DOCUMENT RESUME

ED 098 402 CE 002 507

AUTHOR	O'Brien, Ralph D.
TITLE	Engine Fundamentals: Automotive Mechanics Instructional Program. Block 2.
INSTITUTION	Kentucky Univ., Lexington. Vocational Education Curriculum Development Center.
SPONS AGENCY	Kentucky State Dept. of Education, Frankfort. Bureau of Vocational Education.
PUB DATE	73
NOTE	115p.; For other curriculum guides in the series, see CE 002 506-511
AVAILABLE FROM	Curriculum Development Center, Room 151, Taylor Education Building, University of Kentucky, Lexington, Kentucky 40506 (Single copies only, $3.50)
EDRS PRICE	MF-$0.75 HC-$5.40 PLUS POSTAGE
DESCRIPTORS	*Auto Mechanics; Auto Mechanics (Occupation); Behavioral Objectives; Course Content; Course Descriptions; *Curriculum Guides; *Engines; Industrial Arts; Instructional Materials; Job Skills; Lubricants; *Mechanics (Process); Post Secondary Education; Resource Materials; Secondary Education; Skilled Occupations; *Trade and Industrial Education; Vocational Education
IDENTIFIERS	Kentucky

ABSTRACT

The second of six instructional blocks in automotive mechanics, the lessons and supportive information in the document provide a guide for teachers in planning an instructional program in engine fundamentals at the secondary and postsecondary level. The material, as organized, is a suggested sequence of instruction within each block. Each lesson is stated in terms of a specific teaching objective, teaching aids, references, and an outline of information. Upon successful completion of the 49 lessons, students will be able to: (1) describe the principle of converting fuel and heat to mechanical energy, (2) identify the basic types of power units used for motor vehicles, (3) briefly outline the historical development of the internal combustion piston engine and explain its operating principles, (4) describe and relate the systems, parts, components, and mechanisms essential to the mechanical operation of modern piston engines, (5) disassemble, examine, measure, adjust, align, refit, machine, and reassemble components and mechanisms from practice engines, and (6) describe the purpose and functions of modern engine lubricating systems and relate the use of modern lubricants. Included with the course outline are transparency masters and a reference guide listing related books, texts, and other publications. (MW)

AUTOMOTIVE MECHANICS INSTRUCTIONAL PROGRAM

BLOCK II

Engine Fundamentals

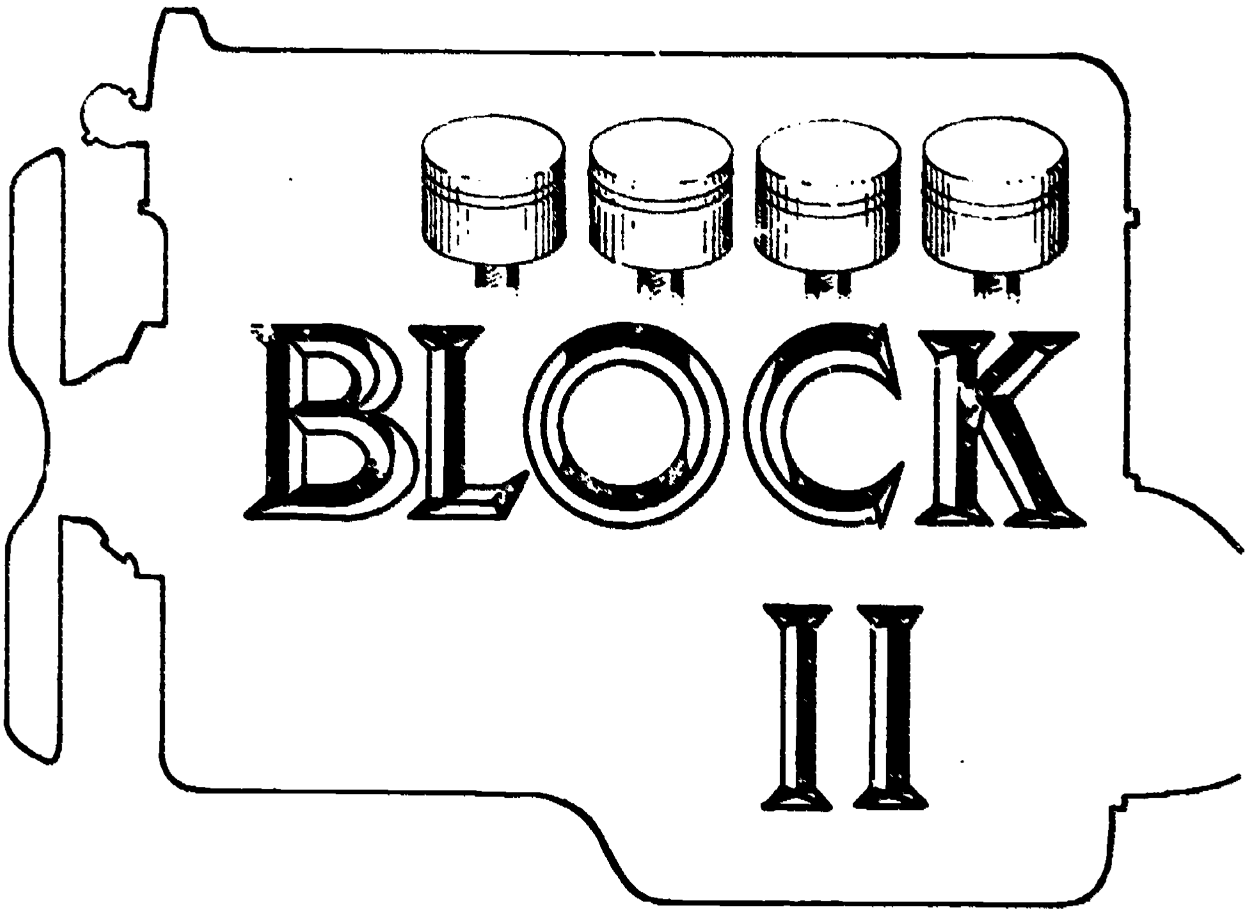
PREPARED FOR

Kentucky Industrial Education Teachers

IN COOPERATION WITH

Bureau of Vocational Education
State Department of Education
Frankfort, Kentucky

Ralph D. O'Brien, Curriculum Specialist
Curriculum Development Center
151 Taylor Education Building
University of Kentucky
Lexington, Kentucky



Engine Fundamentals

Upon successful completion of the forty-nine lessons in this block of work, students will be able to:

1. Describe the principles of converting fuel and heat to mechanical energy.
2. Identify the basic types of power units used for motor vehicles.
3. Briefly outline the historical development of the internal combustion piston engine and explain its operating principles.
4. Describe and relate the systems, parts, components, and mechanisms essential to the mechanical operation of modern piston engines.
5. Disassemble, examine, measure, adjust, align, refit, macnine, and reassemble components and mechanisms from practice engines.
6. Describe the purpose and functions of modern engine lubricating systems and relate the use of modern lubricants.

CONTENTS - BLOCK II

ENGINE FUNDAMENTALS

External Combustion 1
External Combustion 2
Internal Combustion 3
Internal Combustion 4
Piston Engines-Basic Operating Principles 5
Torque, Horsepower, RPM 6
The Piston Engine 7
Reciprocal to Rotary Motion 8
Engine Cycles 9
Engine Cycles 10
Intake. 11
Compression 12
Power 13
Exhaust 14
Four-Stroke Cycle Engine. 15
Engine Classifications. 16
Basic Engine Design Depending on Cyclinder Arrangements 18
Engine Block, Head and Oil Pan. 19
Engine Block, Head, and Pan 21
Gaskets 22
Engine Gaskets. 24
Removing and Replacing Cylinder Head. 25
Rod, Piston and Rings Assembly. 26
Connecting Rod, Piston, and Rings 28
Cleaning and Inspecting Pistons and Rod Assemblies. 29
Examine, Measure, and Align Connecting Rod. 30
Bearings (Precision Type Insert Bearings) 31
Examining and Measuring Bearings. 33
Use of Plastigage 35
Cylinder Wear Limits. 36
Cylinder Ridge, Cause and Correction. 37
Cylinder Taper and Ridge. 39
Micrometer. 40
Micrometers 42
Micrometer Readings 43
Measuring Cylinders 44
Crankshaft Function and Design Characteristics. 45
Crankshafts 46
Crankshaft Inspection 47
Crankshaft. 48
Measuring a Crankshaft. 49
Flywheel Function and Design Characteristics. 50
Engine Components 51
Camshaft Function and Design. 52
Cam Design. 54
Camshaft Drives and Timing Gears. 55
Checking Camshaft Bearing Clearance 56

Crankshaft-Camshaft Relationship.	57
Valve Purpose and Operation	58
Crankshaft, Camshaft, and Valve	59
Valve Construction.	60
Valve Construction.	62
Valve Systems	63
Valve Arrangements, I-Head, T-Head.	65
Valve Arrangements, L-Head, F-Head.	66
Valve Trains.	67
Valve System Mechanisms	69
Valve Seats	70
Valve Seating	71
Removing Valves and Springs	72
Fitting Valve Springs	74
Practicing Valve Grinding and Valve Seat Grinding	75
Valve Lifters - Function and Type	77
Mechanical Valve Lifter	79
Hydraulic Valve Lifter.	[illegible]
Examining Valve Lifters	81
Valve Rotators.	82
Valve Adjustment.	83
Adjusting Valve Tappets (With Engine Operating)	84
Adjusting Valve Tappets (Engine Not Running).	85
Purpose of Engine Lubricating Systems	86
The Four Essential Functions of the Engine Lubricating System	87
Reaction Within Engine Crankcase Temperatures During Operation.	88
Function and Construction of Oil Pumps and Oil Pressure Relief Valve.	89
Location of Oil Pump in the Engine.	90
Gear-Type Oil Pump.	91
Inspecting a Gear Type Oil Pump	92
Inspecting a Rotor Type Oil Pump.	93
Rotor-Type Oil Pump	94
Filtration (Oil Filter Systems)	95
Oil Filter.	96
Spin-On Oil Filter.	97
Full Flow Type System, Easy Change, Fram Corporation.	98
Full Flow Type System, Replaceable Cartridge, Fram Corporation.	99
By-Pass Type System, Easy Change, Fram Corporation.	100
Service Ratings of Oil.	101
Viscosity Standards	103
New Engine Oil Designations	104
Engine Oil Designations	106
Oil Pressure Indicators	107
Electric Circuit Oil Pressure Indicator	108
Oil Pressure Indicator, Bourdon Tube.	109

INFORMATION

Block: Engine Fundamentals

Lesson: External Combustion

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to discuss the principles of external combustion.

Teaching Aids: Transparency:
- External Combustion, p. II-2

Reference: Encyclopedia Americana, Volume 10, 1969

Outline of Information:

1. The external combustion engine is a mechanical energy device that receives its heat energy from fuel having been burned outside the engine cylinder.

2. The steam engine is the most common application of converting external combustion heat energy to mechanical energy.

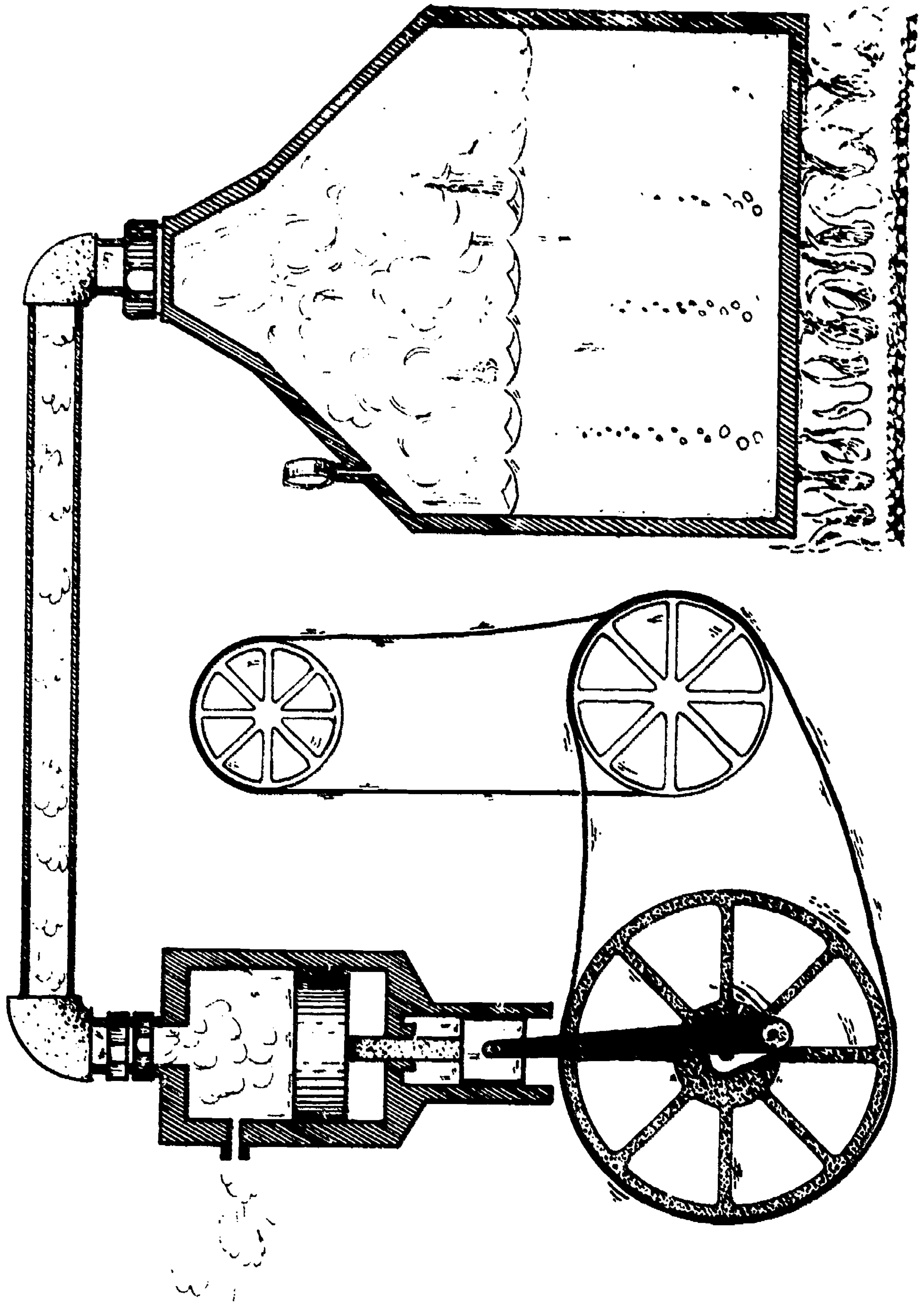
3. Many fuels have been used to produce steam power, such as wood, oil, gas and kerosene. However, coal is most abundantly used.

4. Once the major source of mechanical power in the 20th century, the steam engine has virtually been replaced.

   a. Two types of steam engines
      -- Reciprocating (piston-type)
      -- Steam turbine

   b. The steam engine was used to power some production automobiles in the early 1900's.
      -- Stanley, White, Locomobile

EXTERNAL COMBUSTION



INFORMATION

Block: Engine Fundamentals

Lesson: Internal Combustion

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to discuss the principles of internal combustion.

Teaching Aids: Transparency:
- Internal Combustion, p. II-4

References: Auto Mechanics Fundamentals, Stockel, Chapter 1
"Gasoline as Automotive Fuel," Block IV, pp. IV-1, IV-2

Outline of Information:

1. The internal combustion engine is a device that converts potential energy (the heat energy contained in fuel) into kinetic energy (useful mechanical energy).

   a. All combustible materials contain heat energy, but only a few are suitable as fuel for internal combustion engines.
   -- Gasoline, liquid petroleum gas, natural gas, methane are suitable.
   -- Gunpowder, dynamite are unsuitable.
   -- Kerosene and other grades and types of fuel oil are suitable for Diesel and turbine applications.

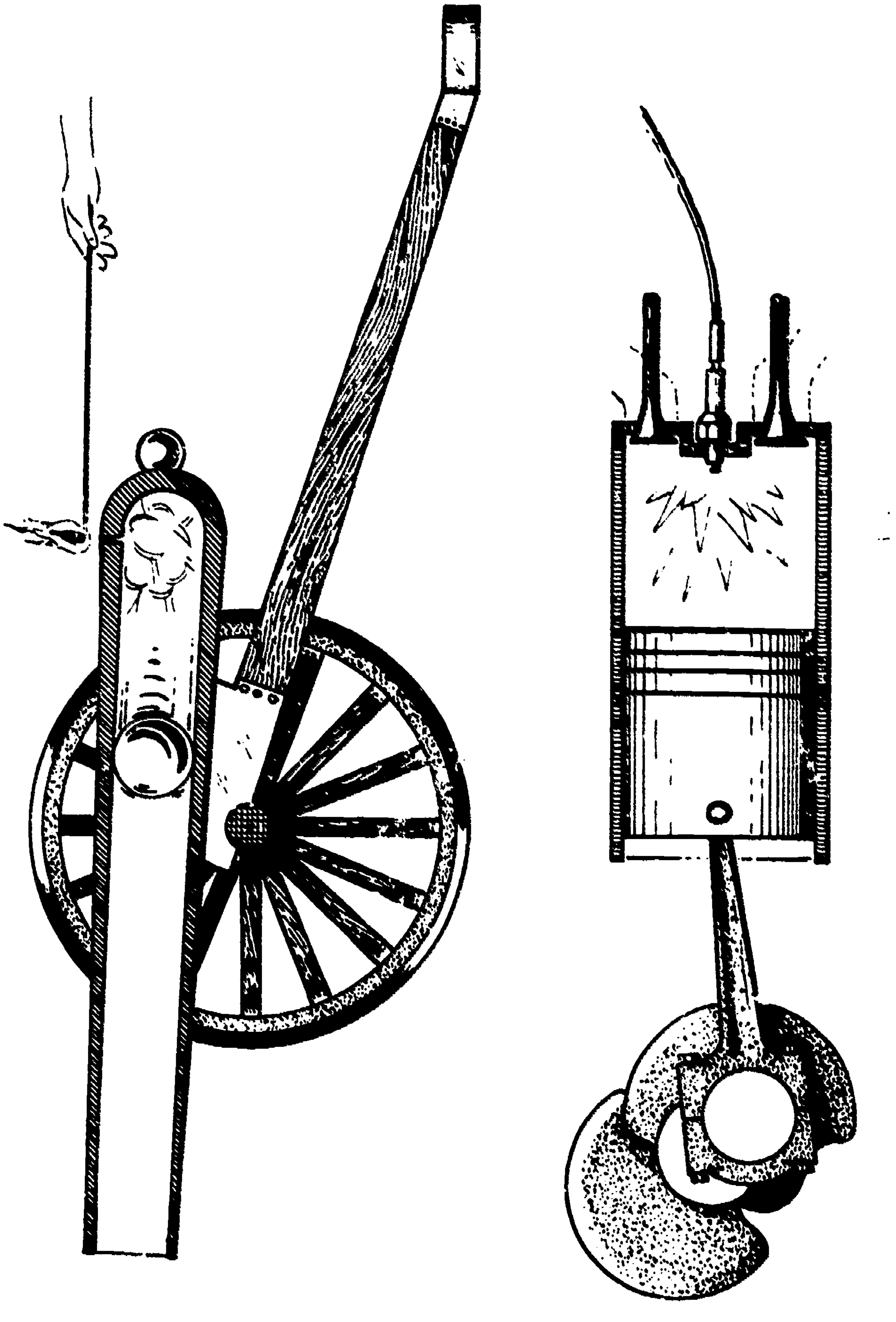
   b. The most common internal combustion engine for automotive application is the four-stroke cycle piston engine. Gasoline is the most commonly-used fuel.

2. As the contained fuel burns, it expands, releases heat, and exerts the force to initiate the kinetic energy.

   a. Explosive force in the cylinder pushes the piston creating the initial movement in the mechanical energy train.

   b. The necessity of controlling the energy and motion has led to the modern, complicated automotive engine systems.

INTERNAL COMBUSTION



INFORMATION

Block: Engine Fundamentals

Lesson: Piston Engines-Basic Operating Principles

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to describe the chemical and physical activities during the combustion process in the internal combustion engine.

Teaching Aids: Transparency:
- Cleaner Exhaust Regulations, p. IV-133

References: Auto Mechanics Fundamentals, Stockel, Chapter 1
Automotive Mechanics, Crouse, Chapter 3

Outline of Information:

1. Atoms and molecules

   a. When two or more atoms combine, molecules form.

   b. Chemical reactions cause molecules to form.

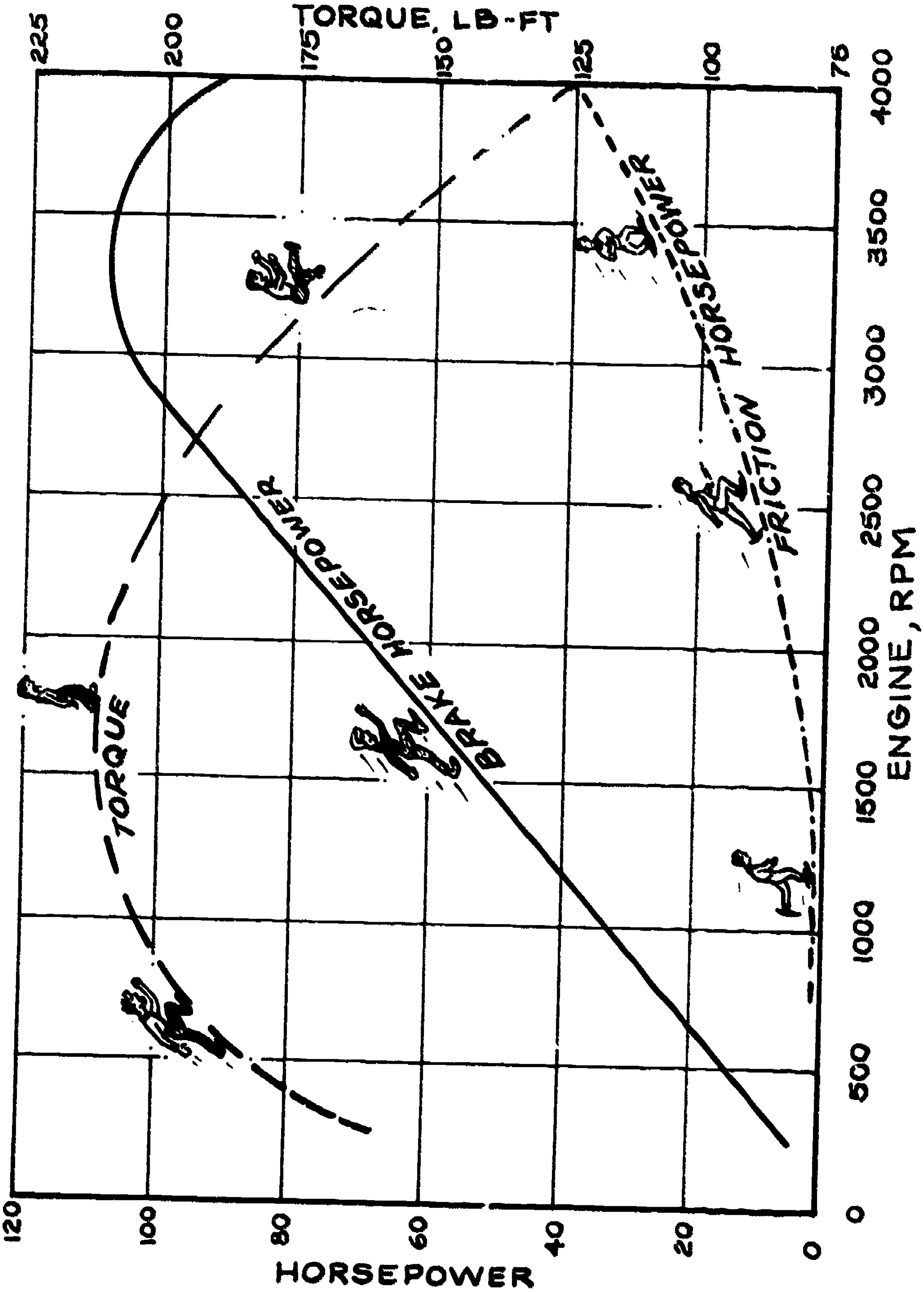
   c. Combustion is a chemical reaction in which oxygen combines with other elements.
      -- Chemically, oxygen is a very active element.

   d. During combustion the following chemistry occurs. (Refer to Block IV, pp. IV-1 - IV-10)
      -- Atoms of oxygen and hydrogen combine to form water (H_2O).
      -- Atoms of oxygen and carbon combine to form carbon dioxide (CO_2).
      -- Atoms of oxygen and carbon combine to form carbon monoxide (CO).

2. Combustion

   a. During combustion, extreme temperature changes occur.
      -- Pressurization of gasses creates heat.
      -- The temperature of compressed air in a diesel engine can reach 1000° F.
      -- The resulting temperature from burning fuel in an engine cylinder is upwards to 6000° F.

   b. The rapid movement of molecules and the chemical changes induces the following physical activities:
      -- Heat causes expansion of liquids and gases.
      -- Heat increases pressures of gases.
      -- Heat causes expansion of solids (metals).
      -- As heat effects pressure, it effects vacuum.


TORQUE, LB-FT
225
200
175
150
125
100
75
TORQUE
BRAKE HORSEPOWER
FRICTION HORSEPOWER
0
500
1000
1500
2000
2500
3000
3500
4000
ENGINE, RPM
120
100
80
60
40
20
0
HORSEPOWER

INFORMATION

Block: Engine Fundamentals

Lesson: The Piston Engine

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to discuss the relationship of work and power to the internal combustion engine and trace the early development of the engine.

Teaching Aids: Motion Picture:
- The ABC of the Automobile Engine, General Motors
Transparency:
- Torque, Horsepower, RPM, p. II-6

References: Automotive Mechanics, Crouse, Chapter 3
Fundamentals of Aircraft Piston Engine, Borden and Cake, Chapter 1

Outline of Information:

1. The piston engine (also called reciprocating engine) is a member of the internal combustion engine family of power plants.

2. The piston engine produces power by burning fuel and converting the released energy from force to controlled motion.

   a. Power is the rate at which work is done

   b. Work is the application of force.

3. Piston engines are the most common source of power in modern use.

4. The early development of the internal combustion piston engine took place during the ninteenth century.

   a. England (1820) - experimentation with exploding hydrogen to move a piston in a cylinder

   b. England (early 1800's) - piston engines burning illuminating gas and air
   -- These engines were inefficient, heavy and sluggish

   c. France (1862) - Beau de Roches developed the pre-ignition, compressed fuel mixture theory and proposed the modern four-stroke cycle.

   d. Germany (1876) - Nikolaus Otto built and sold Otto Silent Gas Engines.
   -- Otto used the four-stroke cycle which is referred to as the Otto cycle

   e. Germany (1886) - Gottlieb Daimler adapted the four-stroke cycle engine for liquid-fuel operation

INFORMATION

Block: Engine Fundamentals

Lesson: Reciprocal to Rotary Motion

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to describe the operating principles of the cylinder and piston and the transfer of reciprocal to rotary motion.

Teaching Aids: Transparencies:
- Internal Combustion, p. II-4
- Engine Block, Head and Pan, p. II-21
- Connecting Rod, Piston and Rings, p. II-28

References: Auto Mechanics Fundamentals, Stockel, Chapter 1
Automotive Mechanics, Crouse, Chapter 3

Outline of Information:

1. The cylinder and the piston

   a. The cylinder is merely cylindrical space, closed at one end, to contain and provide space for the movement of the piston.
      -- Technically the cylinder is one of 6 or 8 (as most modern engines are designed and classified) precision-machined holes in the engine block.
      -- The cylinder head completes the cylinder-combustion chamber in providing a sealed cap.

   b. Refer to lesson "Rod, Piston and Ring Assembly," p. II-26 for piston functioning information.

2. Reciprocating to rotary motion

   a. Reciprocating or straight-line motion is created by the functioning of the piston in the cylinder.

   b. The swinging action of the connecting rod on its small end (piston end) allows it to follow the circular path of the crankshaft, where it is connected by its big end (via bearing cap).
      -- Refer to lesson "Rod, Piston and Ring Assembly," p. II-26 for additional information on connecting rod functioning.

INFORMATION

Block: Engine Fundamentals

Lesson: Engine Cycles

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will relate the four basic functions to piston engine operating principles and will differentiate between two-cycle and four-cycle operation.

Teaching Aids: Transparencies:
- Intake, p. II-11
- Compression, p. II-12
- Power, p. II-13
- Exhaust, p. II-14
- Four-Stroke Cycle Engine, p. II-15

References: Fundamentals of Service, Engines, John Deere, Chapter 1
Automotive Engine Design, William H. Crouse, Chapter 3
Auto Mechanics Fundamentals, Stockel, Chapter 1

Outline of Information:

1. An engine cycle is a series of mechanical-physical functions that must occur in sequence.

2. Four basic engine operating functions:

    a. INTAKE - introduces combustible mixture into combustion chamber.

    b. COMPRESSION - squeezes the fuel mixture into smaller space.

    c. POWER - ignites and burns mixture, releasing its energy.

    d. EXHAUST - evacuates burned gases from combustion chamber.

