Bulletin No. 149—CHARACTERISTICS OF ENGINE KNOCKS AND NOISES

A difficult problem which almost every automobile mechanic encounters every day is the correct diagnosis of engine knocks and noises.

Knocks and noises are generally due to excessive clearances between the various parts of the motor such as wrist pins, pistons, connecting rods, main bearings, valve gear, etc. The possibility of everyone of these items causing a knock presents a very confusing problem especially if one or more parts become loose and knock at the same time.

Sometimes knocks caused by different sources have the same sound or characteristic, and unless the mechanic has a long experience, he will easily be confused in diagnosing the trouble.

For example, noises due to loose wrist pins may often be called piston slap, and if this motor has a loose piston also it is possible that they will be believed to be the same.

It is a fact that each of these noises has a definite relation to engine speed and engine load and it is the purpose of this bulletin to point out the characteristic of each knock and its relation to engine speed and engine load.

Of course, it is understood that each individual case may present a different problem, and the correct diagnosis of the cause of a knock must be based on experience. The analysis given below will be a starting point for mechanics inexperienced in diagnosing causes of knocks and a reminder to those mechanics that have had long experience.

LOOSE WRIST PINS

The average loose wrist pin will show up at idling speed especially when the motor is hot. Generally, short circuiting of the spark plug will reduce the volume of the sound and cause the knock to become twice as fast as before the plug was shorted.

The reason that a wrist pin knock shows up at idling speed is due to the fact that cylinder pressures are much lower than at running speeds when the motor is loaded. The inertia of the piston is not counteracted and the piston overthrows or pitches, taking up the clearance between the wrist pin and the wrist pin bushing.

Shorting of the plug will reduce the pressure further, lessening the volume of sound and causing the piston to overthrow at each end of the stroke increasing the rapidity of the wrist pin knock.

Loose pin knocks will usually disappear with speed and with load even if the load is very light such as that as the cold gear oil in the transmission would cause. It is worse in a hot motor than in a cold one because the viscosity of the oil is lower providing less cushioning effect.

A loose wrist pin has about the same volume of sound as the average piston slap. In rare cases wrist pin noise may be heard when the car is floating along at about 30 miles per hour. The noise is brought about by easing off on the accelerator slightly. The sound will exist for a very short duration and is not often noticed.

Tightly fitted wrist pins are often the cause of a noise that did not occur beforehand. This is due to the pin drag tending to rock the piston, and usually disappears after a short running-in period. Break-in oil will usually help a condition of this sort. Tight pins are often the cause of the car owner's complaint that the noise is worse than before the car was worked on.

LOOSE CONNECTING RODS

Loose connecting rods will rarely make a noise when the engine is running idle, especially when the rods are pressure lubricated. Loose rods will usually not knock when the car is accelerated or when the engine is loaded. A connecting rod knock will usually show up when the car is running along on a level road at 30 to 40 miles per hour.

The noises can sometimes be brought about by running at an even rate of speed then gradually

Bulletin 149 (continued)

easing up on the accelerator. The knock occurs due to the fact that the inertia of the connecting rod and piston assembly overcomes the cylinder pressure for a short time, allowing a take-up in connecting rod bearing clearances.

Another method of detecting loose connecting rods is to race the engine with the car standing still and then allowing the motor to slow down to idling speeds. During the slowing down the connecting rods will clatter if they are loose. This has to be done carefully, however, because the pistons will be pitched, and if there is a weak one in the lot it is likely to break. This also applies to high speed road driving. The foot should never be removed from the accelerator suddenly when driving at high speeds.

A good method of testing makes use of a secondary switch which will enable any spark plug to be shorted while the car is running on the road. Drive the car on a level road at a floating speed of about 30 miles per hour. A loose rod will ordinarily show up and will short out, which, very often, makes it easier to detect a loose connecting rod than it is when listening near the motor.

A knock due to loose rod is sometimes muffled out by the motor fan.

The sound of a rod knock is a medium heavy knock. It differs from a piston slap or a pin knock in that it is not as sharp but is much heavier. It is not as heavy as a main bearing.

MAIN BEARINGS

A main bearing knocks hardest with increased load and speed. A main bearing may knock for a second or so on acceleration or when the motor is started cold before oil gets to the bearings. Loose main bearings can be shorted out by shorting the plug next to it if it is an end bearing. And if it is an intermediary bearing it can be shorted out by shorting the plug on each side of it. A main bearing knock is a very heavy knock.

