

How to fix your Motorcycle

**covers YAMAHA
*one cylinder models***

Published By

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ENGINE DESIGN FUNDAMENTALS

OPERATING PRINCIPLES

ENGINE TYPES

The engines used to power motorcycles and many other items of power equipment in use today are basically similar. All are technically known as "Internal Combustion Reciprocating Engines."

The source of power is heat, formed by the burning of a combustible mixture, usually petroleum products and air. In a reciprocating engine, this burning takes place in a closed cylinder containing a piston. Expansion resulting from the heat of combustion applies pressure on the piston to turn a shaft by means of a crank and connecting rod.

The fuel-air mixture may be ignited by means of an electric spark (Otto Cycle Engine) or by heat formed from compression of air in the engine cylinder (Diesel Cycle Engine). The complete series of events which must take place in order for the engine to run may occur in one revolution of the crankshaft (two strokes of the piston in cylinder) which is referred to as a "Two-Stroke Cycle Engine," or in two revolutions of the crankshaft (four strokes of the piston in cylinder) which is referred to as a "Four-Stroke Cycle Engine."

OTTO CYCLE. In a spark ignited engine, a series of five events is required in order for the engine to provide power. This series of events is called the "Cycle" (or "Work Cycle") and is repeated in each cylinder of the engine as long as work is being done. This series of events which comprise the "Cycle" is as follows:

1. The mixture of fuel and air is pushed into the cylinder by atmospheric pressure when the pressure within the engine cylinder is reduced by the piston moving downward in the cylinder (or by applying pressure to the fuel-air mixture as by crankcase compression in the crankcase of a "Two-Stroke Cycle Engine" which is described in a later paragraph).
2. The mixture of fuel and air is compressed by the piston moving upward in the cylinder.
3. The compressed fuel-air mixture is ignited by a timed electric spark.
4. The burning fuel-air mixture expands, forcing the piston downward in the cylinder thus converting the chemical energy generated by combustion into mechanical power.

5. The gaseous products formed by the burned fuel-air mixture are exhausted from the cylinder so that a new "Cycle" can begin.

The above described five events which comprise the work cycle of an engine are commonly referred to as (1), INTAKE; (2), COMPRESSION; (3), IGNITION; (4) EXPANSION (POWER); and (5), EXHAUST.

TWO STROKE CYCLE. Two stroke cycle engines may be of the Otto Cycle (spark ignition) or Diesel Cycle (compression ignition) type. However, since the two-stroke cycle engines listed in the repair section of this manual are all of the Otto Cycle type, operation of two-stroke Diesel Cycle engines will not be discussed in this section.

In two-stroke cycle engines, the piston is used as a sliding valve for the cylinder intake and exhaust ports. The intake and exhaust ports are both open when the piston is at the bottom of its downward stroke (bottom dead center or "B.D.C.") The exhaust port is open to atmospheric pressure; therefore, the fuel-air mixture must be elevated to a higher than atmospheric pressure in

order for the mixture to enter the cylinder. As the crankshaft is turned from B.D.C. and the piston starts on its upward stroke, the intake and exhaust ports are closed and the fuel-air-mixture in the cylinder is compressed. When the piston is at or near the top of its upward stroke (top dead center or "T.D.C."), an electric spark across the electrode gap of the spark plug ignites the fuel air mixture. As the crankshaft turns past T.D.C. and the piston starts on its downward stroke, the rapidly burning fuel-air mixture expands and forces the piston downward. As the piston nears bottom of its downward stroke, the cylinder exhaust port is opened and the burned gaseous products from combustion of the fuel-air mixture flows out the open port. Slightly further downward travel of the piston opens the cylinder intake port and a fresh charge of fuel-air mixture is forced into the cylinder. Since the exhaust port remains open, the incoming flow of fuel-air mixture helps clean (scavenge) any remaining burned gaseous products from the cylinder. As the crankshaft turns past B.D.C. and the piston starts on its upward stroke, the cylinder intake and exhaust ports are closed and a new cycle begins.

Since the fuel-air mixture must be elevated to a higher than atmospheric pressure to enter the cylinder of a two-stroke cycle engine, a compressor pump must be used. Coincidentally, downward movement of the piston decreases the volume of the engine crankcase. Thus, a compressor pump is made available by sealing the engine crankcase and connecting the carburetor to a port in the crankcase. When the piston moves upward, volume of the crankcase is increased which lowers pressure within the crankcase to below atmospheric. Air will then be forced through the carburetor, where fuel is mixed with the air, and on into the engine crankcase. In order for downward movement of the piston to compress the fuel-air mixture in the crankcase, a valve must be provided to close the carburetor to crankcase port. Three different types of valves are used. In Fig. 1-1, a reed type inlet valve is shown in the schematic diagram of the two-stroke cycle engine. Reeds (R) are forced open by atmospheric pressure as shown in view "B" when the piston is

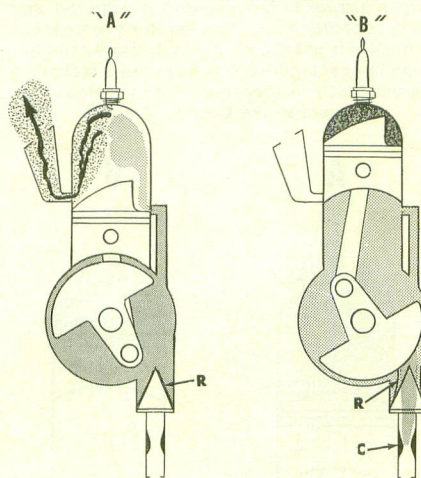


Fig. 1-1-Schematic diagram of a two-stroke cycle engine operating on the Otto Cycle (spark ignition). View "B" shows piston near top of upward stroke and atmospheric pressure is forcing air through carburetor (C), where fuel is mixed with the air, and the fuel-air mixture enters crankcase through open reed valve (R). In view "A", piston is near bottom of downward stroke and has opened the cylinder exhaust and intake ports; fuel-air mixture in crankcase has been compressed by downward stroke of engine and flows into cylinder through open port. Incoming mixture helps clean burned exhaust gases from cylinder.

on its upward stroke and pressure in the crankcase is below atmospheric. When the piston reaches T.D.C., the reeds close as shown in view "A" and fuel-air mixture is trapped in the crankcase to be compressed by downward movement of the piston. In Fig. 1-2, a schematic diagram of a two-stroke cycle engine is shown in which the piston is utilized as a sliding carburetor-crankcase port (third port) valve. In Fig. 1-3, a schematic diagram of a two-stroke cycle engine is shown in which a slotted disc (rotary valve) attached to the engine crankshaft opens the carburetor-crankcase port when the piston is on its upward stroke. In each of the three basic designs shown, a transfer port (TP—Fig. 1-2) connects the crankcase compression chamber to the cylinder; the transfer port is the cylinder intake port through which the compressed fuel-air mixture in the crankcase is transferred to the cylinder when the piston is at bottom of stroke as shown in view "A."

Due to rapid movement of the fuel-air mixture through the crankcase, the crankcase cannot be used as a lubricating oil sump because the oil would be carried into the cylinder. Lubrication is accomplished by mixing a small amount of oil with the fuel or by a separate oil metering system. In either case, the engine lubricating oil is carried through the crankcase and eventually is forced into the combustion chamber where it is burned. Where an oil metering system is used, ratio of oil to fuel by volume is varied by throttle opening and engine speed. When oil is pre-mixed with the fuel, manufacturer's recommended fuel-oil ratio should be strictly observed.

FOUR-STROKE CYCLE. In a four-stroke cycle engine operating on the Otto Cycle (spark ignition), the five

events of the cycle take place in four strokes of the piston, or in two revolutions of the engine crankshaft. Thus, a power stroke occurs only on alternate downward strokes of the piston.

In view "A" of Fig. 1-4, the piston is on the first downward stroke of the cycle. The mechanically operated intake valve has opened the intake port and, as the downward movement of the piston has reduced the air pressure in the cylinder to below atmospheric pressure, air is forced through the carburetor, where fuel is mixed with the air, and into the cylinder through the open intake port. The intake valve remains open and the fuel-air mixture continues to flow into the cylinder until the piston reaches the bottom of its downward stroke. As the piston starts

on its first upward stroke, the mechanically operated intake valve closes and, since the exhaust valve is closed, the fuel-air mixture is compressed as in view "B."

Just before the piston reaches the top of its first upward stroke, a spark at the spark plug electrodes ignites the compressed fuel-air mixture. As the engine crankshaft turns past top center, the burning fuel-air mixture expands rapidly and forces the piston downward on its power stroke as shown in view "C." As the piston reaches the bottom of the power stroke, the mechanically operated exhaust valve starts to open and as the pressure of the burned fuel-air mixture is higher than atmospheric pressure, it starts to flow out the open exhaust port. As the engine crankshaft turns past bottom center, the exhaust valve is almost completely open and remains open during the upward stroke of the piston as shown in view "D." Upward movement of the piston pushes the remaining burned fuel-air mixture out of the exhaust port. Just before the piston reaches the top of its second upward or exhaust stroke, the valve opens and the exhaust valve closes. The cycle is completed as the crankshaft turns past top center and a new cycle begins as the piston starts downward as shown in view "A."

In a four-stroke cycle engine operating on the Diesel Cycle, the sequence of events of the cycle is similar to that described for operation on the Otto Cycle, but with the following exceptions: On the intake stroke, air only is taken into the cylinder. On the compression stroke, the air is highly com-

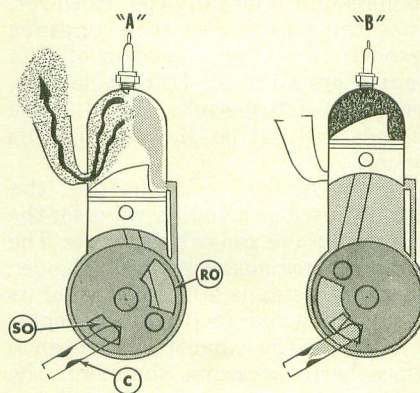


Fig. 1-3-Schematic diagram of two-stroke cycle engine similar to those shown in Figs. 1-1 and 1-2 except that a rotary carburetor to crankcase port valve is used. Disc driven by crankshaft has rotating opening (RO) which uncovers stationary opening (SO) in crankcase when piston is on upward stroke. Carburetor is (C).

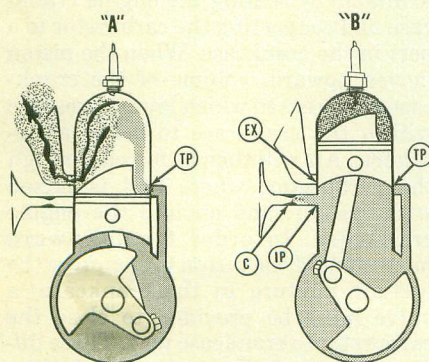


Fig. 1-2-Schematic diagram of two-stroke cycle engine operating on Otto Cycle. Engine differs from that shown in Fig. 1-1 in that piston is utilized as a sliding valve to open and close intake (carburetor to crankcase) port (IP) instead of using reed valve (R-Fig. 1-1).

C. Carburetor
EX. Exhaust port
IP. Intake port (carburetor to crankcase)
TP. Transfer port (crankcase to cylinder)

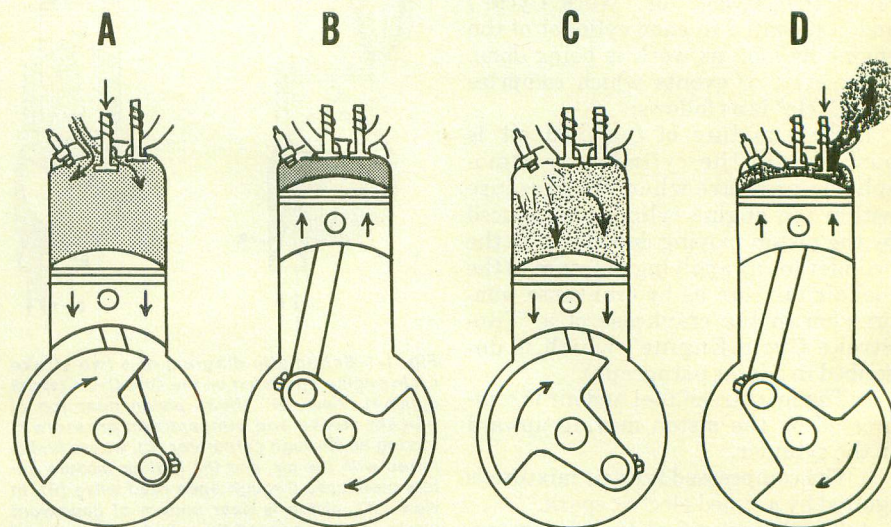


Fig. 1-4-Schematic diagram of four-stroke cycle engine operating on the Otto (spark ignition) cycle. In view "A", piston is on first downward (intake) stroke and atmospheric pressure is forcing fuel-air mixture from carburetor into cylinder through the open intake valve. In view "B", both valves are closed and piston is on its first upward stroke compressing the fuel-air mixture in cylinder. In view "C", spark across electrodes of spark plug has ignited fuel-air mixture and heat of combustion rapidly expands the burning gaseous mixture forcing the piston on its second downward (expansion or power) stroke. In view "D", exhaust valve is open and piston on its second upward (exhaust) stroke forces the burned mixture from cylinder. A new cycle then starts as in view "A".

pressed which raises the temperature of the air. Just before the piston reaches top dead center, fuel is injected into the cylinder and is ignited by the heated, compressed air. The remainder of the cycle is similar to that of the Otto Cycle.

CARBURETORS

Function of the carburetor on a spark-ignition engine is to atomize the fuel and mix the atomized fuel in proper proportions with air flowing to the engine intake port or intake manifold. Carburetors used on engines that are to be operated at constant speeds and under even loads are of simple design since they only have to mix fuel and air in a relatively constant ratio. On engines operating at varying speeds and loads, the carburetors must be more complex because different fuel-air mixtures are required to meet the varying demands of the engine.

Requirements

To meet the demands of an engine being operated at varying speeds and loads, the carburetor must mix fuel and air at different mixture ratios. Gasoline-air mixture ratios required for different operating conditions are approximately as follows:

	Fuel	Air
Starting, cold weather	1 lb.	7 lbs.
Accelerating	1 lb.	9 lbs.
Idling (no load)	1 lb.	11 lbs.
Part open throttle,	1 lb.	15 lbs.
Full load, open throttle	1 lb.	13 lbs.

Basic Design

Carburetor design is based on the venturi principle which simply means

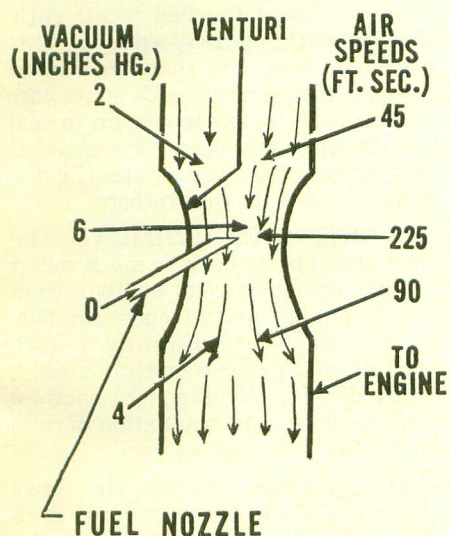


Fig. 1-5—Drawing illustrating the venturi principle upon which carburetor design is based. Figures at left are inches of mercury vacuum and those at right are air speeds in feet per second that are typical of conditions found in a carburetor operating at wide open throttle. Zero vacuum in fuel nozzle corresponds to atmospheric pressure.

that a gas or liquid flowing through a necked-down section (venturi) in a passage undergoes an increase in velocity (speed) and a decrease in pressure as compared to the velocity and pressure in full size sections of the passage. The principle is illustrated in Fig. 1-5, which shows air passing through a carburetor venturi. The figures given for air speeds and vacuum are approximate for a typical wide-open throttle operating condition. Due to low pressure (high vacuum) in the venturi, fuel is forced out through the fuel nozzle by the atmospheric pressure (0 vacuum) on the fuel; as fuel is emitted from the nozzle, it is atomized by the high velocity air flow and mixes with the air.

Although some carburetors may be very basic, the varying requirements of motorcycle engines make it necessary to incorporate features to provide variable fuel-air ratios for different operating conditions. These design features will be described in the following paragraphs which outline the different carburetor types.

Carburetor Types

Carburetors used on motorcycles are usually classified by type of throttle valve, venturi and starting (enriching) method used. The following paragraphs describe the different operating principles. Various combinations of the following features are used in each motorcycle carburetor.

THROTTLE VALVES. In order to vary the speed, a valve is installed between the fuel nozzle and engine which limits the volume of combustible mixture available to the combustion chamber. When less mixture is available to the combustion area, there will be less expansion resulting in less rpm and less power. The two types of throttle valves commonly used are the disc (butterfly) valve (Fig. 1-6) and the variable venturi (slide) valve (Fig. 1-9).

If, after the engine has been started, the throttle valve is in the wide-open position, the engine can obtain enough fuel and air to run at dangerously high speeds so the throttle valve must be partly closed. At no load, the engine requires very little air and fuel to run at its rated speed and the throttle must be moved nearer the closed position. As more load is placed on the engine, more fuel and air mixture is required for the engine to operate at its rated speed. When the engine is required to develop maximum power or speed, the throttle must be in the wide open position.

DISC (BUTTERFLY) VALVE. A typical disc type throttle valve is shown in Figs. 1-6, 1-7 and 1-8. As the throttle disc is turned, the opening of the throttle bore is decreased. When

disc is in position shown in Fig. 1-8, the throttle opening is nearly closed. Idle speed adjustment is accomplished by stopping rotation of the valve before throttle bore is completely closed. When throttle is nearly closed, vacuum at the venturi is insufficient to provide correct fuel-air ratio by using only one fuel nozzle. Usually an additional idle jet (Fig. 1-8) and intermediate jet (Fig. 1-7) are incorporated.

VARIABLE VENTURI (SLIDE) VALVE. A typical slide type carburetor is shown in Fig. 1-9. When the slide is completely open, the small step in the throttle bore serves as a large diameter venturi for high speed. As the slide is lowered, the venturi size is decreased as shown in Fig. 1-10. Decreasing the venturi size slows the speed by decreasing the amount of fuel and air mixture that can be drawn into the engine and also increases the vacuum at the venturi fuel nozzle. A valve needle attached to the throttle slide is incorporated to lower the amount of fuel drawn in by the high

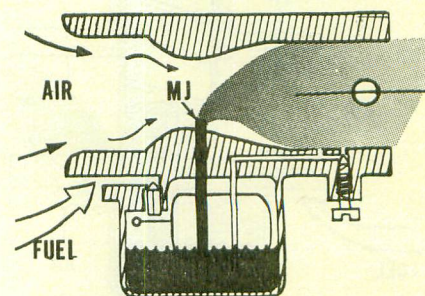


Fig. 1-6—View of carburetor showing disc type throttle valve completely open for high speed operation.

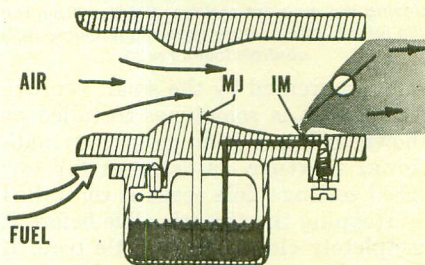


Fig. 1-7—As disc type throttle valve is moved toward the closed position, vacuum at the main jet (MJ) may not be enough to draw fuel into the passing air and an intermediate jet (IM) is provided.

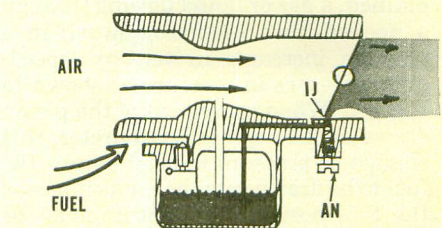


Fig. 1-8—With throttle disc nearly closed, the idle jet (IJ) is used. Usually an adjustment needle (AN) is provided to adjust the idle mixture fuel-air ratio.

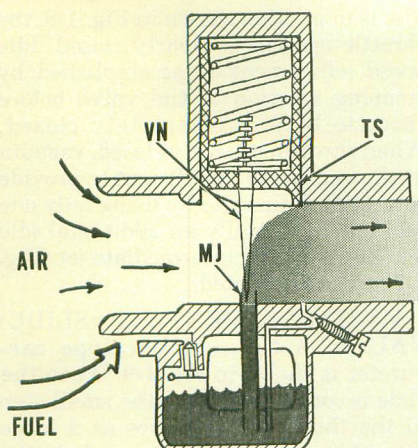


Fig. 1-9—View of variable venturi, slide type throttle valve. Throttle slide (TS) is in the fully raised high speed position. Valve needle (VN) is raised allowing main jet (MJ) to be completely open.

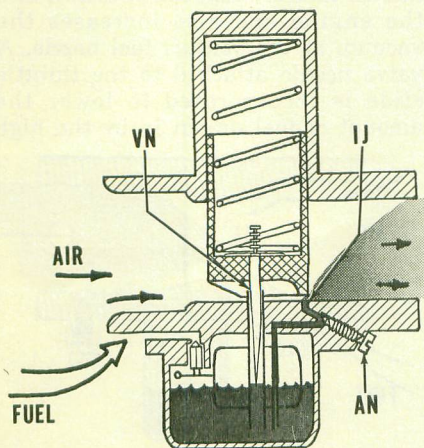


Fig. 1-10—With throttle slide lowered to idle speed position, only a small amount of air is allowed to pass. The valve needle (VN) is lowered, closing the main jet and fuel is drawn from the idle jet (IJ). Idle mixture adjustment needle (AN) controls fuel-air ratio.

vacuum created by the small venturi. An idle jet is sometimes installed as shown in Fig. 1-10 to provide an additional mixture adjustment for low speed settings. Idle speed is controlled by stopping the throttle slide before it completely closes the throttle bore. If the valve needle is raised in the throttle slide, it will increase the fuel flow from the main nozzle at intermediate throttle settings.

VENTURI. As previously explained, a gas or liquid flowing through a necked-down section (venturi) in a passage increases in velocity (speed) and decreases in pressure as shown in Fig. 1-5. When movement of the piston draws air through the carburetor, this change of pressure is what causes the fuel to be drawn into the air as it passes the fuel nozzle. The venturi must be matched to the engine to provide the right amount of pressure drop at the venturi for correct fuel-air mixture. Some adjustment can be accomplished

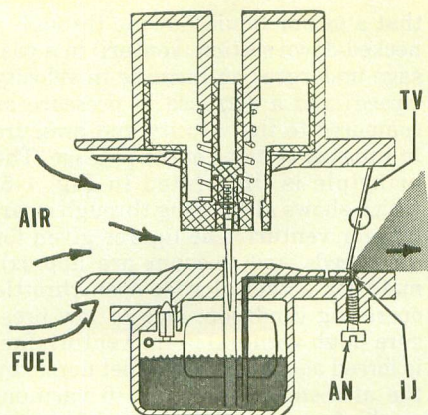


Fig. 1-11—View of vacuum controlled variable venturi type carburetor with throttle valve (TV) nearly closed. Idle mixture adjustment needle (AN) is shown. Fuel is discharged from idle jet (IJ).

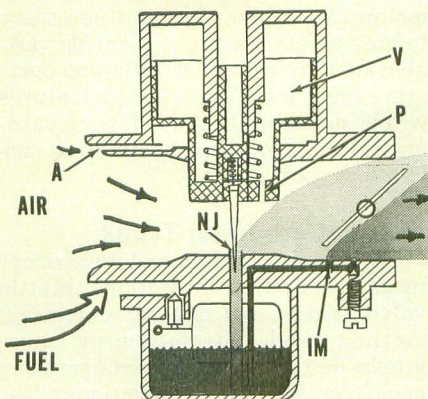


Fig. 1-12—At intermediate throttle setting, atmospheric air pressure is allowed to enter port (A) under the venturi piston and venturi vacuum is transferred to top of piston (V) via port (P). The vacuum above the piston and atmospheric pressure below, causes the venturi piston to raise. Fuel is discharged at partially open needle jet (NJ) and intermediate jet (IM).

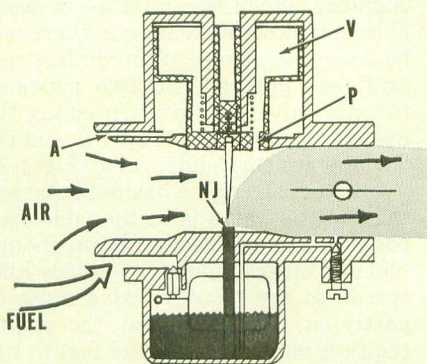


Fig. 1-13—As engine speed and throttle opening are increased, vacuum at venturi port (P) and above venturi piston (V) increases until venturi is completely open. Needle jet (NJ) is completely open.

by making the fuel flow less (or more) restricted by changing the jet sizes; however, manufacturer's recommendation of carburetor and jet sizes should be closely followed.

VARIABLE VENTURI (SLIDE) VALVE. The sliding variable venturi that is commonly used as a throttle is explained in a previous paragraph. If a

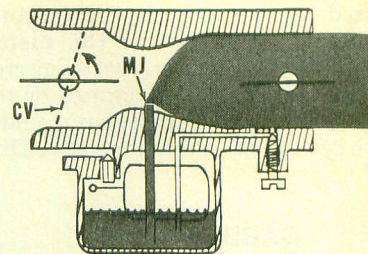


Fig. 1-14—As choke valve (CV) is closed as shown by the broken lines, vacuum is increased at main jet (MJ).

larger carburetor of this same type is installed, it is possible that low speed (part throttle) operation will function normally, but at full open throttle the venturi will be too large to provide the correct fuel-air mixture.

VACUUM CONTROLLED VENTURI. Some models utilize a vacuum controlled, variable venturi as shown in Fig. 1-11. These models use a disc type throttle plate which controls the amount of fuel-air mixture available to the engine. When the engine is running at slow speed (throttle nearly closed) the venturi piston is lowered as shown in Fig. 1-11. As the throttle disc is opened Fig. 1-12 and 1-13 the vacuum at the venturi is transferred into chamber (V) via port (P) and atmospheric pressure is admitted under venturi piston via port (A). The high pressure below the venturi and low pressure above causes the piston to raise as shown in Figs. 1-12 and 1-13. As with the slide type variable venturi, a valve needle is attached to the venturi to limit the amount of fuel drawn from the main nozzle at low speed. An idle mixture jet (IJ—Fig. 1-11) and intermediate jet (IM—Fig. 1-12) are provided to correct the fuel to air ratio throughout the entire speed range. It is extremely important that the venturi piston is free to move easily in its bore and that it fits tightly enough to seal the different pressures. Idle speed is controlled by stopping the throttle disc before it closes the throttle bore.

STARTING ENRICHMENT. The ratio of fuel to air must be much richer when starting in cold weather than when running at full open throttle. Two methods of obtaining a rich starting mixture are commonly used.

CHOKE PLATE. Fig. 1-14 shows a typical choke plate installation in relation to the carburetor venturi.

At cranking speeds, air flows through the carburetor venturi at a slow speed; thus, the pressure in the venturi does not usually decrease to the extent that atmospheric pressure on the fuel will force enough fuel from the nozzle. If the choke plate is closed as shown by the broken line in Fig. 1-14, air cannot enter into the carburetor

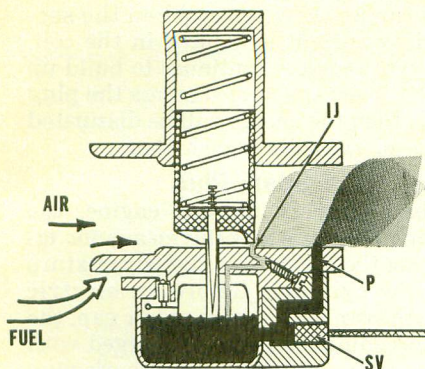


Fig. 1-15-View of simplified starting valve enrichment method. With starting valve (SV) open, the normal idle mixture supplied by idle jet (IJ) is further enriched by starting port (P).

and pressure in the carburetor decreases greatly as the engine is turned at cranking speed. Fuel is then forced from the fuel nozzle. In manufacturing the carburetor choke plate or disc, a small hole or notch is cut in the plate so that some air can flow through the plate when it is in closed position to provide air for the starting fuel-air mixture. In some instances after starting a cold engine, it is advantageous to leave the choke plate in a partly closed position as the restriction of air flow will decrease the air pressure in carburetor venturi, thus causing more fuel to flow from the nozzle resulting in a richer fuel-air mixture. The choke plate or disc should be in fully open position for normal engine operation.

STARTING VALVE. Fig. 1-15 shows a simplified starting system typical of the type found in many carburetors. A combination of two principles is utilized to enrich the fuel-air mixture. First, the passage is normally less restricted (larger) than the normal idle passage and second, the starting port is located between the throttle slide and engine. With the starting port (P) located as shown in Fig. 1-15, closing the throttle slide increases the vacuum at the starting port in much the same way as the choke plate previously described. It is obvious that this rich mixture should not normally be used, so a shut-off valve is incorporated in the system. The starter jet shut-off valve (SV—Fig. 1-15) is sometimes actuated by a control on the carburetor; however, is often remote controlled by a handle bar mounted lever via a control cable.

IGNITION SYSTEM

The timed spark which ignites the fuel charge in the cylinder may be supplied by either a magneto or battery ignition system. To better understand the operation of the components and

the differences and similarities of the two systems, they will be combined in this section and the functions of the various units explained and compared.

Theory

In the modern ignition system, a relatively weak electric current of 6 to 12 volts and 2 to 5 amperes is transformed into a momentary charge of minute amperage and extremely high (10,000-25,000) voltage, capable of jumping the spark plug gap in the cylinder and igniting the fuel charge.

To understand the ignition system theory, electricity can be thought of as a stream of electrons flowing through a conductor. The force of the stream can be increased by restricting volume, or the volume increased by reducing the resistance to movement; but the total amount of power cannot be increased except by employing additional outside force. The current has an inertia of motion and resists being stopped once it has started flowing. If the circuit is broken suddenly, the force will tend to pile up temporarily, attempting to convert the speed of flow into energy.

A short list of useful electrical terms and a brief explanation of their meanings is as follows:

AMPERE. The unit of measurement used to designate the amount, or quantity of flow of an electrical current.

OHM. The unit of measurement used to designate the resistance of a conductor to the flow of current.

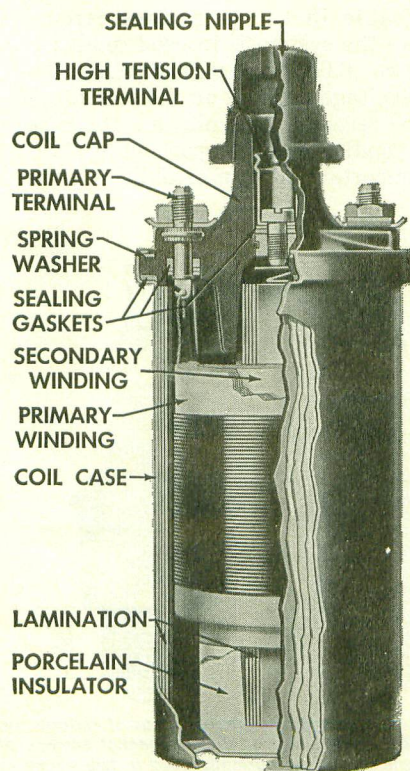


Fig. 1-16-Sectional view of a typical ignition coil.

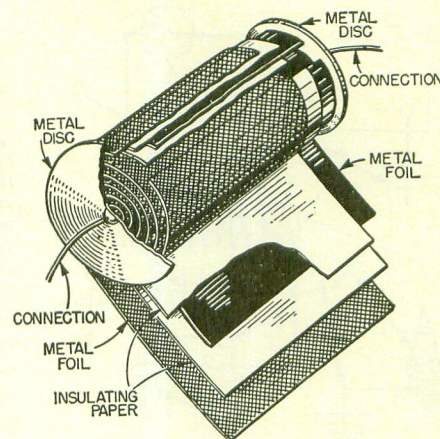


Fig. 1-17-A typical condenser consists of two metal conductors separated by layers of insulating paper and rolled into a tight cylinder.

VOLT. The unit of measurement used to designate the force, or pressure of an electrical current.

WATT. The unit of measurement which designates the ability of an electrical current to perform work; or to measure the amount of work performed.

The four terms are directly interrelated, one ampere equaling the flow of current produced by one volt against a resistance of one ohm. One watt designates the work potential of one ampere at one volt in one second.

Ignition Coil

When an electrical current is flowing through a conductor, a magnetic field exists at right angles to the current flow. As long as the conductor is relatively straight, nothing much happens; but if the conductor is coiled around a soft iron core, then the length of the iron core is at approximately right angles to the wire. A path is provided for the magnetic field and the iron core becomes a magnet as long as the current flows.

A second phenomenon of electrical action is that when a magnetic field is interrupted, a pulsation of electrical energy is formed at right angles to the lines of magnetic flow.

In a battery ignition system, these two peculiarities are combined to form an ignition coil as shown in Fig. 1-16. The inner and outer laminations are composed of soft iron and form a continuous path for a magnetic field. Around the inner laminations but insulated from it, is wound many coils of fine copper wire. Around this coil of fine wire, but insulated from it and the iron core, are fewer turns of heavier copper wire. These windings are encased in the outer laminations, then in a protective case.

The outer winding of heavier wire is connected to the two screw terminals on the coil case and form the primary

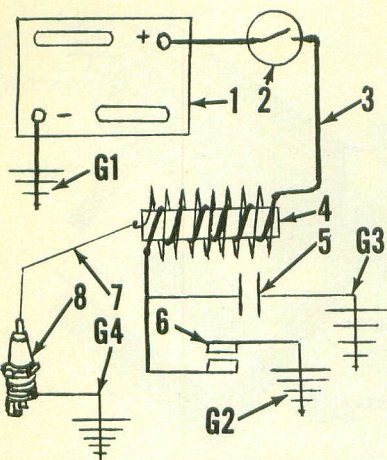


Fig. 1-18—Diagram of a typical battery ignition system. Refer to text for principles of operation.

- | | |
|--------------------|--------------------------------|
| 1. Battery | 6. Contact points |
| 2. Ignition switch | 7. Secondary circuit |
| 3. Primary circuit | 8. Spark plug |
| 4. Ignition coil | G1 thru G4. Ground connections |
| 5. Condenser | |

circuit of the coil. The inner winding of fine wire is grounded at one end while the other end is connected to the insulated, high tension terminal and forms the secondary circuit.

Primary Circuit

The primary circuit is attached to the power source in both the battery and magneto electrical system.

In the battery system, the primary circuit consists of the battery, ignition switch, primary windings, contact points, condenser, and the necessary connecting wiring as shown at (3—Fig. 1-18). When the ignition switch (2) and contact points (6) are closed, the primary circuit (3), primary windings of coil (4) and the closed contact points (6), the ground connections (G1 at battery and G2 at points) plus the engine casting or frame, complete the circuit. As the current flows, a magnetic field is built up in the soft iron laminations of coil (4), which is surrounded by the primary and secondary windings. When contact points (6) open to break the circuit, the current tries to flow through the path of least resistance which is the condenser (5) until condenser capacity is reached; then, the primary current ceases to flow and the magnetic field starts to collapse. This collapse is hastened by the condenser, which tries to discharge its stored energy backward through the primary circuit. When the magnetic field collapses, extremely high voltage is induced in the coil secondary windings which flows through secondary circuit (7) to spark plug (8), where it jumps the plug gap and is dissipated in the engine frame through ground (G4).

In a magneto ignition system, the same principles are involved but the method of application is somewhat different. Instead of stored chemical en-

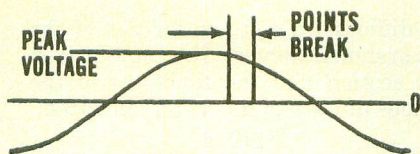


Fig. 1-19—The primary current of a magneto ignition system is an alternating current, thus voltage varies from zero to a predetermined peak during each positive and negative cycle. To produce an adequate spark to ignite the fuel charge, the contact points must break at or near the voltage peak as shown.

ergy of a battery which produces a constant direct current, the source of energy is a pulsating alternating current induced in the magneto primary windings and derived from permanent magnets. Because of variation in voltage and direction of current flow (See Fig. 1-19) the ignition points must not only be correctly timed with relation to the piston, but also to break at or near peak voltage. The proper position with relation to the position of the permanent magnet is decided by laboratory tests and sometimes becomes a part of the service specifications. This position is referred to as "edge gap."

Secondary Circuit

The secondary circuit carries the high voltage current from the coil to the spark plug or plugs. The secondary circuit ground at the spark plug should be of negative polarity. On systems with a separate high tension coil, the secondary current polarity can be reversed by changing the primary circuit leads at the coil or by reversing the connections. The potential voltage available in the secondary circuit where the system is in good condition may be 18,000 to 25,000 volts. The actual voltage depends on the resistance of the secondary circuit, and the type and condition of the spark plug plays an important part in establishing the

operating resistance. When the secondary current is induced in the coil, current strength continues to build up until a spark is formed across the plug gap, then the energy will be dissipated and voltage will rise no higher.

Spark Plug

In any spark ignition engine, the spark plug provides the means for igniting the compressed fuel-air mixture in the cylinder. Before an electric charge can move across an air gap, the intervening air must be charged with electricity, or ionized. The spark plug gap becomes more easily ionized if the spark plug ground (G4—Fig. 1-18) is of negative polarity. If the spark plug is properly gapped and the system is not shorted, not more than 7,000 volts may be required to initiate a spark. Higher voltage is required as the spark plug warms up, or if compression pressures or the distance of the air gap is increased. Compression pressures are highest at full throttle and relatively slow engine speeds, therefore, high voltage requirements or a lack of available secondary voltage most often shows up as a miss during maximum acceleration from a slow engine speed. There are many different types and sizes of spark plugs which are designed for a number of specific requirements.

THREAD SIZE. The threaded, shell portion of the spark plug and the attaching holes in the cylinder are manufactured to meet certain industry established standards. The diameter is referred to as "Thread Size." Those commonly used are: 10MM, 14MM, 18 mm, 7/8 inch and 1/2 inch pipe.

REACH. The length of thread, and the thread depth in cylinder head or wall are also standardized throughout the industry. This dimension is mea-

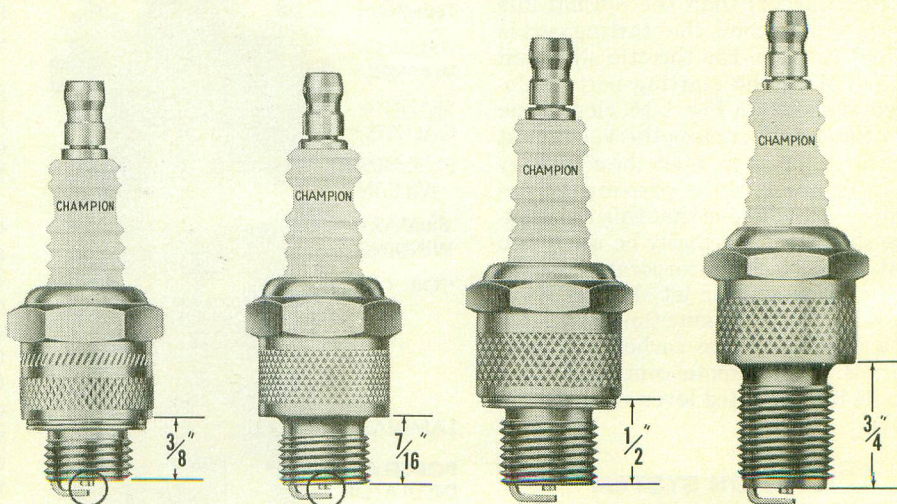


Fig. 1-20—Views showing spark plugs of various "reaches". A 3/8-inch reach spark plug measures 3/8-inch from firing end of shell to gasket surface of shell. The two plugs at left side illustrate the difference in plugs normally used in two-stroke cycle and four-stroke cycle engines; refer to the circled electrodes. Spark plug at left has a shortened ground electrode. The short ground electrode will operate cooler than longer ground electrode.

FUNDAMENTALS

sured from gasket seat of plug to cylinder end of thread.

HEAT RANGE. During engine operation, part of the heat generated during combustion is transferred to the spark plug, and from the plug to the cooling medium through the shell threads and gasket. The operating temperature of the spark plug plays an important part in engine operation. If too much heat is retained by the plug, the fuel-air mixture may be ignited by contact with the heated surface before the ignition spark occurs. If not enough heat is retained, partially burned combustion products (soot, carbon and oil) may build up on the plug tip resulting in "fouling" or shorting out of the plug. If this happens, the secondary current is dissipated uselessly as it is generated instead of bridging the plug gap as a useful spark, and the engine will misfire.

The operating temperature of the plug tip can be controlled, within limits, by altering the length of the path the heat must follow to reach the threads and gasket of the plug. Thus, a plug with a short, stubby insulator around the center electrode will run cooler than one with a long slim insulator. Most plugs in the more popular sizes are available in a number of heat ranges which are interchangeable within the group. The proper heat range is determined by engine design and the type of service. Like most other elements of design, the plug type installed as original equipment is usually a compromise and is either the most suitable plug for average conditions; or the best plug to meet the two extremes of service expected. No one spark plug, however, can be ideally suited for long period of slow-speed operation and still be the best possible type for high-speed operation.

IDENTIFICATION. Each spark plug manufacturer uses a different special code to identify spark plug characteristics. It is impossible to provide a plug cross reference chart which is accepted by all manufacturers; however, the following code identification for some spark plugs may be helpful for selecting the correct plug. The plug listed may not be a valid type, but is used for explanation only.

AC-SPARK PLUGS

SPECIAL FEATURES

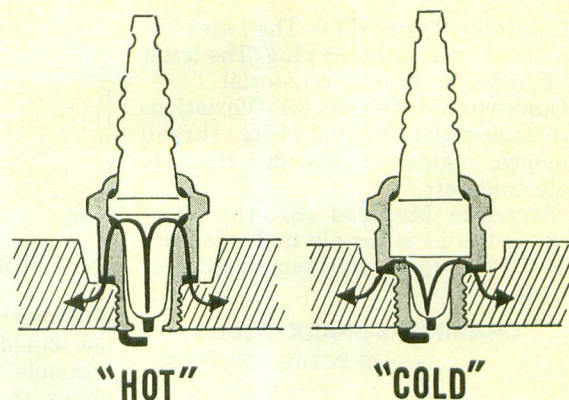
HEAT RANGE

MC124F

THREAD SIZE

DESIGNED USAGE

Fig. 1-21—Spark plug tip temperature is controlled by the length of the path heat must travel to reach cooling surface of the engine cylinder head.



Thread Size (12)—The first part of numbers indicates thread size. The example "12" indicates that plug thread size is 12MM.

First number 2 is 1/2 inch thread size.

First number 4 is 14MM thread size.

First number 7 is 7/8 inch thread size.

First number 8 is 18MM thread size.

First Number 10 is 10MM thread size.

First number 12 is 12MM thread size.

Heat Range (4)—The last number indicates heat range.

Number 0 or 1 is usually the coldest

available in that type of plug. The

Example "4" is approximately midrange.

Last number 9 is extremely hot plug.

Last number 0 or 1 is extremely cold plug.

Suffix Letters (F)—Letter (or letters) after number indicates special features. The "F" in example indicates that plug is "Special reach for Foreign Applications".

B—Neon tube

D—Dual side electrodes

E—Engineer Corps., Shielded (Not an Aircraft type)

F—Special reach for Foreign Applications

FF—1/2" reach fully threaded (14MM)

G—Marine racing gap

H—Special hex size

I—Iridium center electrode

K—Hi-Perf. Marine non-racing gap

L—Long reach (7/16" for 14MM, 3/4" for 18MM)

XL—Extra Long reach (3/4" for 14MM)

N—Extra long reach (14MM) (3/4" reach with 3/8" thread length)

P—Platinum electrodes

R—Resistor

S—(14MM) Extended tip

S—(7/8") Moderate long reach (23/32")

T—Tapered engine seat

TS—Tapered seat with extended tip

W—Recessed termination

X—Special gap

Y—3 prong cloverleaf electrode

Prefix Letters (MC)—Letter (or letters) before numbers indicates designed usage. Many times a standard plug (without MC) will be suitable for motorcycle use and will not be marked "MC."

B—Series gap

C—Commercial

CS—Low profile

G—Gas engine

H—High altitude or weatherproof (shield connector, 3/4-20 thread)

M—Marine

MC—Motorcycle type

LM—Lawn mower type

R—Resistor

S—Shielded (5/8-24 thread)

SN—Snow

TC—Tractor Commercial

V—Surface Gap

W—Water proof (shield connector, 5/8-24 thread)

BOSCH-SPARK PLUGS

ELECTRODE MATERIAL

CONSTRUCTION DETAILS

INSULATOR TYPE

W145RT3S

HEAT RANGE

THREAD SIZE

Thread Size (W)—The first letter (or letters) indicates thread size and general type of plug. The example "W" is 14MM.

M, MA, MG, MV, MAG and

MGV 18MM

U 10MM

W, WD, WG, WK and WKA . 14MM

X 12MM

Z 7/8 inch—18

Thread size codes MA and MAG are tapered seat; WK and WKA are short plugs; WD type is surface gap plug.

Heat Range (145)—The number indicates plug heat range between 20 (hot) to 340 (cold). Example of "145" is approximately mid-range.

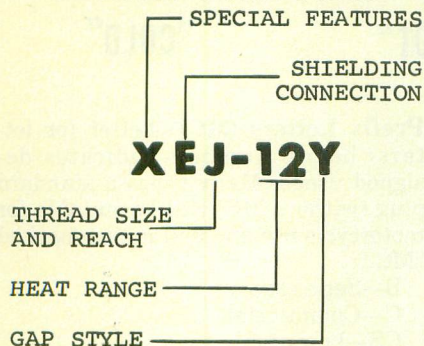
Spark Plugs

Insulator Type (RT)—The letter "R" indicates resistor type plug. The letter "T" indicates insulator material.

Construction Details (3)—Variations in construction including thread length; regular or extended tip, side electrode, etc.

Electrode Material (S)—The letter "S" indicates silver electrode material and "P" indicates platinum tipped electrode.

CHAMPION-SPARK PLUGS



Heat Range (12)—The heat range numbers are divided into four types. Number 1-25 are for automotive, marine and ordnance plugs; numbers 26-50 are for aircraft; numbers 51-75 are racing plugs; numbers 76-99 indicate special features or application. On all types, the higher number (within type range) indicates hotter plug.

Thread Size and Reach (J)—The code letter "J" in the example indicates 14MM thread size with $\frac{3}{8}$ inch reach.

Letter	Thread Size	Thread Reach (Inch)
Y	10MM	$\frac{1}{4}$
Z	10MM	.492
G	10MM	.700
P	12MM	.492
R	12MM	$\frac{3}{4}$
J	14MM	$\frac{3}{8}$
J (preceded by C) ..	14MM	$\frac{3}{8}$
J (preceded by D) ..	14MM	.325
H	14MM	Tapered Seat 7/16
L	14MM	$\frac{1}{2}$ or .472
L (preceded by B) ..	14MM	.460
N	14MM	Tapered Seat $\frac{3}{4}$
N (preceded by B) ..	14MM	.708
E	14MM	Tapered Seat .680
F	18MM	.460
		Tapered Seat

D	18MM	$\frac{1}{2}$
M	18MM	$\frac{1}{2}$
K	18MM	All
B	18MM	13/16
U	18MM	1 $\frac{1}{8}$
W	$\frac{7}{8}$ "-18	All
C	$\frac{7}{8}$ "-18	All
S	1 $\frac{1}{8}$ "-12	.600
None	$\frac{1}{2}$ "-14 Pipe Thread All	
V	Model Airplane Engine Plug	

Type of Shielding Connection (E)—In some cases indicates special short plugs. If this code is not used, plug is not shielded and is not a short plug. Example "E" indicates shielded spark plug with $\frac{5}{8}$ inch—24 threaded connection.

- B—See Thread Size Code L & N
- C—(See thread Size Code J) Short plug, Bantam
- D—(See thread Size Code J) Short plug
- E—Shielded $\frac{5}{8}$ inch-24
- H—Shielded $\frac{3}{4}$ inch-20
- M—Shielded $\frac{5}{8}$ inch-24 Ordinance
- P—Shielded 9/16 inch-27
- S—Shielded 11/16 inch-24 Whitworth
- T—Low Profile plug Shorty
- W—Shielded 13/16 inch-20

Special Internal Features (X)—Indicates resistor or auxiliary gap. If this code is not present, plug is not resistor or auxiliary gap type.

- R—Resistor (less than 6000 ohms)
- X—Resistor (more than 6000 ohms)
- U—Auxiliary gap

Gap Style (Y)—Suffix letters indicate type of electrodes and type of gap. Letter "Y" in the example indicates projected core ("Turbo-Action") gap style.

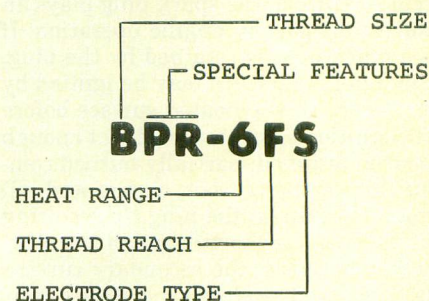
- B—Two heavy duty ground electrodes
- C—Protruding nose, Round ground electrode, Sawed gap
- D—Protruding nose, Round ground electrode
- F—Three heavy duty ground electrodes
- G—"Gold Palladium" center electrode
- J—Cut back ground electrode
- LM—Special lawn mower
- N—Four prong aircraft type
- P—Fine wire Platinum electrodes
- R—Push wire ground electrode
- S—Single ground electrode at side of center electrode

DESIGN FUNDAMENTALS

- T—Keikhaefer Gap
- V—Surface Gap
- Y—Projected core nose

NOTE: The Champion Spark Plug Company suggests using "Gold Palladium" type (suffix G) plug for most motorcycle applications.

NGK SPARK PLUGS



Thread Size (B)—The first letter indicates thread size. The second and third letters (if used) indicate variations. Projected insulator plugs are indicated by using "P" as second letter. Resistor plugs are indicated by using "R" and low profile plugs are indicated by "M" as the second or third letter.

A	18MM
AB	18MM (13/16 inch Hex)
B	14MM
C	10MM
D	12MM

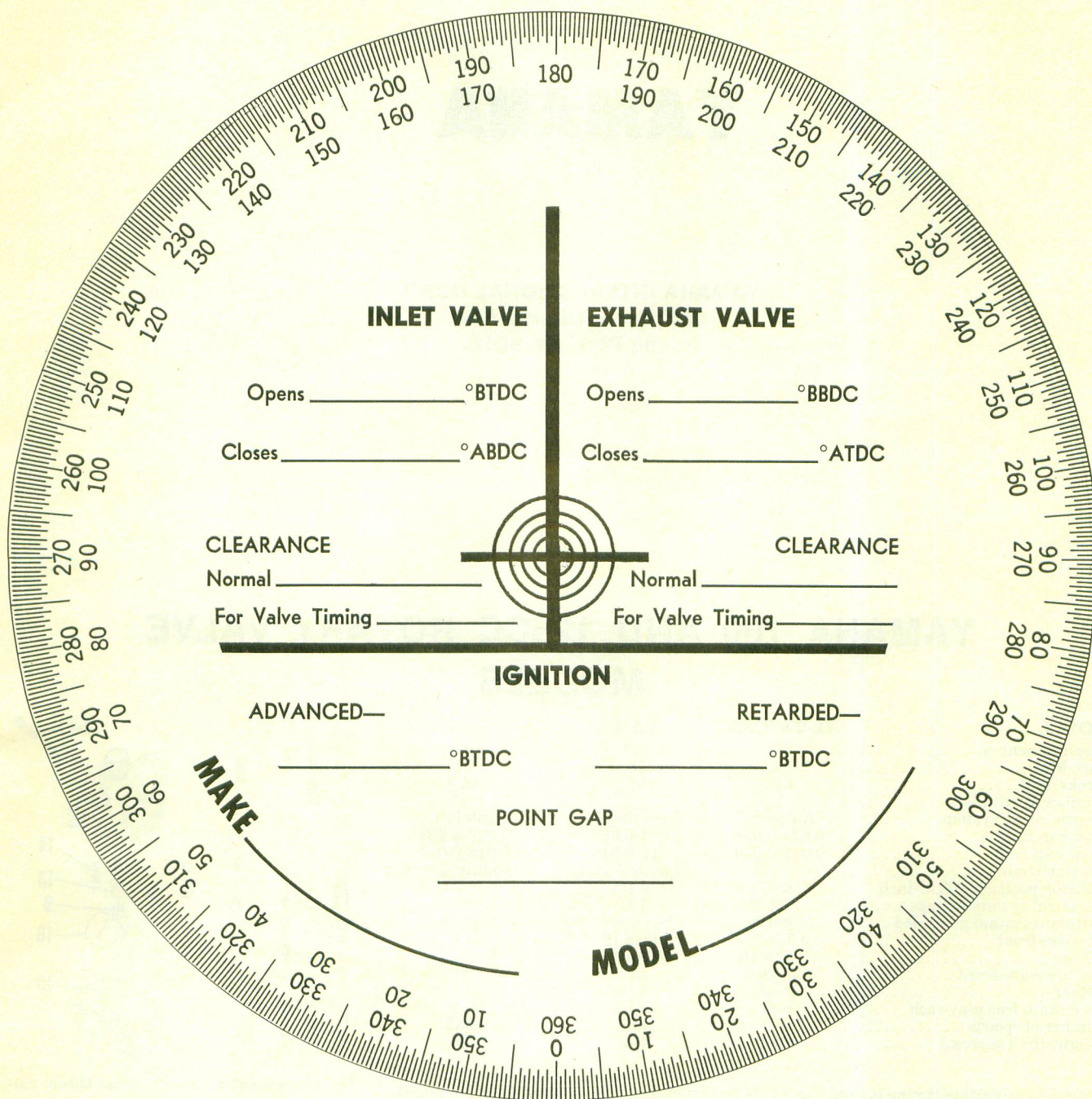
Heat Range (6)—The number indicates the heat range. Numbers are from 2 (hot) to 14 (cold). Number "6" of the example is approximately mid-range.

Thread Reach—Three suffix letters (E, H & L) are used to indicate thread reach. If none of the above letters appear on 14MM plug, reach is $\frac{3}{8}$ inch; if none appear on 18MM plug, reach is 12MM. Letter "F" in suffix (example) indicates taper seat.

E	$\frac{3}{4}$ inch Reach
F	Taper Seat
H	$\frac{1}{2}$ inch Reach
L	7/16 inch Reach

Electrode Type (S)—Special electrodes are identified by last letter. Example "S" is "Super Wide Range Electrode."

- C
- N Competition type electrode
- N ... Racing type (Nickel) electrode
- P . Racing type (Platinum) electrode
- S Super wide range electrode
- X Surface gap electrode



The above degree wheel should be attached to a suitable stiff backing and used to check valve and ignition timing. Center hole must be cut out and degree wheel can be attached to end of crankshaft. Attach pointer to an engine bolt and align with degree marks. If Top Dead Center is not

marked, the following procedure may be used. Insert a depth gage in spark plug hole and turn crankshaft CLOCKWISE until piston just contacts the gage. Move the degree wheel (crankshaft stopped) until 0 degree mark is aligned with the pointer. Turn the crankshaft COUNTER-CLOCKWISE until the piston again contacts the

depth gage. Set the crankshaft halfway between the two points (in the unused angle) which will be TDC. Adjust the degree wheel, without moving crankshaft, until 0 degree mark is aligned with pointer. Later maintenance may be facilitated by scribing mark on flywheel and crankcase to indicate TDC.

YAMAHA

YAMAHA INTERNATIONAL CORP.
6600 Orangethorpe Ave.
Buena Park, Ca. 90620

YAMAHA 100 AND 125CC ROTARY VALVE MODELS

MODEL	YL-2 & YL-2C	YA-6	L5T
Displacement-cc	97	123	97
Bore-MM	52	56	52
Stroke-MM	45.6	50	45.6
Number of cylinders	1	1	1
Engine oiling system	"Autolube"	"Autolube"	"Autolube"
Plug gap-inch	0.024-0.028	0.024-0.028	0.020-0.024
Point gap-inch	0.012-0.014	0.012-0.014	0.012-0.014
Ignition timing	*	Automatic Advance	Automatic Advance
Piston position BTDC-inch	**0.071	**0.100	**0.071
Electrical system voltage	12	12	12
Battery terminal grounded	Negative	Negative	Negative
Tire size-front	†2.50 x 18	3.00 x 16	2.75 x 17
Rear	†2.50 x 18	3.00 x 16	3.00 x 17
Tire pressure-front	24-26	22	20
Rear	26-28	28	28
Rear chain free play-inch	5/8-7/8	5/8-7/8	3/4-1
Number of speeds	4	4	3x2
Weight-lbs. (approx.)	††200	264	198

*On YL-2, ignition timing is fixed. On YL-2C, ignition timing is automatically advanced.

**Ignition timing for YL-2C, L5T and YA-6 is full advance (weights fully extended).

†Tire size for YL-2C models is 3.00 x 18

††Weight for YL-2C models is 205 lbs.

§Transmission in the L5T is equipped with a high and low selector to make in effect a six speed transmission.

Illustrations courtesy of Yamaha International Corporation.

MAINTENANCE

SPARK PLUG. Recommended spark plug electrode gap is 0.024-0.028 inch (0.6-0.7mm) for all models except L5T which should be set at 0.020-0.024 inch (0.5-0.6mm). Recommended spark plug for normal use is NGK type B8HC for 100cc models, B7HZ for 125cc models. Champion type L-81 or L-85 can be used.

