California Vocational Agriculture Curriculum Guidelines Instructional Unit

SMALL GAS ENGINES: TYPES AND SYSTEMS

TABLE OF CONTENTS

Introduction to Agriculture	
Agricultural Production	01.01
Agricultural Supplies/Services	01.02
Agricultural Mechanics	01.03
Agricultural Products/Processing	01.04
Ornamental Horticulture	01.05
Renewable Resources/ Rural Recreation	01.06
Forestry	01.07

SMALL GAS ENGINES: TYPES AND SYSTEMS

Unit Goals:

The student will become aware of the different types and systems of small gas engines.

Unit Performance Objectives:

Upon completion of this unit the student will be able to:

1. Distinguish the different types and systems of small gas engines.
2. Be able to identify major parts of an engine.
3. Understand the basic terminology involved in a study of engines.
4. Understand how an engine works.

Teaching Outline

I. Introduction - Uses and number manufactured each year

A. Estimated:

1. 70,000,000 in use in U.S. at present
2. 1/2 hp to 15 hp
3. Speed of an engine - 3600 rpm = car at 82 mph
4. 2-cycle chain saw may turn 6-8000 rpms
5. Over 6,000,000 produced annually

B. Uses and applications (TM - 1)

C. Like other skill areas working on small engines requires some specific vocabulary (TM - 2)

II. Type of Engine - Determining Type of Engine (4-cycle or 2-cycle)

A. There are four ways to determine what type of an engine you are working with if you are not familiar with that particular engine (TM - 3)

1. Check for an oil sump or oil filler cap. A 4-cycle engine has an oil sump while a 2-cycle engine does not.
2. Check locations of exhaust ports or mufflers. On a 4-cycle engine the exhaust muffler connects at the cylinder head end and in a 2-cycle engine the exhaust ports are about midway on the cylinder.
3. Check the information on the nameplate or in the operator's instructions (TM - 4)
4. If you are still uncertain, use the compression method.
   a. Remove the spark plug and hold your thumb over the opening in the cylinder head to feel the compression.
   b. Put a chalk mark on the starter flange or pulley to determine number of revolutions turned.
   c. Now, crank the engine over slowly by hand, if resistance, caused by compression, is felt at each revolution, it is a two-cycle engine. If resistance is felt only at every other revolution, it is a four-cycle engine.

B. Four-stroke cycle engine (TM - 3, 3A, 4)

(Note: These engines require two revolutions of the crankshaft; four strokes of the piston to complete one cycle)

Here is how a four-stroke cycle engine works:

1. Intake stroke: Cycle starts with the piston in uppermost position in cylinder (TDC) both valves closed. As the piston moves downward, away from the cylinder head, it causes a partial vacuum (low pressure) in the cylinder. The intake valve opens and allows a mixture of fuel and air to be forced into the cylinder by atmospheric pressure (the exhaust valve remains closed). When the piston reaches the bottom of the cylinder (BDC) the intake valve closes. The intake valve is located in the cylinder block next to the carburetor. It is kept closed

	Suggested Learning Activities	Suggested Resource Materials
I.	1. Ask class how many uses they can think of, tell or list on paper.	1. Briggs and Stratton; AAVIM; Mid America Voc. Curr. Consortium; Small Gas Engines, Penn. (TM - 1, 2)
II.	2. Have a small engine in shop, let the students check out by one or more of 4 methods to determine if 2 or 4 cycle.	2. See Teaching Outline
	3. Components of four-stroke cycle engine.	3. TM - 3, 3A, 4

II. B. 1. Intake stroke: (continued) by a strong spring and is opened at the proper time by means of a push rod which is driven by a cam. The cam is located on the camshaft which is timed or geared to the crankshaft or in some cases the cam may be on the crankshaft.

2. Compression stroke: As the piston completes its downward stroke and moves upward, the intake and the exhaust valves remain closed. The upward movement of the piston compresses the fuel-air mixture to approximately 1/6 of the volume it had at atmospheric pressure. The amount of pressure developed depends on the compression ratio of the engine. Compression of the fuel creates heat which prepares the fuel for ignition.

3. Power stroke: As the piston completes its upward stroke, both the intake and exhaust valves are closed. Compressed fuel and air are ignited, an electric spark is developed at the spark plug which ignites the fuel misture. The air-fuel mixture burns, and pressure inside the cylinder increases because of the heat of combustion. Combustion temperatures average approximately 3600 degrees F. The pressure of the burning gases inside the cylinder increases to 3 or 4 times that of the compression pressure which is already 6 times normal atmospheric pressure. This pressure was developed during the compression stroke. The combined pressures drive the piston downward, or away from the cylinder head. The exhaust valve starts to open towards the end of the stroke. The reason the exhaust valve opens toward the end of the power stroke is to allow for better scavenging--more complete removal of the burned gases.

4. Exhaust stroke: When the piston has completed the power stroke and is coming back up, the exhaust valve is open and the intake valve is still closed. The force of the burning gases is gone. The upward piston movement forces the burned gas out the exhaust valve into the exhaust manifold. As the piston reaches the top of the cylinder (TDC), the exhaust valve closes and the intake valve opens to begin the next cycle.

(Note: The complete cycle takes two rotations of the crankshaft or 720° of rotation.)