PISTON SLAP

Piston slap or knock is due to the rocking of the piston from one side of the cylinder to the other during the beginning of the power stroke. It is affected by cylinder wear, piston wear, piston skirt collapse and the position of the wrist pin. It is also affected by the compression ratio, engine temperature and load, and becomes worse with an increase in these factors. Piston slap is not always heard when the motor idles but is brought out when the motor is accelerated with a load and when the motor attains a steady speed the slap will gradually disappear. This is due to the heavier loading at low speeds during acceleration. At high speeds, when the motor is loaded piston slap may not be present due to the fact that the time for the piston to slap is reduced along with the volume of the sound, the piston contacting the cylinder wall with a glancing blow. Piston slap will always short out.

Piston slap will show up at idling speeds only if the motor is subject to a load from thick engine oil or heavy gear oil in the transmission and the pistons are very loose. A good way to test for piston slap is to load the engine against the clutch in high gear with the brakes on.

Cylinder location of slap can be determined by shorting the plugs when the motor is loaded. When shorted, the slap will stop and when the plug is let fire again the knock will come back with a loud clank.

Other things that affect piston slap are connecting rod alignment, piston skirt design, oil film on the cylinder walls and ignition timing.

A cocked rod will destroy the oil suction seal between the piston and the cylinder wall. This oil seal or suction seal is useful in retarding the travel of the piston from one side of the cylinder to the other side, and allows only a glancing blow instead of a square blow.

Ramco piston rings are an excellent means of eliminating piston slap in that the lateral travel of the piston is resisted, preventing knock. When piston skirts of aluminum alloy pistons are collapsed, knocking that would ordinarily occur can be prevented by installing Ramco skirt expanders.

WHY THEY PUMP OIL

By CHAS. A. MARIEN

Research Engineer for Ramsey Accessories Manufacturing Corporation

St. Louis, Mo.

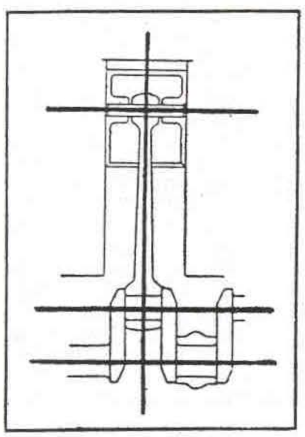
BEFORE taking up the various causes of oil pumping or excessive use of oil, it might not be amiss to point out the fact that a small amount of oil passing by the rings into the combustion chamber, actually develops into excessive consumption of oil, and it is therefore this small amount of oil, in excess of the normal consumption, that we are really called upon to control. In fact, excessive oil consumption is a sensitive proposition, and a very small amount of oil passing by the piston with each stroke will cause excessive consumption. The amount of oil that causes oil consumption is in many cases very minute, and becomes a sensitive problem to control.

For example, if we were to drive, we will say an ordinary six-cylinder car for a distance of about 300 miles, we would get 4,838,400 piston strokes, and if one drop of oil were passed into the combustion chamber at every suction stroke of the pistons, the oil consumption would amount to 21 gallons for the trip.

The late development of the high speed, high compression motor has brought about new problems for the control of excessive oil consumption, due to the fact that the pistons reciprocate at a very high rate of speed, and in their down stroke, the oil piles up against the edge of the piston ring and tends to collapse the ring, allowing the oil to pass by the face of the ring.

A number of manufacturers, recently, have designed their pistons to take four ⅛-inch rings, instead of three $\frac{3}{16}$-inch rings, using two oil rings and two compression rings. It seems evident that, from their experience, it was necessary to do this in order to control the excessive oil consumption. The narrower rings were substituted for the wider ones, for the reason that the narrow edge will wipe the oil easier than the wide edge. In this connection it also seems evident that a more equal radial pressure will be necessary, than that which we have had in the past.

ALIGNMENT



Proper alignment is always the secret of a perfect job.

One of the first fundamental conditions that we must have in a motor to prevent the excessive use of oil is perfect alignment and proper clearance throughout. Starting at the top of the motor, we must have piston rings which in themselves are perfectly machined—meaning that they must be round and the sides must be flat and square with the face. The pistons must be machined perfectly round, the piston grooves parallel to a plane perpendicular to the axis of the piston, and the sides of the piston grooves or ring lands must be perfectly flat and true. Then, the next and all-important item is the pin-hole, which must be perfectly square with the body of the piston.

