Care And Operation Of High Speed Pumping Engines

By W. L. Jenkins
Waukesha Sales & Service, Inc.
Midland, Texas

This paper will deal with the four cycle, spark ignition, carburetor engine designed to operate on gaseous or liquid fuel or a combination of both as practically all so called high speed pumping engines are of this type. Actually the correct classification of these engines should be "medium speed" as compared to engines being used in other industries operating at much higher speeds.

Cycles of Four Cycle Engines

The four cycles in the engine are the intake, compression, power and exhaust. These four cycles are very clearly shown on figure 1.

The first event in the cycle is the intake stroke. The piston starts from its topmost position known as top dead center, with the intake valve open and the exhaust valve closed; the piston moves downward creating a partial vacuum or suction in the cylinder that draws a proportion of filtered air and fuel into the cylinder through the intake valve port; as the piston reaches the bottom of its stroke, or bottom dead center, the intake valve closes, thus sealing the fuel mixture in the cylinder. Valves are assumed to open and close at top or bottom dead center for purpose of explanation.

With both valves closed and the cylinder full of combustible fuel, the piston moves upward in the cylinder until it again reaches the topmost position. This is called the compression stroke. During this stroke the fuel is being compressed into smaller space in the combustion chamber until it is only a fractional part of its original volume (terminology compression ratio). Upon completion of this stroke the crankshaft has revolved one complete turn or 360 degrees and the piston has made two strokes, down and up.

At this point in the cycle the magneto discharges a high tension current to the spark plug, igniting and exploding the highly compressed fuel charge in the cylinders. Due to the heat and expansion of combustion, the gaseous charge builds up pressure and the piston is forced downward to the bottom dead center position. This is called the power stroke.

As the piston nears the bottom dead center position, the exhaust valve opens and the pressure is relieved. The exhaust valve remains open while the piston moves up to the top dead position, forcing the burned gas out of the cylinder through the exhaust valve port. When the piston reaches the top the exhaust valve closes. This is called the exhaust stroke of the engine. The crankshaft has made two complete revolutions or 720 degrees.

To operate an engine of this type with a minimum of trouble and cost, certain preventative maintenance and operation practices should be observed.

To insure long life of an engine properly applied, the operator must see that the engine is lubricated and operated with the correct temperature range (it is just as harmful to run the enegine too cool as too hot), and to see that the engine is supplied with the correct amount of clean fuel, which includes air.

Lubrication

In order to perform these duties, certain instruments are required and their use understood. All engines are equipped with an oil pressure gauge and any appreciable drop in pressure reading warrants investigation to determine the cause. It is necessary, of course, to keep the crankcase full to the mark on the oil level indicator. The weight of oil to be used depends on the crankcase temperature. After obtaining the crankcase temperature with a thermometer, the maintenance manual will indicate the proper weight which is:

Table 1

200 — 220 · F	—	50
180 — 200 · F	—	40
160 — 180 · F	—	30
140 — 160 · F	—	20

There will likely be seasonal variances in the weights to be used. Due to wide differences in loads, climates, operating conditions, etc., it is impossible to make a hard and fast rule to determine the proper length of operating hours between oil changes. Practically all retail oil companies employ lubrication engineers who will be glad to analyze samples of oil from engines to determine the safe life of the oil. You can increase the life of the oil and the engine by properly servicing the lubrication oil filter and periodically cleaning the sludge that may accumulate in the oil pan, with particular attention to the screen of the oil pump. The frequency of these services vary due to circumstances but the operator can very soon ascertain how often they are required by experience. The oil pressure gauge should be read at every opportunity as it serves the same purpose for an engine operator as a fever thermometer for a doctor.

