grit to accumulate are:

Bolt threads	Sockets
Bearing oil passages	Valve guides
Mechanical governor gears	Dirty hands
Cam bearings	Dirty rags
Oil plugs	Dirty engine boxes

Use acetone and a rag to remove excess gasket sealer.

Carburetor re-assembly and gas tank cleaning:
See Carburetor sections:

Gasket Sets:
Not all of the gaskets in a new gasket set will be used. Briggs & Stratton packages gasket sets with extra gaskets so one gasket set will fit several engine models. The gasket set will include at least 3 gaskets for the sump cover. Each sump cover gasket is a different thickness which allows crankshaft end play to be changed. The grey gasket is 0.015" thick, the yellow gasket is 0.010", and the white gasket is 0.005" thick. The grey gasket should always be used, but if the end play is too little an additional gasket may be used to increase end play.

Engine Re-Assembly:

1. Wipe cylinder and inside of crankcase with 10 weight oil and rags. Check for grit in head bolt holes with a bolt, check cam bearing hole in sump (use a small rod and a rage to clean cam bearings), remove oil plugs.

2. Clean cylinder, sump, and head with steam cleaner or pressure washer. Blow dry and scrub cylinder with rags and 10 weight oil. Re-clean if necessary. Make final check for hone dust in cylinder with oily rag. Make sure grey color is gone.

3. Work on a clean table. Use only clean rags.

4. Clean all internal parts with solvent gun and blow dry: cylinder, crank, camshaft, piston, rod, tappets, valves, valve springs, sump, head, oil slinger, rod bolt lock, intake tube, breather tube, oil plugs. Make sure new connecting rod is on piston if a new one was ordered.

5. Check oil seal housings for burrs. Use gasket sealer (No. 2 Permatex) on outside of oil seal. Install new oil seals. Use special oil seal drivers. Check cylinder section of repair manual for proper depth of oil seal. Oil seals should be installed with the inner lip pointing toward the inside of the engine. Install oil plugs. Install mechanical governor arm.

6. Check end gap of new rings by placing them in cylinder. End gaps should be 0.007" – 0.030". Obviously small or large end gaps would indicate incorrect rings.

7. Install rings in proper order on piston (see repair manual section 9) – stagger alignment of ring end gaps. Check ring land clearance – reject if more than 0.007" clearance. Make sure rings rotate freely around piston.

8. Use 30 weight oil on all moving parts (except points) while assembling.

9. Install crankshaft make sure the crankshaft is positioned with the rod journal at the lowest point to allow room when installing the piston and rod.

10. Use oil seal protector sleeve to protect oil seal from damage. Install sump with grey gasket. Install all 6 sump bolts to correct torque (repair manual section 10).

11. Check crankshaft end play with dial indicator. End play should be between 0.002" and 0.020". If end play is too much, a thrust washer will have to be installed. Check repair manual for proper washer in crankshaft section. If end play is too little, install an additional gasket or a thicker gasket.

12. Remove sump – On engine models with a ball bearing on the crankshaft, install tappets, cam gear and crankshaft.

13. Oil piston and cylinder. Install ring compressor on piston with ring compressor flanges down on cast iron cylinders and up on aluminum cylinders. Make sure rod is aligned correctly before piston is installed. On some models the rod cap has a machined groove that provides clearance between the cam lobe and rod cap. On these models the rod cap must point toward the cam gear. On horizontal crank engines, the rod and rod cap alignment marks should point toward the drive end side of the engine. On large model engines a mark on top of piston is installed

toward the magneto side of the engine. Cover the top of the piston with a rag and use two thumbs to push the piston into the cylinder. If the piston does not slide into the cylinder with reasonable force check to make sure the ring compressor was installed correctly.

14. Assemble rod cap correctly and use proper torque (repair manual page II) to tighten rod cap bolts. Horizontal shaft engines oil dipper is assembled on the rod cap. The rod cap is easiest to access if the engine is turned upside down. Once the rod cap is installed rotate the crankshaft to make sure the rod cap is installed correctly.

15. Bend rod bolt lock flat against ones side of bolt head using channel lock pliers. Newer connecting rods use 2 flat washers instead of rod bolt lock. Some newer rods use bolts that do not require flat washers or rod bolt locks.

16. Assemble tappets, cam gear (make sure timing marks on cam gear align with timing marks on crank gear), oil slinger. Models 100000 and 130000 vertical shaft engines have a special thrust washer installed on the cam gear. It is easiest to install the tappets and cam gear if the engine is turned over with the head side down.

17. Assemble mechanical governor. The thrust washer goes between the governor and the sump cover. The metal clip that holds the governor together cannot be purchased separately, don't lose it. Once the governor is installed, turn the sump upside down to make sure the governor is installed correctly, it shouldn't fall off.

18. Have instructor check inside of block before assembling sump. Items to check for:

    a. Proper oiling during assembly
    b. Proper timing
    c. Rod cap assembled correctly
    d. Rod cap lock bent against bolt heads
    e. Tappets and oil slinger/dipper installed
    f. Mechanical governor installed

19. Install sump cover. Use gasket sealer (No. 2 Permatex) on both surfaces and on sump bolt which enters valve spring chamber. Torque to specifications listed on page II of Repair Manual. The governor gear must line up with the cam gear when installing the sump cover. Turn the crankshaft, which will turn the cam gear to line up the teeth between the governor gear and cam gear.

20. Re-check crankshaft end play.

21. Grind tappet clearance (valve clearance). The piston should be ¼" below top dead center of the compression stroke when measuring tappet clearance. Make

sure valves are in proper position as discussed in the compression section (section 6) of the Repair manual. Press down firmly on top of the valve while checking tappet clearance to simulate pressure from the valve spring. Check tappet clearance with a feeler gauge, tappet clearance specifications are on page II of the Repair manual. Grind the end of the valve stem until proper clearance is obtained. Be careful, if too much is ground off a new valve is the only way to fix it.