CARBURETOR. A Mikuni VM carburetor is used. Idle speed is changed by turning adjuster (2—Fig. Y3-1). Idle mixture is adjusted by turning needle (11). Float setting (H—Fig. Y3-2) should be 7/8 inch (22mm) for 100cc models, 0.984 inch (25mm) for 125cc models. Refer to Fig. Y3-1 and the following specifications:

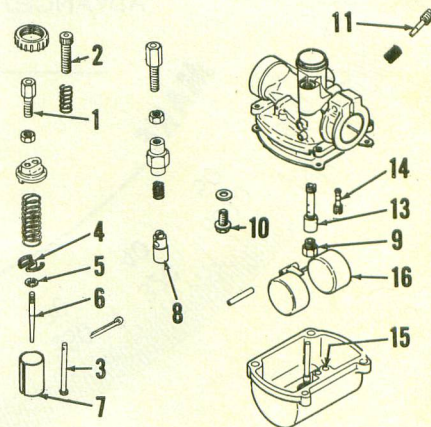


Fig. Y3-1—Exploded view of typical Mikuni carburetor.

- | | |
|-------------------------|-------------------------|
| 1. Throttle cable guide | 9. Main jet |
| 2. Idle speed adjuster | 10. Fuel inlet valve |
| 3. Idle speed rod | 11. Idle mixture needle |
| 4. Retainer | 13. Needle jet |
| 5. Clip | 14. Pilot jet |
| 6. Valve needle | 15. Starting jet |
| 7. Throttle slide | 16. Float |
| 8. Starting valve | |

YL-2

Main jet (9) #120
Pilot jet (14) #20
Starting jet (15) #40
Needle jet (13) D-0
Valve needle (6) 3D3
Clip (5) in third groove from top of needle (6).

Idle mixture needle (11) initial setting is 1 1/2 turns open.

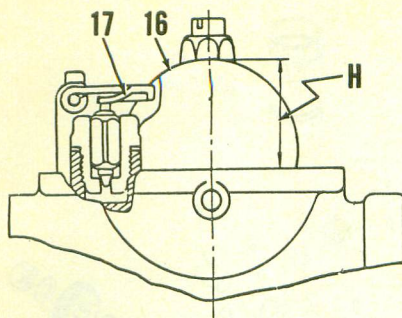


Fig. Y3-2—Refer to text for correct float height (H). Height is changed by bending tang (17).

YL-2C

Main jet (9) #95
 Pilot jet (14) #30
 Starter jet (15) #40
 Needle jet (13) N-8
 Valve needle (6) 4D2
 Clip (5) in third groove from top of needle (6).

Idle mixture needle (11) initial setting is $1\frac{1}{4}$ turns open.

Some YL-2C carburetors have been modified to improve transitional performance from low to high RPM. Standard needle jet (13) is drilled lengthwise with a #36 drill and air holes in side of needle jet drilled out with a #60 drill. Small brass plug at bottom center of throttle bore opening (air bleed plug) is center punched and drilled out with a #60 drill. Main jet should be a #130 or #140 long type.

YA-6

Main jet (9) #190
 Pilot jet (14) #30
 Starter jet (15) #110
 Needle Jet (13) 0-0
 Valve needle (6) 4J6
 Clip (5) in third groove from top of needle (6).

Idle mixture needle (11) initial setting is $1\frac{1}{2}$ turns open.

L5T

Main jet (9) #180
 Pilot jet (14) #20
 Starter jet (15) #40
 Needle jet (13) 0-8
 Valve needle (6) 4D2
 Clip (5) in third groove from top of needle (6).

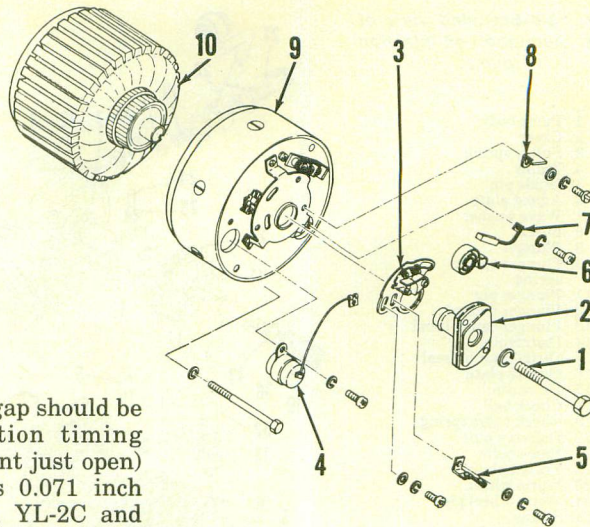
Idle mixture needle (11) initial setting is $\frac{3}{4}$ -turn open.

IGNITION AND ELECTRICAL.

The generator and battery ignition system breaker points are located on the left end of crankshaft on YL-2 models. Models YL-2C, YA-6 and L5T are equipped with a combination starter generator unit similarly mounted. Models with electric starter are provided with a centrifugal (automatic) ignition advance; while ignition timing is fixed and does not change on YL-2 models without electric starter.

Fig. Y3-4—Exploded view of starter-generator used on YL-2C and L5T models. The unit used on YA-6 is similar. The generator used on YL-2 models is similar except ignition cam (2) does not have advance mechanism.

1. Retaining screw
2. Cam and advance unit
3. Breaker points
4. Condenser
5. Lubricator
6. Brush spring
7. Brush
8. Timing plate
9. Field and stator
10. Armature



Ignition breaker point gap should be 0.012-0.014 inch. Ignition timing should occur (breaker point just open) when the piston reaches 0.071 inch (1.8mm) BTDC on YL-2, YL-2C and L5T models. Ignition timing on YA-6 models should occur when piston is 0.100 inch (2.4mm) BTDC. When checking ignition timing on electric starter models, make certain that the centrifugal advance weights are completely extended (out) in the fully advanced position.

LUBRICATION. The engine is lubricated by oil contained in a separate tank which is pumped into the inlet passage in the rotary valve cover plate. For use above 20° F., SAE 30 two-stroke oil is recommended. For temperatures below 20° F., SAE 10W/30 oil should be used. The oil tank should never be allowed to run dry.

The automatic metering system varies the oil ratio depending upon throttle setting. The oil pump and metering unit is located under the right side (carburetor) cover.

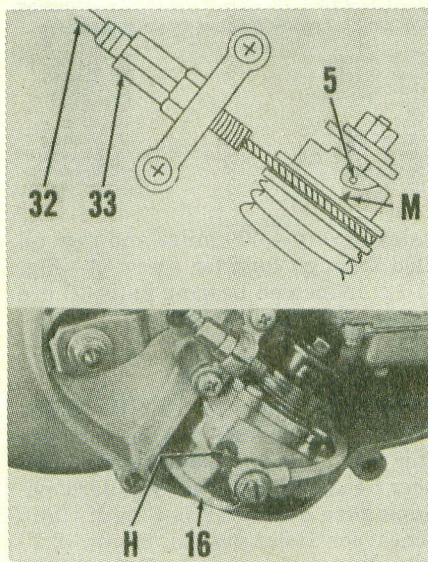


Fig. Y3-6—View of the "Autolube" oil injection pump. Refer to text for bleeding and adjusting procedure.

- H. Bleeding hole
- M. Mark
5. Guide pin
16. Starter plate
32. Pump control cable
33. Cable guide

If the "Autolube" system is drained or the pump unit is renewed, the air should be bled from the system as follows: Remove screw from bleeder hole (H—Fig. Y3-6), pull pump control cable (32) up out of the guide (33) and turn starter plate (16) until oil without air bubbles flows from hole (H). Reinstall the bleeder bolt. Start engine and run at idle speed while pulling pump cable (32) up until oil lines are completely free of air bubbles. If bubbles can not be removed from the pressure line, check for leaking pump seals or inlet oil line.

The pump must be correctly adjusted to provide the correct amount of oil for proper lubrication. Adjustment should be checked every 2,000 miles. To adjust, proceed as follows: Check the plunger minimum stroke by turning the starter plate (16—Fig. Y3-7) until clearance between pulley and adjusting plate is at its minimum, then measure clearance with a feeler gage as shown at (G). If clearance is not within limits of 0.008-0.010 inch (0.20-0.25 mm), vary the number of shims (8—Fig. Y3-8). After plunger minimum stroke is correctly set, twist the throttle until top of "O" mark stamped on carburetor slide is at top of carburetor bore and check alignment mark (M—Fig. Y3-6). Mark (M) should

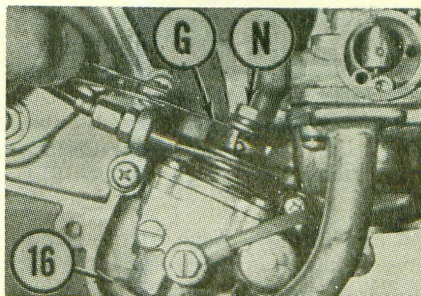


Fig. Y3-7—Feeler gage (G) is used for checking the minimum plunger stroke. Shims can be added or subtracted after removing nut (N) and adjusting plate. Refer to text.

Fig. Y3-8—Exploded view of the "Autolube" oil injection pump.

1. Pump body
2. Cover
3. Pulley spring
4. Pulley
5. Guide pin
6. Adjust plate
7. Wave washer
8. Shims
9. Plunger
10. Plunger return spring
11. Plunger pin
12. Plunger oil seal
13. Plunger cam oil seal
14. Distributor
15. Distributor oil seal
16. Starter plate
17. Drive pin
18. Check ball
19. Check valve spring
20. Delivery pipe
21. Banjo bolts
22. Thrust plate
23. Worm wheel
24. Worm wheel pin
25. Spring
26. Worm shaft
27. Worm shaft bushing
28. Oil seal
29. Pin
30. Drive gear
31. Nut
32. Control cable
33. Cable guide
34. Bracket
35. Bleeder screw
36. Plate
37. Snap ring
38. Spring seat

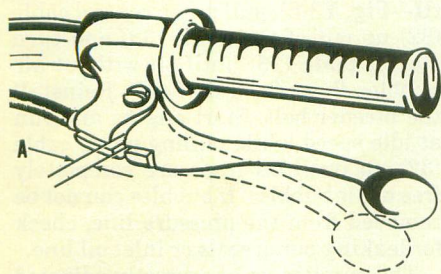
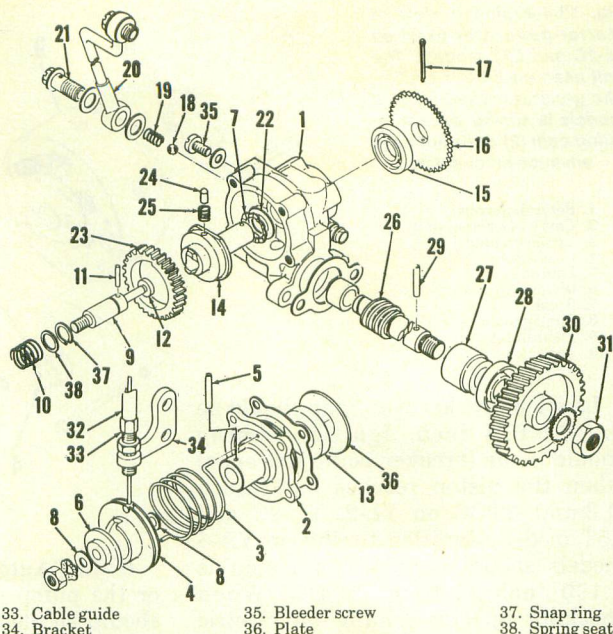


Fig. Y3-10—The clutch should be adjusted to provide 1/16-1/8-inch free play at (A).

be exactly aligned with guide pin (5). If not aligned, loosen the lock nut and turn cable guide (33) until mark is aligned with guide pin.

Yamaha Gear Oil or SAE 20W/40 engine oil should be used in the gear box on all models. Capacity is approximately $\frac{3}{4}$ quart for YL-2, YL-2C and L5T Models; $1\frac{1}{2}$ quarts for YA-6.

CLUTCH CONTROLS. The clutch hand lever should have 1/16- $\frac{1}{8}$ inch (2-3mm) free play at (A—Fig. Y3-10). To adjust, remove the rubber plug from engine left side cover on YA-6 models or the carburetor (right side) cover on YL-2, YL-2C and L5T models. Loosen the lock nut and turn the adjusting screw (under the rubber plug) until slight resistance is felt, then back the screw out $\frac{1}{4}$ turn and tighten lock nut. Adjust the cable guide to provide the correct amount of free play at (A—Fig. Y3-10).

SUSPENSION. Each front suspension unit contains 145cc of oil on YL-2 and YL-2C models; 165-175cc of oil on YA-6 models; 140cc of oil on L5T models. Oil used should be a mixture of 8 parts SAE 30 motor oil and 2 parts of SAE 60 spindle oil. Oil should be

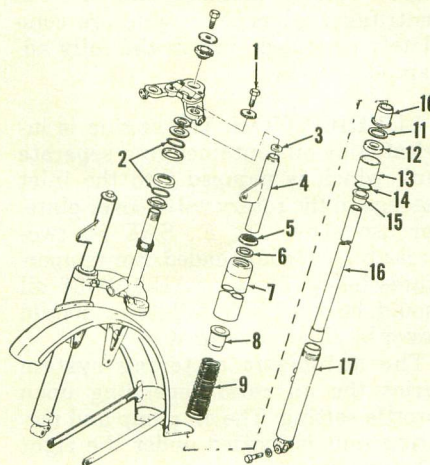


Fig. Y3-12—Exploded view of the front suspension used on YL-2 models. Other models are similar.

1. Filler screw
2. Bearing balls
3. Gasket
4. Cover
5. Washer
6. Gasket
7. Cover
8. Spring seat
9. Spring
10. Spring seat
11. Washer
12. Oil seal
13. Nut
14. "O" ring
15. Bushing
16. Inner tube
17. Lower tube

drained every 4,000 miles and new oil filled through hole for screw (1—Fig. Y3-12). Nineteen bearing balls (2) are used in each race.

REPAIRS

PISTON, RINGS AND CYLINDER. The piston can be removed after removing the exhaust pipe, cylinder head and cylinder. Standard cylinder bore diameter is 52mm (2.05 inches) for 100cc models; 56mm (2.20 inches) for 125cc models. Refer to the following specifications data:

YL-2 and YL-2C

Ring end gap—Both rings 0.15-0.35mm (0.006-0.014 in.)

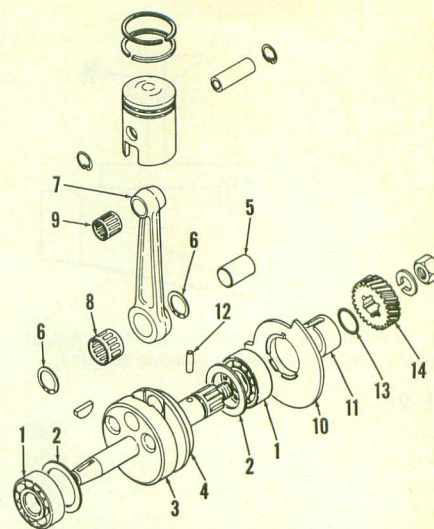


Fig. Y3-14—Exploded view of the crankshaft used on 100cc models. Other models are similar.

1. Main bearings
2. Shims
3. Crankshaft left end
4. Crankshaft right end
5. Crankpin
6. Thrust washers
7. Connecting rod
8. Lower bearing
9. Piston pin bearing
10. Rotary valve disc
11. Valve collar
12. Valve drive pin
13. "O" ring
14. Crankshaft primary drive gear

Ring side clearance in groove—

Top	0.04-0.08mm (0.0016-0.0032 in.)
Second	0.03-0.07mm (0.0012-0.0028 in.)

Piston skirt to cylinder

clearance	0.025-0.030mm (0.0010-0.0012 in.)
-----------	--------------------------------------

Taper or out of round

limit	0.05mm (0.002 in.)
-------	--------------------

L5T

Ring end gap—

both rings	0.15-0.50mm (0.006-0.019 in.)
------------	----------------------------------

Ring side clearance in groove—

both rings	0.04-0.08mm (0.0016-0.003 in.)
------------	-----------------------------------

Piston skirt to cylinder

clearance	0.40-0.45mm (0.016-0.017 in.)
-----------	----------------------------------

Taper or out of round limit

...	0.05mm (0.002 in.)
-----	--------------------

YA-6

Ring end gap—

Top	0.15-0.30mm (0.006-0.012 in.)
Second	0.10-0.20mm (0.004-0.008 in.)

Piston skirt to cylinder

clearance	0.03-0.04mm (0.0012-0.0016 in.)
-----------	------------------------------------

Taper or out of round

limit	0.05mm (0.002 in.)
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Piston skirt to cylinder clearance should be measured by first measuring piston diameter 10mm (0.4 inch) from bottom of piston at right angles to piston pin and cylinder bore diameter, then subtracting. If cylinder is bored

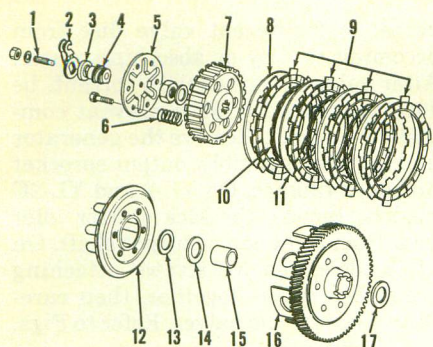


Fig. Y3-16—Exploded view of clutch used on 100cc models. Refer to Fig. Y3-17 for 125cc models.

- | | |
|----------------------------|------------------------------|
| 1. Adjusting screw | 10. Separator rings (4 used) |
| 2. Clutch lever | 11. Clutch plates (3 used) |
| 3. Oil seal | 12. Pressure plate |
| 4. Release screw | 13. Thrust washer |
| 5. Spring plate | 14. Thrust bearing |
| 6. Spring | 15. Spacer |
| 7. Clutch hub | 16. Clutch drum |
| 8. Clutch plate (thick) | 17. Thrust washer |
| 9. Friction discs (4 used) | |

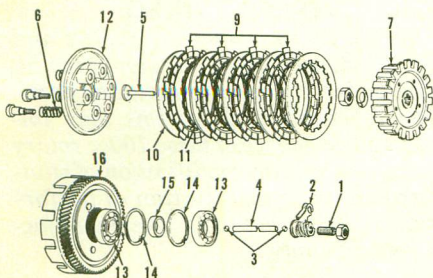


Fig. Y3-17—Exploded view of clutch used on YA-6 models.

- | | |
|----------------------------|------------------------------|
| 1. Adjusting screw | 10. Clutch plates (5 used) |
| 2. Release lever | 11. Separator rings (4 used) |
| 3. Balls | 12. Pressure plate |
| 4. Release rod | 13. Bearings |
| 5. Release plunger | 14. Snap rings |
| 6. Springs | 15. Spacer |
| 7. Clutch hub | 16. Clutch drum |
| 8. Friction discs (4 used) | |

for oversize piston and rings, edges of all ports should be rounded slightly to prevent ring from catching. Chrome plated piston ring should be installed in top groove and dark colored ring in second groove. Rings should be installed with marks on side toward the top of piston. Piston must be installed with arrow on top aimed toward front. The cylinder head retaining stud nuts should be torqued evenly to 180 inch-pounds.

CONNECTING ROD AND CRANKSHAFT. The crankcase halves must be separated to remove the crankshaft. Connecting rod, crankpin and roller bearing are removed by pressing crankshaft apart. Crankshaft should be disassembled **only** if required tools are available to correctly check and align the reassembled crankshaft. If the connecting rod side shake at piston pin end exceeds 2mm (0.079 inch) on 100cc models or 3mm (0.118 inch) on 125cc models, the connecting rod crankpin and lower end bearing should be renewed. The crankshaft eccentricity should be less than

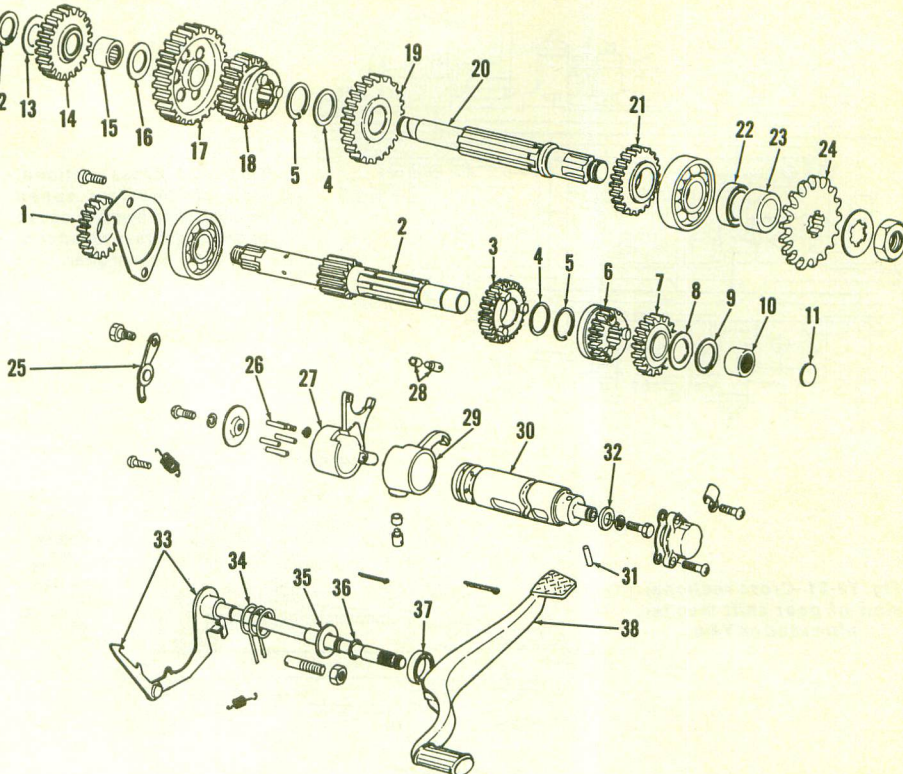
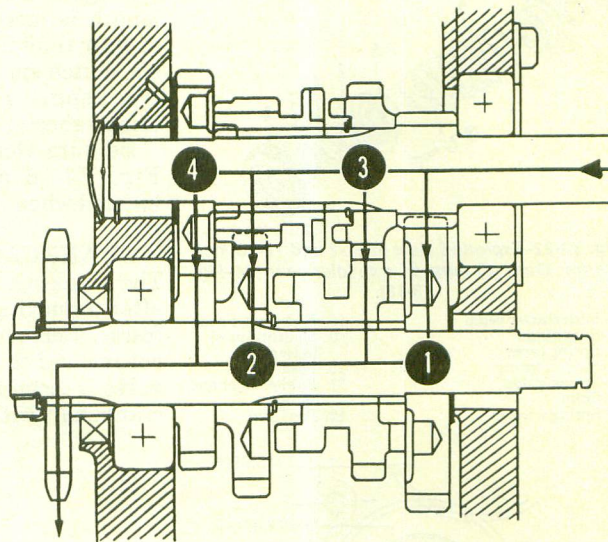


Fig. Y3-18—Exploded view of transmission used on YL-2 and YL-2C models. Refer to Fig. Y3-19 for cross sectional view.

- | | | | |
|-------------------------------|-----------------------------|--------------------------|-------------------------|
| 1. Kick starter gear | 10. Bearing | 19. Second gear | 29. Shift fork |
| 2. Input shaft and first gear | 11. Plug | 20. Output shaft | 30. Shift drum |
| 3. Third gear | 12. Snap ring | 21. Fourth gear | 31. Dowel pin |
| 4. Washers | 13. Thrust washer | 22. Oil seal | 32. Washer |
| 5. Snap rings | 14. Kick starter idler gear | 23. Collar | 33. Shift arm and shaft |
| 6. Sliding gear (2nd) | 15. Bearing | 24. Output sprocket | 34. Return spring |
| 7. Fourth gear | 16. Shims | 25. Detent | 35. Washer |
| 8. Shims | 17. First gear | 26. Shift pins | 36. Snap ring |
| 9. Snap ring | 18. Sliding gear (3rd) | 27. Shift fork | 37. Oil seal |
| | | 28. Guide pin and roller | 38. Change pedal |

Fig. Y3-19—Cross sectional drawing of the transmission used on YL-2 and YL-2C models.



0.03mm (0.0012 inch) when measured at main bearing journals with crankshaft supported between lathe centers.

CLUTCH. Refer to Fig. Y3-16 for clutch used on 100cc models or Fig. Y3-17 for clutch used on 125cc models. The clutch is mounted on the right end of the transmission input shaft on all models.

Standard thickness of friction discs (9—Fig. Y3-16 or Y3-17) is 0.138 inch (3.5mm) for 100cc models, 0.157 inch (4.0mm) for 125cc models. Friction discs less than 0.126 inch (3.2mm) thick on 100cc models or 0.146 inch (3.7mm) thick on 125cc models should be renewed. Free length of new clutch spring on 100cc models is 28.2mm (1.14 inch). On YA-6 free length of new

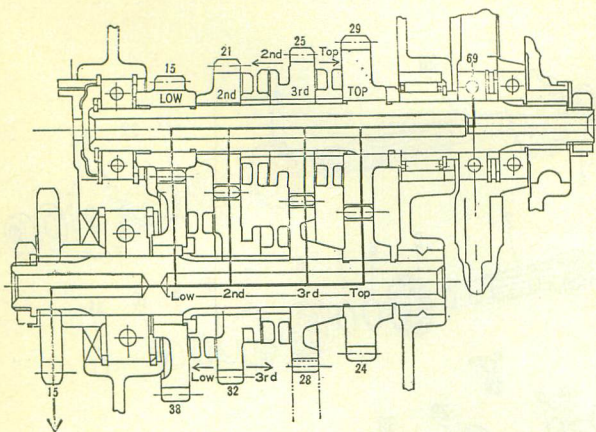


Fig. Y3-20—Cross sectional view of YA-6 four speed transmission. Number above or below gears is number of teeth on that gear.

Fig. Y3-21—Cross sectional view of gear shift mechanism used on YA-6.

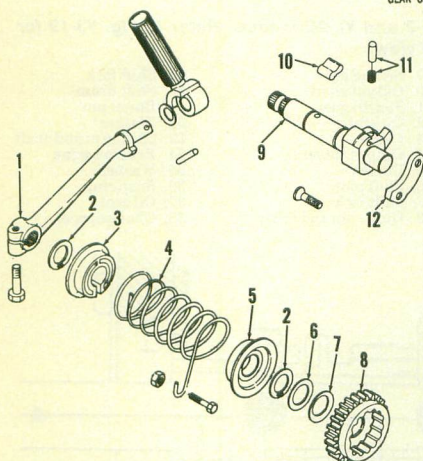
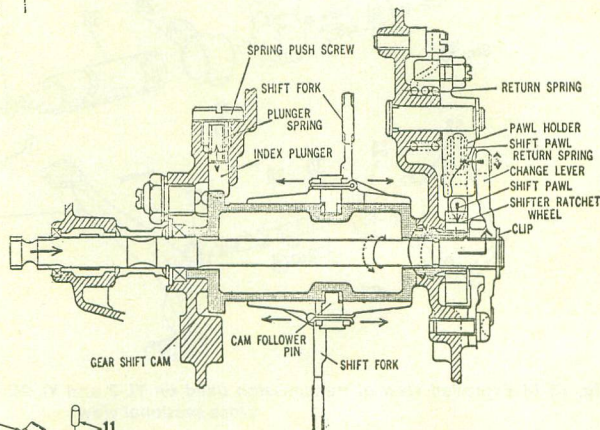


Fig. Y3-22—Exploded view of YL-2 and YL-2C kick starter. Gear (8) meshes with idler gear (14—Fig. Y3-18).

- | | |
|-----------------------|-----------------------------|
| 1. Kick starter pedal | 8. Kick starter gear |
| 2. Snap rings | 9. Shaft and pawl holder |
| 3. Spring cover | 10. Pawl |
| 4. Return spring | 11. Pawl plunger and spring |
| 5. Spring guide | 12. Pawl stop |
| 6. Shim | |
| 7. Spring washer | |

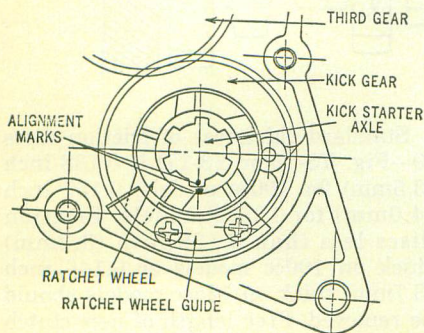


Fig. Y3-23—When assembling YA-6 kick-starter, align marks on axle and ratchet wheel as shown.

clutch spring is 31.5mm (1.24 inch). On YL-2 and YL-2C models, clutch springs should be renewed if free length is more than 0.08 inch (2mm) shorter than new spring. On YA-6 models, springs should be renewed if free length is more than 0.12 inch (3mm) shorter than new spring. On L5T models, clutch spring should be renewed if free length is more than 0.04 inch (1mm) shorter than new spring.

Be sure that separator rings (10—Fig. Y3-16 or 11—Y3-17) are not twisted when installed.

CRANKCASE AND GEAR BOX.

The crankcase halves can be separated after removing the engine from the frame. Remove the piston, clutch and rotary valve assembly. The rotary valve is located on the right end of the crankshaft with a roll pin. Care should

be taken to prevent valve disc from becoming too dry or absorbing water. After valve is washed with solvent, be sure to wipe with oil to prevent complete drying out. Remove the generator and ignition assembly, output sprocket and shift linkage. On YL-2 and YL-2C models, remove the kick starter idler gear from right end of output shaft. On all models, remove screws attaching crankcase halves together, then carefully separate the halves. Refer to Figs. Y3-18 and Y3-19.

The L5T is equipped with a 3 speed high and low range transmission. A lever on the left side of the case changes the gear ratio to high or low. See Fig. Y3-25 for breakdown. The primary shifting linkage is very similar to the YL-2 models.

SPEED TUNING

A "GYT" kit is offered for YL-2 and YL-2C models. Many features of the kit may be incorporated in standard parts. The following modifications may improve performance of these 100cc rotary valve singles. Any modification of standard parts or installation of performance parts will void the manufacturers warranty.

CARBURETOR: Use of a VM22 SC is recommended with the following specifications:

Main jet #160
Jet needle 4 J 6
Needle jet 0-0
Jet needle clip in second groove from top of needle.

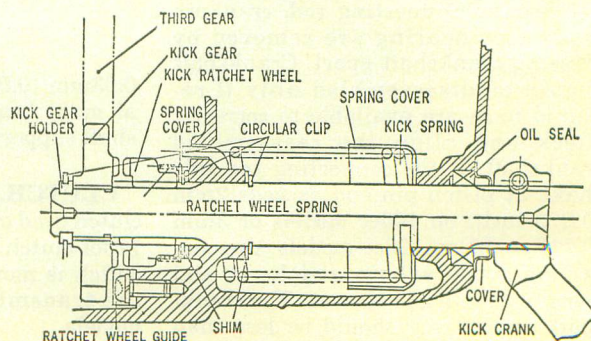
Intake bellmouth of carburetor should be shortened by 9mm (0.35 inch) for better breathing.

CYLINDER, PISTON AND HEAD. Milling of the head is not recommended.

Remove 2mm (0.078 inch) from top of exhaust port in cylinder liner.

Remove 7mm (0.275 inch) from piston skirt all the way around piston (I—Fig. Y3-1) and remove 2mm (0.078 inch) from areas (A, B & C) adja-

Fig. Y3-24—Cross sectional view of YA-6 kick-starter.



SERVICE

Yamaha 90, 125, and 175 (Piston Ported)

Fig. Y3-25—Exploded view of transmission used in L5T.

1. Bearing cover plate
2. Ball bearing
3. Main axle
4. Third pinion gear
5. Second pinion gear
6. Shim
7. Pinion assembly
8. Needle bearing
9. Kick idle gear
10. Drive axle shim
11. First gear wheel
12. Third gear wheel
13. Second gear wheel
14. Counter axle
15. Shift spring
16. Shifter head
17. Shifter rod
18. Shifter collar
19. Drive gear #1
20. Steel ball
21. Drive gear #2
22. Gear drive pin
23. Drive axle
24. Shift rod oil seal
25. Ball bearing
26. Distance collar
27. Shifter knob

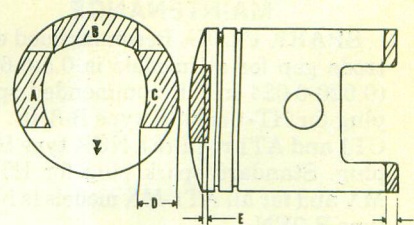
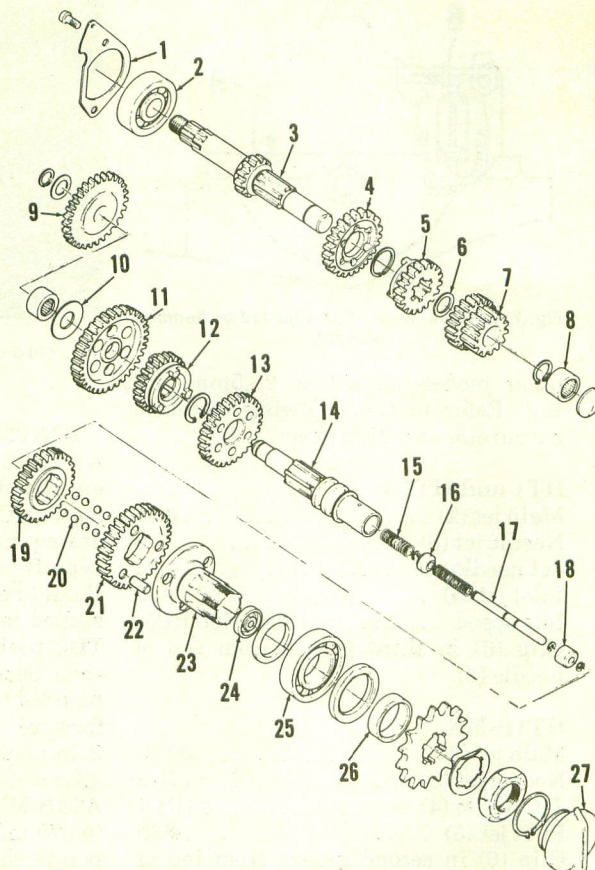


Fig. YT3-1—Areas of piston to be modified. Cuts (A, B & C) should only be as wide as transfer ports and extend 10mm across top of pistons. Cuts should be 2mm deep at edge of piston and taper to zero at end of cut.

cent to transfer ports. Cuts (A, B & C) in top of piston should be 2mm deep at edge (E) and taper to nothing in length (D) 10mm. Cuts should only be as wide as transfer ports in cylinder. Use only top (chrome) piston ring.

YAMAHA 90, 125 AND 175 CC (1969-1971) ENDURO AND MX MODELS

MODEL	ENDURO HT1 HT1-B	MX HT1B-MX	ENDURO AT1 AT1B AT1C	MX AT1-M AT1B-MX AT1C-MX	ENDURO CT1 CT1B CT1C
Displacement-cc	89	89	123	123	171
Bore-MM	50	50	56	56	66
Stroke-MM	45.6	45.6	50	50	50
Oil-Fuel ratio	Oil Pump	Oil Pump*	Oil Pump	Oil Pump*	Oil Pump
Spark plug—					
NGK	B-8HC	B-9EN	B-8ES	B-9EN	B-8ES
Electrode gap-MM	0.5-0.6	0.5-0.6	0.5-0.6	0.5-0.6	0.5-0.6
Inch	0.020-0.024	0.020-0.024	0.020-0.024	0.020-0.024	0.020-0.024
Ignition—					
Point gap-MM	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Inch	0.012-0.016	0.012-0.016	0.012-0.016	0.012-0.016	0.012-0.016
Timing-MM BTDC	1.8	2.5	1.8	2.0	1.9
Electrical system voltage	6	....	12	....	6
Battery terminal grounded	Negative	....	Negative	....	Negative
Tire size-Front	2.75 x 18	3.00 x 18	2.75 x 18	3.25 x 18	3.25 x 18
Rear	3.00 x 18	3.25 x 18	3.00 x 18	3.50 x 18	3.50 x 18
Tire pressure—					
Front-kg/cm ²	1.5	**	1.0	**	1.0
Psi	22	**	14	**	14
Rear-kg/cm ²	2.0	**	1.2	**	1.2
Psi	29	**	17	**	17
Rear chain free play-MM	20	20	25	25	20
Inch	3/4	3/4	1	1	3/4
Rear chain size	#428	#428	#428	#428	#428
Number of speeds	5	5	5	5	5
Weight (approx.)-kg	84.8	82	105.7	91.6	98.4
Pounds	187	181	233	202	217

*Manufacturer recommends a 1:30 oil mix in fuel tank in addition to oil pump. A 1:15 oil to fuel ratio should be used if oil pump is removed.

**Tire pressure should be adjusted to suit rider preference and track conditions.

Illustrations courtesy of Yamaha International Corporation

MAINTENANCE

SPARK PLUG. Recommended electrode gap for all models is 0.5-0.6mm (0.020-0.024 in.). Recommended spark plug for HT-1 is NGK type B-8HC. The CT1 and AT1 require a NGK type B-8E plug. Standard spark plug for HT1B-MX and for all AT1-MX models is NGK type B-9EN.

CARBURETOR. Mikuni sliding valve carburetors are used on all models. Refer to Fig. Y10-1 for exploded view of typical carburetor assembly. Idle mixture screw (1) should be 1¼ turns out on HT1 and HT1B; 1½ turns out on all other models. Float level is adjusted by bending tang (B—Fig. Y10-3) and is measured from top of float to gasket surface of float bowl. Float level should be 22.5mm (0.88 in.) on HT1 and HT1B. Float level on all

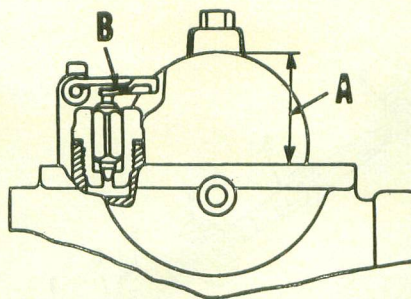


Fig. Y10-3—Float level (A) is adjusted by bending tang (B).

other models should be 25.5mm (1.0 in.). Refer to the following standard carburetor specifications:

HT1 and HT1B

Main jet (2) #85
Needle jet (8) N-6
Jet needle (4) 4D3
Pilot jet (5) #30
Idle speed 1350-1450 RPM
Clip (6) in third groove from top of needle (4).

HT1B-MX

Main jet (2) #130
Needle jet (8) N-8
Jet needle (4) 4 DH 7
Pilot jet (5) #30
Clip (6) in second groove from top of needle (4).

AT1, AT1B, AT1C, CT1, CT1B and CT1C

Main jet (2) #150
Needle jet (8) N-8
Jet needle (4) 4D3
Pilot jet (5) #30
Idle speed 1200-1300 RPM
Clip (6) in third groove from top of needle (4).

AT1-M, AT1B-MX, AT1C-MX

Main jet (2) #170
Needle jet (8) 0-2
Jet needle (4) 4D3
Pilot jet (5) #30
Clip (6) in third groove from top of needle (4).

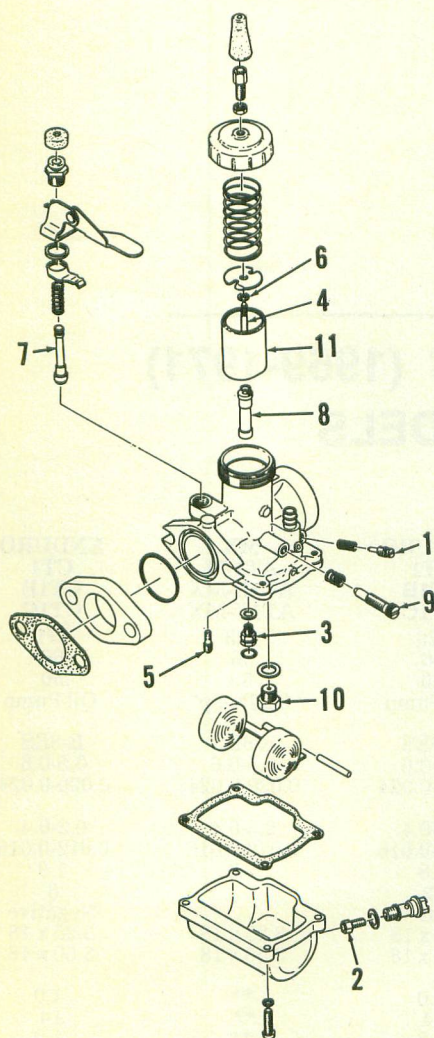


Fig. Y10-1—Exploded view of typical Mikuni carburetor. Unit used on 90cc Enduro models has flange type mount but is otherwise similar in construction.

- | | |
|----------------------|-------------------------|
| 1. Pilot air screw | 7. Starter plunger |
| 2. Main jet | 8. Needle jet |
| 3. Needle jet setter | 9. Throttle screw |
| 4. Jet needle | 10. Valve seat assembly |
| 5. Pilot jet | 11. Throttle slide |
| 6. Jet needle clip | |

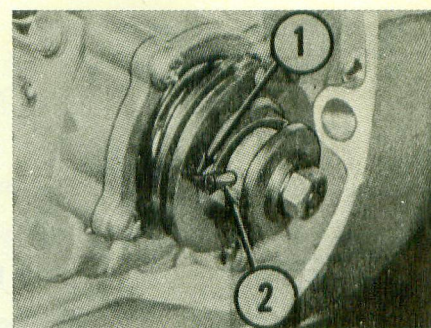


Fig. Y10-5—Mark (1) and guide pin (2) should line up with engine at idle.

IGNITION AND ELECTRICAL.

All AT1 "ENDURO" models are equipped with a combination start motor/DC generator. All other models are equipped with an energy transfer type flywheel magneto. Spark plug should be removed and a dial gage installed to time engine. Bring piston to TDC position and set gage to zero and then back crankshaft up past recommended timing point. Bring crankshaft forward to recommended timing point; 2.5mm (0.098 in.) BTDC on HT1B-MX; 2.0mm (0.078 in.) BTDC on AT1-M, AT1B-MX and AT1C-MX; and 1.8mm (0.070 in.) on all other models. Ignition points should just be opening at this time. On electric start models it is necessary to wedge governor flyweights open during timing operation. See Fig. Y10-4. Maximum point gap should be set at 0.3-0.4mm (0.012-0.016 in.) for all models. A timing pointer, mounted on stator and a timing mark on flywheel should also align at recommended BTDC position. Pointer may be used for future timing checks, once it has been verified with a dial gage.

LUBRICATION. Gearbox should be drained and refilled every 1200 miles with 700-800cc of SAE 10W/30 motor oil. Oil level in transmission should be maintained between two marks on dipstick with dipstick screwed in. Motorcycle should be held in a vertical position to check oil level. Engine lubrication is accomplished with an automatic oil metering system. Manufacturer recommends using a 1:30 oil to fuel mixture in fuel tank in addition to

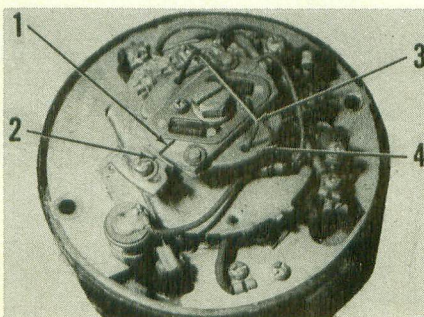


Fig. Y10-4—A bent spoke (3) can be used to hold flyweights open on electric start models. Timing marks (1&2) should be lined up so that future timing checks can be made without the aid of a dial gage.

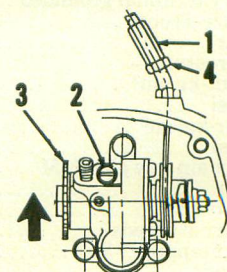


Fig. Y10-6—Arrow stamped on starter plate (3) will indicate direction of rotation.

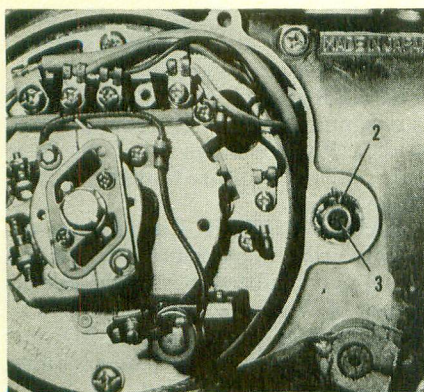


Fig. Y10-7—Remove left engine cover for access to clutch adjustment screw.

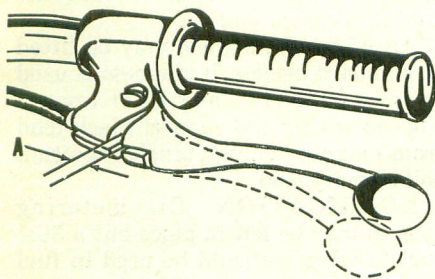


Fig. Y10-8—Adjust clutch lever for 2-3mm free play at (A).

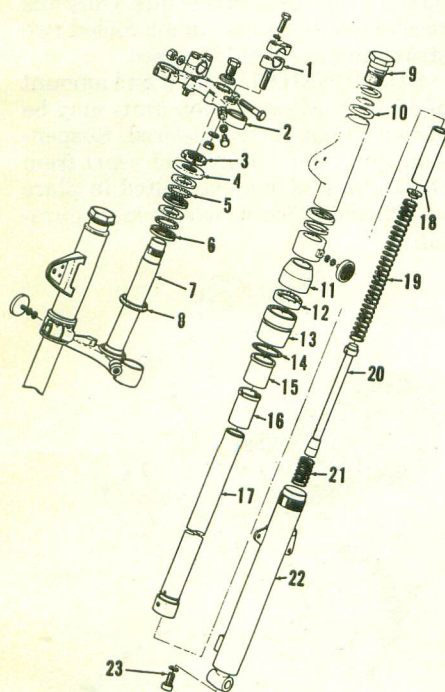


Fig. Y10-9—Exploded view of typical front end assembly used on 125 and 175cc models. HT1 units are similar.

- | | |
|-------------------------------|---------------------|
| 1. Handle bar holder assembly | 12. Oil seal |
| 2. Handle crown | 13. Outer tube nut |
| 3. Fitting nut | 14. "O" ring |
| 4. Ball race cover | 15. Metal slider |
| 5. Ball bearings | 16. Spacer |
| 6. Bearing race | 17. Fork inner tube |
| 7. Steering stem | 18. Damper valve |
| 8. Dust seal | 19. Fork spring |
| 9. Cap bolt | 20. Fork sub spring |
| 10. Cover upper guide | 21. Set bolt |
| 11. Dust seal | |

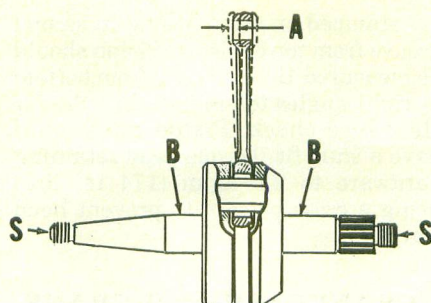


Fig. Y10-10—Support crankshaft on lathe centers at points (S) and place dial indicators at (B) to check runout.

automatic oil metering system on all "MX" models. Oil tank should not be allowed to run dry and only 2-stroke, air cooled, engine oil should be used. Oil pump must be bled if allowed to run dry. To bleed pump, remove bleeder screw (2—Fig. Y10-6) and turn starter plate (3) upward while holding throttle fully open. When air is no longer present in oil coming from hole, replace screw. Oil pump adjustment should be checked with throttle fully closed. Mark on pump adjustment pulley (1—Fig. Y10-5) and guide pin (2) should align with throttle closed. Adjust pump by turning cable adjusters.

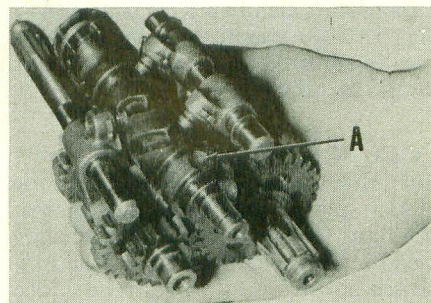


Fig. Y10-11—Transmission and shifter assembly ready for installation. Note position of shift stopper ball detent (A).

Fig. Y10-12—Exploded view of typical transmission unit.

- | | |
|--------------------|------------------------|
| 1. Drive axle | 11. First gear |
| 2. Spacer | 12. Fourth gear |
| 3. Ball bearing | 13. Washer |
| 4. Oil seal | 14. Third gear |
| 5. Distance collar | 15. Fifth gear |
| 6. Drive sprocket | 16. Second gear |
| 7. Snap ring | 17. Cover plate |
| 8. Kick idle gear | 18. Ball bearing |
| 9. Needle bearing | 19. Main axle |
| 10. Shim | 20. Fourth pinion gear |
| | 21. Third pinion gear |
| | 22. Fifth pinion gear |
| | 23. Second pinion gear |
| | 24. Needle bearing |

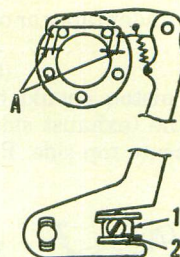
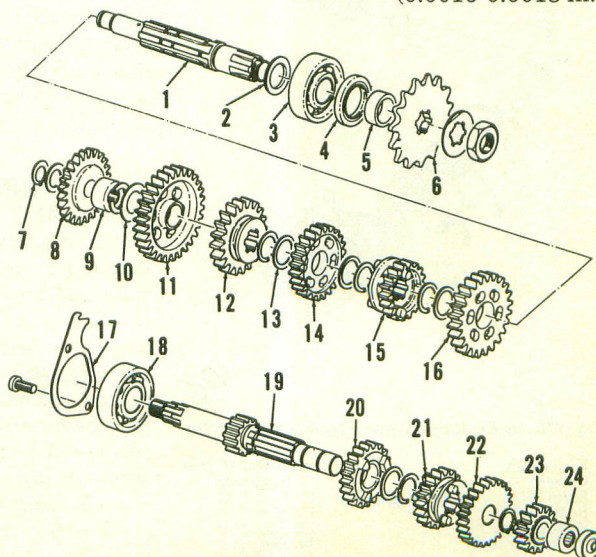


Fig. Y10-13—Shift arm clearance is adjusted by turning eccentric screw (2). Clearance (A) should be equal.

CLUTCH CONTROLS. Clutch is adjusted by loosening lock nut (2—Fig. Y10-7) and turning screw in until it seats lightly, then back screw out $\frac{1}{4}$ turn and tighten lock nut. Clutch lever should have 2-3mm free play as shown in Fig. Y10-8.

SUSPENSION. Front suspension units use SAE 10W/30 motor oil. The HT1 and HT1-B require 140cc of fluid in each fork tube and all other units require 152cc of fluid in each fork tube. Forks may be disassembled by removing the outer tube nut (13—Fig. Y10-9) and set bolt (23). HT-1 and HT1-B forks have no bolt (23).

Rear suspension units are not repairable and should be renewed if leaking or damaged.

REPAIRS

CYLINDER, PISTON AND RINGS. It is necessary to remove head, exhaust pipe, oil delivery line, and cylinder to remove piston. Use the following repair specifications.

Ring end gap—

125cc "MX" models 0.4-0.6mm
(0.016-0.024 in.)

All other models 0.15-0.35mm
(0.006-0.014 in.)

Piston skirt to cylinder

clearance 0.040-0.045mm
(0.0016-0.0018 in.)

Maximum cylinder taper or out
of round 0.05mm
(0.0019 in.)

Arrow on piston should be toward
front of engine (exhaust side). Marks
on rings indicate top side. Rings with

"2" stamped on them belong in second
groove from top of piston. Piston should
be measured 10mm ($\frac{3}{8}$ in.) from bottom
at right angles to pin hole for cylinder
clearance check. Piston pin should
have a snug fit. Torque head retaining
hardware to 2.0 kg-m (174 in. lbs.)
using a cross pattern to prevent head
warpage.

**CRANKCASE AND CRANK-
SHAFT.** Crankcase may be split after
removing cylinder and screws in left
side case. Clean mating surfaces well
and use a non-hardening type sealer
when assembling crankcase halves.

Crankshaft runout should be no
more than 0.03mm (0.0012 in.). Small
end shake (A—Fig. Y10-10) should be
no more than 2mm (0.078 in.). Side
clearance between large end of rod and
crank cheek should be 0.4-0.5mm
(0.016-0.019 in.)

TRANSMISSION. Transmission is
a five speed, constant mesh unit.
Transmission and shifter assembly
must be installed as a unit and in the
neutral position in left engine case.
Parts cannot be installed separately.
Refer to Fig. Y10-11.

Gear shift arm to pin clearance (A—
Fig. Y10-13) should be equal. Clear-
ance is adjusted by loosening lock nut
(1) and turning eccentric screw (2).

CLUTCH. Clutch is of the wet,
multi-disc type. It has five molded cork
friction plates and five steel plates.
Standard free length of clutch springs
used in 90cc models is 34mm (1.34 in.).
Clutch springs used in 125 and 175cc
models have a standard free length of
31.5mm (1.24 in.). Clutch springs
should be renewed if 1mm (0.039 in.) or
shorter than standard. Standard thick-
ness of friction discs is 4mm (0.157 in.).
Friction discs should be renewed if less
than 3.6mm (0.141 in.) thick. All clutch
discs should be checked for signs of
uneven wear or over-heating and re-
newed as necessary.

SPEED TUNING

The "MX" versions of the 90 and
125cc models are basically standard
with parts nonessential for competition
removed and specialized "GYT" parts
installed such as high compression
head, modified piston, larger carbure-
tor, expansion chamber and specially
ported cylinder. Many standard parts
may be modified to meet "GYT" speci-
fications. The following paragraphs list
*some of the differences between MX
models and standard models. Due to
similarities in the AT1 and CT1 mod-
els, many of the modifications will work*

on both versions. These specifications
are a guide only and will void warranty
on any machine they are applied to.

SPARK PLUG. An NGK type B-9E
is recommended for use in competition
models. Plug readings should be care-
fully checked to insure that proper heat
range is used.

CARBURETOR. Carburetor as-
sembly from appropriate competition
model may be fitted to improve perfor-
mance of "Enduro" models. A "GYT"
carburetor for the 250cc DT1-MX has
been found to work well on modified
175cc units.

IGNITION. Ignition timing speci-
fications for "MX" models may be ap-
plied to standard models. Set ignition
timing on 175cc models to AT1-MX
timing specification.

An AT1-MX magneto may be fitted
to standard models. If magneto is used
(standard on HT1 and CT1) remove
unused wiring and connect black lead
from magneto to high tension ignition
coil primary lead.

LUBRICATION. Oil metering
system may be left in place but a 30:1
fuel to oil mix should be used in fuel
tank. If the oil metering system is re-
moved, a 15:1 fuel to oil mix should be
used. Oil used in storage tank should
be same type used in fuel mix. Only oils
recommended for use in air cooled two
stroke engines should be used.

SUSPENSION. Weight and amount
of oil in front suspension units may be
varied to obtain feel desired. Suspen-
sion units (both front and rear) from
the 250cc DT1 may be bolted in place
on 125 and 175cc models for more dura-
bility.

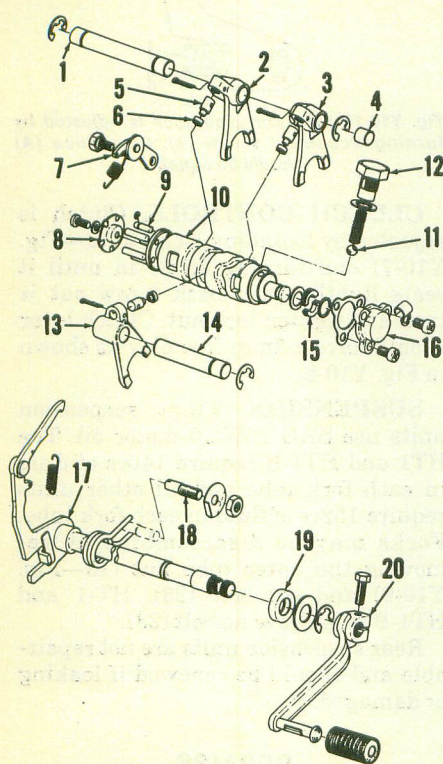


Fig. Y10-14—Exploded view of shifter assembly.

- | | |
|---------------------------|---------------------------|
| 1. Shift fork guide bar | 11. Steel ball |
| 2. Third shift fork | 12. Neutral spring screw |
| 3. First shift fork | 13. Second shift fork |
| 4. Blind plug | 14. Shift fork guide bar |
| 5. Cam follower pin | 15. Shift cam holders |
| 6. Cam follower roller | 16. Blind shift cam plug |
| 7. Stopper lever assembly | 17. Change shaft assembly |
| 8. Slide plate | 18. Eccentric screw |
| 9. Locating pin | 19. Oil seal |
| 10. Shift cam | 20. Shift lever |

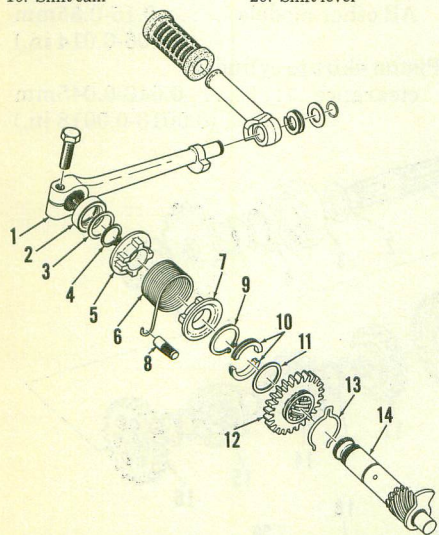


Fig. Y10-15—Exploded view of typical kick starter.

- | | |
|------------------|-------------------|
| 1. Kick crank | 8. Spring stopper |
| 2. Oil seal | 9. Snap ring |
| 3. Shim | 10. Gear holders |
| 4. Snap ring | 11. Shim |
| 5. Spring guide | 12. Kick gear |
| 6. Return spring | 13. Clip |
| 7. Spring guide | 14. Kick shaft |

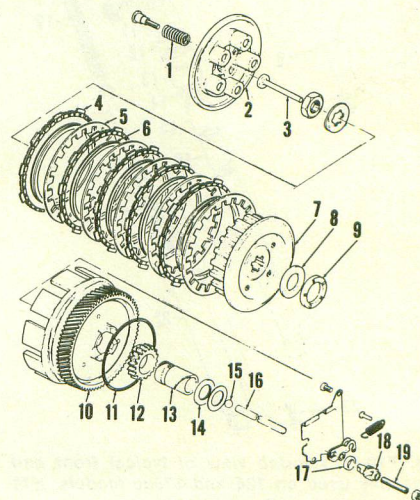


Fig. Y10-16—Exploded view of typical clutch assembly.