Next, the cylinder bores must be straight and round, and in vertical alignment with the crankshaft. In cases where the crankcase is not integral with the cylinder block, it is important that the crankcase, cylinder base and cylinder block base must also be in perfect alignment with the cylinder bores and crankshaft. The pistons, pins and rings and connecting rods, being the operating component part of the motor, must all be in **PERFECT ALIGNMENT** with the cylinder bores and crankshaft. With proper alignment, and when proper clearances have been allowed, the motor will operate perfectly without friction and will very seldom give any trouble on account of excessive consumption of oil.

In presenting most of the important causes of oil pumping, we shall not take the time to point out all of the corrections necessary to overcome these causes, because it is (or should be) very apparent to every one in the automotive trade as to just what is to be done, once the cause of the condition has been established.

CYLINDERS

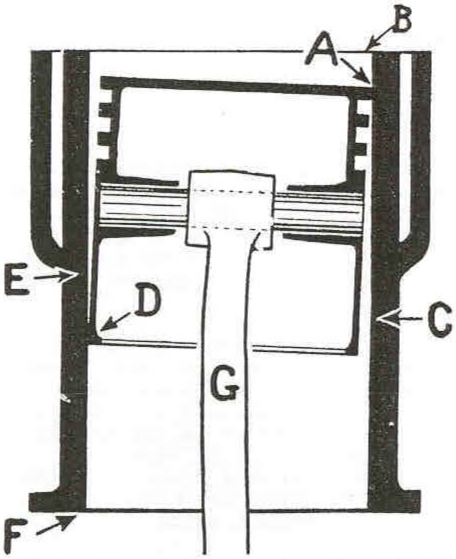
A great deal of oil pumping and excessive consumption of oil is due directly to the condition of the cylinder bores—not only in worn cylinders, but in new and reconditioned cylinders as well. In the case of old cylinders, we have a tapered and out-of-round cylinder, due to wear and cylinders with depressions worn into their sides, caused by pistons slapping. In the other case, we have a cylinder with proper alignment and dimensions when cool, but which assumes a distorted condition after becoming heated.

Experiments have shown that new and reconditioned cylinders distort on account of heat as much as .0025-inch at the upper end, causing a lateral or oscillating movement of the piston ring. It is obvious, therefore, when the rapid reciprocation of the piston is considered, that this oscillating movement of the ring will tend to destroy the piston ring itself, as well as wear the piston grooves and cylinder walls. It is then only a matter of time, or miles, when excessive oil consumption will set in. This is not unusual on reconditioned motors.

PISTONS

A great many pistons are improperly designed. Some pistons will not properly control the oil even though the pistons themselves be fitted with the right clearance, properly machined and the rings perfectly fitted. As an example, I was recently called in on a job that had been reconditioned, and upon examination I found that the cylinder bores were perfect, pistons properly fitted and seated, and still this engine was consuming an excessive amount of oil at high speeds. This particular design of piston had two rings at the top and one at the skirt. The skirt groove was drilled with large drain holes and was fitted with a double-vent oil ring, but the motor, despite this design, used an excessive amount of oil. The reason why the oil was getting by this piston was that the lower ring at the top of the piston, in its rapid reciprocation, piled up the oil and forced it by the face of the ring. By simply beveling the lower edge of the ring land and drilling a few relief holes, we corrected the excessive consumption.

WHY THEY PUMP OIL—*Continued*



Exaggerated example of a bent connecting rod, showing extreme cylinder wear is caused at A and D. Oil pockets are at C and E. Besides an annoying knock, a cylinder in this condition will soon pump oil.

I have also found other defects in piston design. If the piston grooves are snaky or tapered, either through improper machining or abnormal wear, this will cause an imperfect seat between the piston ring and the ring land, which will allow the oil to travel behind the piston ring and upward into the combustion chamber, through a pumping action. I have also found in many cases that if the bottom edge of the pistons was rounded or tapered, this would also cause an oil pumping condition.

In grinding a piston, the abrasive wheel should not be allowed to run off the edge of the piston. If it is allowed to run off, it will, in its return, grind the lower edge of the piston several thousandths smaller than the body of the piston, for a distance of a quarter to a half inch. This will allow the pistons to ride over the oil and allow the oil to work up. Consequently, the rings will not control the oil.