22. Install valve springs:
    a. Make sure proper spring is installed on proper valve. The heavier spring (if they're different) goes on the exhaust valve.
    b. Place the spring and retainer in the valve spring compressor with the bigger part of the retainer hole toward the outside of the engine.
    c. After the valve spring compressor is removed, center the spring around the valve stem.
    d. Re-check tappet clearance.

23. Assemble head and head shield. New head gaskets adhere to the parts once engine runs and heats up adhesive.
    a. If engine has a spark plug kill switch it must be assembled at this time.
    b. Use graphite grease on head bolts.
    c. If head bolts are different lengths, the longer ones go around the exhaust valve.
    d. Torque head bolts in proper sequence. See compression section (section 6) of the Repair Manual, torque specifications are listed on page II.
    e. Install old spark plug if engine is to be re-painted. Install new plug if it is not going to be painted.

24. Install breather. Straighten the tangs or bend them back slightly beyond straight so the screws flatten it out when tightened. Choose correct breather gasket if more than one is supplied.

25. Install breather tube on model 92000 and 110000 engines.

26. Install intake tube on models that have them. A gasket is required between the intake tube and the block.

27. If electronic ignition is used, make sure it is installed on the coil and make sure the point plunger hole is plugged.

28. Install coil:
    a. Secondary wire (spark plug wire) goes toward the outside of the engine.
    b. Install air vane governor with coil. Ground coil on opposite side of governor air vane.
    c. Push coil all the way to the top of the mounting slots and tighten bolts, to leave room to install the flywheel later.

   d. If coil has a kill wire attach the other end to the kill wire switch.

29. Assemble points and condenser if electronic ignition is not used:
    a. Test new condenser
    b. Condenser may have two wires, one wire will attach to the coil and the other will attach to a remote kill switch.
    c. Line up flywheel key slot on crankshaft with point plunger.
    d. Point arm spring hooks into hole nearest the pivot and comes out holes nearest points.
    e. Tighten condenser and adjust point gap to 0.020" using screwdriver to move condenser. Make sure condenser hold down clip is clean.
    f. Clean points with clean, lint-free paper.
    g. Use silicone sealer to seal around the wires before installing breaker cover.
    h. Install breaker cover.

30. On models 100000 and 130000 vertical shaft engines, assemble governor linkage and breather tube.

31. Install flywheel and then install flywheel key:
    a. Make sure concave side of flywheel washer is installed toward the flywheel.
    b. The flywheel key is not square, it should fit tight.
    c. Put a few drops of oil in starter clutch ratchet. Make sure felt washer is in the ratchet.
    d. Torque flywheel nut to specifications on page II of Repair Manual.
    e. Spin flywheel backward to test compression.

32. Install flywheel screen.

33. Adjust armature air gap, specifications are on page II of Repair manual. Make sure that air gap is adjusted with the flywheel magnet below the coil.

34. Install muffler. Make sure that lock nut is installed so it will bite into the block. Some models do not have a muffler lock nut (92000 and those that use bolt on mufflers). Use anti-seize on muffler bolts. Bolt on mufflers should have a bolt lock to bend up against bolt heads.

35. Install cylinder shield. Shield can be left off on models 92000 and 110000.

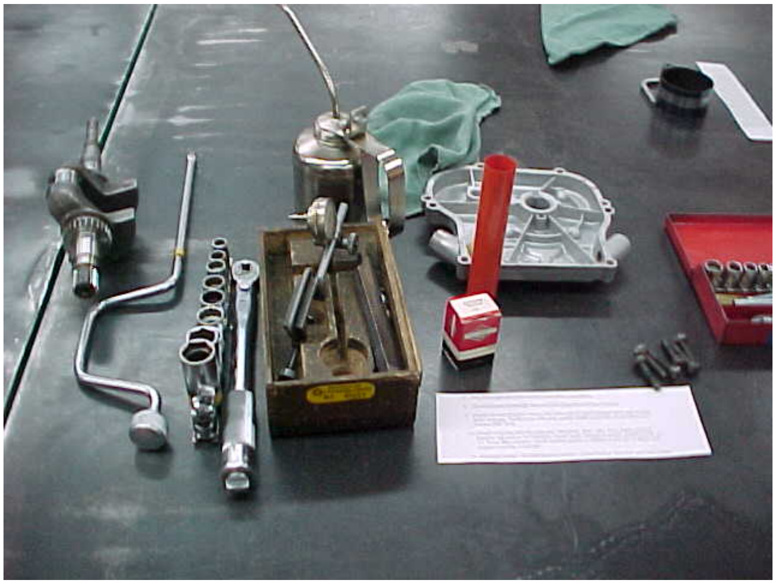
36. Make sure gas tank is clean before assembling. Rusty tanks may be coated with slushing compound.

37. Assemble carburetor. Adjust to proper specifications (see carburetor sections in this guide and Repair Manual carburetor section).