3. Modern piston engines operate on either a two-stroke cycle or a four-stroke cycle.

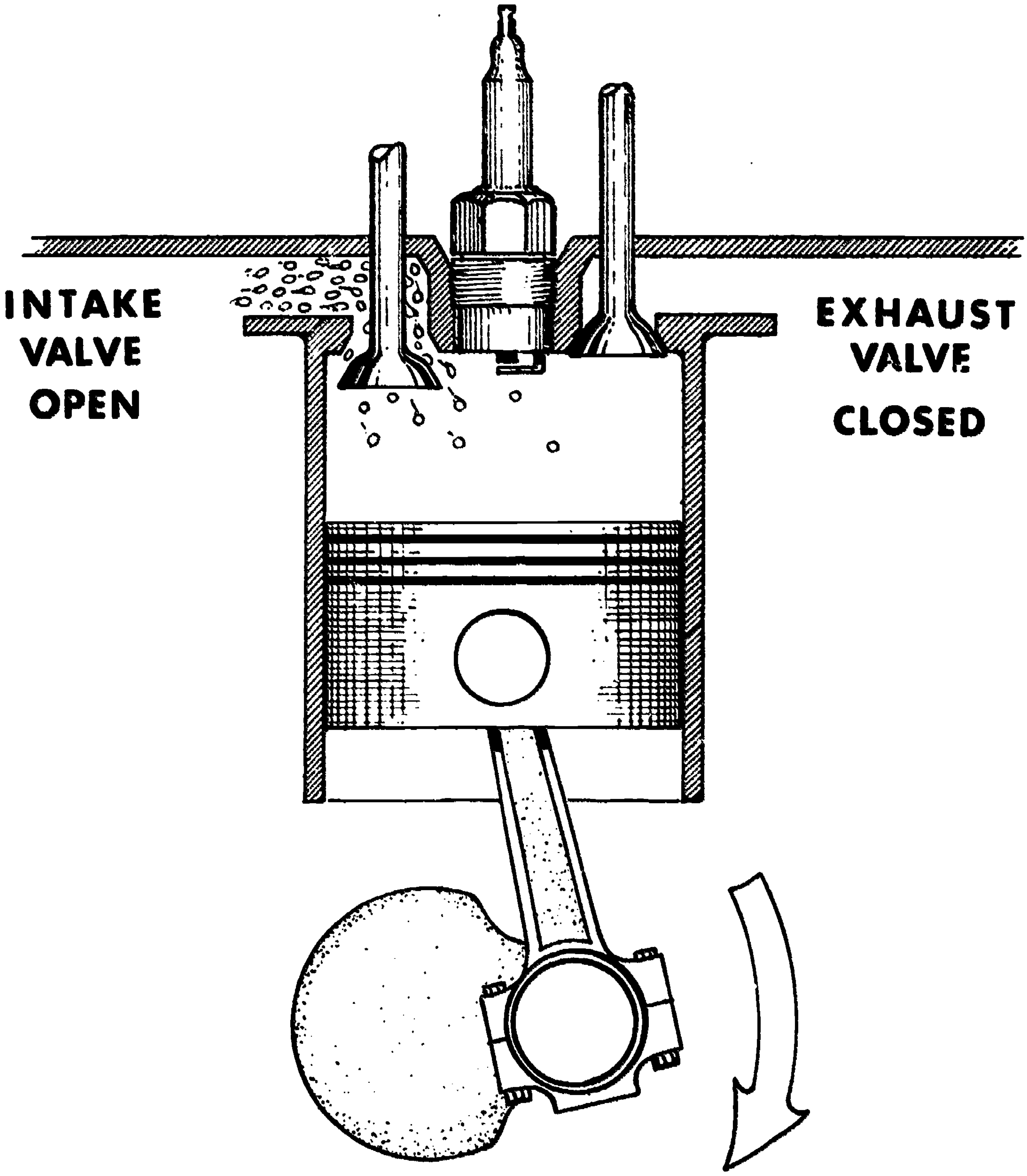
    a. Most automobiles are powered by four-stroke cycle engines.

    b. Diesel engines are two-stroke cycle.

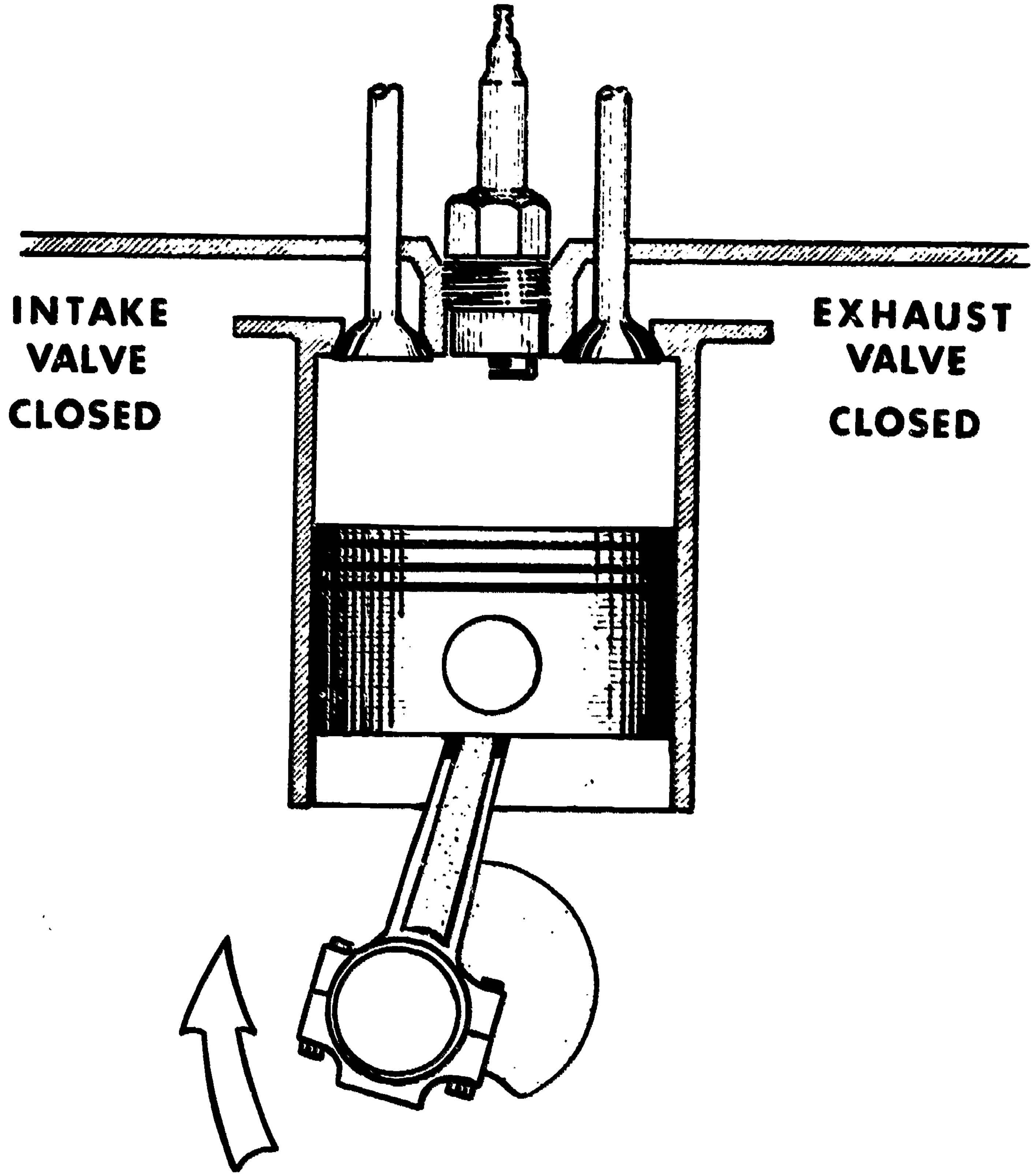
    c. Many small engines for a wide variety of power applications are either two-stroke cycle or four-stroke cycle.

    d. Most outboard marine engines are two-stroke cycle design.

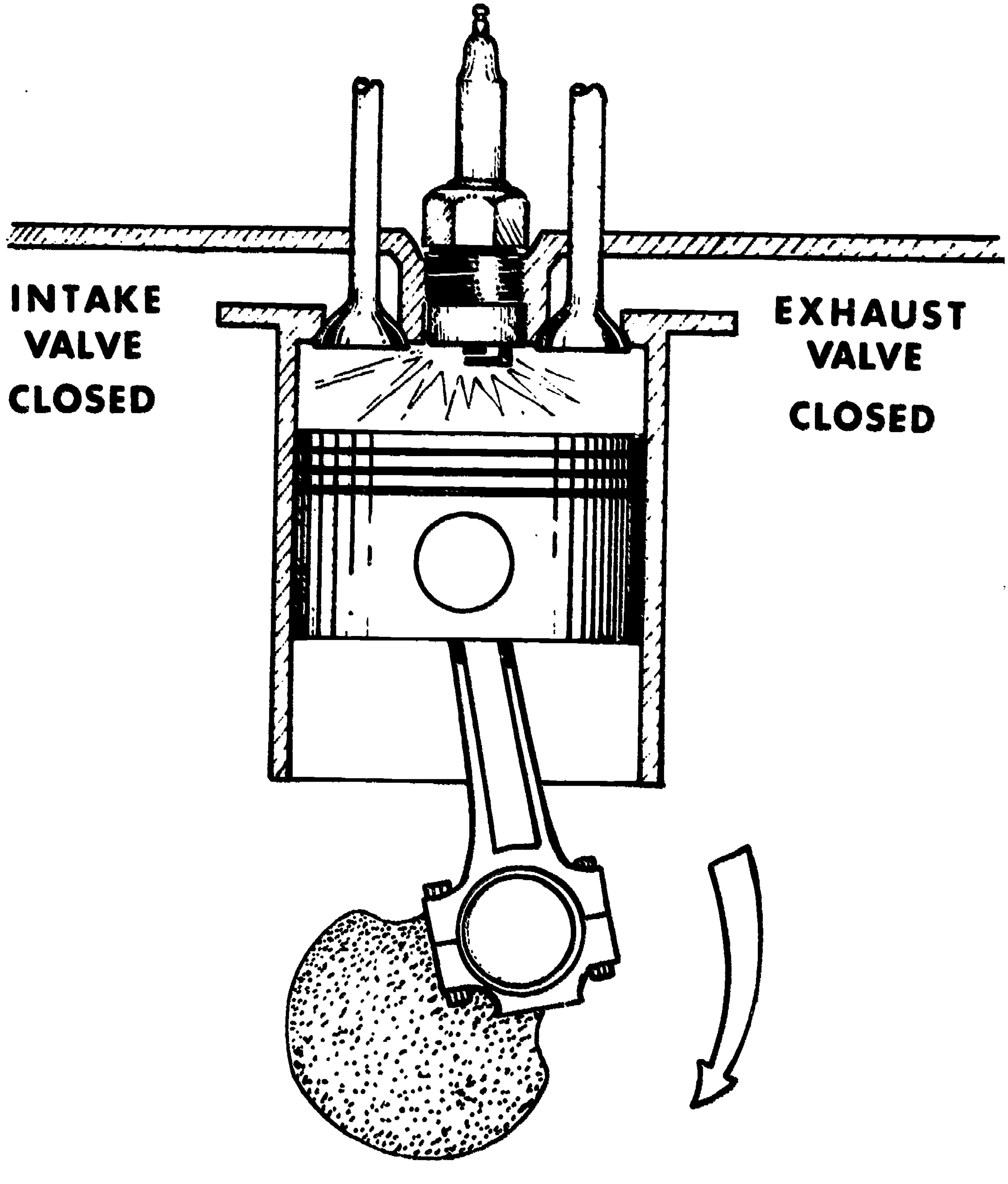
INTAKE



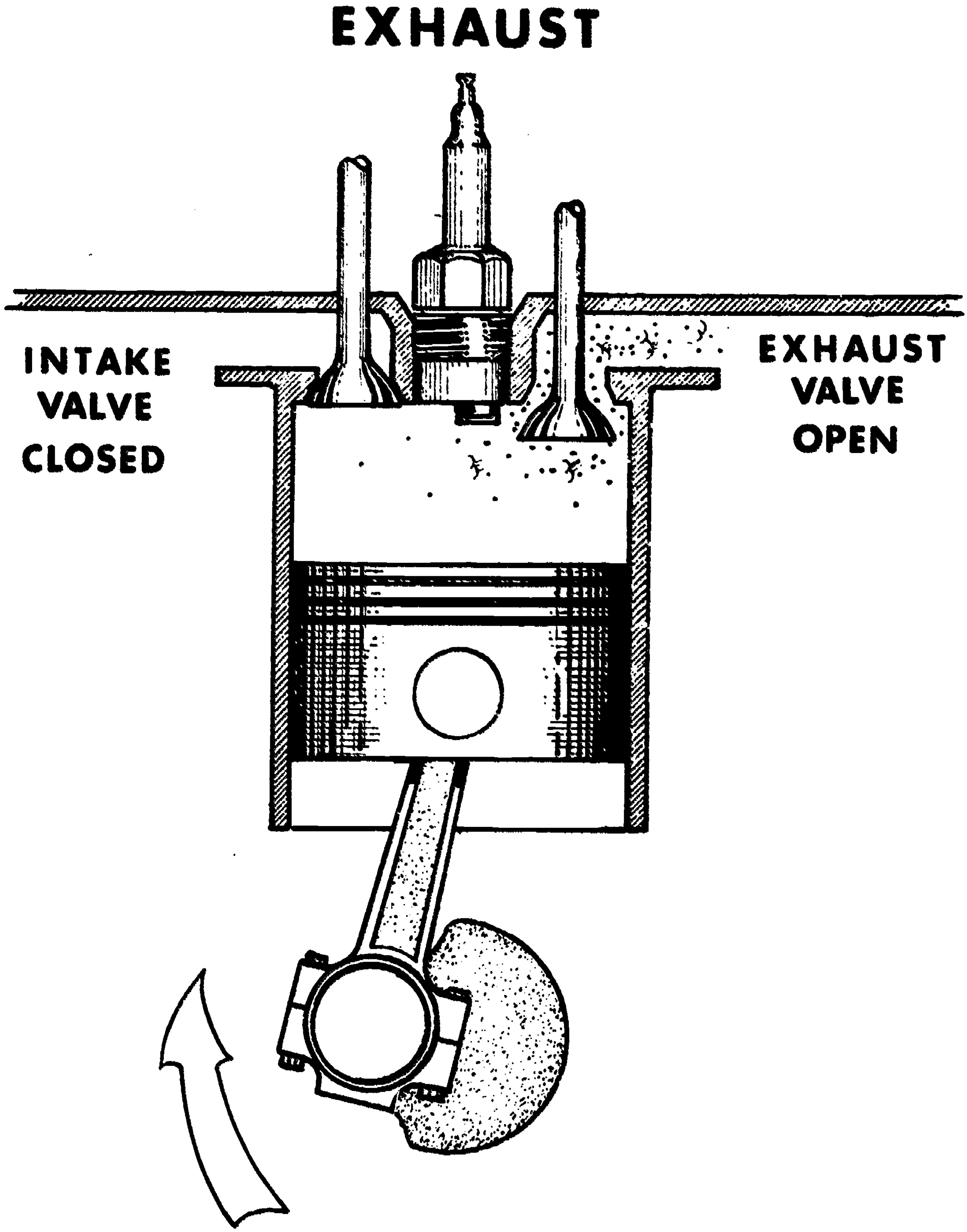
COMPRESSION



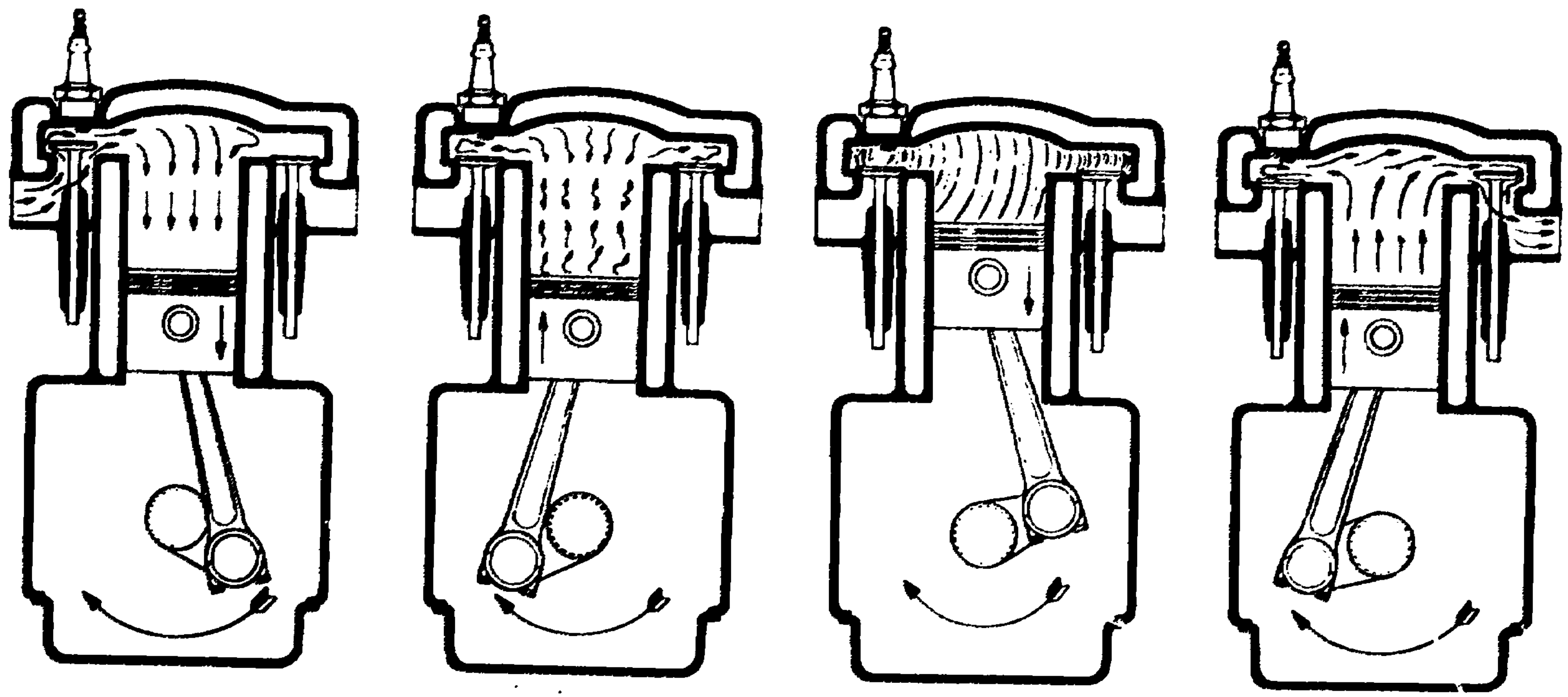
POWER



R GILMORE, INST. MATL. LAB., U.K. 369-9


EXHAUST
INTAKE VALVE CLOSED
EXHAUST VALVE OPEN

FOUR-STROKE CYCLE ENGINE



COURTESY-AUTOMOTIVE ELECTRIC ASSOCIATION.
INST. MATL. LAB UK. R.G. 369-17

INFORMATION

Block: Engine Fundamentals	Block II
	Job ____
Lesson: Engine Classifications	Lesson ____

Teaching Objectives: Upon completion of this lesson, students will be able to classify engine types according to cylinder and valve operational systems, fuel and cooling systems and cyclical design.

Teaching Aids: Transparencies:
- Basic Engine Design Depending on Cylinder Arrangements, p. II-18
- Valve Arrangements, I-Head and T-Head, p. II-65
- Valve Arrangements, L-Head and F-Head, p. II-66

References: Automotive Mechanics, Crouse, Chapter 5

Outline of Information:

1. Number of Cylinders

   a. Most common designs
      -- Single cylinder
      -- Two, four, six, eight cylinders

2. Cylinder Arrangements

   a. In-Line

   b. V-type

   c. Horizontally opposed (pancake)

   d. Radial

3. Valve Arrangements

   a. L-Head

   b. I-Head (overhead)

   c. F-Head

   d. T-Head

Engine Classifications (continued)

4. Type of Fuel

    a. Gasoline

    b. Diesel

    c. L.P.G.

    d. Natural Gas

5. Type of Cooling

    a. Liquid-cooled

    b. Air-cooled

6. Type of Cycle

    a. Diesel

    b. Otto

7. Number of Cycles

    a. Two-cycle

    b. Four-cycle

<u>NOTE</u>: Engines not usually classified by standard classifications

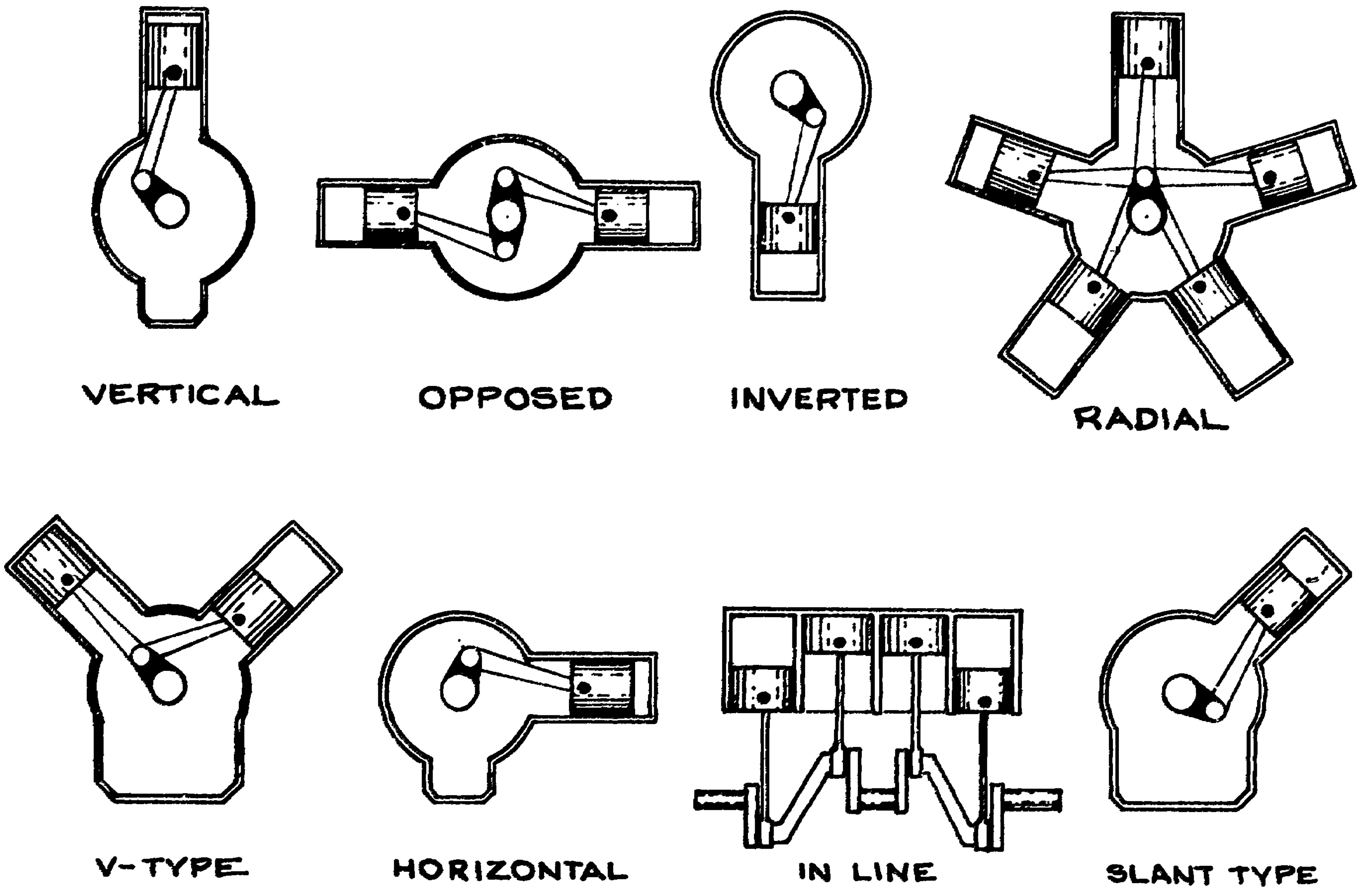
a. Free Piston

b. Wankel

c. Sterling

d. Turbine

BASIC ENGINE DESIGN DEPENDING ON CYLINDER ARRANGEMENTS



INFORMATION

Block: Engine Fundamentals

Lesson: Engine Block, Head and Oil Pan

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to discuss the design characteristics of the engine block, cylinder head and oil pan and relate their functions.

Teaching Aids: Transparencies:
- Engine Components, p. II-51
- Engine Block, Head and Pan, p. II-21
- Cooling Fins, p. VI-9

References: Automotive Mechanics, Crouse, Chapter 6
Automechanics, Glenn, Chapter 1

Outline of Information:

1. Engine Block - constitutes the main structural framework of the engine

   a. Made of gray cast iron, iron-nickel alloy or aluminum, the block accomodates other engine parts.
      -- Cylinder openings
      -- Water jackets
      -- Valve openings and valve parts (depending on engine design)
      -- Oil passages
      -- Mounting holes
      -- Shaft mount openings
      -- Bushing mounts
      -- Oil filter mounts
      -- Bearing mounts
      -- Gasket surfaces
      -- Plug openings (water jacket)
      -- Other essential component mounts

   b. Aluminum blocks require cylinder sleeves (bore liners) made of cast iron or steel.

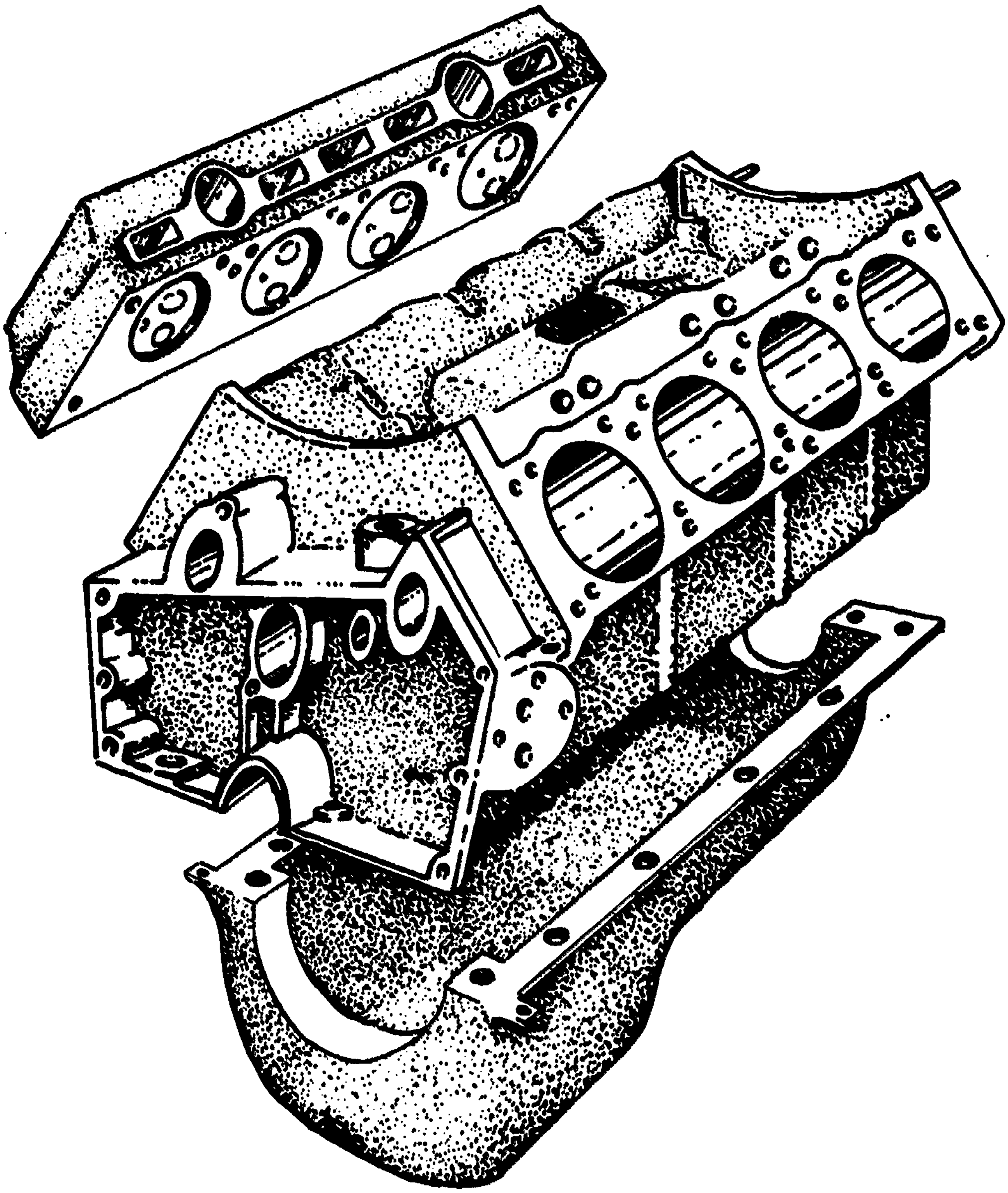
2. Cylinder Head - seals combustion chambers (cylinders)

   a. The heads are cast, usually of the same alloy as the block and they accomodate several other parts and functions.
      -- Water jackets
      -- Spark plug holes
      -- Valve pockets
      -- Valve openings and mechanism accomodations (depending on engine design)
      -- Manifold mounts
      -- Camshaft openings (for OHC engines)

b. Heads for air cooled engines are designed with fins for efficient cooling. (Refer to p. VI-9, Cooling Systems)

3. Oil Pans - (made of pressed steel) seals bottom of engine, provides oil reservoir

ENGINE BLOCK, HEAD, AND PAN



INFORMATION

<u>Block</u>: Engine Fundamentals

<u>Lesson</u>: Gaskets

Block II
Job
Lesson

<u>Teaching Objective</u>: Upon completion of this lesson, students will be able to describe the types, function and construction of automotive gaskets.