- | | |
|-------------------------|----------------------|
| 1. Clutch spring | 11. "O" ring |
| 2. Pressure plate | 12. Kick pinion gear |
| 3. Push rod | 13. Distance collar |
| 4. Friction plate | 14. Thrust plate |
| 5. Steel plate | 15. Ball |
| 6. Rubber cushion | 16. Push rod |
| 7. Clutch boss | 17. Oil seal |
| 8. Shim | 18. Push screw |
| 9. Bearing | 19. Adjusting screw |
| 10. Primary driven gear | |

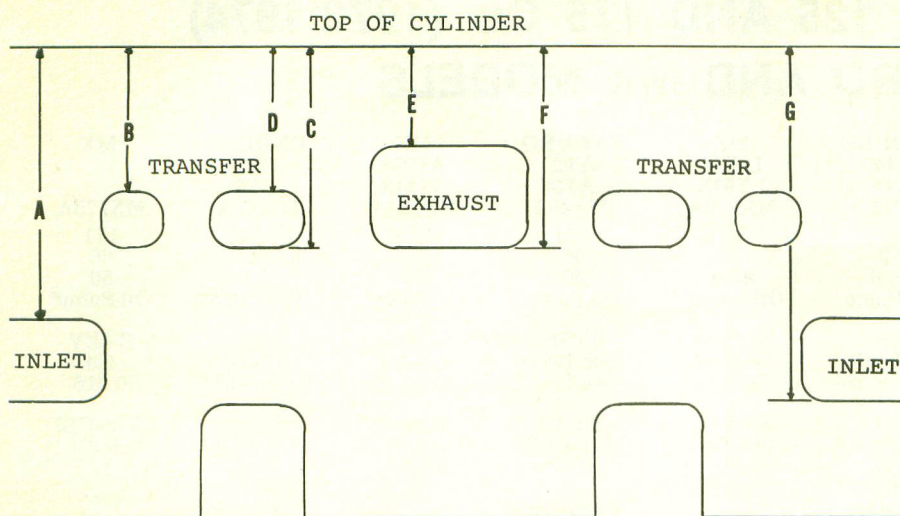


Fig. YT10-1—Cylinder porting diagram for Yamaha 90, 125 and 175cc single Enduro models. Refer to text for modification specifications.

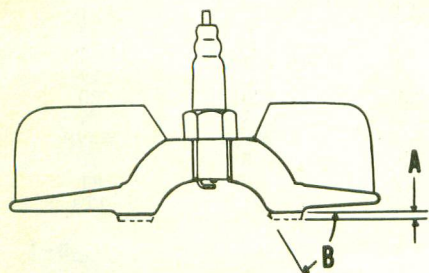


Fig. YT10-2—Angle of taper (B) must be remachined in head after it has been modified for higher compression.

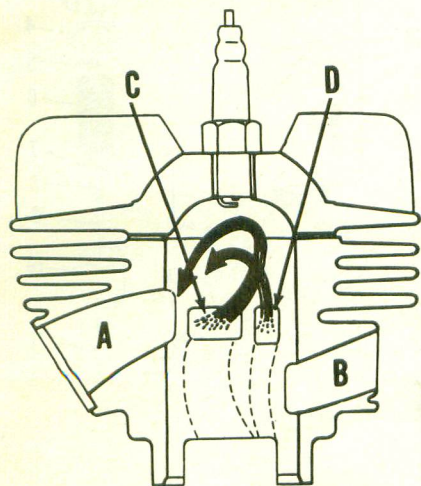


Fig. YT10-3—Basic port pattern of cylinder may be seen in this drawing.

A. Exhaust port
B. Intake port
C. Main transfer port

D. Auxiliary transfer port

PISTON, CYLINDER AND HEAD. Pistons used in MX (GYT) versions of AT1 and HT1 are 3mm (0.118 in.) shorter than standard and have only one piston ring. Standard pistons may be shortened 3mm to increase intake duration.

All top end components (head, cylinder, piston and gaskets) from 125cc MX model may be fitted to either 125 or 175cc engine.

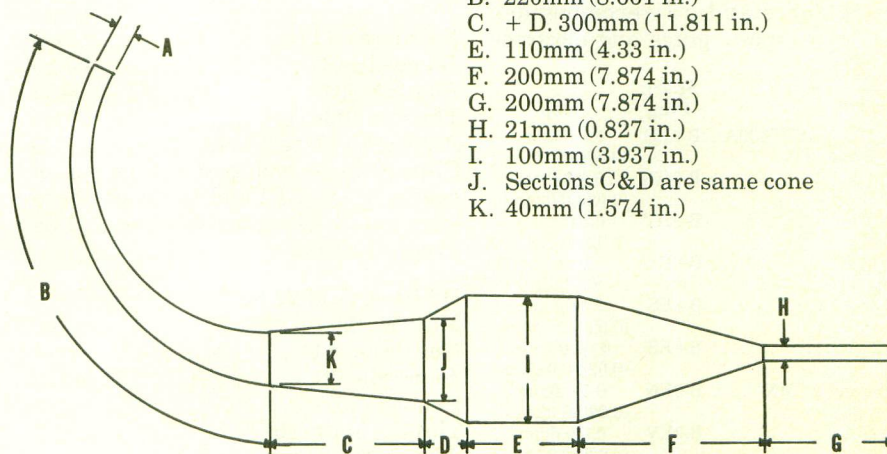


Fig. YT10-4—An expansion chamber will improve the performance of a correctly modified engine. Refer to text for specifications of an HT1-MX expansion chamber.

AT1-MX (GYT-Kit) Cylinder Specifications (Fig. YT10-1)

- A. Same as standard
- B. Same as standard
- C. Same as standard
- D. 39mm (1.535 in.)
- E. 27mm (1.063 in.)
- F. Same as standard
- G. 87mm (3.425 in.)

HT1B-MX (GYT-Kit) Cylinder Specifications (Fig. YT10-1)

- A. 60mm (2.36 in.)
- B. 35mm (1.38 in.)
- C. 46.5mm (1.83 in.)
- D. 35mm (1.38 in.)
- E. 24mm (0.94 in.)
- F. 46.5mm (1.83 in.)
- G. 81.5mm (3.20 in.)

Cylinder heads may be milled to match the capacity of the MX units. Standard head capacity of an AT1 is 14.6cc. AT1-MX head capacity is 11.9cc. A CT1 head may be safely modified to a capacity of 19.2cc instead of the standard 24.2cc. An HT1-MX has a head capacity of 8.3cc. Taper at edge of combustion chamber must be reshaped after milling head. (See Fig. YT10-2).

EXPANSION CHAMBER. The expansion chamber designed for the AT1-MX will also work well on CT1 models.

An HT1-MX expansion chamber may be constructed from the following specifications. (Refer to Fig. YT10-4)

- A. 35mm (1.378 in.)
- B. 220mm (8.661 in.)
- C. + D. 300mm (11.811 in.)
- E. 110mm (4.33 in.)
- F. 200mm (7.874 in.)
- G. 200mm (7.874 in.)
- H. 21mm (0.827 in.)
- I. 100mm (3.937 in.)
- J. Sections C&D are same cone
- K. 40mm (1.574 in.)

YAMAHA 100, 125 AND 175 CC (1972-1974) ENDURO AND MX MODELS

	ENDURO LT2 LT3 DT100A	MX LT2M LTMX MX100A	ENDURO AT2 AT3 DT125A	MX AT2M ATMX MX125A	ENDURO CT2 CT3 DT175A	MX MX175A
MODEL						
Displacement-cc	97	97	123	123	171	171
Bore-mm	52	52	56	56	66	66
Stroke-mm	45.6	45.6	50	50	50	50
Oil-Fuel ratio	Oil Pump	Oil Pump*	Oil Pump	Oil Pump*	Oil Pump	Oil Pump*
Spark plug—						
NGK	B-8HS	See Text	B-8ES	See Text	B-8ES	B-8EV
Electrode gap-mm	0.5-0.6	See Text	See Text	0.5-0.6	0.5-0.6	0.4
Inch	0.020-0.024	See Text	See Text	0.020-0.024	0.020-0.024	0.016
Ignition—						
Point gap-mm	0.3-0.4	See Text	0.3-0.4	0.3-0.4	0.3-0.4	None(CDI)
Inch	0.012-0.016	See Text	0.012-0.016	0.012-0.016	0.012-0.016	None(CDI)
Timing-mm BTDC	1.8	2.0	1.8	2.0	1.8	2.0
Electrical system voltage	6	....	12	....	6	....
Battery terminal grounded	Negative	....	Negative	....	Negative	....
Tire size-Front	2.75 x 18**	2.75 x 19	3.00 x 18**	2.75 x 21	3.25 x 18**	2.75 x 21
Rear	3.00 x 18	3.00 x 18	3.25 x 18	3.50 x 18	3.50 x 18	3.50 x 18
Tire pressure—						
Front-kg/cm ²	1.0	1.0	1.0	1.0	1.0	1.0
Psi	14	14	14	14	14	14
Rear-kg/cm ²	1.2	1.2	1.2	1.2	1.2	1.2
Psi	17	17	17	17	17	17
Rear chain free play-mm	20	20	25	20	20	20
Inch	¾	¾	1	¾	¾	¾
Rear chain size	#428	#428	#428	#428	#428	#428
Number of speeds	5	5	5	5	5	5
Weight (approx.)-kg.	85	80	106	92	98	81
Pounds	187	176	233	202	217	179

*Manufacturer recommended that a 1:30 oil to fuel ratio be used in fuel tank in addition to oil pump.

**Front tire size of DT100A is 2.75 x 19; front tire size of DT125A is 3.00 x 19 and front tire size of DT175A is 3.25 x 19.

Illustrations courtesy of Yamaha International Corporation

MAINTENANCE

SPARK PLUG. Refer to the following for standard recommended NGK type spark plugs and electrode gap:

Model	Spark Plug	Gap
LT2, LT3 and DT100A	B-8HS	0.5-0.6mm (0.020-0.024 in.)
LT2M	B-9HN	0.5-0.6mm (0.020-0.024 in.)
LTMX	B-9HV	0.5-0.6mm (0.020-0.024 in.)
MX100A	B-9EV	0.4mm (0.016 in.)
AT2 and AT3	B-8ES	0.5-0.6mm (0.020-0.024 in.)
DT125A	B-8ES	0.06-0.7mm (0.024-0.028 in.)
AT2M and ATMX	B-9EN	0.5-0.6mm (0.020-0.024 in.)
MX125A	B-9EV	0.5-0.6mm (0.020-0.024 in.)
CT2, CT3 and DT175A	B-8ES	0.5-0.6mm (0.020-0.024 in.)
MX175A	B-8EV	0.4mm (0.016 in.)

CARBURETOR. Mikuni sliding valve type carburetors are used on all models. Refer to Fig. Y18-1 and the following recommended carburetor specifications:

LT2 AND LT3 (VM 20 SH)

Main jet (22)—

LT2	#120
LT3	#130

Needle jet (11) N-6
Jet needle (9) 4 J 13
Pilot jet (23) #25
Throttle slide (10) 1.5
Air screw (13) turns out 1½
Clip (8) in second groove from top of needle (9) on LT2 and in third groove from top on LT3. Float level should be 21mm (13/16 in.).

DT100A (VM 22 SS)

Main jet (22) #160
Needle jet (11) N-4
Jet needle (9) 4 L 6
Pilot jet (23) #25
Throttle slide (10) 1.5
Air screw (13) turns out 1¼
Clip (8) in second groove from top of needle (9). Float level should be 21mm (13/16 in.).

LT2M and LTMX (VM 26 SC)

Main jet (22) #160
Needle jet (11) 0-2
Jet needle (9) 4 F 15
Pilot jet (23) #40
Throttle slide (10) 1.0
Air screw (13) turns out 1¼
Clip (8) in third groove from top of needle (9). Float level should be 25.7mm (1 in.).

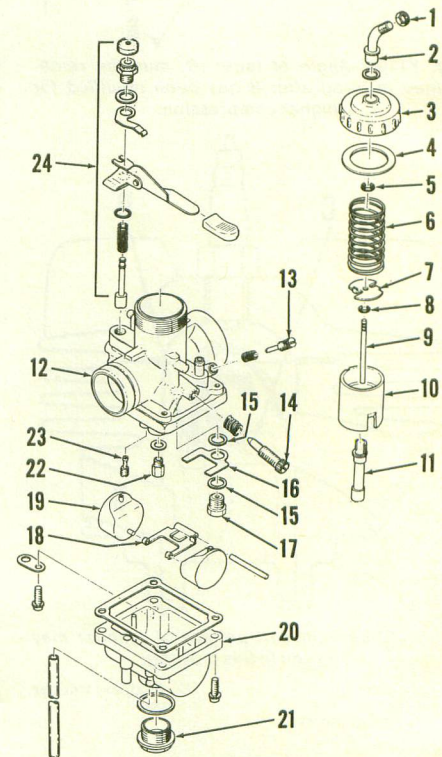


Fig. Y18-1—Exploded view of typical carburetor assembly used on MX models. Other units are similar.

1. Lock nut
2. Cable guide
3. Mixing chamber cap
4. Gasket
5. Lock clip
6. Throttle return spring
7. Spring seat
8. Jet needle clip
9. Jet needle
10. Throttle slide
11. Needle jet
12. Throttle body
13. Pilot air screw
14. Idle speed screw
15. Washers
16. Set plate
17. Inlet valve
18. Float arm
19. Floats
20. Float bowl
21. Access plug
22. Main jet
23. Pilot jet
24. Starter assembly

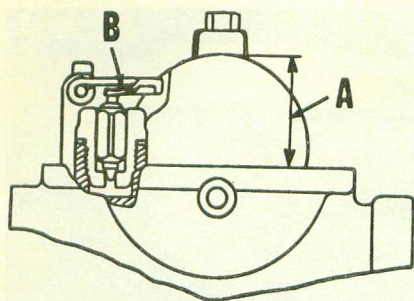


Fig. Y18-2—Carburetor should be held so that inlet valve needle is just closed, spring not compressed. Bend tang (B) on float arm to make adjustments.

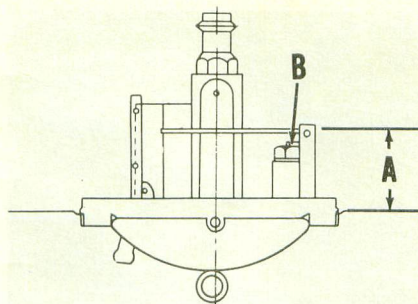


Fig. Y18-3—Float level (A) on models with separate float arm is measured from float arm to gasket surface. Adjust by bending tang (B).

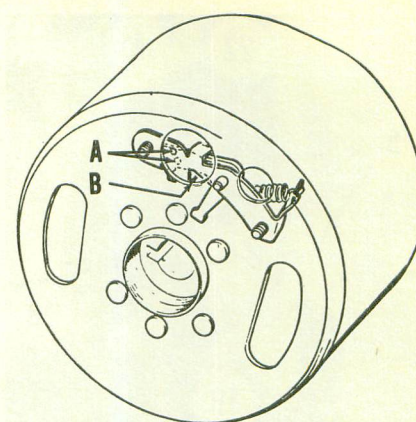


Fig. Y18-5—Flyweight on DT175A magneto may be held in full advance position by inserting a pin through holes (A) after prying weight up at point (B).

MX100A (VM 26 SC)

Main jet (22) #130
Needle jet (11) 0-4
Jet needle (9) 5 F 3
Pilot jet (23) #50
Throttle slide (10) 1.0
Air screw (13) turns out 1½
Clip (8) in third groove from top of needle (9). Float level should be 15.8mm (5/8 in.).

AT2 and AT3 (VM 24 SH)

Main jet (22) #230
Needle jet (11) 0-6
Jet needle (9) 5 J 3
Pilot jet (23) #35
Throttle slide (10) 2.5
Air screw (13) turns out 2
Clip (8) in third groove from top of needle (9). Float level should be 21mm (13/16 in.).

DT125A (VM 24 SH)

Main jet (22) #140
Needle jet (11) 0-0
Jet needle (9) 4 G 2
Pilot jet (23) #24
Throttle slide (10) 2.0
Air screw (13) turns out 1½
Clip (8) in third groove from top of needle (9). Float level should be 21mm (13/16 in.).

AT2M and ATMX (VM 26 SC)

Main jet (22) #190
Needle jet (11) N-8
Jet needle (9) 5 F 3
Pilot jet (23) #60
Throttle slide (10) 2.5
Air screw (13) turns out 1
Clip (8) in third groove from top of needle (9). Float level should be 25mm (31/32 in.).

MX125A (VM 28 SC)

Main jet (22) #170
Needle jet (11) N-8
Jet needle (9) 5 F 3
Pilot jet (23) #60
Throttle slide (10) 2.5
Air screw (13) turns out 1
Clip (8) in second groove from top of needle (9). Float level should be 15.8mm (5/8 in.).

CT2 and CT3 (VM 24 SH)

Main jet (22) #230
Needle jet (11) 0-6
Jet needle (9) 4 J 13
Pilot jet (23) #25
Throttle slide (10) 2.0
Air screw (13) turns out 2¼
Clip (8) in second groove from top of needle (9). Float level should be 21mm (13/16 in.).

DT175A (VM 24 SS)

Main jet (22) #160
Needle jet (11) 0-2
Jet needle (9) 5 G 4
Pilot jet (23) #25
Throttle slide (10) 2.0
Air screw (13) turns out 1
Clip (8) in third groove from top of needle (9). Float level should be 21mm (13/16 in.).

MX175A (VM 28 SC)

Main jet (22) #180
Needle jet (11) N-8
Jet needle (9) 5 F 3
Pilot jet (23) #60
Throttle slide (10) 2.5
Air screw (13) turns out 1
Clip (8) in third groove from top of needle (9). Float level should be 15.8mm (5/8 in.).

Floats may be separate from float arm as shown in Fig. Y18-1 or of one piece construction. Float level on units with one piece float/float arm assembly

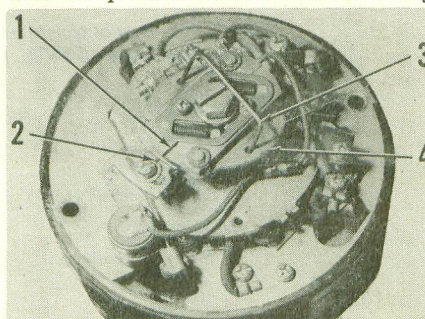


Fig. Y18-4—Flyweights (4) on advance mechanism of electric start models, may be held out with a length of a bent wheel spoke (3). Notch (2) on timing plate should be aligned with timing mark (1) when piston is 1.8mm BTDC.

is measured from gasket surface of throttle body to highest part of float with unit inverted (Fig. Y18-2). Float level on units with separate float arm is measured from gasket surface of throttle body to float arm (Fig. Y18-3).

IGNITION AND ELECTRICAL. A combination start motor/generator is used on all 125cc "Enduro" models. The MX175A is equipped with CDI (Capacitor Discharge Ignition) magneto. All other models are equipped with energy transfer type flywheel magneto. Refer to appropriate following paragraphs for ignition timing procedure.

Set breaker point maximum gap on LTMX to 0.25-0.3mm (0.010-0.012 in.) and to 0.3-0.4mm (0.012-0.016 in.) on all other models with breaker points. Ignition should occur, breaker points just open, when piston reaches 1.8mm (0.070 in.) BTDC on "Enduro" models or 2.0mm (0.078 in.) BTDC on "MX" models. A centrifugal advance mechanism is used on all electric start models and on DT175A models. Mechanism must be held to full advance position during ignition timing check (Fig. Y18-4 and Y18-5). A dial gage should be used to determine correct piston position for ignition timing checks.

To check ignition timing on MX175A, install a dial gage in spark plug hole and bring piston to 2.0mm

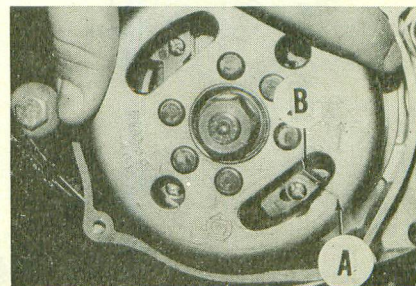


Fig. Y18-6—Timing mark (A) and pointer (B) on MX175A should be aligned when piston is 2.0mm BTDC.

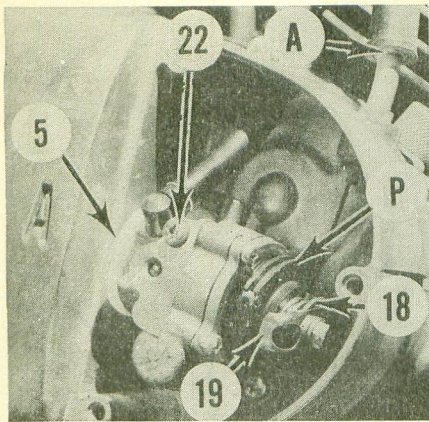


Fig. Y18-7—View of oil pump typical of unit used on all models. Pin, beneath cover plate (19), should align with mark on adjustment pulley (P) just before throttle slide begins to move. Cable adjuster (A) is used to set pump alignment marks.

(0.078 in.) BTDC. Timing mark and pointer (A&B—Fig. Y18-6) should be aligned at this point. Loosen screws (C) and reposition trigger coil to adjust timing.

The charge coil and the trigger coil on stator plate may be checked with an ohmmeter. Resistance between brown wire and black wire on charge coil should be 170 ohms. Resistance between white/red wire and white/green wire on trigger coil should be 55 ohms. A variation of 10% from specified resistance is allowed in both coils.

LUBRICATION. Clutch and transmission components are lubricated by SAE 10W/30 motor oil contained in the gearbox. Lubricant should be maintained at a level between two marks on

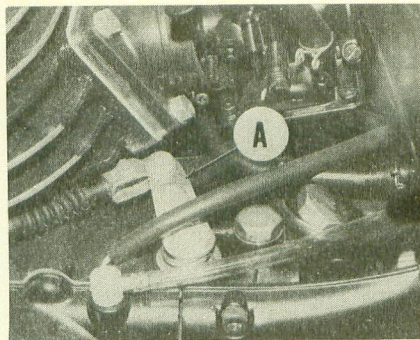


Fig. Y18-9—Loosen cable adjusters then use eccentric screw (19—Fig. Y18-22) to position lever arm (A) as shown. Do not turn eccentric in so far that it binds lever arm in crankcase.

filler plug dipstick with dipstick screwed in. Motorcycle should be held vertical, not on side stand, while making oil level check.

Engine lubrication, on all models, is accomplished by an automatic oil metering system. Oil tank should not be allowed to run dry and only 2-stroke, air cooled, engine oil should be used. Manufacturer recommends that a 1:30 oil to fuel ratio mixture be used in the fuel tank of "MX" models in addition to the automatic oil metering system.

Oil pump must be bled if it has been removed or allowed to run dry. To bleed pump, remove bleeder screw (22—Fig. Y18-7) and turn starter plate (5) upward while holding throttle fully open. When air is no longer present in oil coming from bleed hole, replace screw. Oil pump adjustment should be checked whenever throttle has been adjusted. Mark on pump adjustment pulley (P) should be aligned with pin, located beneath cover plate (19), when slack has been taken up in throttle cable but throttle slide has not started to move. Minimum pump stroke should be 0.20-0.25mm (0.008-0.010 in.). Minimum pump stroke is measured with throttle closed. Turn starter plate (5) until gap between adjuster plate (18) and pulley (P) is widest. Adjust gap to

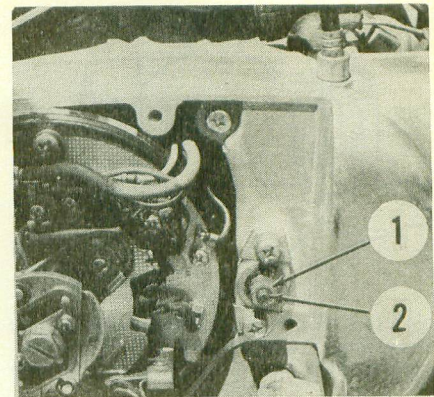


Fig. Y18-10—Turn screw (2) in until resistance is felt then back out 1/4 turn and tighten lock nut (1). Use cable adjusters to obtain proper handlever free play.

minimum stroke specification with various thicknesses of shim (17—Fig. Y18-8).

CLUTCH CONTROLS. Two different type clutch throw out assemblies are used. Unit with lever arm exposed on top of engine case (Fig. Y18-9) is primarily adjusted by turning adjusters in clutch cable. Coarse adjustment is provided by eccentric screw (19—Fig. Y18-22). Hold lever arm in approximate position shown in Fig. Y18-9 and turn eccentric screw until arm is held in proper position. NOTE: Full range of eccentric adjustment is accomplished in 180 degrees of movement. Do not turn screw in far enough to bind lever arm shaft or out so far that it disengages. Use cable adjusters to obtain 2-3mm (1/8 in.) free play at gap of hand-lever pivot.

To adjust unit with internal lever arm (Fig. Y18-10), back clutch cable adjusters off and loosen lock nut (1). Back adjusting screw (2) out until loose then turn it back in until a resistance is felt. Back adjusting screw out 1/4 turn from this position and tighten lock nut. Use cable adjuster to obtain 2-3mm (1/8 in.) free play at gap near handlever pivot.

SUSPENSION. Front suspension units on all models should be serviced with SAE 10W/30 motor oil or motorcycle fork oil. Refer to the following recommended front fork capacities:

MODEL QUANTITY OF OIL PER FORK LEG

LT2, LT2M, LT3 and LTMX	136cc
DT100A	160cc
MX100A	187cc
AT2, AT2M, AT3 and ATMX	120cc
DT125A	130cc
MX125A	134cc
CT2 and CT3	120cc
DT175A	130cc
MX175A	134cc

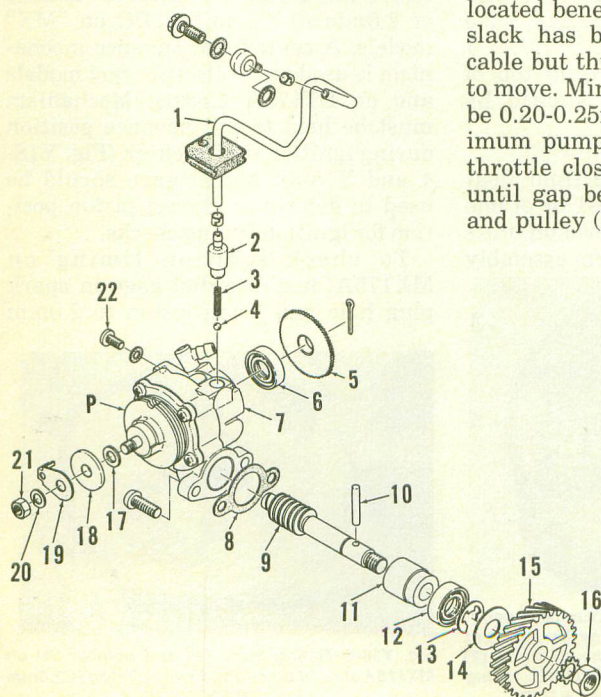


Fig. Y18-8—View of typical oil pump and related parts.

- P. Pump pulley
- 1. Oil pressure line
- 2. Check valve
- 3. Spring
- 4. Check valve ball
- 5. Starter plate
- 6. Oil seal
- 7. Pump assembly
- 8. Gasket
- 9. Worm shaft
- 10. Pin (3 x 21.8)
- 11. Worm shaft bushing
- 12. Oil seal
- 13. "E" ring
- 14. Washer
- 15. Drive gear
- 16. Nut
- 17. Shim
- 18. Adjusting plate
- 19. Cover plate
- 20. Lock washer
- 21. Nut
- 22. Bleed screw

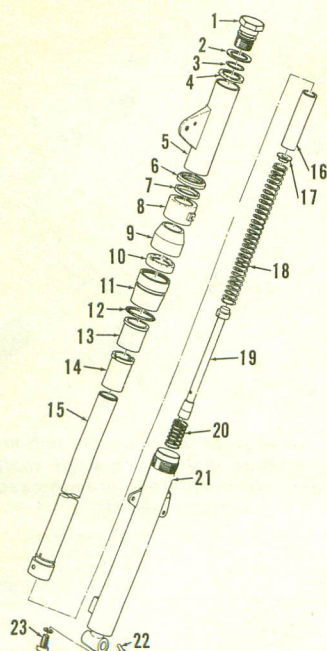


Fig. Y18-11—Exploded view of front suspension unit used on some models.

- | | |
|----------------------|------------------------|
| 1. Top nut | 14. Spacer |
| 2. Washer | 15. Inner fork tube |
| 3. "O" ring | 16. Spacer |
| 4. Rubber washer | 17. Spring seat |
| 5. Headlight bracket | 18. Fork spring |
| 6. Guide | 19. Fork cylinder |
| 7. Rubber washer | 20. Rebound stopper |
| 8. Cover | 21. Outer fork tube |
| 9. Dust cover | 22. Drain screw |
| 10. Oil seal | 23. Cylinder lock bolt |
| 11. Outer tube nut | |
| 12. "O" ring | |
| 13. Metal slider | |

Rear suspension units on MX100A, MX125A and MX175A may be disassembled for cleaning and replacement of dampening fluid. Viscosity of fluid used should be determined by rider preference. Each shock absorber should be serviced with 182.5cc (6.2 oz.) of shock fluid.

Tighten reservoir cap nut to 2.0-2.3 kg-m (14-16 Ft.-Lbs.) torque. Rear suspension units on other models are not repairable and should be renewed if leaking, bent or otherwise damaged.

REPAIRS

PISTON, RINGS AND CYLINDER. Cylinder and piston may be serviced after disconnecting oil delivery line and removing exhaust pipe, carburetor and cylinder head. A shop towel should be placed around connecting rod while cylinder is being lifted to prevent carbon particles or pieces of possible broken piston ring from falling into open crankcase. A suitable puller should be used to remove piston pin so that connecting rod is not damaged. Refer to the following repair specifications:

Piston skirt to cylinder clearance—

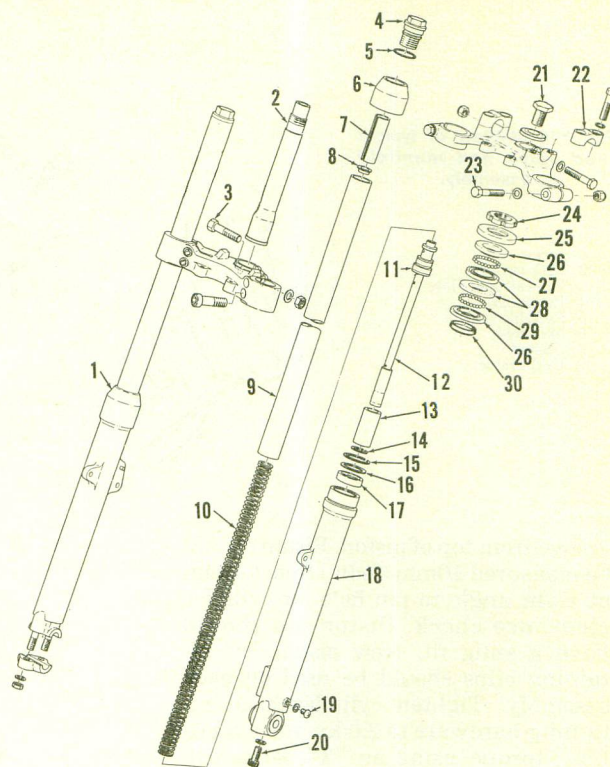
MX125A and

MX175A 0.045-0.050mm
(0.0018-0.0020 in.)

All other models ... 0.040-0.045mm
(0.0016-0.0018 in.)

Fig. Y18-12—View of front suspension unit used on most models. Forks may be disassembled after removal of snap ring (15) and cylinder lock bolt (20). Balls (27) used in top race are smaller than balls (29) used in lower race.

1. Fork assembly
2. Steering stem
3. Pinch bolt
4. Fork top bolt
5. "O" ring
6. Dust cover
7. Spacer
8. Spring seat
9. Inner fork tube
10. Fork spring
11. Valve
12. Cylinder assembly
13. Piston
14. Clip
15. Snap ring
16. Washer
17. Oil seal
18. Outer fork tube
19. Drain screw
20. Cylinder lock bolt
21. Stem bolt
22. Handlebar clamp
23. Pinch bolt
24. Stem nut
25. Cover
26. Bearing cone
27. Bearing balls (22 each)
28. Bearing cups
29. Bearing balls (19 each)
30. Dust seal



Piston ring end gap—
LT2M, LTMX and all 100cc "Enduro"

models—Both rings 0.15-0.35mm
(0.006-0.014 in.)

MX100A and MX125A 0.4-0.5mm
(0.016-0.020 in.)

AT2, AT2M, AT3 and ATMX—
Both rings 0.3-0.5mm
(0.012-0.020 in.)

DT125A—Top ring 0.15-0.35mm
(0.006-0.014 in.)

Bottom ring 0.3-0.5mm
(0.012-0.020 in.)

CT2 and CT3—Both rings .. 0.2-0.4mm
(0.008-0.016 in.)

DT175A and MX175A—
Both rings 0.3-0.5mm
(0.012-0.020 in.)

Maximum cylinder taper—
All models 0.05mm
(0.0019 in.)

Arrow on piston should be toward front of engine (exhaust side). Marks on rings indicate top side. Rings with "2" stamped on them belong in second

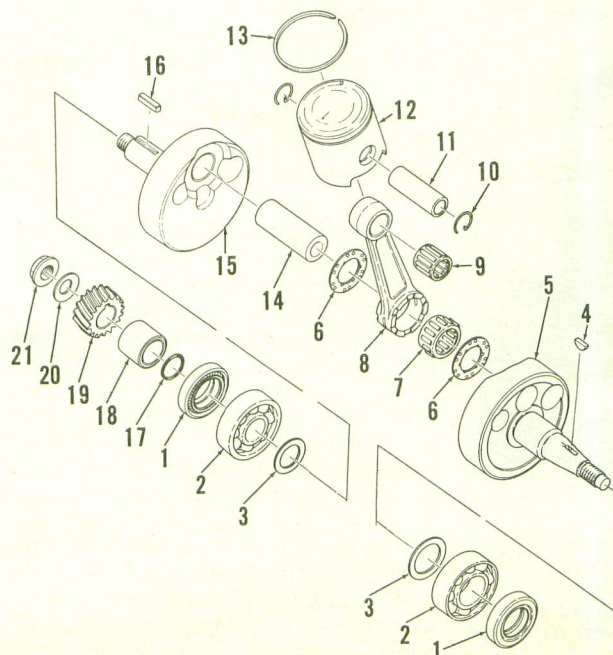
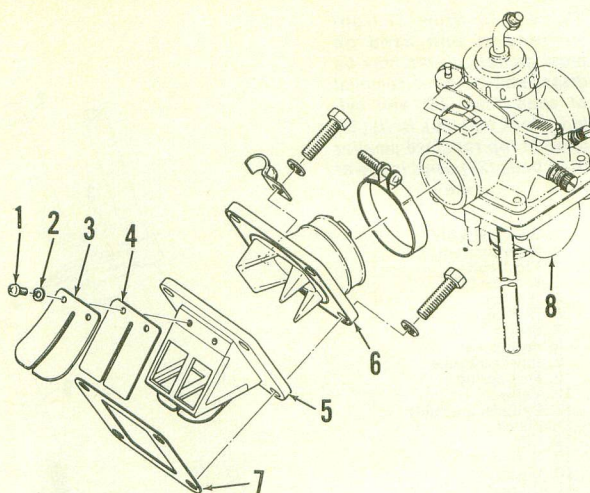


Fig. Y18-13—Exploded view of MX125A crankshaft assembly. Other units are similar.

1. Oil seal
2. Ball bearing
3. Shim
4. Woodruff key
5. Left crank half
6. Side washer
7. Needle bearing
8. Connecting rod
9. Needle bearing
10. Piston pin clip
11. Piston pin
12. Piston
13. Piston ring
14. Crank pin
15. Right crank half
16. Key
17. "O" ring
18. Collar
19. Primary gear
20. Belleville washer
21. Lock nut

Fig. Y18-14—View of typical reed valve and manifold assembly.

1. Screw
2. Lock washer
3. Reed stopper plate
4. Reed petal
5. Reed block
6. Manifold
7. Gasket
8. Carburetor



groove from top of piston. Piston should be measured 10mm ($\frac{3}{8}$ in.) from bottom at right angle to pin hole for cylinder clearance check. Piston pin should have a snug fit. New piston pin retaining clips should be used on each assembly. Tighten cylinder head retaining hardware to 2.0 kg-m (14.5 Ft.-Lbs.) torque using an "X" pattern to prevent warpage.

Inspect reed petals (4—Fig. Y18-14) for cracks or tears. Petals should be renewed if any flaws are detected. Curve of reed stopper plate (3) should be smooth and free of kinks or rough spots. Check rubber coating on reed block (5) for cracking or peeling. When assembling unit, place corner of reed petal with notch (N—Fig. Y18-15) beneath corner of reed stopper plate with flat (F).

CRANKSHAFT AND CONNECTING ROD. Engine must be removed from frame and disassembled to service crankshaft assembly. Refer

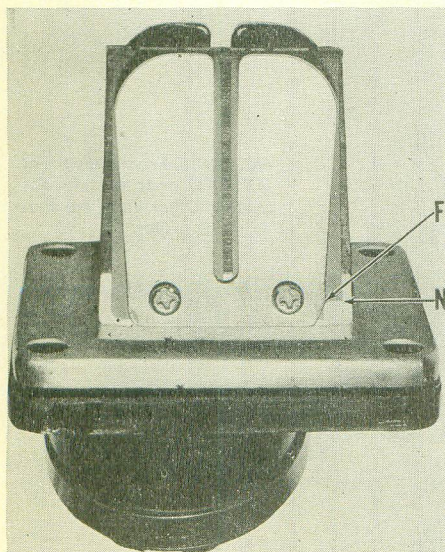


Fig. Y18-15—Notched corner of reed petal (N) should be next to flattened corner (F) of reed stopper plate.

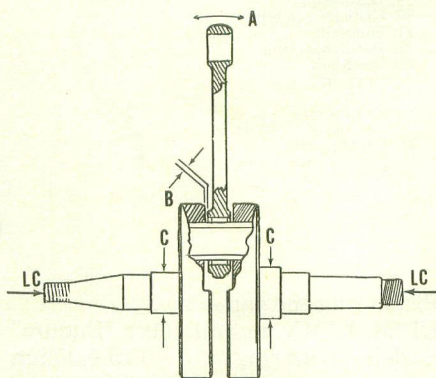


Fig. Y18-16—Crankshaft assembly should be supported on lathe centers (LC) when making checks for runout.

to CRANKCASE AND GEARBOX section for disassembly procedure.

Crankshaft runout, measured on main bearing surfaces, should be no more than 0.03mm (0.0012 in.). Small end shake (A—Fig. Y18-16) should be no more than 2.0mm (0.078 in.). Side clearance (B) between large end of connecting rod and crank wheel should be 0.4-0.5mm (0.016-0.019 in.). Width of crankshaft, measured on flywheel outer faces, should be 50mm (1.968 in.) for 100cc models and 56mm (2.205 in.) for all other models.

CRANKCASE AND GEARBOX.

Gearbox components may be serviced after engine is removed from frame and disassembled. Drain gearbox lubricant. Use appropriate puller to remove magneto flywheel or starter dynamo rotor. Remove clutch assembly, primary drive gear, kick starter and kick idler gear from right side of engine. Remove shifter cover from left side of engines so equipped. Remove "E" ring (8—Fig. Y18-17), change lever (9) and secondary change shaft assembly (3). Pull primary change shaft (12) from right side of engine. Remove change shaft assembly from right side of units with one piece change shaft. Remove shift

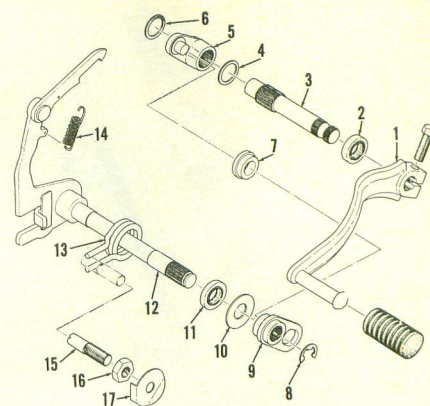


Fig. Y18-17—View of two shaft type shift arm assembly. Change shaft (12) on single shaft type units extends completely through case and mounts lever (1).

- | | |
|---------------------------|--------------------------|
| 1. Foot lever | 9. Lever arm |
| 2. Oil seal | 10. Washer |
| 3. Secondary change shaft | 11. Oil seal |
| 4. Shim washer | 12. Primary change shaft |
| 5. Lever arm | 13. Centering spring |
| 6. Shim washer | 14. Arm return spring |
| 7. Roller | 15. Eccentric screw |
| 8. "E" ring | 16. Nut |
| | 17. Lock washer |

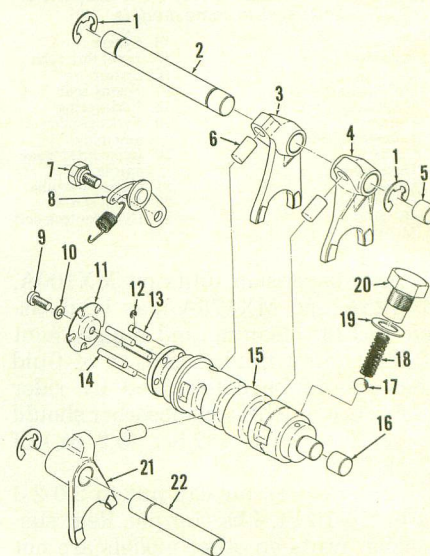


Fig. Y18-18—View of shift drum and forks typical of all models.

- | | |
|-----------------------|---------------------|
| 1. "E" ring | 12. "E" ring |
| 2. Shift fork axle | 13. Locating pin |
| 3. Shift fork | 14. Dowel pins |
| 4. Shift fork | 15. Shift drum |
| 5. Plug | 16. Plug |
| 6. Fork guide roller | 17. Detent ball |
| 7. Stopper lever bolt | 18. Detent spring |
| 8. Stopper lever | 19. Washer |
| 9. Screw | 20. Detent plug |
| 10. Lock washer | 21. Shift fork |
| 11. Side plate | 22. Shift fork axle |

cam stopper assembly (17-20—Fig. Y18-18), then remove pan head screws in left case half. Carefully bump crankcase sections apart. Crankshaft and transmission components should remain in left case half on disassembly.

Inspect thrust pads on shift fork fingers and grooves in sliding gears for signs of excessive wear or overheating. Check engagement dogs on gears for wear. Inspect gears for broken or cracked teeth and check shafts for wear on spines and seal contact areas. When reassembling transmission, make sure

Fig. Y18-19—Exploded view of five speed transmission typical of all models.

1. Nut
2. Lock washer
3. Sprocket
4. Collar
5. Oil seal
6. Ball bearing
7. Output shaft
8. Second gear
9. Washer
10. Snap ring
11. Fifth gear
12. Third gear
13. Fourth gear
14. First gear
15. Shim
16. Snap ring
17. Needle bearing
18. Kick idler gear
19. Thrust washer
20. Second gear
21. Fifth gear
22. Third gear
23. Fourth gear
24. Input shaft

that snap rings are fully seated in grooves. Transmission shafts should be meshed together with shifter forks installed and placed in left case half as an assembly. Unit should be in neutral when installed (Fig. Y18-20). Make certain that mating surfaces of crankcase sections are clean and free of any nicks or burrs. Coat mating surfaces with a even coat of a non-hardening type gasket sealer and assemble. Check all shafts for freedom of movement after screws have been tightened.

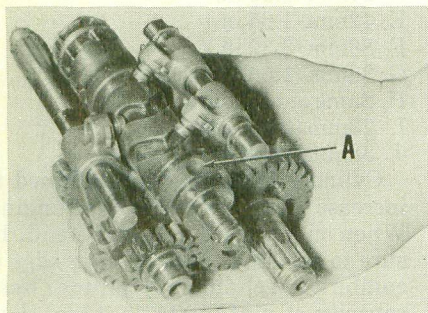


Fig. Y18-20—Install transmission as a unit. Recess (A) for detent ball should be in position shown.

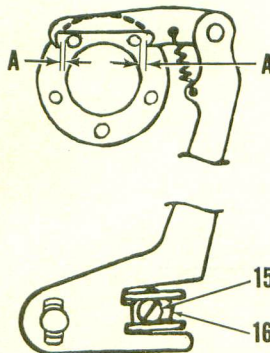


Fig. Y18-21—Turn eccentric screw (15) until clearance (A) between hooks on change arm and dowel pins in end of shift drum is equal. Tighten lock nut (16) and bend over a portion of lock washer when adjustment is completed.

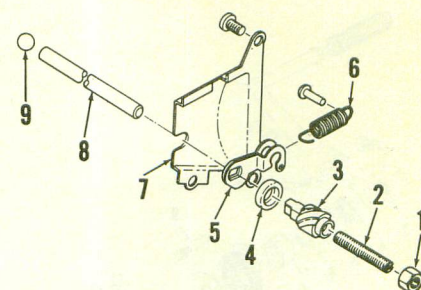
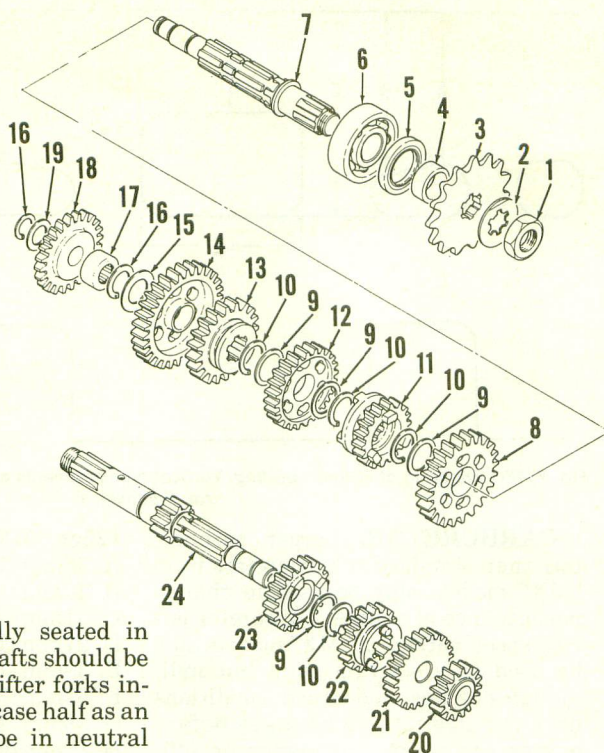


Fig. Y18-23—View of clutch throw out mechanism used on some models.

1. Lock nut
2. Adjusting screw
3. Release screw
4. Oil seal
5. Lever arm
6. Return spring
7. Cover
8. Push rod
9. Steel ball

ferent gears to make certain adjustment is correct.

CLUTCH. The wet type, multiple disc clutch has five friction discs (7—Fig. Y18-22) and five steel plates (8). Standard free length of clutch spring (2) used in AT2, AT3, AT2M, ATMX, CT2 and CT3 models is 31.5mm (1.24 in.). Clutch springs in all other models are 34mm (1.34 in.) long when new. Springs should be renewed if 1mm (0.04 in.) or more shorter than standard. Standard thickness of friction discs (7) is 4mm (0.157 in.). Discs should be renewed if less than 3.6mm (0.141 in.) thick, if worn unevenly or if evidence of overheating is found. Steel plates (8) should be renewed if burned or warped from flat by more than 0.05mm (0.002 in.).

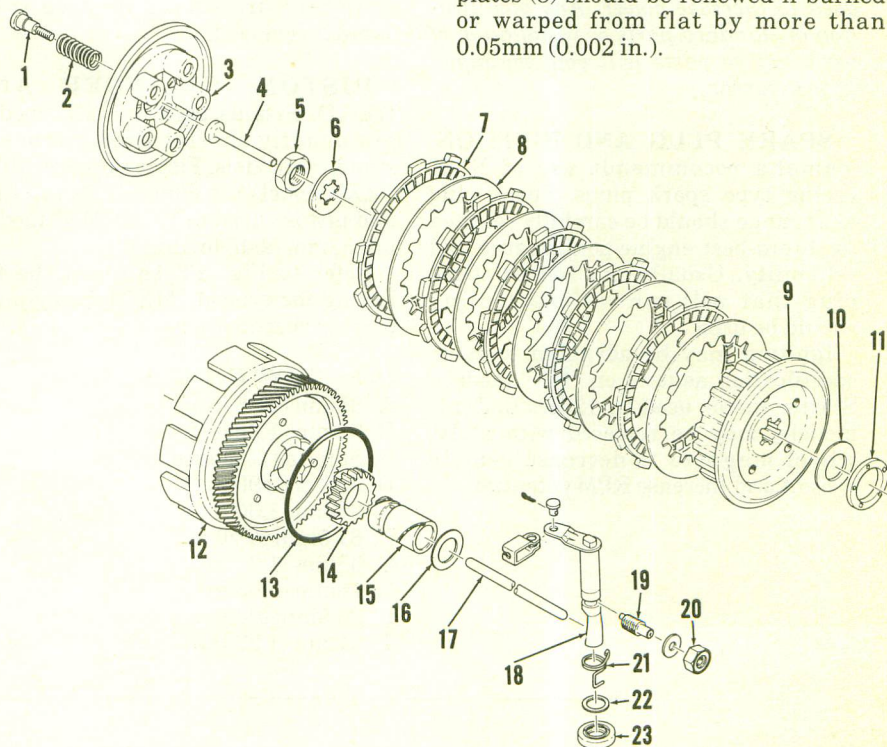


Fig. Y18-22—Exploded view of typical clutch assembly. Throw out mechanism (parts 17-23) is used on some late models. Refer to Fig. Y18-23 for throw out mechanism used on other models.

1. Screws
2. Clutch springs
3. Pressure plate
4. Pusher piece
5. Nut
6. Lock washer
7. Friction disc
8. Steel plate
9. Clutch hub assembly
10. Thrust plate (2mm)
11. Thrust bearing
12. Clutch housing/primary gear
13. "O" ring
14. Kick gear
15. Bushing
16. Thrust plate (3mm)
17. Push rod
18. Lever arm
19. Eccentric screw
20. Lock nut
21. Return spring
22. Shim
23. Oil seal

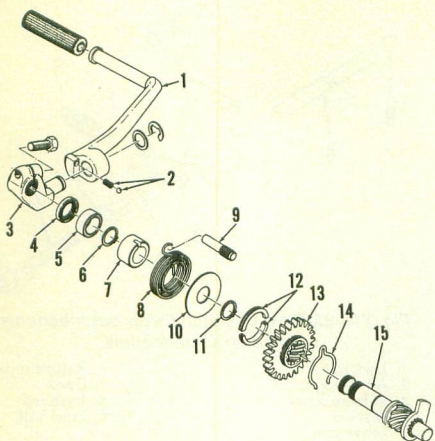


Fig. Y18-24—Exploded view of typical kickstarter assembly.

1. Kick pedal
2. Pedal detent
3. Kick boss
4. Oil seal
5. Spacer
6. Snap ring
7. Spring guide
8. Return spring

9. Pin
10. Washer
11. Snap ring
12. Holder pieces
13. Kick gear
14. Clip
15. Kick shaft

SPEED TUNING

The "MX" models covered in this section are basically "Enduro" models with special high performance parts added and parts not needed in competition removed. Many design specifications of "MX" models may be used to modify standard parts for an increase in performance. The fitting of "MX" parts to standard models may also be used to increase power. Any modification of standard parts or installation of performance parts will void manufacturers warranty.

SPARK PLUG AND IGNITION.

Yamaha recommends use of NGK racing type spark plugs. Spark plug heat range should be carefully selected to obtain best engine performance and reliability. Usually, the coldest spark plug that will run without fouling should be used.

Ignition may be advanced to same specification as used on "MX" models. Starter motor used on 125cc "Enduro" models, may be replaced with a fly-wheel magneto to decrease vehicle weight and increase RPM potential.

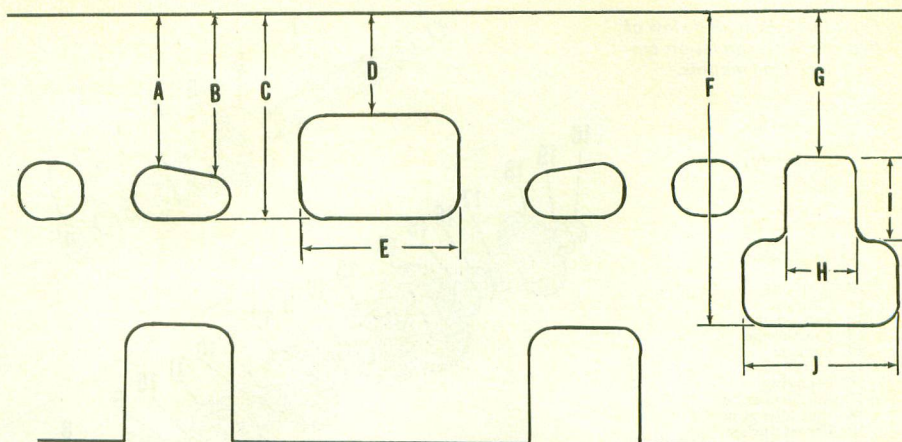


Fig. YT18-1—Diagram of cylinder porting. Vertical measurements are to top of cylinder. Refer to text for dimensions.

CARBURETOR. Larger carburetors than standard or carburetors from "MX" models may be used to change performance of engine. Carburetor jetting specifications of "MX" models may be used as a starting point but individual engines and track conditions may require jetting changes before engine can operate at maximum efficiency.

LUBRICATION. Manufacturer recommends using a 1:30 oil to fuel mix in the fuel tank in addition to the automatic oil metering system on models used in competition. A 1:15 oil to fuel ratio mixture should be used if oil pump is removed.

PISTON, CYLINDER AND HEAD. Pistons used in "MX" models are usually shorter than pistons in standard models. Pistons used in 100cc "MX" models are 60mm (2.36 in.) high and pistons used in 125cc "MX" models are 63mm (2.48 in.) high.

Refer to Fig. YT 18-1 and the following for typical "MX" type cylinder porting specifications:

100cc "MX" Cylinder

- A. 35mm (1.38 in.)
- B. 35mm (1.38 in.)
- C. Same as standard
- D. 23mm (0.90 in.)
- E. 33mm (1.30 in.)
- F. 81.5mm (3.20 in.)
- G. 35mm (1.38 in.)
- H. 16mm (0.63 in.)
- I. 20.5mm (0.80 in.)
- J. 31mm (1.22 in.)

125cc "MX" Cylinder

- A. 38mm (1.50 in.)
- B. 40mm (1.57 in.)
- C. 51mm (2.0 in.)
- D. 27mm (1.06 in.)
- E. 39mm (1.54 in.)
- F. 87mm (3.43 in.)
- G. 38mm (1.50 in.)
- H. 16mm (0.63 in.)
- I. 23mm (0.90 in.)
- J. 36mm (1.42 in.)

175cc "MX" Cylinder

- A. 38mm (1.50 in.)
- B. 38mm (1.50 in.)
- C. 51mm (2.0 in.)
- D. 27mm (1.06 in.)
- E. 42mm (1.65 in.)
- F. 86mm (3.39 in.)
- G. 38mm (1.50 in.)
- H. Same as standard
- I. 23mm (0.90 in.)
- J. 38mm (1.50 in.)

Cylinder head may be machined to increase compression ratio of engine. When machining cylinder head, be sure to reinstall taper at outer edge of combustion chamber. Cylinder head capacity of a MX100A is 9.1cc. Head capacity of a MX125A is 11.3cc and head capacity of a MX175A is 18.8cc.

YAMAHA 250 AND 360 CC (1968-1971) ENDURO AND MX MODELS

	ENDURO	MX	ENDURO	MX
MODEL	DT1 DT1B DT1C DT1E	DT1-MX* DT1C-MX DT1E-MX	RT1 RT1B	RT1-MX RT1B-MX
Displacement-cc	246	246	351	351
Bore-mm	70	70	80	80
Stroke-mm	64	64	70	70
Oil-Fuel ratio	Oil pump	Oil pump**	Oil pump	Oil pump**
Spark plug—				
NGK	B-7E	B-10EN	B-8E	B-9EN
Electrode gap-mm	0.5-0.6	0.5-0.6	0.5-0.6	0.5-0.6
Inch	0.020-0.024	0.020-0.024	0.020-0.024	0.020-0.024
Ignition—				
Point gap-mm	0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Inch	0.012-0.016	0.012-0.016	0.012-0.016	0.012-0.016
Timing-mm BTDC	2.3	2.3	3.4	3.4
Electrical system voltage	6	....	6	....
Battery terminal grounded	Negative	....	Negative	....
Tire size-Front	3.25 x 19	2.75 x 21	3.25 x 19	2.75 x 21
Rear	4.00 x 18	4.00 x 18	4.00 x 18	4.00 x 18
Tire pressure—				
Front-kg/cm ²	1.0§	0.6	0.9§	0.6
Psi	14§	8.5	13§	8.5
Rear-kg/cm ²	1.2§	0.7	1.1§	0.7
Psi	17§	10	16§	10
Rear chain free play-mm	20	20	25	25
Inch	0.8	0.8	1	1
Rear chain size	#520	#520	#520	#520
Number of speeds	5	5	5	5
Weight (approx.)-kg.	115	105	128	108
Pounds	268	232	282	238

*Dealer installed option on 1968 and 1969 Enduro models.

****Manufacturer recommends that a 1:30 oil to fuel mixture be used in the fuel tank in addition to automatic lubrication system. A 1:15 oil to fuel ratio should be used if oil pump is removed.**

§ Tire pressures should be reduced for off road use.

Illustrations courtesy of Yamaha International Corporation

MAINTENANCE

SPARK PLUG. Recommended spark plug electrode gap is 0.5-0.6mm (0.020-0.024 in.) for all models. Recommended spark plug for normal use in DT1 Enduro models is NGK type B-7E. DT1-MX models require NGK racing type B-10EN spark plugs. Standard spark plug for 360cc Enduro models is NGK type B-8E and for 360cc MX models is NGK racing type B-9EN.