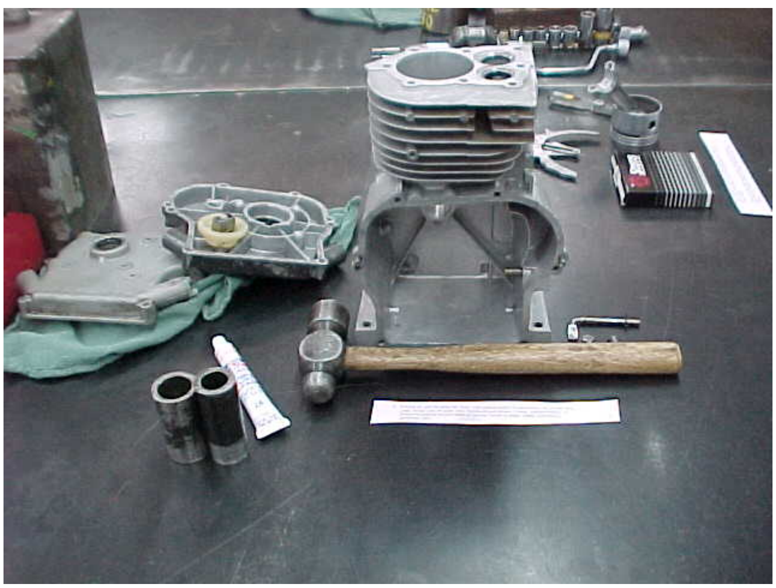
38. On vertical shaft engines, assemble carburetor to tank than install as a unit to the engine. Hook up solid linkage between governor and throttle as carburetor is installed. Gasket is installed between carburetor and tank. On 5 HP horizontal shaft engines, install carburetor to engine and then tank to carburetor.

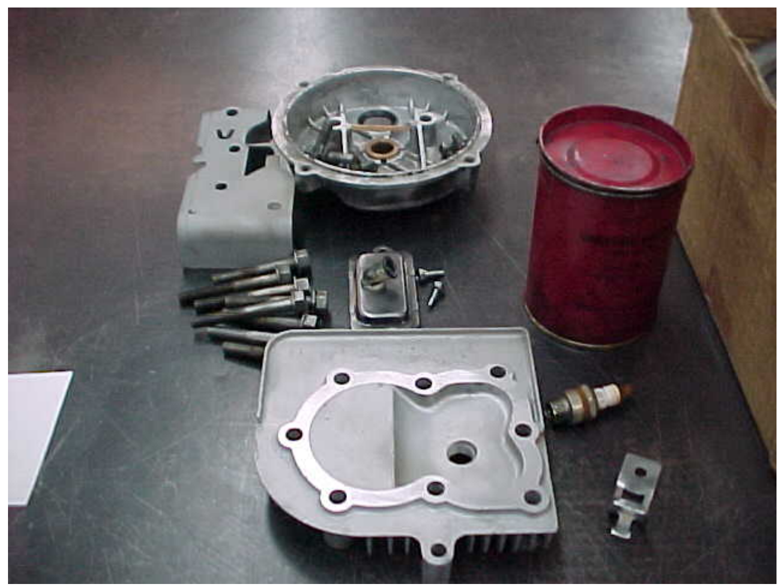
39. Adjust mechanical governor according to Repair Manual governor section (section 4).

40. Check spark using spark tester. Blower housing must be installed in order to crank engine at least 350 rpm for checking spark with electronic ignition.


Tools for checking crankshaft end play. Note the red plastic oil seal protector sleeve.


Cam gear, mechanical governor, and tappets


Tools for installing oil seals (oil seal drivers).


Head, head bolts, head shield, breather, graphite grease, spark plug, and kill switch.

Parts and tools for installing rings and measuring ring land clearance.


Tools and parts for assembling rod, rod bolt lock, and oil dipper


Piston ring compressor


Valve springs, spring retainers and valve spring compressor

Painting

Unit Objective:

By completing this unit students should be able to prepare and paint engine surfaces safely and correctly.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Prepare an engine for painting
- Paint an engine
- Listen for information (Standard 754.01)
- Read for technical information (Standard 658.02)

Steps for students to complete before the next lesson:
Paint Engine

Steps for teacher to complete before next lesson:
Get gas and oil before engine starting lesson.

Teaching Materials:
Parts:
    Engine to be cleaned and painted

Tools & Supplies:
    Bead blaster
    Wire wheel
    Masking tape
    Paper or plastic to cover paint area
    Paint

Teaching Activities:
Demonstrate use of bead blaster and wire wheel
Demonstrate paint spraying

Removing Old Paint:

Use a wire wheel on a pedestal grinder to remove paint from the blower housing and breather. Remove any decals with the wire wheel.

Use a bead blaster to remove all other painted surfaces once the engine has been disassembled. Glass or metal beads should only be used on external parts. It is difficult to clean all of the grit left after bead blasting from internal engine parts. Just a few pieces of glass or metal beads can cause serious engine wear and result in short engine life. Plastic beads or crushed walnut shells work well for removing paint from the engine block.

<u>Instructions for using bead blaster:</u>

1. Remove oil seals and plugs.
2. Parts should be dry – free of oil, grease, and adhesives. It is easier to remove old decals with the wire wheel.
3. Do not bead blast carburetor, breather, gas cap, intake tube, or breather tube. Use the wire wheel or carburetor cleaner.
4. When finished bead blasting use compressed air <u>outside</u> to blow off parts.
    a. Wear safety glasses
    b. Make sure all bolt holes are blown out
5. Wash parts with pressure washer. Caution – high pressure water can cut skin while holding small parts in hands.

6. Blow parts dry with compressed air <u>outside</u>.
    a. Wear safety glasses
    b. Iron parts will rust if not dried immediately
7. Use a 5/16" tap to remove grit from head bolt holes and a ¼" tap to remove grit from sump cover bolt holes.

Paint on the carburetor, intake tube, gas cap, and breather tube will be removed in the carburetor cleaner.

Paint Preparation:

Wipe the entire surface to be painted with a rag and acetone.

Paint the air cleaner separately. All other engine parts can be assembled for painting.

Mask off:

Spark plug wire
Carburetor holes
Rope handle
External shafts

Use an old spark plug to fill the spark plug hole during painting.