<u>Teaching Aids</u>: Sample gasket sets
Transparency:
- Engine Gaskets, p. II-24

<u>References</u>: <u>Automotive Mechanics</u>, Crouse, Chapter 6
<u>Automotive Engine Design</u>, Crouse, Chapter 7

<u>Outline of Information</u>:

1. Types

   a. Steel (Embossed)
   -- Cylinder head and manifold gaskets

   b. Asbestos
   -- Cylinder head, manifold, carburetor flange

   c. Paper (Treated)
   -- For sealing oil, gasoline and water
   -- Oil pan, timing gear, valve cover, rocker arm cover, fuel pump flange, carburetor, thermostat, etc.

   d. Cork
   -- For sealing oil, water, and gasoline
   -- Can be used any place the treated paper gasket is used

   e. Copper
   -- Spark plug gaskets

   f. Combination steel and asbestos (Sandwiched)
   -- Head gaskets
   -- Manifold gaskets

   g. Combination copper and asbestos (Sandwiched)
   -- Head gaskets
   -- Manifold gaskets

Gaskets (continued)

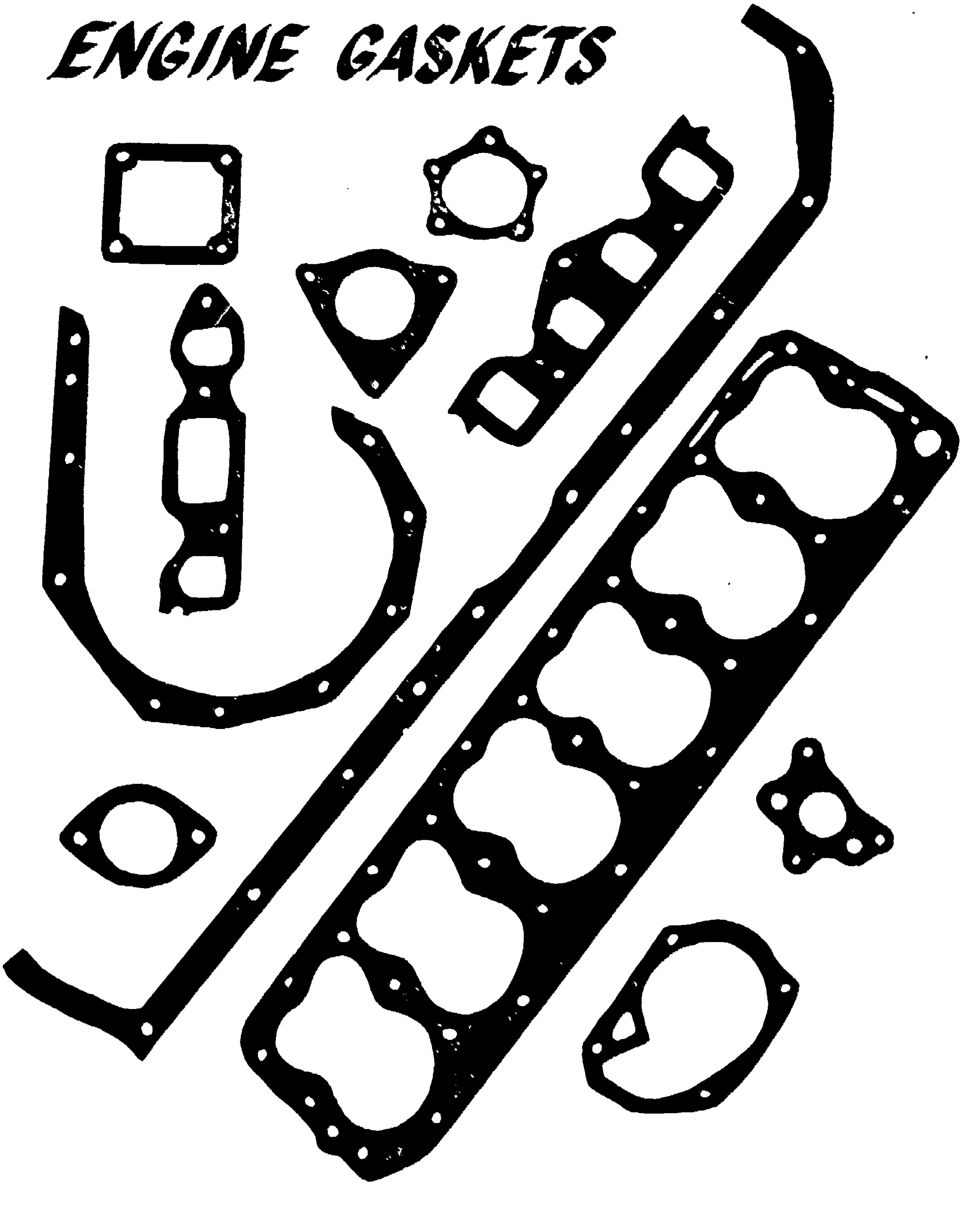
2. The gasket is used to seal two machined mating surfaces. Upon assembly of the two parts, the gasket is compressed, filling the small imperfections formed during the machining operations.

3. Hints on handling gaskets

   a. Care must be exercised in order to prevent gaskets from being bent, folded, torn, especially head and manifold gaskets.

   b. Sometimes cork and paper type gaskets dry out during storage and shrink. They can be brought back to their original size by soaking in hot water.

ENGINE GASKETS



OPERATION

Block: Engine Fundamentals

Operation: Removing and Replacing Cylinder Head

Block II
Job ____
Operation ____

Teaching Objective: To teach students to remove and replace automotive cylinder heads

Tools: Combination wrenches, socket wrench set, pliers, screwdriver, putty knife, wire brush and parts rack

Materials: Gaskets, cloths, cleaning solvent

Teaching Aids: Automobile or engine block

References: Auto Mechanics, Glenn, Chapter 1
Automotive Mechanics, Crouse, Chapter 17
Vehicle Service Manual

Steps:

1. Remove air cleaner

2. Drain cooling system

   CAUTION: Engine should be allowed to cool to prevent any possibility of head or block warpage caused by disassembly while hot.

3. Remove cooling inlet and outlet hoses

4. Disconnect fuel line

5. Remove spark plug wires and distributor

6. Remove intake manifold

7. Remove rocker arm cover

8. Remove rocker arms and push rods

9. Remove exhaust manifold

10. Remove cylinder head bolts and lift off head

11. To replace, reverse procedure using manufacturer's specifications for torquing head bolts

INFORMATION

Block: Engine Fundamentals

Lesson: Rod, Piston and Rings Assembly

Block III
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to list the parts, technically relate the function of each, and describe the design characteristics of this assembly.

Teaching Aids: Transparency:
- Connecting Rod, Piston and Rings, p. II-28
Sample piston and rod assemblies

References: Auto Mechanics, Crouse, Chapter 7
Automotive Engine Design, Crouse, Chapter 7

Outline of Information:

1. Connecting rod

   a. Purpose
      -- Transfers the reciprocating motion of the piston to the rotary motion of the crankshaft

   b. Design Requirements
      -- Must be strong and rigid for power transfer
      -- Must be relatively light in weight to prevent excessive inertia on bearings
      -- Must be matched in sets for original assembly and always reinstalled accordingly

   c. Construction
      -- Precision machined of cast iron or forged steel (machined with the rod cap bolted in place)
      -- Big end bore features groove for accepting the locating tongue on the rod bearing
      -- Oil passage holes drilled to provide lubrication to bearings, piston pins, cylinder walls (Often, oil passage holes are drilled the entire length of the rod.)

2. Piston and Rings

   a. Purpose
      -- Contains the gasses and the pressures of combustion in the combustion chamber
      -- Provides the point of action creating intake vacuum
      -- Delivers the forces to compress fuel-air mixture and to expel burned gases

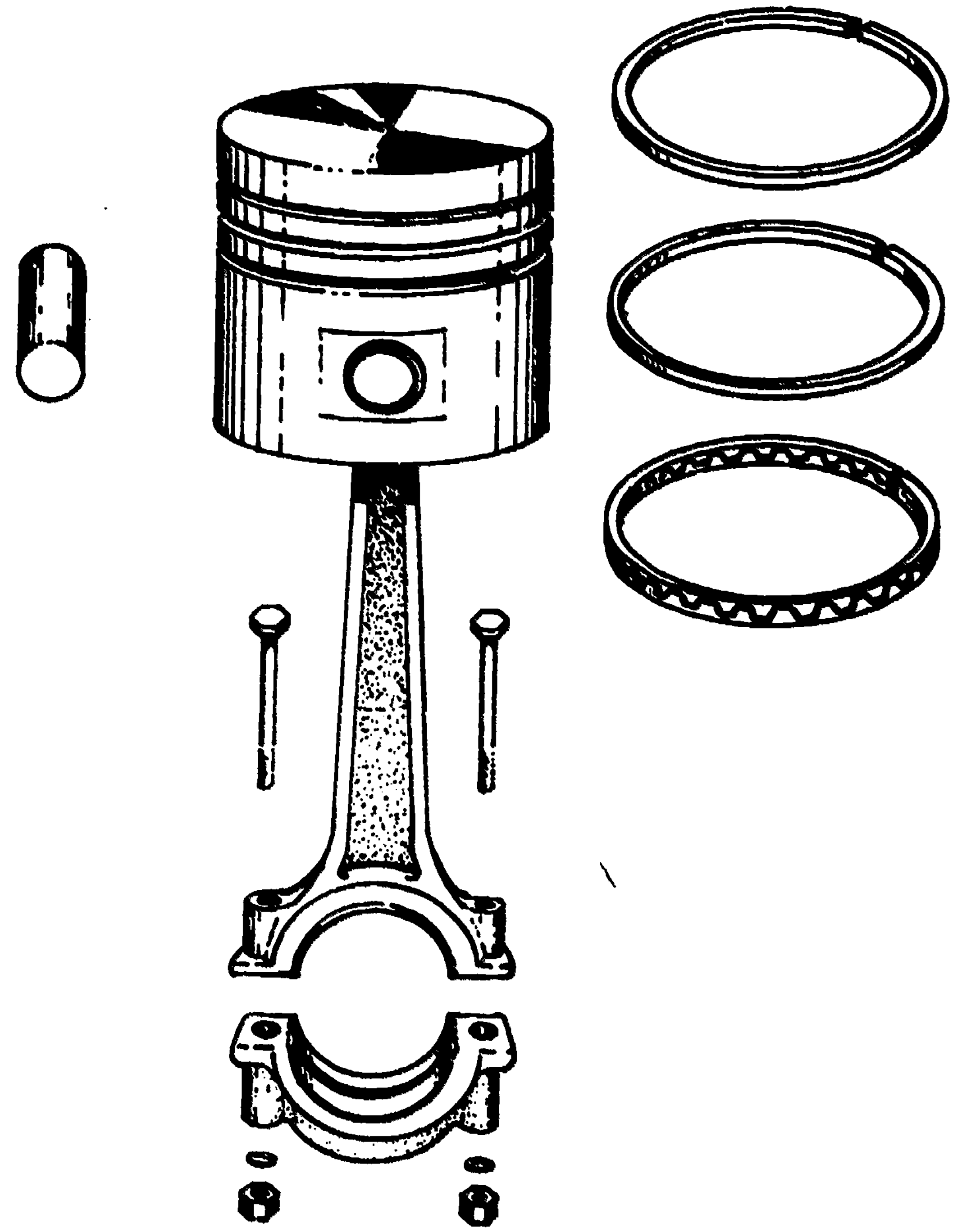
b. Design requirements
   -- Must be strong and rigid to withstand heat and pressures
   -- Must be lightweight to minimize inertia loads
   -- Must provide adequate seal with cylinder walls.

   <u>Note</u>: Changes in metal size, due to temperature variations and wear, do not permit a machined fit of piston to cylinder of such accuracy so as to achieve an adequate seal and yet allow operation. Therefore, precise fitting piston-rings provide the seal.

   -- Piston rings also control oil on cylinder walls and aid the transferral of heat from the piston to the cylinder walls.

c. Construction
   -- A cylindrical plug containing machined grooves near the top for the piston rings. It has a drilled skirt for a pin which is used for attaching a connecting rod.
   -- A complex aluminum alloy casting or forging
   -- Parts
      (1) Ring Grooves
      (2) Ring Lands
      (3) Ring Section
      (4) Skirt Section
      (5) Head
      (6) Piston-Pin Base
      (7) Piston-Pin Bearings
   -- Conformatic Pistons - Some pistons are machined (slightly elliptical) to a few thousandths thicker at a point 90° from the piston pin area to provide for expansion. When the piston reaches normal operating temperature, it expands to a more perfect round and a better fit in the cylinder.

CONNECTING ROD, PISTON, AND RINGS



GILMORE. INST. MATL. LAB., U.K. 389-22

OPERATION

Block: Engine Fundamentals

Operation: Cleaning and Inspecting Pistons and Rod Assemblies

Block II
Job ____
Operation ____

Teaching Objective: To teach students to prepare piston ring grooves for ring installation

Tools: Bench mounted vise with soft jaws, ring groove cleaner, air hose with blow gun, brush, safety glasses

Materials: Wipe cloths, solvent, metal container

Teaching Aids: Transparency:
- Connecting Rod, Piston and Ring, p. II-28

References: *Automotive Mechanic*, Crouse, Chapter 18
Auto Service and Repair, Stockel, Chapter 16

Steps:

1. Lightly clamp rod in soft jawed vise with piston skirt bottom resting on vise jaws

2. Adjust ring groove cleaner tool cutter blade to fit oil groove width in piston

3. Using ring groove cleaner tool, clean the carbon deposits from the oil ring grooves

   CAUTION: Remove carbon deposits only. Stop cutting when metal chips first appear

4. Readjust tool bit cutter blade to fit width of compression ring grooves and repeat step 3, to clean piston compression ring grooves

5. Thoroughly clean piston in solvent after all grooves have been cleaned - blow dry with air hose

   CAUTION: Protect eyes from flying chips with safety glasses

6. Inspect the piston and grooves for burrs or knicks

7. Clean tools and work area. Return tools to storage area

OPERATION

Block: Engine Fundamentals

Operation: Examine, Measure, and Align Connecting Rod

Block II
Job
Operation

Teaching Objective: To teach students to accurately measure and determine wear and condition of connecting rods

Tools: Rod aligner, micrometers

Materials: Several connecting rods with piston pins

Teaching Aids:

References: Automotive Mechanics, Wm. H. Crouse, 5th Ed., pp. 303-304

Steps:

1. Visually inspect the connecting rod and the bores in each end

2. Check rod alignment on a connecting rod alignment fixture

   Note: At the time of engine disassembly, after the piston and rod assembly has been removed and cleaned, wear patterns on the piston show rod alignment or mis-alignment.

3. Rod Alignment: To straighten a rod, insert bar into piston pin hole, bend rod a little past straight, then back to straight. (This relieves stresses set up by the bending actions.)

   Note: Engine manufacturers say that straightened rods will have a tendency to return to the bent position. They recommend replacement and not straightening.

4. Measure, with an inside micrometer, the inside diameter of the piston pin bushing bore. Check the fit with a new pin.

5. Measure, with an inside micrometer, the inside bore of the big end of the connecting rod

   Note 1: This measurement should be taken at least six different positions around the bore to detect any out-of-roundness.

   Note 2: Any out-of-roundness of the big end bore of the connecting rod can be corrected on a connecting rod reconditioning machine.

INFORMATION

Block: Engine Fundamentals

Lesson: Bearings (Precision Type Insert Bearings)

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the design and functions of precision bearings necessary to engine operation.

Teaching Aids: Bearing Samples:
- New, used
- Main and rod
- Sawn in half

Transparencies:
- Connecting Rod, Piston and Rings, p. II-28
- Crankshaft - Camshaft Relationship, p. II-57

References: Automotive Mechanics, Wm. H. Crouse, Chapter 3
Engine Bearing Fundamentals, Thompson Products

Outline of Information:

1. Engine bearings are precision parts constructed with a steel backing and coated or lined with a metal alloy somewhat softer than steel.

   a. Some Diesel Engines use insert bearings which are machined from solid aluminum.

   b. Brass bearings have been used.

   c. Modern automotive bearings are constructed of steel, coated with a very thin overlay of fine bearing material.

   d. Bearing materials
      -- Tin-base alloys
      -- Lead-base alloys
      -- Cadmium alloys
      -- Copper-lead alloys

   e. Spread - Outside diameter of the bearing is slightly larger than its bore so that it will remain seated properly.

   f. Crush - The additional height of each bearing half permits the bearing to seat firmly in its bore when the cap is drawn down or torqued. Depending on design, this additonal height represents a specific measurement beyond the size of the journal radius.

2. Bearings must be used wherever moving parts come into contact with each other.

   a. The precision type insert bearing is of the sleeve type and it is split so that it can be placed around the crankshaft.

   b. Bearing requirements
      -- Load carrying capacity
      -- Fatigue resistance
      -- Embedability
      -- Conformability
      -- Corrosion resistance
      -- Wear rate

   c. Bearing failures (what to look for)
      -- Scoring or scarring
      -- Wiping or seisure
      -- Fatigue or lining break-out
      -- Corrosion
      -- Erosion

   d. Causes of bearing failure
      -- Dirt
      -- Lack of lubrication
      -- Misassembly
      -- Misalignment
      -- Overloading
      -- Corrosion

OPERATION

Block: Engine Fundamentals

Operation: Examining and Measuring Bearings

Block II
Job ____
Operation ____

Teaching Objective: To teach students to examine bearings to determine condition and to accurately measure bearing fit

Tools: Micrometers, Torque wrench, 9/16" socket, plastic hammer

Materials: Engine block, crankshaft, and connecting rods, a matching set of old bearings and a set of new bearings, Plastigage, wipe cloths

Teaching Aids: Samples of used bearings representing various conditions of failure.

References: Automotive Mechanics, Crouse
Vehicle Service Manual

Steps:

1. Visual Inspection of Bearings

a. Look for bearings which are:
-- Worn
-- Burned
-- Scored
-- Pitted
-- Rough
-- Flaked
-- Cracked
-- Other

b. Summation of the causes of bearing failure

-- Dirt	43.1%
-- Lack of lubrication	14.6%
-- Misassembly	13.6%
-- Misalignment	10.0%
-- Overloading	8.4%
-- Other	5.3%

NOTE: If all of the bearings are laid out as they are removed from the engine (complete set), analyzing the cause of failure becomes easy.

2. Measuring Bearings

a. Measuring with instruments
-- With bearing only, bolted and torqued, in its bore (either in the block or connecting rod), measure inside dimensions with an inside micrometer and record your findings

b. Measure outside diameter of the corresponding crankshaft journal and record your findings

c. Subtract the outside diameter of the shaft from the inside diameter of the bearing to find your oil clearance. Compare this reading with the factory recommended clearance as found in the appropriate shop manual.

3. Measuring with Plastigage

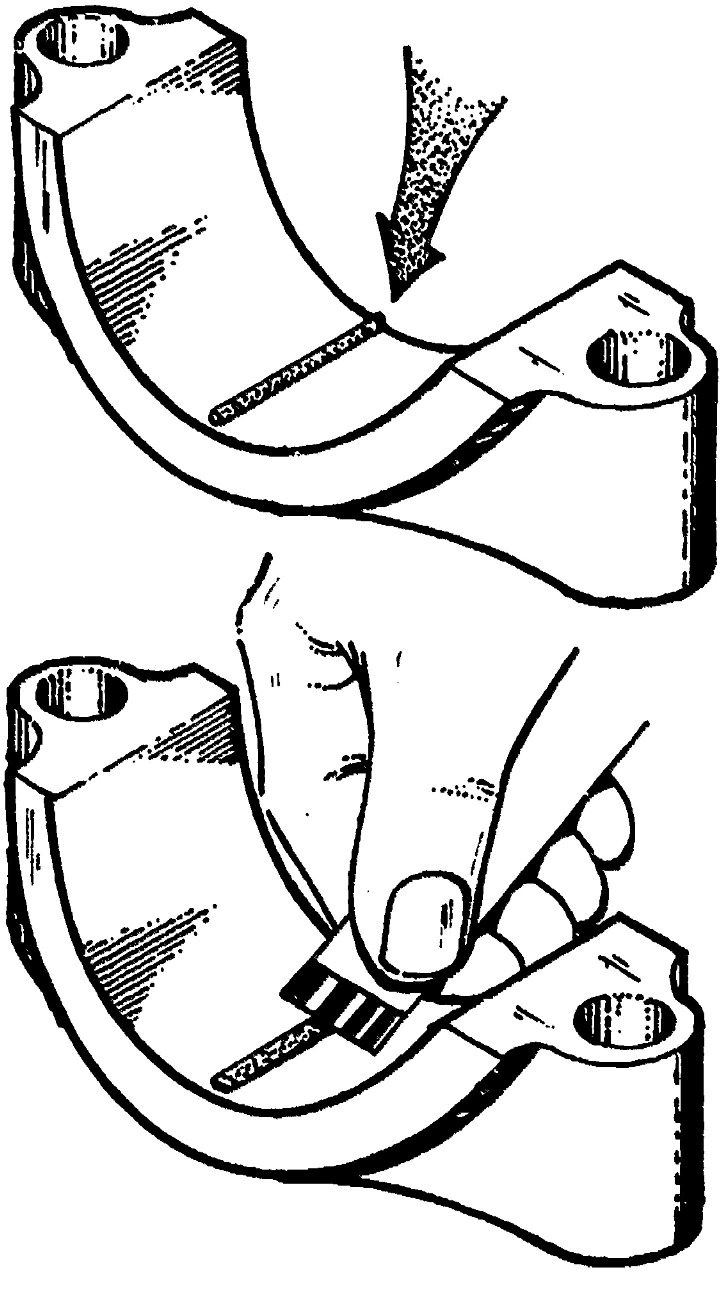
a Remove the bearing cap and wipe the oil from the bearing insert and crankshaft journal

Note: When checking main bearing clearances with the engine in a position where the main bearing caps are supporting the weight of the crankshaft and the flywheel, an erroneous reading due to the weight of the crankshaft and flywheel can be eliminated by supporting the weight of the crankshaft using a jack under the counterweight adjoining the bearing being checked.

-- Place a piece of Plastigage the full length of the bearing insert about 1/4" off center.
-- Rotate the crank about 30° from the bottom dead center and reinstall the bearing cap. Tighten the bolts with a torque indicating wrench as recommended by the manufacturer.
-- Remove the bearing cap. The flattened Plastigage will be found adhering to either the bearing shell or the crankshaft.

b. Compare the width of the flattened Plastigage at its WIDEST point with the graduations on the envelope.
-- The number within the graduation on the envelope indicates the bearing clearance in thousandths of an inch or in millimeters depending on which side of the envelope is used.
-- TAPER is indicated when one end of the flattened Plastigage is wider than the other. Measure each end of the flattened Plastigage. The difference between the readings is the approximate amount of taper.
-- New bearings should be installed if bearing clearance is not within specifications.
-- Excessive taper indicates that a new or reground crankshaft is required.

USE OF PLASTIGAGE



INFORMATION

Block: Engine Fundamentals

Lesson: Cylinder Wear Limits

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to define causes of cylinder wear as related to wear limits.

Teaching Aids: Transparency:
- Cylinder Taper and Ridge, p. II-39

References: Automotive Mechanics, Crouse, Chapter 19
Prescription for Better Gasoline Engine Overhauls, Dana Corp.

Outline of Information:

1. Engine wear continues from initial use until engine is inoperable or discarded

   a. Greatest wear takes place during break-in and during warm-up.

   b. Engines used for stop and go driving are subject to a faster wear rate.

   c. An engine operating under normal conditions with proper lubrication and maintenance has a very slow wear rate and a very long life.

   d. The greatest wear takes place in the top inch of ring travel, which generally causes cylinder taper.

2. Importance of measuring cylinders

   a. If the cylinder is worn beyond usable limits, the piston rings will not function properly.
      -- Engine cooling efficiency will be reduced.
      -- Cleaning function of oil will be impaired.
      -- Sealing ability of piston rings will be reduced.

   b. In excessively worn cylinders the piston tends to rock, causing a rhythmic noise called piston slap.

3. Wear limits

   a. Taper - .008"

   b. Out-of-round - .004"

INFORMATION

Block: Engine Fundamentals

Lesson: Cylinder Ridge, Cause and Correction

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the operating functions causing cylinder ridge and the reasons for corrective measures.

Teaching Aids: Transparency:
- Cylinder, Taper and Ridge, p. II-39

References: For Better Gasoline Engine Overhaul, Dana Corporation, Chapter 1
Automotive Mechanics, Crouse, Chapter 18

Outline of Information:

1. Cause of cylinder ridge

   a. When the engine is new, the cylinder walls are perfectly round and of equal diameter at all points.

   b. Rings exert an outward pressure against the cylinder walls for sealing purposes.

   c. Pressure from burning gasses gets behind the rings and pushes them outward with more pressure against the cylinder walls.

   d. The cylinders wear in the area of ring travel.

   e. Wear is greatest when the engine is under heavy load.

   f. As the expanding gasses are expanded, forcing the piston downward, the pressure is reduced.

   g. The greatest wear takes place near the top of the cylinder where pressures are greatest.

   h. That part of the cylinder above the top of the ring travel becomes the ridge.

   i. Cylinder wear is known as cylinder taper.

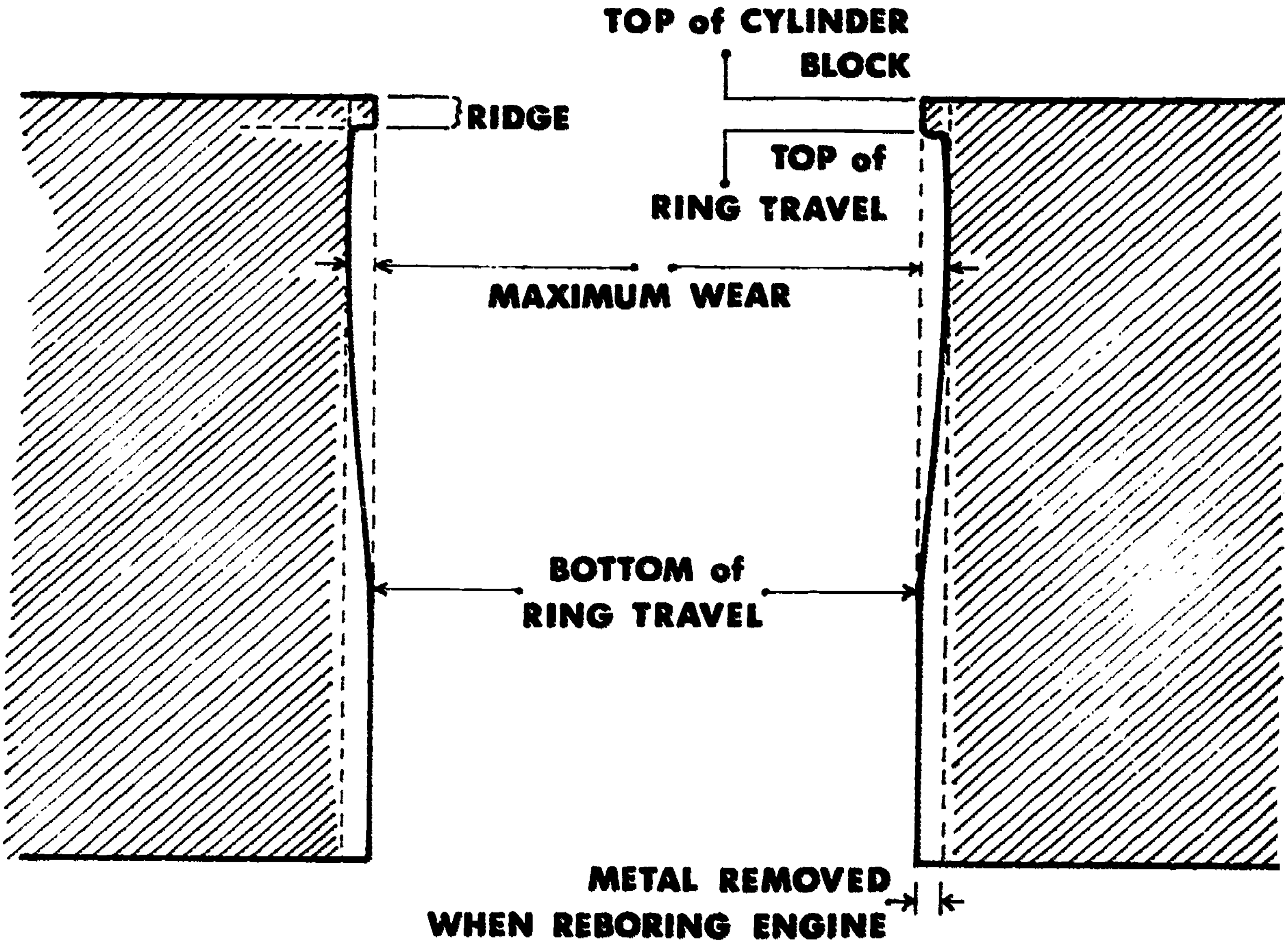
2. Reason for removing ridge

   a. When removing piston, damage to the second land is prevented.

   b. Top ring damage is prevented
      -- If new ring is installed and ridge is not removed, top ring may strike on each upstroke.
      -- Top ring may break or stick.

   c. Clicking and knocking due to striking the ridge is prevented.
      -- To determine whether the ridge is excessive, measure cylinder diameter above and below ridge. If the difference between the two is .004" or more, ridge is excessive and must be removed.

CYLINDER TAPER and RIDGE



INFORMATION

Block: Engine Fundamentals

Lesson: Micrometer

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the design, construction, care and computational use of common outside micrometers.