CARBURETOR All models are equipped with a Mikuni sliding valve type carburetor. Refer to Fig. Y9-4 and the following recommended jetting specifications:

DT1 ENDURO MODELS (VM 26 SH)

Main jet (9) #160*
Needle jet (13) 0-2
Jet needle (6) 5D 1
Pilot jet (14) #35
Throttle slide (7) 2.5
Pilot air screw (11) turns out 1½
Clip (5) in third groove from top of
needle (6).

Float level (H—Fig. Y9-3)—

Carburetor I.D. #214 E1 and
#214E3 14.1mm
(0.555 in.)

Carburetor I.D. #214E4 ... 15.1mm
(0.594 in.)

*DT-1 models before engine serial number 2921 did not have expanders behind piston rings and were equipped with #150 main jets. All flat type replacement piston rings have expander rings and a #160 main jet should be installed.

DT1 MX MODELS (VM 30 SH)

Main jet (9)	#200-#230
Needle jet (13)	0-4
Jet needle (6)	5 D 5
Pilot jet (14)	#80
Throttle slide (7)	3.5

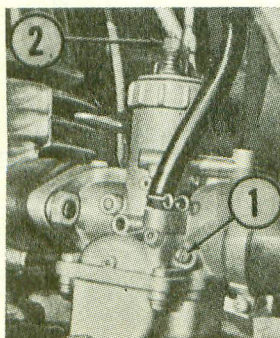


Fig. Y9-1—View of the carburetor used on early 250cc models. Idle mixture is adjusted at pilot air screw (1) and idle speed at adjuster (2).

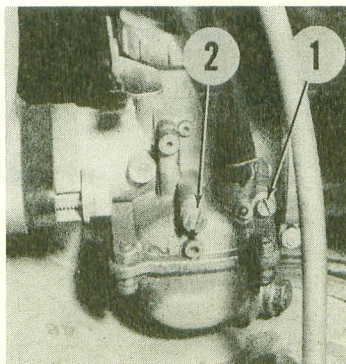


Fig. Y9-2—View of carburetor adjustments common to late model 250 and 360cc units.

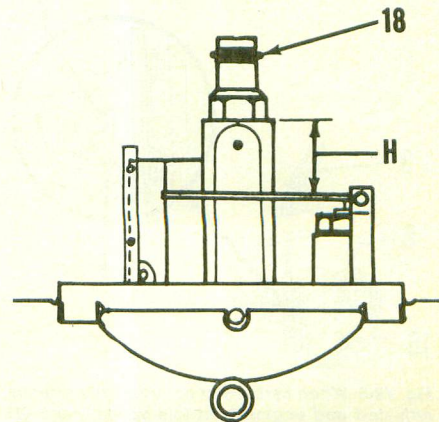


Fig. Y9-3—Make certain that “O” ring (18) is in perfect condition before installing float bowl.

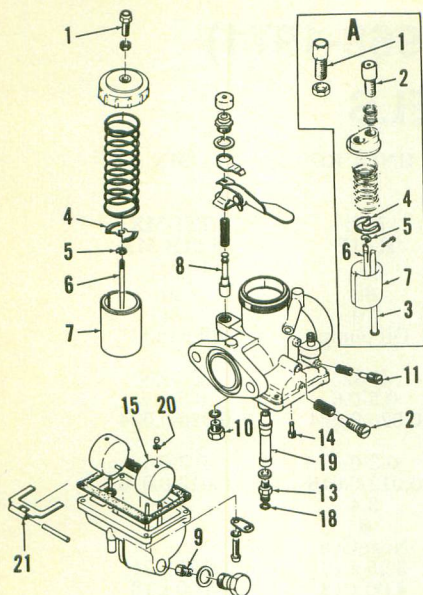


Fig. Y9-4—Exploded view of carburetor. Inset (A) is idle speed adjustment used on early DT-1 units.

- | | |
|------------------------|----------------------|
| 1. Cable guide | 10. Fuel inlet valve |
| 2. Idle speed adjuster | 11. Pilot air screw |
| 3. Idle speed stop rod | 13. Needle jet |
| 4. Retainer | 14. Pilot jet |
| 5. Clip | 15. Floats |
| 6. Jet needle | 18. "O" ring |
| 7. Throttle slide | 19. Main nozzle |
| 8. Starting valve | 20. Clips |
| 9. Main jet | 21. Float lever |

Pilot air screw (11) turns out—
 Carburetor I.D. #214M1 and
 #214M2 1/2
 Carburetor I.D. #285E1 and
 #292E1 1
 Clip (5) in third groove from top of
 needle (6).
 Float level (H—Fig. Y9-3)—
 Carburetor I.D. #214M1 and
 #214M2 14.1mm
 (0.555 in.)
 Carburetor I.D. #285E1 and
 #292E1 25.5mm
 (1.00 in.)

RT1 ENDURO MODELS (VM 32 SH)

Main jet (9) #220-#240*
 Needle jet (13) 0-4

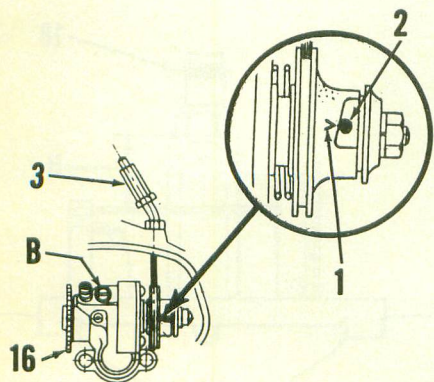


Fig. Y9-5—When carburetor controls are correctly adjusted and engine is at idle speed, mark (1) should be aligned with guide pin (2). Cable adjuster is shown at (3).

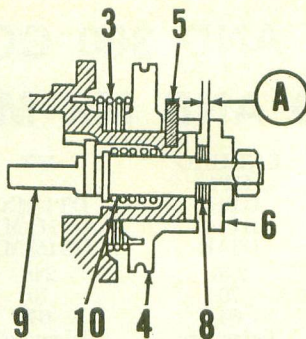


Fig. Y9-6—Clearance (A) should be 0.20-0.25mm and is adjusted by varying shims (8).

Jet needle (6) 6 DP 1*
 Pilot jet (14) #30
 Throttle slide (7) 1.5
 Pilot air screw (11) turns out 1 1/4*
 Float level (H—Fig. Y9-3) 8.5mm
 (0.33 in.)

*Some RT-1 models were equipped with a 6 CL 1 jet needle to smooth engine performance. If this needle is used a #230-#240 main jet is recommended and pilot air screw (11—Fig. Y9-4) should be 1 1/4 turns out.

Clip (5) in fourth groove from top of 6 DP 1 needle and second groove from top of 6 DF 1 needle.

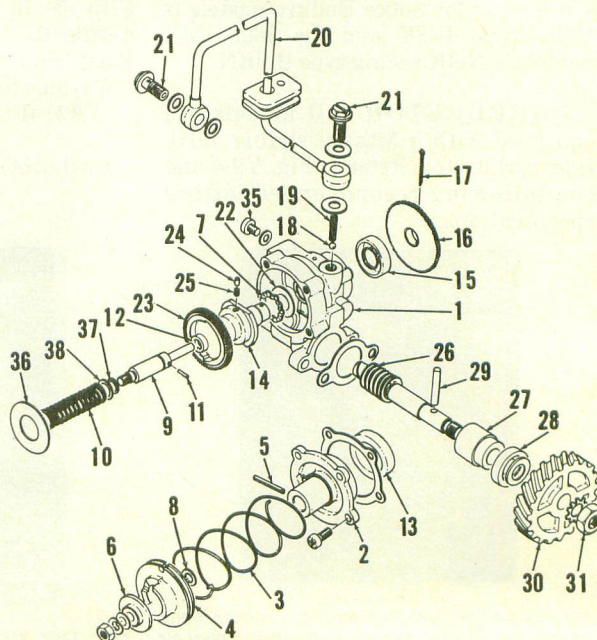
RT 1 MX MODELS (VM 34 SH)

Main jet (9) #310
 Needle jet (13) P-O
 Jet needle (6) 6 DH
 Pilot jet (14) #60
 Throttle slide (7) 2.5
 Pilot air screw (11) turns out 1 1/2
 Float level (H—Fig. Y9-3) 8.5mm
 (0.33 in.)

Throttle cable on all models should have 0.5-1.0mm (0.02-0.04 in.) free play at idle. Idle speed should be ad-

Fig. Y9-7—Exploded view of the "Autolube" oil injection pump.

- | | |
|---------------------------|------------------------|
| 1. Pump body | 21. Banjo bolts |
| 2. Cover | 22. Thrust plate |
| 3. Pulley spring | 23. Worm wheel |
| 4. Pulley | 24. Worm wheel pin |
| 5. Guide pin | 25. Spring |
| 6. Adjust plate | 26. Worm shaft |
| 7. Wave washer | 27. Worm shaft bushing |
| 8. Shims | 28. Oil seal |
| 9. Plunger | 29. Pin |
| 10. Plunger return spring | 30. Drive gear |
| 11. Plunger pin | 31. Nut |
| 12. Plunger oil seal | 35. Bleeder screw |
| 13. Plunger cam oil seal | 36. Plate |
| 14. Distributor | 37. Snap ring |
| 15. Distributor oil seal | 38. Spring seat |
| 16. Starter plate | |
| 17. Drive pin | |
| 18. Check ball | |
| 19. Check valve spring | |
| 20. Delivery pipe | |



justed with engine at normal operating temperature. Turn idle speed adjuster (2—Fig. Y9-1 or Fig. Y9-2) to obtain an idle speed of 1200-1400 RPM for 250cc models or 1400-1500 RPM for 360cc models.

IGNITION AND ELECTRICAL.

Enduro models are equipped with a 6V 2AH battery mounted beneath the seat. A single wave rectifier, also beneath seat, is used to convert AC current to DC for battery charging, horn and brake light. Magneto used on MX models also produces alternating current but no rectifier, battery or lights are fitted.

Ignition breaker point gap should be 0.3-0.4mm (0.012-0.016 in.) at maximum opening. Ignition should occur (points just open) when piston is 3.2mm (0.126 inch) BTDC on 250cc models and when piston is 3.4mm (0.134 inch) BTDC on 360cc models. When checking ignition timing on 360cc models it is necessary to secure advance mechanism flyweights to full open position. A dial gage may be used after removing cylinder head.

Mark on rotor can normally be aligned with pointer on stator when crankshaft is in correct position for ignition.

LUBRICATION. Oil contained in a separate tank is pumped into the inlet passage to lubricate the engine. The oil tank should be filled with SAE 30 two-stroke air-cooled engine oil and should **never** be allowed to run dry.

If the "Autolube" system is drained or the pump unit is renewed, the air should be bled from the system as follows: Remove screw (B—Fig. Y9-5) from bleeder hole, pull control cable up

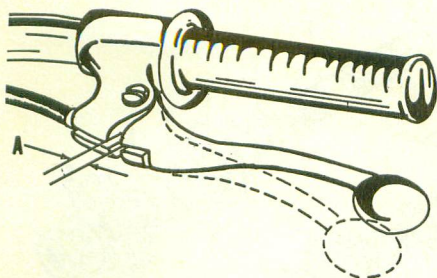


Fig. Y9-8—Clutch hand lever should have 2-3mm free play at (A). Refer to text for adjustment.

out of the guide (3) and turn starter plate (16) until oil without air bubbles flows from bleeder screw hole. Reinstall bleeder screw, then start engine and run at idle speed while pulling pump cable up until the oil delivery line is completely free of air bubbles. If bubbles cannot be removed from the pressure line, check for leaking pump seals or inlet oil line.

The pump must be correctly adjusted to provide the correct amount of oil for proper lubrication. Adjustment should be checked every 2,000 miles. To adjust, proceed as follows: Check the plunger minimum stroke by turning the starter plate (16) until clearance between pulley and adjusting plate is at its minimum, then measure clearance (A—Fig. Y9-6) with a feeler gage. If clearance is not within limits of 0.20-0.25mm (0.008-0.010 in.), vary the number of shims (8). Turn the throttle hand grip just enough to take up free play from the throttle cables (without changing idle speed) and check the oil pump setting mark and guide pin as shown in Fig. Y9-5. If the mark (1) is not exactly aligned with guide pin (2), loosen the lock nut and turn the pump cable adjuster (3) as required to align.

SAE 10W/30 engine oil should be used in the gear box. Capacity is 1000cc. Gear box should be drained and filled with new oil every 1200 miles.

CLUTCH CONTROLS. The clutch hand lever should have 2-3mm (0.08-0.12 in.) free play at (A—Fig. Y9-8). To adjust, remove the small plate from engine left side cover. Loosen the lock nut and turn the adjusting screw (S—Fig. Y9-9) in until slight resistance is

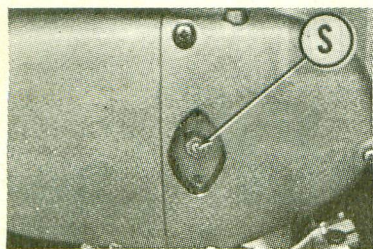


Fig. Y9-9—Clutch adjusting screw (S) is located under small plate on left side of engine. Make certain that lock nut is tightened after adjustment is complete.

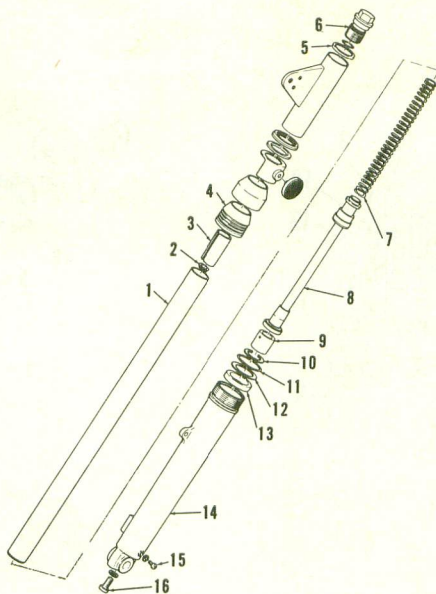


Fig. Y9-10—Exploded view of typical DT1E/RT1B front suspension unit. Holding bolt (16) must be removed to disassemble unit.

- | | |
|----------------------|---------------------|
| 1. Inner fork tube | 9. Piston |
| 2. Upper spring seat | 10. Snap ring |
| 3. Spacer | 11. Oil seal clip |
| 4. Dust seal | 12. Oil seal washer |
| 5. Upper cover guide | 13. Oil seal |
| 6. Cap bolt | 14. Outer fork tube |
| 7. Fork spring | 15. Oil drain plug |
| 8. Damper valve | 16. Holding bolt |

felt, then back the screw out $\frac{1}{4}$ turn and tighten lock nut. Adjust the cable guide at hand lever end to provide the correct amount of free play at (A—Fig. Y9-8).

SUSPENSION. Front suspension units on all models should be serviced with SAE 10W/30 motor oil. Front forks on DT1E, DT1E-MX, RT1B and RT1B-MX should be serviced with 175cc of lubricant each. Front forks on all other models should be serviced with 210cc of lubricant each.

Rear suspension units are not repairable and should be renewed if leaking, bent or otherwise damaged.

REPAIRS

PISTON, RINGS AND CYLINDER. Piston can be removed after removing exhaust pipe, carburetor, cylinder head and cylinder. Refer to the following repair specifications:

- Piston skirt to cylinder clearance—
- | | |
|--------------|---------------------|
| 250cc models | 0.040-0.045mm |
| | (0.0015-0.0017 in.) |
| 360cc models | 0.045-0.050mm |
| | (0.0017-0.0019 in.) |
- Piston ring end gap—
- | | |
|--------------|--------------------|
| 250cc models | 0.2-0.4mm |
| | (0.008-0.0016 in.) |
| 360cc models | 0.3-0.5mm |
| | (0.012-0.020 in.) |
- Maximum cylinder taper or out of round
- | | |
|-------|--------------|
| ..... | 0.05mm |
| | (0.0019 in.) |

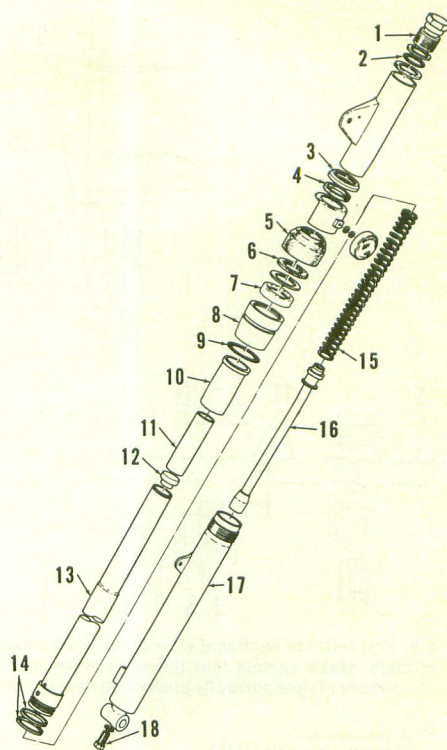


Fig. Y9-11—Exploded view of front suspension unit used on DT1C and RT1 models. Front forks used on earlier models are similar.

- | | |
|-------------------|-----------------------|
| 1. Cap bolt | 10. Metal slide |
| 2. "O" ring | 11. Spacer |
| 3. Cover guide | 12. Upper spring seat |
| 4. Packing | 13. Inner tube |
| 5. Dust seal | 14. Piston rings |
| 6. Washer | 15. Fork spring |
| 7. Oil seal | 16. Damper valve |
| 8. Outer tube nut | 17. Outer tube |
| 9. "O" ring | 18. Holding bolt |

NOTE: DT1 models before engine serial number 2921 did not have expanders behind piston rings and were equipped with #150 main jets. Replacement piston ring sets for early pistons are equipped with expander rings and should have a #160 main jet installed.

Standard and Keystone type rings have been used. Rings are not interchangeable between the two types of pistons. Keystone pistons can be identified by the letter "K" stamped on top of piston. Keystone type ring marked "1N" or "1T" should be installed in top groove. Keystone ring marked "2N" or "2T" should be installed in second groove. Marks on all types of piston rings should be toward top of pistons. Make certain that arrow on top of piston points toward front. On 250cc models, tighten cylinder head retaining hardware to 3.5-4.0 kg-m (25.3-29 Ft.-Lbs.) torque. On 360cc models, tighten 8mm stud nuts to 2.0 kg-m (13 Ft.-Lbs.) torque and 10mm stud bolts to 3.5-4.0 kg-m (25.3-29 Ft.-Lbs.) torque.

RT1B models are equipped with a decompression valve to aid in engine starting. If valve is suspected of being faulty it may be checked by removing

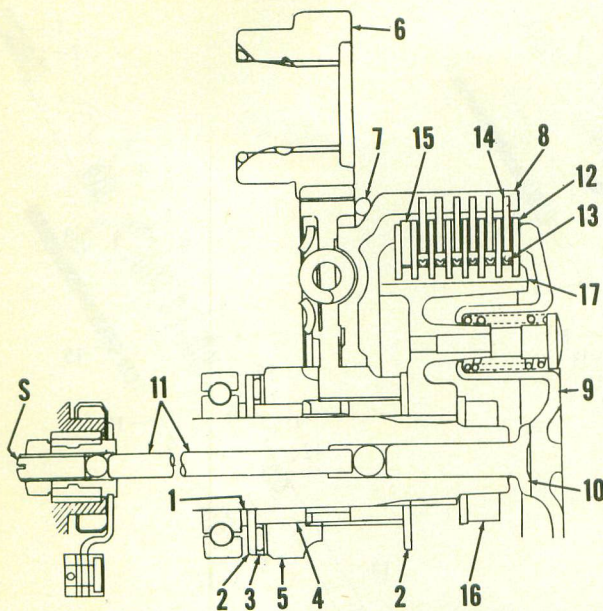


Fig. Y9-12—Cross sectional view of the clutch assembly typical of all models. Make certain that thrust washers (1 & 2), bearing (3) and spacer (4) are correctly positioned before tightening nut (16).

- | | |
|------------------------------------|----------------------------|
| S. Adjusting screw | 9. Pressure plate |
| 1. Thrust washer (small O.D.) | 10. Clutch release plunger |
| 2. Thrust washers (large O.D.) | 11. Release rods (2 used) |
| 3. Thrust bearing | 12. Driver plates |
| 4. Spacer | 13. Separator rings |
| 5. Kickstarter gear | 14. Friction discs |
| 6. Crankshaft (primary drive) gear | 15. Spacer |
| 7. "O" ring | 16. Nut |
| 8. Clutch drum | 17. Clutch hub |

the valve cover and squirting oil onto the valve with engine running. If oil is sucked in or blown off, check for the following; bent valve stem, maladjusted cable, carbon on valve seat or valve not completely screwed into head.

CONNECTING ROD AND CRANKSHAFT. The crankcase halves must be separated to remove the crankshaft. Connecting rod, crankpin and roller bearing are removed by pressing crankshaft apart. Crankshaft should be disassembled **only** if required tools are available to correctly check and align the reassembled crankshaft. If the connecting rod side shake at piston pin end exceeds 2mm (0.079 in.), the connecting rod, crankpin and lower end bearing should be renewed. The crankshaft eccentricity should be less than 0.03mm (0.0012 in.) when measured at main bearing journals with crankshaft supported between lathe centers. Connecting rod side clearance between crankshaft counter weights should be 0.4-0.5mm (0.016-0.020 in.).

CLUTCH. The clutch is located on the right end of the transmission input shaft and can be removed after removing the engine right side cover. Inspect all parts for wear, warpage or evidence of overheating. Free length of a clutch spring is 36.4mm (1.433 in.).

Replace the springs if they are 1mm (0.04 in.) shorter than standard. When assembling, make certain that clutch drum thrust washers (1&2—Fig. Y9-

12), thrust bearing (3) and spacer (4) are correctly installed. Spacer (15) is replaced with a friction disc on 360cc models.

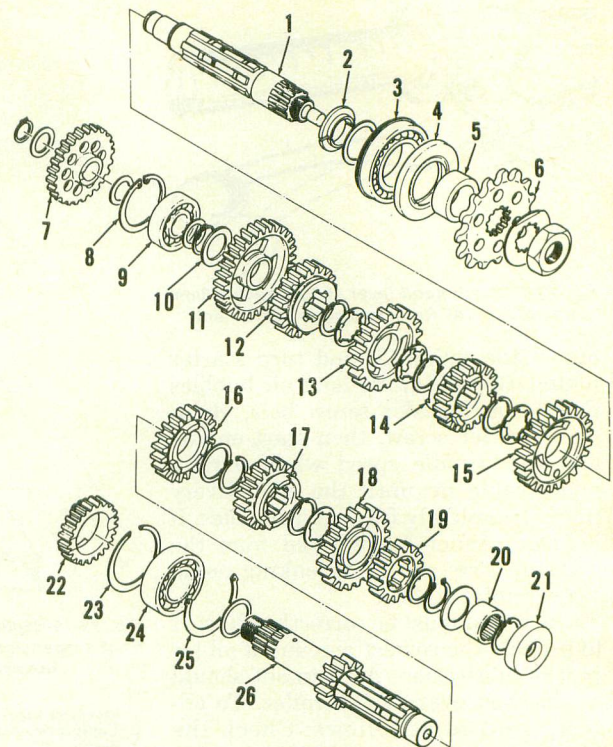


Fig. Y9-13—Exploded view of transmission common to all models.

- | | |
|-------------------------|------------------------|
| 1. Drive shaft | 14. Fifth pinion gear |
| 2. Drive shaft spacers | 15. Second gear wheel |
| 3. Ball bearing | 16. Fourth pinion gear |
| 4. Oil seal | 17. Third pinion gear |
| 5. Spacer | 18. Fifth gear wheel |
| 6. Drive sprocket | 19. Second pinion gear |
| 7. Idler gear | 20. Bearing |
| 8. Retaining clip | 21. Oil seal |
| 9. Ball bearing | 22. Kick pinion |
| 10. Gear holding washer | 23. Retaining clip |
| 11. First gear wheel | 24. Ball bearing |
| 12. Fourth gear wheel | 25. Retaining clip |
| 13. Third gear wheel | 26. Counter shaft |

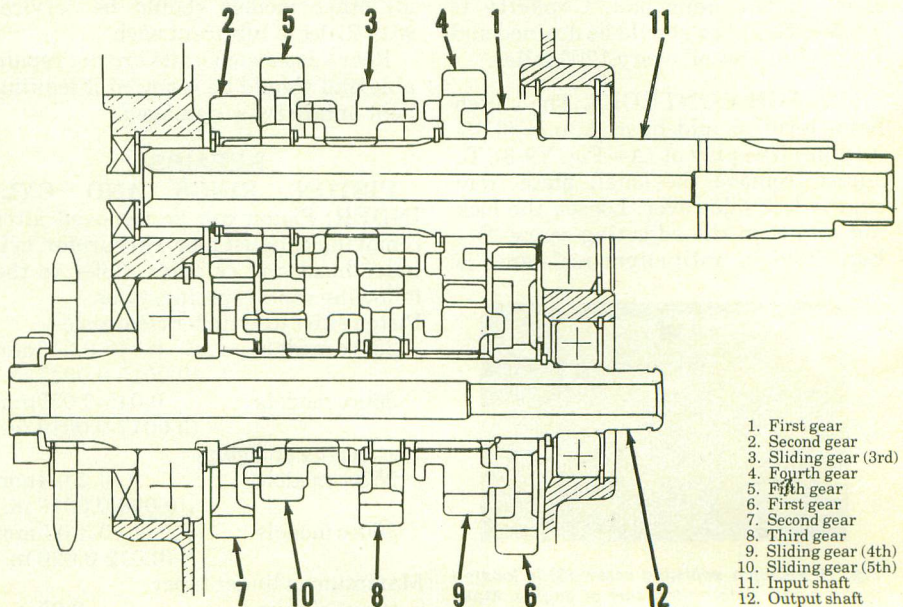


Fig. Y9-14—Cross sectional view of the five speed transmission common to all models.

- | |
|------------------------|
| 1. First gear |
| 2. Second gear |
| 3. Sliding gear (3rd) |
| 4. Fourth gear |
| 5. Fifth gear |
| 6. First gear |
| 7. Second gear |
| 8. Third gear |
| 9. Sliding gear (4th) |
| 10. Sliding gear (5th) |
| 11. Input shaft |
| 12. Output shaft |

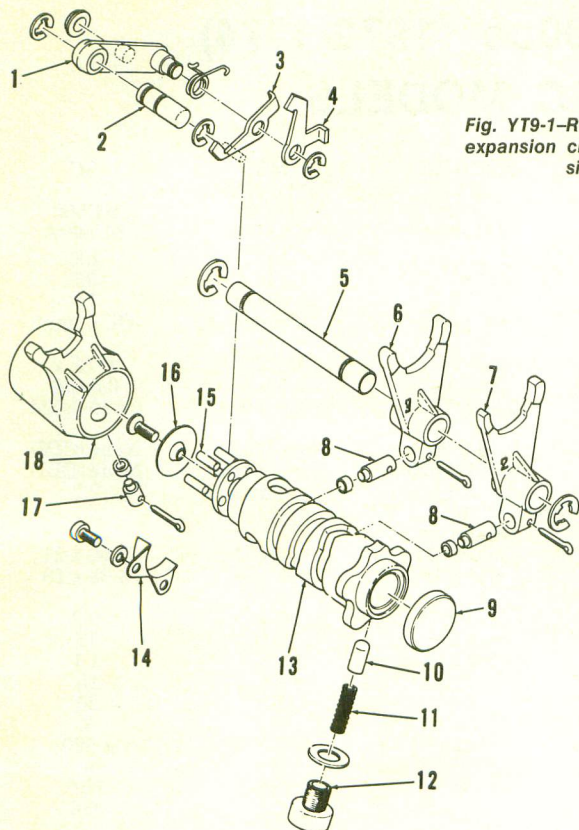


Fig. YT9-1—Refer to text for expansion chamber dimensions.

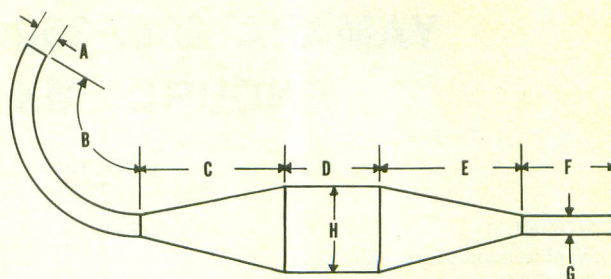


Fig. Y9-15—Exploded view of shift components used in all models.

1. Change lever bracket
2. Bracket axle
3. Change lever
4. Change lever
5. Shift fork guide bar
6. Shift fork
7. Shift fork
8. Shift fork guide pins
9. Blind plug
10. Cam stopper
11. Cam stopper spring
12. Cam stopper plug
13. Shift cam
14. Change lever guide
15. Dowel pins
16. Side plate
17. Shift fork guide pin
18. Shift fork

CRANKCASE AND GEAR BOX.

The crankcase halves can be separated after removing the engine from the frame. Remove the piston, clutch, magneto, crankshaft primary drive gear, output sprocket and shift linkage. Remove the kickstarter idler gear from the right side, then remove the screws attaching crankcase halves together. Carefully separate the halves.

The shifter assembly and transmission assembly must be installed as a unit. The transmission must also be in the neutral position.

SPEED TUNING

The MX versions of DT1 and RT1 are basically standard models with special high performance parts installed and components nonessential for competition removed.

Many features of the MX models may be incorporated in standard parts for an increase in power. Any modifications of standard parts or installation of perfor-

mance parts will void manufacturers warranty.

SPARK PLUG AND IGNITION.

NGK racing type spark plugs are recommended. Standard spark plug for competition prepared 250cc models is B-10EN. Recommended spark plug for 360cc models is B-9EN.

Ignition should be carefully set to standard specifications. When removing unnecessary wiring from an Enduro model, connect black wire from magneto to orange lead of ignition coil and ground positive lead of ignition coil.

CARBURETOR. Carburetor assemblies from MX models may be adapted to Enduro models of the same displacement.

LUBRICATION: Automatic oil metering system is used on MX models. For added lubrication needs such as flat track racing, a 30:1 fuel to oil mix-

ture should be used in fuel tank as well as the oil injection system.

If the oil metering system is removed a mixture of 15 parts gasoline to 1 part oil should be used in the fuel tank.

SUSPENSION. The weight and amount of oil used in front suspension units may be varied to tailor front fork action.

PISTON, CYLINDER AND CYLINDER HEAD. A DT1-MX piston has a 4mm (0.157 in.) shorter skirt than standard and transfer cutaways in side are also 4mm higher than standard. MX piston has only one ring groove. When using a modified standard piston, use only top piston ring.

Standard cylinder head used on 250cc Enduro models has a combustion chamber capacity of 37.5cc. Cylinder head used on 250cc MX models has a capacity of 27.5cc.

Refer to the following for a comparison of Enduro and MX port timing specifications:

	Intake Open Degrees BTDC	Exhaust Open Degrees ATDC	Transfer Open Degrees ATDC
250cc Enduro ...	80	94	123
250cc MX	91	91	124
360cc Enduro ...	80	98	125
360cc MX	79	94	121

EXPANSION CHAMBER. MX models are equipped with expansion chambers. An expansion chamber designed to increase performance in DT1 models may be constructed with the following dimensions: (Fig. YT9-1)

- A. 47mm (1 3/4 in.)
- B. 330mm (13 in.)
- C. 280mm (11 in.)
- D. 200mm (7 7/8 in.)
- E. 250mm (9 13/16 in.)
- F. 254mm (10 in.)
- G. 25mm (1 in.)
- H. 95mm (3 3/4 in.)

YAMAHA 250, 360 and 500cc (1972-1974)

ENDURO, MX AND SC MODELS

MODEL	ENDURO DT2 DT3 DT250A	MX DT2-MX MX250 MX250A	ENDURO RT2 RT3 DT360A	MX RT2-MX MX360 MX360A	SC SC500 SC500A
Displacement-cc	246	246	351	351	496
Bore-mm	70	70	80	80	95
Stroke-mm	64	64	70	70	70
Oil-Fuel ratio	Oil pump	Oil pump*	Oil pump	Oil pump*	Oil pump*
Spark plug—					
NGK	B-8ES	B-8EV	See Text	B-8EV	B-8EV
Electrode gap-mm	0.5-0.6	0.5-0.6	0.5-0.6	0.5-0.6	0.5-0.6
Inch	0.020-0.024	0.020-0.024	0.020-0.024	0.020-0.024	0.020-0.024
Ignition—					
Point gap-mm	0.35-0.50	0.3-0.4**	0.35-0.50**	None (CDI)	None (CDI)
Inch	0.014-0.020	0.012-0.016	0.014-0.020	None (CDI)	None (CDI)
Timing-mm BTDC	See Text	2.3	2.9	2.5	2.7
Electrical system voltage	6	6	6	6	6
Battery terminal grounded	Negative	.....	Negative	.....	.....
Tire size-Front	3.00 x 21§	3.00 x 21	3.00 x 21§	3.00 x 21	3.00 x 21
Rear	4.00 x 18	4.00 x 18	4.00 x 18	4.00 x 18	4.60 x 18
Tire pressure—					
Front-kg/cm ²	0.9	0.9	0.9	0.9	0.9
Psi	13	13	13	13	13
Rear-kg/cm ²	1.2	1.1	1.2	1.1	1.1
Psi	17	15	17	15	15
Rear chain free play-mm	20	20	20	20	20
Inch	¾	¾	¾	¾	¾
Rear chain size	#520	#520	#520	#520	#520
Number of speeds	5	5	5	5	4
Weight (approx.)-kg	113	103	118	106	107
Pounds	271	227	282	234	236

*A 1:30 oil to fuel mix should be used in fuel tank in addition to oil pump.

**Some models are fitted with breakerless CDI type ignitions.

§Front tire on DT2 and RT2 is size 3.25 x 19

Illustrations courtesy of Yamaha International Corporation

MAINTENANCE

SPARK PLUG. Recommended spark plug for normal use in 250cc "Enduro" and DT360A models is NGK type B-8ES. RT2 and RT3 models should have NGK type B-9ES spark plugs. Recommended spark plug for all "MX" and "SC" models is NGK type B-8EV. Electrode gap should be set to 0.5-0.6mm (0.020-0.024 in.) on all models.

CARBURETOR. Mikuni sliding valve carburetors are used on all models. Refer to Fig. Y19-1 and following recommended carburetor specifications:

DT2 and DT3

Main jet (21) #160
Needle jet (10) N-8
Jet needle (8) 5DP7
Pilot jet (17) #30
Throttle slide (9) 1.5
Air screw (13) turns out 1½
Clip (7) in third groove from top of needle (8).

DT250A

Main jet (21) #140
Needle jet (10) 0-0
Jet needle (8) 5DP7
Pilot jet (17) #60
Throttle slide (9) 2.0
Air screw (13) turns out 1½

Clip (7) in third groove from top of needle (8). Float arm should be parallel with gasket surface of throttle body.

DT2-MX and MX250

Main jet (21) #250
Needle jet (10) P-5
Jet needle (8) 6 F 5
Pilot jet (17) #60
Throttle slide (9) 2.5
Air screw (13) turns out 1
Clip (7) in third groove from top of needle (8).

MX250A

Main jet (21) #260
Needle jet (10) P-8
Jet needle (8) 6 F 15
Pilot jet (17) #50
Throttle slide (9) 3.0
Air screw (13) turns out 1½
Clip (7) in second groove from top of needle (8). Float level should be 23.4mm (0.92 in.)

RT2 and RT3

Main jet (21) #230
Needle jet (10) 0-2
Jet needle (8) 6DH3
Pilot jet (17) #45
Throttle slide (9) 3.0
Air screw (13) turns out 1½
Clip (7) in third groove from top of needle (8). Float level should be 21.4mm (0.85 in.).

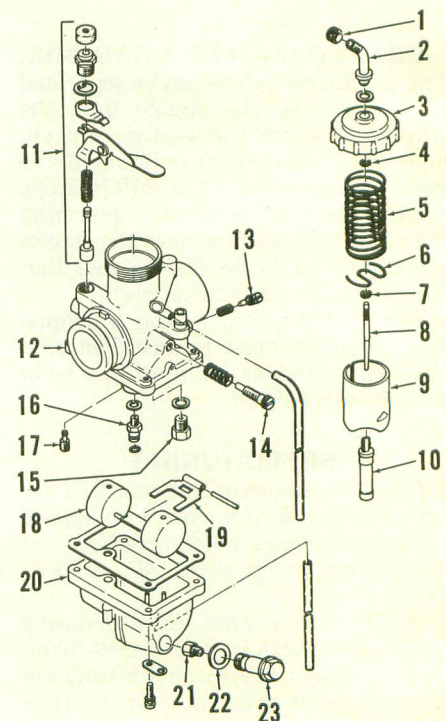


Fig. Y19-1—Exploded view of typical Mikuni carburetor assembly.

1. Lock nut
2. Cable guide
3. Mixing chamber cap
4. Clip
5. Throttle return spring
6. Retainer clip
7. Jet needle clip
8. Jet needle
9. Throttle slide
10. Needle jet
11. Starter valve
12. Throttle body
13. Pilot air screw
14. Idle speed screw
15. Inlet needle & seat
16. Jet setter
17. Pilot jet
18. Float arm
19. Floats
20. Float bowl
21. Main jet
22. Gasket
23. Jet holder

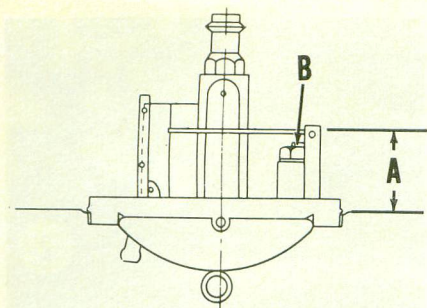


Fig. Y19-2—Float level (A) is adjusted by bending tang (B) on float arm. Float level should be correct when float arm is parallel with gasket surface of throttle body.

DT360A

Main jet (21) #180
 Needle jet (10) 0-8
 Jet needle (8) 5EJ8
 Pilot jet (17) #50
 Throttle slide (9) 3.0
 Air screw (13) turns out 1½
 Clip (7) in third groove from top of needle (8). Float arm should be parallel with gasket surface of throttle body.

RT2-MX and MX360

Main jet (21) #310
 Needle jet (10) P-8
 Jet needle (8) 6F15
 Pilot jet (17) #50
 Throttle slide (9) 3.0
 Air screw (13) turns out 1
 Clip (7) in third groove from top of needle (8). Float arm should be parallel with gasket surface of throttle body.

MX360A

Main jet (21) #270
 Needle jet (10) P-8
 Jet needle (8) 6F15
 Pilot jet (17) #50
 Throttle slide (9) 3.0
 Air screw (13) turns out 1½
 Clip (7) in second groove from top of needle (8). Float level should be 23.4mm (0.92 in.).

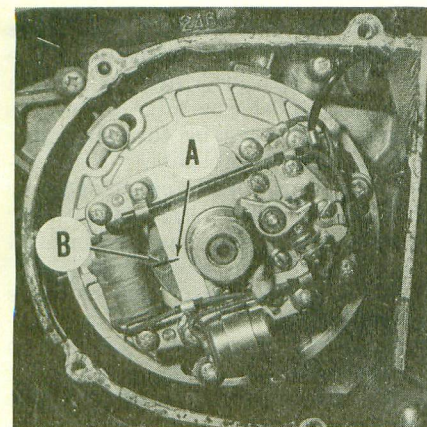


Fig. Y19-4—View of breaker point timed magneto used on DT2-MX. Stator should be adjusted so that marks (A & B) align when piston is at specified BTDC position for ignition. Breaker points should just open at this point.

SC500 and SC500A

Main jet (21)—

SC500 #400
 SC500A #340
 Needle jet (10) 0-8
 Jet needle (8) 6F16
 Pilot jet (17) #80
 Throttle slide (9) 3.5
 Air screw (13) turns out—

SC500 1½
 SC500A 1¾
 Clip (7) in second groove from top of needle (8). Float level should be 17.8mm (0.7 in.).

Float level on all models is measured with float bowl and floats removed and throttle body inverted. Distance (A—Fig. Y19-2) from float arm to gasket surface of throttle body is float level. In most cases, float arm will be parallel with gasket surface when adjustment is correct.

IGNITION AND ELECTRICAL.

An energy transfer type flywheel magneto is used on RT2, RT3 and all 250cc "Enduro" models. Breaker points on these models should be set to a maximum gap of 0.35-0.50mm (0.014-0.020 in.). A breaker point timed magneto with a small rotor turning inside the stator assembly is used on DT2-MX models. Maximum breaker point gap

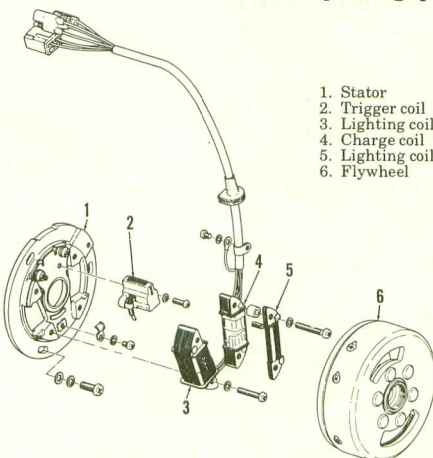


Fig. Y19-5—View of CDI magneto used on some 360cc "Enduro" models. Magneto used on SC500 models is similar but is not equipped with lighting coils.

should be set to 0.3-0.4mm (0.012-0.016 in.). A C.D.I. (Capacitor Discharge Ignition) magneto is used on DT360A, MX250, MX250A, on all 360cc "MX" models and SC500 models.

A dial gage should be used to determine piston position for ignition timing check. Refer to the following timing specifications:

Model	Piston Position BTDC
DT2 and DT3	3.0mm (0.118 in.)
DT250A	3.2mm (0.126 in.)
DT2-MX, MX250 and MX250A	2.3mm (0.090 in.)
RT2, RT3 and DT360A	2.9mm (0.114 in.)
RT2-MX, MX360 and MX360A	2.5mm (0.098 in.)
SC500 and SC500A	2.7mm (0.106 in.)

On breaker point models, breaker points should just open as piston reaches correct BTDC position. A timing pointer, mounted on stator of "Enduro" models, should align with timing mark on flywheel at this point. Timing mark (A—Fig. Y19-4) on DT2-MX models, should align with mark (B) on rotor when piston is set to proper BTDC position. Adjust breaker point base plate so that points just open as marks (A & B) align.

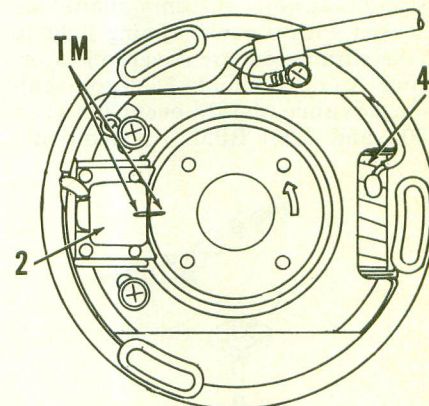


Fig. Y19-6—View of timing marks (TM) on CDI magneto used on some 250 and 360cc "MX" models.

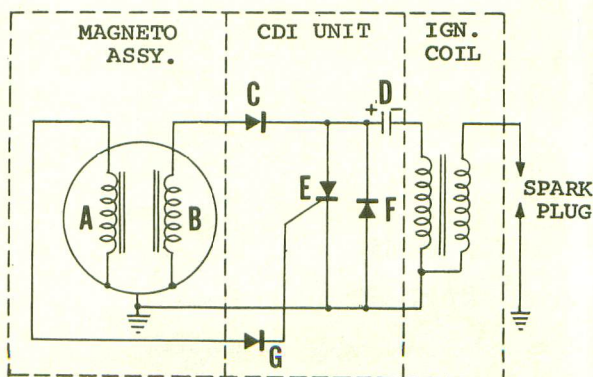


Fig. Y19-7—Simplified diagram of CDI system. Current produced in charge coil (B) is rectified by diodes (C & F) and stored in capacitor (D). Current from trigger coil (A), triggers thyristor (E) and allows stored current to flow to ignition coil.

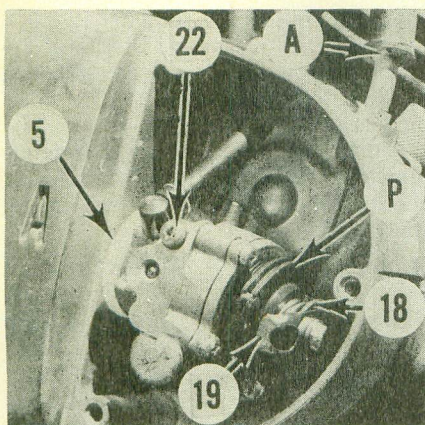


Fig. Y19-8—View of typical oil pump assembly. Pin, beneath cover plate (19), should align with mark on adjustment pulley (P) just before throttle slide begins to move. Use cable adjuster (A) to align marks.

On models equipped with capacitor discharge ignition system, timing mark on flywheel or magneto rotor, should align with mark on trigger coil (2—Fig. Y19-5 or Y19-6) when piston is at specified BTDC position. Adjust ignition timing by repositioning trigger coil. If stator has been removed from SC500 models, be sure to coat top, forward stator mount screw with gasket sealer before reinstalling. Crankcase pressure may leak through if screw hole is not sealed.

CDI magneto systems should be checked with a power timing light to make sure automatic advance is operating. An approximate 15 degree ignition advance should occur between 2500 and 3200 RPM. An additional

0.22 microfarad condenser fitted to ignition system of some SC500 models is used to change point of ignition advance. Advance of ignition should begin at approximately 1000 RPM on models equipped with additional condenser. Condenser is connected to red/white wire from trigger coil.

Some components of the CDI systems can be checked with an ohmmeter. Resistance between white/red wire and white/green wire of trigger coil on 250 and 360cc "MX" models should be 54 ohms. On DT360A models, resistance between white/red wire and white/green wire should be 100 ohms. On SC500 models, resistance between white/red and white/green wire on trigger coil should be 88 ohms. Charging coil on 250 and 360cc "MX" models should have 790 ohms resistance between brown wire and black wire; 84 ohms resistance between red wire and black wire. Charging coil on DT360A should show 125 ohms resistance between brown wire and black wire. Charging coil on SC500 models should have 204 ohms resistance between brown wire and black wire. A variation of 10% is allowed on resistance specifications of all coils.

LUBRICATION. Clutch and transmission components are lubricated by SAE 10W/30 motor oil contained in gearbox. Lubricant should be maintained at a level between two marks on filler plug dipstick with dipstick screwed in. Motorcycle should be held vertical, not on side stand, while making oil level check.

Engine lubrication is accomplished by an automatic oil metering system. Oil tank should not be allowed to run dry and only oils intended for use in air cooled, two stroke engines, should be used. On "MX" and "SC" models, manufacturer recommends using a 30:1 fuel to oil mixture in fuel tank in addition to automatic lubrication system.

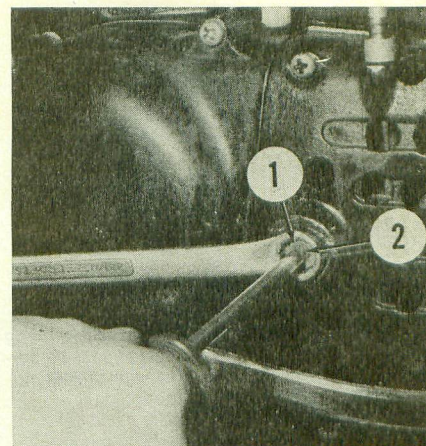


Fig. Y19-11—View of clutch adjuster used on some models. Turn screw (2) in until a resistance is felt then back out 1/4 turn and tighten lock nut (1).

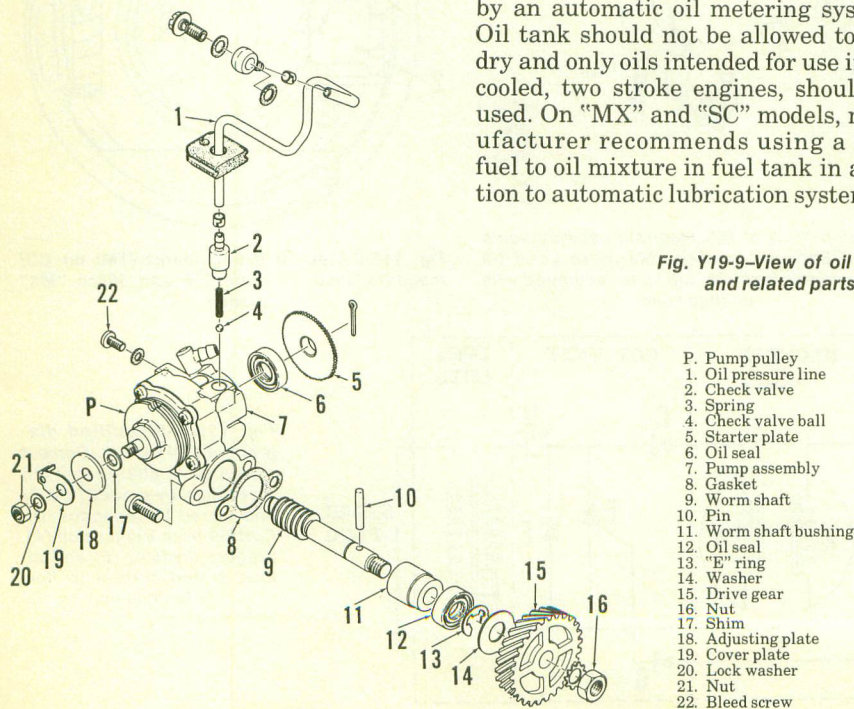
Oil pump must be bled if it has been removed or allowed to run dry. To bleed pump, remove bleeder screw (22—Fig. Y19-8) and turn starter plate (5) upward while holding throttle fully open. When air is no longer present in oil coming from bleed hole, replace screw. Oil pump adjustment should be checked whenever throttle has been adjusted. Mark on pump adjustment pulley (P) should be aligned with pin, located beneath cover plate (19), when slack has been taken up in throttle cable but throttle slide has not started to move. Minimum pump stroke should be 0.20-0.25mm (0.008-0.010 in.) on "Enduro" models and 0.60-0.65mm (0.024-0.026 in.) on "MX" and "SC" models. Minimum pump stroke is measured with throttle closed. Turn starter plate (5) until gap between adjuster plate (18) and pulley (P) is widest. Adjust gap to minimum stroke specification with various thicknesses of shim (17—Fig. Y19-9).

CLUTCH CONTROLS. Two types of clutch throw out mechanisms are used. Unit with lever arm exposed on lower side of engine (Fig. Y19-31) is primarily adjusted by turning adjusters in clutch control cable. Coarse adjustment is provided by eccentric screw (25). Turn eccentric screw until lever arm is positioned slightly behind center line of transmission shaft.

NOTE: Full range of adjustment is accomplished in 180 degrees of movement. Do not turn screw in far enough to bind lever arm shaft or out so far that it disengages. Turn clutch cable adjusters to obtain 2-3mm (1/8 in.) free play at gap of handlebar pivot.

To adjust units with internal lever arm (Fig. Y19-30), back clutch cable adjusters off and loosen lock nut (1—Fig. Y19-11). Turn adjusting screw (2)

Fig. Y19-9—View of oil pump and related parts.



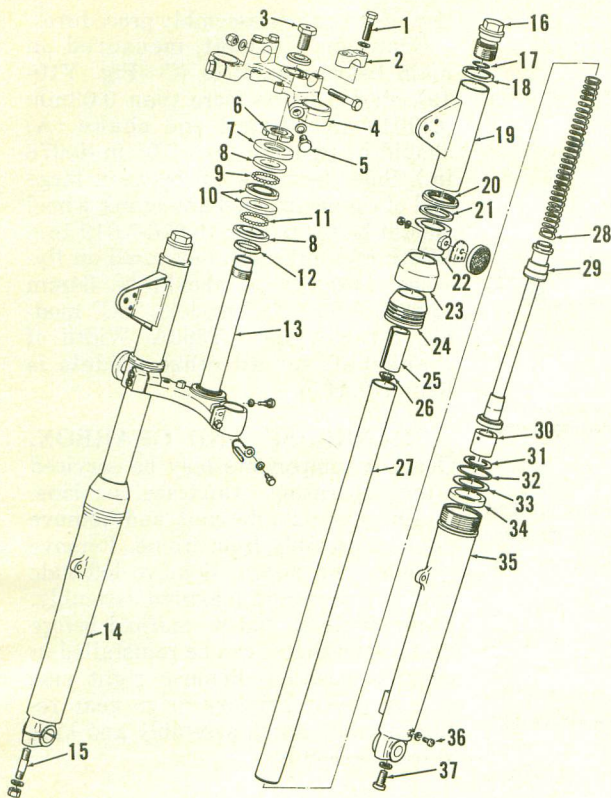


Fig. Y19-13—Exploded view of typical front suspension unit. Bearing balls (11) in lower race are larger than balls (9) in top race.

1. Bolt
2. Handlebar clamp
3. Stem bolt
4. Top crown
5. Pinch bolt
6. Stem nut
7. Cover
8. Bearing cones
9. Bearing balls (22 each)
10. Bearing cups
11. Bearing balls (19 each)
12. Dust seal
13. Steering stem
14. Fork leg assembly
15. Axle clamp stud
16. Fork top bolt
17. "O" ring
18. Guide
19. Headlight bracket
20. Guide
21. Rubber gasket
22. Reflector bracket
23. Dust cover
24. Dust seal
25. Spacer
26. Spring seat
27. Inner fork tube
28. Fork spring
29. Damper
30. Damper piston
31. Clip
32. Oil seal clip
33. Washer
34. Oil seal
35. Outer fork tube
36. Drain screw
37. Damper holding screw

out until loose then turn it back in until a resistance is felt. Turn adjusting screw back out $\frac{1}{4}$ turn and tighten lock nut. Use cable adjusters to obtain 2-3mm ($\frac{1}{8}$ in.) free play at gap of handlebar pivot.

SUSPENSION. Front suspension units on all models should be serviced with SAE 10W/30 motor oil or motorcycle fork oil. Refer to the following recommended fork capacities:

Model	Amount of Oil Per Fork Leg
All "Enduro" models	175cc
DT2-MX, MX250, RT2-MX, MX360 and SC500	175cc
MX250A, MX360A and SC500A	194cc

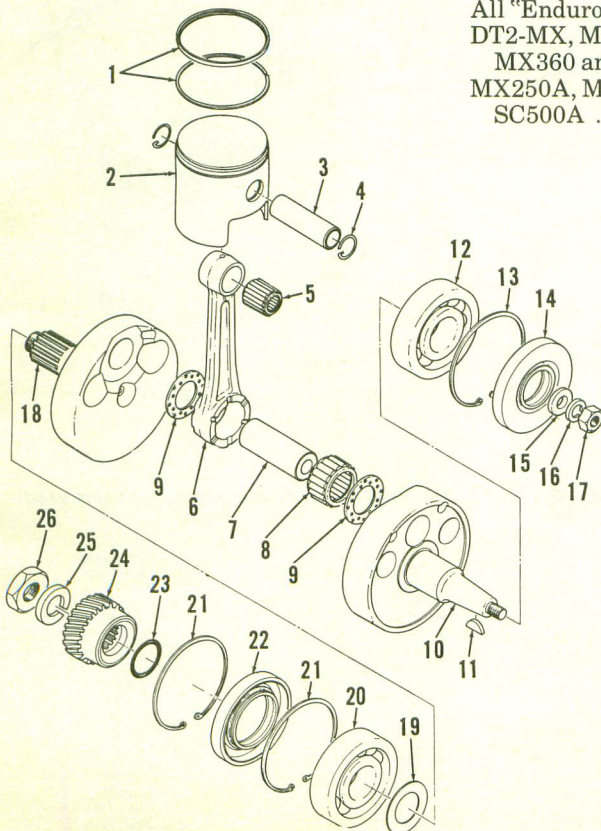


Fig. Y19-15—Exploded view of typical crankshaft assembly.

1. Piston rings
2. Piston
3. Piston pin
4. Piston pin clip
5. Needle bearing
6. Connecting rod
7. Crank pin
8. Needle bearing
9. Side washer
10. Left crank wheel
11. Woodruff key
12. Ball bearing
13. Snap ring
14. Oil seal
15. Washer
16. Spring washer
17. Nut
18. Right crank wheel
19. Adjusting shim
20. Ball bearing
21. Snap rings
22. Oil seal
23. "O" ring
24. Primary gear
25. Lock washer
26. Nut

Rear suspension units with separate oil reservoir attached to shock absorber body may be disassembled for service. Reservoirs should be serviced with 182.5cc of hydraulic shock fluid each. Shock absorbers without reservoir are not repairable and should be renewed if leaking, bent or otherwise damaged.

REPAIRS

PISTON, RINGS AND CYLINDER. Cylinder and piston may be serviced after disconnecting oil delivery line and removing exhaust pipe, carburetor and cylinder head. A shop towel should be placed around connecting rod as cylinder is lifted to prevent carbon particles or pieces of possible broken piston rings from falling into open crankcase. A suitable puller should be used to remove piston pin so that connecting rod is not damaged. Refer to the following repair specifications:

Piston skirt to cylinder clearance—

All 250cc "Enduro" models	0.040-0.045mm (0.0016-0.0018 in.)
RT2 and RT3	0.045-0.050mm (0.0018-0.002 in.)
DT360A	0.040-0.045mm (0.0016-0.0018 in.)
DT2-MX and MX250	0.040-0.045mm (0.0016-0.0018 in.)
RT2-MX, MX360 and SC500	0.055-0.060mm (0.0021-0.0024 in.)
MX250A and MX360A	0.045-0.050mm (0.0018-0.002 in.)
SC500A	0.050-0.060mm (0.002-0.0024 in.)

Piston ring end gap—

All 250cc "Enduro" models	0.2-0.3mm (0.008-0.016 in.)
All 360cc "Enduro" models	0.3-0.5mm (0.012-0.020 in.)
All 250 and 360cc "MX" models	0.4-0.5mm (0.016-0.020 in.)
SC500 and SC500A	0.3-0.5mm (0.012-0.020 in.)