Painting:

Use a good quality brand of spray paint. Typically the longer the drying time, the better the paint is. Follow the instructions on the paint can. Some paints have time restrictions between the times for applying additional coat. Be sure to follow any time restrictions or the paint may peel.

Apply at least two coats of paint. The first coat is called a fog coat. It shouldn't completely color the entire engine. It should look like a fog on the engine. Allow that coat to dry as long as the instructions say. The second coat is called the color coat. This is the coat where the entire engine surface should be colored. If desired a third coat may be applied. The third coat is called the gloss coat. This coat will give the color a glossy finish.

Apply paint in horizontal strokes releasing the trigger and stopping the flow momentarily while changing the stroke direction. It is common to get runs if the flow of paint is left on when changing directions because that area is covered twice.

Starting Engines

Unit Objective:

After completion of this unit, student engines will be started and all work should be complete.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Convert between quarts, fluid ounces, and liters (Standard 349.01)
- Start engines
- Read a vibration tachometer
- Adjust carburetors to specifications
- Recognize if an engine is running too rich or too lean

Steps for students to complete before the next lesson:
Put oil in crankcase
Start engines
Adjust carburetors
Run engines for 15 – 20 minutes
Change oil
Re-torque head and sump bolts

Teaching Materials:
Tools and supplies:
- Oil and gas
- Flywheel weights
- Starting stands
- Speed control cables
- Tachometer
- Carburetor screwdrivers
- Torque wrench

Resources:
- Briggs & Stratton Repair Manual

Teaching Activities:
Use 2 or 3 student engines to demonstrate use of starting stands, flywheel weight, and carburetor adjustments.
Discuss engine oil capacities and conversions from quarts to fluid ounces or liters.

Vibration Tachometer Use:
A vibration tachometer reads engine speed base on the speed of the engine vibration. To use a vibration tachometer, hold it firmly on the engine (caution avoid electrical shock, do not hold it near the spark plug wire). Adjust the tachometer dial with the tachometer on the engine until the tachometer cable vibrates in a circular motion. Stop adjusting at point where the cable makes the a circle that is 1 ½" in diameter read the rpm scale.

Priming Carburetors:
Do not fill gas tanks any more than necessary when initially starting overhauled engines. This will save time and gas if there is a problem with the engine, not as much gas has to be drained before removing the carburetor or gas tank.

Before attempting to start an engine with a pulsa-jet carburetor for the first time, the tank either needs to be completely full or the carburetor needs to be primed. Use a pump oil can with gas in it and squirt some gas into the top of the carburetor. Pull the rope, this will bring gas from the tank into the fuel reservoir below the fuel tubes. If the engine carburetor has a primer button push it 3 times and it will do the same thing without the gas from the oil can.

Fuel Mixtures:

Carburetors mix fuel with air to maximize the efficiency of combustion in the cylinder as described in the Carburetion Theory section of this curriculum guide. If a carburetor is said to have a rich fuel mixture that means that the carburetor is supplying too much fuel and not enough air to the cylinder. If the carburetor has a lean fuel mixture it is the opposite, not enough fuel and too much air.

Starting Engines:

1. If engine has a light weight (aluminum) flywheel, install a flywheel weight. Use a woodruff key in the crankshaft keyway and a lock washer on the bolt. Tighten bolt securely. If a clattering noise is heard when engine is running, stop engine and check tightness of bolt that hold the weight to the crankshaft.

2. Bolt the engine to a starting stand with 3 or 4 bolts. Make sure bolts are tight.

3. Add oil (SAE 30) to the engine. If engine has no dip stick add oil to the second thread from the top of the oil plug threads. See Repair Manual lubrication section (section 8) or page II for oil capacities.

4. Service air cleaner – two tablespoons of SAE 30 oil on foam element and squeeze out excess oil. Fill oil bath air cleaner to fill line. Put oil in gear reduction unit, if engine has one.

5. New spark plug – check gap with spark plug gapping tool. The gap for all models is 0.030". Torque spark plug to 240 in.-lbs. for aluminum heads.

6. Install engine speed control cable if engine is not equipped with speed control.

7. Add gas to engine. Fill tanks as follows:
   a. Vacu – jet carburetors - ¼ full
   b. Pulsa – jet carburetors – full
   c. Flow – jet carburetors – ¼ full

   Put gas away in flammable liquids storage immediately after filling tank.

8. Make sure initial carburetor adjustments are made. See Carburetor Theory section of this curriculum guide and Carburetion section (section 3) of the Repair Manual.

9. Make sure mechanical governor is adjusted. See Governor Controls section (section 4) of the Repair Manual.

10. Set engine for high speed and choke. If the engine has a fuel primer button, push it 3 times to prime the carburetor. A warm engine will usually need choked for only one pull of the rope. If engine is flooded, shut off main needle (screw it all the way in) and pull rope a few times. If starting with air cleaner off, vacu-jet and pulsa-jet air cleaner screw must be installed if the engine has automatic choke. It is easier to make carburetor adjustments with the air cleaner off and out of the way.

11. Let engine warm up for 15 minutes and adjust carburetor. Read adjusting instructions in Carburetor Theory section of this curriculum guide and Carburetion section (section 3) of the Repair Manual.

    a. Adjust high speed mixture first.
    b. Set idle speed – use vibration tachometer
    c. Set idle mixture on flo-jet carburetor while engine is idling and re-check idle speed. Do not try to use main adjustment needle for adjusting idle fuel mixture.
    d. Make sure engine accelerates smoothly:
       i. If engine dies on acceleration, a richer mixture is probably needed
       ii. If engine backfires on deceleration, a richer mixture is needed
       iii. If engine governor hunts (surges), richer fuel mixture is needed. It may also need a governor link spring or stronger governor spring.
       iv. If engine puts out black smoke, a leaner mixture is needed
       v. Blue smoke indicates engine is burning oil
    e. Check high speed with vibration tachometer

12. Check top speed. Check Governor section (section 4) of the Repair Manual to make sure the lawn mower does not over speed the blade. Write top speed on a note attached to the engine. Top speed is adjusted on most engines by changing governor spring or by bending the spring anchor tang.