Teaching Aids: Transparencies
- Micrometers, p. II-42
- Micrometer Readings, p. II-43

References: *Motor Service's Automotive Encyclopedia*, Chapter 3
Automotive Mechanics, Crouse, Chapter 2

Outline of Information:

1. Design and construction

   a. Frame - the main body of the micrometer which supports all other parts and surrounds one side of the object being measured

   b. Anvil - the stationary measuring point of the micrometer

   c. Spindle - the moveable measuring point of the micrometer

   d. Sleeve - a hollow tube fastened solid to the frame
      -- Contains a revolution line running along its length
         (1) Contains two calibrations along this line
         (2) Eleven calibration marks on top of the line equally spaced and marked: 0 1 2 3 4 5 6 7 8 9 0 (exactly one inch between the two "0" marks, .100" between each calibration mark)
         (3) Forty-one calibration marks below the line equally spaced exactly .025", a total of one inch

   e. Thimble - a hollow tube rigidly fastened to the spindle, rotating with it on threads with a pitch of 40 (40 threads per inch)
      -- Graduated in 25 equal marks around its circumference
      -- Each graduation represents .001", a full turn represents .025"

   f. Ratchet stop - a slip clutch device which permits closing the spindle anvil against the work being measured with light uniform pressure

2. Computation of measurements:

   a. Record largest reading on the sleeve (exposed by the thimble)

   b. Record largest reading on thimble

   c. Add the two above readings to find the exact distance between the anvil and the tip of the spindle

3. Care of the micrometer

   a. Keep clean and well oiled

   b. Store in case or box when not in use

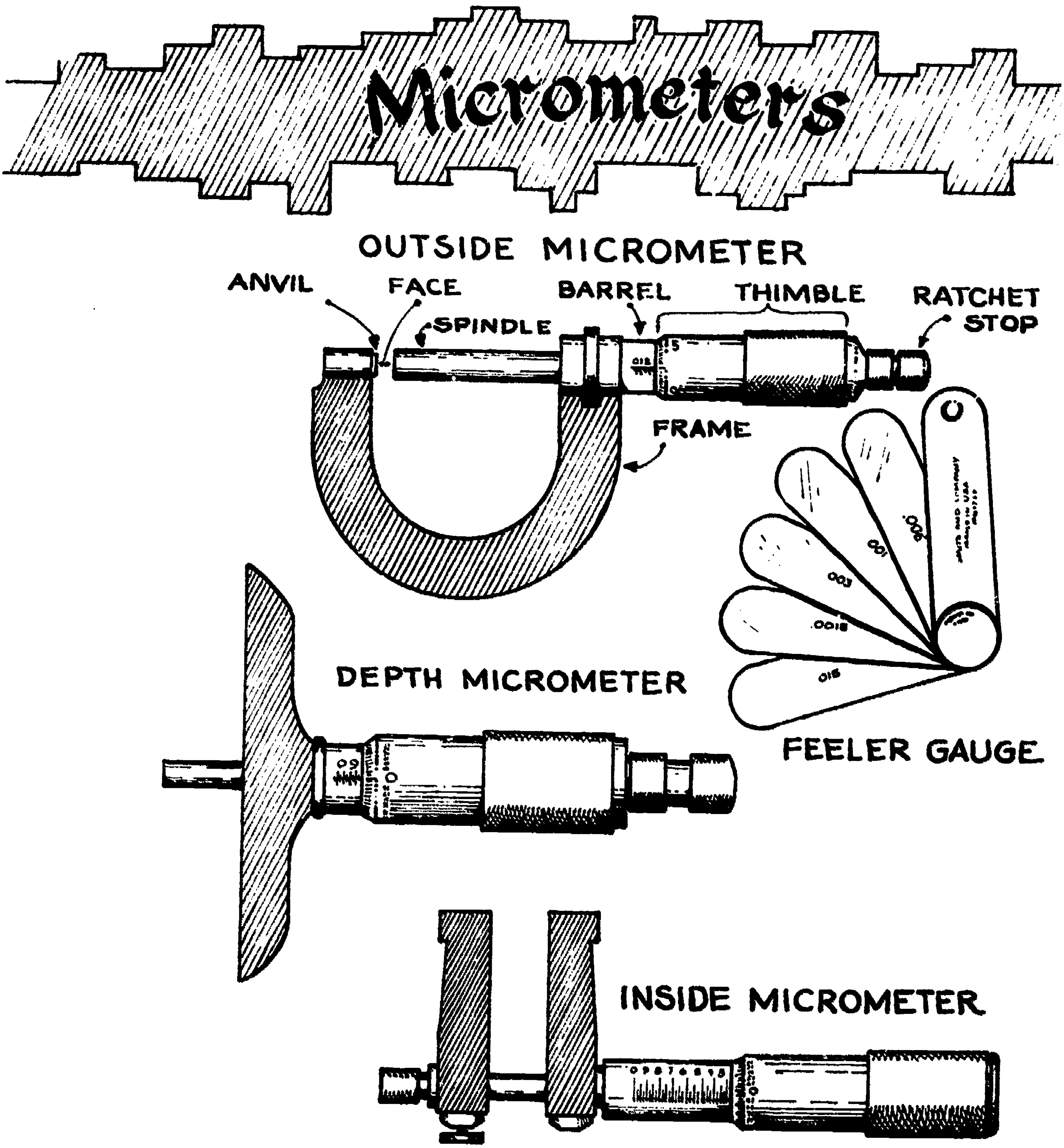
   c. For dependable accuracy, do not drop, force, jam, or abuse.

   d. Do not use around grit and dirt

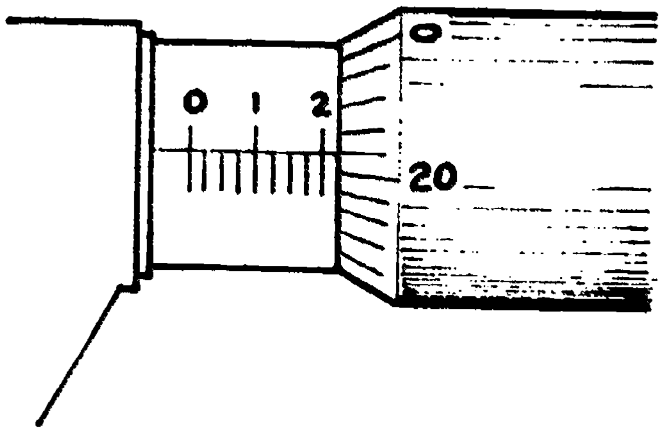
   e. Do not submerge in cleaning solvent

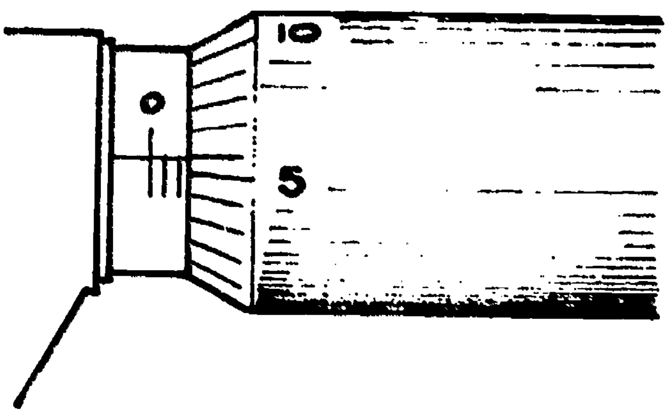
   f. Do not hammer, file, stamp, or etch numbers or letters on precision tools.

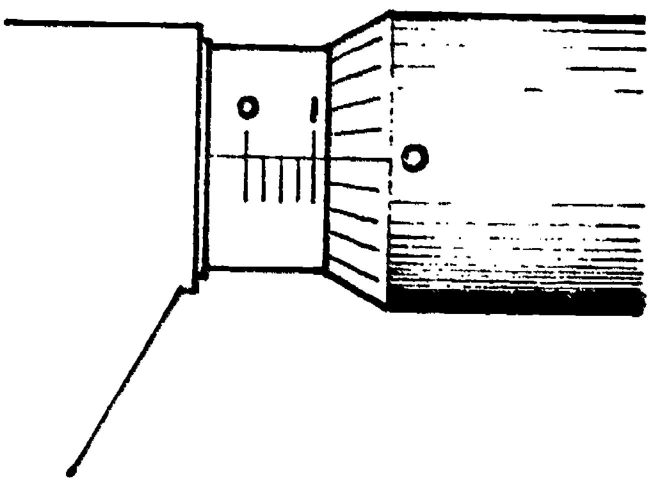
   NOTE: Micrometers are precision instruments which represent substantial investment. Proper use and care will extend the useful life of all such tools.

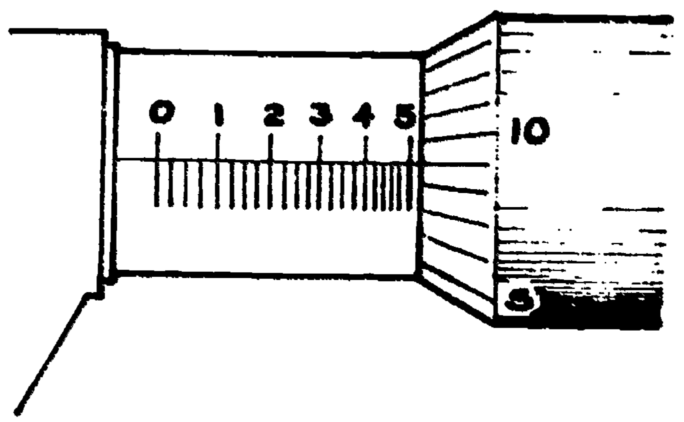

Micrometers
OUTSIDE MICROMETER
ANVIL
FACE
SPINDLE
BARREL
THIMBLE
RATCHET STOP
FRAME
DEPTH MICROMETER
FEELER GAUGE
INSIDE MICROMETER

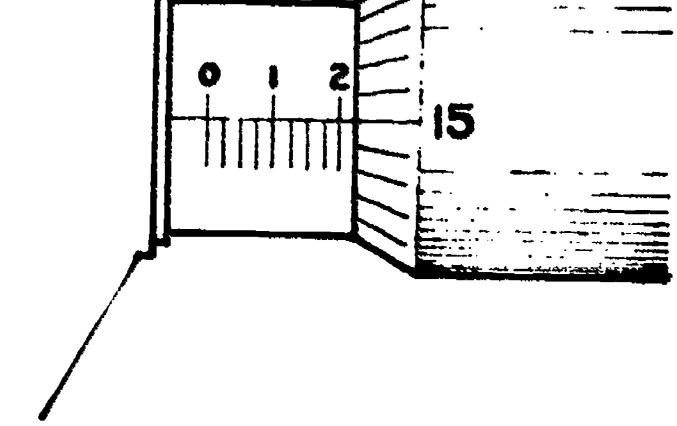
Micrometer Readings

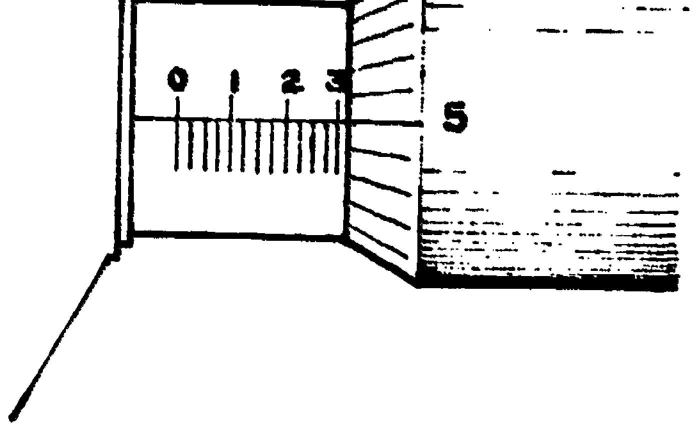












OPERATION

Block: Engine

Operation: Measuring Cylinders

Block II
Job
Operation

Teaching Objective: To teach students how to measure cylinders for wear

Tools: Inside micrometer, cylinder taper gauge

Materials: Wipe cloths

Teaching Aids: Used engine blocks which have been disassembled

References: Engine Overhauls, Perfect Circle Division, Dana Corporation
Automechanics, Glenn, Chapter 5
Automotive Mechanics, Crouse, Chapter 19

Steps:

1. Using an inside micrometer, measure the cylinder diameter near the top just under the highest point of ring travel.

   CAUTION: Micrometers are precision instruments. Handle with care.

2. Make several measurements at different points as above to check for concentricity (out-of-round).

3. Measure the cylinder diameter below the bottom of the ring travel to determine the amount of cylinder taper. Subtract bottom reading from top reading.

4. Cylinder taper can be determined with the use of a cylinder taper gauge. Simply insert the gauge into the cylinder and slide it from the top to the bottom and record reading.

   NOTE: If cylinder taper does not exceed .008", new rings will give satisfactory service. If greater than .008" the block must be rebored.

INFORMATION

<u>Block</u>: Engine Fundamentals

<u>Lesson</u>: Crankshaft Function and Design Characteristics

Block II
Job
Lesson

<u>Teaching Objective</u>: Upon completion of this lesson, students will be able to describe the function and design of the automotive crankshaft.

<u>Teaching Aids</u>: Transparencies:
- Crankshafts, p. II-46
- Crankshaft, p. II-48
- Engine Components, p. II-51
- Crankshaft - Camshaft Relationship, p. II-57
- Crankshaft, Camshaft and Valve, p. II-59

<u>References</u>: <u>Auto Mechanics Fundamentals</u>, Stockel, Chapter 2

<u>Outline of Information</u>:

1. Crankshaft function

   a. Provides constant turning force to wheels

   b. Connecting rods attached to crankshaft throws

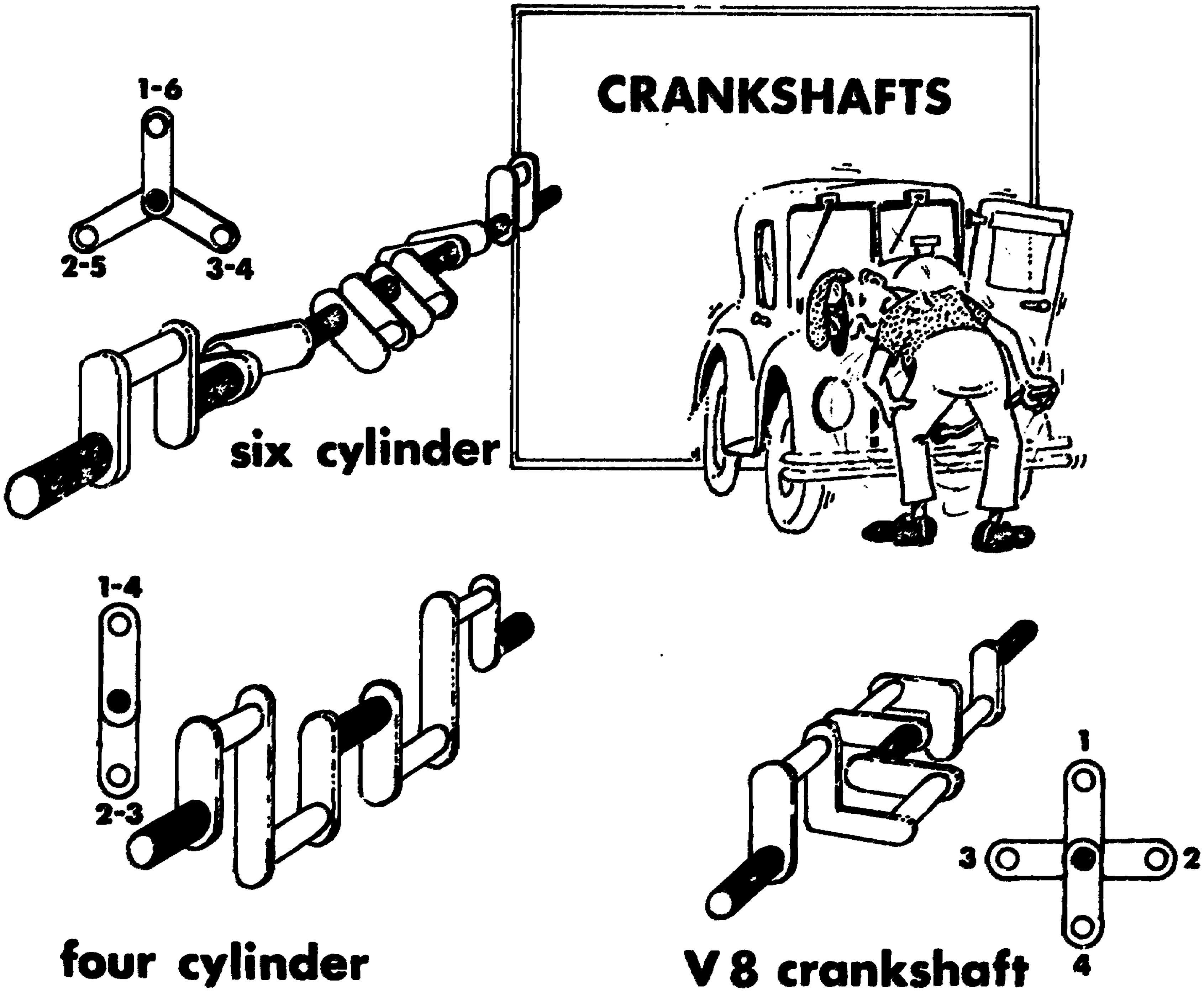
   c. Changes reciprocating motion of piston and rod to rotary motion

   d. Flywheel regulates crankshaft speed

2. Crankshaft design

   a. Cast or forged from heat treated, steel alloy
      -- One piece construction
      -- Must have extreme strength to resist distortion
      -- Counterweights opposite the cranks provide essential balance.

   b. Precision machined to accomodate standardized bearings


CRANKSHAFTS
1-6
2-5
3-4
six cylinder
1-4
2-3
four cylinder
1
2
3
4
V 8 crankshaft

INFORMATION

Block: Engine Fundamentals

Lesson: Crankshaft Inspection

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to describe the causes of wear, necessity of accurate measurements and corrective machining processes for automotive crankshafts.

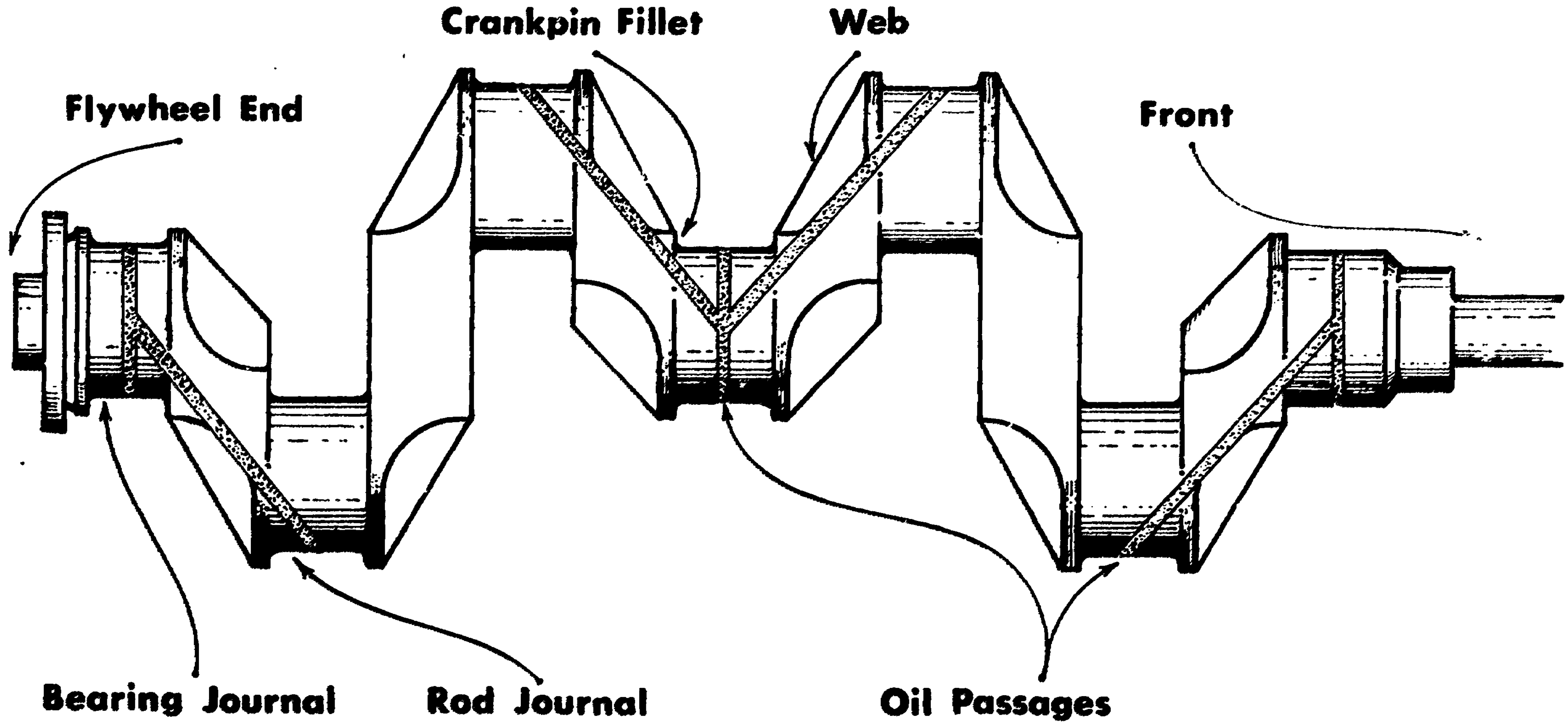
Teaching Aids: Transparency:
- Crankshaft, p. II-48

References: Automotive Mechanics, Crouse, Chapter 19

Outline of Information:

1. Causes of wear
    a. Lubricant contamination
    b. Loss of oil pressure
    c. Normal wear
2. Necessity of measurements
    a. To insure a trouble free, long life repair
    b. To determine the size of replacement bearings
    c. To determine whether or not the shaft is usable
3. Machine shop repairs available on crankshafts
    a. Straightening of bent or misaligned crankshafts
    b. Regrinding of out-of-round journals
    c. Regrinding of tapered journals
    d. Special undersize bearings available for shaft that has been reground to a standard undersize
    e. Common undersize bearings available for reground shafts are .010", .020", and .030"
    f. Grinding a journal more than .030" not recommended.

CRANKSHAFT


Crankpin Fillet
Web
Flywheel End
Front
Bearing Journal
Rod Journal
Oil Passages

OPERATION

Block: Engine Fundamentals

Operation: Measuring a Crankshaft

Block II
Job ____
Operation ____

Teaching Objective: To teach students to determine the conditions of a used automotive crankshaft by accurate, precision measurements

Tools: Micrometer, vee blocks, dial indicator, outside calipers

Materials: Wipe cloths

Teaching Aids: Several used crankshafts

References: *Auto Service and Repair*, Stockel, Chapter 14
Automotive Mechanics, Crouse, Chapter 19

Steps:

1. Check all journals for out-of-round conditions.

   a. Using a micrometer, check the exact diameter of each journal.

   b. Measure each journal around the circumference at several places to determine if an out-of-round condition exists.

2. Check all journals for taper

   a. Measure each journal several places along its width to determine taper.

   b. After the student becomes proficient, he will be able to check for taper and out-of-round in one operation.

3. Check crankshaft for misalignment.

   a. Mount the crankshaft in two vee blocks, one under each outer end.

   b. Mount a dial indicator to contact the surface of the center main bearing.

   c. While rotating the crankshaft, observe the dial indicator needle for movement. Any movement of the needle will indicate a bent condition which will indicate a need for repair or replacement.

INFORMATION

<u>Block</u>: Engine Fundamentals | Block II | Job ____ | Lesson ____

<u>Lesson</u>: Flywheel Function and Design Characteristics

<u>Teaching Objective</u>: Upon completion of this lesson, students will be able to describe the function and design of the automotive flywheel.

<u>Teaching Aids</u>: Samples of: flywheel, crankshaft, bolts, clutch assembly, starter drive or starter assembly
Transparency:
- Engine Components, p. II-51

<u>References</u>: <u>Automotive Mechanics</u>, Crouse, Chapter 3

<u>Outline of Information</u>:

1. Functions

   a. Provides an even flow of power by keeping the crankshaft turning between power strokes (inertia)

   b. Is the driving member of the clutch
      -- Has provisions for fastening the clutch pressure plate
      -- Has machined face for contact of the clutch driven disc

   c. Provides a means of cranking the engine for starting
      -- Starter ring gear on the outer circumference
      -- Ring gear ratio between starter gear and flywheel gear is about 15 to 1

2. Design

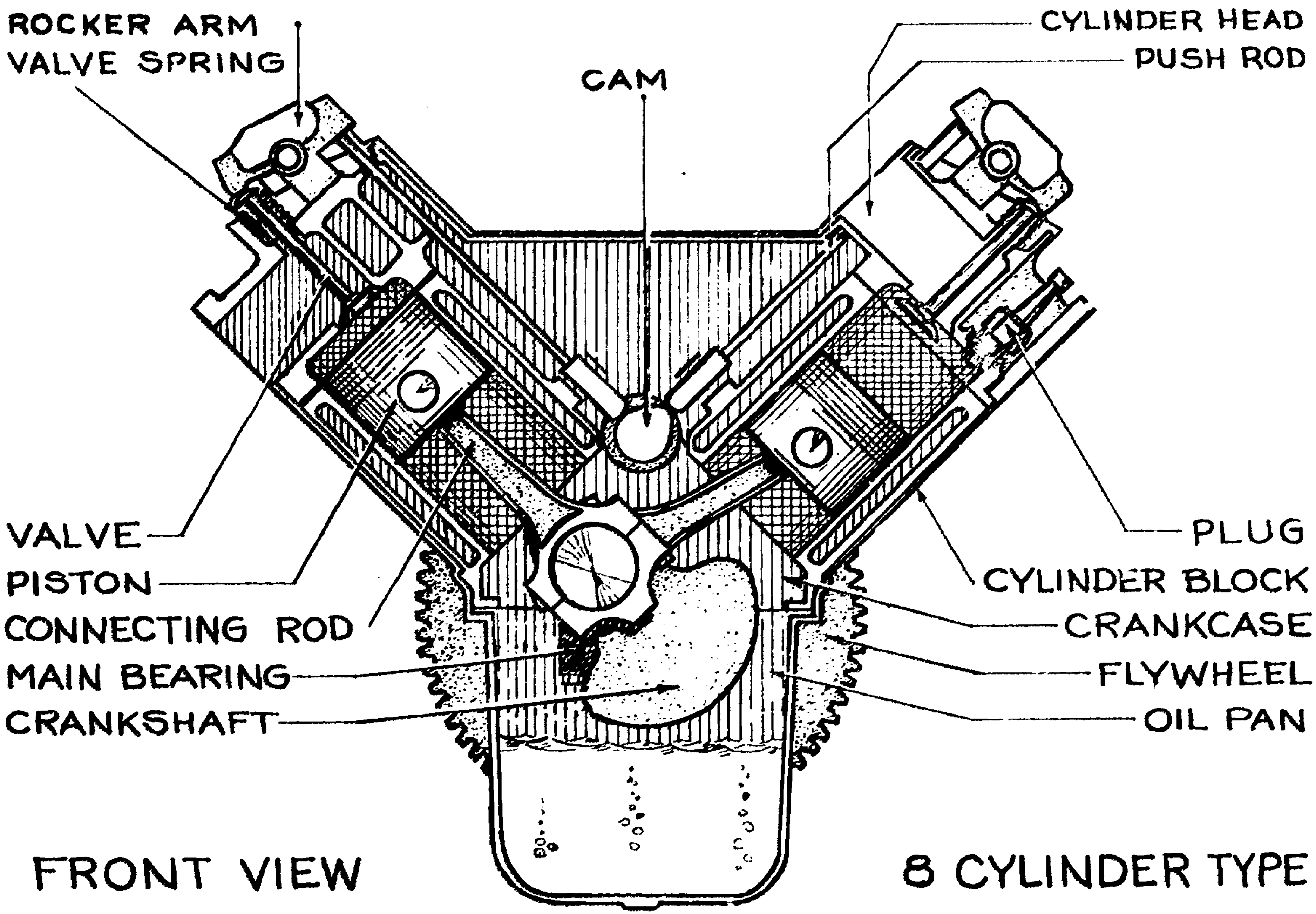
   a. Fastened with bolts rigidly to the rear end of the crankshaft and turns with it

   b. Usually machined from cast iron or steel

   c. Provides a means of balancing the engine, crankshaft, flywheel, and clutch assembly
      -- Permits vibration free operation
      -- Outer part of the flywheel can be drilled to remove weight for balancing purposes (this is done during manufacture or remanufacture)

   d. Size and weight of the flywheel is determined by the engineer according to:
      -- Size of the engine according to piston displacement
      -- Number of cylinders
      -- Type of service for which the engine is to be used

ENGINE COMPONENTS



FRONT VIEW

8 CYLINDER TYPE

INFORMATION

Block: Engine Fundamentals

Lesson: Camshaft Function and Design

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to describe functions and design characteristics of automotive camshafts.

Teaching Aids: Transparencies:
- Cam Design, p. II-54
- Mechanical Valve Lifter, p. II-79
- Hydraulic Valve Lifter, p. II-80
- Crankshaft, Camshaft and Valve, II-59
- Crankshaft-Camshaft Relationship, p. II-57

References: Automotive Encyclopedia, Tolboldt and Johnson, pp. 63-69, 142.
Automotive Mechanics, Crouse, Chapter 8

Outline of Information:

1. Camshaft Function

    a. Activates poppet valves in precisely timed sequence

    b. Converts rotary to straight-line motion

    c. Valve cycle (open and close) completed by one shaft revolution

    d. One cam (lobe) per valve in four-cycle engines
    -- Eight cylinder engine - eight intake valves plus eight exhaust valves necessitates 16 cams on shaft (eight cams on each of two shafts for V-8)
    -- Six cylinder engine - 12 cams on shaft
    -- Four cylinder engine - 8 cams on shaft

    e. In some engines, such as a pancake design with opposing cylinders each cam may activate two poppet valves. Example: Volkswagen

2. Camshaft Design

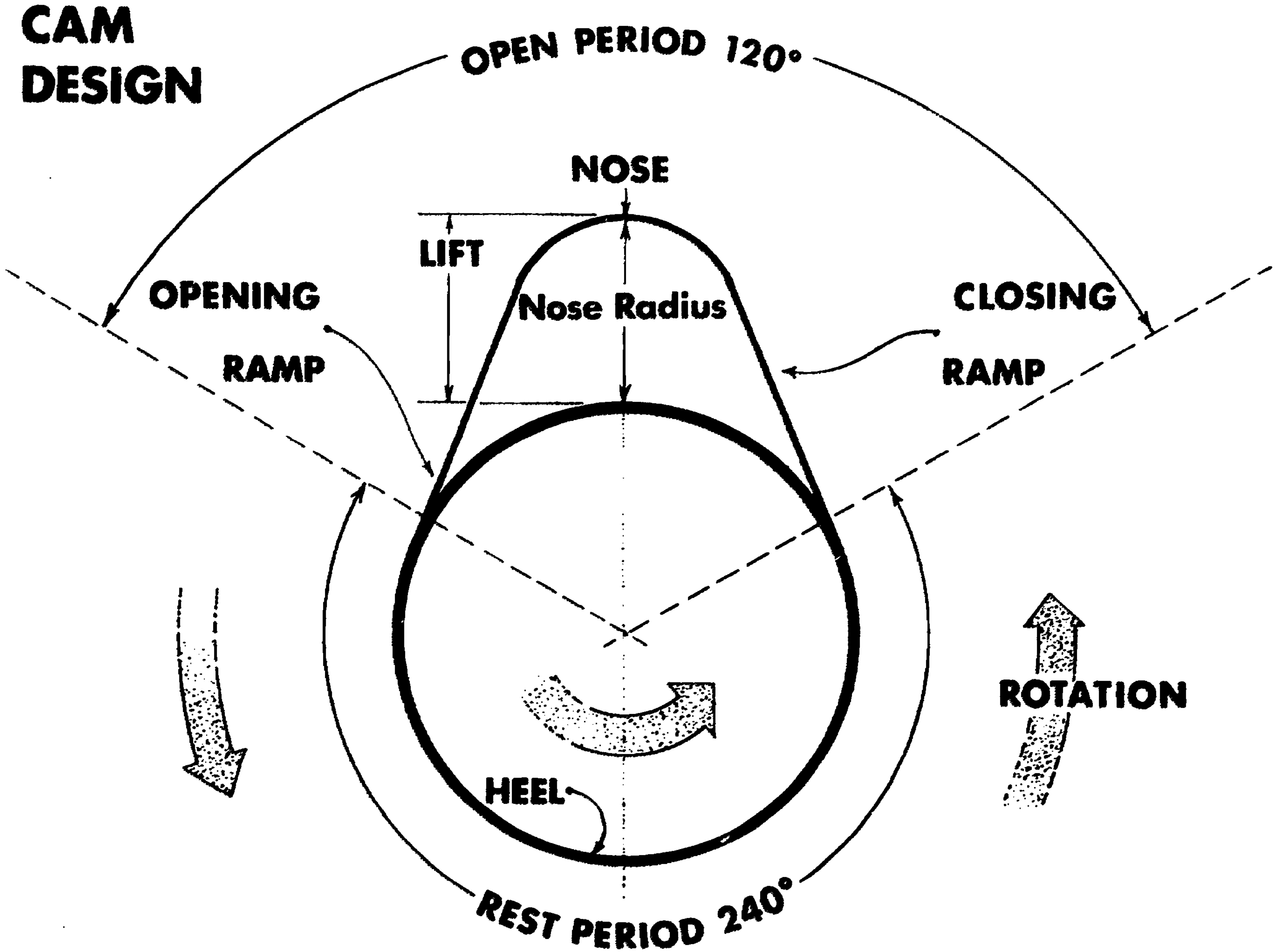
    a. Straight shaft with eccentric lobes

    b. Precision machined, forged steel
    -- Lobes are hardened and precision ground
    -- Bearing journals are precision ground

    c. Racing engine cams
    -- Steeper ramps and wider toes for quicker opening and closing

d. Rotation direction
   -- Chain driven camshaft rotates same direction as crankshaft
   -- Gear driven camshaft rotates opposite from crankshaft

e. Lift of the cam
   -- Area of size and shape where valve lifter movement takes place
   -- Cam lift measured as the difference between the highest point and the lowest point on the cam
   -- Lift measurement necessary for comparing amount of wear with minimum allowable regrinding tolerance


CAM
DESIGN
OPEN PERIOD 120°
NOSE
LIFT
Nose Radius
OPENING
RAMP
CLOSING
RAMP
ROTATION
HEEL
REST PERIOD 240°

INFORMATION

Block: Engine Fundamentals

Lesson: Camshaft Drives and Timing Gears

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be ab.e to identify basic types of camshaft drives and relate the function of timing gears.