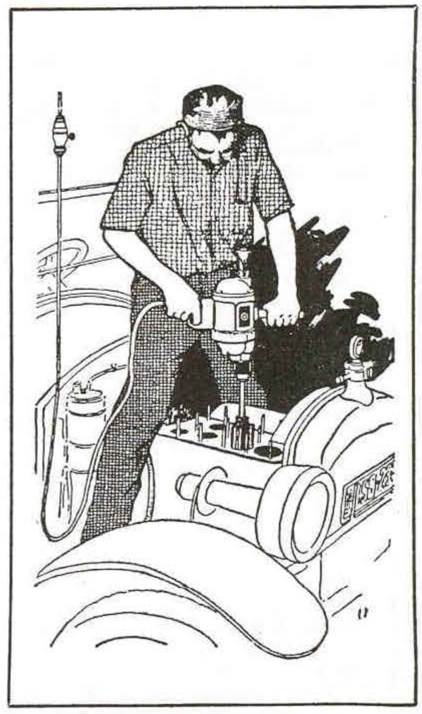
It is unfortunate that because of the expansion at the top of the piston, we have to allow a great deal of ring-land clearance and especially so in aluminum alloy pistons, the land clearance in alloy pistons being several times as much as in cast iron pistons. This, of course, does not give the piston its proper support in its entire length, particularly depending upon the design of the piston, and very soon they begin to teeter or rock in the cylinders. This causes rapid wear to the pistons, cylinder walls and piston rings, creating depressions in the cylinder walls, "barrelled-faced" piston rings and excessive clearances, which in turn bring about a condition where we have a greater film of oil to control, and consequently, excessive consumption of oil.

Of course, we all understand that pistons should be fitted with not too much clearance, as too much clearance between pistons and cylinder walls, either because of wear or too loose a fit, will place a burden on the rings. When the rings are overburdened there is likely to be lack of control on their part, and thus excessive consumption of oil. Practically all pistons are "relieved" to prevent scoring, due to unequal expansion of the pistons. In many cases engines pump oil or use an excessive amount of it, due to oil accumulating in the relieved portion of the piston. This condition has lately been materially corrected by drilling drain holes at the bottom of the relief.

Very often oil pumping is caused by the pistons being out of alignment with the crankshaft and cylinder bores, either through inaccurate machining of the pistons, or twisted and out-of-line connecting rods. These conditions allow the oil to "pocket" on one side of the piston and at the same time throwing the face of the rings out of contact with the cylinder wall, which will rapidly wear the cylinder and "barrel-face" the piston rings.

PISTON RINGS

Piston rings are the main factor for controlling oil. Therefore if we have snaky piston rings, or rings that are out-of-round, not flat and face square to each other, rings of insufficient tension or rings of unequal radial wall tension, either through wear or inaccurate machining, we are likely to have excessive oil consumption. Any one of these factors may be the cause of "oil pumping."


Sometimes a reconditioned job will turn out to be an oil-pumper. Read this article and find out the reasons why.

Rings which are too tight in the piston ring grooves are also responsible for oil pumping, for the reason that if a ring does not have free radial movement in the piston groove, it will not follow the cylinder wall, due to its rapid reciprocation and consequently let the oil pass by the face of the rings.

When we get too much clearance between the piston and cylinder, it is only natural that we carry a greater film of oil. Then when the explosion takes place and we drive the piston against the wall, we create an "oil-pressure" and the rings not only have to withhold this oil pressure, but they also have to scrape down this excess amount of oil. Therefore if the rings do not have sufficient tension, and there is not sufficient relief for the excessive oil, the oil will not only pass by, underneath the rings, but the rings will also collapse and let the oil by the face of the ring.

The vented and scraper types of oil rings that are now so universally used, together with drain holes drilled in the ring groove back of the oil ring, tend to correct this trouble, proprovided, of course, that the condition of the motor is not worn beyond its abnormal clearances.

EXCESSIVE LUBRICATION

One of the major and underlying causes of oil pumping is the source of lubrication which takes place in the crankcase, or by force-feed lubrication through the bearings. I would say that in about one-half of the cases reported as oil pumpers, the trouble originates BELOW the cylinders. We all know that if we take an engine that is functioning properly, not using an excessive amount of oil, and then over-fill the crankcase, thus splashing too much oil into the cylinders, that we immediately cause the engine to throw out clouds of smoke. This proves that we cannot control the oil beyond a certain point with piston rings, unless we would give the piston ring too much tension, which would in turn give us other troubles, such as lack of acceleration, lack of speed, excessive cylinder wear and overheating.