Maximum allowable cylinder taper—

250 and 360cc models	0.05mm (0.002 in.)
SC500 models	0.065mm (0.0026 in.)

Arrow on top of piston should be toward front of engine (exhaust side). Markings on piston rings indicate top side of ring and proper ring groove. Pistons should be measured for cylinder clearance check at a point approximately 13mm ($\frac{1}{2}$ in.) from bottom of

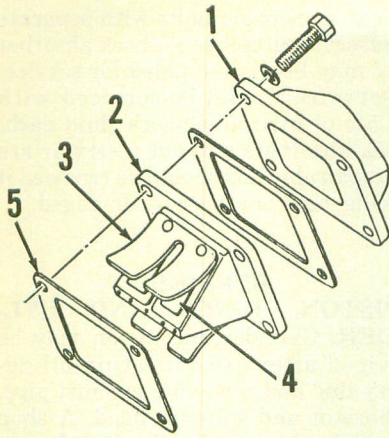


Fig. Y19-16—View of typical reed manifold assembly.

1. Manifold
2. Reed block
3. Reed stopper plate
4. Reed petal
5. Gasket

skirt on a right angle to piston pin hole. Piston pin should be snug fit in piston. Install new piston pin retaining clips on each reassembly. Tighten cylinder head retaining hardware to 3.5-4.0 kg-m (26-29 ft.-lbs.) torque.

Decompressor valve used on 500 and some 360cc models should be cleaned of carbon and checked for leaks. Make sure control cable has a small amount of free play to ensure that valve is not

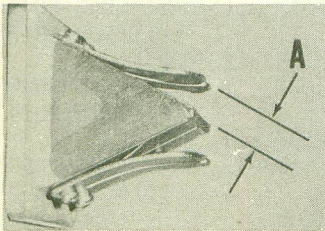


Fig. Y19-17—Height (A) of reed stopper plate should be 9.3-9.6mm.

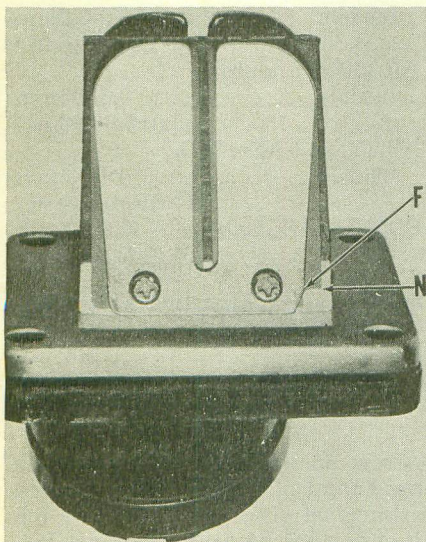


Fig. Y19-18—Cutaway (N) at edge of reed petal should be installed next to flat (F) on reed stopper plate.

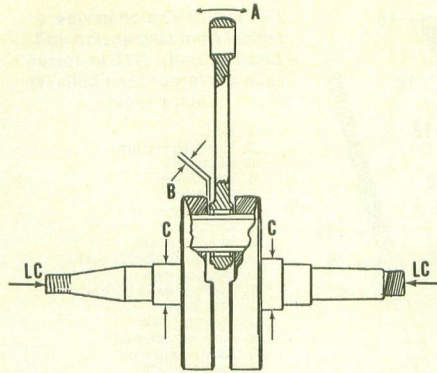


Fig. Y19-19—Crankshaft should be supported between lathe centers (LC) when making runout checks.

held off seat. Adjust control cable, on late models with kick starter actuated decompressor, so that valve of decompressor just opens as kick gear engages.

Inspect reed petals (4—Fig. Y19-16) for cracks or tears. Petals should be renewed if any flaws are detected. Curve of reed stopper plate (3) should be smooth and free of kinks or rough spots. Check rubber coating on reed block (2) for cracking or peeling. Height (A—Fig. Y19-17) of reed stopper should be 9.3-9.6mm (0.36-0.38 in.). When reassembling unit, place corner of reed petal with notch (N—Fig. Y19-18) beneath corner of reed stopper plate with flat (F).

CRANKSHAFT AND CONNECTING ROD. Engine must be removed from frame and disassembled to service crankshaft assembly. Refer to CRANKCASE AND GEARBOX sec-

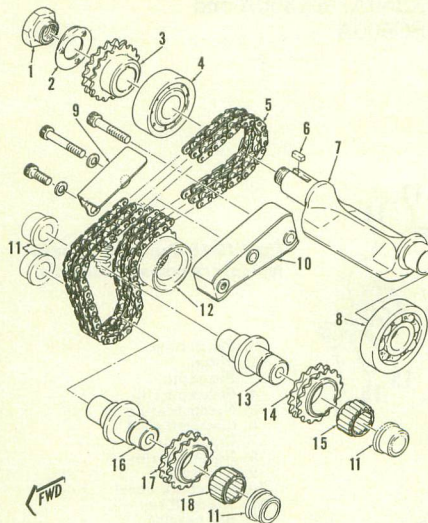


Fig. Y19-20—View of counterweight and drive components used on 500cc models.

1. Special nut
2. Lock washer
3. Drive sprocket
4. Bearing
5. Drive chain
6. Key
7. Counterweight
8. Bearing
9. Chain guide
10. Guide block
11. Bushings
12. Primary gear
13. Idler sprocket shaft
14. Idler sprocket
15. Needle bearing
16. Idler sprocket shaft
17. Idler sprocket
18. Needle bearing

tion for engine disassembly procedure.

Crankshaft runout, measured on main bearing surfaces (C—Fig. Y19-19), should be no more than 0.03mm (0.0012 in.). Small end shake (A) should be no more than 2.0mm (0.078 in.). Side clearance (B) between large end of connecting rod and crank wheel should be 0.4-0.5mm (0.016-0.019 in.). Width of crankshaft, measured on fly-wheel outer faces, should be 64mm (2.52 in.) for "MX" models, "SC" models, DT250A and DT360A. Width of crankshaft for all other models is 62mm (2.44 in.).

CRANKCASE AND GEARBOX.

Gearbox components may be serviced after separating crankcase sections. Drain gearbox lubricant and remove engine assembly from frame. Remove cylinder and piston. Remove left side engine covers and magneto assembly. Stator plate should be marked before removal so that it can be reinstalled in original position. Remove right side engine cover, primary drive gear retaining nut, clutch assembly and kick starter assembly.

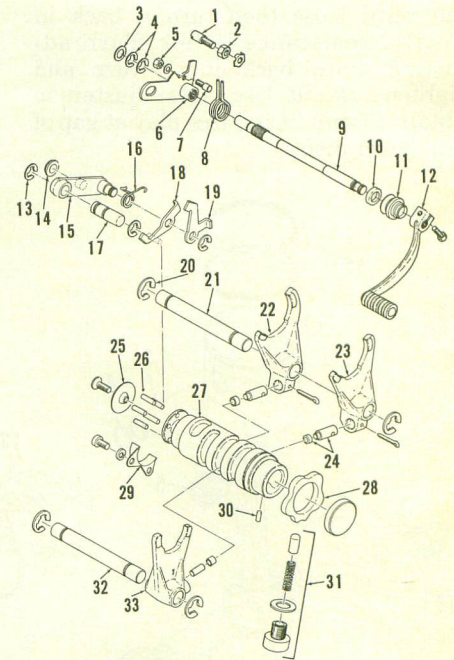


Fig. Y19-21—View of gearshift components used in early models.

1. Eccentric pin
2. Nut
3. Washer
4. Clips
5. Nut
6. Change arm
7. Eccentric pin
8. Centering spring
9. Change shaft
10. Oil seal
11. Boot
12. Change pedal
13. Clip
14. Roller
15. Lever arm
16. Spring
17. Axle
18. Lever arm
19. Lever arm
20. Clip
21. Shift fork axle
22. Shift fork "3"
23. Shift fork "2"
24. Shift fork guide & roller
25. Side plate
26. Pins
27. Shift drum
28. Stopper plate
29. Guide
30. Pin
31. Stopper detent assembly
32. Shift fork axle
33. Shift fork "1"

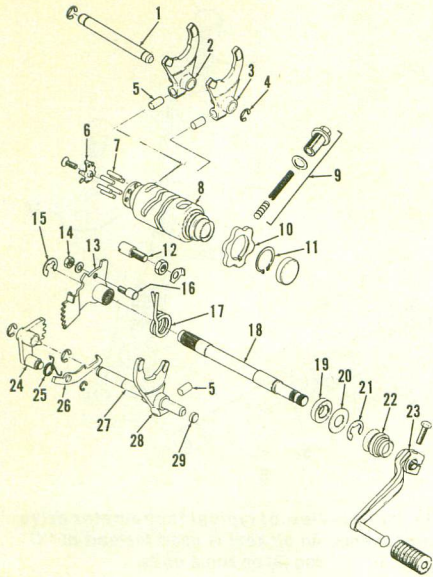


Fig. Y19-22—View of shifter components used on later models.

- | | |
|----------------------------|----------------------|
| 1. Shift fork axle | 16. Eccentric pin |
| 2. Shift fork | 17. Centering spring |
| 3. Shift fork | 18. Change shaft |
| 4. Clip | 19. Oil seal |
| 5. Shift fork guide | 20. Washer |
| 6. Side plate | 21. Clip |
| 7. Pins | 22. Boot |
| 8. Shift drum | 23. Change pedal |
| 9. Stopper detent assembly | 24. Change lever |
| 10. Stopper plate | 25. Spring |
| 11. Snap ring | 26. Change arm |
| 12. Stopper pin | 27. Shift fork axle |
| 13. Change lever | 28. Shift fork |
| 14. Nut | 29. Plug |
| 15. Clip | |

To remove counterweight drive chain on SC500 models, remove chain guide (9—Fig. Y19-20). Fold down bent portion of lock washer (2) and remove nut (1) on counterweight shaft (7). Pull idler sprocket shaft (13) and remove sprocket (14). Pull counterweight drive sprocket off shaft and remove drive chain. Pull primary gear from crankshaft.

Remove gear change shaft and gear change ratcheting mechanism from right side of engine case. Remove screws holding crankcase sections together and carefully separate the cases.

Inspect transmission gears for cracked or broken teeth and wear on engagement dogs. Check sliding gears for wear in shift fork groove. Check thrust pads on shift forks for signs of excessive wear or discoloration. Check shafts for wear of splines and seal contact areas.

Assemble transmission shift drum and shift forks and install as a unit in left engine case. Make certain that mating surfaces of crankcase sections are clean and free of nicks or burrs then apply an even coat of a non-hardening type gasket sealer and assemble. Tighten screws and check all shafts for freedom of movement.

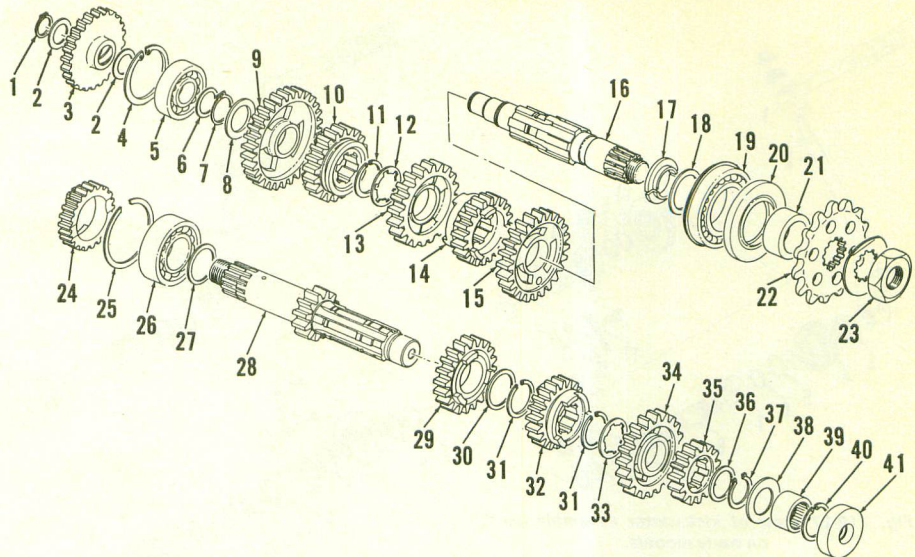


Fig. Y19-23—Exploded view of typical five speed transmission assembly. Four speed unit used in 500cc models is similar.

- | | | | |
|-------------------|-------------------|----------------------|-------------------|
| 1. Snap ring | 11. Clip | 22. Sprocket | 32. Third gear |
| 2. Shim | 12. Spline washer | 23. Nut | 33. Spline washer |
| 3. Kick idle gear | 13. Third gear | 24. Kick pinion gear | 34. Fifth gear |
| 4. Snap ring | 14. Fifth gear | 25. Clip | 35. Second gear |
| 5. Ball bearing | 15. Second gear | 26. Bearing | 36. Washer |
| 6. Shim | 16. Output shaft | 27. Shim | 37. Snap ring |
| 7. Snap ring | 17. Spacers | 28. Input shaft | 38. Shim |
| 8. Washer | 18. Shim | 29. Fourth gear | 39. Bearing |
| 9. First gear | 19. Bearing | 30. Washer | 40. Snap ring |
| 10. Fourth gear | 20. Oil seal | 31. Clip | 41. Oil seal |

Shift mechanisms should be adjusted to provide proper gear engagement. Two different types of gear change mechanisms are used.

Early type shifter (Fig. Y19-21) is adjusted by turning eccentric pins (1 & 7—Fig. Y19-24). Loosen lock nut on eccentric (1) and move gear change pedal to full extent of travel in both

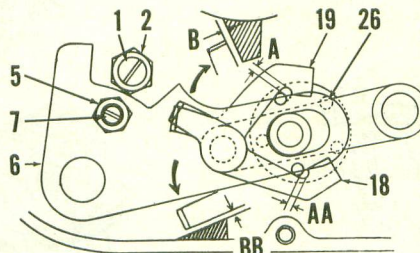


Fig. Y19-24—View of shift mechanism adjustment points for shifter shown in Fig. Y19-21. Refer to text and Fig. Y19-21 for legend.

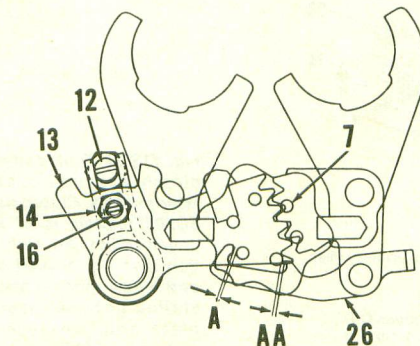


Fig. Y19-25—View of shift mechanism adjustment for unit shown in Fig. Y19-22. Refer to Fig. Y19-22 for legend.

directions. Turn pin (1) until clearances (B & BB) between lever arms and case bosses are equal when pedal is held to each extreme.

Turn eccentric pin (7) until clearances (A & AA) between lever arms (18 & 19) and shift drum pins (26) are equal with pedal at rest.

Gear change mechanism (Fig. Y19-22) used on later models is adjusted by turning eccentric pin (16—Fig. Y19-25). Shift transmission into second or fourth gear and observe clearances (A & AA) between change arm (26) and shift drum pins (7). Loosen lock nut and turn eccentric pin (16) until clearances (A & AA) are equal.

Counterweight drive chain on SC500 models may be installed as follows: Install counterweight sprocket (3—Fig. Y19-26) then turn it to align punch mark with pointer cast into engine case. Install primary drive gear (12) with punch mark on gear aligned with

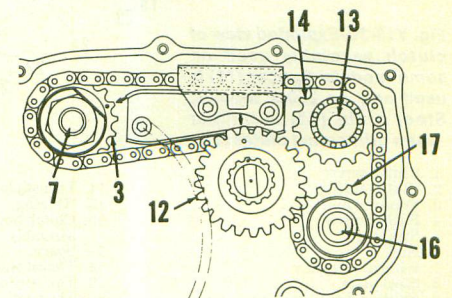


Fig. Y19-26—View of timing marks for installation counterweight drive chain on SC500 models. Refer to text for installation procedure.

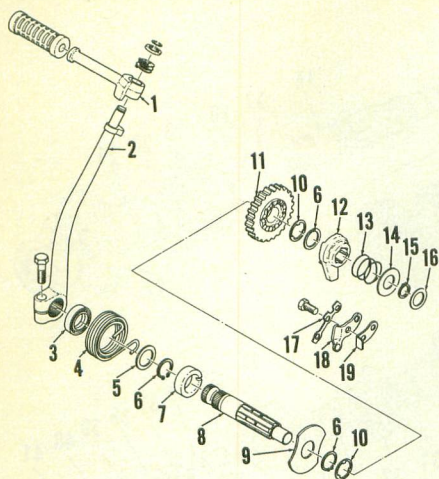


Fig. Y19-27-View of kickstarter assembly used on early models.

- | | |
|-------------------|-------------------|
| 1. Pedal | 11. Kick gear |
| 2. Lever | 12. Ratchet |
| 3. Oil seal | 13. Spring |
| 4. Return spring | 14. Spring cover |
| 5. Shim | 15. Snap ring |
| 6. Snap ring | 16. Shim |
| 7. Spring guide | 17. Lock plate |
| 8. Kick shaft | 18. Ratchet guide |
| 9. Spring cover | 19. Stopper |
| 10. Spline washer | |

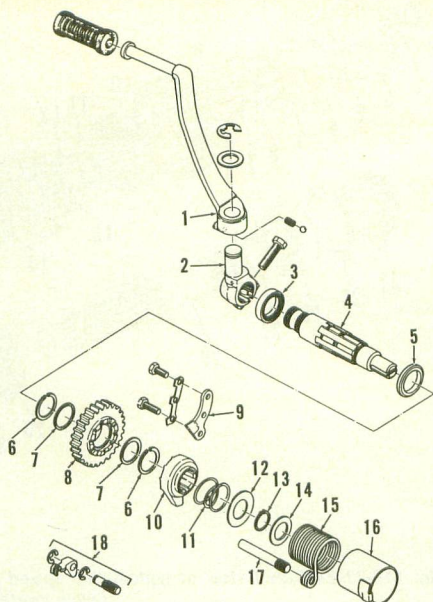


Fig. Y19-28-View of kickstarter assembly used on later models.

- | | |
|---------------|---|
| 1. Pedal | 11. Spring |
| 2. Kick boss | 12. Spring cover |
| 3. Oil seal | 13. Snap ring |
| 4. Kick shaft | 14. Washer |
| 5. Spacer | 15. Return spring |
| 6. Clip | 16. Spring guide |
| 7. Washer | 17. Pin |
| 8. Kick gear | 18. Decompressor lever
(360 & 500cc models only) |
| 9. Ratchet | |

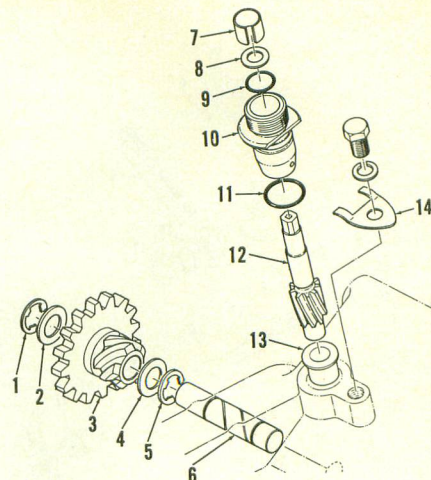


Fig. Y19-29-View of typical tachometer drive components. An oil seal is used instead of "O" ring (9) on some units.

- | | |
|---------------|-----------------|
| 1. Clip | 8. Shim |
| 2. Shim | 9. "O" ring |
| 3. Drive gear | 10. Housing |
| 4. Shim | 11. "O" ring |
| 5. Clip | 12. Drive shaft |
| 6. Axle | 13. Bushing |
| 7. Bushing | 14. Set plate |

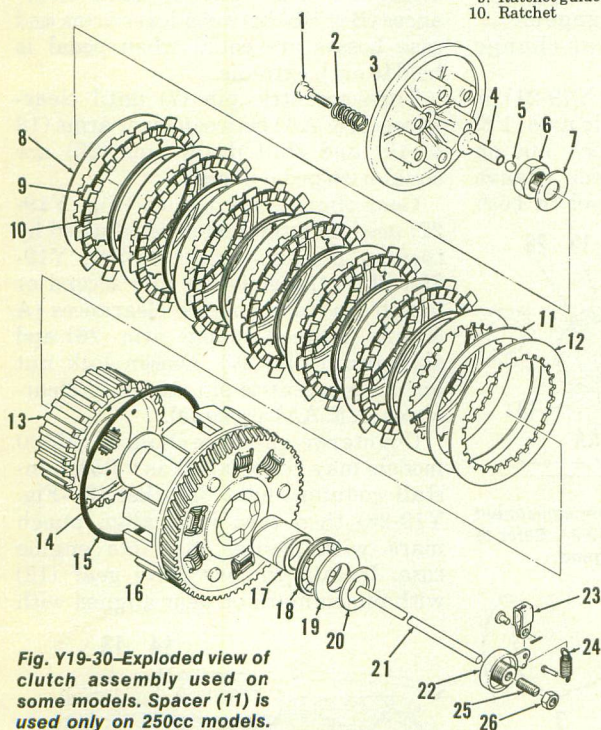


Fig. Y19-30-Exploded view of clutch assembly used on some models. Spacer (11) is used only on 250cc models. Steel plate (12) is thicker than other steel plates (8).

- | | |
|---|--|
| 1. Clutch screw | 14. Thrust plate |
| 2. Clutch spring | 15. "O" ring |
| 3. Pressure plate | 16. Clutch housing/primary gear assembly |
| 4. Pusher piece | 17. Spacer |
| 5. Steel ball | 18. Thrust washer |
| 6. Nut | 19. Thrust plate (50mm O.D.) |
| 7. Belleville washer | 20. Thrust plate (34mm O.D.) |
| 8. Steel plate | 21. Push rod |
| 9. Friction disc (7 each on 360cc models) | 22. Release lever |
| 10. Cushion (7 each on 360cc models) | 23. Release holder |
| 11. Spacer (250cc models only) | 24. Spring |
| 12. Steel plate (thick) | 25. Adjuster screw |
| 13. Hub | 26. Lock nut |

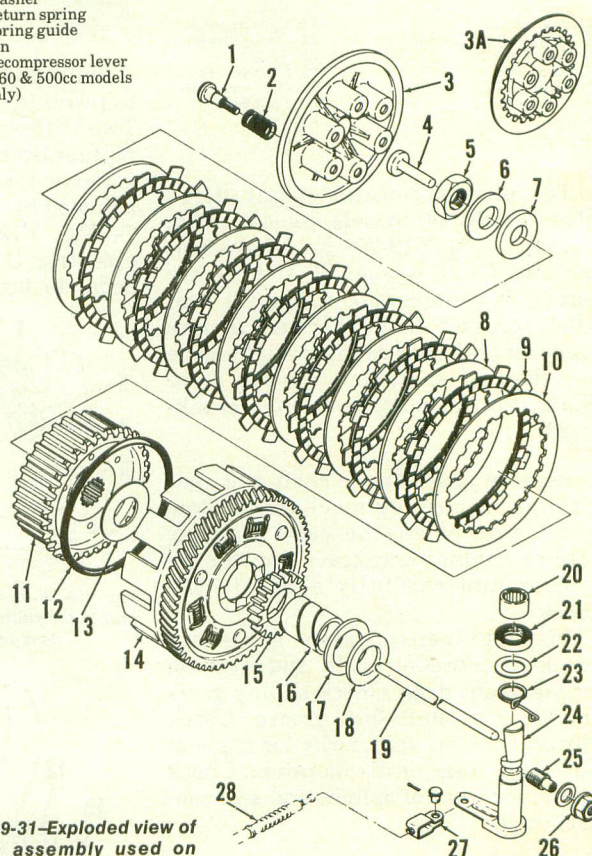


Fig. Y19-31-Exploded view of clutch assembly used on later models. Clutch used on SC500 models is of similar construction. An eighth friction disc (9) is used on 360 and 500cc models and is installed between last steel plate and pressure plate (3A).

- | | |
|------------------------------------|----------------------|
| 1. Clutch screw | 15. Kick pinion gear |
| 2. Clutch spring | 16. Spacer |
| 3. Pressure plate (250cc only) | 17. Thrust bearing |
| 3A. Pressure plate (360 and 500cc) | 18. Thrust plate |
| | 19. Push rod |
| | 20. Bearing |
| | 21. Oil seal |
| | 22. Washer |
| | 23. Spring |
| | 24. Lever arm shaft |
| | 25. Eccentric screw |
| | 26. Lock nut |
| | 27. Cable holder |
| | 28. Clutch cable end |

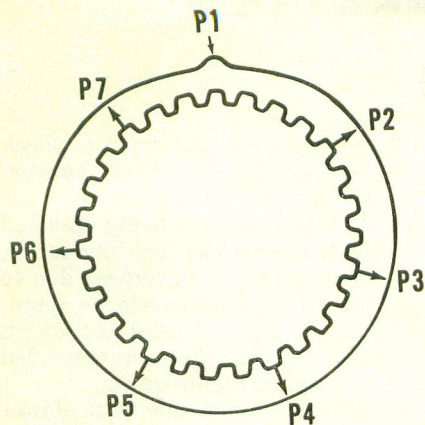


Fig. Y19-32—Steel plates (8—Fig. Y19-31) used in some clutches have asymmetrical shapes. Assemble clutch with point (P) of each plate positioned approximately 50 degrees from point of previous plate.

punched spline on crankshaft. Turn crankshaft until punch mark on primary gear is aligned with pointer cast in crankcase. Crankshaft will be at TDC at this point. Place chain around drive sprocket (3) and primary gear (12) without changing alignment of timing marks. Install idler sprockets (14 & 17) then slide shafts (13 & 16) into position.

Install kick starter assembly (Fig. Y19-27 or Y19-28). On 500cc and some 360cc models, the engine decompressor mechanism is linked, by cable, to kick-starter. Cable should have a small amount of slack to ensure full seating of decompressor valve and should be adjusted to actuate valve just as kick gear engages.

CLUTCH. The wet type, multiple disc clutch is located on right end of transmission input shaft. Standard thickness of friction disc (9—Fig. Y19-30 or Y19-31) is 3mm (0.118 in.). Friction discs should be renewed if worn to less than 2.7mm (0.106 in.) thick or if worn unevenly. Check steel clutch plate for warpage or signs of overheating. Steel plates in some clutches are built with an eccentric cut out of them. Each of these plates should be installed with point (P—Fig. Y19-32) placed approximately 50 degrees (4 teeth on clutch hub) from previous plate to prevent an unbalanced condition in assembled unit.

SERVICE FUNDAMENTALS

TROUBLE SHOOTING

Most performance problems such as failure to start, failure to run properly or missing out are caused by malfunction of the ignition system or fuel system. The experienced serviceman generally develops and follows a logical sequence in trouble shooting which will most likely lead him quickly to the source of trouble. One such sequence might be as follows:

FAILS TO START

1. Remove and examine spark plugs. If fuel is reaching the cylinder in proper amount, there should be an odor of gasoline on the plugs if they are cold. Too much fuel or oil can foul the plugs causing engine not to start. Fouled plugs are wet in appearance and easily detected. The presence of fouled plugs is not a sure indication that the trouble has been located, however. The engine might have started before fouling occurred if ignition system had been in good shape.

2. With spark plug removed, hold wire about $\frac{1}{8}$ to $\frac{1}{4}$ inch away from an unpainted part of the cylinder head or cylinder and crank the engine sharply. The resulting spark may not be visible in bright daylight but a distinct snap should be heard as the spark jumps the gap.

If carburetor and ignition were both in apparently good condition when tested in (1) and (2) above, check other elements of the engine such as crossed spark plug wires, improper timing, etc. A systematic search will usually pinpoint the cause of trouble with a minimum delay or confusion.

DIAGNOSIS. If the presence of fuel was not apparent when checked as in (1) above; and the spark seemed satisfactory when checked as in (2), systematically check the fuel system for the cause of trouble. The following are some of the probable causes:

- a. No fuel in tank
- b. Fuel shut off valve closed
- c. Fuel tank vent closed or plugged
- d. Carburetor not primed
- e. Choke or starting valve incorrectly used or malfunctioning
- f. Water or dirt in the fuel
- g. Fuel line pinched or kinked
- h. Clogged fuel shut off, fuel line or filter
- i. Carburetor dirty or incorrectly adjusted.

If ignition trouble was indicated when checked as outlined in (2) above, check the electrical system for causes of trouble. Some probable causes are as follows:

- a. Battery voltage low (Battery ignition models)
 - b. Ignition breaker points improperly adjusted
 - c. Shorted wire or stop switch
 - d. Open (broken) wire
 - e. Loosen or corroded connections
 - f. Condenser shorted
 - g. Improperly mounted coil (Incorrect gap between primary coil and fly-wheel magnets)
 - h. Flywheel loose
 - i. Faulty coil
 - j. Ignition breaker points stuck open
 - k. Ignition breaker point contacts pitted, burned or dirty
- (New ignition points are sometimes coated with protective oil).

FAULTY RUNNING ENGINE

The diagnosis of trouble in a running engine depends on experience, knowledge and acute observation. A continuous miss on one cylinder of a two cylinder engine can usually be isolated by observing the items listed in the previous paragraphs (FAILS TO START).

Faults such as not enough power (or speed) can usually be traced to improper tuning. Make sure that air filter is clean and in good condition and that exhaust pipe and muffler are open (not clogged). Ignition timing and carburetor(s) must be correctly adjusted. The carburetor jet sizes, clip position in valve needle and idle mixture needle settings listed in the individual service sections in this manual are "normal" settings. Altitude above sea level, riders weight, driving habits etc. may require different sizes and settings than those listed. On motorcycles with two carburetors, make certain that the throttles are synchronized to open exactly the same amount. Ignition timing on two cylinder motorcycles must be the same for each cylinder. In addition to normal engine tuning procedures, check the following: Sprocket sizes incorrect. Drive chain too tight or too loose. Tire pressure too low. Brakes dragging. Clutch slipping. Damaged pistons, rings and/or cylinders. Loose cylinder head nuts or leaking head gasket. Leaking crankcase seals.

SPECIAL NOTES ON TROUBLE SHOOTING

ENGINE OVERHEATS. The following lists some probable causes of engine overheating.

1. Check for dirt or debris accumulated on or between cooling fins on cylinder and head.
2. Too lean fuel-air adjustment of carburetor.

3. Improper ignition timing. Check breaker point gap and ignition timing.
4. Two-cycle engines being operated with an improper fuel-lubricating oil mixture may overheat due to lack of lubrication; refer to appropriate engine service section in this manual for recommended lubrication requirements.
5. Missing or bent shields or blower housing. (On models with cooling blower, never attempt to operate without all shields and blower housing in place.)
6. Engines being operated under loads in excess of rated engine horsepower or at extremely high ambient (surrounding) air temperatures may overheat.

TWO-STROKE CYCLE ENGINE

EXHAUST PORTS. Two-stroke engines, and especially those being operated on an overly rich fuel-air mixture or with too much lubricating oil mixed with the fuel, will tend to build up carbon in the cylinder exhaust ports. It is recommended that the muffler be removed periodically and the carbon removed from the exhaust ports, exhaust pipe and muffler.

On two-stroke cycle engines that are hard to start, or where complaint is loss of power, it is wise to remove the exhaust pipe and inspect the exhaust ports for carbon build up.

TWO-STROKE CYCLE ENGINES WITH REED VALVE. On two-stroke cycle engine, the incoming fuel-air mixture must be compressed in engine crankcase in order for the mixture to properly reach the engine cylinder. On engines utilizing reed type carburetor to crankcase intake valve, a bent or broken reed will not allow compression build up in the crankcase. Thus, if such an engine seems otherwise OK, remove and inspect the reed valve unit. Refer to appropriate engine repair section in this manual for information on individual two-stroke cycle engine models.

SPARK PLUG

The appearance of the spark plug will be altered by use and careful examination of the plug tip can contribute useful information. It must be remembered that contributing factors differ in two stroke cycle and four stroke cycle engine operation and although the appearance of two spark plugs may be similar, the corrective measures may depend on whether the engine is of two-cycle or four-cycle design. The accompanying pictures (Figs.

FUNDAMENTALS

2-1 thru 2-8) are provided by Champion Spark Plug Company to illustrate typical conditions. Listed also are the probable causes and suggested corrective measures.

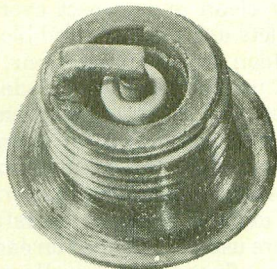


Fig. 2-1—Normal plug appearance. Insulator is light tan to gray in color and electrodes are not burned. Renew plug at regular intervals as recommended by manufacturer.

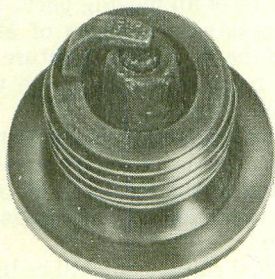


Fig. 2-2—Appearance of spark plug indicating cold fouling. Cause of cold fouling may be use of a too-cold plug, excessive idling or light loads, carburetor choke (or starting valve) out of adjustment, carburetor adjusted too "rich" or air filter dirty or wet.

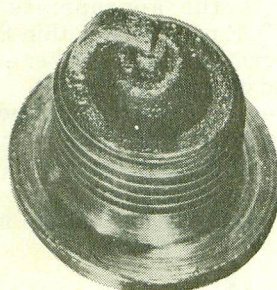


Fig. 2-3—Appearance of spark plug indicating wet fouling; a wet, black oil film is over entire firing end of plug. Cause may be incorrect fuel-oil ratio, incorrectly adjusted oil pump or leakage of transmission oil into crankcase (through crankshaft seals).

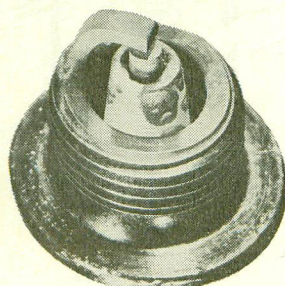


Fig. 2-4—Appearance of spark plug indicating splash fouling. Carbon deposits which have accumulated during a long period may be loosened suddenly upon installation of new spark plugs. When the newly tuned engine is placed under load, excess carbon deposits shed off the piston and are thrown against the hot insulator surface. These deposits can foul the plug, but can be removed from the plug by cleaning.

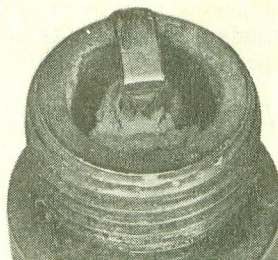


Fig. 2-5—Appearance of spark plug indicating core bridging. This condition is similar to, and caused by, the same combustion chamber deposits that cause splash fouling (Fig. 2-4). When the deposits become lodged between the insulator and the spark plug shell, an electrical bridge is formed, resulting in plug misfire.

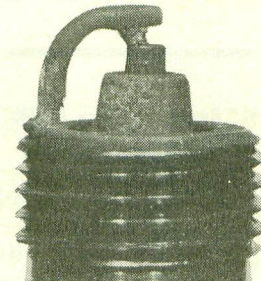


Fig. 2-6—Gap bridging usually results from excessive carbon deposits from prolonged usage, improper oil or incorrect oil to fuel ratio or high-speed operation immediately upon starting.

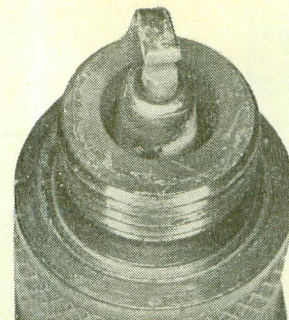


Fig. 2-7—If plug has been in use for some time electrodes may be badly eroded. Could be caused by lean carburetor mixture, fast timing, overloading, improper cooling or spark plug heat range too hot.

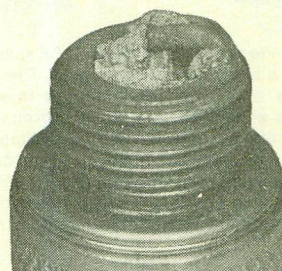


Fig. 2-8—Gray, metallic aluminum deposits on plug. This condition is caused by internal engine damage. Engine should be overhauled and cause of damage corrected.

MAINTENANCE

SPARK PLUG

The recommended type of spark plug, heat range and electrode gap is listed in the appropriate MAINTENANCE section for each motorcycle. Under light loads, low speeds or only short trips, a spark plug of the same size with a higher (hotter) heat range may be installed. If subjected to heavy loads, high speeds and/or long (cross country) trips, a colder plug may be necessary.

The spark plug electrode gap should be adjusted on most plugs by bending the ground electrode. Refer to Fig. 2-10. The ground electrode for some extremely cold (racing) plugs is constructed as shown by "COLD PLUG" in

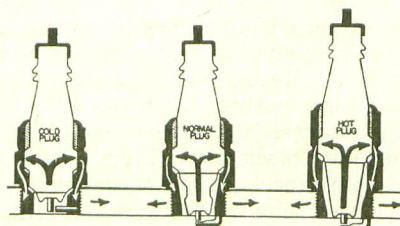


Fig. 2-9—A principal characteristic of a "COLD" plug is that it has a shorter path for heat to travel from the insulator tip to the metal shell than the "HOT" plug shown at the right.

Fig. 2-9 and electrode gap is pre-set or adjusted with a special tool.

Spark plugs are usually cleaned by abrasive action commonly referred to as "sand blasting." Actually, ordinary sand is not used, but a special abrasive which is nonconductive to electricity even when melted, thus the abrasive cannot short out the plug current. Extreme care should be used in cleaning the plugs after sand blasting; however,

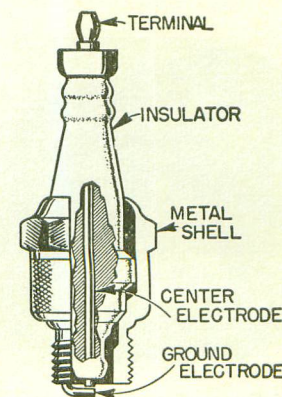


Fig. 2-10—Cross sectional view of spark plug showing typical construction and nomenclature. Recommended gap between center electrode and ground electrode is listed in appropriate section for each motorcycle.

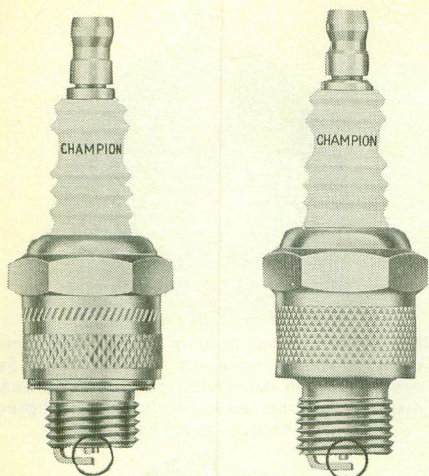


Fig. 2-11—View of a Champion J-8J spark plug (left) and a similar J-8 plug on right. The J suffix indicates that ground electrode is slightly shorter as shown. Plugs with short ground electrode usually require less ignition voltage than standard type and lessen the chance of bridging between electrodes. The short ground electrode operates cooler than standard length even though plugs are considered same heat range.

as any particles of abrasive left on the plug may cause damage to piston rings, piston or cylinder walls.

After plug is cleaned by abrasive, and before gap is set, the electrode surfaces between the grounded and insulated electrodes should be cleaned and returned as nearly as possible to original shape by filing with a point file. Failure to properly dress the points can result in high secondary voltage requirements, and misfire of the plugs.

CAUTION: Use special caution when filing the electrodes of spark plugs using precious metal electrodes. Fig. 2-11A shows the center electrode of a Champion "Gold Palladium" spark plug which has been bent by filing. Precious metal electrodes are usually softer than normal plugs and easily damaged by filing. Electrode gap for plugs with precious metal electrodes can be set for less gap than other spark plugs.

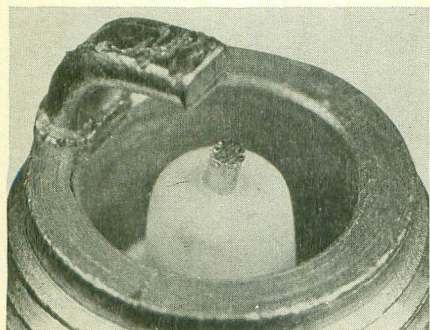


Fig. 2-11A—Use care to prevent damage to the electrodes, especially those made of precious metals. The center electrode shown has been roughened, shortened and bent by filing. The plug shown is a Champion "Gold Palladium" type.

The following may be used to compare standard types to "Gold Palladium" spark plugs:

14mm / 5/8" Reach			14mm / .472" Reach	
—	—	HOT ↑ ↓ COLD	—	—
J-8J	—		L-86	—
—	UJ-11G		—	—
J-7J	—		—	—
—	UJ-7G		L-81	L-6G
J-6J	—		—	—
—	—		—	—
J-4J	—		L-78	L-3G
—	—		—	—
J-57R	—		L-77J	L-2G

14mm / 5/8" Reach			18mm / .445" Reach	
—	—	HOT ↑ ↓ COLD	K-13	—
—	—		—	K-12G
N-5	—		K-9	—
—	—		—	K-8G
N-4	N-4G		K-8	—
—	—		—	K-5G
N-3	N-3G		K-7	—
—	—		—	—
N-2	N-2G		K-60R*	K-3G
—	—		K-57R*	K-2G

* .500" Reach

It is usually necessary to clean or renew spark plugs shortly after overhauling the engine. The oil used to coat engine parts during assembly may foul the plugs quickly.

CARBURETOR

The bulk of carburetor service consists of cleaning, inspection and adjustment. After considerable service it may become necessary to overhaul the carburetor and renew worn parts to restore original operating efficiency. Although carburetor condition affects engine operating economy and power, ignition and engine compression must also be considered to determine and correct causes.

Before dismantling carburetor for cleaning and inspection, clean all external surfaces and remove accumulated dirt and grease. If fuel starvation is suspected, all filters in carburetor, shut-off valve and tank should be inspected. Because of inadequate fuel handling methods, rust and other foreign matter may sometimes block or partially block these filters. Under no circumstances should these filters be removed from the fuel system. If filters are removed, the blockage will most likely occur within the carburetor and cleaning will be frequent and more difficult.

Refer to appropriate engine repair section for carburetor exploded or cross sectional views. Disassemble the carburetor and note any discrepancies which may cause a malfunction. Thoroughly clean and inspect every part. Wash jets and passages and blow clear with clean, dry, compressed air. **NOTE:** Do not use a drill or wire to clean jets, because the possible enlargement of holes will disturb calibration. Measurement of jets to determine extent of wear is difficult and installation of new parts usually assures satisfaction. Sizes are usually stamped on each jet.

Inspect float pin and needle valve for wear and renew if necessary. Check metal floats for leaks and dual type floats for alignment of float sections. Check fit of all moving parts. Binding or excessive clearance of all parts should be corrected. Mixture adjustment needles must not be worn or grooved.

When reassembling, be sure float level (or fuel level) is properly adjusted as listed in the CARBURETOR paragraph of the appropriate engine repair section.

Normal adjustment will be limited to replacement of recommended standard size jets and turning idle mixture needle (screw); however, the following procedure may be useful for carburetors that are particularly hard to adjust. Refer to the appropriate CARBURETOR paragraph within the specific repair section for further explanation and views of carburetors.

Idle mixture adjustment needle controls mixture from idle to approximately 1/4 throttle opening. Throttle slide cut-away (Fig. 2-12), on variable venturi carburetors, controls mixture

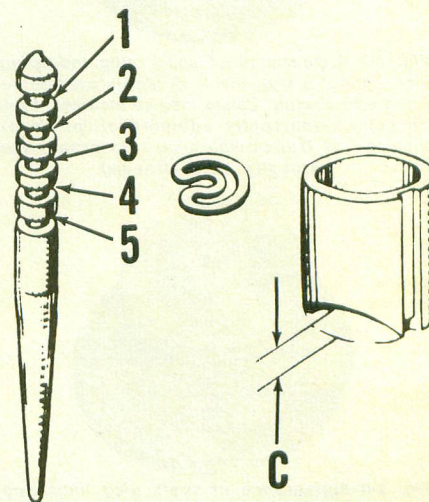


Fig. 2-12—View of slide type throttle valve. A large cut-away (C) leans the mixture in the 1/8-1/4 throttle range. Installation of clip in a groove nearer the top (such as No. 1) of valve needle leans the mixture in the 1/4-3/4 throttle opening range.

from $\frac{1}{8}$ to $\frac{1}{4}$ throttle opening. A larger cut-away leans the mixture in this range. The valve needle located in sliding venturi, controls mixture from $\frac{1}{4}$ to $\frac{3}{4}$ throttle opening. Lowering the needle in the slide leans mixture. The size of the main jet controls mixture from $\frac{3}{4}$ to full open throttle.

When two carburetors are used on two cylinder engines, mixture adjustments are sometimes facilitated by removing the spark plug wire from the other cylinder while tuning. Setting for the two carburetors should not differ greatly. Large differences in mixture settings for proper engine operation indicates air leak in inlet manifold, faulty carburetor or engine internal faults.

IGNITION AND ELECTRICAL

The fundamentals of ignition and electrical system service are outlined in the following paragraphs. Refer to the appropriate heading for type of system being inspected or overhauled. A simple, easily constructed test lamp is shown in Fig. 2-13. A similar test lamp or Ohmmeter can be used to facilitate repair.

Battery Ignition

Repair is usually limited to renewal of breaker points and/or condenser and adjustment of ignition timing. Refer to the appropriate MAINTENANCE section for recommended breaker point gap and ignition timing for each model.

BREAKER POINTS. Using a small screwdriver, separate and inspect condition of contacts. If burned or deeply pitted, points should be renewed. If contacts are clean to grayish in color, disconnect condenser and coil lead wires from breaker point terminal. Connect one lead (C1—Fig. 2-13) to the

insulated breaker point terminal and the other (C2) to engine (ground). Light should burn with points closed and go out with points open. If light does not burn, little or no contact is indicated and points should be cleaned or renewed and contact maximum gap should be reset. NOTE: In some cases, new breaker point contact surfaces may be coated with oil or wax. If light does not go out when points are opened, breaker arm insulation is defective and points should be renewed.

Adjust breaker point gap as follows unless manufacturer specifies adjusting breaker gap to obtain correct ignition timing. First, turn engine so that points are closed to be sure that the contact surfaces are in alignment and seat squarely. Then, turn engine so that breaker point opening is maximum and adjust breaker gap to manufacturer's specification. Be sure to recheck gap after tightening breaker point base retaining screws.

CONDENSER. To check condition of the condenser without special test equipment, proceed as follows: The condenser case and wire should be visually checked for any obvious damage. Connect one end of the test lamp (C1—Fig. 2-13) to terminal at end of condenser wire and other end to condenser case. If light goes on, condenser is shorted and should be renewed. It is usually a good practice to renew condenser when new breaker points are installed.

IGNITION COIL. If a coil tester is available, condition of coil can be checked. However, if tester is not available, a reasonably satisfactory performance test can be made as follows:

Disconnect high tension wire from spark plug. Turn engine so that cam has allowed breaker points to close. With ignition switch on, open and close points with small screwdriver while holding high tension lead about $\frac{1}{8}$ to $\frac{1}{4}$ -inch away from engine ground. A bright blue spark should snap across

the gap between spark plug wire and ground each time the points are opened. If no spark occurs, or spark is weak and yellow-orange, renewal of the ignition coil is indicated.

Sometimes, an ignition coil may perform satisfactorily when cold but fail after engine has run for some time and coil is hot. Check coil when hot if this condition is indicated.

IGNITION TIMING. On some engines, ignition timing is non-adjustable and a certain breaker point gap is specified. On other engines, timing is adjustable by changing the position of the stator plate with a specified breaker point gap or by simply varying the breaker point gap to obtain correct timing. Ignition timing is usually specified either in degrees of engine (crankshaft) rotation or in piston travel before the piston reaches top dead center position.

Some engines may have timing marks or locating pin to locate the crankshaft at proper position for the ignition spark to occur (breaker points begin to open). If not, it will be necessary to measure piston travel or install a degree wheel on engine crankshaft. Refer to Figs. 2-15 and 2-16.

A timing light as shown in Fig. 2-13 is a valuable aid in checking or adjusting engine timing. After disconnecting the ignition coil lead from the breaker point terminal, connect the leads of the timing light as shown. If timing is adjustable by moving the stator plate, be sure that the breaker point gap is adjusted as specified. Then to check timing, slowly turn engine in normal direction of rotation past the point at which ignition spark should occur. The timing light should be on, then go out (breaker points open) just as the correct timing location is passed. If not, turn engine to proper timing

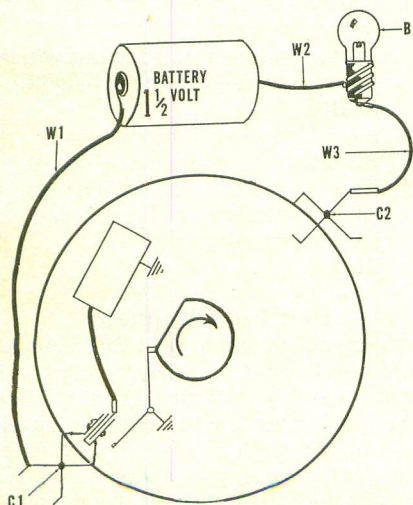


Fig. 2-13—Drawing of a simple test lamp for checking ignition timing and various other complete circuits.

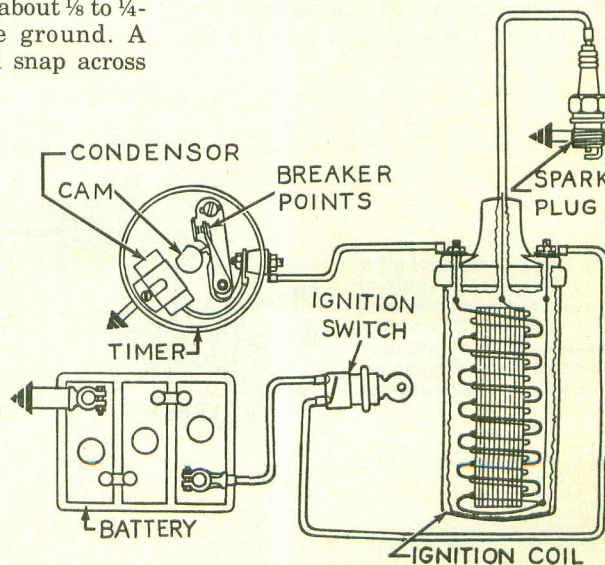


Fig. 2-14—Drawing of a typical battery ignition system for single cylinder engine. Ignition switch closes to complete the circuit.

location and adjust timing by relocating the breaker point base plate or varying the breaker contact gap as specified by appropriate section for each model. Recheck timing to be sure adjustment is correct.

If ignition is equipped with advancing mechanism (manual control or automatic, centrifugal advance), make sure timing is checked when fully advanced. On some models, timing can be checked using an automotive, power timing light when engine is running.

FLYWHEEL MAGNETO

Repair is usually limited to renewal of breaker points and/or condenser and adjustment of ignition timing. Refer to the appropriate MAINTENANCE section for recommended breaker point gap and ignition timing for each model.

BREAKER POINTS. The same general service procedure is used as in the preceding paragraph for BATTERY IGNITION. Holes are usually provided in the flywheel for adjustment, however flywheel usually must be removed for renewal of ignition points.

CONDENSER. The same general procedure is used to check condenser as outlined in previous BATTERY IGNITION system. Condenser is usually located under the flywheel.

ARMATURE AIR GAP. To fully concentrate the magnetic field of the flywheel, magnets pass as closely to the armature core as possible without danger of metal to metal contact. The clearance between the flywheel magnets and the legs of the armature core is called the armature air gap.

On magnetos where the armature and high tension coil are located outside of the flywheel rim, adjustment of the armature air gap is made as follows: Turn the engine so that the fly-

wheel magnets are located directly under the legs of the armature core and check the clearance between the armature core and flywheel magnets. If the measured clearance is not within manufacturers specifications, loosen the armature mounting screws and place shims of thickness equal to minimum air gap specification between the magnets and armature core. The magnets will pull the armature core against the shim stock. Tighten the armature core mounting screws, remove the shim stock and turn the engine through several revolutions to be sure the flywheel does not contact the armature core.

Where the armature core is located under or behind the flywheel, the following methods may be used to check and adjust armature air gap: On some engines, slots or openings are provided in the flywheel through which the armature air gap can be checked. Some engine manufacturers provide a cut-away flywheel that can be installed temporarily for checking the armature air gap.

Another method of checking the armature air gap is to remove the flywheel and place a layer of plastic tape equal to the minimum specified air gap over the legs of the armature core. Reinstall flywheel and turn engine through several revolutions and remove flywheel; no evidence of contact between the flywheel magnets and plastic tape should be noticed. Then cover the legs of the armature core with a layer of tape of thickness equal to the maximum specified air gap; then, reinstall flywheel and turn engine through several revolutions. Indication of the flywheel magnets contacting the plastic tape should be noticed after the flywheel is again

removed. If the magnets contact the first thin layer of tape applied to the armature core legs, or if they do not contact the second thicker layer of tape, armature air gap is not within specifications and should be adjusted. NOTE: Before loosening armature core mounting screws, scribe a mark on mounting plate against edge of armature core so that adjustment of air gap can be gaged.

MAGNETO EDGE GAP. The point of maximum acceleration of the movement of the flywheel magnetic field through the high tension coil (and therefore, the point of maximum current induced in the primary coil windings) occurs when the trailing edge of the flywheel magnet is slightly past the last leg of the armature core. The exact point of maximum primary current is determined by using electrical measuring devices, the distance between the trailing edge of the flywheel magnet and the leg of the armature core at this point is measured and becomes a service specification. This distance, which is stated either in thousandths of an inch or in degrees of flywheel rotation, is called the Edge Gap or "E" Gap.

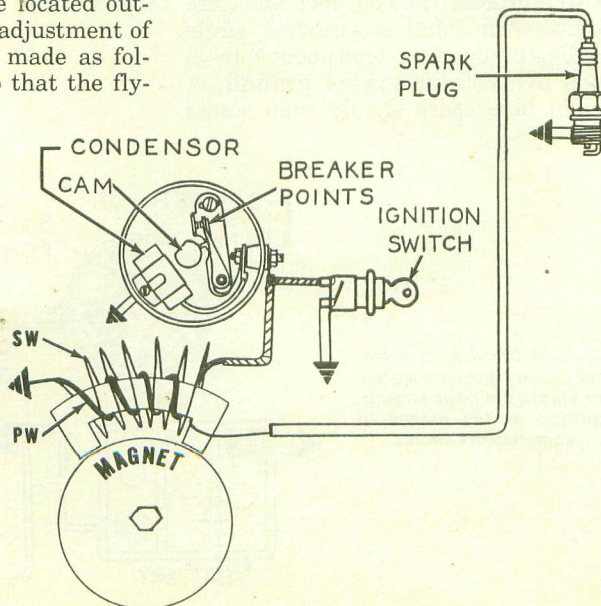
For maximum strength of the ignition spark, the breaker points should just start to open when the flywheel magnets are at the specified edge gap position. Usually, edge gap is non-adjustable and will be maintained at the proper dimension if the contact breaker points are adjusted to the recommended gap and the correct breaker cam is installed. However, magneto edge gap can change (and spark intensity thereby reduced) due to the following:

- a. Flywheel drive key sheared
- b. Flywheel drive key worn (loose)
- c. Keyway in flywheel or crankshaft worn (oversized)
- d. Loose flywheel retaining nut which can also cause any above listed difficulty.
- e. Excessive wear on breaker cam
- f. Breaker cam loose on crankshaft
- g. Excessive wear on breaker point rubbing block so that points cannot be properly adjusted.

Unit Type Magneto

Improper functioning of the carburetor, spark plug or other components often causes difficulties that are thought to be an improperly functioning magneto. Since a brief inspection will often locate other causes for engine malfunction, it is recommended that one be certain the magneto is at fault before opening the magneto housing.

Fig. 2-14A—Drawing of a typical magneto ignition system. Coil primary winding is shown at (PW) and secondary winding at (SW). Ignition switch grounds the primary circuit to stop engine.



BREAKER POINTS AND CONDENSER. The same general procedure is used to service and check as outlined in previous paragraphs for BATTERY IGNITION system. Usually complete magneto housing is rotated when adjusting ignition timing.

COIL. The ignition coil can be tested without removing the coil from the housing. The instruction provided with coil tester should have coil test specifications listed.

ROTOR. Usually, service on the magneto rotor is limited to renewal of bushings or bearings, if damaged. Check to be sure rotor turns freely and does not drag or have excessive end play.

MAGNETO INSTALLATION. When installing a unit type magneto on an engine, refer to IGNITION paragraph in appropriate engine repair section for magneto to engine timing information.

Energy Transfer System

The energy transfer ignition system operates very much as the previously described flywheel magneto system except the components are not in one area of the engine. Refer to Fig. 2-14B. The rotor (rotating magnet) is attached to the crankshaft with the low tension coil around it. As the magnet revolves, current generated in the low tension coil (LT) is grounded by the closed ignition breaker points. When the current generated in the low tension coil reaches its maximum voltage, the ignition points open causing a rapid build up of the primary current in the high tension coil. The rapid build-up of current in the high tension coil primary windings (PW) induces a high tension current in the secondary windings (SW) in much the same way as the rapid collapse in a battery ignition system. A special high tension coil is used and cannot be interchanged with a battery ignition coil.