Teaching Aids: Sample sets
- Timing gears
- Timing sprockets and chain

Transparencies:
- Crankshaft, Camshaft and Valves, p. II-59
- Crankshaft - Camshaft Relationship, p. II-57

References: Automotive Mechanics, Crouse, Chapter 17
Automechanics, Glenn, Chapter

Outline of Information:

1. Types of camshaft drives

   a. Timing gears

   b. Timing chains and sprockets

2. Construction of sprockets, gears and chains

   a. Metal gears and sprockets

   b. Fiber sprockets and gears

   c. Timing chains

3. Timing mechanism, failures due to

   a. Normal wear

   b. Insufficient lubrication

4. Results of excessive wear or insufficient lubrication

   a. Noisy operating engine

   b. Inefficient operation

   c. Possible seriously damaged engine

OPERATION

Block: Engine Fundamentals

Operation: Checking Camshaft Bearing Clearance

Block II
Job ____
Operation ____

Teaching Objective: To teach students to accurately measure camshaft journals and bearings

Tools: Telescoping gauge and micrometer

Materials: Engine cylinder block with camshaft removed

Teaching Aids: Transparency:
- Crankshaft-Camshaft Relationship, p. II-57

References: Automotive Mechanics, Crouse, Chapter 17
Vehicle Service Manual

Steps:

1. Starting with front of engine, measure and record each bearing diameter

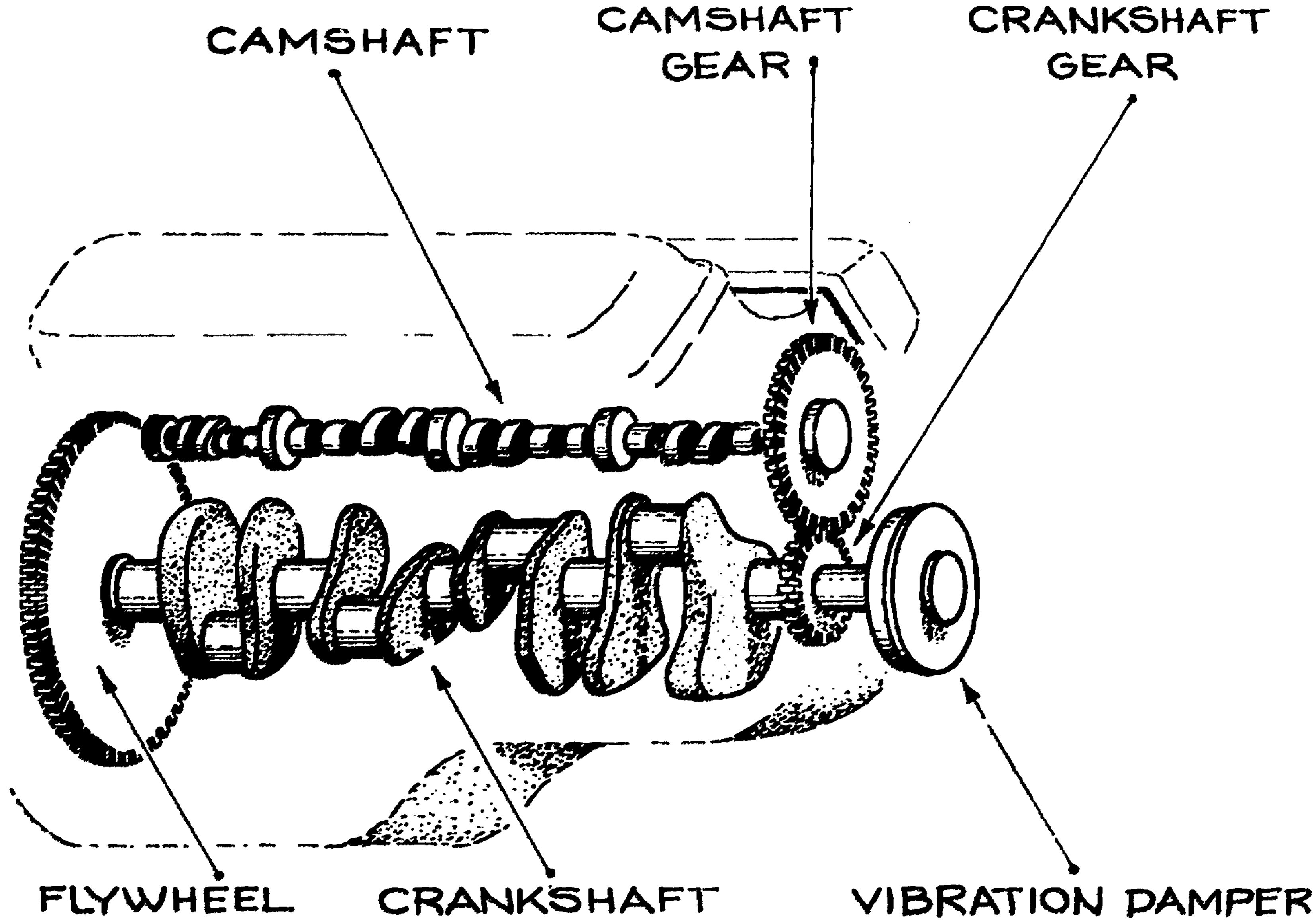
2. Starting with front of camshaft, measure and record each journal diameter

3. Compare and determine clearance of each bearing

4. Check manufacturer's manual for recommended oil clearance

   NOTE: If excessive clearance is encountered, bearings must be replaced.

CRANKSHAFT-CAMSHAFT RELATIONSHIP



INFORMATION

Block: Engine Fundamentals

Lesson: Valve Purpose and Operation

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to basically define the purpose of automatic engine valves and describe their operation.

Teaching Aids: Small cutaway engine partially disassembled
Transparencies:
- Intake, p. II-11
- Compression, p. II-12
- Power, p. II-13
- Exhaust, p. II-14
- Crankshaft, Camshaft and Valve, p. II-59

References: Automotive Mechanics, Crouse, 6th Edition
Small Gasoline Engines, Stephenson, Section II, Unit 3

Outline of Information:

1. Purpose of the valves

   a. Intake valve
      -- Opens to allow fuel mixture to enter

   b. Exhaust valve
      -- Opens to allow burned gases to escape

2. Valve operation

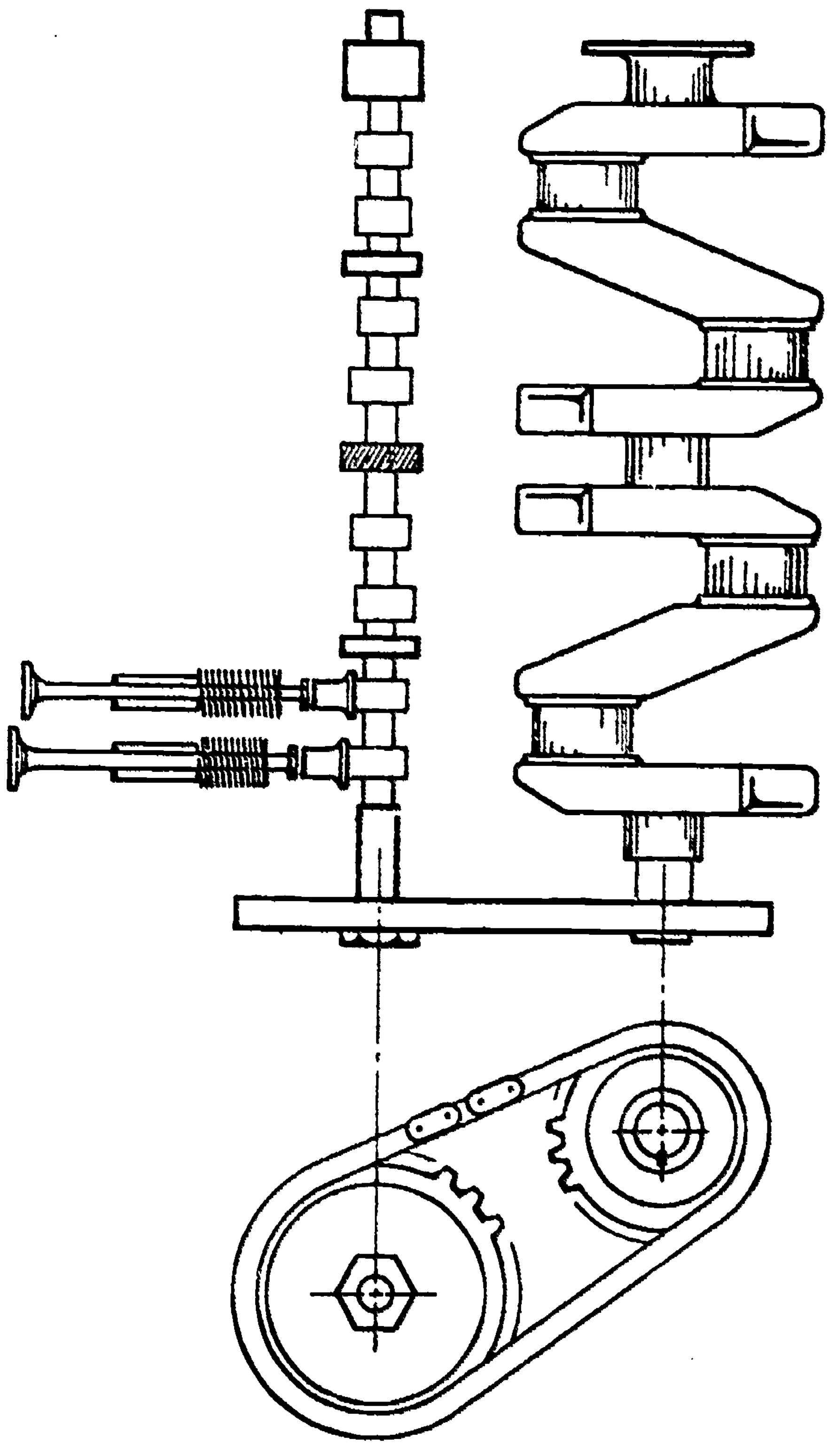
   a. Valve operation requires the mechanical functioning of the "valve train." The valve train includes the following:
      -- Valves (intake and exhaust)
      -- Valve lifter (tappet) - hydraulic or solid type
      -- Valve spring - closes valve and holds it tightly against seat

      NOTE: A spring retainer keyed to the valve stem holds the spring in place.

      -- Cam - Precision ground lobes on camshaft. The cam is considered a member of the valve train, since it initiates valve operation.

   b. Automotive valves are of the poppet type.
      -- Rises perpendicularly to and from seat
      -- Activated by a cam

CRANKSHAFT, CAMSHAFT, AND VALVE



COURTESY - AUTOMOTIVE ELECTRIC/ASSOCIATION II-59
INST. MATL. LAB., UK RG 389-16

INFORMATION

Block: Engine Fundamentals	Block	II
	Job	
Lesson: Valve Construction	Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to describe the construction of automotive engine valves and relate the operating circumstances which effect the selection of proper materials and design characteristics.

Teaching Aids: Transparencies:
- Valve Construction, p. II-62
- Mechanical Valve Lifter, p. II-79

Valve samples

References: Automotive Engine Design, Crouse, Chapter 15
Automotive Mechanics, Crouse, Chapter 8

Outline of Information:

1. Materials for valves must be selected with consideration to several conditional factors.

   a. Excessively high temperature can cause changes in material.
      -- The material must hold up under high engine operating temperatures.
      -- Temperature control helps to maintain proper shape and specified size.
      -- Temperature control is essential to resistance of warpage, distortion and deterioration.

   b. Wear rate
      -- Valves must maintain size specifications while enduring rapid and repeated contact and impact.
      -- Valves are engineered to operate in excess of 60,000 miles under normal conditions.

   c. Corrosion
      -- Polluted lubricants can effect corrosion.
      -- High temperatures and exhaust gasses effect corrosion.
      -- Lead oxide (PbO), often present in exhaust, effects valve corrosion.

2. Most automotive valves are forged from austenitic steel.

   a. Valves are also made from chromium and stainless steels.

   b. Some valves and valve seats are faced with tungsten-cobalt.

3. Areas and surfaces of the valve must be identified for purposes of size and machine specifications.

   a. Head

   b. Margin
      -- Precision machined

   c. Face
      -- Machine ground to same angle as matching valve seat

   d. Stem
      -- Machined for clearance of valve guide

   e. Lock groove or slot
      -- Necessary to accomodate spring retainer

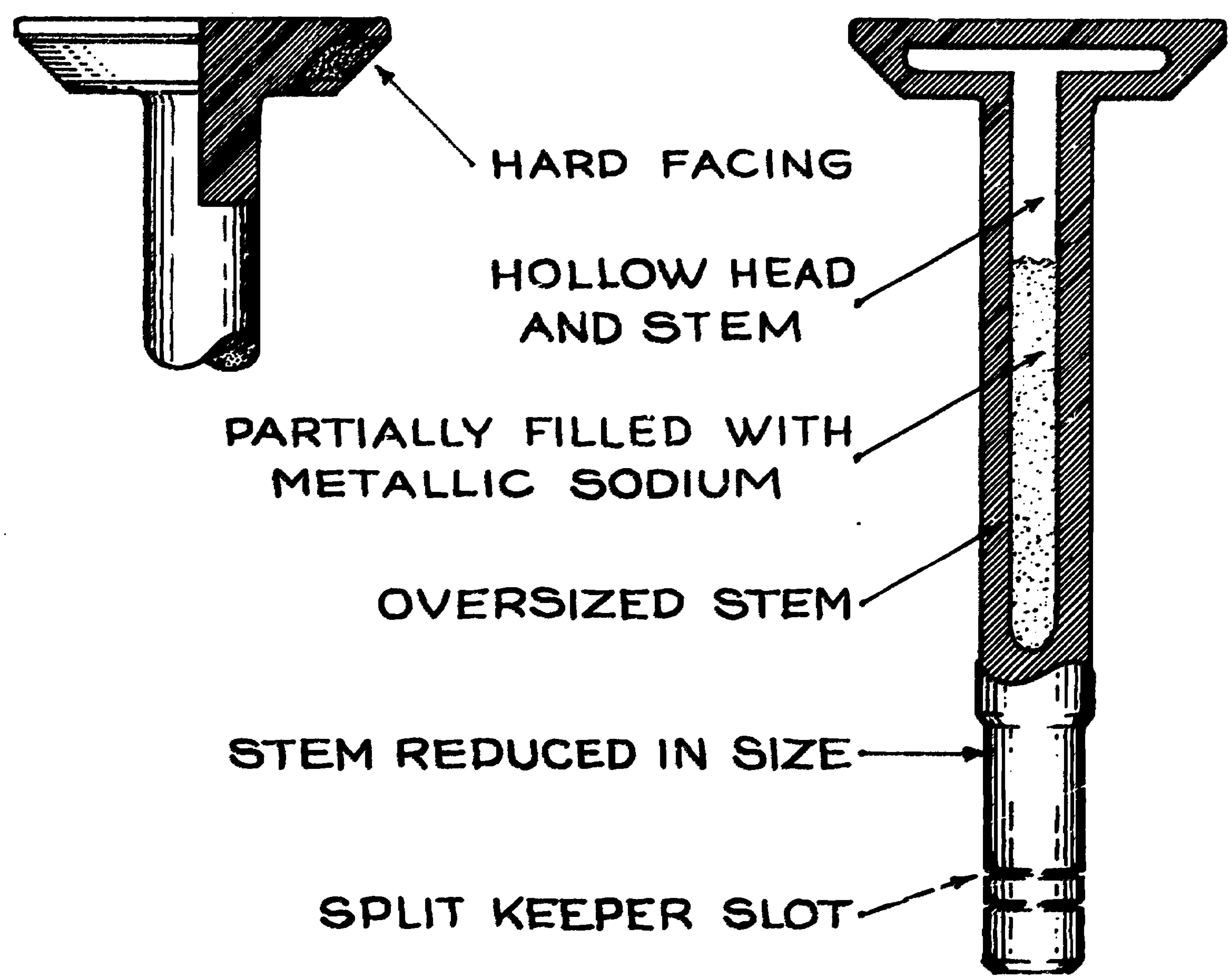
4. Exhaust valves require special design characteristics.

   a. Proper cooling is most important to valve condition, operation,and longevity.
      -- Various coolant flow designs have proven successful.
      -- Adequate lubrication is essential for proper cooling.

   b. Sodium valves
      -- Metallic sodium absorbs heat and helps to relieve valve head area of excessive heat by circulation.
      -- Metallic sodium melts at 208^{o} F.
      -- Valve stems cool more evenly than heat surrounded heads.

   <u>CAUTION</u>: Metallic sodium is highly volative. It explodes upon contact with water and contact with skin can be injurious. Broken or cracked valves could leak this substance.

VALVE CONSTRUCTION



INFORMATION

Block: Engine Fundamentals	Block	II
	Job	
Lesson: Valve Systems	Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to identify the common types of internal combustion engine valve operating systems and compare the operating characteristics of each.

Teaching Aids: Transparencies:
- Valve System Mechanisms, p. II-69
- Valve Arrangements, I-Head, T-Head, p. II-65
- Valve Arrangements, L-Head, F-Head, p. II-66

References: Fundamentals of Service, Engines, Deere and Company, Chapter 2
Automotive Fundamentals, Crouse, Chapter 8
Auto Service and Repair, Stockel, Chapter 13

Outline of Information:

1. The four most common valve systems used in modern automotive engines are described as follows:

   a. L-Head engine
      -- Valves are located in the cylinder block.
      -- If engine is V-8, a line of valves is located in each bank.
      -- Service is relatively easy.
      -- L-Head engine can be designed for mechanical or hydraulic lifters.
      -- L-Head engine has simplified valve train (direct operation).
      -- L-Head design is not suited to high compressions.

   b. I-Head engine
      -- Valve locations vary with specific design.
         (1) Single line of valves
         (2) Two lines of valves (one line for intake - one line for exhaust)
      -- Most I-Head engines use single camshaft.
      -- Push rods and rocker arms are required in the valve train.
      -- Although hydraulic lifters are used most often in the I-Head engine, mechanical lifters are satisfactorily utilized.

   c. F-Head engine
      -- F-Head engine combines the design features of L-Head and I-Head
      -- Intake valves are in the head.
      -- Exhaust valves are in the block.
      -- Both sets of valves operate from the same camshaft.
      -- The valve train requires push rods and rocker arms.

d. T-Head engine
-- Intake valves are in the block on one side of cylinder.
-- Exhaust valves are in the block on the opposite side of cylinder from intake valves.
-- T-Head design is not used for modern vehicle engines.

2. Overhead camshaft designs are used for higher performance engines.

a. Single overhead camshaft applications are of special design.

b. Cams are often in direct operation on valve lifters or rocker arms.

3. Valve systems other than cam-operated poppet-types are used in internal combustion engines.

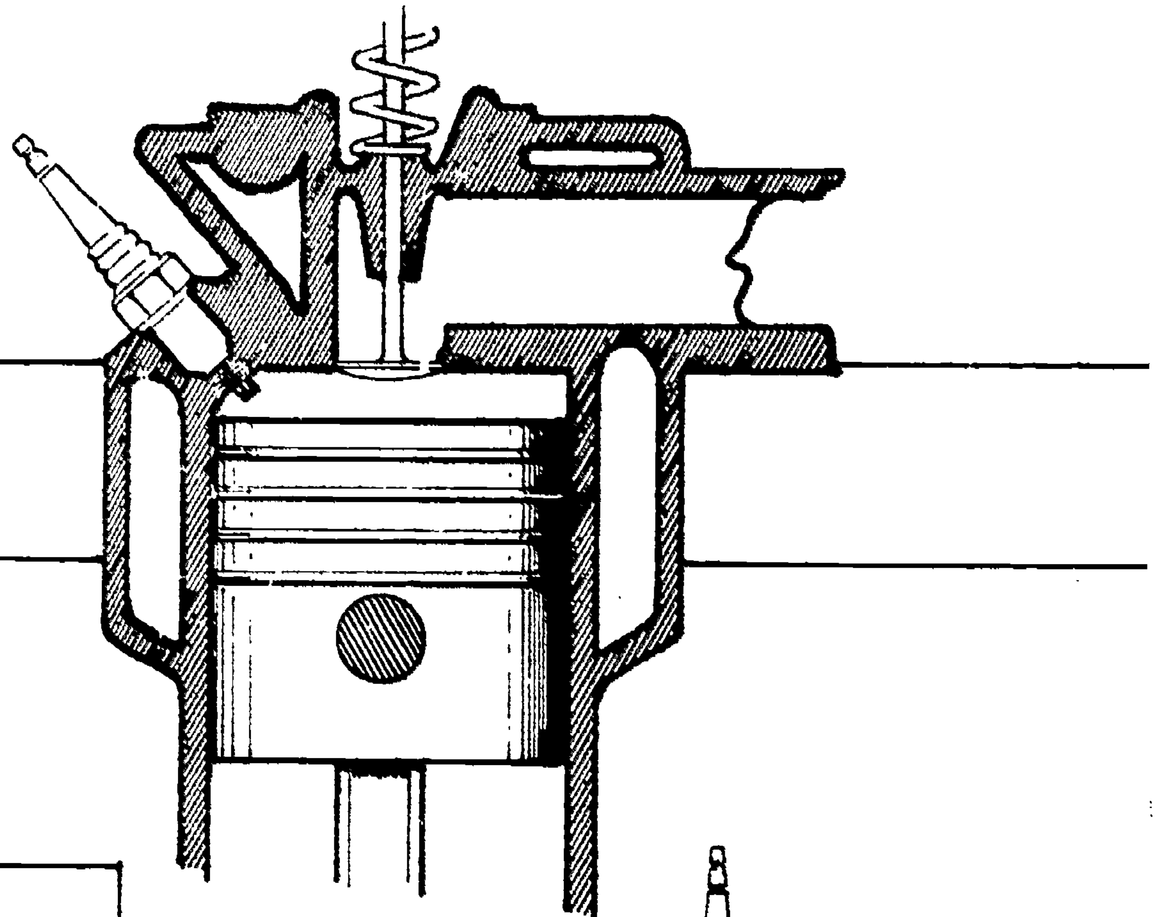
a. Reed (leaf) valves
-- Made of thin, spring steel

b. Rotary valves
-- Usually operate in synchronization with crankshaft

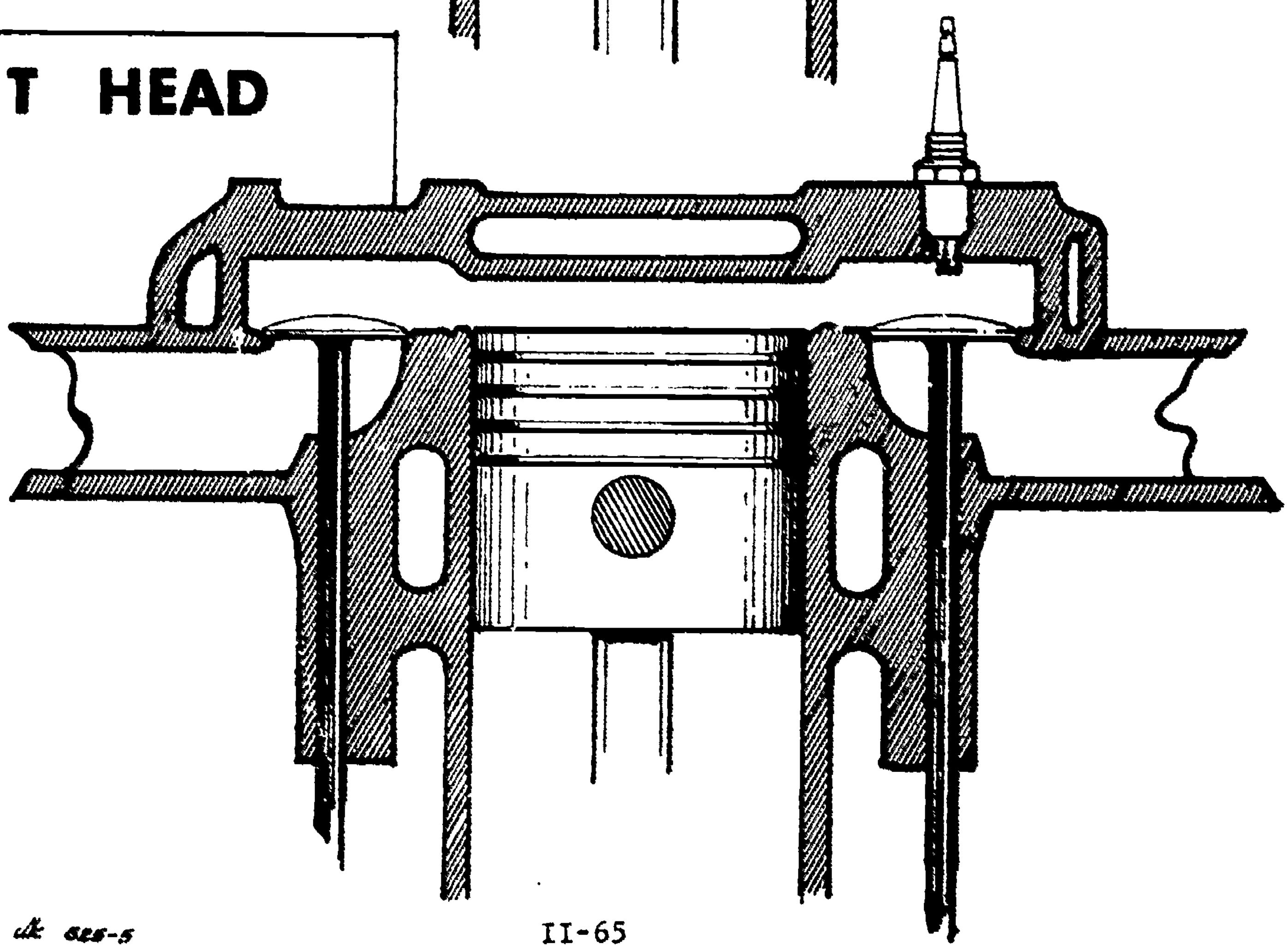
c. Pressure-operated poppet valves
-- Open and close with vacuum and pressure

VALVE ARRANGEMENTS

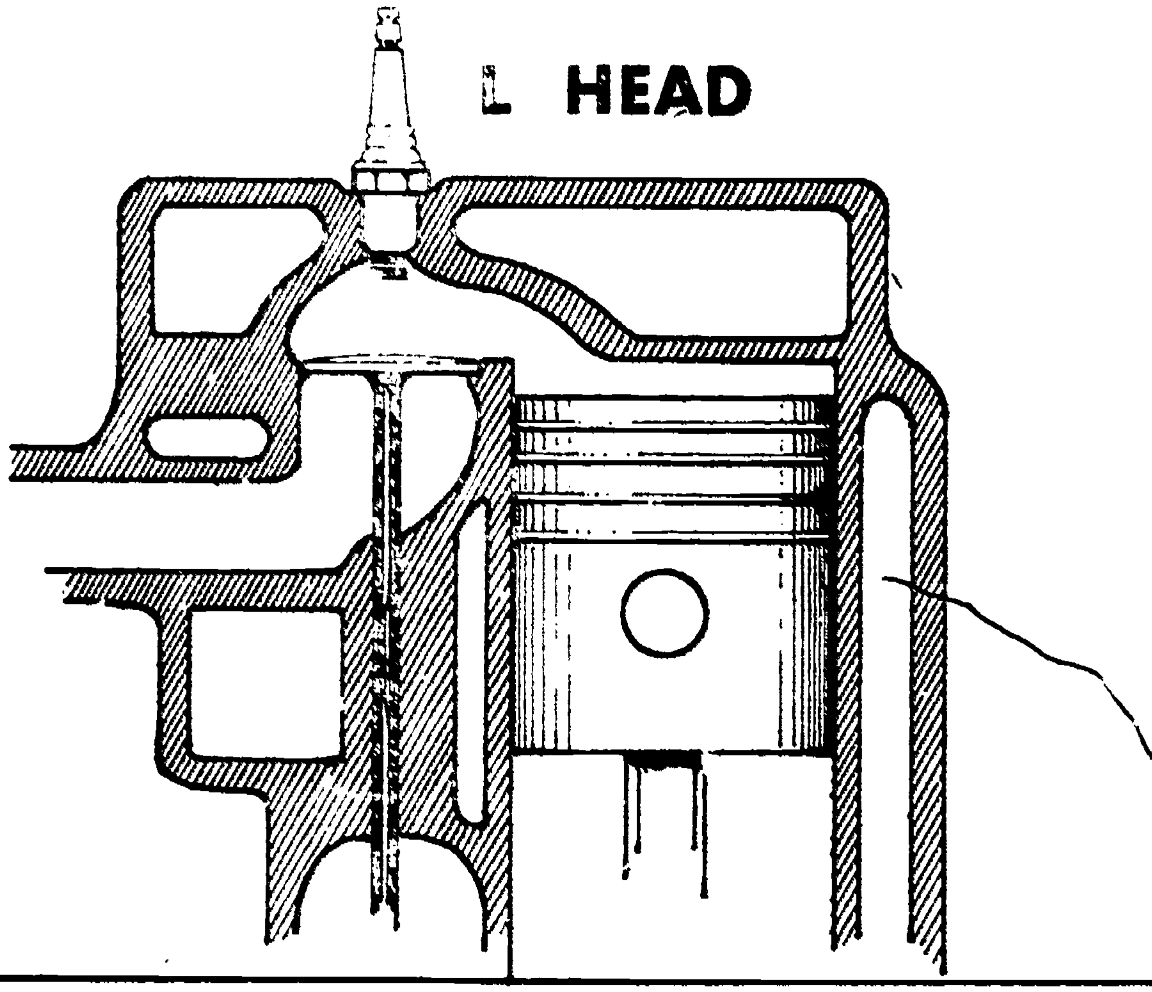
I HEAD



T HEAD

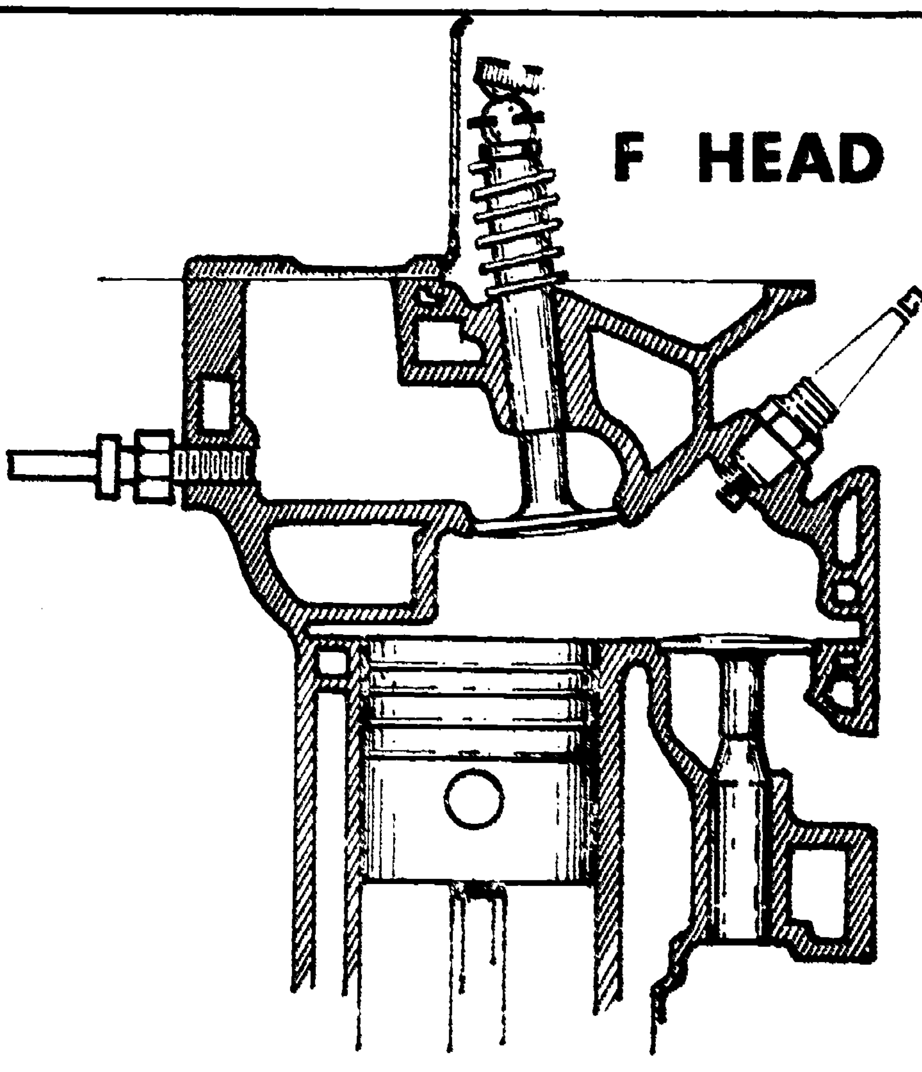


L HEAD



VALVE ARRANGEMENTS

F HEAD



INFORMATION

Block: Engine Fundamentals

Lesson: Valve Trains

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to describe the construction and function of typical valve train components.