WHY THEY PUMP OIL—*Continued*

Since there is a limit to the amount of tension that we can exert in the piston ring, we must control the amount of oil which is carried through the bearings from the crankcase into the cylinders. Therefore, it is obvious that a great many oil pumpers are directly caused by too high an oil level in the crankcase, as in the older motors and too much pressure in the later type of motors. If not too much pressure, then leaky bearings, due to improper fitting, faulty oil grooves and too much clearance in the main or connecting rod bearings, either due to poor fitting or wear, which causes the oil to spurt up on to the cylinder walls.

Then again, many cases reported as high oil consumers are really not oil pumpers, but after inspection, are revealed to be because of leaks in the crankcase, rear or front main bearings, and NOT through the combustion chamber. It often happens that these leaks do not show up until higher speeds are reached, or the car is driven on the road, when they cannot be readily detected.

WORN BEARINGS

A great deal of oil pumping in force-feed lubricated motors is caused by worn connecting rod bearings that have been taken up and improperly fitted. When a connecting rod is worn beyond a certain clearance, the oil is forced throguh the bearing in excessive quantity and is thrown into the cylinder. "Taking up" the connecting rods when in this condition does not always remedy the trouble, since you only take up the clearance endwise, still leaving an excessive clearance on both sides, or at the bolt ends of the rod. Improper shimming, or worn and broken shims are also very often the cause of excessive oil consumption.

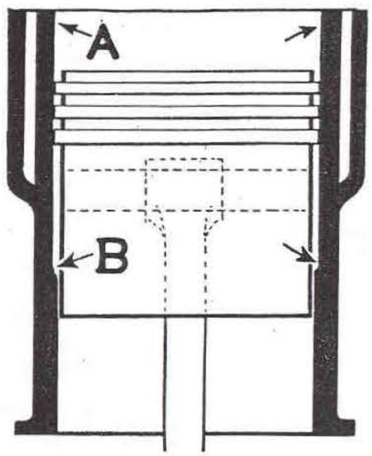
Another cause of oil pumping is seen in insufficient ventilation in the crankcase, causing an excessive pressure, which forces the oil through the bearings and also past the piston rings. We have found in many cases an accumulation of sediment in the crankcase, such as road dust, iron cuttings and other abrasives that were not thoroughly cleaned out after the engines had been reconditioned. When the crankcase is not cleaned out often enough, this heavy sludge of oil and dirt will rapidly wear down the piston clearances and rings, and clog in between the rings and lands, thus setting up a condition that allows the oil to pass very rapidly by the piston rings.

We all know that in the suction stroke we create a vacuum in the combustion chamber and if we do not have the proper seal around the piston rings, this vacuum will naturally assist in pulling the oil by the rings. Improper timing is another cause, especially in those cases where the timing is off from two to three teeth. It is plain to see that this condition will cause imperfect combustion as well as creating greater vacuum, which in turn will pull the oil by the piston rings.

Leaky valves, either due to the valves themselves, or the seats, will cause an accumulation of oil in the combustion chamber and consequently foul the spark plugs, and at the same time, if the motor is allowed to operate in this condition, it will carbonize the piston rings and cause additional trouble.

MOTOR TUNE-UP

Imperfect carburetion, especially in heavy mixtures, will cause fouled spark plugs and also dilute the oil on the cylinder walls, breaking down the oil seal between the piston rings and grooves and cause further dilution in the crankcase. The oil then becomes thin and loses its viscosity and in this condition it will easily get by the piston rings and into the combustion chamber. This condition will also cause a leakage in compression by the piston rings, burn the oil (turning it into carbon) and lock the piston rings.



Illustrating wear in wall extending throughout "ring travel". Oil pumping can be caused by the oil being pocketed at B and forced up behind the rings into the combustion chamber A, on the downstroke of the piston. Reconditioning of course, is the remedy in this case.