5. Terms and definitions of 4-cycle engines (TM - 4)

a.	Intake stroke:	Downward movement of piston which permits air-fuel mixture to enter cylinder
b.	Compression: stroke	Upward movement of piston which compresses fuel-air mixture
c.	Power stroke:	Downward piston movement caused by spark ignition of compressed fuel-air mixture
d.	Exhaust: stroke	Upward piston movement which expels burnt gases from cylinder

Suggested Learning Activities	Suggested Resource Materials

II. B. 5. e. Valve: Device for alternately opening and closing a passage

f. Intake valve: Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke

g. Exhaust valve: Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder

h. Overlap: Brief period when both intake and exhaust valves are open

i. Cam lobe: Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating valve

j. Camshaft: Shaft which contains lobes or cams to operate engine valves

k. Valve lifter: or tappet Push rod or plunger placed between the cam and the valve on an engine

l. Valve seat: Matched surface upon which the valve rests

m. Valve spring: Spring attached to a valve to return it to the seat

C. Multiple cylinder small engines

1. Same four-stroke cycle occurs in each cylinder

2. Firing order of each cylinder is determined by design of the camshaft or placement of the cam lobes on the camshaft

D. Two stroke-cycle engines (TM - 5, 5A) - It is designed to complete all of the actions (a cycle) described for the four-stroke cycle engine but it does them during one revolution of the crankshaft and two strokes of the piston.

1. Stroke I - Power, exhaust, intake (TM - 6)

a. Power - pressure of the burning gases, caused by the heat of combustion, pushes the piston downward. This action provides power to turn the crankshaft through the connecting rod (the fuel was ignited about the time the piston reached to top of the previous stroke).

Before the piston reaches the end of its downward movement, it exposes in the cylinder wall two holes, or sets of holes which are located on opposite sides of the cylinder. These holes are called "ports." One is the "exhaust port" and the other is the "intake port."

b. Exhaust - As the piston moves down the exhaust port is uncovered first. Hot gases which are still under pressure from combustion escape through the open exhaust port.

c. Intake - As the piston continues downward after uncovering the exhaust port, the intake port is uncovered. A fresh charge of the fuel-air mixture is forced into the combustion chamber. The charge comes from the crankcase where the fuel-air mixture is under pressure.
Pressure develops in the crankcase as a result of the downward movement of the piston. The pressure causes the reed valve to close and pressure to build up in the crankcase. This is only a slight-pressure compared to the compression pressure developed in the combustion chamber--approximately 4 to 6 pounds per square inch (psi). It is enough however to force the new charge of fuel into the combustion chamber. This also helps to drive out the remaining exhaust gases. (TM - 7)

2. Stroke 2 - Compression:

a. The piston is now moving up, starting the second stroke. Both ports are closed (covered) by the piston as it moves up the cylinder, so that the fuel-air charge in the top of the cylinder is trapped and compressed.

	Suggested Learning Activities	Suggested Resource Materials
II.D.	1. Review the parts of a two stroke cycle.	1a. TM - 5 b. Two-cycle engines, McCulloch. c. Texas Voc. Curr. d. Mid-America, Vocational Curriculum Consortium e. AAVIM

II. D. 2. b. Just before the piston reaches the top of the cylinder on the upward stroke, a spark from the spark plug ignites the mixture, and it starts to burn. This begins another power stroke.

c. Another event which does not occur in 4-cycle engines takes place in the compression stroke. As the piston moves upward, a partial vacuum (low pressure) is created in the crankcase. Atmospheric presure opens the reed valve and forces a new charge of fuel and air (from the carburetor) into the crankcase.

d. Most valves in 2-cycle engines are of the metallic reed type. Reeds are made of metal, phenolic or plastic. Some 2-cycle engines, however, have sliding valves, and others have rotary valves.(TM - 7)

3. Terms and definitions (2-cycle engines):

a. Ports: Openings in the cylinder wall which allows the fuel-air mixture to enter and the exhaust to escape

b. Transfer port: Passage which allows movement of the fuel-air mixture from the crankcase into the combusion chamber

c. Rotary valve: Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase

d. Reed valve (leaf valve): One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only. (TM - 6)

e. Crankcase pressure: Pressure built up in the crankcase by the downward movement of the piston
(Note: This causes the fuel-air mixture to move into the combustion chamber.)

f. Crankcase vacuum: Negative crankcase pressure created when piston moves upward in cylinder

g. Expansion: Exhaust system specially designed to produce maximum horsepower at a specific RPM range

h. Chamber: Where the burning of fuel starts.

4. Advantages of 2-cycle:

a. Simple design
b. Light weight
c. Smaller size for equivalent horsepower
d. Adequate lubrication in any position
e. Continuous supply of new, clean oil to all moving parts

5. Major differences in the four-cycle and two-cycle engines

Four cycle	Two Cycle
Has regular intake and exhaust valves	Piston or thin piece of metal over an opening (reed valve) serves as a valve
Oil is used entirely as a lubricant.	Oil is mixed with gasoline and used as a fuel and lubricant.
Two revolutions of the crankshaft are one cycle.	One revolution of the crankshaft is a cycle.
Crankcase contains only a lubricant.	Crankcase contains a fuel that also serves as a lubricant.
Four strokes of the piston complete one cycle.	Two strokes of the piston complete one cycle.
Has valve lifters, valve springs and a camshaft.	Has no camshaft, valve lifters, or valve springs.
More difficult to handle on very small equipment.	Less difficult to handle on small hand equipment.