Teaching Aids: Transparencies:
- Crankshaft, Camshaft and Valve, p. II-59
- Valve System Mechanisms, p. II-69

References: Auto Mechanics, Crouse, 6th Edition
Automechanics, Glenn, Chapter 4

Outline of Information:

1. Camshafts

   a. Constructed of cast iron

   b. Contains several lobes; two per cylinder, one per valve

   c. Sometimes provides a gear for driving the distributor and/or oil pump

   d. Has a means of attaching a gear or sprocket wheel to provide a means of driving it by the crankshaft

   e. Usually provides an eccentric for driving the fuel pump

2. Lifters

   a. Ground and polished for a precision fit in its bore in the engine block

   b. Provides a bearing surface which follows the cam lobe and provides a seat for the lower end of the push rod

   c. Sometimes used for providing an adjustment in the valve train where hydraulic lifters are used

3. Push rod

   a. Constructed of a solid rod or a hollow pipe for lubrication purposes

   b. Ends are precision machined to mate with the lifter and the rocker arm

   c. Transmits motion from the lifter to rocker arm

Valve Trains (continued)

4. Rocker arm

   a. Shaft mounted
      -- Pivots on a precision ground hollow oil-filled shaft
      -- Pressure lubricated

   b. Ball and stud mounted
      -- Ball and socket-type pivot
      -- Usually splash or spray lubricated by oil which is delivered through the hollow push rod

   c. Usually contains the means of adjustment on solid lifter-type valve trains

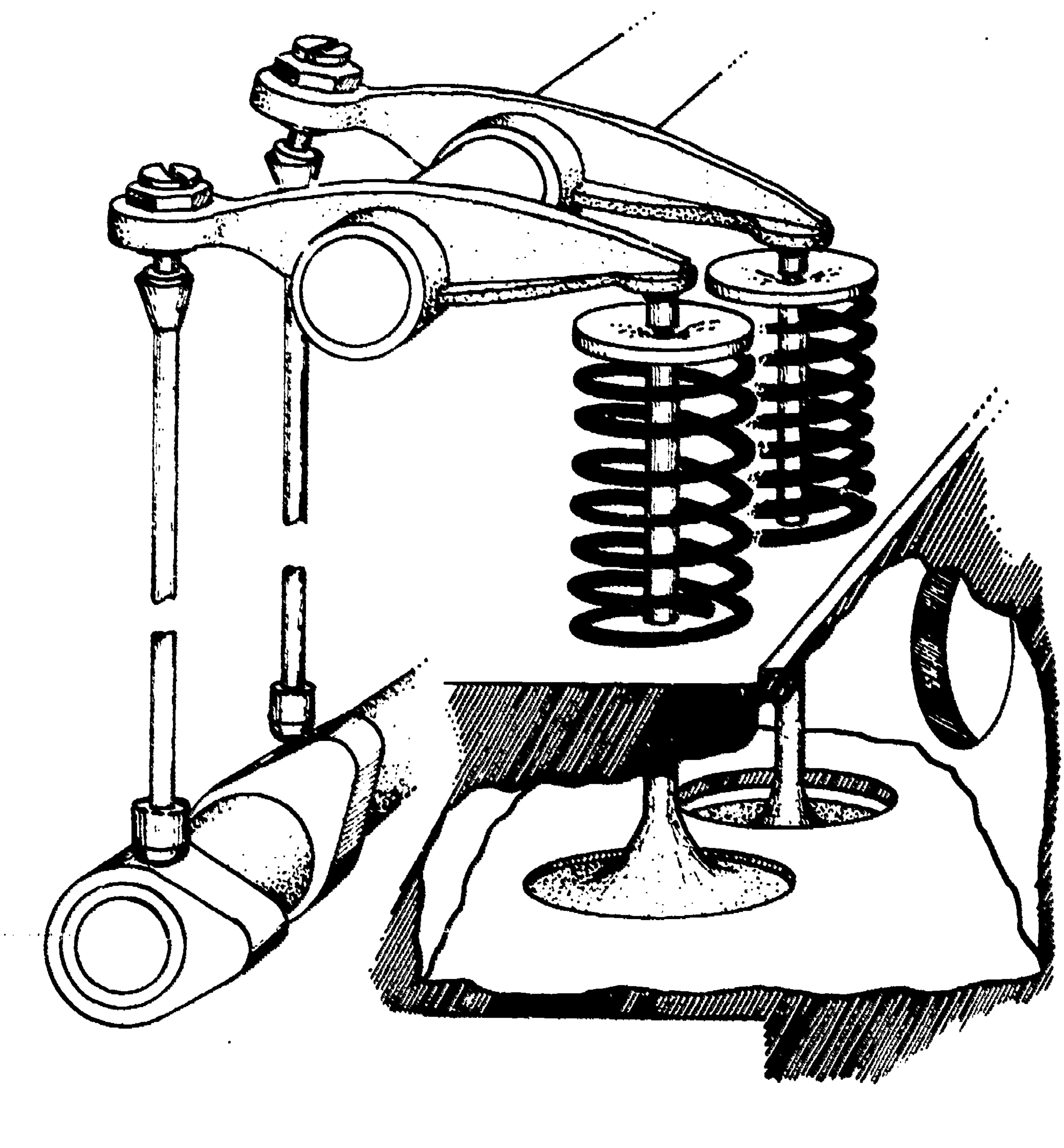
   d. Reverses the motion of the push rod

   e. Depresses the valve when the cam raises the lifter and push rod

5. Valve spring, retainers, and keepers

   NOTE: See information sheet on valve, purpose and operation, pp. II-

Valve System Mechanisms



INFORMATION

Block: Engine Fundamentals

Lesson: Valve Seats

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, the student will be able to describe the function of valve seats and identify the various types.

Teaching Aids: Cylinder head assembly with integral-type valve seats
Cylinder head assembly with insert-type valve seats
Transparency:
- Mechanical Valve Lifter, p. II-79

References: Automotive Mechanics, Crouse, Chapters 3, 17
Auto Service and Repair, Stockel, Chapter 13

Outline of Information:

1. Purpose of valve seats

   a. Provides a tight seal between the valve and combustion chamber surface when the valve is closed

   b. Transfers some of the heat absorbed by the valve to the seat and then to the cooling medium

2. Types of valve seats

   a. Ring insert type seats
      -- Made of a high heat resistant, special alloy metal
      -- Require special tools for removal and replacement
      -- Cost of manufacture is greater, but engine and valve life are extended

   b. Integral valve seats
      -- A part of the casting of which the cylinder head is made
      -- Cannot be replaced - Damage would result in discarding and replacing the cylinder head.

   NOTE: Head could be salvaged by re-machining and installing valve seat inserts if cost were prohibitive

      -- Cost of manufacture is less than with valve seat insert type
      -- Engine and valve life are shortened, especially if used for heavy duty service

INFORMATION

Block: Engine Fundamentals

Lesson: Valve Seating

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will relate correct valve seating to proper engine functioning.

Teaching Aids: Samples:
- Valves (good condition, poor condition)
- Valve seat inserts

Transparencies:
- Intake, p. II-11
- Compression, p. II-12
- Power, p. II-13
- Exhaust, p. II-14
- Mechanical Valve Lifter, p. II-79

References: Automotive Mechanics, Crouse, Chapter 17

Outline of Information:

1. Compression is required of good combustion. The more the fuel air mixture is compressed, the more efficient the combustion. Therefore, more power is produced.

2. Valves are closed on the compression and power stroke, confining the gasses.

3. Any leakage past the valves would result in lower compression, therefore loss of power.

4. Hot gasses escaping past a leaking valve tend to overheat it causing it to burn and leak more.

5. Low compression causes loss of power, hard starting, backfiring, excessive fuel consumption, and inefficient operation.

OPERATION

Block: Engine Fundamentals	Block II
	Job ____
Operation: Removing Valves and Springs	Operation ____

Teaching Objective: To teach students to properly remove valves and springs

Tools: Valve spring compressor, ball-pein hammer, short length of pipe, small block of wood, rack to organize removed parts

Materials: Solvent, wipe cloths

Teaching Aids: Several engines or cylinder heads with valves assembled

References: *Automotive Mechanics*, Crouse, Chapter 17
Automechanics, Glenn, Chapter 4
Fundamentals of Service, Engines, John Deere, Chapter 2

Steps:

1. Place cylinder head upright on a clean workbench

2. With a small block of wood under the valve, place a short length of pipe on the valve retainer and strike lightly with a hammer

   Caution: During operation the valve retainer tends to "set" or "freeze" to the valve stem. The valve spring compressor will not break it loose, and if attempted in this manner will only result in damage to the spring compressor. By using the wood block, hammer and pipe, they can easily be broken loose.

3. Place the cylinder head on its side, springs pointing away from the operator

   Caution: Compressed springs of any type are a hazard in the shop. Work with care

4. Place the valve spring compressor in position and compress the spring

5. Remove the "keepers"

6. Release the valve spring compressor slowly, cautiously

Removing Valves and Springs (continued)

7. Remove the spring retainer and spring

8. Remove valve

9. Place all parts in a rack so they can be reassembled in the same location from which they were removed

   NOTE: Occasionally the valve stem becomes slightly battered on the end (because of excessive valve lash) and will not slide free through the guide. Filing will remove this "mushrooming."

OPERATION

Block: Engine Fundamentals

Operation: Fitting Valve Springs

Block II
Job ____
Operation ____

Teaching Objective: To teach students to properly fit valve springs

Tools: Valve spring compressor, steel scale, dividers

Materials: Wipe cloths, solvent, lubricating oil

Teaching Aids: Engines or cylinder heads with valves, valve spring shims (assortment)

References: Vehicle Service Manual
Automotive Mechanics, Crouse, Chapter 17

Steps:

1. After the cylinder head has been cleaned, valves have been replaced, seats ground and springs checked for squareness (see fig. 17-23, p. 268, Crouse, 6th Ed.) assemble the cylinder head in the reverse order of valve removal

2. Check the valve spring compressed height with dividers

3. Transfer measurement to a steel scale and compare reading to manufacturer's specifications

   NOTE: When valves and seats are ground, metal is removed, allowing the valve to set deeper into the cylinder head, resulting in a greater valve spring assembled length. This must be corrected with the proper shim placed between the spring and spring seat on the cylinder head.

4. Select the proper valve spring shim and install

   CAUTION: Note the position of valve springs and install properly. There is a difference between top and bottom with some springs. If the spring is equipped with a damper, make certain that damper is in place.

5. Repeat on all valve springs

6. Cylinder head is now ready for installation.

OPERATION

Block: Engine Fundamentals

Operation: Practicing Valve Grinding and Valve Seat Grinding

Block II
Job ____
Operation ____

Teaching Objective: To teach students to properly grind (reface) valves

Tools: Bench grinder with wire brush, portable drill with a carbon cleaning brush, valve guide cleaning brush, valve grinder, valve seat grinder

Materials: Prussian blue, valve stem seals, grinding compound, wipe cloths, solvent

Teaching Aids: Cylinder heads
Manufacturer's Instructions

References: Automotive Mechanics, Crouse, Chapter 17
Vehicle Service Manual

Steps:

1. Remove valves from the cylinder head

   NOTE: Because of different wear patterns, valves must be reinstalled into the same guide from which they were removed; therefore, some means must be employed to keep the valves in proper order.

2. Clean the cylinder head. Use a carbon cleaning brush to clean the area around the valve seats, valve ports and combustion chambers

3. Clean valves with a wire brush mounted on a bench grinder

4. Clean valve guides using a valve guide cleaning brush

   CAUTION: When using power equipment to remove carbon from cylinder heads and valves, goggles must be worn to protect the eyes.

5. Insert pilot into the valve guide

6. Install proper grinding stone and holder onto the pilot

7. Install the driver and with light pressure grind the seat. Inspect the seat frequently. Remove only enough metal to remove all pits and polish the seat

   NOTE: Refer to equipment manufacturer's instructions for proper operation of the equipment

8. Check seat width and if seat is too wide, narrowing stones must be used. Again refer to the manufacturer's instructions for proper operation

9. Repeat until all valve seats have been ground

10. Set Valve Refacer to proper seat angle (Refer to Specifications)

11. Install valve in chuck

12. Turn ON-OFF switch to ON position and wait until coolant starts to flow

13. Slowly bring the rotating valve into contact (very lightly) with the revolving grinding stone

    CAUTION: This is the place to work slowly and cautiously. Jamming or forcing the valve into contact with the stone results in damage to both the valve and the equipment. The quality of the finish on the valve face is reflected by the quality of workmanship.

14. Work the rotating valve back and forth across the face of the stone, feeding the valve into the stone only as fast as metal is removed

    REPEAT CAUTION: Work slowly until all of the seat is polished

15. Repeat on all valves

    CAUTION: Some engines use a different valve seat angle for intake and exhaust. Refer to specifications

INFORMATION

Block: Engine Fundamentals

Lesson: Valve Lifters - Function and Type

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to describe the function and operation of automotive engine valve lifters.

Teaching Aids: Several sample lifters (both mechanical and hydraulic)
Transparencies:
- Valve System Mechanisms, p. II-69
- Mechanical Valve Lifters, p. II-79
- Hydraulic Valve Lifters, p. II-80

References: Automotive Mechanics, Crouse, Chapter 8
Fundamentals of Service Engines, John Deere, Chapter 2

Outline of Information:

1. Function

   a. The lifter (sometimes called a cam follower or tappet) transfers the motion of the cam to the push rod or valve stem.

   b. The diameter of the push rod or the valve stem is too small to provide a good bearing surface against the cam, therefore; the lifter, having a larger diameter, is necessary.

   c. Some mechanical (solid) lifters, and all hydraulic lifters provide for the necessary adjustment in the valve train.

2. Mechanical lifters

   a. Construction is solid to a precise dimension, with some lifters having a slightly convex face at cam contact. This causes the lifter to rotate. Some have a screw type adjuster with a means of locking the adjustment.

   b. Because metal expands when heated, clearance or valve lash is necessary in the valve train with this type lifter.

3. Hydraulic lifters

   a. Construction
      -- Body - Hollow cylinder closed on the lower end. Manufactured under controlled conditions to exact tolerances.
      -- Plunger - Fits tightly in the body, but moves freely and allows for slight leakage around its outer diameter.
      -- Valve - Either a ball or disc type usually spring loaded. Closed the duration of valve lift.

Valve Lifters - function and type (continued)

b. Operation

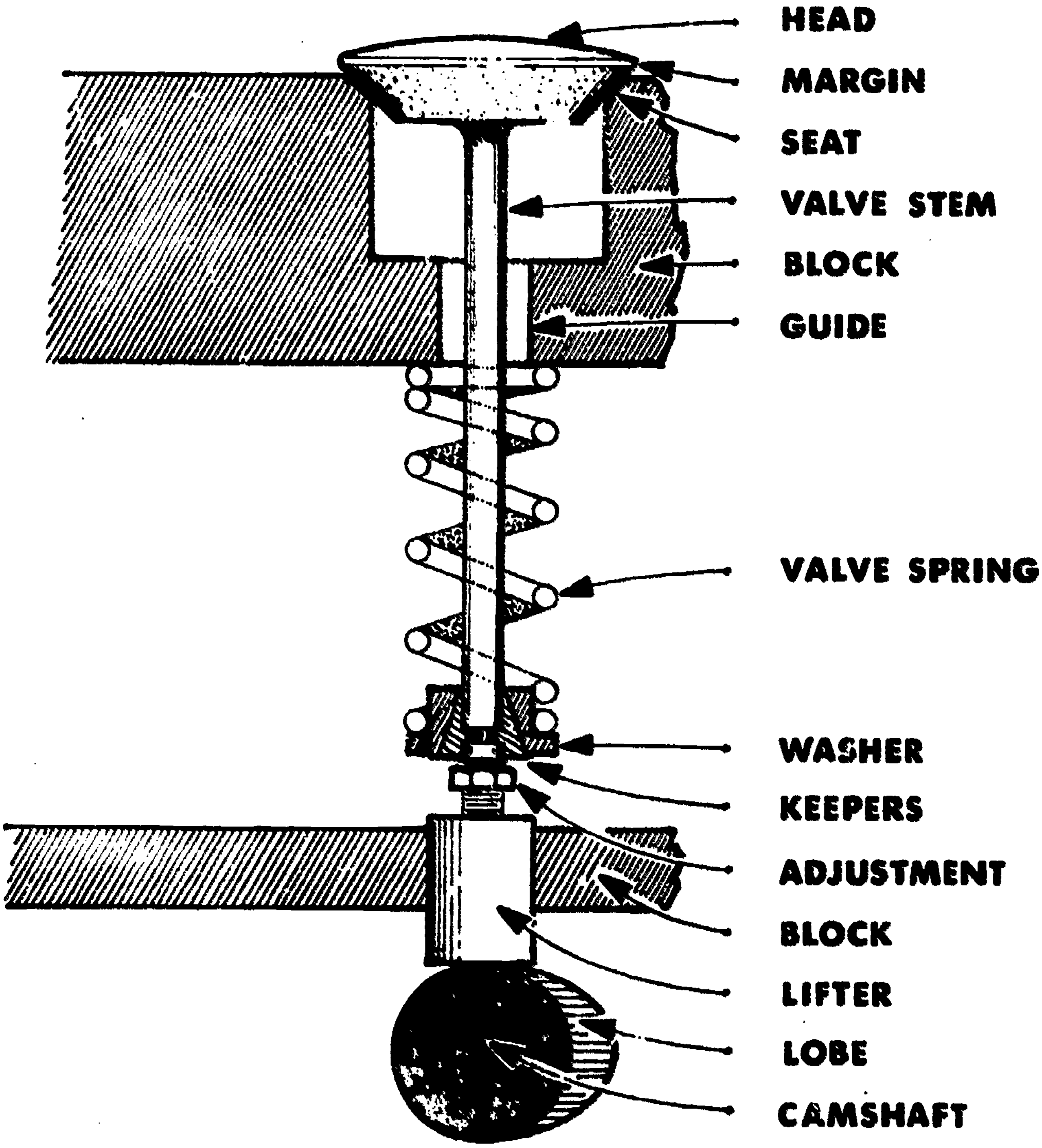
-- When the intake or exhaust valve is closed, oil pressure from the oil pump fills the lifter body, pushing the plunger out.

-- As the nose of the cam begins to raise the lifter, the valve inside the lifter closes, trapping the oil, causing the lifter to act with a solid thrust, raising the engine valve off its seat.

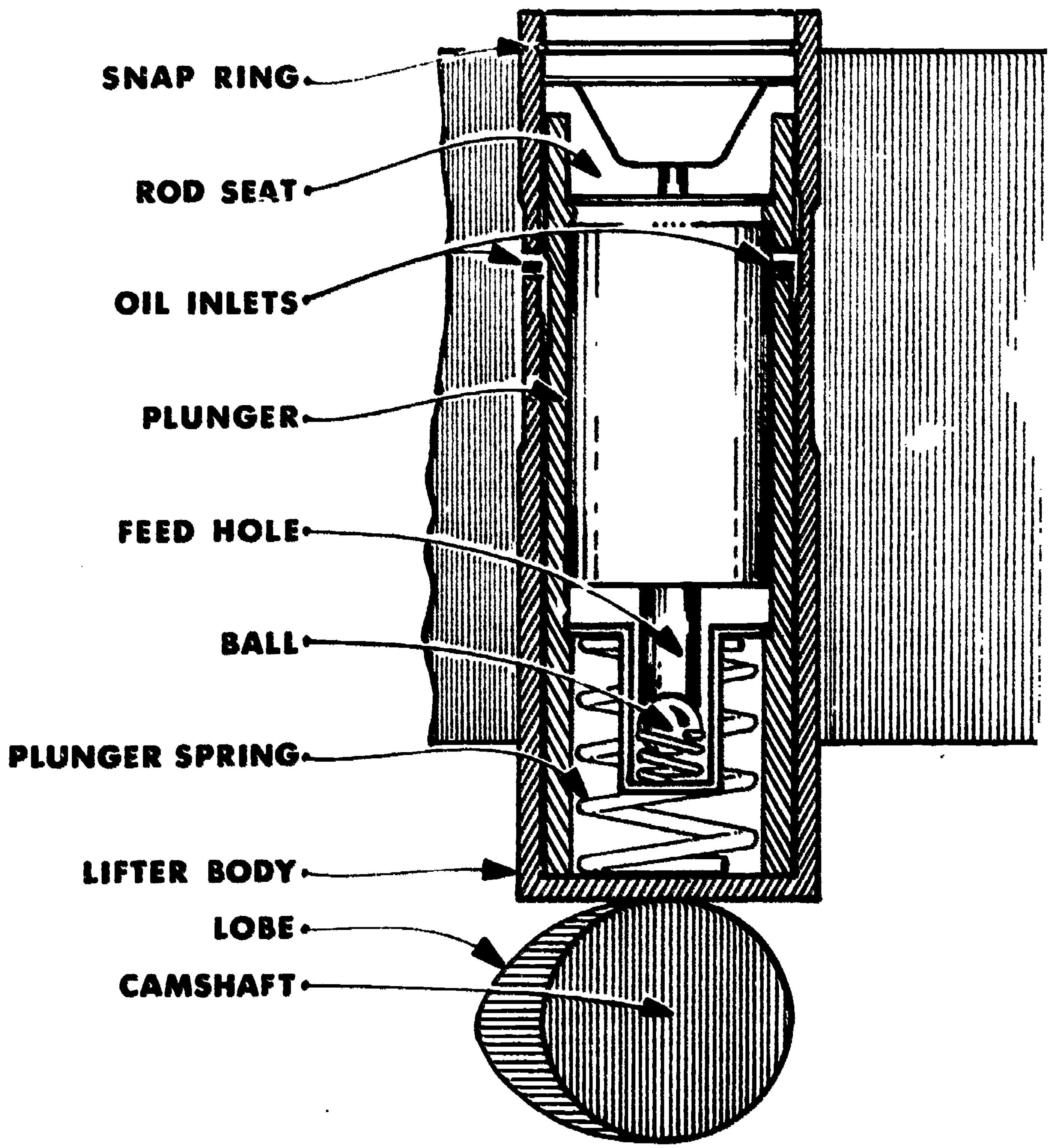
-- As the engine valve is lowered onto its seat, and pressure is relieved, the valve inside the lifter opens and allows oil pump pressure to push on the plunger.

-- In this way zero valve lash is maintained at all times.

MECHANICAL VALVE LIFTER



HYDRAULIC VALVE LIFTER



LMORE CDC, UK 825-F

OPERATION

Block: Engine Fundamentals

Operation: Examining Valve Lifters

Block II
Job
Operation

Teaching Objectives: To teach students to examine valve lifters

Tools: Leak-down testing fixture, micrometer, wipe cloths

Materials: Engines equipped with lifters or sets of lifters which have been removed

References: Vehicle Service Manual
Automotive Mechanics, Crouse, Chapters 8, 17

Steps:

1. Examine camshaft area of the lifter for wear and pitting

2. Examine outer surface of the lifter for scuffing and wear

3. Measure "OD" of lifter with micrometer and compare with manufacturer's tolerances

4. Examine face on adjusting screw for wear (L-Head)

5. Examine area where pushrod contacts the lifter

   NOTE: Hydraulic lifter may be disassembled, inspected for wear or broken spring, and reassembled.

6. Check leak-down rate on special tester (Fig. 17-59, p. 282, Crouse, 6th Ed.)

   NOTE:
   1. The most critical wear point on lifters is the area which is in contact with the cam lobe.
   2. If hydraulic lifters are causing trouble on high mileage cars, it could be the result of a loss of engine oil pressure.
   3. Because of different wear patterns, lifters must be replaced into the same bores from which they are removed. A wood holding fixture is valuable in keeping them in the proper order.

INFORMATION

Block: Engine Fundamentals

Lesson: Valve Rotators

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to list purposes of valve rotation and describe the construction and operation of two commonly used types.

Teaching Aids: Samples of the free-type rotator and the positive type rotator

References: Automotive Mechanics, Crouse, Chapter 8
Fundamentals of Service, Engines, John Deere, Chapter 2

Outline of Information:

1. Purpose of rotators

   a. Rotating the valve during operation extends valve life.

   b. Rotation keeps the face wiped clean and free of deposits, which prevents burning.

   c. Rotation keeps the stem and guide wiped clean of deposits, preventing sticking, which causes burning.

2. Free-type rotator

   a. Construction consists of a spring retainer lock, a tip cup, and a spring retainer.

   b. Operation: As the lifter or rocker arm begins to open the valve, pressure is applied to the tip cup and the spring retainer, leaving the valve free of any spring pressure. The valve is not forced to revolve but since it is free, it will rotate.

3. Positive-type rotator

   a. Construction consists of spring loaded steel balls between two washer type races. Similar to a thrust bearing except one of the races containing inclined planes for each ball.

   b. Operation - During the first part of the valve lift, the balls are forced down the inclined planes. This causes the retainer to rotate which turns the valve a few degrees each time the valve is opened.

INFORMATION

Block: Engine Fundamentals		Block	II
		Job	
Lesson: Valve Adjustment		Lesson	

Teaching Objective: Upon completion of this lesson, students will be able to describe the rationale relating to automotive valve adjustment.

Teaching Aids: Transparency:
- Valve System Mechanisms, p. II-69

References: Automotive Mechanics, Crouse, Chapter 17
Motor's Auto Repair Manual, 1965, p. 645

Outline of Information:

1. Reasons for adjusting valves

   a. To insure uniform valve timing by adjusting all clearances within specified tolerances

   b. To prevent burning of valves which have insufficient clearance

   c. To prevent noise

   NOTE: Valve train damage can result when clearances are beyond tolerances.

   d. Performance improvements. When all valves are adjusted to specification, combustion in the cylinders will be more nearly equal.

2. Specifications

   a. Valves must be adjusted to factory specifications.

   b. Usually, the settings for intake and exhaust valves are different:
   -- Exhaust valves run hotter. Because of heat expansion, they require more clearance.
   -- Intake valves run cooler, expand less and require less clearance.

   c. Valves must be adjusted with the piston at top-dead-center on the compression stroke.

OPERATION

Block: Engine

Operation: Adjusting Valve Tappets (With Engine Operating)

Block II
Job
Operation

Teaching Objective: To teach students to adjust valve tappets

Tools: Feeler gauge, screwdriver, open-end wrench set

Materials: Wipe cloths, gaskets

Teaching Aids: Transparency:
- Valve System Mechanisms, p. II-69

Automobile or operating engine on stand

References: Automotive Mechanics, Crouse, Chapter 17
Automechanics, Glenn, Chapter 4
Vehicle Service Manual

Steps:

1. Run engine to normal temperature
2. Remove valve cover

   CAUTION: Oil, squirting from rocker arms and push rods, may be lost during operation with covers removed. An old cover with the top cut out will help return the oil to the sump. Also, aluminum foil can be molded around the rocker arms to direct the oil downward.

3. Make adjustments with engine idling
4. Insert feeler gauge between rocker arm and valve stem
5. Adjust to specifications. After final adjustment, recheck locking nuts if so equipped. (Some adjustments are self-locking)
6. Replace rocker arm covers with new gaskets and check for leaks

OPERATION

Block: Engine Fundamentals		Block	II
		Job	
Operation: Adjusting Valve Tappets (Engine Not Running)		Operation	

Teaching Objective: To teach students to adjust valve tappets

Tools: Feeler gauge, drive socket set (3/8), box end wrenches, screwdrivers

Materials: Wipe cloths

Teaching Aids: Live V-8 engine

References: Chilton's Auto Repair Manual, 1966
Automechanics, Glenn, Chapter 4
Vehicle Service Manual

Steps:

1. Warm up the engine and turn ignition off
2. Remove valve covers on both sides
3. Write firing order on paper - Example 15486372
4. Turn engine clockwise until No. 1 cylinder is at top dead center on compression stroke
5. Adjust both intake and exhaust valves on No. 1 cylinder to correct specifications
6. Remove distributor cap and observe position of breaker cam
7. Turn engine clockwise 90° by observing the breaker cam which will move 45°
8. Adjust both intake and exhaust valve on No. 5 cylinder
9. Repeat same procedure on all cylinders as they are read in the firing order

INFORMATION

Block: Engine Fundamentals

Lesson: Purpose of Engine Lubricating Systems

Block: II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will be able to list the four essential functions of the engine lubricating system and relate these concepts to engine operation.