13. Remove engine from stand. Caution – engine parts are hot avoid the muffler

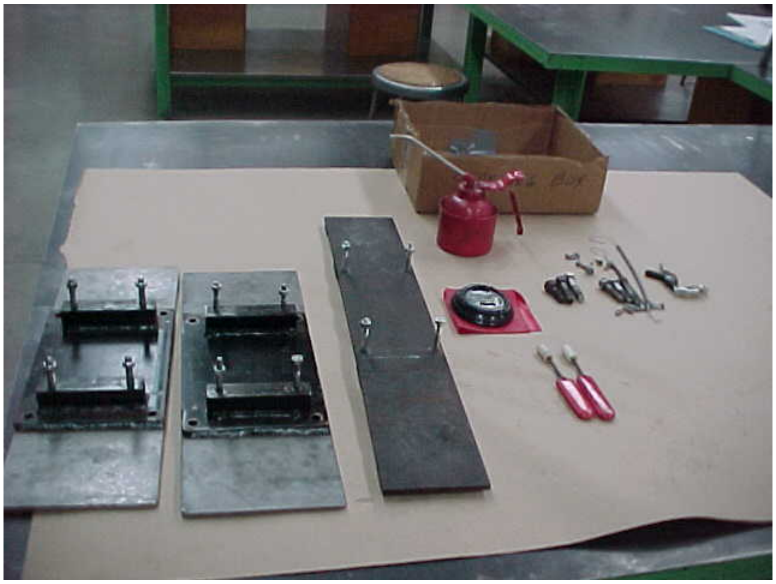
14. On vertical shaft engines drain gas then remove the flywheel weight.

15. Change oil while engine is still hot. Suspended particles will be flushed out, use a clean drain pan so oil can be inspected for particles. If excess particles are found in the oil the engine may have to be disassembled and inspected for wear or depending on the severity of the particles the engine could be run again with new oil and inspect the oil again.

16. After 3 to 4 hours of cooling time re-torque the head and sump cover bolts.

17. Let the engine sit in a clean area for one week and check for oil or gas leaks.

18. Remove spark plug and put a few drops of oil into the cylinder.



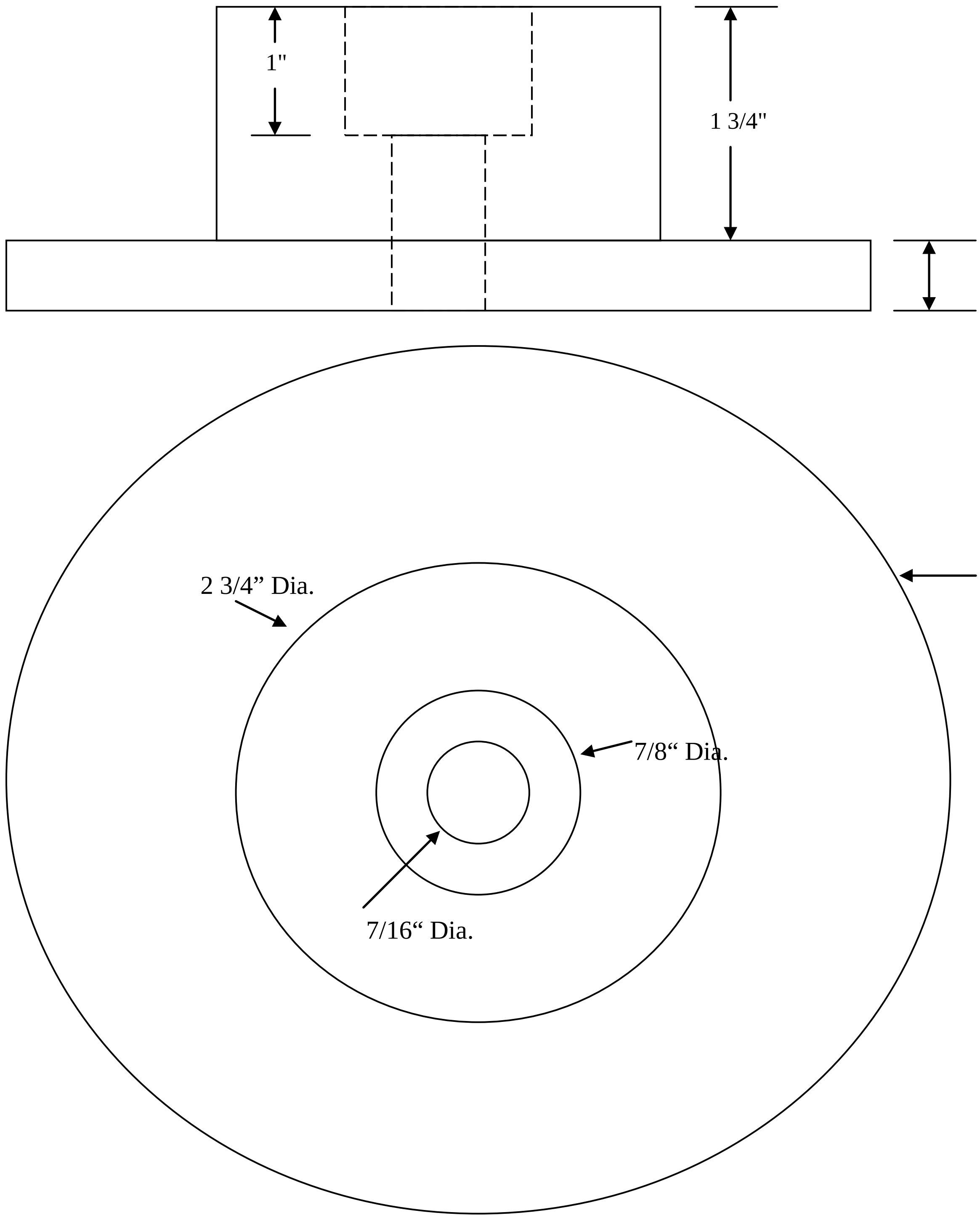
Starting stands (horizontal shaft engines), carburetor screwdrivers (red handles), Oil can with gas in it used to prime vacu-jet carbs., vibration tachometer, speed control cables, bolts for flywheel weight.