Suggested Learning Activities	Suggested Resource Materials

Suggested Learning Activities	Suggested Resource Materials

Student Evaluation

Four-Stroke Cycle Engine Test

Name _____

Date _____

1. Match the terms on the right to the correct definitions.

_____	a.	Spring attached to a valve to return it to the seat	1. Exhaust valve
_____	b.	Device for alternately opening and closing a passage	2. Power stroke
_____	c.	Off-center or eccentric enlargement on the camshaft which converts rotary motion to reciprocating motion for operating a valve	3. Valve seat
			4. Camshaft
_____	d.	Brief period when both intake and exhaust valves are open	5. Intake stroke
_____	e.	Upward movement of piston which compresses fuel-air mixture	6. Cam lobe
_____	f.	Downward movement of piston which permits fuel air mixture to enter cylinder	7. Valve
_____	g.	Push rod or plunger placed between the cam and the valve on an engine	8. Valve spring
_____	h.	Matched surface upon which the valve rests	9. Intake valve
_____	i.	Shaft which contains lobes or cams to operate engine valves	10. Overlap
_____	j.	Engine component which opens during exhaust stroke and allows burnt gases to be expelled from cylinder	11. Compression stroke
_____	k.	Upward piston movement which expels burnt gases from cylinder	12. Exhaust stroke
_____	l.	Downward piston movement caused by spark ignition of compressed fuel-air mixture	13. Valve lifter or tappet
_____	m.	Engine component which opens to allow fuel-air mixture to enter cylinder during intake stroke	

2. Identify the components of a four-stroke cycle engine.

Student Evaluation

Two-Stroke Cycle Engine Test

Name _____

Date _____

1. Match the terms on the right to the correct definitions.

_____	a.	Pressure built up in the crankcase by the downward movement of the piston	1. Transfer port
_____	b.	One way valve made of spring steel which allows the fuel-air mixture to flow in one direction only	2. Reed valve (leaf valve)
_____	c.	Openings in the cylinder wall which allows the fuel-air mixture to enter and the exhaust to escape	3. Ports
_____	d.	Passage which allows movement of the fuel-air mixture from the crankcase into the combustion chamber	4. Expansion chamber
_____	e.	Flat circular plate with a section of the plate cut away that operates between the carburetor and the crankcase	5. Crankcase pressure
_____	f.	Exhaust system specially designed to produce maximum horsepower at a specific RPM range	6. Crankcase vacuum
_____	g.	Negative crankcase pressure created when piston moves upward in cylinder	7. Rotary valve

2. Identify the components of a two-stroke cycle engine.

WHY SMALL ENGINES ARE ADAPTABLE TO MANY KINDS OF JOBS

TM-1

Lightweight	Portable
Economical on Fuel Use	Air-cooled
Compact	Easy to Service
Source of Power for Small Equipment	

EQUIPMENT POWERED BY SMALL ENGINES

Mowers	Brush Cutters
Chain Saws	Rotary Tillers
Conveyors	Irrigation Pumps
Elevators	Sprayers
Post Hole Diggers	Concrete Vibrator
Small Feed Grinders	Generators
Concrete Surfacers	Outboard Boats
Air Compressors	Small Tractors

GLOSSARY

Air Cleaner	A device for filtering, cleaning, and removing inert material from the air admitted to an engine.
Air-fuel ration	The ration, by weight, of fuel and air in the carburetor mixture.
Back-fire	Ignition of the mixture in the intake manifold caused by flame from the cylinder, such as might occur from a leaking intake valve.
Bearing	A part on which a journal or pivot turns or moves.
Blow-by	A leakage or loss of pressure, often used with reference to leakage of compression past the piston rings.
Bore	The diameter of a hole, such as a cylinder; also a tool used to enlarge a hole.
Breaker-points	Two contact surfaces that are mechanically opened and closed to control flow of electricity; essentially an electrical switch.
Camshaft	The shaft containing lobes, or cams, to operate the engine valves.
Carbon	A black, non-metallic element which is an excellent conductor of electricity. Carbon residues form in the combustion chamber of an engine during the burning of fuels, which are largely composed of hydrocarbons.
Carburetor	A device for automatically mixing fuel in the proper proportion with air to produce a combustible gas.
Check-valve	A gate or valve which allows passage of gas or fluid in only one direction.
Choke	A reduced passage, such as a valve placed in a carburetor air horn to limit the volume of air admitted.
Circuit	The path of electrical current, fluids, or gases.
Clearance	The space between two parts, such as between a journal and a bearing.
Coil	Essentially a transformer which through the action of induction converts low voltage to high voltage.
Combustion	The process of rapid burning or explosion.
Combustion chamber	A cylindrical space shaped by the cylinder walls, with the engine head enclosing the space on one end and the piston head enclosing it on the other end.
Compression	The reduction in volume or the "squeezing" of a gas.
Compression ratio	The volume of the combustion chamber when the crankshaft is at bottom-dead center as compared to the volume when the crankshaft is at top-dead center.
Condenser	A device for temporarily collecting and storing a surge of electrical current for later discharge.
Conductor	A material along or through which electricity will flow with slight resistance.