Teaching Aids: Transparencies:
- The Four Essential Functions of the Engine Lubricating System, p. II-87
- Location of Oil Pump in the Engine, p. II-90
- Reaction Within Engine Crankcase Temperatures During Operation, p. II-88

Film, 16mm
- Oil Films In Action, General Motors Corporation

References: Automotive Mechanics, Crouse, Chapter 11

Outline of Information:

1. Lubricating

   a. Allows movement of metal parts by providing a uniform friction reducing coating

   b. Reduces noise of parts rubbing together

   c. Reduces wear

2. Cooling

   a. Absorbs excess heat from engine parts during circulation

   b. Loses some heat while contained in oil pan

3. Cleansing

   a. Minimizes engine deposits and sludge formation

   b. Flushes foreign particles from parts
      -- Heavier, unfiltered particles sink to bottom of oil pan

4. Sealing

   a. Seals around piston ring and cylinder area

   b. Seals around valve guides and valve stems

   c. Aids sealing function of gaskets

THE FOUR ESSENTIAL FUNCTIONS OF THE ENGINE LUBRICATING SYSTEM

1. LUBRICATING

   - Reduces Friction Between Moving Parts

2. COOLING

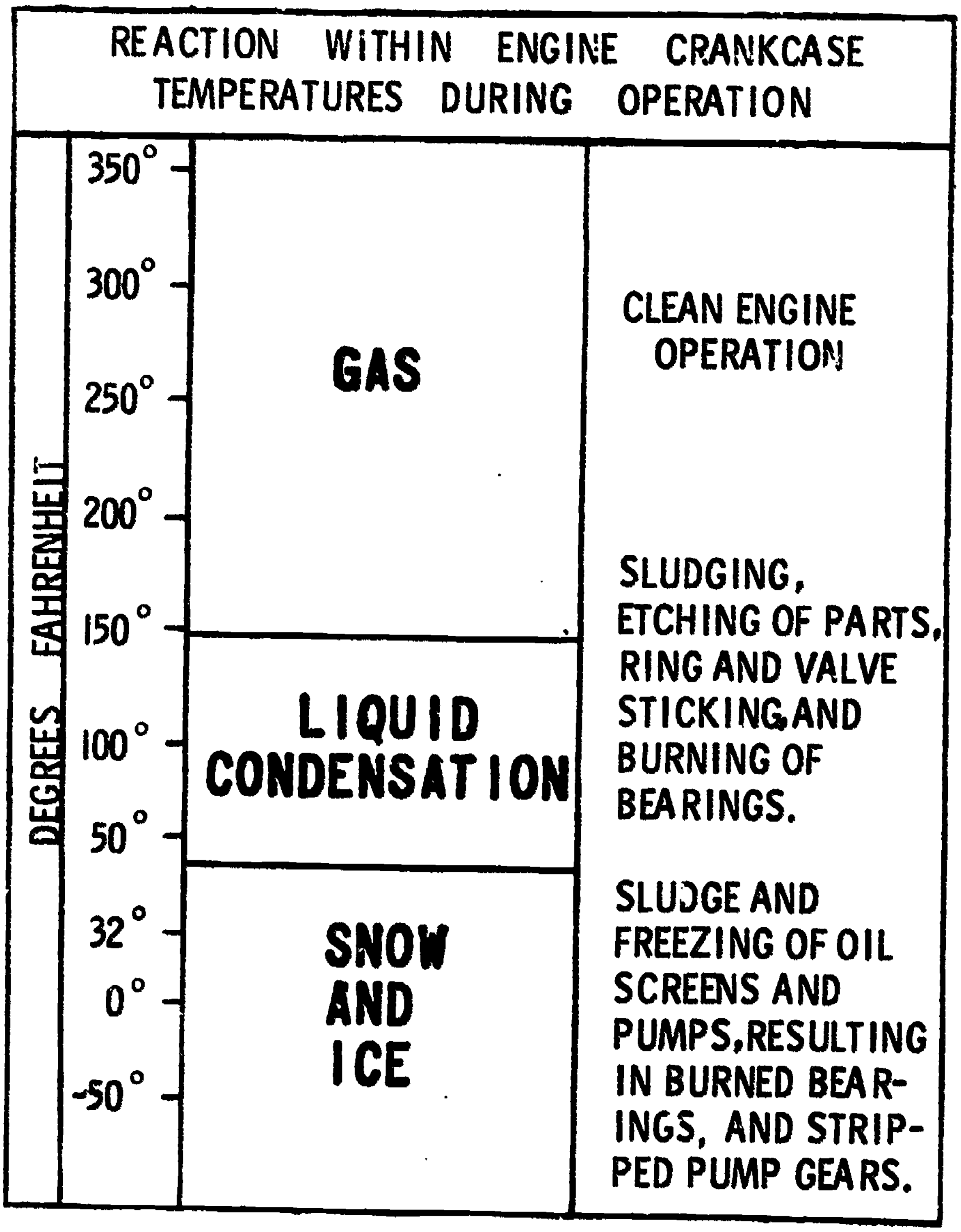
   - Prevents Heat Concentration By Distributing Heat Via Circulation

3. CLEANSING

   - Flushes Foreign Particles and By-Products of Wear and Combustion From Moving Parts

4. SEALING

   - Prevents Gaskets From Drying Out and Separating


REACTION WITHIN ENGINE CRANKCASE TEMPERATURES DURING OPERATION
DEGREES FAHRENHEIT
350°
300°
250°
200°
150°
100°
50°
32°
0°
-50°
GAS
LIQUID CONDENSATION
SNOW AND ICE
CLEAN ENGINE OPERATION
SLUDGING, ETCHING OF PARTS, RING AND VALVE STICKING,AND BURNING OF BEARINGS.
SLUDGE AND FREEZING OF OIL SCREENS AND PUMPS,RESULTING IN BURNED BEARINGS, AND STRIPPED PUMP GEARS.

INFORMATION

Block: Engine Fundamentals

Lesson: Function and Construction of Oil Pumps and Oil Pressure Relief Valve

Block II
Job ____
Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to describe the function and design of automotive oil pumps and pressure relief valves.

Teaching Aids: Transparencies:
- Location of Oil Pump in the Engine, p. II-90
- Gear-Type Oil Pump, p. II-91
- Rotor-Type Oil Pump, p. II-94

References: Automotive Mechanics, Crouse, Chapter 11
Automotive Encyclopedia, Toboldt and Johnson, pp. 94,95

Outline of Information:

1. Oil pump function

   a. Supplies engine oil to all working parts of the engine

   b. Picks up oil through a screen in the pump

   c. Forces oil through the filter on its way to the bearings

2. Types of oil pumps

   a. Gear-type pump
      -- Consists of two meshed gears enclosed in a metal housing
      -- One gear is driven by a shaft, usually geared to an integral gear on the camshaft
      -- Oil is carried around between the gear teeth and housing, creating pressure

   b. Rotor-type pump
      -- Consists of an inner and outer rotor which rotate in a metal housing
      -- The inner rotor is driven by a shaft geared to the camshaft
      -- As the rotors turn, oil is drawn in and forced out of the pump

3. Oil pressure relief valve function and design

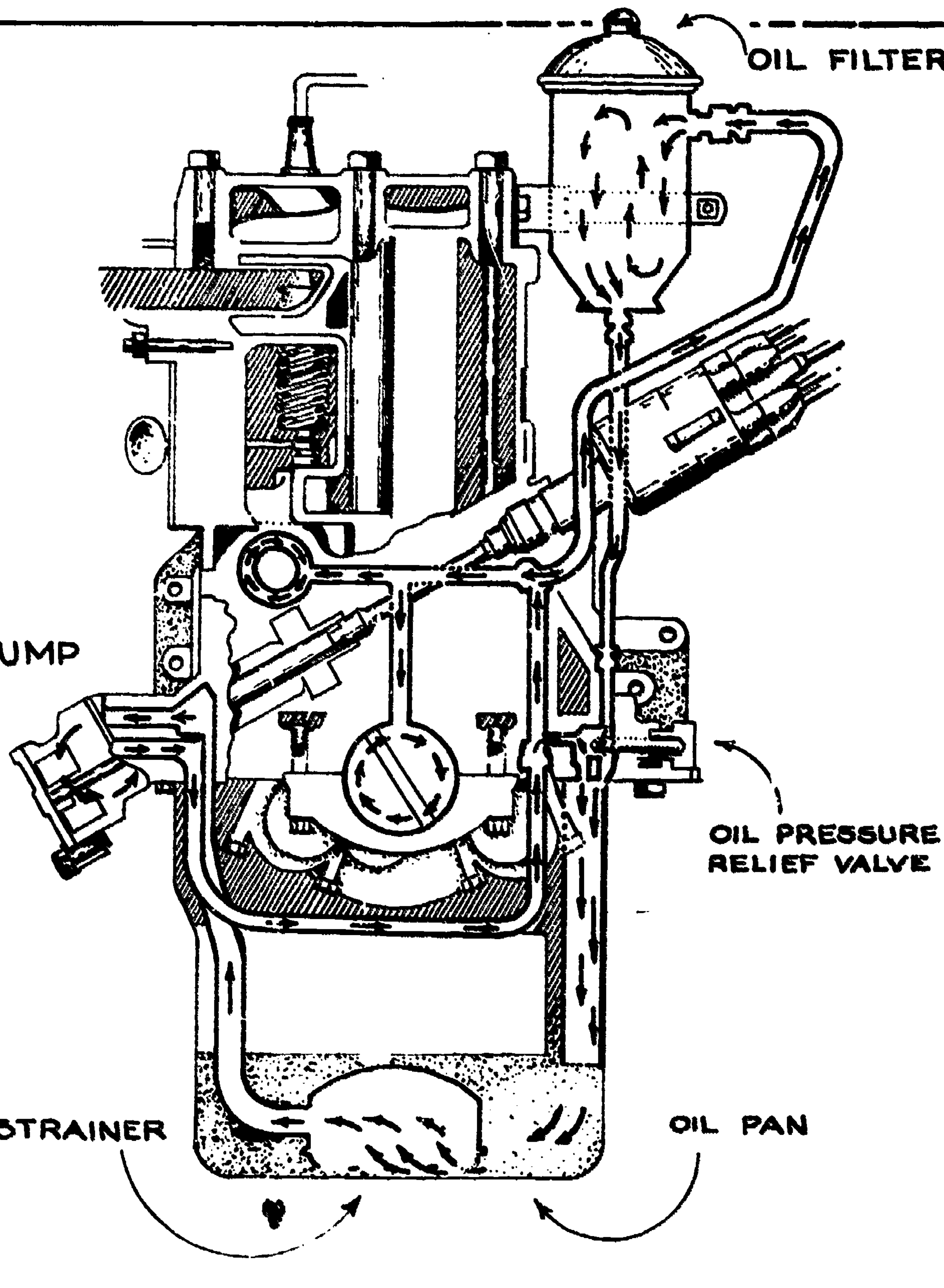
   a. Used on both types of oil pumps

   b. Limits the amount of oil pressure entering the lubrication system

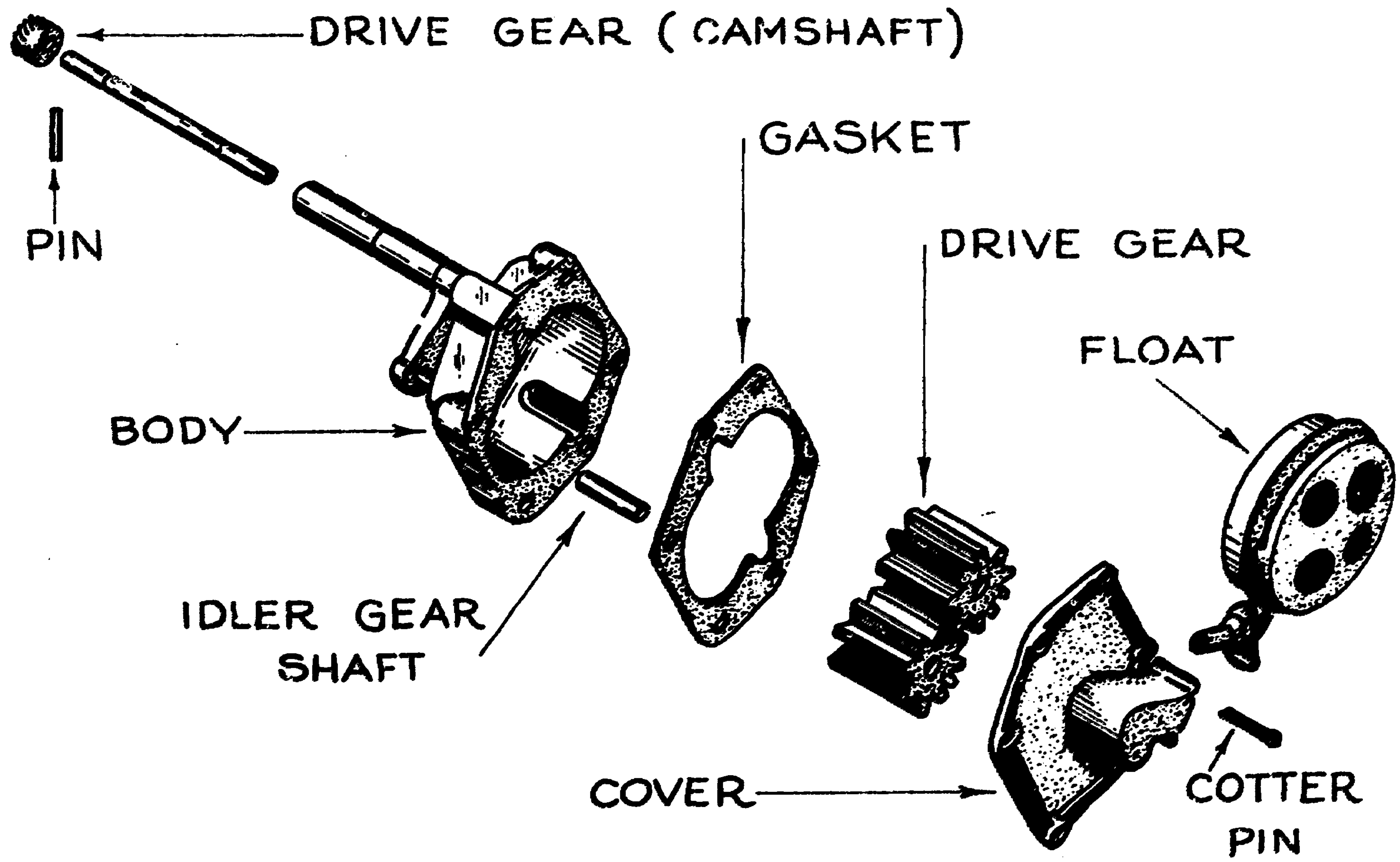
   c. Prevents damage to the oil pump, oil filter, seals and other lubrication system parts

   d. Consists simply of a spring loaded valve

LOCATION OF OIL PUMP IN THE ENGINE



GEAR-TYPE OIL PUMP



OPERATION

Block: Engine Fundamentals

Operation: Inspecting a Gear Type Oil Pump

Block II
Job ____
Operation ____

Teaching Objective: To teach students how to inspect gear-type oil pumps

Tools: Combination wrenches (7/16 and 1/2), screwdriver, drill motor

Materials: Gasket, cleaning solvent, oil, wipe cloths

Teaching Aids: Transparency:
- Gear Type Oil Pump, p. II-91

References: *Automechanics*, Glenn, Chapter 3
Automotive Mechanics, Crouse, Chapter 11

Steps:

1. Remove oil pump screen
2. Remove bolts securing cover
3. Remove cover
4. Turn pump upside down and remove driven gear
5. Push shaft through housing to remove driving gear
6. Clean all parts
7. Check cover, gears and shaft for wear
8. Reassemble shaft and gears in housing

   NOTE: A check for wear can be made by inserting a feeler gauge blade between the gear teeth and between the gear and housing. Consult the manufacturer's specifications for proper gauge thickness.

9. Replace cover, installing a new gasket
10. Place pump in a pan of oil and power rotate with drill motor to test the pump

OPERATION

Block: Engine Fundamentals

Operation: Inspecting a Rotor Type Oil Pump

Block II
Job ____
Operation ____

Teaching Objective: To teach students how to inspect rotor-type oil pumps

Tools: Combination wrenches (7/16 and 1/2), screwdriver and drill motor

Materials: Seal, cleaning solvent, oil, wipe cloths

Teaching Aids: Rotor-type Oil Pumps, p. II-94

References: Automechanics, Glenn, Chapter 3
Automotive Mechanics, Crouse, Chapter 11

Steps:

1. Loosen and remove oil pump cover bolts

2. Remove cover and oil ring seal

3. Remove the rotor and shaft

4. Clean all parts

5. Inspect the rotary shaft and cover for wear

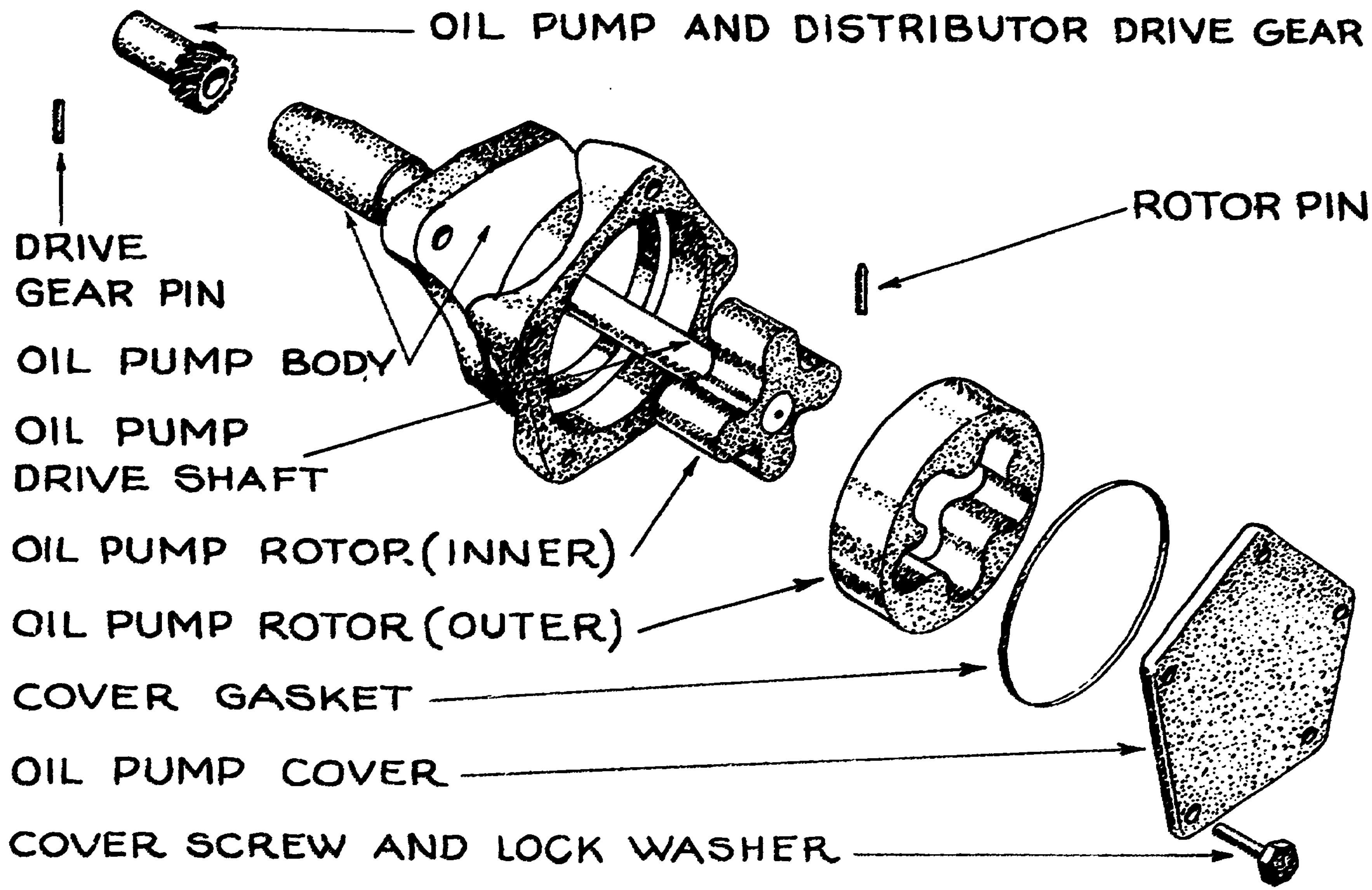
   NOTE: A check for wear can be made by inserting a feeler gauge leaf between inner and outer rotor and between outer rotor and housing. Consult the manufacturer's specifications for proper gauge thickness.

6. Install a new oil seal

7. Replace cover and tighten cover screws securely

8. Place pump in a pan of oil and power rotate with a drill motor to test the pump

ROTOR-TYPE OIL PUMP



INFORMATION

Block: Engine Fundamentals

Lesson: Filtration (Oil Filter Systems)

Block II
Job ______
Lesson ______

Teaching Objective: Upon completion of this lesson, students will be able to describe the typical types of engine oil filtration systems.

Teaching Aids: Sample oil filters:
- Disassembled
- Sectioned

Transparencies:
- Oil Filter, p. II-96
- Spin-on Oil Filter, p. II-97
- Full Flow Type System, Easy Change, Fram Corporation, p. II-98
- Full Flow Type System, Replaceable Cartridge, Fram Corporation, p. II-99
- By-Pass Type System, Easy Change, Fram Corporation, p. II-100

References: Automotive Mechanics, Crouse, Chapter 11
Filtration, Fram Corporation

Outline of Information:

1. Function

   a. Removes contaminants from the lubricating oil
      -- Dirt which makes its way to the crankcase
      -- Moisture formed during condensation
      -- Microscopic metalic particles which are torn away from engine parts during normal wear

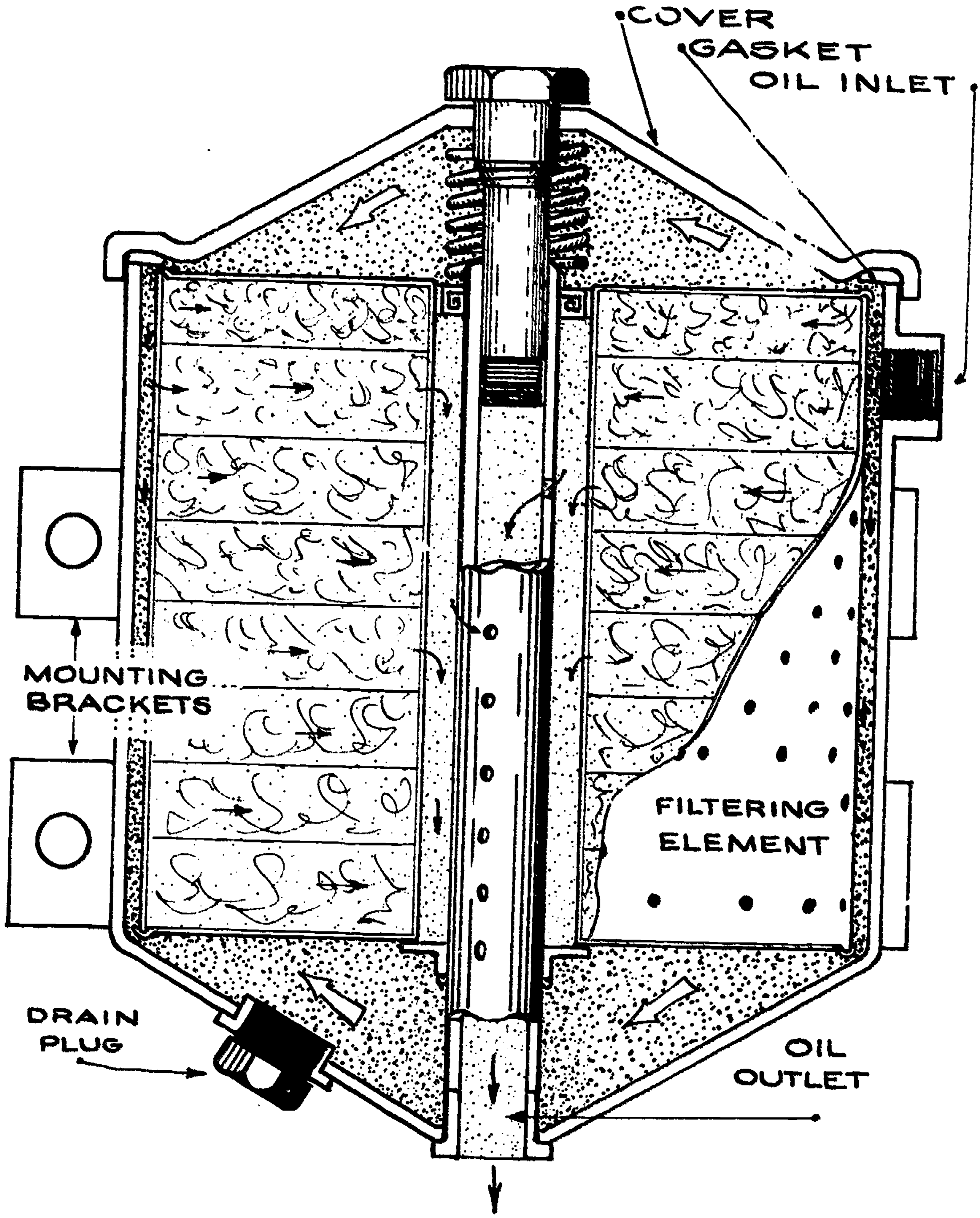
   b. Allows full circulation while removing contaminants

2 Types

   a. By-Pass system
      -- Filters only part of the oil from the pump supply and returns it to the sump
      -- With this system, unfiltered oil can make its way to bearings
      -- Should this type filter become clogged so no oil will pass, lubrication system oil supply not affected

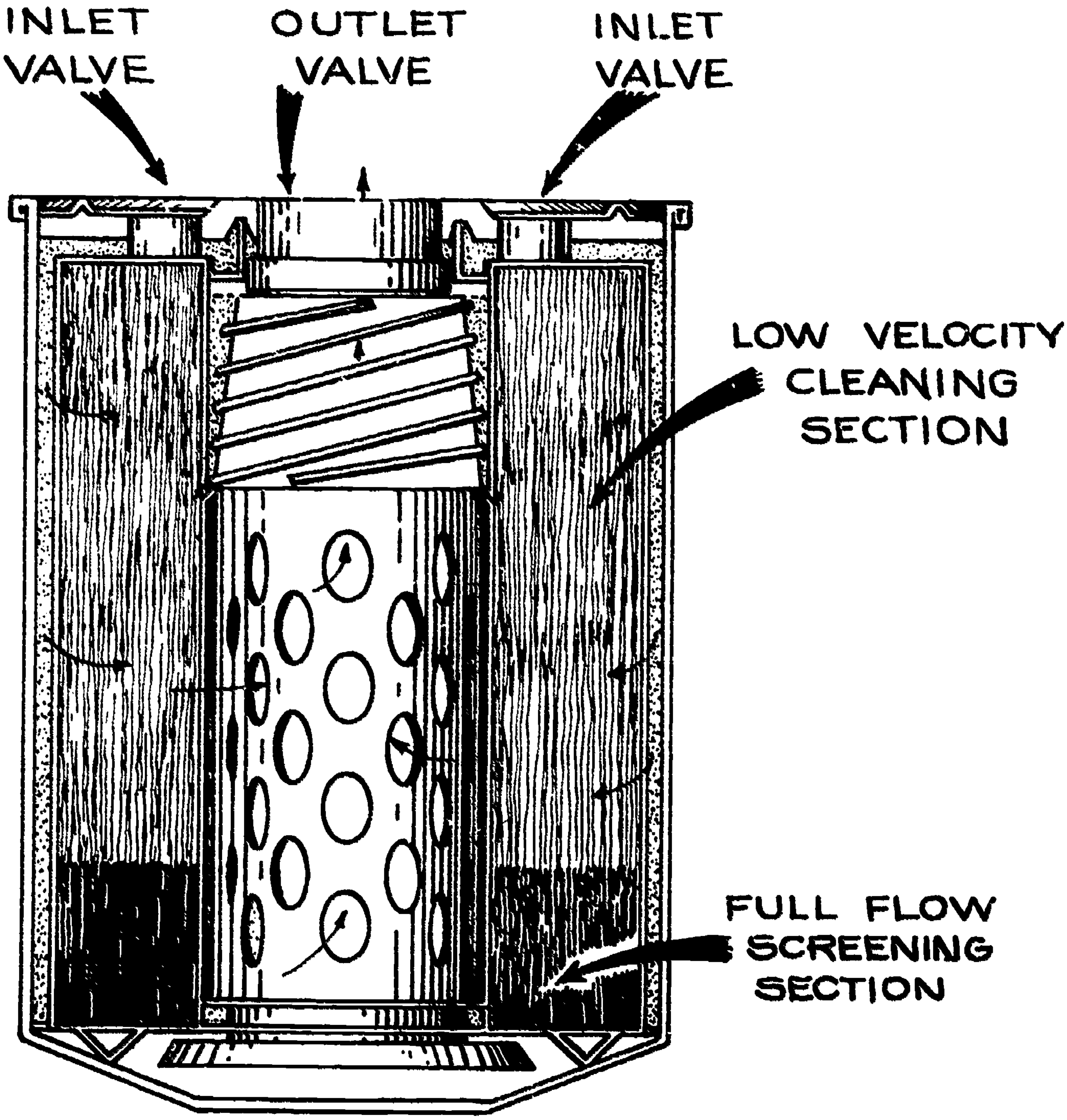
   b. Full flow system
      -- Filters 100% of the oil entering the engine lubrication
      -- Insures that all of the oil entering the bearings will be clean and free of dirt
      -- Should filter become clogged with contaminants, by-pass valve is forced open by the oil pressure allowing oil to flow around filtering element into lubrication system
      -- Contaminated oil is allowed to enter the engine bearings only after the filter becomes clogged. This explains the need for periodic filter replacement.