Speed control cables, speed control cable clamps and bolts, bolts and keys for flywheel weight, spark tester.

Starting stand for vertical shaft engines

Briggs & Stratton carburetor screwdrivers have a plastic sleeve over them to keep the screwdriver on the screw while the engine is running. Vibration tachometer also shown.

A flywheel weight can be made as shown below (drawing not to scale) for use in starting small engines with light weight flywheels. This weight simulates the blade on a lawnmower to balance the engine while running. This weight must be turned and balanced on a lathe. Use either a 3/8" or 7/16" NF bolt to fasten securely to the crankshaft.




Jack with a Honda!

Trouble Shooting

Unit Objective:

After completion of this unit, students will be able to reason through a logical process to determine why an engine does not run correctly.

Specific Objectives and Competencies

After completion of this unit students should be able to:

- Understand systems, order, and organization (Standard 648.01)

- Understand concepts and processes of evidence, models, and explanation (Standard 648.02)

- Isolate engine problems to one of three areas (compression, carburetion, ignition)

Resources:

Briggs & Stratton Repair Manual
Operational Theory sections of this curriculum guide.
Trouble shooting chart and engine condition sheets in this section

Teaching Activities:

Use 2 or 3 different engines to demonstrate and discuss trouble shooting processes in class.

Finding the problem:

An engine must have compression, fuel, and ignition in the cylinder to run. When troubleshooting an engine, first narrow the problem down to one of these three areas.

Use a spark tester to test for spark. If there is spark with a spark tester either test the spark plug with a tester or try a new plug. Sometimes a spark plug will not work because of the pressure inside the cylinder. A true spark plug test puts the plug under 70 or 80 psi and then checks for spark. If there is spark and the spark plug is known to be good, check the flywheel key. If the key is sheared, partially sheared, or missing the spark is probably not timed correctly. If the ignition system is working, test carburetion and compression.

Spin the flywheel backwards to test compression, if the flywheel rebounds sharply the problem is not lack of compression. Compression cannot be accurately tested by pulling the starter rope and guessing how much pressure it takes to turn the engine over. Test ignition and carburetion.

If the engine has compression and spark, remove the spark plug squirt some gas into the top of the cylinder, replace the spark plug, and try starting the engine. If the engine runs momentarily and then dies, the problem is with the carburetion system.

Another way to test carburetion is to pull the starter a few times and then remove the spark plug. Look at the spark plug to see if it has gasoline on it. This could mean that the carburetor is working or that the fuel mixture it too rich. If an engine has an obvious fuel leak from the carburetor while trying to start the engine, the problem is with the carburetor providing too rich of fuel mixture to the cylinder. If the spark plug is wet and there is no fuel leaking from the carburetor, the carburetion system is probably leaking.

Once the problem is isolated to one of these three areas, it is much easier to fix.

Check ignition:

Remove the spark plug and check for proper gap. Test for spark at the end of the secondary wire with a spark tester.

If no spark, check for:

1. Incorrect armature air gap
2. Incorrect breaker point gap (should be 0.020" when points are open)
3. Dirty or oily points
4. Dirty or oily condenser hold down clip. A small amount of dirt, oil, or corrosion will keep the condenser from adequate grounding.
5. Wire extending through the condenser and shorting out
6. Shorted primary circuit wire. Trace the primary wire from the coil to the condenser or ignition module. There may be a break in the insulation.
7. Continuity of the primary wire. Sometimes the wire looks good but it is broken inside the insulation. Check for continuity with an ohm meter.
8. Shorted grounding or kill switch wire
9. Bad condenser
10. Bad coil (1 in 50 coils is bad)
11. Bad spark plug
12. Closed kill switch
13. Bad electronic ignition module

Also check for missing or sheared flywheel key. The engine could still have spark but not at the correct time.

Checking carburetion:

Before making a carburetion check, be sure the fuel tank has an ample supply of fresh, clean gasoline. On gravity feed models, see that the shut off valve is open and fuel flows freely through the fuel line. On all model, inspect and adjust the needle valves. Check to see that the choke closes completely. If engine will not start, remove and inspect the spark plug.

If plug is wet, look for:

1. Over choking. On pulsa-jet models, where the diaphragm is located between the carburetor and the tank, there may be an air leak between the carburetor and the tank caused by warpage. A vacuum under the diaphragm opens the choke so this must be an air tight enclosure. Disassemble the tank and flatten as described in the carburetion section.
2. Water in gas or old stale gas.
3. Excessively rich fuel mixture.
    a. On all carburetors check the air cleaner, a clogged air cleaner may restrict too much air.
    b. On pulsa-jet carburetors, check the brass seat under the main adjustment needle.
    c. On flo-jet carburetors:

i. Check adjustment of main adjusting needle (1 ½ turns out from full seat)
ii. Check for venturi gasket
iii. Main jet may not be tight enough. It must make a seal against the housing of the lower body.
iv. Dirty or worn float needle and seat will allow fuel to continue to flow when float is up. Briggs & Stratton has a tool for testing the seal of the float needle and seat.
v. Improper float adjustment
vi. Check float seat gasket