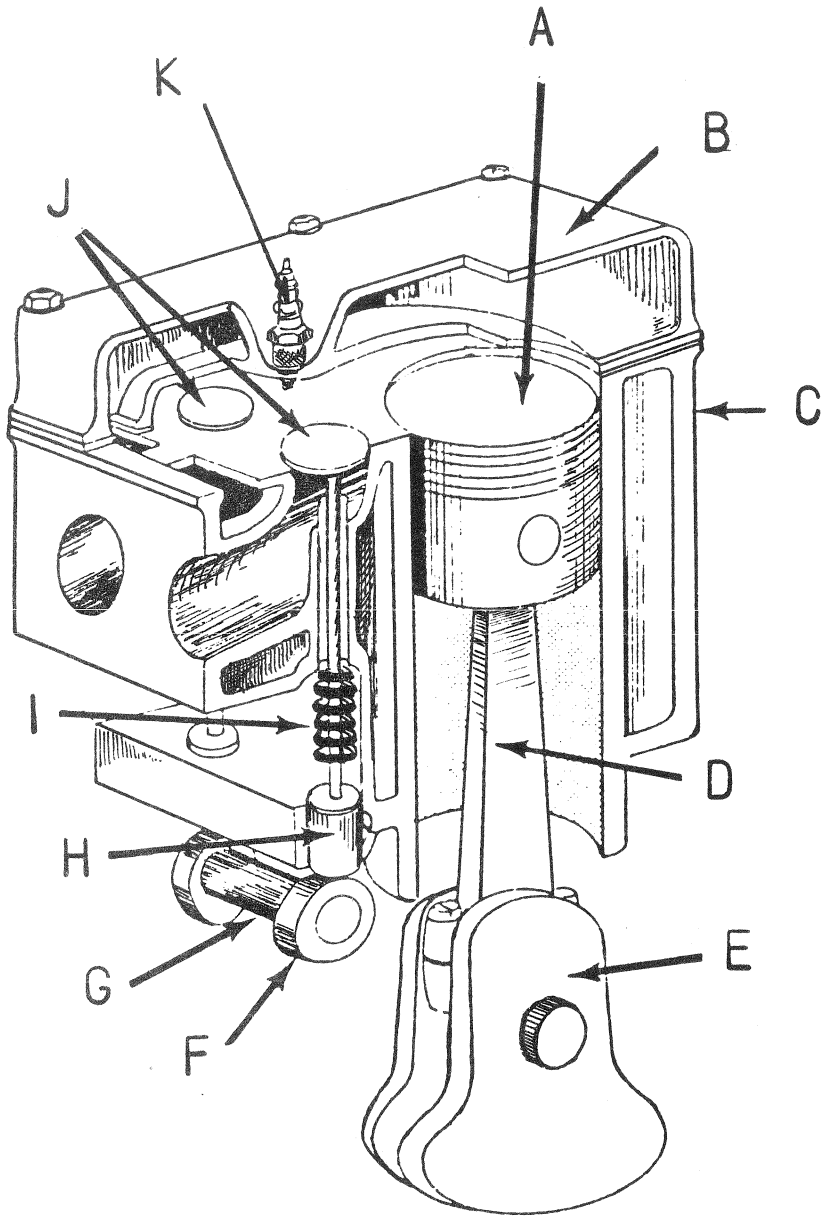
Connecting rod	The device that connects the piston to the crankshaft.
Crankcase	The housing within which the crankshaft and many other parts of the engine operate. It is often used as a storage vat for engine lubrication oil.
Crankshaft	The main shaft of the engine which in conjunction with the connecting rods changes the linear reciprocating motion of the piston into rotary motion.
Cylinder	A round hole bored to receive a piston; sometimes referred to as "bore" or "barrel."
Cylinder block	The main mass of metal in which the cylinders are bored and the pistons are placed.
Cylinder head	Usually a detachable portion of an engine fastened securely to the top of the cylinder block. The cylinder head and the cylinder block may be constructed in one casting as often is the case with two-stroke cycle engines.
Cylinder sleeve	A liner or tube interposed between the piston and the cylinder block to provide a readily renewable wearing surface for the cylinder.
Exhaust pipe	The pipe connecting the engine's exhaust passage to the muffler, and it conducts exhaust gases away from the engine.
Exhaust valve	A valve which permits a gas to exit the combustion chamber and which seals the exit.
Float	A hollow tank filled with air, bouyant in the fluid in which it rests and which is ordinarily used to automatically operate a valve controlling the entrance of fuel.
Float level	The pre-determined height of the fuel in the carburetor bowl, usually regulated by means of a float valve.
Four-stroke cycle engine	An explosion occurs every second revolution of the crankshaft, a stroke being considered as one-half revolution of the crankshaft. These strokes are (1) suction or intake, (2) compression,(3) power, and (4) exhaust.
Gasket	Anything used as a packing, usually a non-metallic substance placed between two metal surfaces to act as a seal.
Governor	A device used to automatically regulate speed.
Idle	Refers to the engine operating at its slowest recommended speed.
Ignition system	The means for igniting fuel in the cylinders; includes sparkplugs, wiring, ignition, distributor, ignition coil, and source of electric supply.
Intake valve	A valve which permits a gas to enter the combustion chamber and seals the entrance.
Intake manifold	The tube used to conduct the air-fuel mixture from the carburetor to the engine cylinder.
Internal combustion	The burning of a fuel within an enclosed space.