In the event the pressure drops, and no excessive leaks, oil line breaks or stopped up oil pump screens are

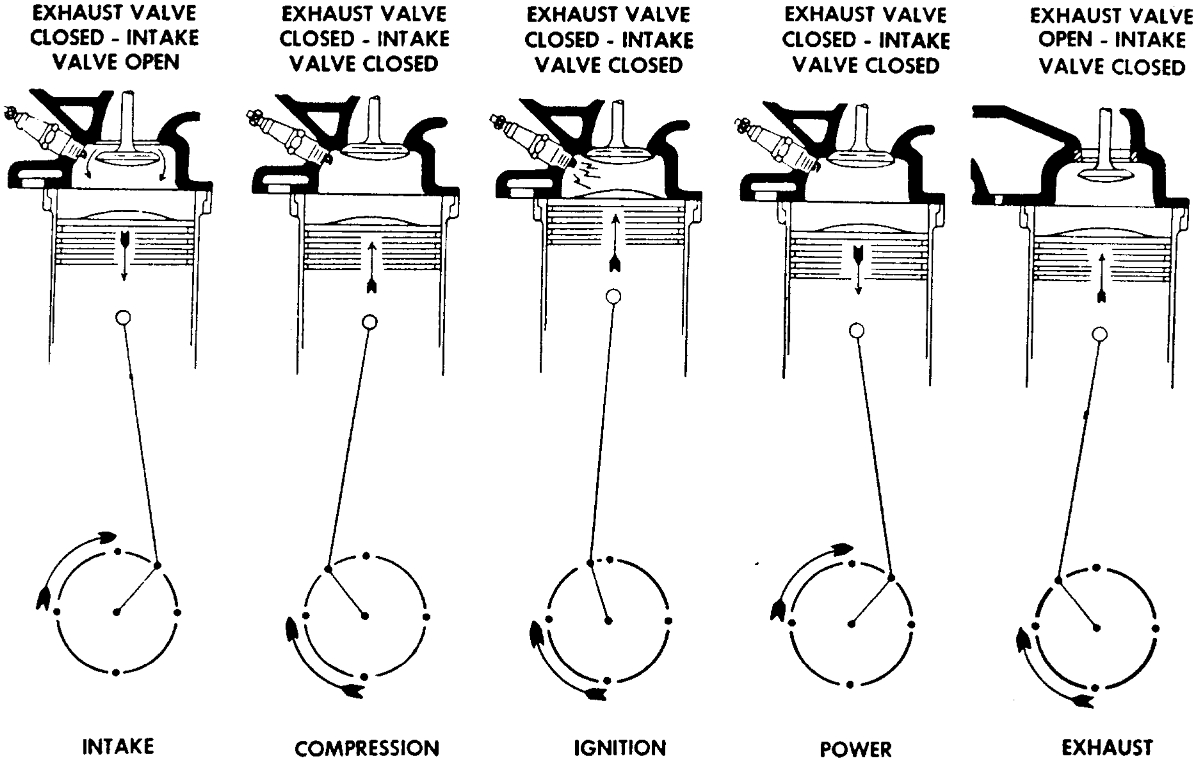

FIGURE 1

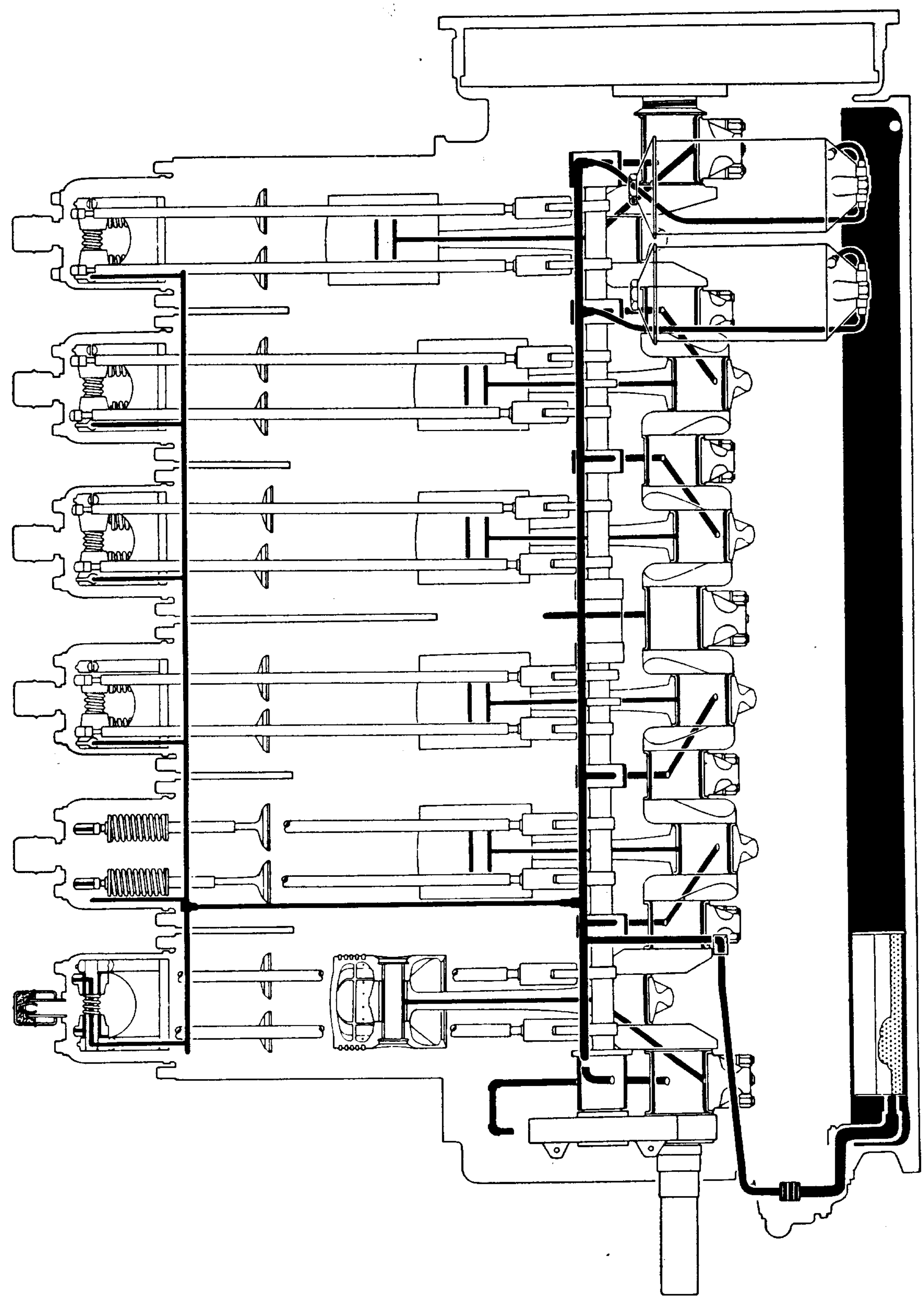

FIGURE 2

found, it is a good indication of serious trouble. The importance of lubrication cannot be stressed too much. But by observing these few simple rules and precautions, the correct lubrication of the internal or enclosed portion of an engine can be assured. However, in some cases where extremely dry gas is encountered, it is necessary to furnish additional lubrication of the valves by the use of a top cylinder lubricator. If this type lubricator is used, it is wise not to use too much as it might cause fouling of spark plugs. A few drops per minute will suffice, with a probable range of six to fifteen drops depending on the size of the engine.

Figure 2 shows the lubrication system of a certain large engine. This system is not the same on all engines but the general idea is very similar. The outside parts in need of lubrication are few and simple. Some water pumps require no lubrication between repairs. A good grade of water pump grease should be used on the type pumps requiring lubrication. Weekly greasing of pumps is adequate in most cases.

The fan bearings should be greased monthly with a No. 2, long fibre, soda soap grease. Many engines have the fan blade attached to the water pump and do not have separate fan bearings.

The clutch power takeoff usually has three points requiring lubrication. The throwout collar should be greased daily. The clutch shaft bearings should also be greased daily while the pilot bearing, which is greased thru the hollow clutch shaft, requires grease about every fifty hours. A cover on the clutch housing gives detailed instructions. If engine is equipped with electric starting equipment, the generator will require a few drops of oil occasionally.

As an engine wears, due to normal use, a very gradual drop in oil pressure will be noted. The pressure should be maintained at 40 lbs. P.S.I., for most engines. To compensate for the drop due to normal wear, an oil pressure relief valve is located on either the crankcase, oil pump or both. By adjusting this valve the 40 P.S.I. can be maintained until the wear becomes excessive, necessitating repairs.