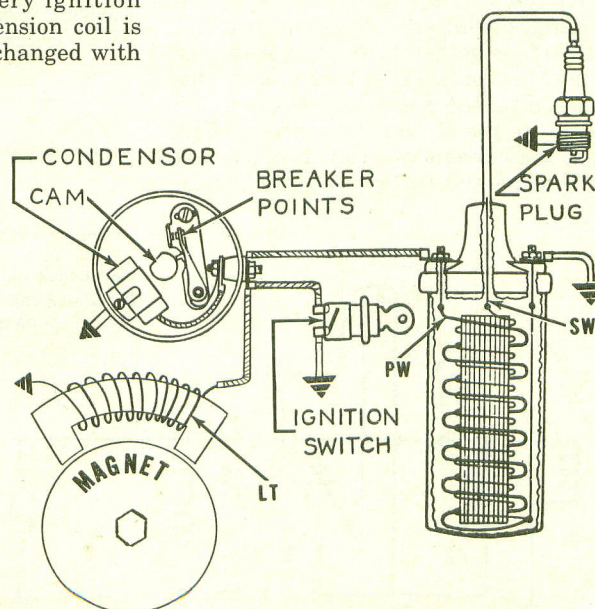


Fig. 2-14B—Drawing of a typical energy transfer ignition system. Low tension generating coil is shown at (LT). When breaker points are closed, current completes circuit through the points. When breaker points open, current rushes into the high tension coil primary winding (PW) and induces voltage in the secondary (SW). Ignition switch grounds the low tension circuit to stop engine.

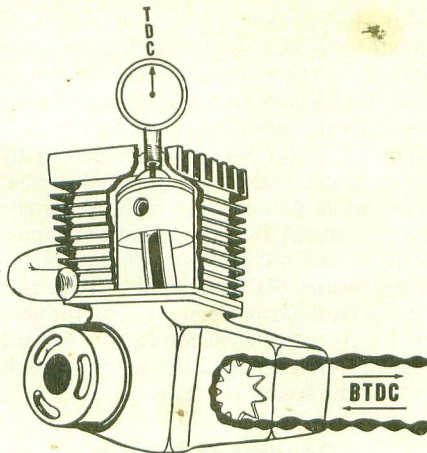


Fig. 2-15—On some engines, it will be necessary to measure piston travel with rule, dial indicator or special timing gage when adjusting or checking ignition timing. Arrows show direction to move chain to position piston Before Top Dead Center after TDC has been located.

If the ignition timing cam and rotating magnet (rotor) are separately mounted, each must be individually timed with crankshaft to obtain the correct magneto edge gap. Refer to preceding paragraph in FLYWHEEL MAGNETO section for explanation of EDGE GAP. On models where the rotor is keyed to the crankshaft, advancing the time of ignition breaker point opening causes a low voltage in the primary winding resulting in insufficient secondary voltage. If the rotor is moveable on the crankshaft, it is important that the rotor position and ignition breaker point opening not be changed from the recommended settings listed in the repair section of this manual.

Make certain that the high tension coil is securely attached. On many

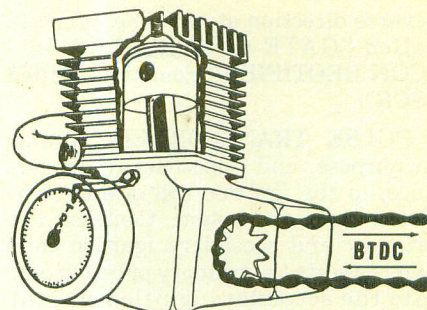


Fig. 2-16—View of typical degree wheel installation for checking ignition timing. Degree wheel can also be used for checking rotary valve timing and piston port opening.

models, the attaching screws provide the ground for the high tension coil. If not mounted correctly, ignition will be affected.

Capacitor Discharge System

This system differs radically from conventional units in that a relatively high voltage current is fed into a capacitor which discharges through a pulse transformer (ignition coil) to generate the ignition spark. The secondary current is induced by the rapid build-up rather than by collapse of the primary current. The result is a high-energy ignition spark ideally suited to high-speed, two-stroke engine operation.

One development which made the new systems possible was the introduction of semi-conductors suitable for ignition system control. While solid state technology and the capacitor discharge system are not interdependent they are uniquely compatible and each has features which are desirable from the standpoint of reliability and performance.

A flywheel magneto is most generally used as the primary current source in engines of the size and type found on motorcycles because of the relatively high voltage obtainable and compact, light-weight parts available. If battery current is used as the power source, it must be amplified or converted to obtain the necessary voltage.

The introduction of the new ignition systems is bringing unfamiliar words into use which might be defined in the following non-technical terms:

CAPACITOR. The storage capacitor, or condenser.

DIODE. A device which will allow electrical current to flow in one direction but will block a reverse flow.

GATE CONTROLLED SWITCH. A semi-conductor which will pass the flow of electrical current in one direction only when a second, small "TRIGGER CURRENT" opens the "GATE". Current will not flow in the

reverse direction at any time. Properly called "GATE CONTROLLED SILICON RECTIFIER". Sometimes called "SCR".

PULSE TRANSFORMER. Similar in purpose, and sometimes in appearance, to the ignition coil of a conventional ignition system. Contains the primary and secondary ignition coils and converts the primary pulse current into the secondary ignition current which fires the plug. Cannot be interchanged with regular ignition coil.

RECTIFIER. Any device which allows the flow of current in one direction only, or converts Alternating Current to Direct Current. Diodes are sometimes used in combination to form a BRIDGE RECTIFIER.

SCR. See GATE CONTROLLED SWITCH.

SEMI-CONDUCTOR. Any of several materials which permit partial or controlled flow of electrical current. Used in the manufacture of Diodes, Rectifiers, SCR's, Thermistors, Thyristors, etc.

SILICON SWITCH. See GATE CONTROLLED SILICON SWITCH.

SOLID STATE. That branch of electronic technology which deals with the use of semi-conductors as control devices. See SEMI-CONDUCTOR.

THERMISTOR. A solid state regulating device which decreases in resistance as its temperature rises. Used for "Temperature Compensating" a control circuit.

THYRISTOR. A "Safety Valve" placed in the circuit which will not pass current in either direction but is used to provide surge protection for the other elements.

TRIGGER. The timed, small current which controls, or opens, the "GATE", thus initiating the spark.

ZENER DIODE. A Zener Diode will permit free flow of current in one direction, and will also permit current to flow in the opposite direction when the voltage reaches a pre-determined level.

Fig. 2-16A shows a circuit diagram of a typical single cylinder, capacitor discharge, breakerless ignition system using permanent flywheel magnets as the energy source. The magnets pass by the input generating coil (1) to charge the capacitor (6), then by the trigger coil (4) to open the gate and permit the discharge pulse to enter the pulse transformer (7) and generate the spark which fires the plug (8). Only half of the generated current passes through diode (3) to charge the capacitor.

itor. Reverse current is blocked by diode (3) but passes through diode (2) to complete the reverse circuit. Diode (2) may be a Zener Diode to limit the maximum voltage of the forward current. When the flywheel magnet passes by the trigger coil (4) a small electrical current is generated which opens the gate of the SCR (5) allowing the capacitor to discharge through the pulse transformer (7). The rapid voltage rise in the transformer primary coil induces a high-voltage secondary current which forms the ignition spark when it jumps the spark plug gap.

Generating System FLYWHEEL ALTERNATORS.

Alternating current is readily available on engines using a flywheel magneto or energy transfer ignition system by installing an additional armature core (lighting coil) in a position similar to the ignition coil. The principle of this type of system is similar to the flywheel magneto, however only one winding is necessary. The voltage and amperage can be limited by the resistance (length, diameter, etc.) of the wire used in the lighting coil windings and the alternating current (AC) generated is satisfactory for lighting requirements. However, if a battery is used, the generated Alternating Current must be changed to Direct Current (DC) usually via a rectifier.

RECTIFIER. Repair of a rectifier is limited to renewal of the unit, however certain precautions and inspections may be more easily accomplished after a brief description of its operation.

Direct Current (DC), like the type available from a battery, has an established negative terminal and a positive terminal. Alternating current such as generated by a magneto or alternator changes polarity as the magnetic field of force is broken by the armature core (lighting core). This simply means that one end of the coil wire is first negative then as the flywheel (magnets) move on, the current reverses direction and the same end becomes positive. If the

AC current were connected to a battery (DC), the current would first flow into the battery, then as the AC changed polarity (direction) it would withdraw the same amount.

Electricity in a wire is similar to liquid in a pipe. In a pipe, a check valve can be installed to allow a liquid to flow only in one direction as shown in Fig. 2-17. A rectifier is a similar valve for an electrical system Fig. 2-18. The simplicity of modern rectifier construction is shown in Fig. 2-19. The changing of AC polarity can be shown on elaborate testing equipment similar to drawing (Fig. 2-20). Where the curved line crosses the center line is

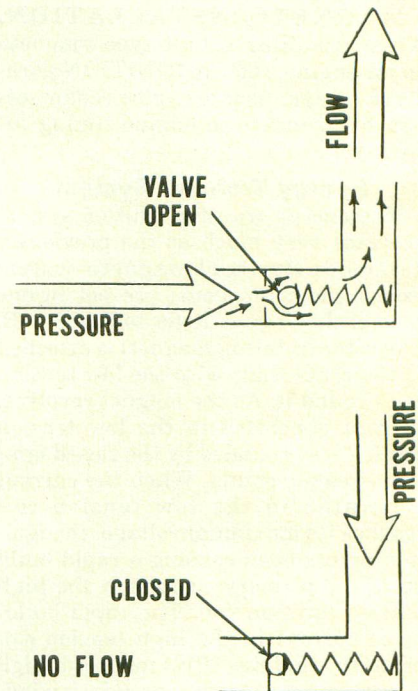


Fig. 2-17—A check valve can be installed in a pipe to allow a liquid to flow only in one direction. A rectifier serves a similar function in an electrical system.

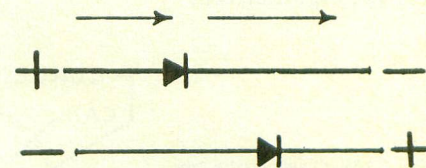


Fig. 2-18—A rectifier serves a similar function to the check valve in Fig. 2-17 allowing current to pass only in one direction.

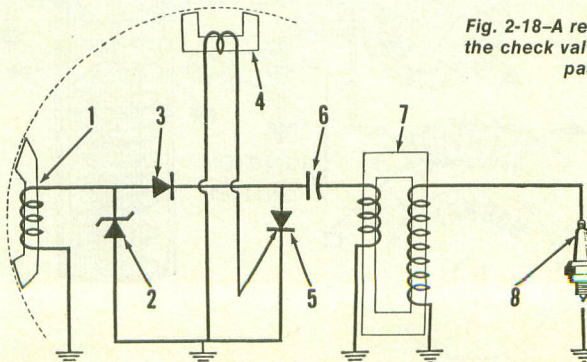


Fig. 2-16A—Schematic diagram of a typical Capacitor Discharge "Solid State" ignition system.

1. Generating coil
2. Zener diode
3. Diode
4. Trigger coil
5. Gate Controlled Switch (SCR)
6. Capacitor
7. Pulse transformer (coil)
8. Spark plug

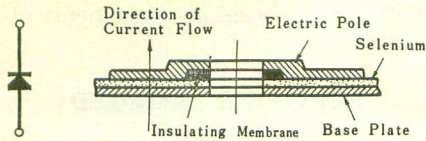


Fig. 2-19-Drawing showing the simplicity of typical modern rectifier construction. Type shown is Selenium.

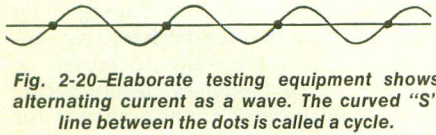


Fig. 2-20-Elaborate testing equipment shows alternating current as a wave. The curved "S" line between the dots is called a cycle.

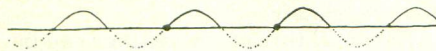


Fig. 2-21-Alternating current shown by dotted lines is unused when using only one rectifier.

the exact time that the current reverses polarity. Installation of a rectifier stops current flow in one direction so the current flow can be pictured as shown by the solid line in Fig. 2-21. Half of the current generated (shown by the broken lines) is lost. A typical, simple, complete system is shown in Fig. 2-22.

In order to use the current which is normally lost in the previously described simple system, a combination of rectifiers can be used. Normally they are constructed as one rectifying unit. Fig. 2-23 shows a typical complete system.

Rectifiers must be installed to allow current flow from the alternator into the battery. If the rectifier terminals are reversed, current from the battery will be fed into the lighting coil and coil and/or rectifier will be damaged by the resulting short circuit. The rectifier may be damaged if the system is operated without the battery connected or if battery terminals are reversed. Direction of current flow through the rectifier can be easily checked with a battery, light and wire (or ohmmeter) as shown in Fig. 2-24.

If the rectifier will not pass current in either direction using the simple test shown in Fig. 2-24, or if light continues to burn with connections reversed, rectifier may be considered faulty. Paint should not be scraped from rectifier plates and plates should not be discolored (from heat) or bent. The center bolt torque is pre-set and should NOT be disturbed.

LUBRICATION

Refer to the appropriate MAINTENANCE section for each model for recommended type and quantity of lubrication oils used in engine, gear box and primary (engine to transmission) drive case.

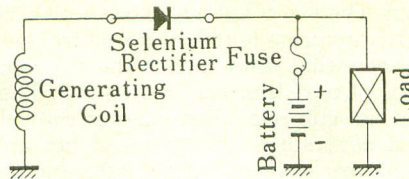


Fig. 2-22-A complete, simple electrical system using only one rectifier is basically as shown.

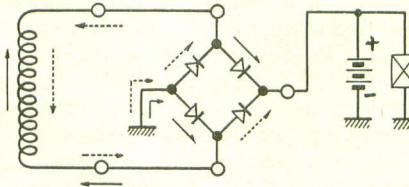


Fig. 2-23-Wiring diagram of full wave rectifying system. The four rectifiers shown are usually constructed as one unit.

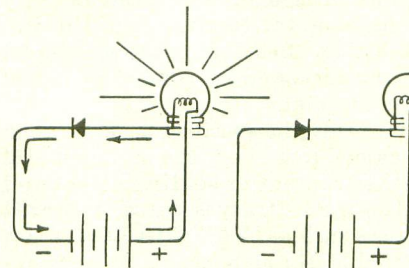


Fig. 2-24-A simple test can be made as shown on a rectifier to show which direction current can flow. Wires should be connected to rectifier so that current is allowed to pass as shown by arrows in wiring diagrams.

OIL-FUEL RATIO. Some engines are lubricated by oil that is mixed with the fuel. It is important that the manufacturer's recommended oil to fuel ratio be closely followed. Excessive oil will

cause low power, plug fouling and excessive carbon build-up. Insufficient amount of oil will result in inadequate lubrication and rapid internal damage. The recommended ratios and type of oil are listed in LUBRICATION paragraph of each MAINTENANCE section. Oil should be mixed with gasoline in a separate container before it is poured into the fuel tank. The following table may be useful in mixing the correct ratio.

RATIO	Oil	Gasoline
1:14	½ Pint	.88 Gallon
1:15	½ Pint	.94 Gallon
1:16	½ Pint	1.0 Gallon
1:20	½ Pint	1.25 Gallons
1:24	½ Pint	1.5 Gallons
1:25	½ Pint	1.56 Gallons
1:50	½ Pint	3.13 Gallons

OIL PUMP ADJUSTMENT. Some models are equipped with a separate oil tank and pump for lubricating the engine. It is important that the oil pump is properly adjusted to provide the correct amount of oil. If the pump does not deliver the correct amount of oil, the engine may be damaged. Refer to the appropriate engine section for adjustment procedure. It is recommended that adjustment be checked periodically to make sure that oil delivery is correct. Wear and/or control cable stretch will decrease the amount of oil delivered.

CLUTCH CONTROL

Clutch cable and/or control linkage is usually provided with adjustments to compensate for some stretch in cable and small amount of clutch plate wear. Clutch linkage should not prevent clutch from completely engaging and when the control is actuated, clutch should not drag. Refer to appropriate section for adjustment procedure and requirements of each model.

REPAIRS

Because of the close tolerance of the interior parts, cleanliness is of utmost importance. It is suggested that the exterior of the engine and all nearby areas be absolutely clean before any repair is started. Manufacturer's recommended torque values for tightening screw fasteners should be followed closely. The soft threads in aluminum castings are often damaged by carelessness in over-tightening fasteners or in attempting to loosen or remove seized fasteners.

DISASSEMBLY AND ASSEMBLY

When removing the cylinder head, loosen the screws evenly in a diagonal pattern to prevent warpage. After cylinder head is removed, carefully check for distortion using a lapping block or similar flat area.

Two or more identical pistons, rings, connecting rods and bearings may be used, but parts should never be interchanged when reassembling. As parts are removed, they should all be marked to identify the correct position. All

wearing parts seat to the mating parts during operation. If parts are mixed during reassembly, a new wear pattern is established and early failure may result.

A given amount of heat applied to aluminum or magnesium will cause it to expand a greater amount than will steel under similar conditions. Because of the different expansion characteristics, heat is usually recommended for easy installation of bearings, pins, etc., in aluminum or magnesium castings. Sometimes, heat can be used to free parts that are seized or where an interference fit is used. Heat, therefore, becomes a service tool and the application of heat, one of the required service techniques. An open flame is not usually advised because it destroys the paint and other protective coatings and because a uniform and controlled temperature with open flame is difficult to obtain. Methods commonly used for heating are: 1. In oil or water, 2. An electric oven or Kiln, 3. With a hot air

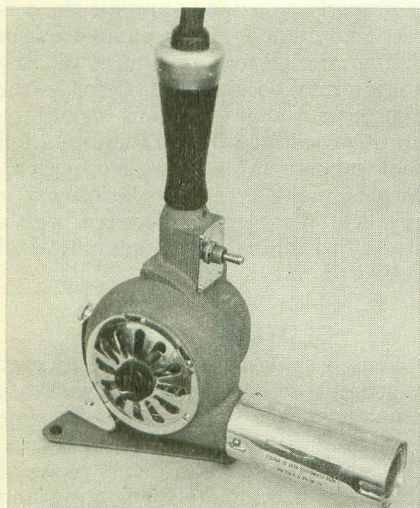


Fig. 2-25—The heat gun shown above has a built in fan. This heat gun and the one shown in Fig. 2-25A are available from Master Appliance Corp., 1745 Flett Ave., Racine, Wis. 53403.

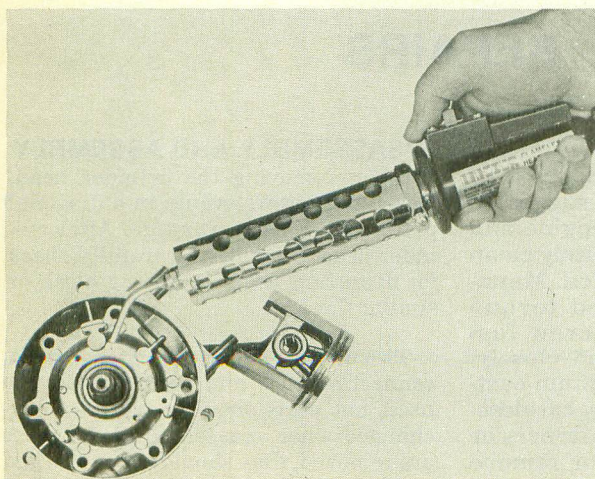


Fig. 2-25A—The heat gun shown uses compressed air from an outside source. The air is electrically heated and temperature is varied (up to 1000° F.) by controlling air pressure.

gun. The use of hot water or oil gives a fairly accurate temperature control but is somewhat limited as to the size and type of part that can be handled. The hot air gun has advantages of control and portability. Two types of hot air guns are shown in Figs. 2-25 and 2-25A. Thermal crayons are available which can be used to determine the temperature of a heated part. These crayons melt when the part reaches specified temperature, and a number of crayons for different temperatures are available. Temperature indicating crayons are usually available at welding equipment supply houses.

The crankcase and combustion chambers must be sealed against pressure, vacuum and oil leakage. To assure a perfect seal, nicks, scratches and warpage are to be avoided, especially where no gasket is used. Slight imperfections can be removed by using a fine-grit sand-paper. Flat surfaces can be lapped by using a surface plate or a smooth piece of plate glass, and a sheet of fine sandpaper or lapping compound. Use a figure-eight motion with minimum pressure, and remove only enough metal to eliminate the imperfection. Bearing clearances must not be lessened by removing metal from the joint.

Use only the specified gaskets when re-assembling, and use an approved gasket cement or sealing compound unless the contrary is stated. Approved sealers such as "YAMAHA BOND" are available through the U.S. distributors. A different type sealer is usually suggested for use with gaskets than without gasket. All friction surfaces, including bearings and seals, should be coated with oil before assembling.

It is desirable to lock some threaded parts when assembling, using a product such as "Loctite". Some locations suggested for using "Loctite" are cylinder studs, bearing retainer plates,

shift stops, suspension components attached to frame, etc.

REPAIRING DAMAGED THREADS

Special techniques must be developed in repair of engines of aluminum alloy or magnesium alloy construction. Soft threads in aluminum or magnesium castings are often damaged by carelessness in over-tightening fasteners or in attempting to loosen or remove seized fasteners. Manufacturer's recommended torque values for tightening screw fasteners should be followed closely.

Damaged threads in castings can be renewed by use of thread repair kits which are recommended by a number of manufacturers. Use of thread repair kits is not difficult, but instructions must be carefully followed. Refer to Figs. 2-26 through 2-28 which illus-

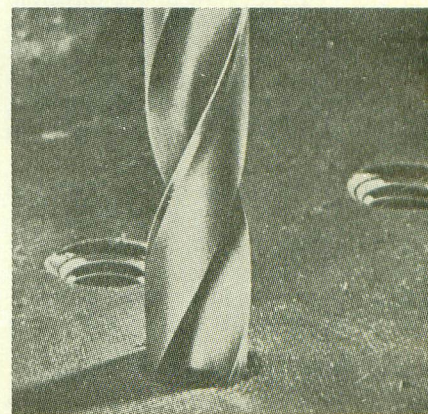


Fig. 2-26—First step in repairing damaged threads is to drill out old threads using exact size drill recommended in instructions provided with thread repair kit. Drill all the way through an open hole or all the way to bottom of blind hole, making sure hole is straight and that centerline of hole is not moved in drilling process. (Series of photos provided by Heli-Coil Corp., Danbury, Conn.)

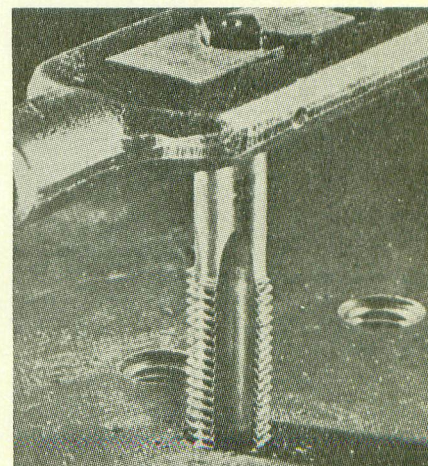


Fig. 2-27—Special drill taps are provided in thread repair kit for threading drilled hole to correct size for outside of thread insert. A standard tap cannot be used.

trate the use of Heli-Coil thread repair kits that are manufactured by the Heli-Coil Corporation, Danbury, Connecticut.

Heli-Coil thread repair kits are available through the parts departments of most engine and equipment manufacturers; the thread inserts are available in most of the common thread sizes and types.

FASTENER THREADS

Due to the international manufacturing and usage, servicing will require a knowledge of the different types of fastener threads in current use. The normal precaution of making sure threads match before applying force to the fastener must be followed. Due to recent changes in some thread standards, "eyeballing" different fasteners to match threads is virtually impossible and the fasteners must be mated more than one or two turns to detect a difference. A trial fit should always be used when there is any doubt as to threads matching.

Currently, three thread systems are the basis for threaded parts manufactured internationally. They are: the Inch-Thread System, the Whitworth Thread System and the Metric Thread System. The Whitworth Thread System is used mainly in Britain. The Inch Thread System is found in countries using the English system of measurement and has been used in a relatively unchanged state for a long period of time. The Metric Thread System has, however, undergone recent changes which should be noted.

Even though the Metric Thread System is based on the metric system of measurement, standards as to thread pitch, depth and diameter have not

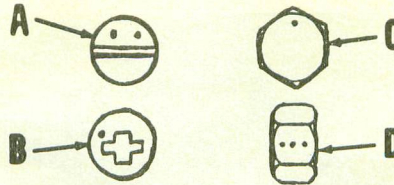


Fig. 2-28A—Marks used by one manufacturer to identify fasteners having ISO Threads. Small dots represent punch or die marks. Slotted screw and set screw marks are shown at (A), Phillips head screw at (B), bolt head at (C) and side view of nut at (D).

been internationally consistent. In an effort towards standardization of the Metric Thread System, the major manufacturing countries of the world have agreed to follow the thread standards set-up by the International Standardization Organization (ISO). In the future, fasteners of the same size having ISO metric threads will be interchangeable regardless of manufacturing origin. Identification of ISO fasteners may be different between manufacturers, but some identifying marks are similar and one manufacturer's identifying marks are shown in Fig. 2-28A. In addition to thread changes, some bolt head sizes have been changed. Be sure the tool fits the bolt head.

PISTON, RINGS, PIN AND CYLINDER

When servicing pistons, rings and cylinders, it is important that all recommended tolerances be closely observed. Parts that are damaged should be carefully examined to determine the cause. A piston damaged as shown in Fig. 2-29 is obviously not a result of normal wear and if the cause is not corrected, new parts may be similarly damaged in a short time. On this particular piston, the skirt is not scored and the first glance will show melted aluminum which has covered the ring on one side. The melted spot (D) on top

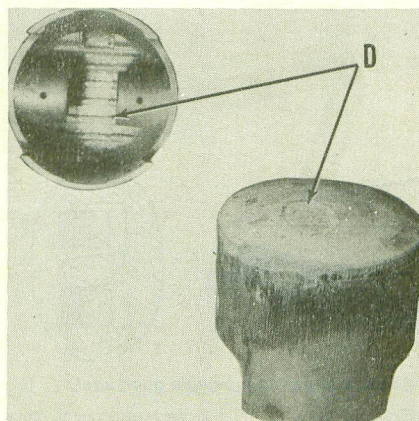


Fig. 2-29—If parts are excessively damaged, cause should be determined and corrected before returning motor to service.

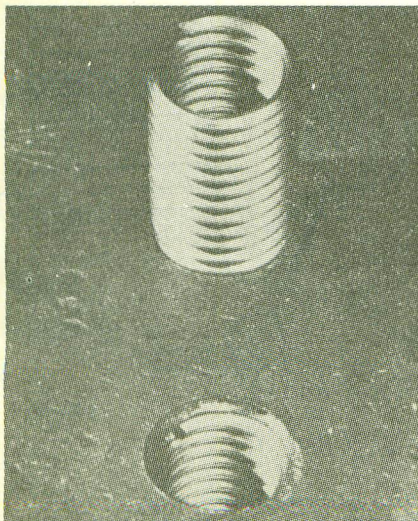


Fig. 2-28—A thread insert and a completed repair are shown above. Special tools are provided in thread repair kit for installation of thread insert.

and below piston crown is conclusive proof of detonation damage and the cause must be corrected during overhaul or the same failure can be expected to recur.

If pistons are scuffed or scored, look for metal transfer to cylinder walls. Metal transfer and score marks must be removed from cylinder walls with a hone. Chrome plated cylinder bores should not be honed.

Full strength muriatic acid can be used to remove aluminum deposits from a cast iron cylinder bore. Muriatic acid can be purchased in a drug store. It is also used as a soldering acid, although the supply kept in most radiator shops has usually been cut (diluted) with zinc. Use acid carefully, it can cause painful burns if spilled on the skin and the fumes are toxic. It is most easily used by carefully transferring a small amount to a plastic squeeze bottle, or to another small container and applying with a cotton swab. DO NOT allow the acid to spill or run onto aluminum portions of the cylinder, it will rapidly attack and dissolve the metal. Do not use the acid on a chrome bore. When applied to aluminum deposits, the acid will immediately start to boil and foam. When the action stops the aluminum has been dissolved or the acid is diluted; wipe the area with an old rag or towel which can be discarded. If deposits remain, repeat the process. Flush the area with water when aluminum is removed. Water will dilute the acid and can be used to stop the action if desired, or if acid runs off onto aluminum portion of cylinder, is accidentally spilled, etc. Immediately coat treated portion of cylinder with oil, as the acid makes the cast iron especially susceptible to rust.

A rule of thumb says scuffing or scoring of piston above the piston pin is due to overheating. Damage below the pin is more likely due to insufficient lubrication or improper fit. Overheating may be caused by a lean mixture, overloading, a damaged cooling fan or fins, air leaks in carburetor mounting gasket or manifold, blow-by (stuck or broken rings) as well as carbon build-up.

Before installing new piston rings, check ring end gap as follows: Position the ring near the bottom of cylinder bore. The piston should be used to slide the ring in cylinder to locate ring squarely in bore. Measure the gap between end of ring using a feeler gage as shown in Fig. 2-30. Slide the ring down in the cylinder to the area of transfer and exhaust ports and again measure gap. Rings may break if end gap is too tight at any point; but, will not seal

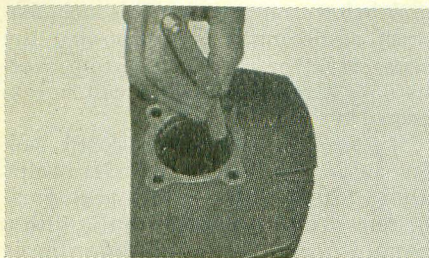


Fig. 2-30—Gap between ends of ring should be within recommended limits.

properly if gap is too wide. Variation in gap indicates cylinder wear (usually near the ports and at top of ring travel).

Ring grooves in the piston should be carefully cleaned and examined. Use caution when cleaning to prevent damage to piston. Grooves for Dykes (L rings), Keystone (Both sides angled) and Half Keystone rings are especially easily damaged. Carelessness can result in poor performance and possibly extensive internal engine damage. Refer to Fig. 2-31. When installing rings on piston, expand only far enough to slip over the piston and **do not twist rings**. After installing rings on piston, use feeler gage to measure ring side clearance in groove as shown in Fig. 2-32. Excessive side clearance will prevent an effective seal and may cause rings to break.

On models with cast iron cylinder or cylinder liner, cylinder bore should be honed to remove glaze from cylinder walls before installing new piston rings. Ridge at top and bottom of ring travel should be removed by honing. If ridge is not removed, new rings may catch enough to bend the ring lands as

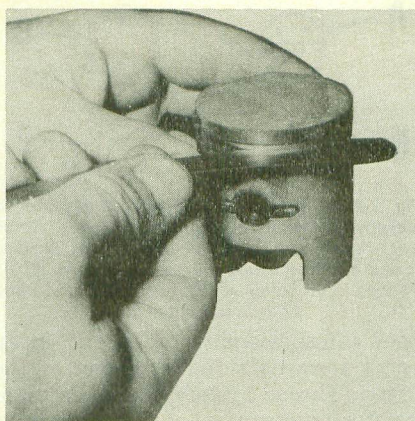


Fig. 2-32—Ring side clearance in groove should be measured with gage as shown. Clearance should be within recommended limits and the same all the way around piston.

shown at (G—Fig. 2-31). The finished cylinder should have light cross-hatch pattern as shown in Fig. 2-33. After honing, wash cylinder assembly with soap and water to remove all traces of abrasive. After cylinder is dry, swab cylinder bore with oil making sure that it is absolutely clean.

NOTE: On models with chrome plated aluminum cylinder bore, the cylinder should not be honed or rebored to an oversize. Chrome plated piston rings should not be installed in chrome cylinder bore.

Some manufacturers have oversize piston and ring sets available for use in repairing engines in which the cylinder bore is excessively worn and standard size piston and rings cannot be used. If care and approved procedures are used in oversizing the cylinder bore, installation of an oversize piston and ring set

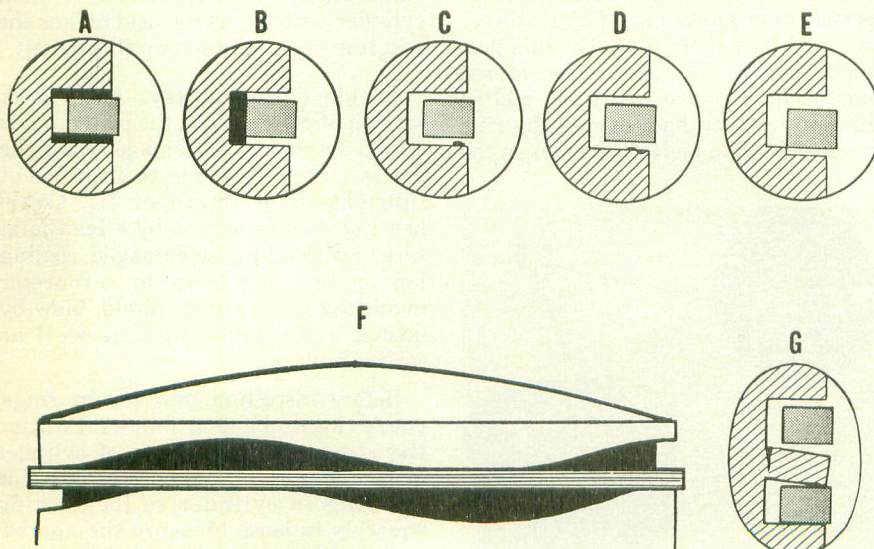


Fig. 2-31—Piston ring grooves must be clean and not damaged to provide a good seal.

A. Carbon on sides of groove may cause ring to stick in groove.

B. Carbon on bottom (back) of groove may prevent rings from compressing.

C & D. Small pieces of carbon (C) or nicks (D) in groove will prevent a good seal.

E. If groove is worn as shown, renew the piston.

F. If groove is not straight, renew piston.

G. Renew piston if ring land is bent.

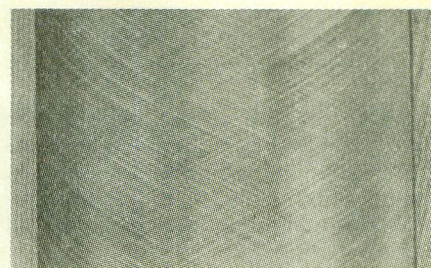


Fig. 2-33—A cross-hatch pattern as shown should be obtained by moving hone up and down cylinder bore as it is being turned by slow speed electric drill.

should result in a highly satisfactory overhaul.

The cylinder bore may be oversized by using either a boring bar or a hone; however, if a boring bar is used it is usually recommended the cylinder bore be finished with a hone. Refer to Fig. 2-33. Before attempting to rebore or hone the cylinder to oversize, carefully measure the cylinder bore to be sure that new, standard size piston and rings will not fit within tolerance. Also, it may be possible that the cylinder is excessively worn or damaged and that reboring or honing to largest oversize will not clean up the worn or scored surface.

Some manufacturers recommend that after boring a cylinder to an oversize, the top and bottom edges of the ports in the cylinder wall be rounded (or beveled) to prevent the rings from catching on sharp port edges. Fig. 2-34 shows typical port cross section with area to be removed shown enlarged at inset.

When assembling piston to connecting rod, observe special precautions outlined in the individual repair sections. The top of the piston is usually marked with an arrow for cor-

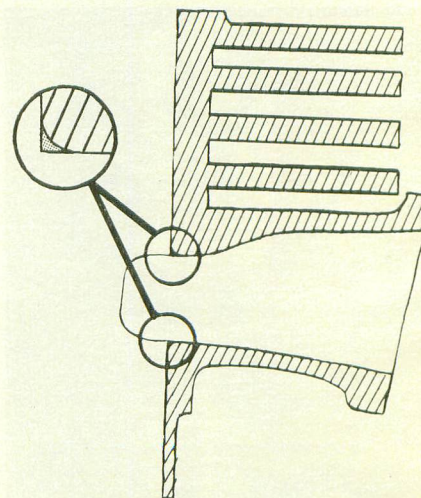


Fig. 2-34—Manufacturers of some two stroke cycle engines recommend that top and bottom edges of ports be chamfered (as shown in the insert) after reboring to prevent piston rings from catching on the sharp edges of ports.

FUNDAMENTALS

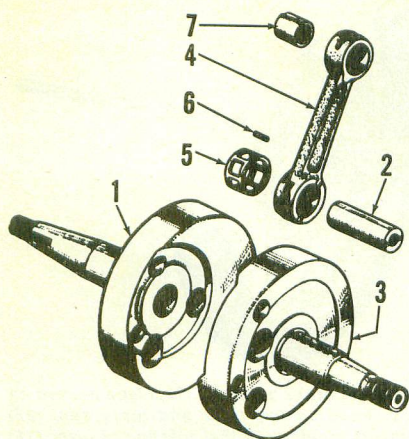


Fig. 2-35—Exploded view of typical press together crankshaft assembly. Many manufacturers have preassembled complete units available as service part.

rect assembly. In addition to positioning ring end gaps so that ends will not catch in ports, the piston pin bore in piston is usually off center. If piston is incorrectly installed, the piston skirt may be broken. Lubricate piston pin bearing (or bushing), piston, rings and cylinder before assembling.

CONNECTING ROD AND CRANKSHAFT

Many of the crankshafts are pressed together and are composed of parts shown in Fig. 2-35. To remove the connecting rod from these units, it is usually necessary to support one of the crankshaft counterweights and press crankpin out. When reassembling, it is necessary to accurately align the crankshaft assembly using a dial indicator and "V" blocks or lathe as shown in Fig. 2-36 or Fig. 2-37. Specification for maximum eccentricity and suggested method of measuring is given, in appropriate REPAIR section for each model.

NOTE: The crankshaft should be disassembled only if the required tools are available to check and align the reassembled crankshaft. On some models, repair parts are not available and the complete assembly is renewed on an exchange basis.

CRANKCASE AND GEARBOX

Most crankcases are composed of two halves which must be separated to remove internal parts. Usually dowel pins are used to align the two halves. The crankshaft bearings, dowel pins, transmission bearings and sealer all hold the two halves together and it is sometimes difficult to separate. **Extreme caution should be exercised when separating halves.** The mating surfaces will be difficult to seal if nicked or scarred. The crankshaft may be knocked out of alignment if main bearings are dislodged by pounding on

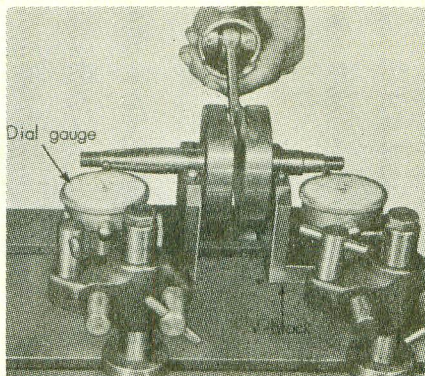


Fig. 2-36—Method of measuring crankshaft run-out (eccentricity) using "V" blocks and dial indicators is shown above.

end of crankshaft. Some manufacturers provide special tools for removing (and installing) crankshaft and main bearings from crankcase bores.

FRAME AND COMPONENTS

BRAKES

Front and rear brake action should be checked each time before the motorcycle is ridden. The front brake hand lever should **never** be compressed against hand grip even with brake fully applied. Normal **minimum** suggested clearance (as shown in Fig. 2-39) is approximately $\frac{1}{8}$ inch with front brake locked. Adjustment is accomplished at cable adjusters shown in Fig. 2-40 and Fig. 2-41 or at hand lever end of cable. Rear brake pedal should be compressed approximately $\frac{1}{8}$ inch (as

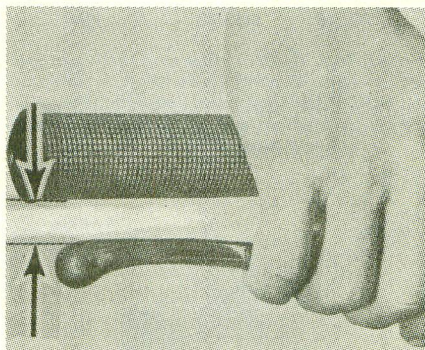


Fig. 2-39—The front brake hand lever should never contact the hand grip.

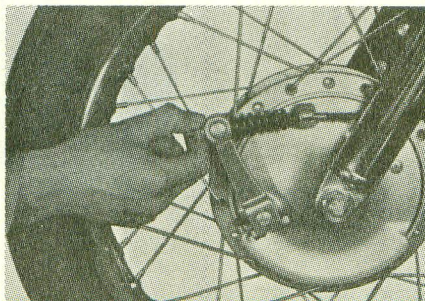


Fig. 2-40—Some models are provided with an adjustment nut as shown at end of front brake cable.

Frame and Components

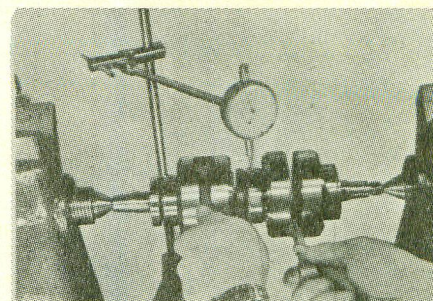


Fig. 2-37—Method of measuring eccentricity with crankshaft mounted between lathe centers using a dial indicator.

During reassembly of the transmission assembly, each gear selection should be engaged and crankshaft (or transmission shaft) rotated to make certain that reassembly is correct **BEFORE** completing the reassembly and installation.

shown in Fig. 2-42) with rear brake locked. Adjustment is normally accomplished as shown in Fig. 2-41 or 2-43.

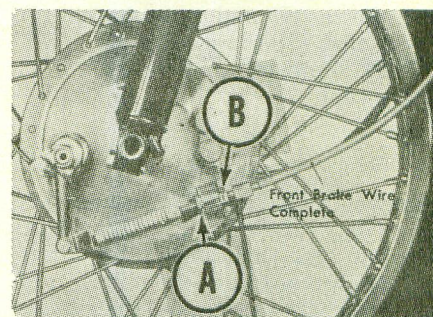


Fig. 2-41—Some front and rear brakes are adjusted at cable guides shown at (B) after locknut (A) is loosened.

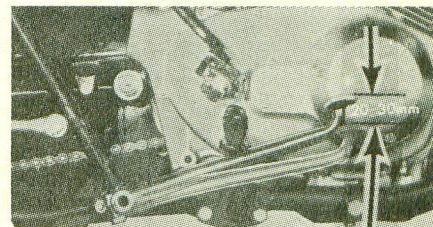


Fig. 2-42—Rear brake pedal should normally lock rear wheel when compressed approximately $\frac{1}{8}$ inch.

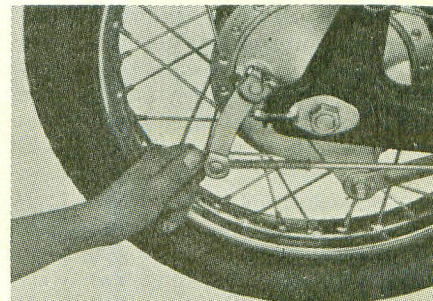


Fig. 2-43—An adjuster nut is provided at end of rear brake rod on some models as shown. Adjustment of other models may be similar to front wheel shown in Fig. 2-41.

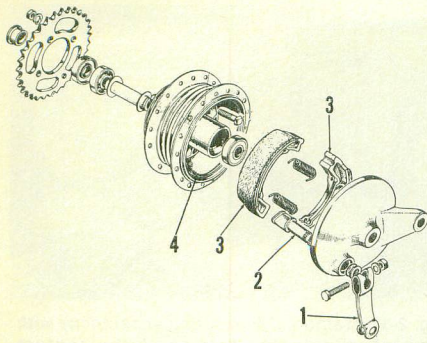


Fig. 2-44—Exploded view of simple rear brake assembly. Front brake may be similar. Lever (1) is actuated by controls and turns cam (2) expanding shoes (3) against drum (4).

When adjusting brakes, setting should not be so tight that wheels are hard to turn with brakes released. Typical exploded views of brake assemblies are shown in Figs. 2-44, 2-45 and 2-46.

On dual cam brakes, rod (5—Fig. 2-45) should be adjusted as follows: Disconnect brake cable from lever (1F) and remove pin (6). Adjust length of connector pin rod (5) until holes from pin (6) in lever (1F) and connector rod (5) are aligned without moving levers (1F and 1R). Reinstall pin (6) and adjust control cable.

CHAIN

Servicing drive chains consists of cleaning, lubricating, tightening, aligning and replacement. Improper maintenance and neglect not only shortens chain life but also contributes to sprocket wear.

The rear chain should periodically be removed and cleaned then lubricated with a commercial chain grease. Lubricant for the bushing area (White Arrows—Fig. 2-47) must work into bushing between the close fitting side plates and immersion is the most satisfactory way of assuring complete lubrication. Most of the chain lubricants require heating to thin the grease and allow the lubricant to enter all surfaces of the chain.

Sprocket tooth profile is precisely ground to fit the roller diameter and chain pitch. Refer to Fig. 2-48. When chain and sprocket are new, the chain moves around the sprocket smoothly with a minimum of friction, and the load is evenly distributed over several sprocket teeth. Wear on pins and bushings of a roller chain results in a lengthening or "stretch" of each individual chain pitch as well as a lengthening of the complete chain. The worn chain, therefore, no longer perfectly fits the sprocket. Each roller contacts the sprocket tooth higher up on the bearing area (C) and that tooth bears the total load until the next tooth and

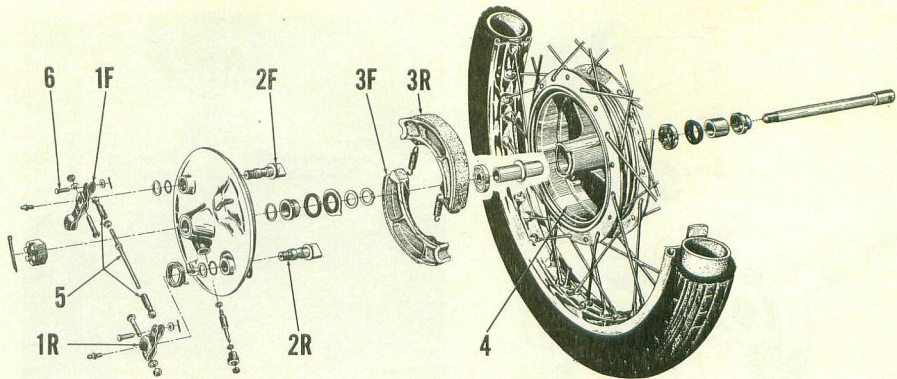


Fig. 2-45—Exploded view of dual cam (full self-energizing) front brake assembly. This type is used on rear on some models. Front lever (1F) is actuated by hand control lever and turns cam (2F) expanding brake shoe (3F). Rod (5) connects the two levers together so that rotation of lever (1F) will also rotate lever (1R).

roller make contact. Chain wear will therefore quickly result in increased sprocket wear.

As a rule of thumb, the chain should be inspected periodically and renewed whenever chain stretch exceeds 2% (or 1/4-inch per foot). Check sprockets carefully for wear if chain wear is substantially greater than 2%, and renew

sprockets if in doubt. Sprocket wear usually shows up as a hooked tooth profile. A good test is to fit the sprocket to a new chain. Wear on sides of sprocket indicates misalignment. If sprockets must be renewed because of wear, always renew the chain. Early failure

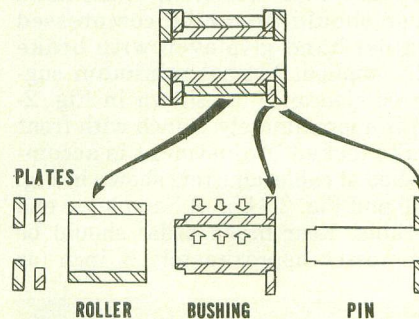


Fig. 2-47—The lubricant must work between the plates to enter bearing areas (white arrows) on each side of bushing. Occasional immersion is the only satisfactory way of assuring complete lubrication.

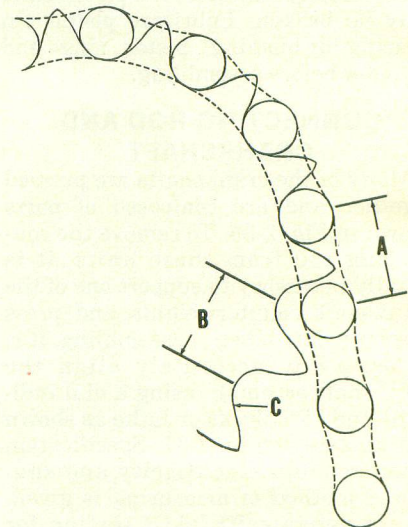


Fig. 2-48—Chain pitch (A) must exactly equal sprocket pitch (B) to prevent excessive wear on bearing edge of sprocket tooth (C). Refer to text.

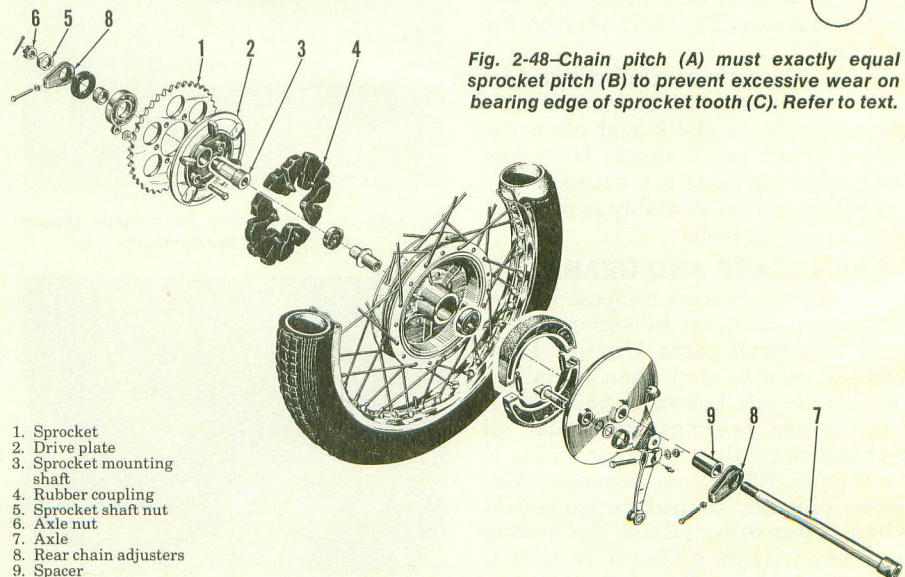
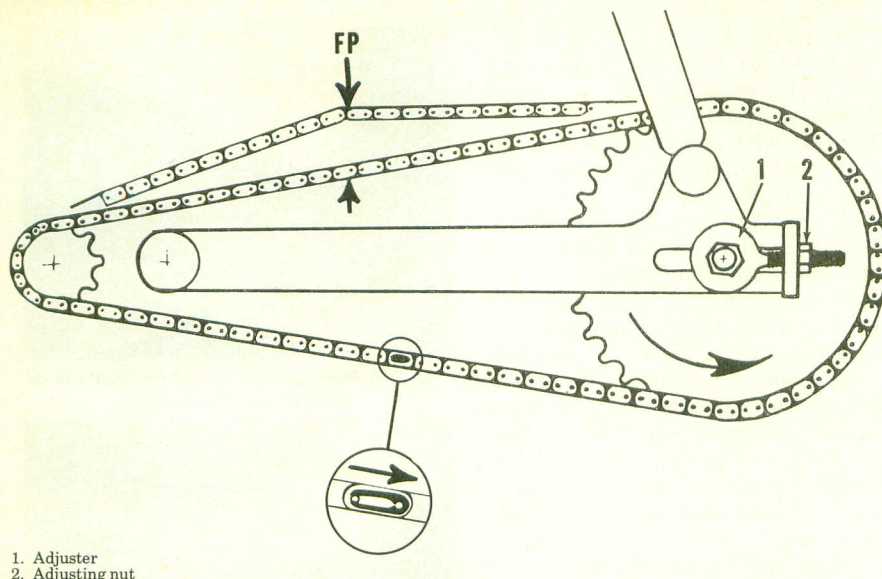


Fig. 2-46—On some models, the rear wheel can be removed without disturbing rear sprocket (1). Lugs on drive plate (2) fit into coupling (4) in wheel.

FUNDAMENTALS



1. Adjuster
2. Adjusting nut

Fig. 2-49—The recommended rear chain free play (FP) is listed in the table preceding each maintenance section. Inset shows correct master link installation.

can be expected if a new chain is mated with worn sprockets or new sprockets with a worn chain.

The rear chain is usually tightened by an adjuster similar to the one shown at (1—Fig. 2-49) located at each end of the rear axle. The adjuster located on the side of the chain provides most of the chain tightening, however every time the chain free play is adjusted, the sprocket alignment must also be checked. Improper alignment will subject the chain to side load and rapid wear and sprocket will show wear on sides of teeth. Free play should be measured midway between sprockets as shown at (FP—Fig. 2-49). Recommended rear chain free play is listed in the table preceding MAINTENANCE section of each model. Adjusters on both sides of axle should be tightened to provide correct free play and align sprockets. Refer to Fig. 2-51.

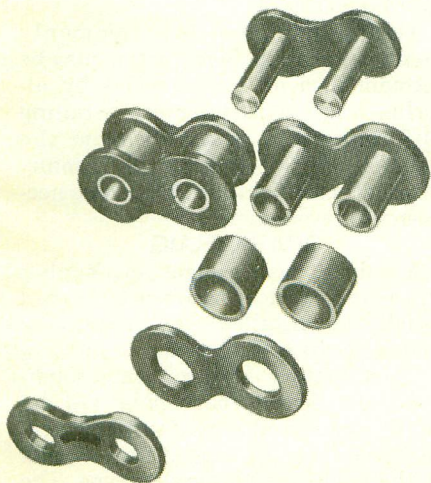


Fig. 2-50—Exploded view of typical single row drive chain.

Adjustment procedure for primary chain on models so equipped is outlined in MAINTENANCE section for that model.

WIRE WHEELS

Particular attention should be applied to the maintenance of wire wheels. Spokes should be checked for tightness periodically and any missing, bent or broken spokes renewed. The condition of the wheel hub should also be noted. The load of the motorcycle and rider is taken by the top spokes as the wheel revolves. Each spoke is designed to accept a part of the load, but as spokes are damaged, an unequal amount of the load is carried by other spokes which may eventually cause wheel failure.

Spoke tightness should be checked occasionally by gently hitting a metal object, such as a screwdriver, against each spoke. If the spokes are tightened evenly, each spoke, when hit, will produce a sound with a pitch approximately the same as the rest of the spokes. Tighten spokes with a spoke wrench until the same approximate pitch is heard on all spokes.

Single spokes may be renewed without dismounting wheel if rim and hub are not damaged. Release a small amount of air but do not flatten tire. Remove hooked end of spoke from hub, cut spoke to remove it if not already broken. Unscrew spoke from nipple being careful not to force nipple into rim. Insert replacement spoke through hub and attach to nipple. Spoke may be slightly bent on installation but should pull straight when tightened. New spoke should be checked for tightness after a few hours of run in time.

Most wheels are equipped with two different types of spokes, commonly

Frame and Components

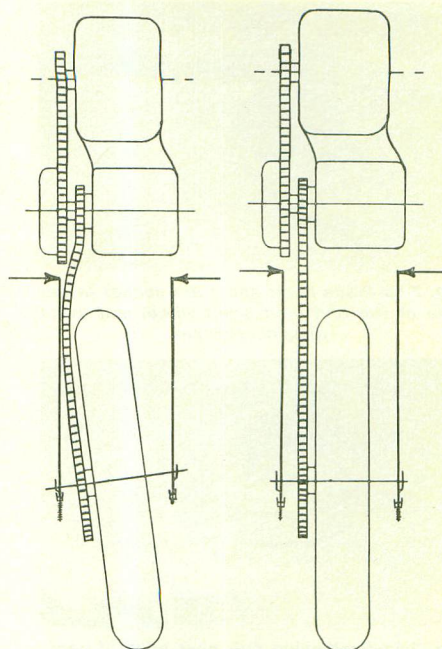


Fig. 2-51—The rear chain should be adjusted to provide correct chain alignment as shown in the right view.

called inner and outer spokes (Fig. 2-52). Outer spokes (A) tend to have more of a right angle bend while inner spokes (B) have a smaller angle bend. Inner and outer spokes are identical on some wheels but on units where the spokes are different they must be installed correctly.

If rim is bent or hub is broken, it will be necessary to remove and disassemble wheel. Before dismantling wheel, pay special attention to pattern of spoke lacing. There are several ways to lace wheels and sometimes wheels will be laced two different ways on the same motorcycle. When dismantling wheel, segregate inner and outer spokes and place spoke nipples in a container of light oil or solvent to aid reassembly.

Place hub on work bench and install outer, then inner spokes of top rim on

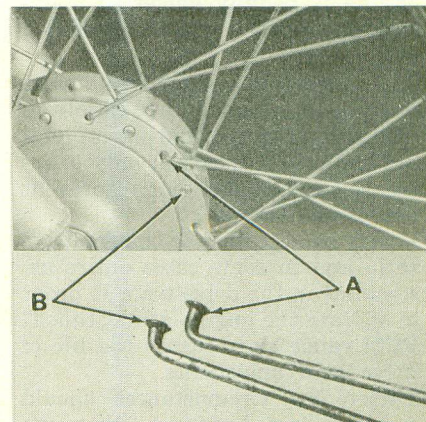


Fig. 2-52—Inner spokes (B) and outer spokes (A) may have different radius bend at head.

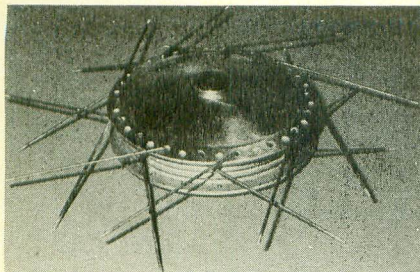


Fig. 2-53—Place inner and outer spokes in one side of rim and then invert wheel and install remaining spokes.

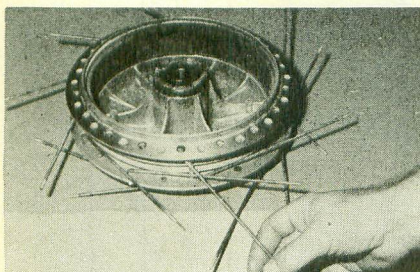


Fig. 2-54—Positioning hub near edge of bench will ease spoke installation.

hub (Fig. 2—53). Carefully invert hub and install remaining spokes. Placing hub close to edge of work bench will ease installation (Fig. 2—54). After installing all spokes and placing them in the approximate pattern they will be in, place wheel rim in position.

Examination of rim will show that spoke holes are drilled at various angles to match different angles at which spokes meet wheel.

Working with one row at a time, install all spoke nipples one or two turns or just enough to hold them in place. Wheel is ready to be trued.