Muffler	A chamber attached to the end of the exhaust pipe which allows the exhaust gases to expand and cool. It is usually fitted with baffles or porous plates and serves to subdue some noise created by the engine.
Piston	A cylindrical part closed at one end which is connected to the crankshaft by the connecting rod. The force of explosion in the cylinder is against the closed end of the piston, causing the connecting rod to move the crankshaft.
Piston displacement	The volume of air extracted by moving the piston from one end of its stroke to the other end.
Piston head	The part of the piston above the rings and the part that receives the thrust of combustion.
Piston pin	The journal for the bearing in the small end of an engine's connecting rod which also passes through piston walls; also known as a wrist pin.
Piston ring	An expanding ring placed in the groove of the piston to provide a seal; prevents passage of fluid or gas past the piston, and minimizes the contact of the piston to the cylinder wall.
Piston ring end-gap	The clearance between the ends of the piston rings when placed in a cylinder.
Piston ring-groove	The channel or slot in the piston in which the piston rings are placed.
Port	A hole through which gases may enter or exit.
Scoring	A scratch, ridge, or groove marring a finished surface.
Spark	An electrical current possessing sufficient pressure to jump through the air from one electrode to another.
Spark advance	When used with reference to an ignition distributor, means to cause the spark to occur at an earlier time in the timing circle.
Spark gap	The space between the electrodes of a sparkplug through which the spark jumps.
Sparkplug	A device inserted into the combustion chamber of an engine containing an insulated control electrode for conducting current. It delivers the spark needed for combustion.
Stroke	The total distance moved by the piston in one-half revolution of the crankshaft.
Throw	The distance from the center of the crankshaft main bearing to the center of the connecting rod journal.
Two-stroke cycle engine	An engine design permitting one power stroke for each revolution of the crankshaft.
Valve	A device for opening and closing the passage that admits the air and gas mixture into the cylinder.
Valve clearance	The gap allowed between the end of the valve stem and the valve lifter to compensate for expansion of the valve due to heat.

Valve face	That part of a valve which mates with and rests upon a seating surface.
Valve head	The portion of the valve upon which the valve face is machined.
Valve seat	The matched surface upon which the valve face rests.
Valve stem	That portion of a valve which rests within a valve stem guide.
Valve stem guide	A bushing or hole in which the valve stem is placed. Tolerances between guide and stem are small.
Vapor lock	A condition where the fuel boils in the fuel system forming bubbles which retard or stop the flow of fuel to the carburetor.
Venturi	An area in an air-flow tube that restricts in part the easy flow of air through the tube and makes low pressure at the restricted area.