Ignition is another cause for oil pumping. It doesn't in the first instance cause excessive consumption of oil, but if the ignition is poor, and as a result we do not get the proper expansion of gases, it will not burn up the normal passage of oil. Continued running of the motor in this condition will cause an accumulation of carbon, which will get in between the piston rings and grooves, breaking down the seal, and will most likely cause crankcase dilution, the breaking down of the oil and finally result in oil pumping.

In past years we have had a great deal more trouble with fouled spark plugs than we have at the present time. This fouling of spark plugs in slight oil pumpers has been greatly overcome by the present day design of spark plugs. We now have what are called "hot" plugs and "cold" plugs. In cases where a slight oil pumper would cause a spark plug to foul, due to the plug running too cool, this condition has been overcome by designing a spark plug that will operate at higher temperatures, thus consuming a slight film of oil, rather than accumulating carbon and missing fire.

If too light oil is used, or oil of poor quality which does not have the proper viscosity and flash test, the oil will naturally break down and pass by the piston rings, resulting in an imperfect seal. In turn, the hot gasses would pass by the piston rings and carbonize the oil, thus causing a condition of oil pumping, to say nothing of the other bad effects such as premature dilution, etc.

Engines that are operated under dirty or sandy road conditions will very rapidly develop into excessive oil users, due generally to rapid wear. We know of many cases where new or reconditioned motors operated under these conditions for as short a period as three months, which then were bothered with all sorts of oil troubles. This can be prevented, or minimized, of course, by the use of oil filters, air cleaners and other similar devices.

Hints on Locating Trouble

Many times it is just some little thing that may cause a motor to overheat, knock, pump oil, or lose compression. Below we list a number of these causes. Check against this list the next time you have a job that's giving you trouble from one of these causes.

28 CAUSES OF OVERHEATED MOTORS

Rings fitted too tight.
Thick rings in shallow grooves.
Clogged radiator.
Clogged hose and connections.
Clogged cylinder block and passages with sludge scale and rust.
Clogged muffler and pipes.
Tight pistons.
Tight piston pins.
Tight main or connecting rod bearings.
Faulty ignition.
Ignition timing late.
Valve timing incorrect.
Defective condenser.
Defective coil.
Burnt ignition points.
Defective spark plugs.
Leak in high tension wire assembly.
Improper lubrication.
Lack of lubrication.
Improper carburetion.
Too much carbon in combustion chamber.
Loose, broken or slipping fan belt.
Air passages of radiator stopped with dirt or insects.
Stuck automatic spark control.
Faulty Thermostat in motor or shutter.
Pump spiller slipping on shaft.
Dragging brakes.
Low water level due to leakage.

78 CAUSES OF EXCESSIVE OIL CONSUMPTION

Following is a list of factors which cause excessive oil consumption. Either one or a combination of several can be the real cause for the excessive use of oil.

Cylinder bores worn or refinished out of alignment.
Cylinder block out of alignment with crank-case.
Piston and connecting rod assembly out of alignment.
Main bearings and crank-shaft out of alignment.
Poor workmansip in assembling motor.
Excessive clearance between piston and cylinder bore due to wear, or improper fitting.
Excessive clearance in main and connecting rod bearings due to wear, or improper fitting.
Bores excessively worn, tapered, or out-of-round.
Ledge at top and bottom of ring travel.
Wavy cylinder bores caused by improper cylinder reconditioning, heat distortion, or unusual wear.
Bellied cylinders.
Depressions in cylinder walls caused by rocking pistons, piston vibration, or collapsed pistons.
Scored cylinder bores.
Rough finish in cylinder bores causing rapid wear of rings.
Poorly designed pistons.
Pistons improperly finished or fitted.
Snaky piston ring grooves.
Piston pin hole out of alignment.
Badly worn pistons.
Collapsed pistons.
Ring grooves worn overwidth or flared.
Pistons distorted or badly out-of-round.
Insufficient number of drain holes in oil ring grooves.
Drain holes in oil ring grooves too small.
Lower land of oil ring groove not beveled.
Lack of drain holes in bevel or chamfer.
Poorly designed rings.
Cheaply constructed rings.
Snaky rings.
Improper seating of rings in groove.
Insufficient clearance at ring gap.
Rings with insufficient tension causing ring flutter.
Out-of-round rings.
Warped or twisted rings.
Rings fitted too tight in grooves.
Wrong size rings.
Unequalized wall pressure of rings.
Insufficient ventilation in oil rings, slots too narrow.
Slots in oil rings clogged with carbon.
Excessively worn piston pins.
Wrong type pin.
Bent or twisted rods.
Loose or elliptical shaped connecting rod bearings.
Improper shimming, or worn and broken shims.
Rifled connecting rods with loose piston pins, or piston pins installed upside down, or wrong pin.
Scored connecting rod bearings; burnt or cracked babbitt.
Spurt holes in worn connecting rods.
Excessively worn main bearings.
Oil leaking past front and rear main bearings.
Scored or burnt main bearings.
Too much oil thrown out of main and connecting rod bearings which cannot be controlled by piston rings.
Bent crank-shaft.
Excessively worn crank-shaft.
Journals scored and out-of-round.
Crank-case gasket leaks.
Cracked crank-case.
Worn main bearing oil retaining washers worn.
Too high an oil level in crank-case when splash system is used.
Broken oil pipe in crank-case spraying oil into cylinder bores.
Breather pipe too small or clogged.
No baffle in breather pipe.
Worn intake valve stems and guides.
Leaky or burnt valves.
Improperly timed valves; intake valve timed too late.
Improper tappet adjustment.
Ignition timing incorrect.
Defective ignition parts, or improper adjustment.
Defective spark plugs.
Faulty carburetion.
Defective vacuum tank.
Leaky intake manifold or manifold gaskets.
Poor grade of oil.
Thin oil.
Dirty oil.
Abrasive in crank-case.
Over-heated engine thinning oil.
Oil pressure too high.
Clogged oil filter.