Mount wheel on an axle and place in a vice or a suitable stand that will allow wheel to rotate freely. Begin by gradually tightening inner spokes a few turns at a time, constantly checking for eccentricity. Gradually decrease the amount each spoke is tightened each revolution of the wheel. High spots on rim may be isolated by gradually moving a grease pencil or other marker toward rim from outside. Loosen spokes opposite high spot $\frac{1}{2}$ -turn each and tighten spokes next to high spot $\frac{1}{2}$ turn each. Wipe away mark and recheck.

When all eccentricity is removed, gradually tighten outer spokes in the same manner. Bring marker in from side to check for side-to-side play. Loosen spokes pulling rim off center and tighten adjacent spokes to help bring rim toward center. When wheel is completely aligned strike each spoke with a small metal object to make certain that none have been left loose.

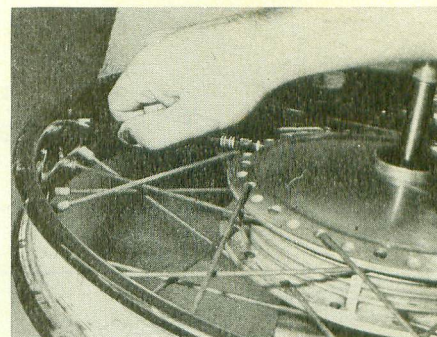


Fig. 2-55—Move grease pencil from inside to detect out of round condition.

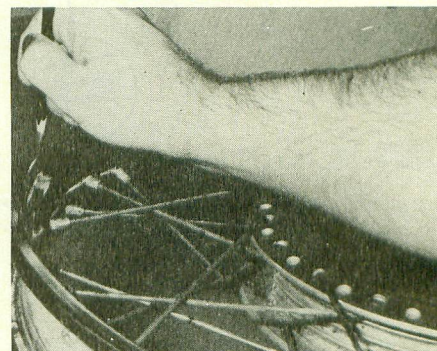


Fig. 2-56—Move grease pencil from side of rim to detect side to side play.

Any portion of spoke protruding past nipple into rim should be ground off to prevent tire damage.

SPEED TUNING

Procedures and specifications for modifying individual engines are included in some of the engine service sections. These modifications may be accomplished with varying degrees of success. Before any alterations are started, several things must be considered.

1. The life of an original production engine is usually longer (if maintained properly) than a modified engine.
2. Clearances and settings for all parts must be maintained more closely on modified engines than on original production engines, not only to increase performance but to prevent extensive damage.
3. It may be necessary to change drive ratio and in some cases entire assemblies in the drive train in order to operate the engine at its "tuned" RPM range or to insure the life of drive train components.
4. Under NO circumstances should work be started without a thorough knowledge of what and why it is being done.

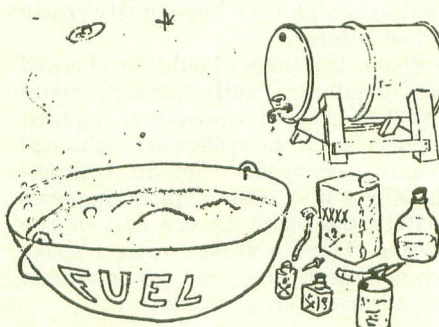


Fig. 3-1—Some fuel mixtures can be used successfully, but be careful when experimenting.

5. Make certain that the correct tools are used. Port modification, etc. may result in less power and/or destruction of an engine if improperly or carelessly done.
6. Any modification will void manufacturer's warranty.

The data included in the individual engine service sections is generally not the ultimate in modifications and is not intended to be. The changes listed are made available only after the manufacturer has completed extensive tests

and is convinced the modifications are safe and practical.

Many motorcycles can be modified to increase performance for the type of riding for which it was designed; however, it is more difficult to change its intended use (such as a trials model into a road racer).

The following outlines commonly used modification. Modification may be accomplished on some models by altering original parts or by installing different parts available from the manufacturer or other source. In many cases, all modifications will not be necessary or recommended.

SPARK PLUG

A colder (heat range) spark plug than original equipment should usually be installed. The spark plug should be the coldest which can be run without fouling. Under racing conditions, the correct spark plug will depend upon ambient temperature, length of race and type of race as well as the engine condition and type. The correct heat range may be too cold for operation until engine has been started

FUNDAMENTALS

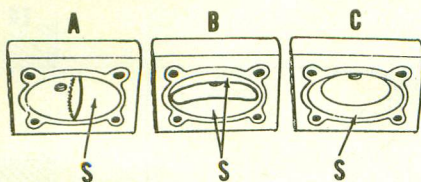


Fig. 3-2—Drawing showing typical cylinder heads. Type "A" has squish area (S) only on one side. Type "B", sometimes called a trench type head, has squish area (S) on two sides. Type "C" is hemispherical with squish area (S) completely around edge.

and warmed up. If the correct plug for racing conditions fouls before engine reaches normal temperature, use a hotter plug (such as original equipment type) to start and warm up the engine. If the spark plug is too cold, the plug will foul without causing excessive damage; however, the engine may be damaged if plug heat range is too high.

Make certain that the correct reach (thread length) and thread type (SAE or ISO) is selected. In some cases, it may be necessary to install different thickness spark plug gasket or two gaskets in order to have correct heat range and reach. Booster gap spark plugs are not recommended for most racing applications.

FUEL SYSTEM

The fuel system should receive careful consideration. Make certain that fuel fittings, lines and filters do not restrict fuel flow causing lean mixture at high speed.

If a different carburetor is installed, extreme care should be exercised. It is possible to install a carburetor that is too large on most engines. Some carburetor changes will cause "flat spots" at various RPM, loss of torque (especially at low RPM), hard starting or extensive engine damage from incorrect fuel-air mixture. When selecting a different carburetor, make certain that it is correct for your application. Carburetor and engine manufacturers are usually very helpful.

When adjusting mixture, a slightly rich setting is more desirable than a lean mixture. Check condition of fuel filters and fuel lines if mixture can not be set too rich at high RPM. Air leaks in crankcase will also cause lean mixture, especially at low RPM.

Fuels other than gasoline or additives for use with gasoline should be used with extreme caution. A great many different chemicals will aid performance, but many increase engine temperature and/or require a much richer fuel to air ratio. Sometimes the standard fuel lines will not supply enough volume, drilled passages and jets must be enlarged and some fuels will corrode or otherwise damage fuel

system parts. Several commonly used fuels will not mix with petroleum based oils and some require the use of an ester to mix with a lubricant.

IGNITION SYSTEM

Various ignition system changes are possible, including total loss battery ignition, capacitor discharge, energy transfer, etc. The system that seems to work for one engine tuner with one make (or model) of engine in one type of race may not be at all satisfactory to another. One thing common to all systems used for racing is that the ignition system must be maintained in much better condition than required for lower speed, lighter load applications.

On most engines, the original production timing will be correct or nearly correct. If ignition timing is to be advanced beyond original setting, begin with the original setting then slowly and carefully experiment with different timing. Excessive spark advance can destroy an engine very quickly.

CYLINDER HEAD

The cylinder head should usually be modified. The effective compression ratio is determined by displacement when the piston closes the exhaust port, not total displacement when piston is at Bottom Dead Center. If the exhaust port is raised, the effective compression ratio will be lowered and power may decrease if the cylinder head is not changed also. Some cylinder heads are manufactured to be used in combination with the raised exhaust port. If these cylinder heads are used on standard cylinder (with lower exhaust port), the engine may be damaged or power may decrease because of too high compression (preignition).

Many cylinder heads have a squish area (part of the cylinder head is very close to piston at Top Dead Center). The part of the cylinder head closest to piston may be all around the edge of cylinder (C—Fig. 3-2), only one side of cylinder (A) or on two sides (B). The squish area is provided to cause turbulence of the gaseous mixture for more complete burning. It is very important that the original clearance between low part of cylinder head and piston be maintained if the cylinder head is modified. If only the lower surface of cylinder head is milled, the piston will probably hit the cylinder head. If the squish area is also machined, but not enough material was removed (resulting in too little squish clearance), the engine may not run properly because of localized hot spots and/or trapped pockets of the gaseous mixture. Squish area should usually be machined to follow the original contour

Speed Tuning

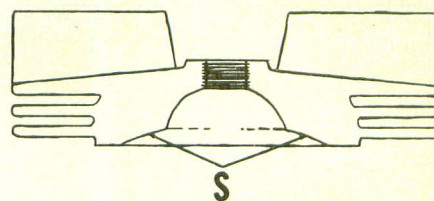


Fig. 3-3—If the cylinder head is milled, the squish area (S) must be changed also. Clearance between piston and squish area should be the same as original.

and clearance. Make certain that squish clearance is continued to the edge of the cylinder bore.

It is not necessary to polish the combustion chamber surface to a mirror finish; however, all sharp edges should be removed to prevent hot spots which might cause pre-ignition.

CYLINDER

Use extreme caution when modifying the cylinder in any way. The inlet, transfer and exhaust ports and passages are carefully designed and manufactured originally, and even more care should be exercised when changing them. The gases are timed by the vertical location of the ports in cylinder wall. Direction and velocity of flow is controlled by the width of ports and size and shape of the passages. If modification is sloppy or incorrect, power may be less than with original cylinder.

Carefully inspect the removed cylinder. Note the cylinder material and condition of cylinder bore. The three types of cylinders generally used are cast iron, aluminum with iron sleeve and aluminum with hard chrome plating in bore. A worn out or damaged cylinder should not be modified unless it can be repaired. If cast iron or aluminum with cast iron sleeve type cylinder is to be rebored to larger size, the cylinder should be resized before modifying ports. Refer to PISTON paragraphs for fitting piston.

Modification of cylinder made of cast iron or aluminum with cast iron sleeve can be accomplished by using a rotary grinder if carefully done. Work slowly and carefully, using as fine a stone as practical. A stone which is too coarse will have a tendency to work into one area, will be difficult to control and will result in rough irregular shapes. On some models with aluminum cylinder and cast iron sleeve, the cylinder can be heated, old sleeve removed and new chilled sleeve pressed into place. Make certain that all ports and passages are aligned when installing new sleeve.

Aluminum cylinder with hard chrome bore is normally found on higher performance models and extensive modification is not necessary. If any changes are made, be especially

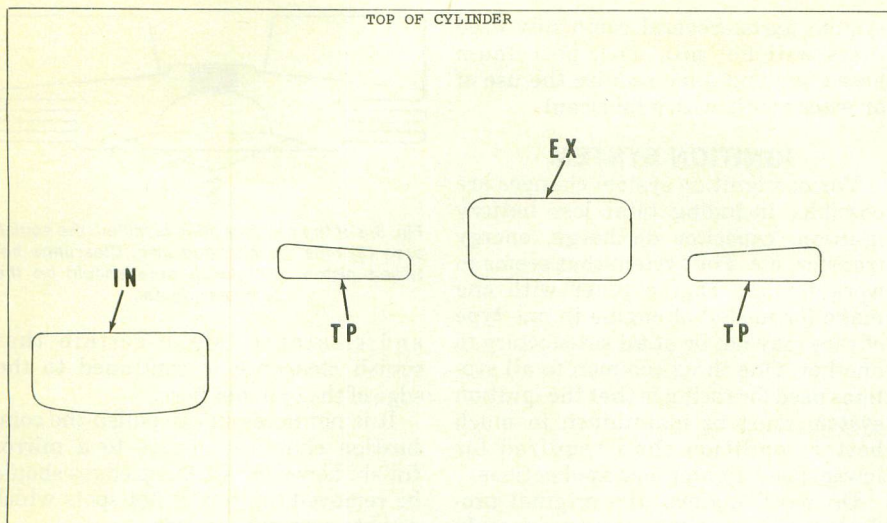


Fig. 3-5—A pattern of the original ports in cylinder should be made before changing any of the openings. Radii of the corners and edges are difficult or impossible to draw in the cylinder without a pattern.

careful or the chrome plating will be ruined and the cylinder will be useless. DO NOT bore or hone aluminum cylinder with hard chrome plated bore. Additional clearance between piston and cylinder can be accomplished by carefully finishing the piston. Refer to PISTON paragraphs for fitting piston to cylinder. If small amounts of material from piston have stuck to chrome cylinder bore, they can be removed by hand sanding. Very carefully sand diagonally as shown in Fig. 3-13. Using #400 or #600 sandpaper with oil or gasoline. Sand only by hand and stop when piston material is removed. DO NOT DAMAGE the chrome plating.

Before any grinding is done, examine original ports and note location, size and shape. Location and shape of ports can be transferred to paper positioned in cylinder bore and gently pressed against all of the port openings and top and bottom edges of cylinder bore. Be sure that paper does not move or an incorrect pattern will result. If carefully done, the removed paper should be marked similar to Fig. 3-5. All suggested radii are difficult (or impossible) to draw in the cylinder and if first

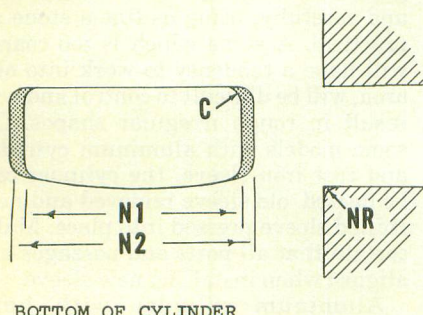


Fig. 3-6—Increasing the width of inlet port will only increase size and will not change timing. The lower edge (NR) should usually be rounded or beveled to prevent piston skirt from catching.

drawn on paper pattern can be more easily transferred to the cylinder.

Changes in port sizes and shapes should be drawn on inside of cylinder bore before grinding. Coat the area where changes are to be made with machinist dye or similar material, then scratch lightly through the coating to show material to be removed. In most cases, a pattern of the modified port will facilitate marking.

The inlet port and exhaust port are usually the easiest to work with and should be done first. On loop scavenged engines, modification to only one of the transfer ports and/or passages (or unequal modification to all transfer ports and passages) will prevent correct balance and possibly direction of the incoming fuel-air mixture. The result is usually reduced power and increased fuel consumption.

The inlet port (IN—Fig. 3-5), on piston ported models, is opened as the piston skirt moves toward the upper part of the cylinder. Advanced inlet timing (open sooner) and increased duration (stays open longer) can be accomplished on most models by cutting part of the piston skirt off. Lowering the bottom edge of port will also advance inlet timing and increase duration and is sometimes recommended. Advancing inlet timing on piston ported engines will also cause the port to close later resulting in less compression in the crankcase. Changing the width (Fig. 3-6) of inlet port only increases size. On most models, the lower edge of inlet port should be rounded slightly (NR) to prevent the piston skirt from catching on edge.

The inlet passage from carburetor to inlet port should be smoothed and in some cases be enlarged. Make certain that carburetor, gaskets, heat shields,

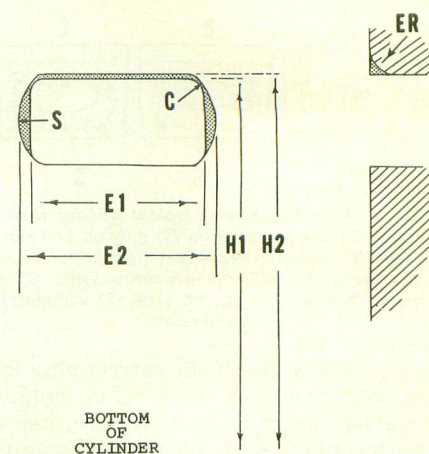


Fig. 3-7—Raising the exhaust port in cylinder will cause port to open sooner. If port modifications are incorrect, rings will probably catch and cause extensive damage. Radius (S) at sides and rounded edge (ER) guide rings back into grooves.

adapters, etc. are all aligned and passage through these parts and into inlet passage is smooth. Any misalignment will cause turbulence and restriction resulting in less power.

The exhaust port (EX—Fig. 3-5) is often raised and enlarged (width increased). Certain precautions must be taken or results will be totally unsatisfactory. Raising the exhaust port will cause it to open sooner and close later. While this is often desirable, raising the port will decrease compression of the fuel-air mixture before ignition, decrease the length of time for burning after top dead center and decrease the length of the power stroke. Within limits and with other modifications, raising the exhaust port can sometimes increase power. The limits suggested by the manufacturer should usually be considered the safe maximum. If width of exhaust port is increased, the piston rings may expand into and catch in the port. On some engines, the exhaust port is bridged to hold the rings, on some the top edge is rounded or beveled (ER—Fig. 3-7) and on some the sides of the ports are tapered or round (S) to guide the ring back into the grooves. Many engines use a combination of ways to hold and guide the rings out of the exhaust port. Extensive damage is sure to result if the rings catch in the exhaust port and the engine will probably not run long enough to determine whether power was increased or not. Width should not be increased beyond suggested limits.

The transfer ports (TP—Fig. 3-5) are usually difficult to reach in order to modify and the transfer passages (usually cast with the cylinder) are even more difficult. Some suggest that the piston be notched (Fig. 3-9) or spacer (S—Fig. 3-10) be installed between cyl-

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inder and crankcase as alternate methods of advancing transfer port timing. The method suggested in the individual engine section should be fol-

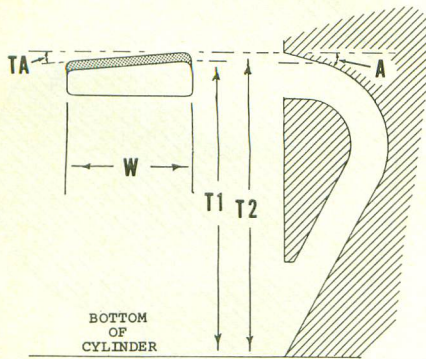


Fig. 3-8—Raising the transfer ports will cause ports to open sooner. Angles of passage (A) and port (TA) direct fuel into cylinder and should be closely maintained.

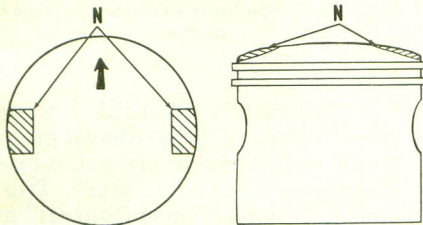


Fig. 3-9—If manufacturer recommends cutting the piston (N) to advance transfer port timing, use extreme care. Depth of cut will weaken piston and possibly damage piston rings.

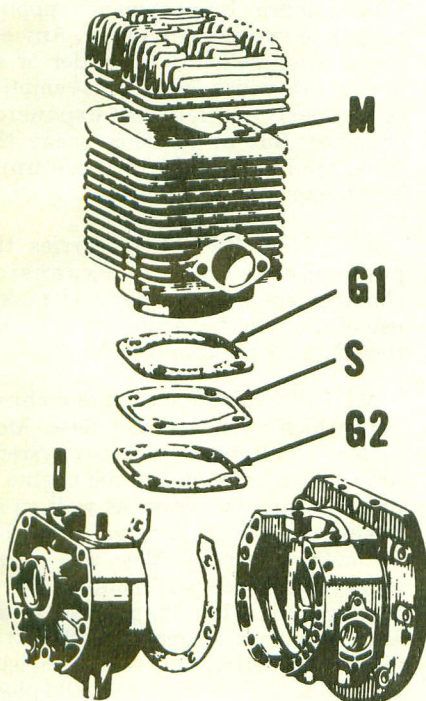


Fig. 3-10—Sometimes a spacer (S) is installed below cylinder to raise the transfer ports. Be sure to note that all ports (inlet and exhaust as well as transfer ports) will be raised. A second gasket (G2) should be used below spacer and combined thickness of spacer (S) and gasket (G2) is the amount that cylinder is raised. The amount that cylinder is raised should be machined from top of cylinder (M).

lowed. If the transfer ports and passages are reshaped; be sure that they are all alike and correct. The angle (A—Fig. 3-8) of the inlet passage and port (TA) determines the direction of the fuel-air charge entering the cylinder; if incorrect, fuel will be wasted and the cylinder will not be cleared of old gases. The transfer passage in crankcase, gasket, cylinder, and sometimes piston skirt, should be matched to provide smooth, nonrestrictive flow. Refer to Fig. 3-11.

Modifications to cylinder such as addition of transfer ports (fifth porting, gully porting, etc.) should usually be discouraged. When performed by an experienced shop, these modifications may increase performance, but should be considered risky.

PISTON

Special performance pistons, using thin rings, "L" rings, etc. are available from many sources including some of the engine manufacturers. The rings used on high performance pistons are designed to resist fluttering at high engine speeds. If the special pistons

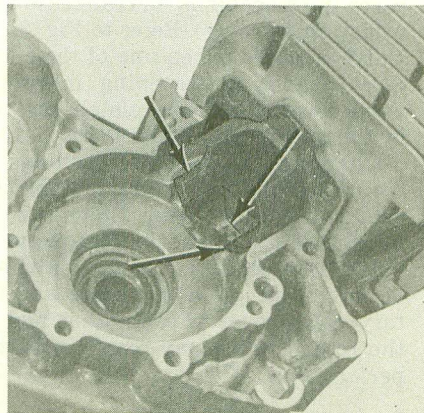


Fig. 3-11—The cylinder should match with crankcase openings. Arrows indicate locations of possible misalignment.

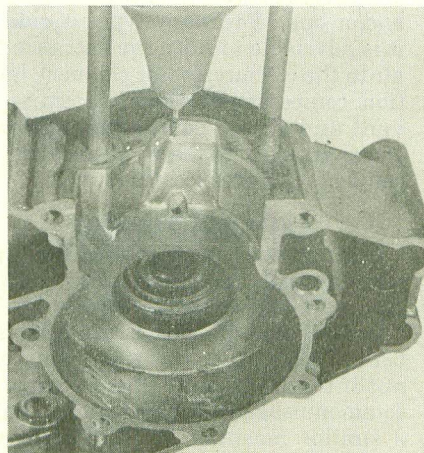


Fig. 3-11A—All bearings should be removed when correcting misalignment of passages. Make certain that all parts are completely cleaned before assembling.

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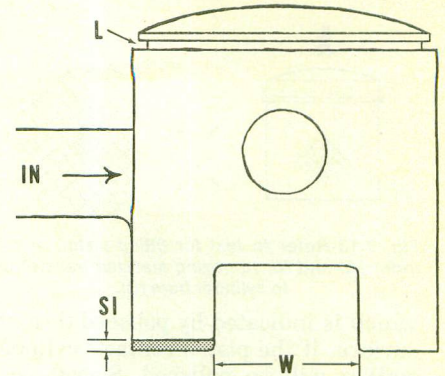


Fig. 3-12—Some pistons designed for high speed operation use an "L" shaped ring. Cutting bottom edge of piston skirt (S1) off will cause inlet port (IN) to open sooner. Slot (W) in lower edge of piston should match with similar openings in cylinder at Bottom Dead Center.

and rings are available, installation is usually advisable.

NOTE: Never install chrome plated rings in chrome plated cylinder bore. Do not install "L" ring and piston in cylinder bore which has been operated with standard type ring unless cylinder is rebored to remove old ridge.

On most engines with piston port inlet, the inlet timing is advanced and inlet duration increased by removing part of the piston skirt (S1—Fig. 3-12) that covers the inlet port. Only a small amount of the lower edge should be removed on most engines. If piston is marked for installation in the cylinder (nearly all are marked), make sure that piston is cut correctly. If the piston has windows (W) in lower edges which align with the lower end of transfer passages, they should not partially block the passages. After cutting the piston, be sure to round off all sharp edges and corners.

Any modifications to piston (welding, drilling holes, etc.) should be considered risky. Some modifications involving these techniques may be successful when accomplished by experienced personnel but should not be attempted without considering the risk.

The piston to cylinder clearance on high performance engines should usually be more than on standard production models. If cylinder material was originally cast iron and was changed to aluminum with hard chrome bore, the clearance when cold may be less.

The piston should be fitted as follows, if new piston and/or cylinder is installed: Run the machine at partial RPM and partial load for a short time (approximately 5 to 10 minutes), then remove cylinder and piston. Check the piston for any localized high spots

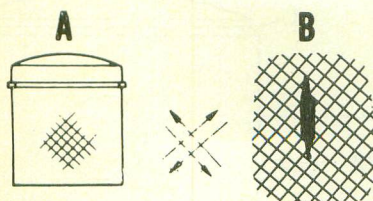


Fig. 3-13—Refer to text for fitting piston to cylinder (A) and for removing material transferred to cylinder bore (B).

which is indicated by polished (bright) surface. If the piston contacts cylinder wall it will be polished. Smooth any polished surface of piston carefully by hand using #400 or #600 sandpaper. Refer to B—Fig. 3-13. Also check the cylinder for deposits of aluminum transferred from the piston. If deposits are present, sand diagonally as shown at (A—Fig. 3-13) very carefully using #400 or #600 sandpaper with oil. Sand only by hand and stop when piston material (aluminum) is removed. Thoroughly clean and reassemble. The machine should be run (gradually increasing RPM and load), disassembled, checked and fitted (sanded) as many times as required to perfectly fit the piston to cylinder. Do not remove too much material from piston at one time. Do not run engine too long, too fast or at too much RPM and load. The preceding is in addition to the normal piston fitting to provide a more controlled break-in, not as a substitute for fitting the piston to cylinder at initial assembly.

Piston damage can be caused by incorrect piston to cylinder clearance, improper lubrication, incorrect ring clearances, incorrect ignition timing, detonation, incorrect fuel-air mixture, pre-ignition, incorrect piston to cylinder head clearance, incorrect shape or size of ports, etc. As many safety precautions as possible should be taken when first running, such as slightly rich fuel-air mixture, slightly rich lubrication, ignition timing not overly advanced, installation of cold plug. As running time increases, the optimum settings can be established.

ROTARY VALVE

The rotary inlet valve can be modified to provide different opening and closing than standard; however, several precautions should be noted.

Use extreme care when modifying a standard rotary valve. The valve may be weakened and (especially if operated at higher than standard rpm) valve may fly apart causing extensive damage. Some motorcycle manufacturers (and other sources) offer rotary valves with timing (cutaway) different than standard. These high speed rotary valves usually operate more safely than modified standard units.

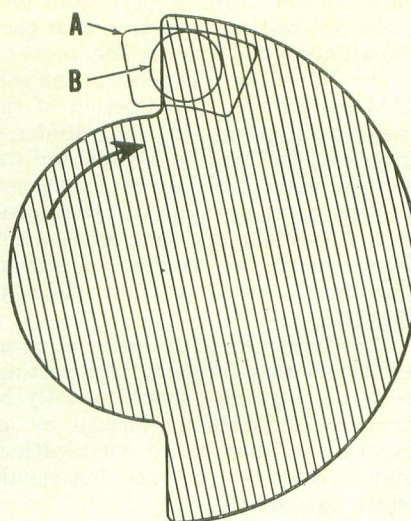


Fig. 3-14—The rotary valve opening begins when passage in crankcase (A) and passage in rotary valve cover (B) are both uncovered. Round port openings such as shown at (B) cause more gradual opening and closing than square port as shown at (A).

The rotary valve is sandwiched between the crankcase and a cover. Inlet opens when rotary valve begins to uncover **both** openings (in crankcase and rotary valve cover). Refer to Fig. 3-14. Valve is closed, when **one** of the openings (usually the opening in rotary valve cover first) is completely covered by the rotary valve. Refer to Fig. 3-15.

Changing the width of openings in crankcase and rotary valve cover can change the inlet timing. Changing the height of the openings can prevent valve from sealing. Careful matching of port openings in crankcase and rotary valve cover to each other and to the rotary valve may result in better performance.

SEALING

Many products are available for sealing around grommets, wires, hoses and covers to prevent entrance of water and/or dust. For many types of riding, it is advisable to raise the entrance for air to the carburetor (air cleaner), ignition compartment vent, transmission vent and clutch compartment vent. Hoses attached to the vent tubes can be routed to a higher location.

EXHAUST TUNING

One of the most interesting and effective tools for tailoring the performance of a two stroke engine is the "Tuned Exhaust" or "Expansion Chamber". Technically, the two terms are not interchangeable, but because of common usage they have come to have a similar meaning. A third term related to exhaust design but not interchangeable with the other two is "Silencing". It might be worthwhile at this point to briefly define the terms as they are used here.

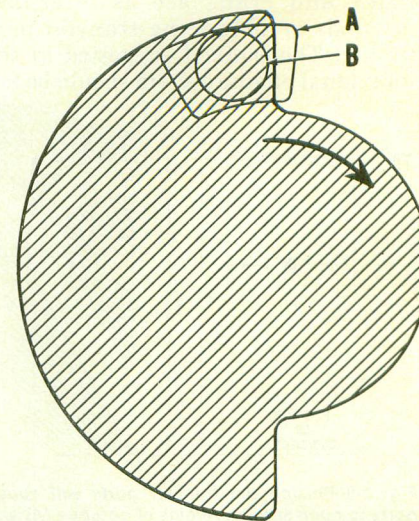


Fig. 3-15—The rotary valve is closed when one of the ports is completely covered. Usually opening (B) in rotary valve cover is smaller and is the first covered.

EXPANSION CHAMBER. There are three reasons why the exhaust gases of a two stroke engine are not released directly into the atmosphere. Two of these reasons, "Noise Control" and "Flame Suppression" apply to the entire family of engines whether they are two stroke, four stroke or rotating combustion type. The third reason "Performance Improvement" applies mainly to two stroke engines. Any enclosed area including a muffler or silencer, into which the exhaust empties is properly called an expansion chamber. But in common usage the term applies mainly to those units which improve performance.

A **TUNED EXHAUST** carries the performance oriented expansion chamber one step further and makes use of the reflected sound wave to further improve performance.

MUFFLERS are expansion chambers which quiet exhaust noise. Most motorcycle standard exhaust systems are carefully matched to the engine in order to increase power as well as reducing noise level. Removal of muffler or muffler parts (baffles) will nearly always decrease performance. Some racing expansion chambers are designed with a silencer built in the outlet pipe (stinger) or with provision for adding a silencer to the outlet pipe.

OPERATION. In the exchange cycle of a two stroke engine, the exhaust gases are removed from the cylinder and the cylinder recharged from the crankcase for the next cycle. Efficiency and power will be greatest when this exchange is completed at the highest possible cylinder pressure as

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the exhaust ports close. It should be remembered that, at 6000 rpm the complete operating cycle occurs 100 times a second and the exchange cycle occupies only about 60% of the total cycle. Therefore the exchange takes place in the smallest fraction of a second.

During the exchange cycle of an engine equipped with an expansion chamber, several events occur simultaneously; a rise of pressure in the expansion chamber, the exchange of gases in the cylinder, and the lowering of pressure in the crankcase. If the first and last events are properly balanced, complete exchange of gases is accomplished at a pressure equal to or above ambient atmospheric pressure. The higher the pressure (or the denser the fresh charge) the greater the horsepower output. If the expansion chamber is too small, improperly designed, or the outlet partially blocked, there will be incomplete exchange of gases in the cylinder, some exhaust gas will remain and output will suffer. If the expansion chamber is too large (not designed for the engine) no improvement is gained.

It should be remembered that a cylinder ported engine is symmetrical in design. An exhaust port that is uncovered at 110° after TDC on the power stroke will be closed 110° before TDC on the compression stroke. The exhaust port must open before the transfer ports, and therefore must close after the transfer ports close. "Exhaust Tuning" attempts to hold the pressure in the cylinder above that of the outside air when the exhaust ports close to trap the charge. The principle involved is the same as that which produces the echo when sound is directed toward a distant object. When the exhaust port opens on a two cycle engine, the escaping gases create an explosive noise which enters the expansion chamber with the exhaust gas. The main force of the sound wave travels straight outward until it escapes or is reflected by the expansion chamber walls. A

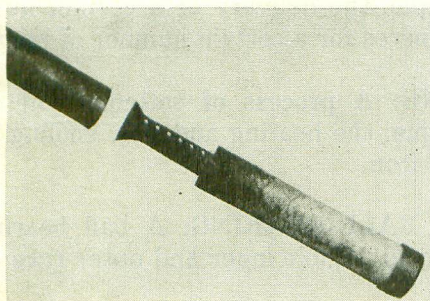


Fig. 3-16—Horsepower may be increased without an increase in noise. View of "Hooker Exhaust Tuner" with fibreglass wrapped perforated stinger core.

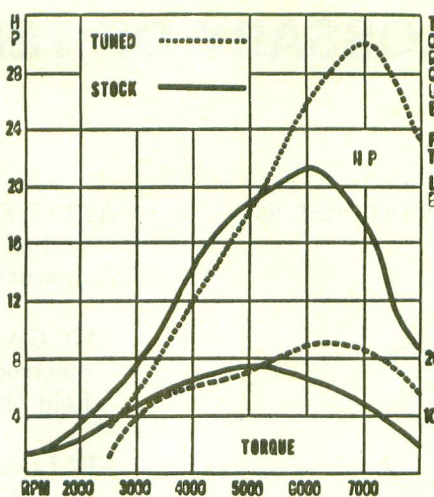


Fig. 3-18—Advertised horsepower and torque curves of a 250 cc single cylinder motorcycle showing performance variations obtainable.

TUNED exhaust returns the reflected sound wave to the exhaust ports while the ports are still open and after the transfer ports have closed. The sound wave is accompanied by a pressure rise which reverses the outflow of scavenging gases at the exhaust ports as they are closing, thus increasing the density of the fuel mixture in the cylinder. Exhaust tuning is effective through a relatively narrow range of engine operation and the area of improvement can be detected from the sound and feel of engine performance. To be fully effective, exhaust tuning should be accompanied by other changes, including carburetion, port timing and induction. Fig. 3-18 shows the advertised performance curves of a stock and factory tuned 250cc single cylinder motorcycle engine. The effect of tuning is most apparent by the reverse bend of the torque curve at 5000 rpm and by the wide divergence of the two horsepower curves at the upper end.

CONSTRUCTION. Specifications are included in specific Speed Tuning sections for building expansion chambers for individual models. Construction is sometimes difficult; however, units are available which are ready to bolt onto many popular motorcycle

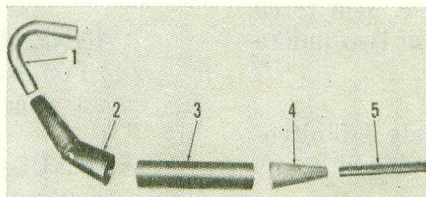


Fig. 3-19—The expansion chamber shown can be welded together of separate pieces. Specifications for header pipe (1), divergent cone (2), chamber body (3), convergent cone (4) and stinger (5) are included in text for individual models.

Speed Tuning

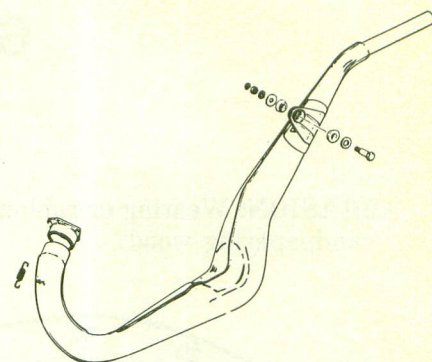


Fig. 3-19A—Drawing of a typical factory expansion chamber. Units are usually stamped and conform to fit closely to specific models.

models. Some of the expansion chambers available are manufactured from stampings (Fig. 3-19A) which permit the chamber to curve smoothly around engine and frame components without causing restrictions.

Others are manufactured from cones and cylinders which are welded together to create the expansion chamber (Fig. 3-19).

SPECIAL NOTES

It is important that all screws and nuts be secured, using safety wire, lock plates, lock washers, self-locking nuts or locking compound (such as LOC-TITE). All parts should be checked often for security.

Be extremely careful when filling the fuel tank. Filters should be used to prevent foreign matter from entering tank. Check the fuel filters on vehicle at regular intervals and renew units when in doubt, to prevent lean mixture from damaging engine.

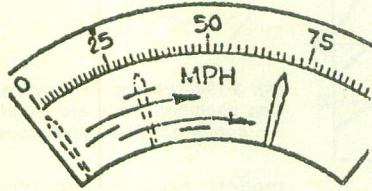
SUMMARY

The expected results of engine modifications are more torque and more RPM. The materials used to manufacture motorcycle engines do have a stress limit at which point any given part will fail. It is much easier to exceed the limits of the materials after modification and much more caution should be exercised. As an example, it may be impossible to exceed the RPM limit (Red Line) in any gear except first before modification; however after modification the RPM limit may be exceeded in the lower three gears. It is also possible that the suspension components will not withstand the increased strains.

The end result of full race tuning is outstanding performance over a relatively narrow operating range. There will be corresponding sacrifices in service life, operating economy, ease of starting and dependability.

GLOSSARY OF TERMS

ABRASION: Wearing or rubbing away, such as sandpapering wood.

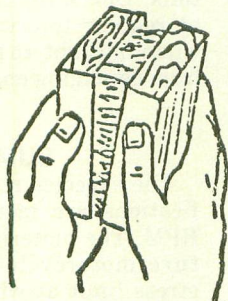


ACCELERATION

ACCELERATION: The increase in velocity or speed.

ACETYLENE OR OXY-ACETYLENE WELDING: The utilization of an acetylene flame to provide heat to bring metal to the fusion or melting point when uniting it.

ADDITIVE: As used with reference to automotive oils, a material added to the oil to give it certain properties. For example, a material added to engine oil to lessen its tendency to congeal or thicken at low temperature.



ADHESION

ADHESION: The tendency for the surface of one substance to stick to another. The force that holds together the surfaces of two unlike substances.

AIR: A gas containing approximately 4/5 nitrogen, 1/5 oxygen and some carbonic gas.

AIR CLEANER: A device for filtering, cleaning, and removing dust from the air admitted to a unit, such as an engine or air compressor.

AIR-FUEL RATIO: The ratio by weight of the fuel as compared to the air of the carburetor mixture.

AIR GAP: The space between spark plug electrodes, motor and generator armatures, field shoes, etc.

AIR-LOCK: A bubble of air trapped in a fluid circuit which interferes with normal circulation of the fluid.

ALIGNMENT: An adjustment to a line or to bring into a line.

ALLEN WRENCH: A hexagonal wrench which fits into a recessed hexagonal hole. Ordinarily used in set screws or very hard screws.

ALLOY: A mixture of different metals such as solder which is an alloy consisting of lead and tin.

ALTERNATING CURRENT: An electrical current continuously reversing its direction of flow.

ALUMINUM: A metal noted for its lightness and often alloyed with small quantities of other metals.

AMMETER: An instrument for measuring the flow of an electrical current.

AMPERE: The unit of measurement for the flow of electric current.

AMPERE-HOUR CAPACITY: A term used to indicate the capacity of a storage battery. For example, the delivery of a certain number of amperes for a certain number of hours.

ANNEALING: A process of softening metal. For example, the heating and slow cooling of a piece of iron.

ANNULAR BALL BEARING: A ball bearing with a non-adjustable inner and outer race or races.

ANODE: A positive pole or electrode of an electrical circuit.

ANTI-CLOCKWISE ROTATION: Rotating the opposite direction of the hands on a clock. The same as counter-clockwise rotation.

ANTI-FREEZE: A material such as alcohol, glycerin, etc., added to water to lower its freezing point.

ANTI-FRICTION BEARING: A bearing constructed with balls, rollers or the like between the journal and the bearing surface to provide rolling instead of sliding friction.

APERTURE: An opening, hole or port.

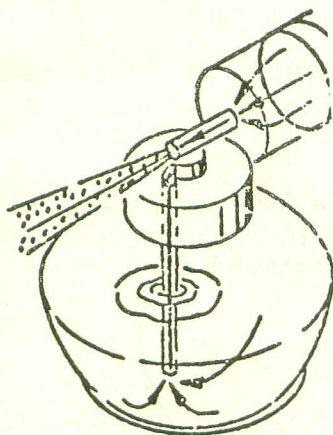
API: American Petroleum Institute.

ARC WELDING: A method of utilizing the heat of an electric current jumping an air gap to provide heat for welding metal.

ARMATURE: That part of an electrical machine which includes the main current-carrying winding which rotates within the pole shoes which are surrounded by the field coils.

ASBESTOS: A natural fibrous mineral with great heat resisting ability.

ATMOSPHERIC PRESSURE: The weight of the air at sea level; about 14.7 lbs. per square inch; less at higher altitudes.

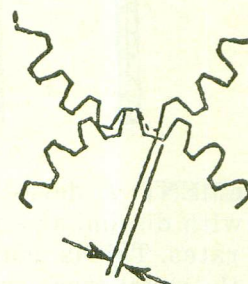


ATOMIZE

ATOMIZE: To break up a liquid into minute particles such as a fine spray.

B & S GAGE: Brown and Sharpe gage which is a standard measure of wire size. The smaller the number, the larger the wire.

BACKFIRE: An explosion in the exhaust system caused by incorrect timing or poor combustion. Backfire may also occur through the intake manifold and carburetor with a premature firing of the combustion mixture.



BACKLASH

BACKLASH: The play between mating-gear teeth. This is measured as the amount of movement of one gear against another that is held stationary.

BACK-PRESSURE: A resistance to free flow, such as a restriction in the exhaust line.

BAFFLE OR BAFFLE PLATE: An obstruction for checking or deflecting the flow of gases or sound.

BALL BEARING: An anti-friction bearing consisting of a hardened inner and outer race with hardened steel balls interposed between the two races.

BATTERY: Any number of complete electrical cells assembled in one housing or case.

BBDC: Before Bottom Dead Center.

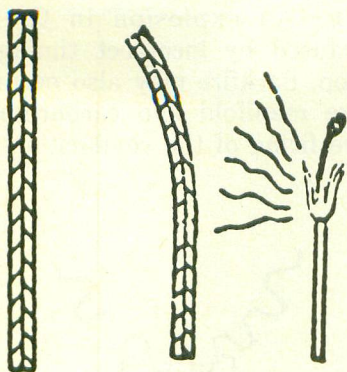
B.D.C.: Bottom Dead Center.

BEARING: A part in which a journal, pivot or the like turns or moves.

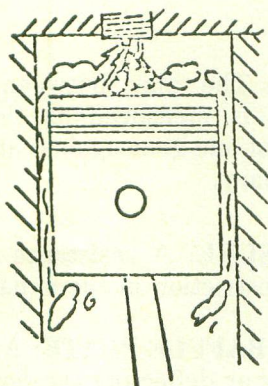
BENZOL: A by-product of the manufacture of coke sometimes used as an engine fuel.

BEZEL: The groove in which a transparent instrument cover is placed.

B.H.P. (BRAKE HORSEPOWER): A measurement of the power developed by an engine in actual operation.



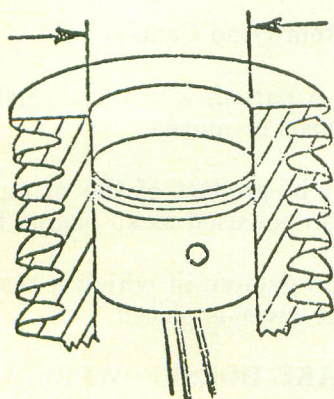
BIMETAL ELEMENT: A device composed of two metals with dissimilar expansion and contraction rates. This is usually a spiral-shaped unit; the spiral opens or closes as the temperature changes.



BLOW-BY

BLOW-BY: The excessive leaking of the expanding combustion force in the cylinder. This may be past leaky piston rings into the crankcase or past leaky valves into the intake or exhaust systems.

BOILING POINT: The temperature at atmospheric pressure at which bubbles or vapors rise to the surface and escape.



BORE

BORE: The diameter of a hole, such as a cylinder; also the hole into which a bearing is installed.

BORING BAR: A stiff bar equipped with multiple cutting bits which is used to bore a series of bearings or journals in proper alignment with each other.

BOSS: An extension or strengthened section, such as the projections within a piston which support the piston pin or piston pin bushings.

BOTTLED GAS: Liquefied petroleum gas compressed and contained in portable cylinders.

BRAZE: To join two pieces of metal with the use of a comparatively high melting point material. An example is to join two pieces of steel by using brass or bronze as a solder.

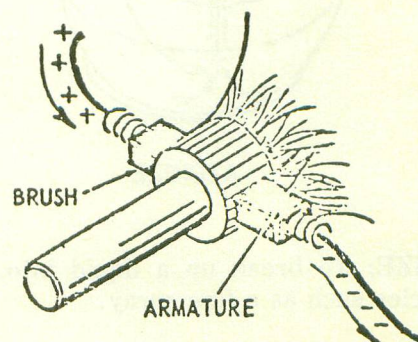
BREAKER ARM: The movable part of a pair of contact points in an electrical distributor or magneto.

BREAKER POINT: Also called contact points. Two separable points usually faced with silver, platinum or tungsten which interrupt the primary circuit in the distributor or magneto for the purpose of inducing a high tension current in the ignition system.

BREAK-IN: The process of wearing in to a desirable fit between the surfaces of two new or reconditioned parts.

BRINELL HARDNESS: A scale for designating the degree of hardness possessed by a substance.

BROACH: To finish the surface of metal by pushing or pulling a multiple edge cutting tool over or through it.



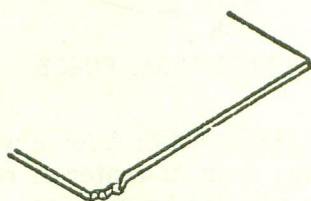
**BRUSH
(ELECTRICAL)**

BRUSHES: The bars of carbon or other conducting material which contact the commutator of an electric motor or generator or the slip rings of an alternator.

B.T.U. (British Thermal Unit): A measurement of the amount of heat required to raise the temperature of 1 lb. of water, 1 degree, Fahrenheit.

BUCKLED PLATES: Battery plates that have been bent or warped out of a flat plane.

BURNISH: To smooth or polish by the use of a sliding tool under pressure.

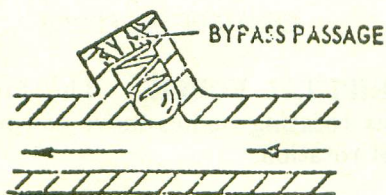


BURR

BURR: A thin, rough edge of metal left on the tip of a part being machined, ground or filed.

BUSHING: A removable liner for a bearing.

BUTANE: A petroleum hydrocarbon compound which has a boiling point of about 32 degrees F. which is used as engine fuel. Loosely referred to as Liquefied Petroleum Gas and often combined with Propane.



BYPASS

BY-PASS: A passage, usually with a valve arrangement, giving an alternate route for liquids or vapors.

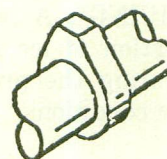
CALIBRATE: To determine or adjust the graduation or scale of any instrument giving quantitative measurements.

CALIPERS (Inside and Outside): An adjustable tool for determining the inside or outside diameter by contact and retaining the dimension for measurement or comparison.

CALORIFIC VALUE: A measure of the heating value of fuel.

CALORIMETER: An instrument to measure the amount of heat given off by a substance when burned.

CALORIE: The metric measurement of the amount of heat required to raise 1 gram of water from zero degrees to 1 degree Centigrade, at normal atmospheric pressure.



CAM

CAM: A wheel-like projection from a shaft with an extended lobe for moving or lifting some adjacent part.

CAM ANGLE: Also known as dwell period. Referring to an ignition distributor, the number of degrees of rotation of the ignition distributor shaft during which the contact points are closed.

CAM FOLLOWER: A lever, plunger or bellcrank which follows the profile of the cam and transmits this motion to other parts. Usually operating the engine valves.

CAM GROUND PISTON: A piston ground to a slightly oval shape which under the heat of operation becomes round.

CAMSHAFT: The shaft containing lobes or cams to operate the engine valves.

CAPE CHISEL: A metal cutting chisel shaped to cut or work in channels or grooves.

CARBON: A common non-metallic element which is an excellent conductor of electricity. It also forms in the combustion chamber of an engine during the burning of fuel and lubricating oil.

CARBON DIOXIDE: Compressed into solid form, this material is known as "dry ice" and remains at a temperature of -109 degrees, F. It goes directly from a solid to a vapor state.

CARBONIZE: To coat with carbon. The process of carbon formation with an engine, such as on the spark plugs and within the combustion chamber.

CARBURETOR: A device for automatically mixing fuel in the proper proportion with air to produce a combustible gas.

CARBURETOR "ICING": A term used to describe the formation of ice on a carburetor throttle plate during the prevalence of certain atmospheric conditions.

CASE-HARDEN: To harden the surface of steel.

CASING HEAD GASOLINE: A term used to describe the lighter parts of petroleum products which were obtained as a natural gasoline by condensing natural gas from an oil well.

CASTELLATE: Formed to resemble a castle battlement as in a castellated nut.

CATHODE: The negative pole or terminal of an electric circuit.

C.C.: Cubic centimeter.

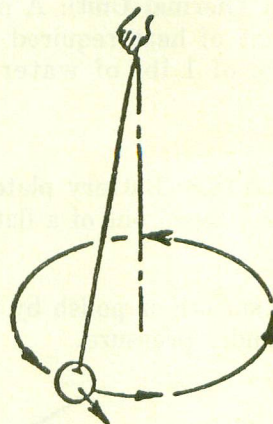
CELL: An electrical cell is the unit of a battery containing a group of positive and negative plates along with electrolyte.

CELL CONNECTOR: The lead bar or link connecting the pole of one cell to the pole of another.

CELLULOID: A compound of gun cotton and camphor which is flexible and transparent.

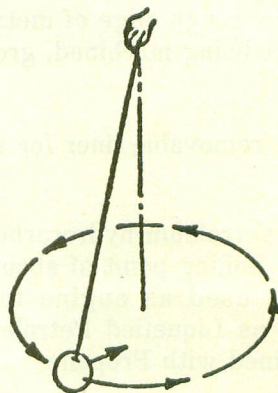
CENTER OF GRAVITY: The point at which a mass of matter balances. For example, the center of gravity of a wheel is the center of the wheel hub.

CENTIGRADE: The metric temperature scale, zero on the Centigrade scale being 32 degrees on the Fahrenheit scale. Also called Celsius.



CENTRIFUGAL FORCE

CENTRIFUGAL FORCE: A force which moves a body away from its center of rotation. An example is supplied by whirling a weight attached to a string.



CENTRIPETAL FORCE

CENTRIPETAL FORCE: The force which makes rotating bodies move toward the center of rotation.

CHAMFER: A bevel or taper at the edge of a hole.

CHARGE (or Recharge): Passing an electrical current through a battery to restore it to activity.

CHASE: To straighten up or repair damaged threads.

CHECK-VALVE: A gate or valve which allows passage of gas or fluid in one direction only.

CHEMICAL COMPOUND: The combination of two or more chemical elements which can be a gas, a liquid or a solid.

CHEMICAL ELEMENT: Gaseous, liquid or solid matter which cannot be divided into simpler form.

CHILLED IRON: Cast iron on which the surface has been hardened.

CHIP: To cut with a chisel.

CHOKE: A reduced passage, such as a valve placed in a carburetor air inlet to restrict the volume of air admitted.

CHROMIUM STEEL: An alloy of steel with a small amount of chromium to produce a metal which is highly resistant to oxidation and corrosion.

CIRCUIT: The path of electrical current, fluids or gases. Examples: for electricity, a wire; for fluids and gases, a pipe.

CIRCUIT BREAKER: A device for interrupting an electrical circuit; often automatic and may be known as "contact breaker," "interrupter," "cut-out" or "relay".

CLEARANCE: The amount of space between two adjacent moving parts, or between one moving and one stationary part such as between a journal and a bearing.

CLOCKWISE ROTATION: Rotation in the same direction as the hands of a clock.

COEFFICIENT OF FRICTION: A measurement of the amount of friction developed between two surfaces pressed together and moved one on the other.

"COLD" MANIFOLD: An intake manifold to which the exhaust gas is not applied for heating purposes.

COMBUSTION: The act or process of burning.

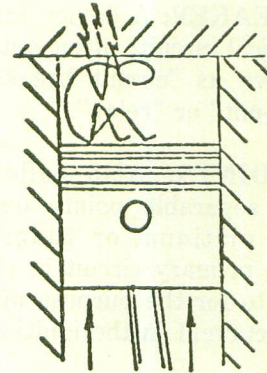
COMBUSTION SPACE OR CHAMBER: In internal combustion engines, the volume of the cylinder above the piston with the piston on top center.

COMMUTATOR: A ring of adjacent copper bars insulated from each other to which the

wires of the armature or winding are attached.

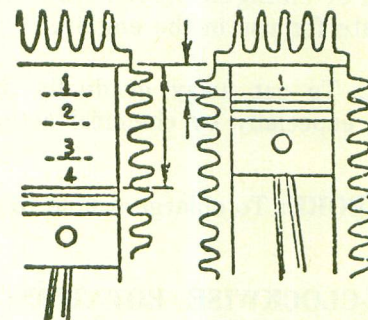
COMPOUND: A mixture of two or more ingredients.

COMPOUND WINDING: Two electric windings, one in series and the other in shunt or parallel with other electric units or equipment. When applied to electric motors or generators, one winding is shunted across the armature while the other is in series with the armature.



COMPRESSION

COMPRESSION: The reduction in volume or the "squeezing" of a gas. As applied to metal, such as a coil spring, compression is the opposite of tension.



COMPRESSION RATIO

COMPRESSION RATIO: The ratio of the volume in the cylinder when the piston is at top-dead-center to the volume in the cylinder when the piston is at bottom-dead-center.

CONCENTRIC: Two or more circles having a common center.

CONDENSATION: The process of a vapor becoming a liquid; the reverse of evaporation.

CONDENSER: A device for turning vapor into liquid form if applied to gas. If applied to an electric circuit, the condenser is a device for temporarily collecting and storing a surge of electrical current for later discharge.

CONDUCTOR: A material along or through which electricity will flow with slight resistance; silver, copper and carbon are good conductors.

CONNECTING ROD: Rod that connects the piston to the crankshaft.

CONTACT BREAKER: A device for interrupting an electrical circuit; often automatic and may be known as "circuit breaker," "interrupter," "cut-out" or "relay".

CONTACT POINTS: Also called breaker points. Two separable points usually faced with silver, platinum or tungsten which interrupt the primary circuit in the distributor or magneto for the purpose of inducing a high tension current in the ignition system.

CONTRACTION: A reduction in mass or dimension; the opposite of expansion.

CONVECTION: A transfer of heat by circulating heated air.

CONVERTER: As used in connection with liquefied petroleum gas, it is a device which converts or changes L.P.G. from liquid to vapor state for use in the engine.

CORRODE: To eat away gradually as if by gnawing, especially by chemical action, such as rust.

COUNTERBORE: To enlarge a hole to a given depth.

COUNTER-CLOCKWISE ROTATION: Rotating the opposite direction of the hands on a clock. The same as anti-clockwise rotation.

COUNTERSINK: To cut or form a depression to allow the head of a screw to go below the surface.

COUNTERWEIGHT: The weight added to a shaft to balance the normal load and offset vibration.

COUPLING: A connecting means for transferring movement from one part to another; may be mechanical, hydraulic or electrical.

CRANKCASE: The housing within which the crankshaft and many other parts of the engine operate.

CRANKCASE DILUTION: Under certain conditions of operation, unburned portions of the fuel find their way past the piston rings into the crankcase and oil reservoir where they dilute or "thin" the engine lubricating oil.

CRANKSHAFT: The main shaft of an engine which in conjunction with the connecting rods changes the reciprocating motion of the pistons into rotary motion.

CRANKSHAFT COUNTER-BALANCE: A series of weights attached to or forged integrally with the crankshaft so placed as to offset the reciprocating weight of each piston and rod assembly.

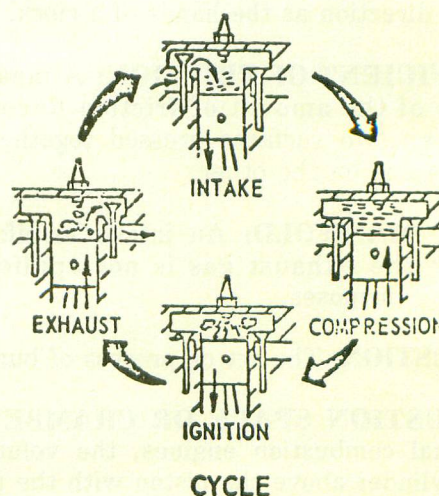
CRUDE OIL: Liquid oil as it comes from the ground.

CU. IN.: Cubic inch.

CURRENT: The flow rate of electricity, measured in Amperes.

CUT-OUT (Electric): A device for interrupting an electrical circuit; often automatic and may be known as "circuit breaker," "interrupter," "contact breaker," or "relay."

CUT-OUT (Muffler): A valve which can be used to divert the exhaust gases directly to the atmosphere instead of through the muffler.



CYCLE: A series of occurrences in which conditions at the end of the series are the same as they were at the beginning.

CYLINDER: A round hole having some depth bored to receive a piston; also sometimes referred to as "bore" or "barrel."

CYLINDER BLOCK: The largest single part of an engine. The basic or main mass of metal in which the cylinders are bored or placed.

CYLINDER HEAD: A detachable portion of an engine fastened securely to the cylinder block which contains all or a portion of the combustion chamber.

CYLINDER SLEEVE: A liner or tube interposed between the piston and the cylinder wall or cylinder block to provide a readily renewable wearing surface for the cylinder.

DASH POT: A device consisting of a piston and cylinder with a restricted opening used to slow down or delay the operation of some moving part.

DEAD CENTER: The extreme upper or lower position of the crankshaft throw at which the piston is not moving in either direction.

DEGREE: Abbreviated deg. or indicated by a small "o" placed alongside a figure; may be used to designate temperature readings or may be used to designate angularity, one degree being 1/360 part of a circle.

DEMAGNETIZE: To remove the magnetism of a pole which has previously been magnetized.

DENATURED ALCOHOL: Ethyl alcohol to which a denaturant has been added to make it unfit as a beverage.

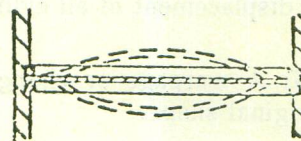
DENSITY: Compactness; relative mass of matter in a given volume.

DEPOLARIZE: To remove polarity, such as to demagnetize a permanent magnet.

DETERGENT: A compound of a soap-like nature used in engine oil to remove engine deposits and hold them in suspension in the oil.

DETONATION: Indicates a too rapid burning or explosion of the mixture in the engine cylinders. It becomes audible through a vibration of the combustion chamber walls and is sometimes confused with a "ping" or spark knock.

DIAL GAUGE (Dial Indicator): A type of micrometer wherein the readings are indicated on a dial rather than on a thimble as in a micrometer.