If plug is dry, look for:

1. Leaking carburetor mounting gaskets, missing intake tube seal.
2. Plugged or gummed up jets, tank shut off valve, fuel line, float seat, fuel filter.
    a. Look in tank with flashlight for rust or other particles.
3. Check for loose mounting bolts or missing gaskets
    a. No air should be able to flow into the system causing a lean fuel mixture other than through the air cleaner.
4. Make sure enough fuel is in tank.
    a. Gas tank of pulsa-jet models must be filled so that small chamber in tank is filled with gas.
    b. Gas tank of vacu-jet models should be half full of gas.
    c. Gas tank of flo-jet models should be about one quarter full.
5. On pulsa-jet and vacu-jet models:
    a. Remove the main adjustment needle and seat. The two fuel metering holes located under the seat in the carburetor housing must be free of gum and dirt.
    b. Check for a hole in the carburetor diaphragm.
    c. Make sure spring and cup are on the correct side of diaphragm on pulsa-jet models. Spring and cup go on the carburetor side of the diaphragm.
    d. Make sure fuel tubes are in place, check for clogged screens on fuel tubes.
6. On flo-jet models:
    a. Check float level.
    b. Make sure small wire that is attached to the float needle is hooked over the float tang and is not under the carburetor bowl gasket. This wire assures that the needle will be pulled from the seat and allow gas to flow into the carburetor.
    c. Make sure there is not space between upper and lower body of carburetor. If there is as space, place the upper body in a vise and carefully bend the corners of the upper body with a crescent wrench. When carburetor is re-assembled there shouldn't be a space.
    d. Check venturi and bowl gaskets.

Checking Compression:

If compression is poor, look for:
1. Loose spark plug
2. Loose head bolts
3. Bad head gasket
4. No tappet clearance
5. Valves not seating
6. Worn cylinder or rings

Briggs & Stratton has a tool for testing and finding compression problems, see Repair Manual compression section (section 6).

Common Symptoms:

Engine starts but does not operate properly:

1. Rich air-fuel mixture indicated by black smoke:
    a. Pulsa-jet or vacu-jet models:
        i. Brass seat is bad or missing
        ii. Warped carburetor of fuel tank top on models with diaphragm type automatic chokes
    b. Flo-jet carburetor:
        i. Main needle is turned out too far.
        ii. Missing or bad venturi gasket
        iii. Float level set too high
        iv. Missing or bad float seat gasket
        v. Loose main jet
2. Lean air-fuel mixture indicated by backfiring on deceleration or by governor hunting:
    a. Pulsa-jet or vacu-jet models
        i. Intake tube gasket missing or bad
        ii. Intake tube seal missing or bad
        iii. Fuel pipe screens clogged
        iv. Fuel metering holes clogged
        v. Warped face where carburetor bolts to engine
    b. Flo-jet carburetors
        i. Missing gaskets on intake manifold
        ii. Warped face where carburetor bolts to engine
        iii. Float level set too low (may have two float seat gaskets)

3. Governor hunting or surging:
    a. Lean air-fuel mixture
    b. Weak governor spring
    c. Springs around governor link missing. These springs reduce the free play between the governor link and the governor and throttle lever holes.

4. Engine stops after running 5 to 20 minutes:

a. Faulty condenser or coil, may test good when cold but faulty after it is warmed up
b. Worn point plunger bushing allows oil to enter points chamber
c. Particles from dirty fuel tank may clog fuel screens, fuel line, fuel tank shut off valve, inline fuel filter, float seat.
d. Fuel tank cap not vented
e. On flo-jet carburetors check to be sure vent on upper body is open

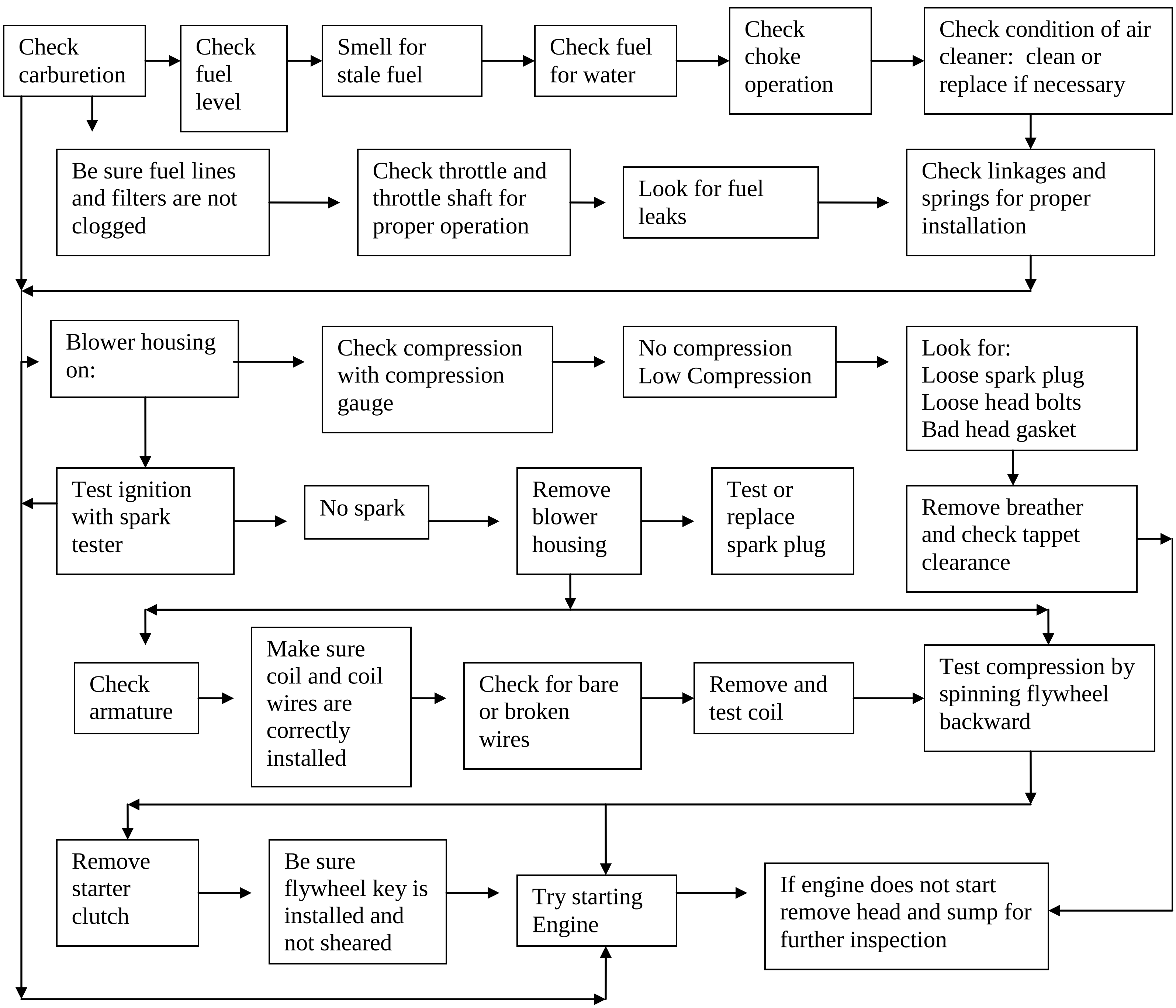
5. Excess blue smoke indicating oil consumption:
    a. Faulty crankcase breather
    b. Rings not seating properly. Failure to break cylinder glaze or re-using old rings
    c. Excess ring clearance. Wrong ring set for engine
    d. Excess valve guide clearance