Cooling

The cooling system of an engine of the type being discussed is designed to operate at a range of 150 - 180 deg. F., at the point the water leaves the engine to enter the radiator. An engine operating at too low temperature will not allow the proper expansion of the pistons and rings, causing too much clearance between these parts and the cylinder walls. As a result, crankcase oil is allowed to enter the firing chamber, depositing carbon, fouling plugs, and cylinder gases are allowed to blow by the rings causing deterioration of the lubricating oil. A more efficient combustion is assured with a hot engine. From the standpoint of damage to the engine, 200 deg. or even boiling should not cause trouble. However, at these temperatures evaporation of the coolant increases making it necessary to add water more often. Another real danger is adding cool water to a hot engine, which probably causes more cracked heads and manifolds than all other reasons combined.

The ideal cooling fluid is treated water. Since distilled water is too expensive and rain water too scarce in West Texas, we usually use whatever water is available. The harder the water, the more difficult it is to maintain a good cooling system as the minerals which are in suspension drop out at approximately 170 deg. leaving a deposit, the most common being lime. This deposit naturally reduces the efficiency of the system and should be removed by the use of various types of acid treatments. However, these acids sometimes cause radiator cores to begin leaking or even the cylinder sleeve packing rings to leak, as lime, which may have plugged a hole in the radiator core, or a groove in the rubber ring is removed. Outside of these two possible points of troubles, the acids will usually do a good job and will remove the scale. The acid treatment will not dilute any sand, which may be in the system, so extra care should be used to assure clean containers for adding to both oil and water. Water softeners are olso helpful.

The engine manufacturers use a very effective and very inexpensive item in the first water placed in the engine. A solution of soluble oil, two ounces to one gallon of water, is used. The soluble oil has a tendency to form a protective coating on the metal thus keeping the scale more or less in suspension. The system should be completely flushed monthly and soluble oil added. Extremely bad water may require more frequent flushings. One of the most effective and economical compounds to use in cleaning a system is plain washing soda (tri-sodium phosphate). If the scaling condition is severe, use one-half pound soda for each gallon of water. Use this solution for about 24 hours and drain before the engine cools. The soda should be placed in the system after the engine reaches operating temperature. In winter months it is often desirable to use antifreeze solutions. Before adding the anti-freeze, it is a good idea to flush the engine and radiator. Check all rubber hose connections, and tighten all other connections. Table 11 shows the percentage quantity of various types of solutions to be used for various atmospheric temperatures.

Table 11

Anti-Freeze Solutions
Percentage by Volume

Pure Methyl Wood Alcohol %	Denatured Wood Alcohol %	Ethylene Gylcol %	Radiator Glycerine %	Freezes At Degrees F.	C.
13	17	16	37	20	—7
20	26	25	55	10	—12
27	34	33	70	0	—18
32	40	39	81	—10	—23
37	40	44	92	—20	—29
40	53	48	100	—30	—35

If alcohol is used it is imperative to use soluble oil and to remember it will boil and evaporate at temperatures ranging from 160 - 175 deg. F. depending on the concentration.

If an engine is found operating below 150 deg. F. Steps should be taken to increase the temperature. The thermostats should be checked to see if they are closing. This can be done by removing the thermostat and checking to see if it is in a closed position at atmospheric temperature. If the engine is too lightly loaded, even with the thermostat closed, it is sometimes impossible to bring it up to temperature unless the radiator is partially blocked off. Commercial automatic shutters are available to control temperature under these conditions. If the engine overheats the thermostat may be stuck closed. This condition can be checked by removing the thermostat and applying heat, either flame or heated liquid, to see if it will open. The fan belt should be checked to see if it is properly tightened. The correctly tightened fan belt is just tight enough to keep from slipping. If these are in order, the water pump should be observed. Note the circulation by removing the radiator cap or opening a pet cock. If the system is clean, other causes for heating may be improper timing of the magneto or overloading the engine. The difference in the temperature of the water entering the radiator and leaving it after being cooled by the air furnished by the fan should not vary over 15 deg. F.