COMPONENTS OF A FOUR-STROKE CYCLE ENGINE

TM-3



A _____

B _____

C _____

D _____

E _____

F _____

G _____

H _____

I _____

J _____

K _____

COMPONENTS OF A FOUR-STROKE CYCLE ENGINE

TM-3A

A. PISTON

B. CYLINDER HEAD

C. CYLINDER BLOCK

D. CONNECTING ROD

E. CRANKSHAFT

F. CAM LOBE

G. CAMSHAFT

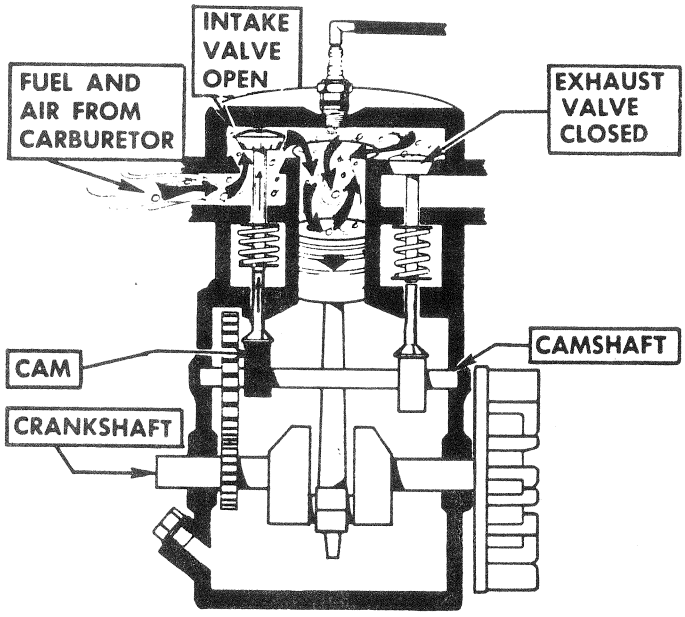
H. VALVE LIFTER

I. VALVE SPRING

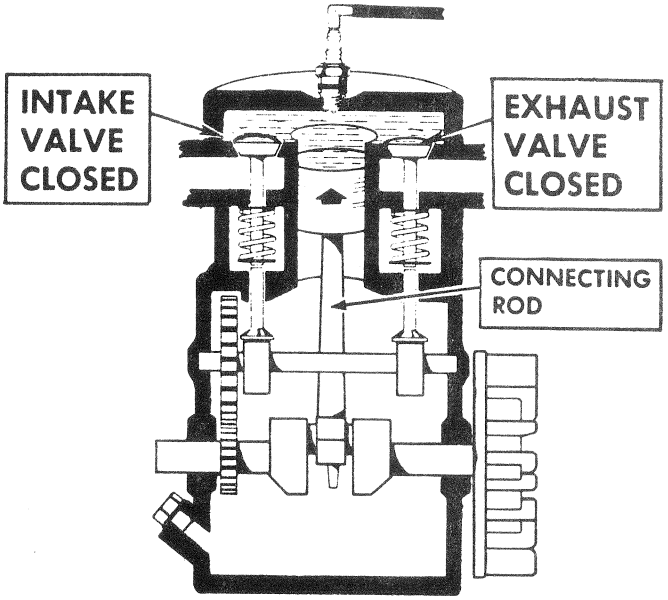
J. VALVES

K. SPARK PLUG

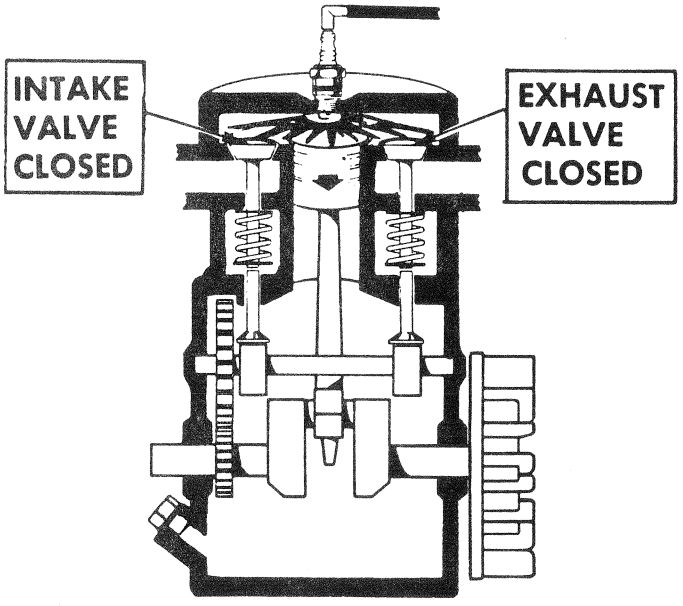
FOUR – STROKE CYCLE



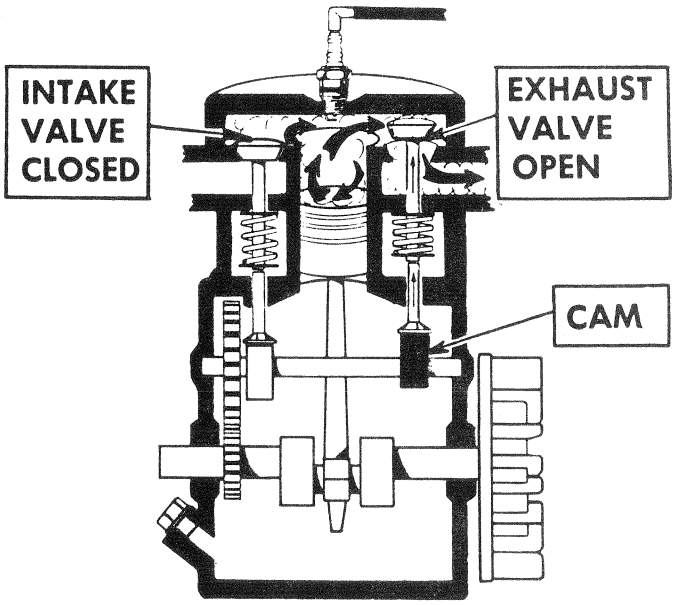
PISTON INTAKE STROKE



PISTON COMPRESSION STROKE



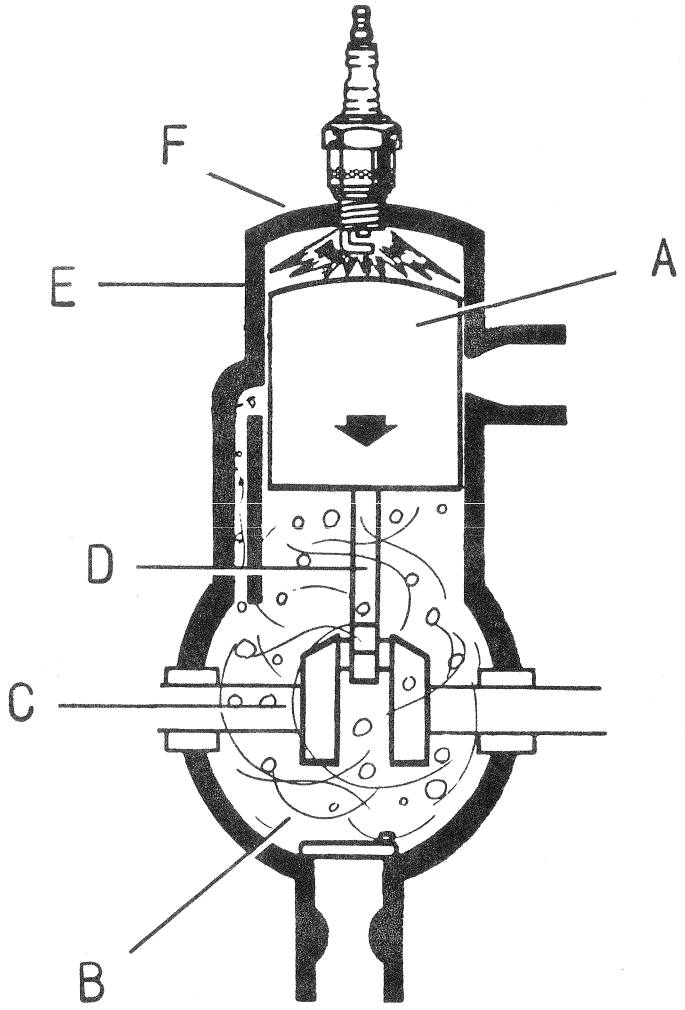
PISTON POWER STROKE



PISTON EXHAUST STROKE

COMPONENTS OF A TWO-STROKE CYCLE ENGINE

TM-5



A _____

B _____

C _____

D _____