6. Uneven running and rough idling:
    a. On vertical crank engines with light weight flywheel, extra weight may be needed to take place of lawnmower blade
    b. Bad condenser. Check spark while engine is running
    c. Shouldered main adjusting needle valve on flo-jet carburetor makes fine adjusting impossible
    d. Worn throttle shaft and bushings which allow excess air to enter carburetor
    e. Brass seat bad in pulsa-jet or vacu-jet carburetors

7. Starter ratchet screaming and starter rope unwinding:
    a. Starter ratchet worn. Replace old starter ratchet with new type starter ratchet. Place a few drops of oil on the felt inside the ratchet
    b. Remove rust and burrs from end of crankshaft that enters the starter ratchet.

Trouble Shooting Chart

Engines should be assessed for obvious problems prior to opening the crankcase.



Engine Condition

With blower housing on:

Test compression ________psi?

Test ignition ________spark?

With blower housing off:

Spin flywheel backward ________flywheel rebounds sharply?

Test Spark Plug ________Good/Bad?

Carburetion: _______enough gas to operate? ________Stale gas?

________Water in gas? ________ Choke operative?

Air cleaner: Foam type _____Clean _____Dirty _____Oiled _____Dry

Cartridge _____Clean _____Dirty _____Oily _____Dry

Cooling fins: _____Open _____Clogged

Tappet Clearance: ________Intake ________Exhaust

Armature Air Gap: ________"

Crankshaft: _____Bent _____Straight ________Measure end play

Cylinder: __________Scratched or scored ________Original hone marks

Amount of carbon built up on cylinder?___________Low/Med./High

Interchangeable Engine Parts

Many parts of Briggs & Stratton engines are interchangeable between engine models. The best way to verify it parts are interchangeable is to look up the part numbers for both models. If the part numbers are the same, the part is interchangeable. For example, if you look up the part number of the connecting rod for a model 80000 and a model 92000 engine, you'll notice the same part number for both models. Therefore, the part is interchangeable.

The following is a list of models and parts that are interchangeable. Interchangeable parts are not limited to this list:

Later model 60000 horizontal shaft:
- Same block as 80000 horizontal
- Valves, flywheel, and tin same as 80000

Model 80000 horizontal shaft: 2.375" bore – same block as late model 60000
- Crankshaft same as 92000, but may require machining on drive end
- Connecting rod same as 92000
- Same size valves, springs, and camshaft as 92000
- Piston rings for aluminum cylinders not the same for cast iron cylinders

Model 92000 vertical shaft: 2.5625" bore
- Same crankshaft dimensions as 80000
- Connecting rod same as 80000
- Same pistons as 130000
- Same rings as 130000
- Same sump as 110000 – older sumps had oil fill on sump, newer sumps do not. If old block is used with a new sump there is not place to add oil.

Model 110000 vertical shaft: 2.7812" bore
- Same sump as 92000 (see note above)

Model 100000 horizontal shaft: 2.500" bore
- Discontinued model – expensive parts
- Old 45° valve is expensive, change the valve seat to 30° and get a cheaper valve
- Same valves as 130000
- All parts except crankshaft, rod, and cam are same as 130000

Model 130000 vertical and horizontal shafts: bore 2.5625"
- Same valves as 100000
- Same piston and rings as 92000
- Old 45° valve is expensive, change the valve seat to 30° and get a cheaper valve
- Piston and rings for aluminum cylinder not the same for cast iron cylinder
- All parts except crankshaft, rod, and cam are same as 100000

Model 170000 horizontal shaft: 3.000" bore

Same block as 180000

All parts except crankshaft and rod same as 190000

Model number 190000 horizontal shaft: 3.00" bore

Same block as 170000

All parts except crankshaft and rod same as 170000