Gauges and Instruments

In adidtion to the oil pressure gauge, which is standard equipment, a thermometer should be available. A bayonet type is very desirable as it can be used in the oil filler cap for taking crankcase temperatures and can be punched through radiator hose, without causing a leak, for water temperatures. In addition a vacuum gauge should be available to determine the applied load. Engines should not operate continuously below five inches of vacuum with 8 or 9 more desirable. It is not wise, economically, to operate one above 10 or 11. Engines, of the type under discussion are designed to operate between 1000 and 1600 RPM for the most satisfactory service. Engines running too slowly will usually run too cool, unless overloaded. If overloaded the drive should be changed to allow the engine to operate at the proper speed and vacuum reading.

If a thermometer is not available the speed of the engine can be ascertained by counting the strokes of the pumping unit and multiplying by the ratio of the gear box. The result is the RPM of the input shaft of the unit. Next. measure the sheaves on the unit and the engine and compute the ratio of the drive. Multiply the ratio of the drive by the speed of the input shaft of the unit and the result will be the engine speed.

Another instrument which is helpful is the compression gauge. If loss of power is noted and the fuel adjustment, (to be discussed later), is correct, valve adjustment satisfactory, the cylinder compression should be checked by removing the spark plugs, turning off the ignition, and opening the throttle. Insert the gauge in No. 1 plug hole and turn the engine several times. Note the highest gauge reading while engine is being cranked. take a reading at each cylinder in the same manner. Analyze the readings. Readings will vary from one cylinder to another depending upon the cranking speeds, engine temperature, oil viscosity, compression ratios and general condition of the engine. However, the readings in any engine should be reasonably high (90 lbs. or more) and all cylinders should show uniform readings within approximately 15 lbs. If a variance over 15 lbs. is observed, repeat the performance of the low cylinders after a liberal amount of light oil is poured into the cylinder through the spark plug hole. If the second reading is considerably higher, the trouble is rings or pistons. If no appreciable difference is shown, then valve troube is likely.

Air Cleaners and Breathers

The supply of fuel, regardless of type, must be clean. To insure clean fuel mixtures in the carburetors, clean air must be provided. Engines are equipped with oil bath air cleaners which should be zealously serviced, especially in this sandy area. A few grains of sand can cause a great amount of damage. The oil bath air cleaner has an oil level mark and should be kept full to this level with a light weight oil. A fouled carburetor air cleaner reduces engine power, makes the exhaust black with unburned fuel, creates excessive carbon and will shorten the life of an engine. Under extreme conditions the air cleaner oil should be changed daily. However, experience will show how often cleaners, under certain conditions, should be changed, but they should be checked often and after each sand storm. If the oil is very thick or if 1/4 or more of the oil is displaced with sediment, replace the oil with SAE 20, or SAE 10 in cold weather. Be sure to wash the cleaner prior to filling with new oil.

Remove and clean the rocker arm cover breather caps when changing crankcase oil. Be sure to saturate the breather cap filter in oil after washing and prior to reinstalling.

Carburetion

Fuels most commonly used are natural and butane gas. Both use the same type carburetor which is very simple and once set, it is seldom necessary to adjust. With either fuel the most important item in the system is the low pressure regulator. Fuel should be supplied to this regulator at a pressure of 4-6 ounces and with pipe size of the same diameter as the inlet of the regulator. High pressure regulators are necessary to reduce the pressure from the original state to 4-6 ounces. If clean gas or butane is introduced into the low pressure regulator at the specified pressure, little trouble will be encountered. Dirty fuel or too high pressure will damage the diaphragms or valves in the regulator. An ounce gauge should be available for checking the pressure. It is not wise, as a rule, to leave this gauge on the regulator as vibration will quickly damage it.

Magneto Ignition

Since practically all pumping engines are magneto ignition, we will omit other types. Unless a magneto is operating in very dusty conditions, it requires no regular service beyond keeping it clean and dry. Under dirty operating conditions, it is advisable to remove the cap and seee that all carbon-brushes work freely and have some spring tension. Check the contact points and resurface with a fine stone if they are burned or pitted. Adjust points to .014-.016. This will vary somewhat with different magnetos.