E _____

F _____

COMPONENTS OF A TWO-STROKE CYCLE ENGINE

TM-5A

A. PISTON

B. CRANKCASE

C. CRANKSHAFT

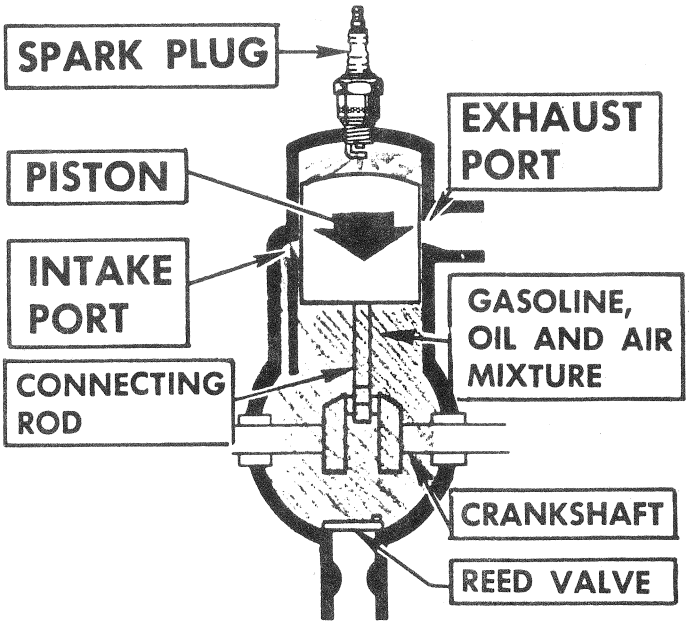
D. CONNECTING ROD

E. CYLINDER

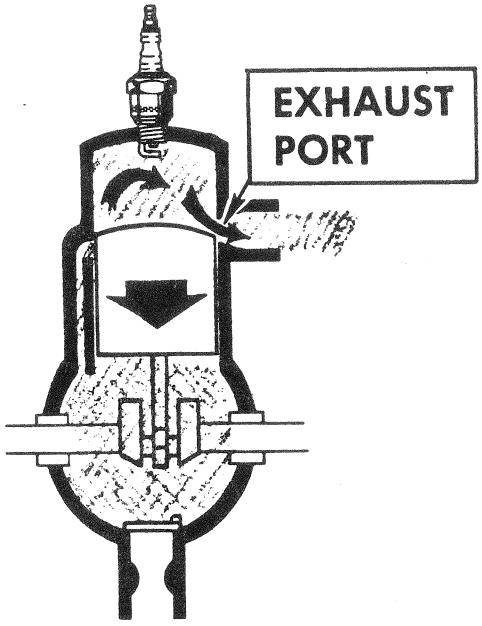
F. CYLINDER HEAD

TWO-STROKE CYCLE

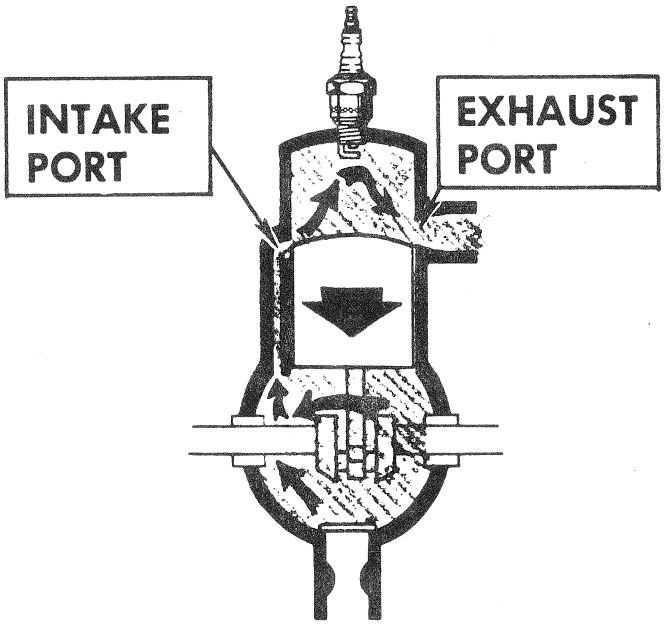
TM-6



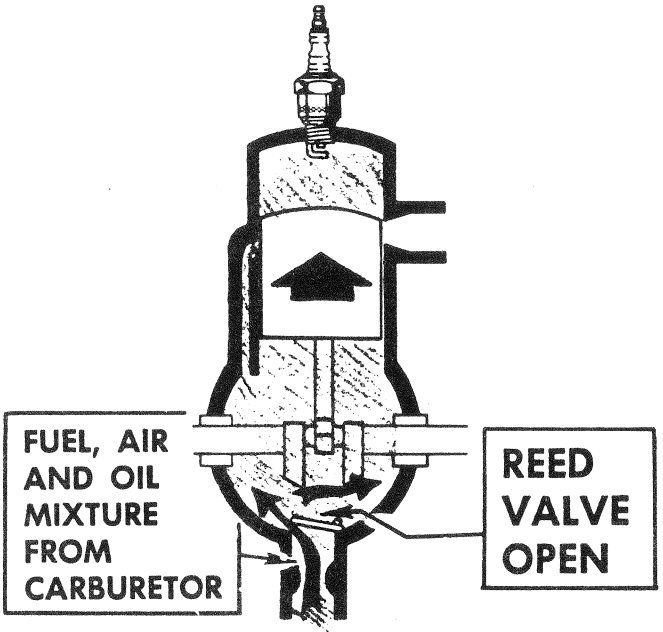
STROKE I — POWER



STROKE I — EXHAUST

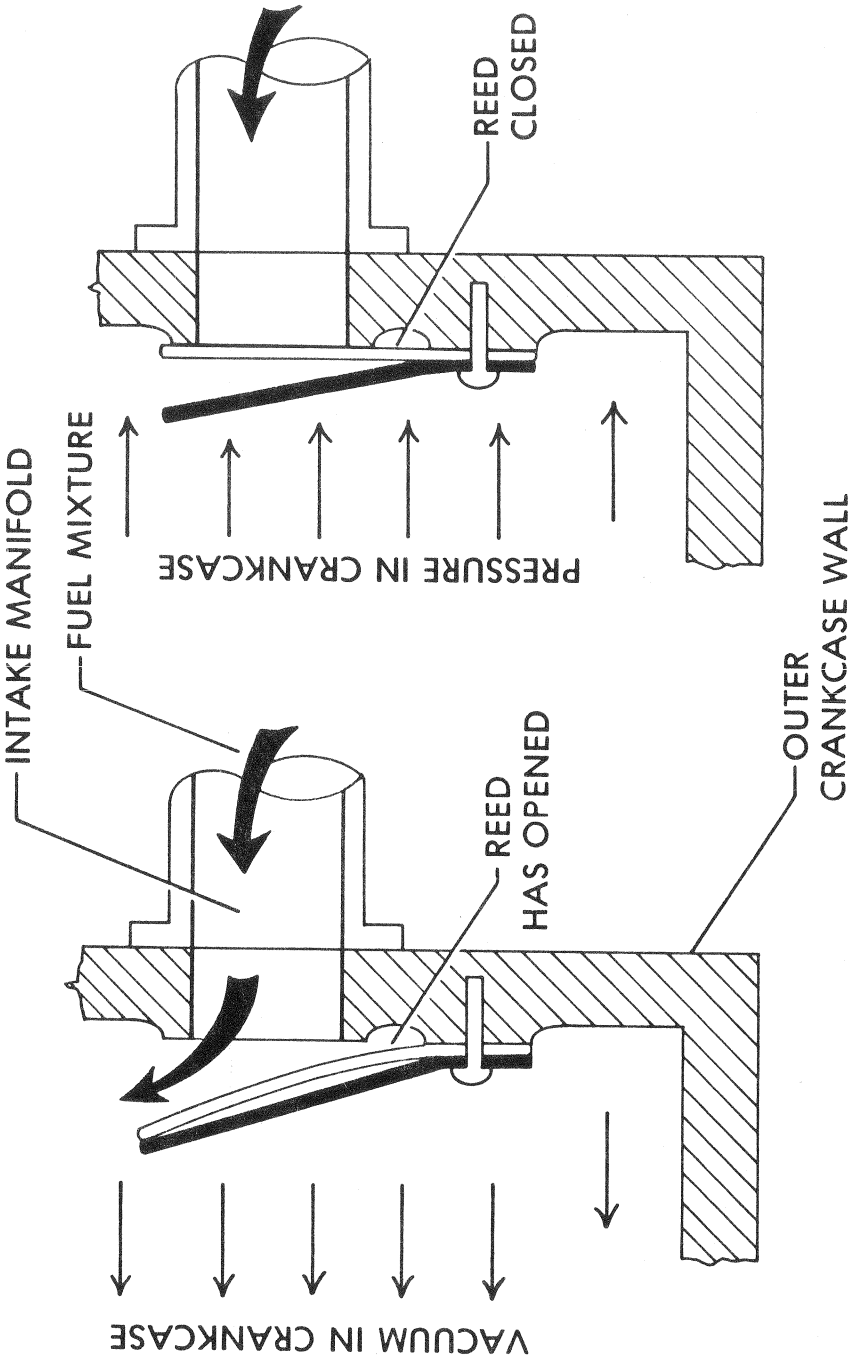


STROKE I — INTAKE



STROKE II — COMPRESSION

REED VALVES


REED CLOSED
PRESSURE IN CRANKCASE
INTAKE MANIFOLD
FUEL MIXTURE
REED HAS OPENED
OUTER CRANKCASE WALL
VACUUM IN CRANKCASE

General References

Small Engines, Vol. 1, 2, 3rd edition. American Association for Vocational Instruction Materials, Engineering Center, Athens, Georgia, 30602.

Texas Curriculum Materials. Basic VoAg 3rd year, Vocational Inst. Services, Texas A & M University, College Station, Texas, 77843.

Comprehensive Small Engine Repair, Mid-America Vocational Curriculum Consortium, Inc., Instructions Materials Lab, State Dept. of Voc. E. Tech. Ed. Stillwater, Okla.

The Two-Cycle Engine, McCulloch Corp., L.A., California.

Briggs & Stratton: Repair Instruction IV, Milwaukee, Wisconsin, 53201.

Kohler, Co., Kohler, Wisconsin, 53044.

Wisonsin Motor Corp, Milwaukee, Wisconsin, 53246.

Jim Bermann: VEP Small Engines for OH.

Tecumsen Products, Co., Lauson-Power Products Engine Div., Grafton, Wisconsin, 53024.

Small Gasoline Engines, Student Handbook, Penn State University, College of Agriculture, Department of Ag Ed., University Park, Pennsylvania, 16802.