DIAPHRAGM

DIAPHRAGM: A stationary disc or partition which can flex in the center while the edges are clamped. A flexible partition or wall separating two cavities.

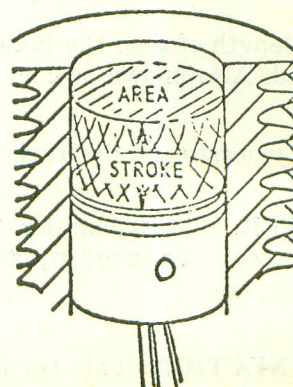
DIE: One of a pair of hardened metal blocks for forming metal into a desired shape or thread die for cutting external threads.

DIE CASTING: An accurate and smooth casting made by pouring molten metal or composition into a metal mold or die under pressure.

DIESEL ENGINE: Named after its developer, Dr. Rudolph Diesel, the engine ignites the fuel in the cylinder from the heat generated by compression. The fuel is an oil rather than gasoline and no spark plug or carburetor is required.

DIRECT CURRENT: Electric current which flows continuously in one direction. An example is a storage battery.

DISCHARGE: With reference to a battery, the flow of electric current from the battery; the opposite of charge.



DISPLACEMENT

DISPLACEMENT (Engine Displacement): The volume added to the combustion chamber in the cylinder when the piston moves from the top to the bottom of its stroke (area times stroke length). In a multi-cylinder engine, it is the total displacement of all cylinders.

DISTORTION: A warpage or change in form from the original shape.

DOG CLUTCH: Mating collars or flanges with projecting lugs or fingers which interlock when engaged.

DOWEL PIN: A pin inserted in matching holes in two parts to maintain those parts in fixed relation one to the other.

DOWN-DRAFT: Used to describe a carburetor type wherein the mixture flows downward to the engine.

DRAW: To form by stretching process or to soften hard metal.

DRAW-FILING: A method of filing wherein the file is drawn across the work while held at a right angle to the length of the file.

DRIVE-FIT: Also known as a force-fit or press-fit. This term is used when the shaft is slightly larger than the hole and must be forced in place.

DROP FORGING: A piece of steel shaped between dies while hot.

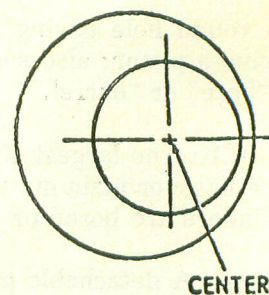
DRY BATTERIES: Also called dry cell. A complete battery unit which does not contain liquid electrolyte.

DWELL: The length of time the breaker points remain closed. Also known as cam angle.

DYNAMO: A generator of electricity.

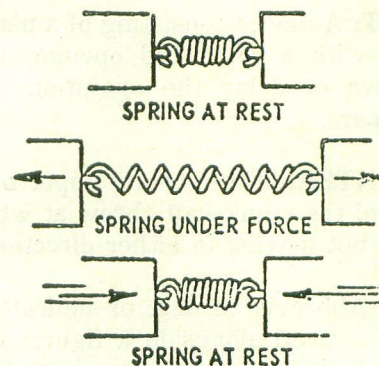
DYNAMOMETER: A machine for measuring the actual power produced by an internal combustion engine.

EARTH CONNECTION: This term is sometimes used to designate a "ground" in the electrical system. See Ground.



ECCENTRIC

ECCENTRIC: One circle within another circle wherein both circles do not have the same center. An example of this is a cam on a camshaft.



ELASTICITY

ELASTICITY: The property of a substance that causes it to return to its original shape and size after being deformed or stretched.

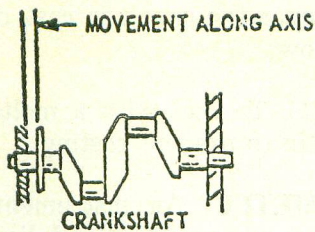
ELECTRODE: Usually refers to the insulated center rod of a spark plug. It is also sometimes used to refer to the rods attached to the shell of the spark plug.

ELECTROLYTE: Liquid or paste which carries current, as the mixture of sulphuric acid and distilled water used in storage batteries of the wet type.

ELECTRO-MAGNET: A coil of insulated wire wound around an iron rod or series of rods will magnetize the rod or rods and cause it to attract any other iron in the vicinity provided an electrical current is passed through the wire. An example of this is a solenoid magnet.

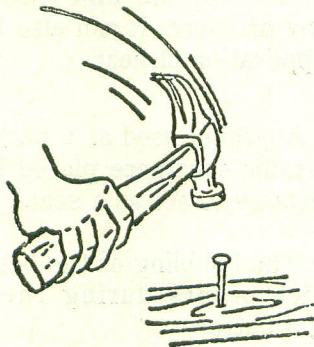
ELEMENT: One set of positive plates and one set of negative plates complete with separators assembled together.

E.M.F. (Electromotive Force): See Voltage.



END PLAY

END PLAY: The movement along the axis of a mounted shaft.



ENERGY

ENERGY: A force capable of producing work.

ETHYL GASOLINE: Gasoline to which Ethyl fluid has been added. Ethyl fluid is a compound of tetraethyl lead, ethylene dibromide and thylene dichloride. The purpose of the material is to slow down and control the rate of burning of the fuel in the cylinder to produce an expansive force rather than an explosive force and thus reduce detonation or "knocking" in an engine.

EVAPORATION: The process of changing from a liquid to a vapor, such as boiling water to produce steam; evaporation is the opposite of condensation.

EXCITER: Often used in referring to the third brush where this mode of regulation is used for a generator.

EXHAUST GAS ANALYZER: An instrument for determining the efficiency with which an engine is burning fuel.

EXHAUST PIPE: The pipe connecting the engine to the muffler to conduct the exhausted or spent gases away from the engine.

EXPANSION: An increase in size. For example, when a metal rod is heated it increases in length and perhaps also in diameter; expansion is the opposite of contraction.

FAHRENHEIT (F.): A scale of temperature measurement used in some countries. The boiling point of water is 212 degrees, Fahrenheit, as compared to 100 degrees Centigrade.

FEELER GAGE: A metal strip or blade finished accurately with regard to thickness used for measuring the clearance between two parts.

FERROUS METAL: Metals which contain iron or steel and are therefore subject to rust.

F-HEAD ENGINE: A four stroke engine designed with one valve in the cylinder block at the side of the piston and the other valve in the cylinder head above the piston.

FIELD: In a generator or electric motor the area in which magnetic flow occurs.

FIELD COIL: A coil of insulated wire surrounding the field pole.

FILE: To finish or trim with a hardened rasp or file.

FILLET: A rounded filling between two parts joined at an angle.

FILTER (Oil, Water, Gasoline, Etc.): A unit containing an element, such as a screen of varying materials depending upon the size of the foreign particles to be eliminated from the fluid being filtered.

FIN: One of a series of metal projections from a surface designed to provide increased surface exposure for air cooling or heat transfer.

FIT: A kind of contact between two machined surfaces.

FLANGE: A projecting rim or collar on an object for keeping it in place.

FLASH POINT: The temperature at which an oil when heated will flash and burn.

FLOAT: A hollow tank which is lighter than the fluid in which it rests and which is

ordinarily used to operate automatically a valve controlling the entrance of the fluid.

FLOATING PISTON PIN: A piston pin which is not locked in the connecting rod or the piston, but is free to turn or oscillate in both the connecting rod and the piston.

FLOAT LEVEL: The pre-determined height of the fuel in the carburetor bowl, usually regulated by means of a suitable valve.

"FLUTTER" OR "BOUNCE": As applied to engine valves, refers to a condition wherein the valve is not held tightly on its seat during the time the cam is not lifting it.

FLUX, ELECTRIC OR MAGNETIC: Lines of magnetic force passing or flowing in a magnetic field.

FLUX, SOLDERING WELDING, BRAZING: The material used to cause the joining metal to adhere to both parts to be joined.

FLYWHEEL: A heavy wheel in which energy is absorbed and stored by means of momentum.

FORCE-FIT: Also known as a press-fit or drive-fit. This term is used when the shaft is slightly larger than the hole and must be forced in place.

FORGE: To shape metal while hot by hammering.

FOUR STROKE ENGINE: Also known as Otto cycle, wherein an explosion occurs every other revolution of the crankshaft; a cycle being considered as 1/2 revolution of the crankshaft. These strokes are (1) intake stroke; (2) compression stroke; (3) power stroke; (4) exhaust stroke.

FRACTURE: A crack or break in a part.

FUEL KNOCK: Same as detonation.

FULCRUM: The support on which a lever turns in moving a body.

FUSE: A fuse consists of a piece of wire which will carry a limited amount of current only. It is placed in an electrical circuit as a safety measure to avoid damage and is designed to

melt and open the circuit in case of excessive current flow.

GALVANIZE: To coat with a molten alloy of lead and tin to prevent rusting.

GALVANOMETER: An instrument used for the location, measurement and direction of an electric current.

GAS: A substance which can be changed in volume and shape according to the temperature and pressure applied to it. For example, air is a gas which can be compressed into smaller volume and into any shape desired by pressure. It can also be expanded by the application of heat.

GASKET: Anything used as a packing, such as a non-metallic substance placed between two metal surfaces to act as a seal.

GASSING: The bubbling of the battery electrolyte which occurs during the process of charging a battery.

GEAR RATIO: A relationship between the speeds of two or more meshed gears that numerically expresses the speed of the output in proportion to the speed of the input. For example, if one gear makes three revolutions while the other gear makes one revolution, the gear ratio would be 3 to 1.

GENERATOR: A device consisting of an armature, field coils and other parts which when rotated will generate electricity.

GLAZE: As used to describe the surface of the cylinder, an extremely smooth or glossy surface such as a cylinder wall highly polished over a long period of time by the friction of the piston rings.

GLAZE BREAKER: A tool for removing the glossy surface finish in an engine cylinder.

GOVERNOR: A device to control and regulate speed. May be mechanical, pneumatic, hydraulic or electrical.

GRAM: A metric unit of weight which is equal to 1/454th part of a pound.

GRID: The metal framework of an individual battery plate in which the active material is placed.

GRIND: To finish or polish a surface by means of an abrasive wheel.

GROUP: In a battery a set of plates either positive or negative joined together but not assembled with separators.

GROWLER: An electrical device for testing electric motor or generator armatures.

GUDGEON PIN: Also known as "wrist pin" and piston pin. This is the pin that connects the connecting rod to the piston and piston pin is the preferred term.

GUM: In automotive fuels, this refers to oxidized petroleum products which accumulate in the fuel system, carburetor or engine parts.

HARD SOLDER: Uniting two pieces of metal with a material having a melting point higher than "soft" solder. An example is silver soldering wherein silver is used instead of lead-tin alloy.

HARMONIC BALANCER: A device to reduce the torsional or twisting vibration which occurs along the length of the crankshaft used in multiple cylinder engines. Also known as a vibration damper.

HEAT TREATMENT: A combination of heating and cooling operations timed and applied to a metal in a solid state in a way that will produce desired properties.

HEEL: The outside or larger half of the gear tooth.

HELICAL: Shaped like a coil of wire or a screw thread.

HELICAL GEAR: A gear design wherein the gear teeth are cut at an angle to the shaft.

HERRINGBONE GEAR: A pair of helical gears designed to operate together in which the angle of the pair of gears forms a V.

HIGH TENSION (HIGH VOLTAGE): As used in electricity, it refers to the secondary or induced high voltage electrical current; includes the wiring from the cap of the ignition distributor to the coil and to each of the spark plugs.

HONE: An abrasive tool for correcting small irregularities or differences in diameter in a cylinder, such as an engine cylinder.

HOT SPOT: Refers to a comparatively thin section or area of the wall between the inlet and exhaust manifold of an engine, the purpose being to allow the hot exhaust gases to heat the comparatively cool incoming mixture. Also used to designate local areas of the cooling system which have attained above average temperatures.

HP (HORSEPOWER): The energy required to lift 550 lbs. 1 ft. in 1 second or 33,000 lbs. 1 ft. in 1 minute.

HYDROCARBON: Any compound composed entirely of carbon and hydrogen, such as petroleum products.

HYDROCARBON ENGINE: An engine using petroleum products, such as gas, liquefied gas, gasoline, kerosene or fuel oil as a fuel.

HYDROMETER: An instrument for determining the state of charge in a battery by finding specific gravity of the electrolyte.

I.D.: Inside Diameter.

IDLE: Refers to the engine operating at its slowest speed.

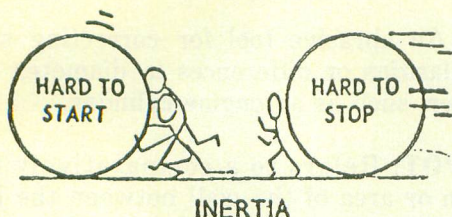
IGNITION DISTRIBUTOR: An electrical unit sometimes containing the circuit breaker for the primary circuit and providing a means for conveying the secondary or high tension current to the spark plug wires as required.

IGNITION SYSTEM: The means for igniting the fuel in the cylinders; includes spark plugs, wiring, ignition distributor, ignition coil and source of electrical current supply.

INDUCTION: The influence of magnetic fields of different strength not electrically connected to one another.

INDUCTION COIL: Essentially a transformer which through the action of induction creates a high tension current by means of an increase in voltage.

INERTIA: The tendency of objects to remain forever in a state of rest if at rest, or to continue in the same motion unless disturbed by an external force.



INHIBITOR: A material to restrain or hinder some unwanted action, such as a rust inhibitor which is a chemical added to cooling systems to retard the formation of rust.

INLET VALVE OR INTAKE VALVE: A valve which permits a fluid or gas to enter a chamber and seals against exit.

INSULATION: Any material which does not conduct electricity; used to prevent the flow or leakage of current from a conductor. Also used to describe a material which does not conduct heat readily.

INSULATOR: An electrical conductor covered or shielded with a non-conducting material, such as a copper wire, within a rubber tube.

INTAKE MANIFOLD: The tube used to conduct the gasoline and air mixture from the carburetor to the engine cylinders.

INTEGRAL: The whole made up of parts.

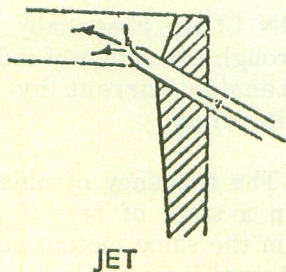
INTENSIFY: To increase or concentrate, such as to increase the voltage of an electrical current.

INTERMITTENT: Motion or action that is not constant but occurs at intervals.

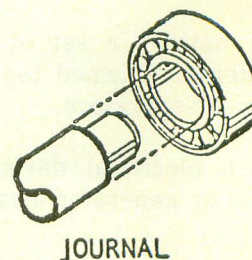
INTERNAL COMBUSTION: The burning of a fuel within an enclosed space.

INTERRUPTER: A device for interrupting an electrical circuit; often automatic and may be known as "contact breaker," "circuit breaker," "cut-out" or "relay".

I.S.O.: International Standards Organization.



JET: A small, tube-like device or hole through which a fluid or gas flows.



JOURNAL: The part of a shaft which is machined to fit a bearing.

JUMP SPARK: A high tension electrical current which jumps through the air from one terminal to the other.

KEEPER: See Valve Key.

KEY: A small block inserted between the shaft and hub to prevent circumferential movement.

KEYWAY OR KEYSEAT: A groove or slot cut to permit the insertion of a key.

KILOWATT: A measure of electrical energy consisting of 1,000 watts; it is equal to 1-1/3 horsepower.

KNURL: To indent or roughen a finished surface.

KNOCK: A general term used to describe various noises occurring in an engine; may be used to describe noises made by loose, broken or worn mechanical parts, pre-ignition, detonation, etc.

LAMINATE: To build up or construct out of a number of thin sheets. An example is the laminated core in an electric motor or generator.

LAPPING: The process of fitting one surface to another by rubbing them together with an abrasive material between the two surfaces.

L-HEAD ENGINE: An engine design in which both valves are located in the cylinder block on one side of the engine cylinder.

LINER: Usually a thin section placed between two parts, such as a replaceable cylinder liner in an engine.

LINKAGE: Any series of rods, belcranks, yokes, and levers, etc., used to transmit motion from one unit to another.

LIQUID: Any substance which assumes the shape of the vessel in which it is placed without changing volume.

LITER: A metric measure equal to 1000 c.c.

LIVE: Electrical parts connected to the insulated side of the electrical system, such as an insulated wire connected to the battery and often referred to as the "hot" wire.

LOST MOTION: Motion between a driving part and a driven part which does not cause actuation of the driven part. Also see Backlash.

L.P.G., LIQUEFIED PETROLEUM GAS: Made usable as a fuel for internal combustion engines by compressing volatile petroleum gases to liquid form. When so used, must be kept under pressure or at low temperature in order to remain in liquid form.

MAGNET (Permanent): Any material which is or has been charged with magnetic power and can retain same, such as a lodestone.

MAGNETIC FIELD: The flow of magnetic force or magnetism between the opposite poles of a magnet.

MAGNETO: An electrical device which generates current when rotated by an outside source of power; may be used for the generation of either low tension or high tension current.

MALLEABLE CASTING: A casting which has been toughened by annealing.

MANIFOLD: A pipe with multiple openings used to connect various cylinders to one inlet or outlet.

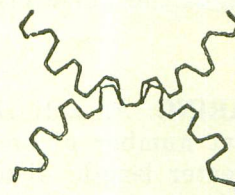
MANGANESE BRONZE: An alloy of copper, zinc and manganese.

MANOMETER: A device for measuring a vacuum consisting of a "U" shaped tube partially filled with fluid. One end of the tube is open to the air and the other is connected to the chamber in which the vacuum is to be measured. Water and Mercury are two commonly used fluids. A column of Mercury 30

in. high equals 14.7 lbs. per square in. which is atmospheric pressure at sea level.

MECHANICAL EFFICIENCY (Engine): The ratio between the indicated horsepower and the brake horsepower of an engine.

MERCURY COLUMN: A reference term used in connection with a Manometer. Readings are given in inches of Mercury.



MESH

MESH: The fitting of the teeth of one gear wheel into the spaces between another gear wheel, allowing one gear to turn or drive another.

METHANOL OR WOOD ALCOHOL: A poisonous alcohol made from distillation of wood; can also be made synthetically.

MICROMETER: A measuring instrument for either external or internal measurement in thousandths and sometimes tenths of thousandths of inches.

MILL: To cut or machine with rotating tooth cutters.

MILLIMETER (mm.): One millimeter is the metric equivalent of 0.039370 of an inch or one inch being the equivalent of 25.4 mm.

MISS (MISFIRING): Failure of an explosion to occur in one or more cylinders while the engine is running; may be continuous or intermittent failure.

MOLECULE: Assumed to be the smallest subdivision of a compound representing a single unit of a substance.

MOMENTUM: The quantity of motion; the property of a moving body which determines the length of time required to bring it to rest when under the action of a constant force.

MONO-BLOCK: Means that complete assembly is contained in one casting; for example, the carburetor venturi and float chamber in one

casting or engine crankcase and cylinder in one casting.

MOTOR: Actually this term should be used in connection with an electric motor and should not be used when referring to the engine.

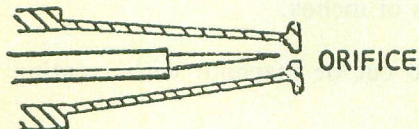
MUFFLER: A chamber attached to the end of the exhaust pipe which allows the exhaust gases to expand and cool. It is usually fitted with baffles or porous plates and serves to subdue much of the noise created by the exhaust.

NEEDLE BEARING: An anti-friction bearing using a great number of small diameter rollers of greater length; also known as a quill type bearing.

NICKEL STEEL: Nickel is alloyed with steel to form a heat and corrosion resistant metal.

NON-FERROUS METALS: This designation includes practically all metals which contain no iron or very little iron and are therefore not subject to rusting.

NORTH POLE: The pole of a magnet from whence the lines of force start; the opposite of south pole.



NOZZLE

NOZZLE: A device for discharging a gas or liquid in a directed flow.

OCTANE NUMBER: A unit of measurement on a scale intended to indicate the tendency of a fuel to detonate or knock.

O.D. Outside diameter.

OFFSET: To set to one side of center.

OHM: A measurement of the resistance to the flow of an electrical current through a conductor.

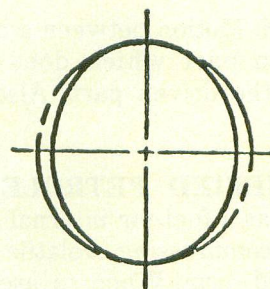
O.H.V.: See Overhead Valve.

OIL PUMPING: A term used to describe a four stroke engine which is using an excessive amount of lubricating oil.

OPEN CIRCUIT: A break or opening in an electrical circuit which interferes with the passage of the current.

ORIFICE: A small opening in a passage, jet, or nozzle.

OSCILLATE: To swing back and forth like a pendulum.



OUT-OF-ROUND

OUT-OF-ROUND: Not a perfect circle.

OVERDRIVE: Any arrangement of gearing which produces more revolutions of the driven shaft than of the driving shaft.

OVERHEAD VALVE OR VALVE-IN-HEAD ENGINE: An engine design having valves located in the cylinder head directly above the pistons.

OVERRUN COUPLING: A device to permit rotation in one direction but not in the other. (Overrunning or sprag clutch.)

OXIDIZE: To combine an element with oxygen or convert into its oxide. The process is often accomplished by combination; for example, when carbon burns, it combines with oxygen to form carbon dioxide or carbon monoxide. An example is rusted iron wherein the iron has combined with the oxygen in the air to form an oxide of iron or in other words rust.

PAWL: A bar adapted to engage with the teeth of a ratchet or the like used either to prevent or impart motion.

PEEN: To stretch or clinch over by pounding with the rounded end of a hammer.

PERIPHERY: The circumference of a circle such as the tread of a tire.

PETCOCK: A small valve placed at various points in a fluid circuit usually for draining purposes.

PETROL: European name for gasoline.

PETROLEUM: A group of liquid and gaseous compounds composed of carbon and hydrogen which are removed from the earth.

PHILLIPS SCREW OR SCREWDRIVER: A type of screw head having a cross instead of a slot for a corresponding type of screwdriver.

PHOSPHOR-BRONZE: An alloy consisting of copper, tin and lead sometimes used in heavy duty bearings.

PILOT VALVE: A small valve used to control the action of a larger valve, such as a main valve.

PINION: A small gear having the teeth formed in the hub.

PINION CARRIER: The mounting or bracket which retains the bearings supporting a pinion shaft.

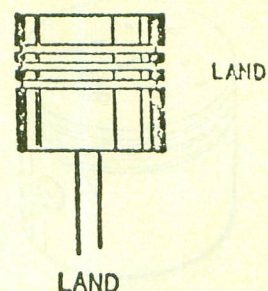
PISTON: A cylindrical part closed at one end which is connected to the crankshaft by the connecting rod. The force of the explosion in the cylinder is exerted against the closed end of the piston causing the connecting rod to move the crankshaft.

PISTON COLLAPSE: A condition describing a collapse or a reduction in diameter of the piston skirt due to heat or stress.

PISTON DISPLACEMENT: The volume of air moved or displaced by moving the piston from one end of its stroke to the other.

PISTON HEAD: That part of the piston above the rings.

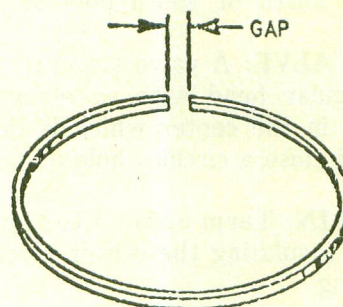
PISTON LANDS: Those parts of a piston between the piston rings.



PISTON PIN: The journal for the bearing in the small end of an engine connecting rod which also passes through piston walls; also known as a wrist pin.

PISTON RING: An expanding ring placed in the grooves of the piston to provide a seal to prevent the passage of fluid or gas past the piston.

PISTON RING EXPANDER: A spring placed behind the piston ring in the groove to increase the pressure of the ring against the cylinder wall.



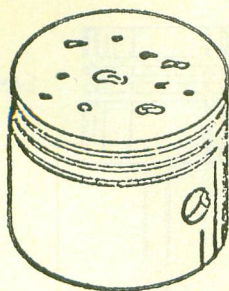
PISTON RING END GAP

PISTON RING GAP: The clearance between the ends of the piston ring.

PISTON RING GROOVE: The channel or slots in the piston in which the piston rings are placed.

PISTON SKIRT: That part of the piston below the rings.

PISTON SKIRT EXPANDER: A spring or other device inserted in the piston skirt to compensate for collapse or decrease in diameter.



PITTED

PITTED: Having small, generally circular, holes or depressions of varying diameter and depth.

PIVOT: A pin or short shaft upon which another part rests or turns upon and about which another part rotates or oscillates.

PLATINUM: An expensive metal having an extremely high melting point and good electrical conductivity. Sometimes used in breaker points.

POLARITY: Refers to the positive or negative terminal of a battery or an electric circuit; also the north or south pole of a magnet.

POPPET VALVE: A valve structure consisting of a circular head with an elongated stem attached in the center which is designed to open and close a circular hole or port.

PORCELAIN: Term applied to the material used for insulating the center electrode of a spark plug.

PORT: In engines, the openings in the cylinder block for valves, exhaust and inlet pipes, or water connections. In two-cycle engines the openings in the cylinder for inlet and exhaust purposes.

"PORTING": As applied to racing engines, the enlarging, matching, streamlining and polishing of the inside of the manifolds and valve ports to reduce the friction of the flow of gases.

POTENTIAL: An indication of the amount of energy available.

POTENTIAL DIFFERENCE: A difference of electrical pressure which sets up a flow of electric current.

PRE-HEATING: The application of heat as a preliminary step to some further thermal or mechanical treatment.

PRE-IGNITION: Ignition occurring earlier than intended. For example, the explosive mixture being fired in a cylinder as by a flake of incandescent carbon before the electric spark occurs.

PRE-LOADING: To place a small amount of pressure or tension on an anti-friction bearing by adjustment to eliminate any semblance of looseness.

PRESS-FIT: Also known as a force-fit or drive-fit. This term is used when the shaft is slightly larger than the hole and must be forced in place.

PRIMARY WINDING: In an ignition coil or magneto armature is a wire which conducts the low tension current which is to be transformed by induction into high tension current in the secondary winding.

PRIMARY WIRES: The wiring circuit used for conducting the low tension or primary current to the points where it is to be used.

PRONY BRAKE: A machine for testing the power of an engine while running against a friction brake.

PROPANE: A petroleum hydrocarbon compound which has a boiling point about -44 degrees, F. and which is used as an engine fuel; loosely referred to as L.P.G. and often combined with Butane.

P.S.I.: Expression of pressure measured in pounds per square inch.

PUSH ROD: A connecting link in an operating mechanism, such as the rod interposed between the valve lifter and rocker arm on an overhead valve engine.

QUENCHING: A process of rapid cooling of hot metal by contact with liquid, gases or solids.

QUILL BEARING: See Needle Bearing.

RACE: As used with reference to bearings, a finished inner and outer surface in which or on which balls or rollers operate.

RADIAL ENGINE: An engine construction wherein the cylinders are mounted in a row or circle around the crankcase.

RADIATION: The transfer of heat by rays, such as heat from the sun.

RATIO: The relation or proportion that one number bears to another.

REAM: To finish a hole accurately with a rotating fluted tool.

RECIPROCATING: A back and forth movement, such as the action of a piston in a cylinder.

RECTIFIER: An electrical device for transforming or changing alternating current into direct current.

REGULATOR: An automatic pressure reducing or regulating valve.

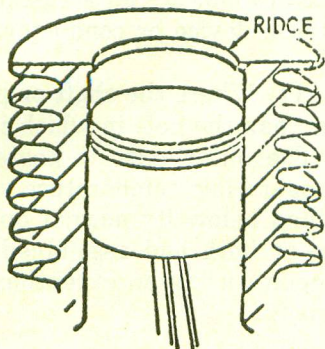
RELAY: A device for interrupting an electrical circuit; often automatic and may be known as "circuit breaker," "interrupter," "contact breaker," or "cut-out."

RELIEF: The amount one surface is set below or above another surface.

RESISTANCE (ELECTRICAL): The property of a substance which enables it to resist the flow of an electric current through it.

RESISTANCE (MECHANICAL): An opposing or retarding force.

RESISTOR: A current consuming piece of metal wire or carbon inserted into an electrical circuit to decrease the flow.



RIDGE

RETARD: When used with reference to an ignition distributor, means to cause the spark to occur at a later time in the cycle of engine operation; opposite of spark advance.

RIDGE: A narrow, raised rib or strip.

RIVET: To attach with rivets or to batter or upset the end of a pin.

ROCKER ARM: In an engine a lever located on a fulcrum or shaft, one end of the lever being on the valve stem; the other being on the push rod.

ROCKWELL HARDNESS: A scale for designating the degree of hardness possessed by a substance.

ROLLER BEARING: An inner and outer race upon which hardened steel rollers operate.

ROTARY VALVE: A valve construction in which ported holes come into and out of register with each other to allow entrance and exit of fluids or gases.

R.P.M.: Revolutions per minute.

RUBBER: An elastic vibration absorbing material of either natural or synthetic origin.

RUNNING-FIT: Where sufficient clearance has been allowed between the shaft and journal to allow free running without overheating.

SAE: Society of Automotive Engineers.

SAE STEELS: A numerical index system used to identify composition of SAE steel. Basically the first digit indicating the type to which the steel belongs; thus (1) indicates a carbon steel, (2) a nickel steel, etc. The second digit generally indicates the approximate percentage of the predominant alloying element. Usually the last two or three digits indicate the approximate average carbon content in points of hundredths of 1 per cent. Thus (SAE 2340 steel) indicates a nickel steel of approximately 3 per cent nickel and 40 per cent carbon.

SAE THREAD: Refers to a table of threads set up by the Society of Automotive Engineers and determines the number of threads per inch. For example, a quarter inch diameter rod with an SAE thread would have 28 threads per inch.

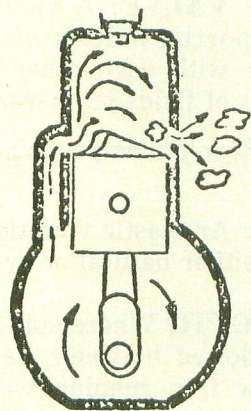
SAFETY FACTOR: The degree of surplus strength over and above normal requirements which serves as an insurance against failure.

SAFETY RELIEF VALVE: A spring loaded valve designed to open and thus relieve excessive pressure in a vessel when it exceeds a pre-determined safe point.

SAND BLAST: To clean a surface by means of sand propelled by compressed air.

SAYBOLT TEST: A method of measuring the viscosity of oil with the use of a viscosimeter.

SCALE: A flaky deposit occurring on steel or iron. Ordinarily used to describe the accumulation of minerals and metals accumulating in a cooling system.



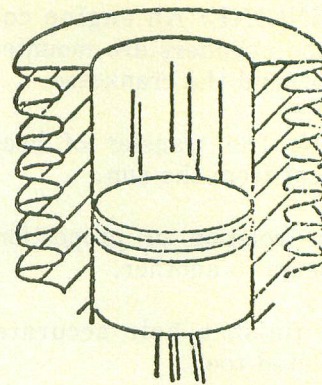
SCAVENGE

SCAVENGE: The driving of hot burned exhaust gases from the cylinder through the exhaust port.

SCORING: The scratches or grooves on a surface in the direction of the part moving against it.

SEAT: A surface, usually machined, upon which another part rests or seats; for example, the surface upon which a valve face rests.

SECONDARY WINDING: In an ignition coil or magneto armature, a wire in which a secondary or high tension current is created by induction due to the interruption of the current in the adjacent primary winding.



SCORING

SEDIMENT: In a fluid this refers to the material which is heaviest and gradually settles to the bottom and accumulates at the bottom of the container.

SEIZE: When one surface moving upon another scratches, it is said to seize. An example is a piston score or abrasion in a cylinder due to lack of lubrication or over-expansion.

SERIES WINDING: An electric winding or coil of wire in series with other electrical equipment. When applied to electric generators or motors, the field coil is connected in series with the armature.

"SHAVE": See Mill.

SHEAR: To cut between two blades.

SHIM: Thin sheets used as spacers between two parts, such as the two halves of a journal bearing.

SHORT CIRCUIT: To provide a shorter path; often used to indicate an accidental ground in an electrical device or conductor.

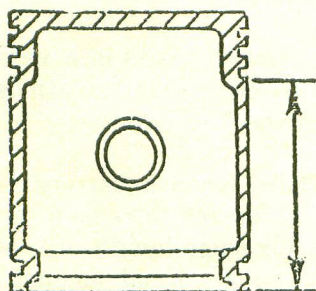
SHRINK-FIT: Where the shaft or part is slightly larger than the hole in which it is to be inserted. The outer part is heated above its normal operating temperature or the inner part chilled below its normal operating temperature or both and assembled in this condition; upon cooling an exceptionally tight fit is obtained.

SHUNT: To by-pass around or turn aside; in electrical apparatus an alternate path for the current.

SHUNT WINDING: An electric winding or coil of wire, which forms a bypass or alternate path for electric current. When applied to electric generators or motors, each end of the field winding is connected to an armature brush.

SILICON STEEL: An alloy of silicon and chromium with steel. As this alloy resists burning and oxidation and does not warp readily, it is often used for exhaust valves of internal combustion engines.

SILVER SOLDERING: Same as Hard Soldering.



SKIRT

SKIRT: The lower, hollow part of the piston.

SLEEVE: A hard, cylindrical insert usually installed to increase the life of a part or to provide a wear surface.

SLIDING-FIT: Where sufficient clearance has been allowed between the shaft and journal to allow free running without overheating.

SLIP-IN BEARING: A liner made to extremely accurate measurements which can be used for replacement purposes without additional fitting.

SLUDGE: Indicates a composition of oxidized petroleum products along with an emulsion formed by the mixture of oil and water. This forms a pasty substance and clogs oil lines and passages and interferes with engine lubrication.

SOLDER: An alloy of lead and tin used to unite two metal parts.

SOLDERING: To unite two pieces of metal with a material, such as solder having a comparatively low melting point.

SOLENOID: An iron core surrounded by a coil of wire which moves due to magnetic attraction when an electrical current is fed to the coil; often used to actuate mechanisms by electrical means.

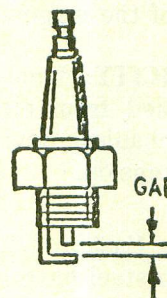
SOLVENT: A solution which dissolves some other material. For example, water is a solvent for sugar.

SOUTH POLE: The pole of a magnet to which the lines of force flow; the opposite of north pole.

SPARK: An electrical current possessing sufficient pressure to jump through the air from one conductor to another.

SPARK ADVANCE: When used with reference to an ignition distributor, means to cause the spark to occur at an earlier time in the cycle of engine operation; opposite of retard.

SPARK KNOCK: Same as Pre-ignition.



SPARK GAP

SPARK PLUG: A device inserted into the combustion chamber of an engine containing an insulated central electrode for conducting the high tension current from the ignition distributor or magneto. This insulated electrode is spaced a pre-determined distance from the shell or side electrode in order to control the dimensions of the gap for the spark to jump across.

SPECIFIC GRAVITY: The relative weight of a substance as compared to water. For example, if a cubic inch of acid weighs twice as much as a cubic inch of water, the specific gravity of the substance would be 2.

SPIRAL BEVEL GEAR: A gear and pinion wherein the mating teeth are curved and placed at an angle with pinion shaft.

SPLINE: A long keyway.

SPLINE JOINT: Two mating parts each with a series of splines around their circumference, one inner and one outer in order to provide a longitudinally movable joint without circumferential motion.

SPOT WELD: To attach in spots by localized fusion of the metal parts with the aid of an electric current.

SPRAG CLUTCH: A clutch that permits turning in one direction or permits one part to turn but automatically disengages when the driven part attempts to turn the driving part.

SPUR GEAR: A gear in which the teeth are cut parallel to the shaft.

STAMPING: A piece of sheet metal cut and formed into the desired shape with the use of dies.

STATOR: The non-moving part, such as the stationary part of the magneto.

STATIC ELECTRICITY: Atmospheric electricity as distinguished from electricity as produced by a mechanical device. Usually has extremely high tension.

STEEL CASTING: Cast iron to which varying amounts of scrap steel have been added.

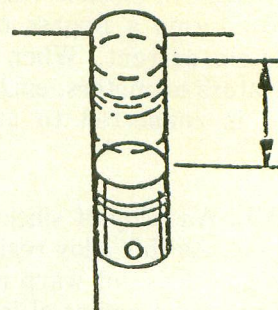
STELLITE: An alloy of cobalt, chrome and tungsten which is often used for exhaust valve seat inserts. It has a high melting point, good corrosion resistance and unusual hardness when hot.

STRESS: The force or strain to which a material is subjected.

STROBOSCOPE: A term applied to an ignition timing light which gives the effect of making a marking on a rapidly rotating wheel, such as a flywheel, appear to stand still for observation.

STROKE: The length of piston travel in a cylinder.

"STROKING": As applied to racing engines, re-machining the crankshaft throws off center to alter the stroke.



STROKE

STUDS: A rod with threads cut on both ends, such as a cylinder stud which screws into the cylinder block on one end and has a nut placed on the other end to hold the cylinder head in place.

SUCTION: Suction exists in a vessel when the pressure is lower than the atmospheric pressure; also see Vacuum.

SULPHATED: When a battery is improperly charged or allowed to remain in a discharged condition for some length of time, the plates will have an abnormal amount of lead sulphate. The battery is then said to be "sulphated".

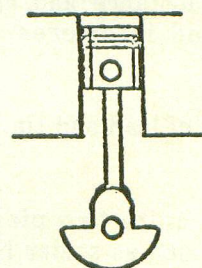
SUPERCHARGER: A blower or pump which forces air into the cylinders at higher than atmospheric pressure. In an engine the increased pressure forces more air into the cylinder, thus enabling more gasoline to be burned and more power produced.

SWEAT: To join metal pieces by clamping together with solder between them and applying heat.

SYNCHRONIZE: To cause two events to occur at the same time.

TACHOMETER: A device for measuring and indicating the rotative speed of an engine.

TAP: To cut threads in a hole with a tapered, fluted, threaded tool.



TOP-DEAD-CENTER

T.D.C.: Top dead center.

TEMPER: To change the physical characteristics of metal by the application of heat.

TENSION: Effort devoted towards elongation or "stretching" of a material.

TERMINAL: In electrical work, a junction point where connections are made, such as the terminal fitting on the end of a wire.

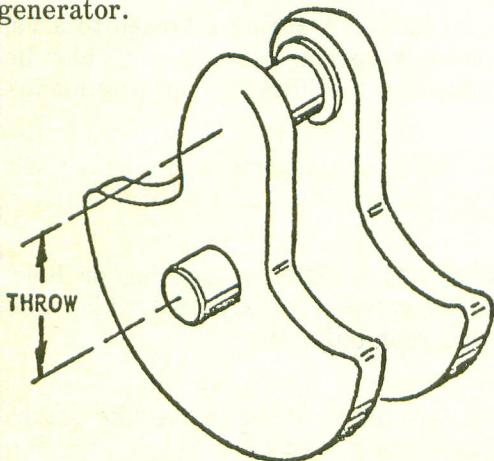
T-HEAD ENGINE: An engine design wherein the inlet valves are placed on one side of the cylinder and the exhaust valves placed on the other.

THERMAL EFFICIENCY: A gallon of fuel contains a certain amount of potential energy in the form of heat when burned in the combustion chamber. Some of this heat is lost and some is converted into power. The thermal efficiency is the ratio of work accomplished compared to the total quantity of heat contained in the fuel.

THERMOSTAT: A heat controlled valve used in the cooling system of an engine to regulate the flow of water or used in the electrical circuit to control the current.

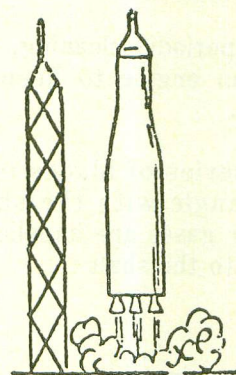
THERMO-SYPHON: A method of cooling an engine which utilizes the difference in specific gravity of hot and cold water. No pump is used, but the water passages are larger than in the pump circulation system.

THIRD BRUSH: As used on generators, this is an auxiliary brush placed on the commutator in such relation to the main brushes that it serves to control the current output of the generator.



THROW

THROW: With reference to an engine, usually the distance from the center of the crankshaft main bearing to the center of the connecting rod journal.



THRUST

THRUST: A force directed along the axis of a part.

TIMER: Refers to the ignition distributor which times or supplies a spark to the spark plugs at the proper instant.

TIMING CHAIN: Chain used to drive camshaft and accessory shafts of an engine.

TIMING GEARS: Any group of gears which are driven from the engine crankshaft to cause the valves, ignition and other engine driven apparatus to operate at the desired time during the engine cycle.

TOLERANCE: A permissible variation between the two extremes of a specification of dimensions.



TORQUE

TORQUE: An effort devoted toward twisting (turning) or rotary motion.

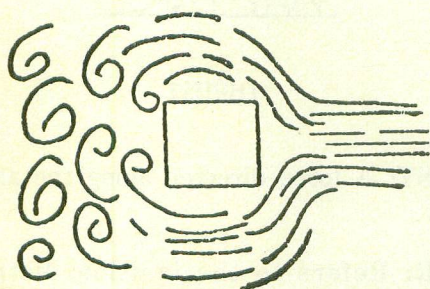
TORQUE WRENCH: A special wrench with a built-in indicator to measure the applied force.

TRANSFORMER: An electrical device, such as a high tension coil which transforms or changes the characteristics of an electrical current.

TROUBLE SHOOTING: The methodical check of a malfunctioning engine to discover the cause of the malfunction.

TUNE-UP The periodic cleaning, testing and adjusting of an engine to keep it in good working order.

TURBINE: A series of blades located on a wheel at an angle with the shaft against which fluids or gases are impelled to impart rotary motion to the shaft.



TURBULENCE

TURBULENCE: An agitation or disturbance in the normal flow pattern. Irregular motion of fluids or gases.

TWO-STROKE ENGINE: An engine design permitting a power stroke once for each revolution of the crankshaft.

UNIVERSAL JOINT: A connection for transmitting power from a driving to a driven shaft through an angle.

UPSET: To compress endwise causing an increase in diameter.

VACUUM: A space completely without matter. A vacuum exists where there is absolutely no pressure. In connection with a gasoline engine this word is used to define a pressure less than atmospheric pressure. The vacuum in a cylinder means suction.

VACUUM GAGE: An instrument designed to measure the degree of vacuum existing in a chamber.

VALVE: Used in great variety and of many types. A valve is a device which regulates flow.

VALVE CLEARANCE: The air gap allowed between the end of the valve stem and the valve lifter or rocker arm to compensate for expansion due to heat.

VALVE FACE: That part of a valve which mates with and rests upon a seating surface.

VALVE GRINDING: The process of mating the valve seat and valve face usually performed with the aid of an abrasive.

VALVE GUIDE: See Valve Stem Guide.

VALVE HEAD: The portion of the valve upon which the valve face is machined.

VALVE-IN-HEAD ENGINE: Same as overhead valve engine.

VALVE KEY, KEEPER OR VALVE LOCK: The key, washer, or other device which holds the valve spring cup or washer in place on the valve stem.

VALVE LIFTER: See Cam Follower.

VALVE MARGIN: On a poppet valve, the space or rim between the surface of the head and the surface of the valve face.

VALVE OVERLAP: An interval expressed in degrees where both valves of an engine cylinder are open at the same time.

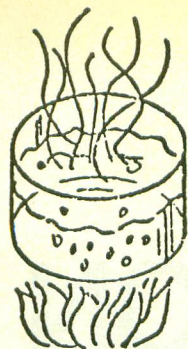
VALVE SEAT: The matched surface upon which the valve face rests.

VALVE SPRING: A spring attached to a valve to return it to the seat after it has been released from the lifting or opening means.

VALVE STEM: That portion of a valve which rests within a guide.

VALVE STEM GUIDE: A bushing or hole in which the valve stem is placed which allows lateral motion only.

VANES: Any plate, blade or the like attached to an axis and moved by or in air or a liquid.

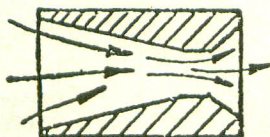


VAPORIZE

VAPORIZE: To change a liquid to a gaseous form.

VAPORIZER: A device for transforming or helping to transform a liquid into a vapor; often includes the application of heat.

VAPOR LOCK: A condition wherein the fuel boils in the fuel system forming bubbles which retard or stop the flow of fuel to the carburetor.



VENTURI

VENTURI: Two tapering streamlined tubes joined at their small ends so as to reduce the internal diameter.

VIBRATION DAMPER: A device to reduce the torsional or twisting vibration which occurs along the length of the crankshaft used in multiple cylinder engines; also known as a harmonic balancer.

VISCOSITY: The resistance to flow or adhesive characteristics of an oil.

VOLATILITY: The tendency for a fluid to evaporate rapidly or pass off in the form of vapor. For example, gasoline is more volatile than kerosene as it evaporates at a lower temperature.

VOLT: A unit of electrical force which will cause a current of one ampere to flow through a resistance of one ohm.

VOLTAGE REGULATOR: An electrical device for controlling or regulating voltage.

VOLTMETER: An instrument for measuring the voltage in an electrical circuit.

VOLUME: The measure of space expressed as cubic centimeters, cubic inches, cubic feet, etc.

VOLUMETRIC EFFICIENCY: A combination between the ideal and actual efficiency of an internal combustion engine. If the engine completely filled each cylinder on each induction stroke the volumetric efficiency of the engine would be 100 per cent. In actual operation, however, volumetric efficiency is lowered by the inertia of the gases, the friction between the gases and the manifolds, the temperature of the gases and the pressure of the air entering the carburetor. Volumetric efficiency is ordinarily increased by the use of large valves, ports, and manifolds and can be further increased with the aid of a supercharger.

VORTEX: A whirling movement or mass of liquid or air.

WATER COLUMN: A reference term used in connection with a Manometer.

WATT: A measuring unit of electrical power. It is obtained by multiplying amperes by volts.

WELDING: To join two pieces of metal by heating them to the fusion or melting point.

WHITE METAL: An alloy of tin, lead and antimony having a low melting point and a low co-efficient of friction.

WIRING DIAGRAM: A detailed drawing of all wiring, connections and units connected together in an electrical circuit.

WORM GEAR: A shaft having an extremely coarse thread which is designed to operate in engagement with a toothed wheel, as a pair of gears.

WRIST PIN: The journal for the bearing in the small end of an engine connecting rod which also passes through piston walls; also known as a piston pin.

METRIC CONVERSION

METRIC TAP AND DRILL SIZES WITH INCH EQUIVALENTS AND CLOSEST INCH DRILL SIZE

Metric Tap Size	Metric Drill Size	Inch Equivalent of Metric Drill Size	Closest Inch Drill Size	Decimal Equivalent of Inch Drill Size
M3x0.5*	2.50	0.0984	#40	0.0980
M3.5x0.6*	2.90	0.1142	#33	0.1130
M4x0.7*	3.30	0.1299	#30	0.1285
M4.5x0.75*	3.70	0.1457	#26	0.1470
M5x0.8*	4.20	0.1654	#19	0.1660
M6x1*	5.00	0.1968	#9	0.1960
M7x1*	6.00	0.2362	15/64	0.2344
M8x1.25*	6.70	0.2638	17/64	0.2656
M8x1	7.00	0.2756	J	0.2770
M10x1.5*	8.50	0.3346	Q	0.3320
M10x1.25	8.70	0.3425	11/32	0.3438
M12x1.75*	10.20	0.4016	Y	0.4040
M12x1.25	10.80	0.4252	27/64	0.4219
M14x2*	12.00	0.4724	15/32	0.4688
M16x2*	14.00	0.5512	35/64	0.5469
M18x2.5*	15.50	0.6102	39/64	0.6094
M20x2.5*	17.50	0.6890	11/16	0.6875

*International Organization for Standardization metric sizes (ISO metrics).

The above guide may be used to determine the proper hole size for metric taps.

Metric taps are designated by an "M" followed by the nominal tap size in MM and the width between threads (pitch) also in MM. For example a 10 MM tap with 1.5 MM pitch threads will have a designation of M10x1.5.

When no designation is given for thread pitch, such as a tap marked "M14", it is understood to have the standard ISO course pitch of 2 MM. In most instances, the entire designation

M14x2, will be given; however, either designation is correct.

Additional numbers and letters following a dash (—) refer to tolerance limits and locations. Numbers in the tolerance designation refer to the amount of tolerance allowed. Numbers used in tolerance designations range from 3 to 9. General purpose hardware has a standard tolerance of 6. Tighter tolerances will be designated with a smaller number and looser tolerances will be designated with a larger number.

Letters are used in the tolerance designation to denote the location of the tolerance such as, the maximum diameter at the thread tips or the minimum diameter between threads. Capitals and lower case letters are used to denote if the tolerance applies to external threads (lower case) or internal threads (capitals).

Below are examples of ISO metric tap designations.

M7x1
M14
M18x2.5-7H
M16-6g

METRIC

CONVERSION

Cubic meters	= .02832	x Cubic Feet	Metric tons		
Cubic meters	x 1.308	= Cubic Yards	(1,000		
Cubic meters	= .765	x Cubic Yards	kilograms)	x 1.1023	= Tons (2,000
Liters	x 61.023	= Cubic Inches			Pounds)
Liters	= .01639	x Cubic Inches	Metric tons		
Liters	x .26418	= U.S. Gallons	(1,000		
Liters	= 3.7854	x U.S. Gallons	kilograms)	= .9072	x Tons (2,000
Grams	x 15.4324	= Grains			Pounds)
Grams	= .0648	x Grains	Kilowatts	= 1.3405	x Horsepower
Grams	x .03527	= Ounces,	Kilowatts	x .746	= Horsepower
		avoirdupois			
Grams	= 28.3495	x Ounces,	Millimeters	x .03937	= Inches
		avoirdupois	Millimeters	= 25.400	x Inches
Kilograms	x 2.2046	= Pounds	Meters	x 3.2809	= Feet
Kilograms	= .4536	x Pounds	Meters	= .3048	x Feet
Kilograms per			Kilometers	x .621377	= Miles
square			Kilometers	= 1.6093	x Miles
centimeter	x 14.2231	= Pounds per	Square		
		square Inch	centimeters	x .15500	= Square
Kilograms					Inches
per square			Square		
centimeter	= .0703	x Pounds per	centimeters	= 6.4515	x Square Inches
		square Inch	Square meters	x 10.76410	= Square Feet
Kilograms per			Square meters	= .09290	x Square Feet
cubic meter	x .06243	= Pounds per	Cubic		
		cubic Foot	centimeters	x .061025	= Cubic Inches
Kilograms per			Cubic		
cubic meter	= 16.01890	x Pounds per	centimeters	= 16.3866	x Cubic Inches
		cubic Foot	Cubic meters	x 35.3156	= Cubic Feet

METRIC

CONVERSION

MM.	INCHES	MM.	INCHES	MM.	INCHES	MM.	INCHES	MM.	INCHES	MM.	INCHES	MM.	INCHES
1	0.0394	1/16	1.5875	101	3.9764	3 11/16	151	5.9449	5 11/16	201	7.9134	7 11/16	251
2	0.0787	1/8	3.1750	102	4.0157	4 1/8	152	5.9842	5 1/8	202	7.9527	7 1/8	252
3	0.1181	3/16	4.7625	103	4.0551	4 1/8	153	6.0236	6 1/8	203	7.9921	8.0	253
4	0.1575	1/4	6.3500	104	4.0945	4 1/8	154	6.0630	6 1/8	204	8.0315	8 1/8	254
5	0.1969	5/16	7.9375	105	4.1339	4 1/8	155	6.1024	6 1/8	205	8.0709	8 1/8	255
6	0.2362	3/8	9.5250	106	4.1732	4 1/8	156	6.1417	6 1/8	206	8.1102	8 1/8	256
7	0.2756	1/2	12.0750	107	4.2126	4 1/8	157	6.1811	6 1/8	207	8.1496	8 1/8	257
8	0.3150	5/8	15.8750	108	4.2520	4 1/8	158	6.2205	6 1/8	208	8.1890	8 1/8	258
9	0.3543	3/4	19.6875	109	4.2913	4 1/8	159	6.2598	6 1/8	209	8.2283	8 1/8	259
10	0.3937	7/8	23.5000	110	4.3307	4 1/8	160	6.2992	6 1/8	210	8.2677	8 1/8	260
11	0.4331	1	25.4000	111	4.3701	4 1/8	161	6.3386	6 1/8	211	8.3071	8 1/8	261
12	0.4724	1 1/16	27.1438	112	4.4094	4 1/8	162	6.3779	6 1/8	212	8.3464	8 1/8	262
13	0.5118	1 1/8	28.8750	113	4.4488	4 1/8	163	6.4173	6 1/8	213	8.3858	8 1/8	263
14	0.5512	1 1/4	30.6250	114	4.4882	4 1/8	164	6.4567	6 1/8	214	8.4252	8 1/8	264
15	0.5906	1 1/2	32.3750	115	4.5276	4 1/8	165	6.4961	6 1/8	215	8.4646	8 1/8	265
16	0.6299	1 3/4	34.1250	116	4.5669	4 1/8	166	6.5354	6 1/8	216	8.5039	8 1/8	266
17	0.6693	1 7/8	35.8750	117	4.6063	4 1/8	167	6.5748	6 1/8	217	8.5433	8 1/8	267
18	0.7087	2	37.6250	118	4.6457	4 1/8	168	6.6142	6 1/8	218	8.5827	8 1/8	268
19	0.7480	2 1/16	39.3750	119	4.6850	4 1/8	169	6.6535	6 1/8	219	8.6220	8 1/8	269
20	0.7874	2 1/8	41.1250	120	4.7244	4 1/8	170	6.6929	6 1/8	220	8.6614	8 1/8	270
21	0.8268	2 1/4	42.8750	121	4.7638	4 1/8	171	6.7323	6 1/8	221	8.7008	8 1/8	271
22	0.8661	2 1/2	44.6250	122	4.8031	4 1/8	172	6.7716	6 1/8	222	8.7401	8 1/8	272
23	0.9055	2 3/4	46.3750	123	4.8425	4 1/8	173	6.8110	6 1/8	223	8.7795	8 1/8	273
24	0.9449	2 5/8	48.1250	124	4.8819	4 1/8	174	6.8504	6 1/8	224	8.8189	8 1/8	274
25	0.9843	2 3/4	49.8750	125	4.9213	4 1/8	175	6.8898	6 1/8	225	8.8583	8 1/8	275
26	1.0236	2 7/8	51.6250	126	4.9606	4 1/8	176	6.9291	6 1/8	226	8.8976	8 1/8	276
27	1.0630	3	53.3750	127	5.0000	5.0	177	6.9685	6 1/8	227	8.9370	8 1/8	277
28	1.1024	3 1/16	55.1250	128	5.0394	5 1/8	178	7.0079	7.0	228	8.9764	8 1/8	278
29	1.1417	3 1/8	56.8750	129	5.0787	5 1/8	179	7.0472	7 1/8	229	9.0157	8 1/8	279
30	1.1811	3 1/4	58.6250	130	5.1181	5 1/8	180	7.0866	7 1/8	230	9.0551	8 1/8	280
31	1.2205	3 1/2	60.3750	131	5.1575	5 1/8	181	7.1260	7 1/8	231	9.0945	8 1/8	281
32	1.2598	3 3/4	62.1250	132	5.1968	5 1/8	182	7.1653	7 1/8	232	9.1338	8 1/8	282
33	1.2992	3 5/8	63.8750	133	5.2362	5 1/8	183	7.2047	7 1/8	233	9.1732	8 1/8	283
34	1.3386	3 7/8	65.6250	134	5.2756	5 1/8	184	7.2441	7 1/8	234	9.2126	8 1/8	284
35	1.3780	4	67.3750	135	5.3150	5 1/8	185	7.2835	7 1/8	235	9.2520	8 1/8	285
36	1.4173	4 1/16	69.1250	136	5.3543	5 1/8	186	7.3228	7 1/8	236	9.2913	8 1/8	286
37	1.4567	4 1/8	70.8750	137	5.3937	5 1/8	187	7.3622	7 1/8	237	9.3307	8 1/8	287
38	1.4961	4 1/4	72.6250	138	5.4331	5 1/8	188	7.4016	7 1/8	238	9.3701	8 1/8	288
39	1.5354	4 1/2	74.3750	139	5.4724	5 1/8	189	7.4409	7 1/8	239	9.4094	8 1/8	289
40	1.5748	4 3/4	76.1250	140	5.5118	5 1/8	190	7.4803	7 1/8	240	9.4488	8 1/8	290
41	1.6142	4 5/8	77.8750	141	5.5512	5 1/8	191	7.5197	7 1/8	241	9.4882	8 1/8	291
42	1.6535	4 3/4	79.6250	142	5.5905	5 1/8	192	7.5590	7 1/8	242	9.5275	8 1/8	292
43	1.6929	4 7/8	81.3750	143	5.6299	5 1/8	193	7.5984	7 1/8	243	9.5669	8 1/8	293
44	1.7323	5	83.1250	144	5.6693	5 1/8	194	7.6378	7 1/8	244	9.6063	8 1/8	294
45	1.7717	5 1/16	84.8750	145	5.7087	5 1/8	195	7.6772	7 1/8	245	9.6457	8 1/8	295
46	1.8110	5 1/8	86.6250	146	5.7480	5 1/8	196	7.7165	7 1/8	246	9.6850	8 1/8	296
47	1.8504	5 1/4	88.3750	147	5.7874	5 1/8	197	7.7559	7 1/8	247	9.7244	8 1/8	297
48	1.8898	5 1/2	90.1250	148	5.8268	5 1/8	198	7.7953	7 1/8	248	9.7638	8 1/8	298
49	1.9291	5 3/4	91.8750	149	5.8661	5 1/8	199	7.8346	7 1/8	249	9.8031	8 1/8	299
50	1.9685	5 7/8	93.6250	150	5.9055	5 1/8	200	7.8740	7 1/8	250	9.8425	8 1/8	300

NOTE: The + or - sign indicates that the decimal equivalent is larger or smaller than the fractional equivalent.