Timing

To replace a magneto in the field the following timing procedure can be used: the engine must be turned over until the mag or fire mark on the flywheel is centered in the timing opening and number 1 piston is coming up on compression stroke. This is the point at which firing occurs when the engine is running and the impulses coupling is disengaged. Hence this is also the point at which the breaker contacts must just begin to separate when the magneto is rotated in the direction indicated by the arrow on the name plate.

When the Impulse coupling is engaged, as it will be when starting to time the magneto, it must be disengaged in order not to incorporate its lag angle in the timing procedure. The easiest way to do this is to turn the magneto impulse coupling backwards as needed to align the rotor tip with the terminal connecting to number one spark plug. Reverse rotation automatically disengages the impulse unit. With the breaker point cover open, it will be seen that the points just close as the rotor lines up with the terminal. Rotate the impulse coupling very slightly in the opposite (normal) direction to just open the points, hold the rotor from further turning, and insert the magneto in the engine so the drive gear meshes.

Final timing is done with the clamp screws finger tight. Here, either a timing light or cellophane may be used to determine the exact location where the points open. If cellophane is used, be extremely careful that a tiny fragment does not tear away and remain between the points. If a timing light is used, ample current will be available from a few flashlight cells. Clip one side of the circuit to the breaker points and the other side to the magneto housing for a ground. If excessive current is used for such a timing light, two things may happen. First, by grounding back through the primary coil, which has too much resistance to permit passage of a small current, erroneous results will be obtained. Secondly, passage of current through the primary wires may cause weakening of the magneto.

Whichever method is used to determine point opening, the remaining steps are the same. With the engine in firing position, tap the magneto with the hand enough to rotate it on the mounting flange. With careful tapping, one direction or another as needed, the exact point opening position is readily determined and the mounting screws may be given their final tension. Replace the breaker cover and install spark plug cables. It is recommended the magneto be taken to an authorized service station for reconditioning once a year.

Spark Plugs

The spark plugs should be inspected and cleaned regularly. Check gap with a feeler gauge and reset to .025"-.030" wide open. Replace plugs that have broken or cracked porcelain, and any spark plugs or cables that are oil soaked or frayed.

Governor

Most governor troubles are due to wear producing loose joints in operating rods and links, sticking joints, bent or deformed rods or dirt and rust accumulation above pivots, shafts, and connection. When any one of these conditions exists, the engine throttle may not open fully and the power will be low, or the engine may not pick up its load promptly because the governor lags. At other times surging or irregular operating will result. Adjusting the speed regulating screw will not correct any of these troubles, but will make them worse. The only remedy is to go through all the system of rods, levers, and connections taking up the play or replacing worn parts. Cleaning rust and dirt from shafts and connections, straightening any of the rods that may have become bent, and adjusting all connections so they operate freely and smoothly without any back lash or binding.

Valve Clearance Adjustment

Valve tappet clearance should be checked monthly if the engine is operating continuously. Make adjustments while the engine is cold. That is, atmospheric temperature.

Loose tappets not only cause hammering of parts but also cause the engine to lose power.

Tappet adjustment must be done right to avoid burning valves. Tappet clearance should not be less than the recommended setting. Too close tappet clearance will result in severe burning of the valve seats and faces due to the heat and pressure of combustion. To adjust the tappet clearance, remove the rocker arm covers.

Always loosen the rocker arm adjusting screw lock before attempting to turn the adjusting screw. Turn the rocker arm adjusting screw so a feeler gauge or the correct stock will slip snugly between the end of the valve stem and the rocker arm contact point. Tighten the adjusting screw lock nut and recheck the valve clearance. For correct tappet setting see an instruction manual. This setting is often found on the name plate of the engine.

The above procedure is for an overhead valve engine but the 'L' head is the same procedure except for location of parts, and 'L' head engines do not have rocker arms.

Clutch Power Takeoff

Most oil field pumping engines are equipped with a dry or friction type clutch. These clutches give very little trouble if properly lubricated and adjusted, but if allowed to become too loose will quickly burn out. The adjustment is very simple and instructions for this need not be given unless someone requests it. The proper adjustment is obtained when the clutch engages with a snap by pressure applied to the lever. Trouble is sometimes caused by running belts too tightly. The belts should be just tight enough not to slip.