OIL FILTER

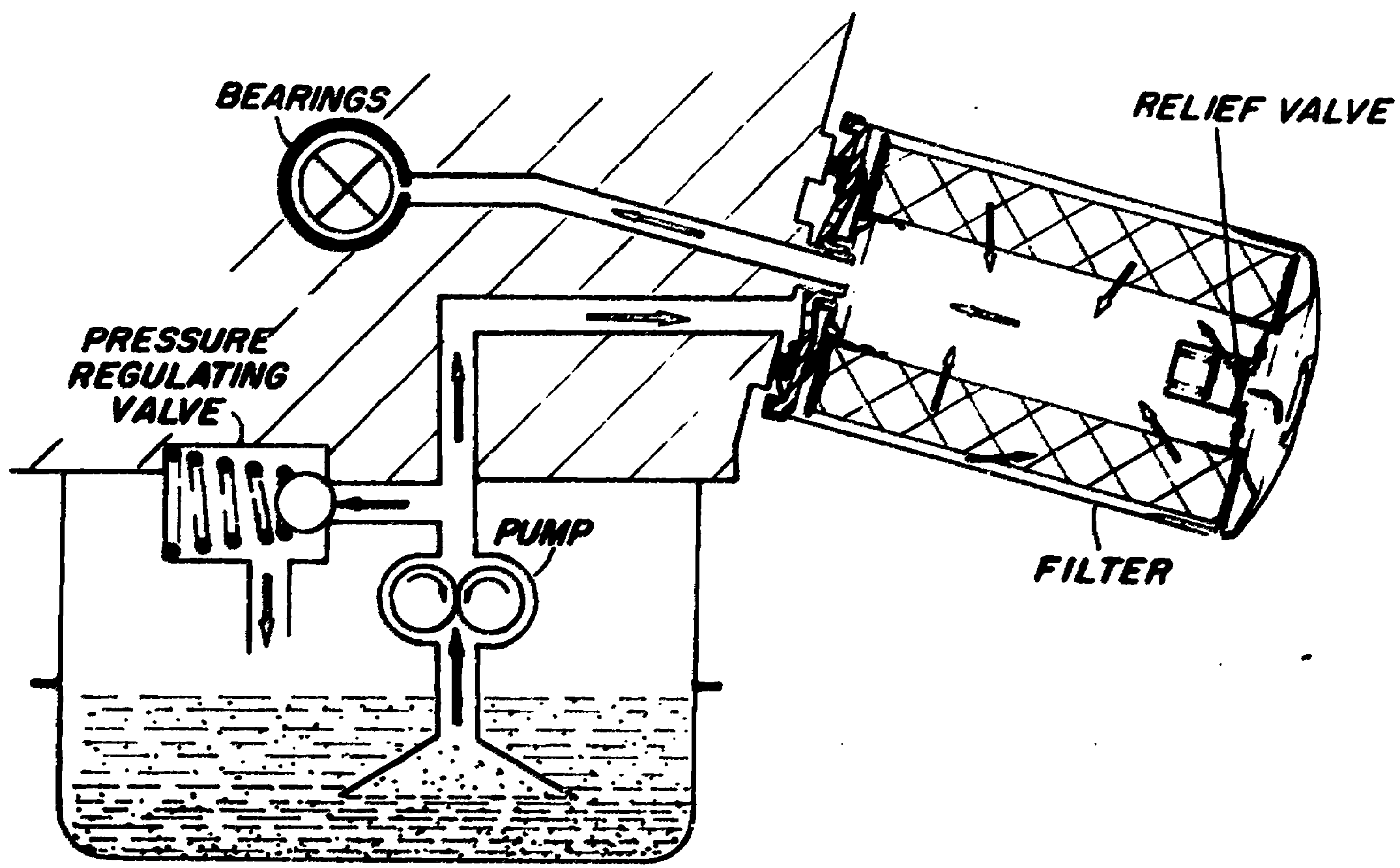


RGILMORE, INST. MATL. LAB., U.K. 369-2 II-96

SPIN-ON OIL FILTER

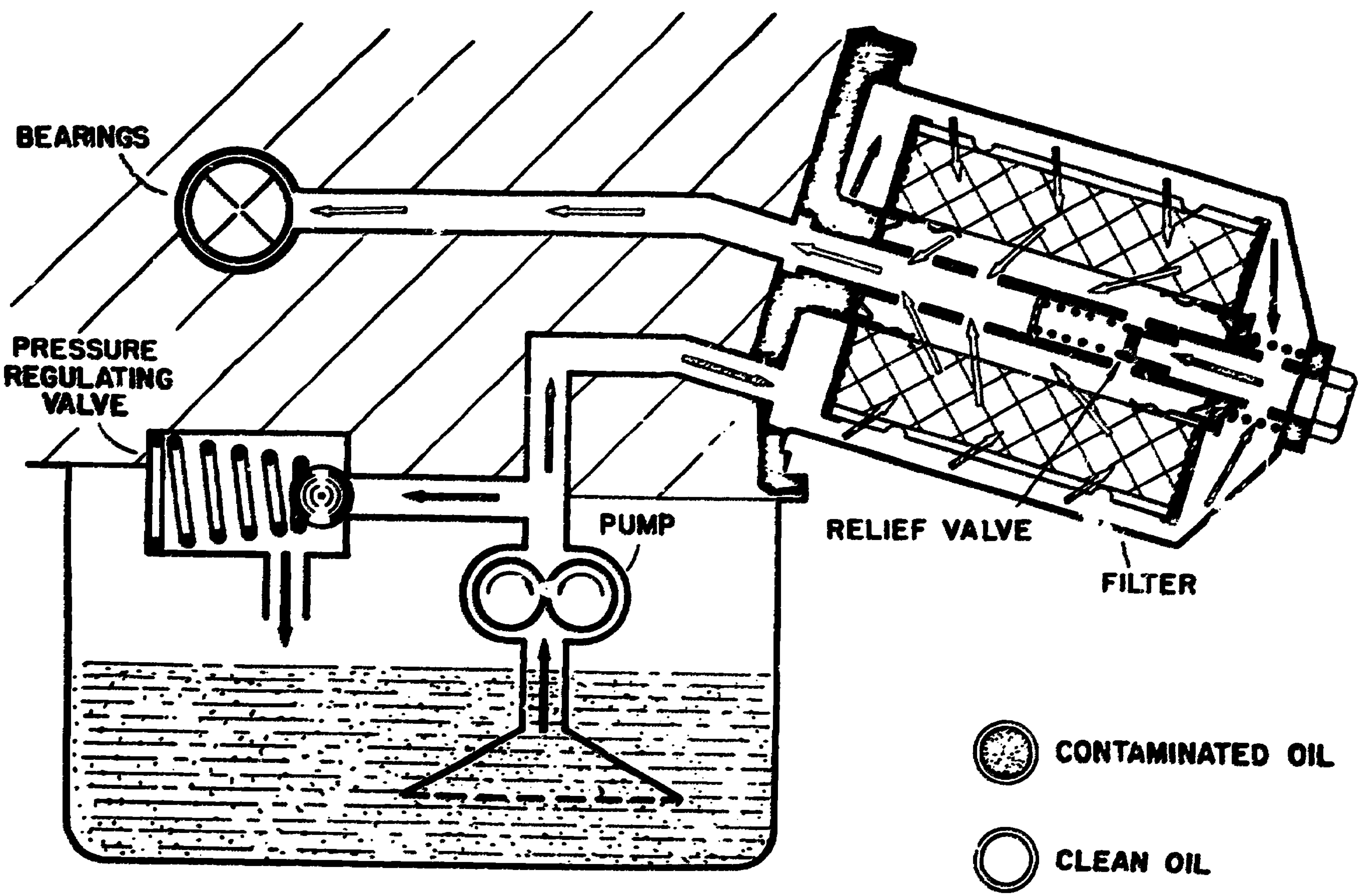


FULL FLOW TYPE SYSTEM
USING EASY-CHANGE TYPE FILTER



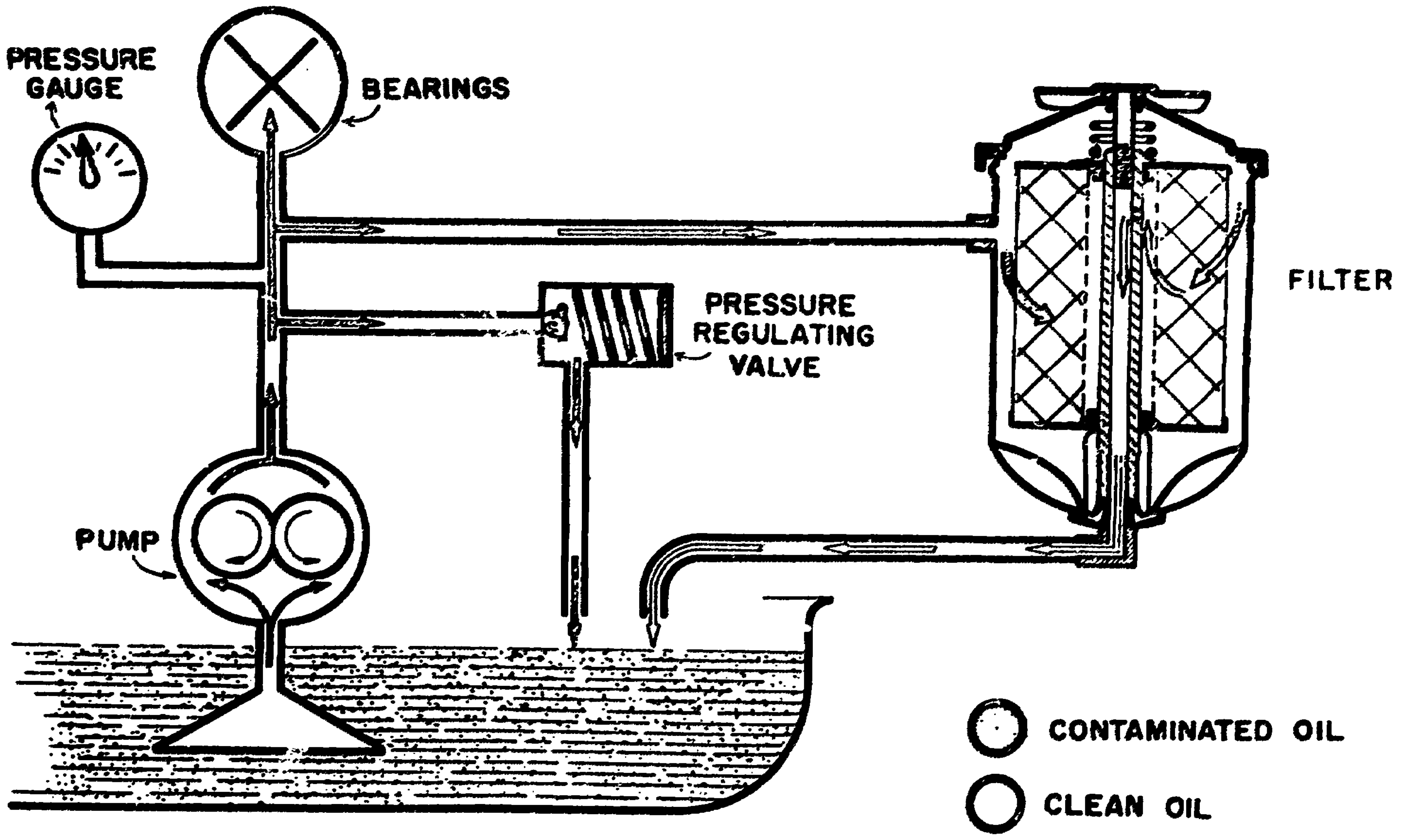
FULL FLOW TYPE SYSTEM

USING REPLACEABLE CARTRIDGE TYPE FILTER



COURTESY FROM CBRP CUMR. Development CNTR. 840-1

BY-PASS TYPE SYSTEM
USING REPLACEABLE CARTRIDGE TYPE FILTER



INFORMATION

Block: Engine Fundamentals | Block II
Job ____
Lesson: Service Ratings of Oil | Lesson ____

Teaching Objective: Upon completion of this lesson, students will be able to relate the service ratings of motor oils to the SAE viscosity designations.

Teaching Aids: Filmstrip
- Know Your Motor Oil, E. I. duPont de Nemours and Company

Motor Oil Samples
Transparency:
- Viscosity Standards, p. II-103

References: *Automotive Mechanics*, Crouse, Chapter 11
Automotive Encyclopedia, Tolboldt & Johnson, pp. 89-91
Automotive Essentials, Kuns, Chapter 6

Outline of Information:

1. MS oil

    a. Low operating temperature and short trip driving as found in city operation

    b. High speed driving (highway), where the oil becomes extremely hot, as on a long trip

    c. Operation under heavy load, long distance truck service

2. MM oil

    a. High speed short trips

    b. Continuous operation under heavy load, high temperature conditions

    c. Operation under fairly cold weather conditions when used for both long and short trips

3. ML oil

    a. Used where no extreme hot or cold weather is encountered

    b. Used when driving distances are ten or more miles

    NOTE: Do not confuse "viscosity rating" (SAE) and "service rating" (API)

Service Ratings of Oil (continued)

4. DS oil

   a. For diesel engines

   b. Light load and low temperature, continuous operation

   c. Heavy load and high temperature, continuous operation

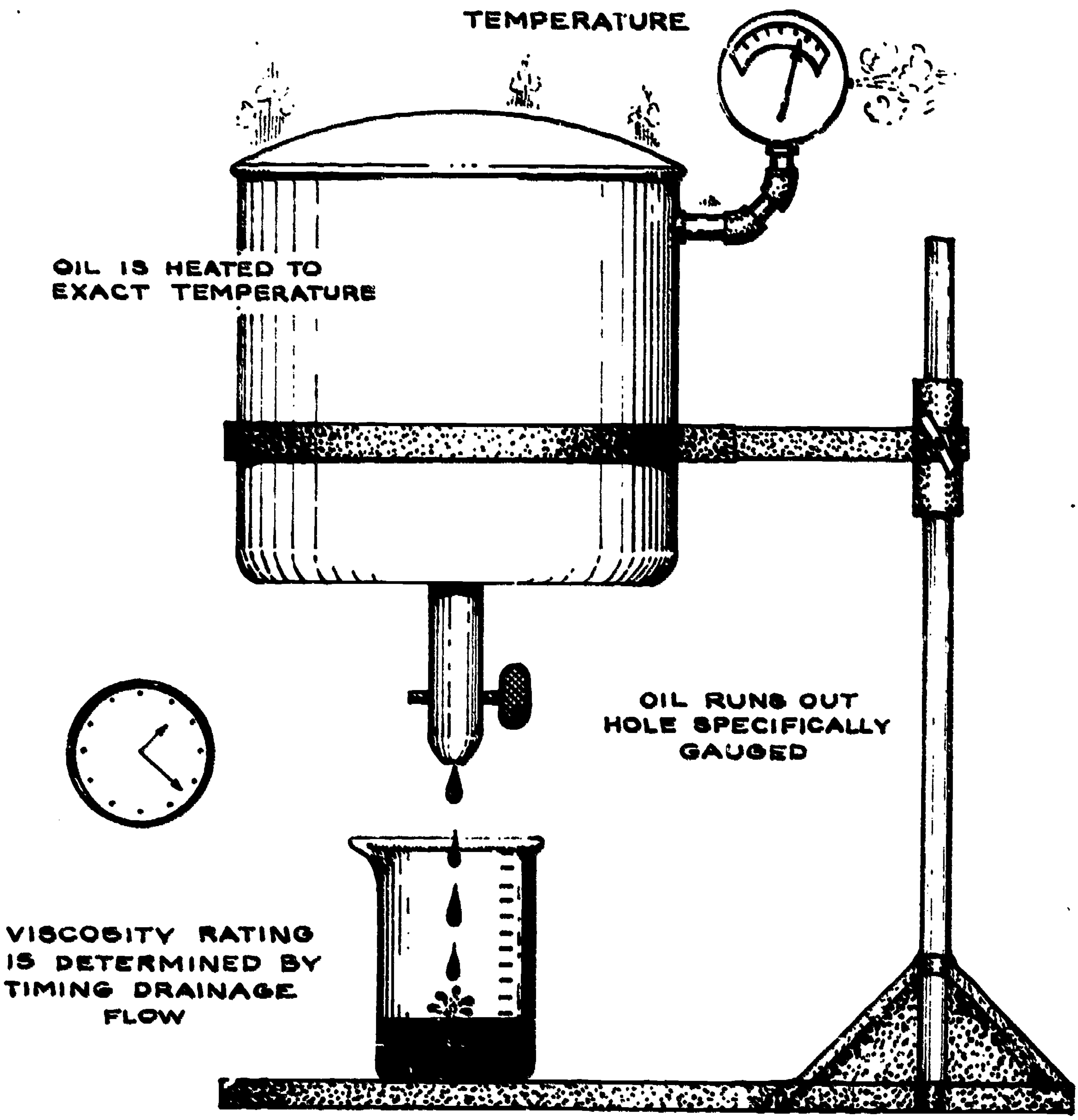
   d. To be used when the fuel is of abnorm volatility or has a high sulphur content

5. DG oil

   a. For diesel engines

   b. Light loads and normal conditions such as farm tractors and most trucks

VISCOSITY STANDARDS



INFORMATION

Block: Engine Fundamentals

Lesson: New Engine Oil Designations

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, students will relate new oil designations, which appear in owners manuals, shop manuals and lubrication charts beginning with the 1972 year models, with previously used designations.

Teaching Aids: Chalkboard
Transparency:
- Engine Oil Designations, p. II-106

References: "Wommell News," Automotive Magazine, Lexington, Kentucky, June, 1971

Outline of Information:

1. Replaces the old American Petroleum Institute ratings: MM, ML, MS, DG, DS

2. Created and approved cooperatively by Society of Automotive Engineer, American Petroleum Institute and American Society for Testing Materials

3. New designations consist of the "S" group for automobiles and light trucks, and the "C" group for heavy vehicles and stationary engines.

4. The "S" group designations

   a. SA For engines which operate under mild conditions and do not require the protection given by compounded oils

   b. SB For engines which operate under such mild conditions that only anti-scuff capability, resistance to oil oxidation, and bearing corrosion additives are required

   c. SC Minimum requirement for 1964 to 1967 cars and light trucks
   -- Provides control of high and low temperature deposits, wear, rust, and corrosion in gasoline engines

   d. SD For gasoline engines in cars and light trucks since 1968, operating under manufacturer's warranties
   -- Has better high and low temperature deposit control than "SC", is also rust and corrosion resistant

New Engine Oil Designations (continued)

5. The "C" group designations

   a. CA For diesel engines operated under light and moderate duty on high quality fuels
      -- Also protects against bearing corrosion and high temperature deposits

   b. CB Mild to moderate diesel engine operation on lower quality fuels
      -- Additives protect against wear, bearing corrosion, and high temperature deposits

   c. CC For certain heavy duty gasoline engines and for moderate duty lightly-supercharged diesel engines
      -- In the lightly-supercharged diesel engine, it protects against high temperature deposits and from rust, corrosion and low temperature deposits in the heavy duty gasoline engine

   d. CD For heavy duty and severe duty-supercharged diesel engines operating on all types and qualities of fuels
      -- In engines operating on fuels of a wide quality range it provides protection from bearing corrosion and from high temperature deposits

ENGINE OIL DESIGNATIONS

"S" GROUP

SA - MINIMUM PROTECTION

SB - ANTI-SCUFF PROTECTION

SC - GOOD PROTECTION
(Vehicles thru 1967)

SD - GOOD PROTECTION
(Modern Engines)

"C" GROUP

CA - LIGHT DUTY
(Diesel Engines)

CB - MODERATE DUTY
(Diesel Engines)

CC - HEAVY DUTY
(Gasoline and Diesel Engines)

CD - HEAVY AND SEVERE DUTY
(Diesel Engines)

INFORMATION

Block: Engine Fundamentals

Lesson: Oil Pressure Indicators

Block II
Job
Lesson

Teaching Objective: Upon completion of this lesson, the student will be able to describe different oil pressure indicators and discuss how they function.

Teaching Aids: Transparencies:
- Electric Circuit Oil Pressure Indicator, p. II-108
- Oil Pressure Indicator, Bourdon Tube, p. II-109

References: Automotive Mechanics, Crouse, Chapter 11
Automotive Engine Design, Crouse, Chapter 19

Outline of Information:

1. Purpose of oil pressure indicators

   a. Tells the driver what the oil pressure is in the engine

   b. Gives warning if some stoppage occurs in the lubrication system

2. Types of indicators

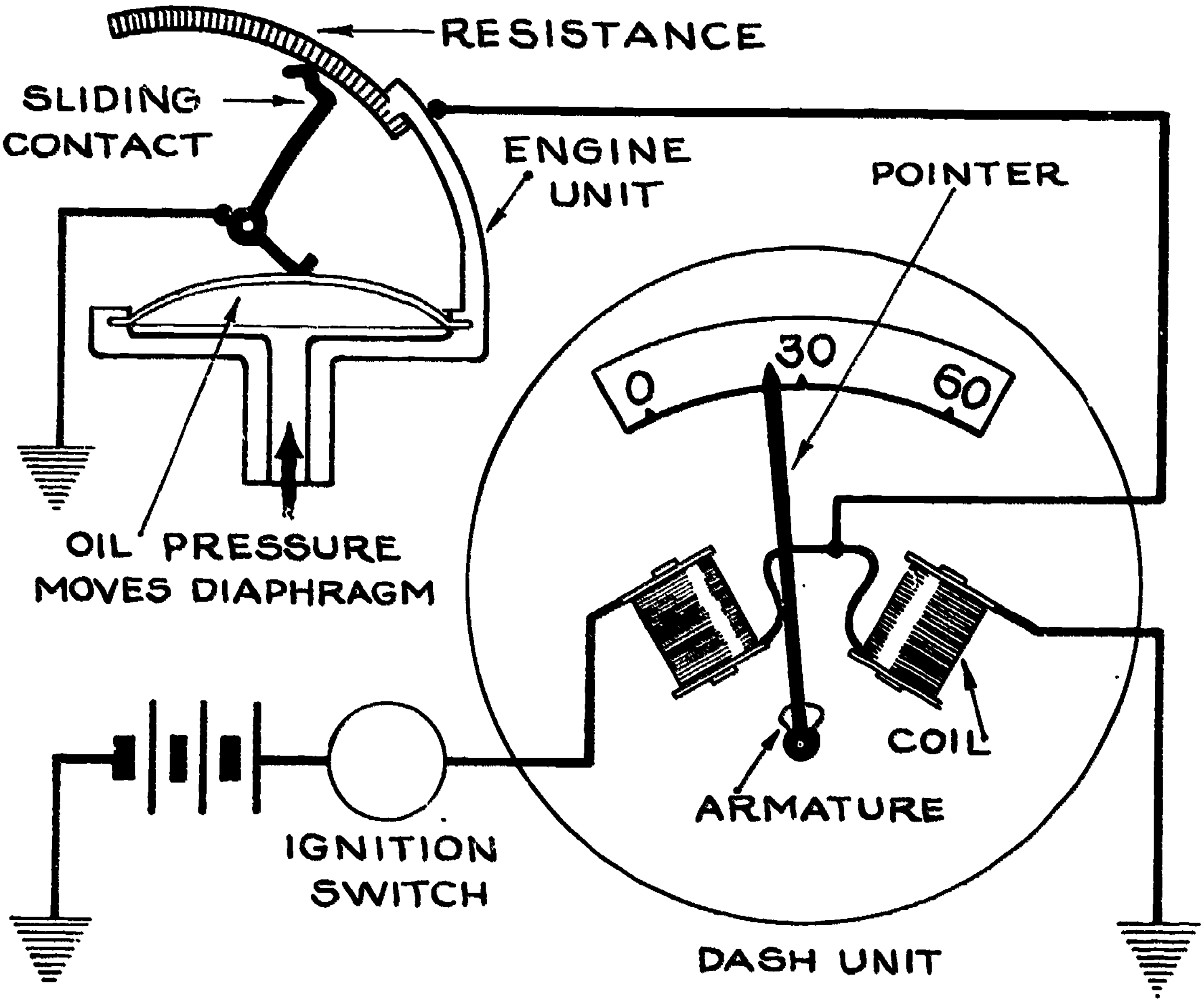
   a. Pressure - expansion
      -- Uses a hollow bourdon (curved) tube fastened at one end and free at the other
      -- As oil pressure is applied to the tube, it tends to straighten out
      -- Movement causes needle to move and register oil pressure

   b. Electrical - resistance
      -- Balancing - coil type
         (1) Uses two separate units, engine unit and indicator
         (2) The engine unit consists of a movable resistance that moves from one end to other
         (3) Indicating units consist of two coils that balance each other (similar to fuel gauges) Refer p. IV-20 - IV-24.

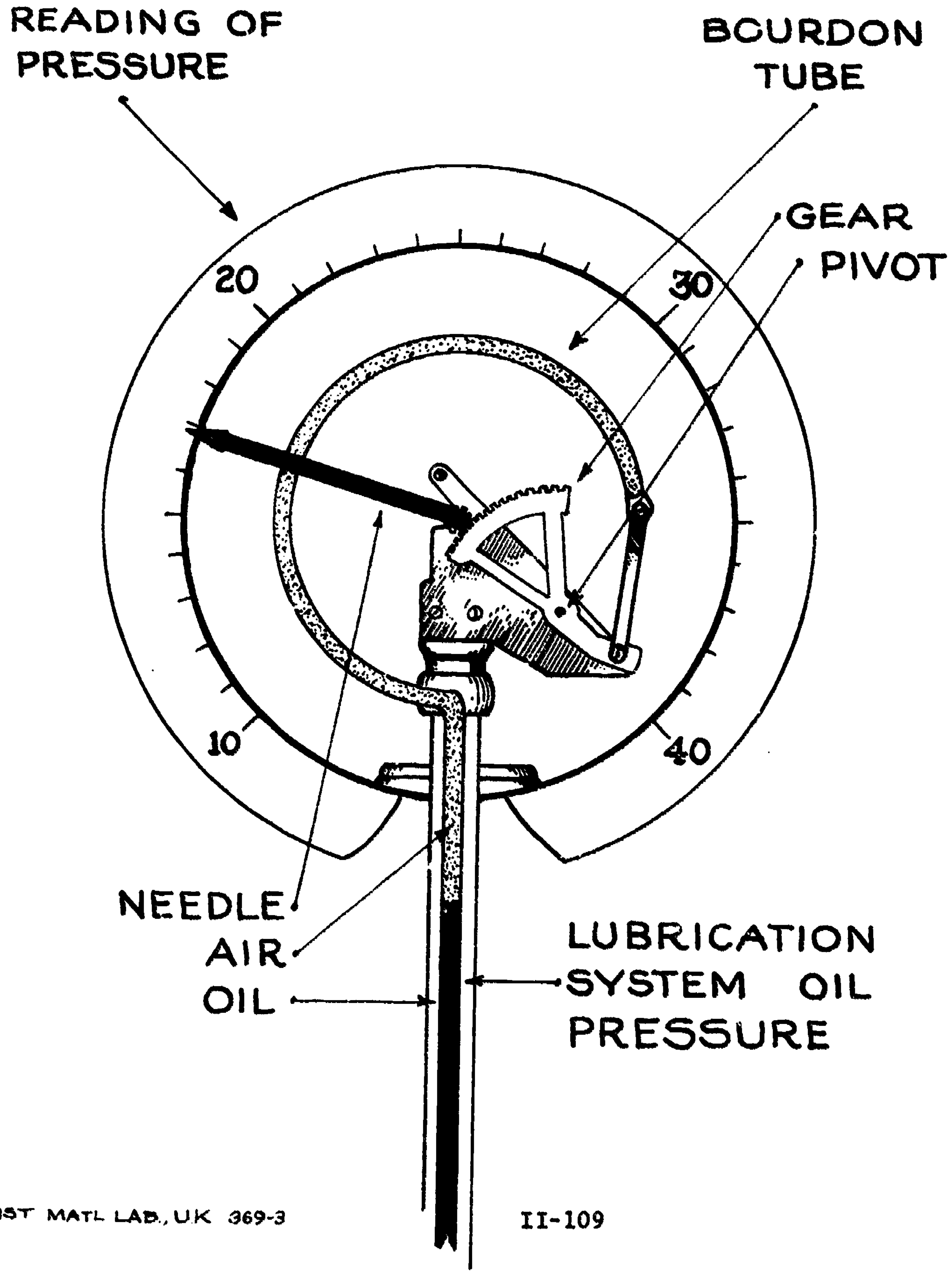
   c. Bimetal-thermostat type
      -- Similar to bimetal-thermostat fuel gauge

   d. Indicator light
      -- When key on, oil pressure low, light burns
      -- Light and pressure switch connected in series to battery through ignition switch

ELECTRIC CIRCUIT
OIL PRESSURE INDICATOR



OIL PRESSURE INDICATOR, BOURDON TUBE



References - Block II

Books and Texts

1. Borden, Norman E., and Walter J. Cake. Fundamentals of Aircraft Piston Engines. New York: Hayden Book Company, 1971.

2. Chilton's Auto Repair Manual. Philadelphia: Chilton Book Company, 1968.

3. Crouse, William H. Automotive Engine Design. New York: McGraw-Hill Book Company, 1970.

4. Crouse, William H. Automotive Mechanics, 6th ed. St. Louis: McGraw-Hill Book Company, 1970.

5. Deere, John. Fundamentals of Service Engines. Moline, Illinois: Deere and Company, 1968.

6. Encyclopedia Americana, Volume 10. New York: Grolier Educational Corporation, 1969.

7. Glenn, Harold T. Automechanics, 2nd ed. Peoria, Illinois: Charles A. Bennett Company, Incorporated, 1962.

8. Kuns, Ray F. Automotive Essentials. Milwaukee: Bruce Publishing Company, 1966.

9. Motor's Auto Repair Manual. New York: Motor's Publishing Company, 1968.

10. Stephenson, George E. Small Gasoline Engines. Albany, New York: Delmar Publishers, 1964.

11. Stockle, Martin W. Auto Mechanics Fundamentals. South Holland, Illinois: The Goodheart-Wilcox Company, Inc., 1969.

12. Stockel, Martin W. Auto Service and Repair. Homewood, Illinois: The Goodheart-Wilcox Company, Inc., 1969.

13. Tolboldt, William K., and Larry Johnson. Motor Service Automotive Encyclopedia. Homewood, Illinois: The Goodheart-Wilcox Co., Inc.

References - Block II
(continued)

Other Publications (Manuals, Bulletins, Booklets)

1. "Engine Bearing Fundamentals." Cleveland, Ohio: Thompson Products.

2. "Engine Overhauls." Perfect Circle Division, Dana Corporation.

3. "Filtration." Providence, Rhode Island: Fram Corporation.

4. "Prescription for Better Gasoline Engine Overhauls." Hagerstown, Indiana: Dana Corporation.

5. "Vehicle Service Manual." (Refer to appropriate manual for vehicle)

6. "Womwell News." Automotive Magazine. Lexington, Kentucky, 1971.