35 CAUSES OF MOTOR KNOCK OR SLAP

Bent connecting rod.
Twisted connecting rod.
Worn or burnt connecting rod bearing.
Broken connecting rod bolt.
Connecting rod bolts loose.
Connecting rod piston pin clamp bolt loose.
Piston pin bushing worn.
Piston pin worn.
Piston pin loose in piston one side or both.
Rod too close to pin boss.
Piston pin out of center.
Loose piston.
Loose strut.
Cracked piston.
Piston badly out of round.
Piston scored.
Piston or ring striking ledge at end of ring travel top or bottom.
Incorrect alignment of piston, pin and rod assembly.
Piston striking cylinder head or gasket.
Worn cylinder walls and pistons; too much clearance between cylinder bores and pistons.
Slotted side of piston installed wrong side.
Loose main bearing.
Broken or loose main bearing stud.
Burnt or crack main bearing.
Bent crank-shaft.
Too much crank-shaft end play.
Loose flywheel.
Cracked or loose bearing supports.
Loose or worn timing gears or chains.
Loose or worn cam-shaft bearing.
Loose valve push rods, tappets, tappet guides, valve guides, rocker arm bushings, rocker arm shafts, bent valves, etc.
Flat or worn cams.
Flat or worn cam roller and pins.
Loose or worn clutch parts.
Loose vibration dampener.

51 CAUSES OF COMPRESSION LOSS

Ring grooves worn over width.
Ring lands warped or worn uneven.
Ring lands broken.
Grooves too deep, heavier expanders needed.
Oil holes drilled into second groove from top.
Piston ring grooves out-of-line with body of piston.
Piston pin hole out of alignment.
Dirt and grit around piston and piston rings when assembled causing ring face to be destroyed very rapidly.
Hole in top of piston.
Cracked piston head.
Piston cracked or cut through at bottom of ring groove.
Cylinder head gasket blown out.
Rings undersize.
Standard rings in oversize bores.
Wrong size rings.
Lack of inner ring tension.
Inner rings left out.
Badly worn cylinder walls.
Cylinders bored or honed out of line.
Improper finish in bore.
Top ring striking shoulder in cylinder, either at top or bottom of ring groove.
Badly worn pistons, barrel shaped.
Distortion of motor block caused by heat. Some motors blow-by badly after continuous running at high speed or heavy loads.
Poor oil which does not hold its viscosity at high temperatures.
Imperfect oil seal.
Top rings running dry due to skirt rings (and rings below pin) holding down the oil.
Top rings running dry due to gasoline dilution, caused by imperfect carburization.
Rings badly worn.
Rings weak at the gap ends.
Defective machining of rings.
Rings out-of-round, out-of-square, out-of-flat, or insufficient tension.
Rings frozen into ring grooves.
Insufficient ring gap clearings causing buckling of ring and breaking of gap ends.
Too much gap clearance.
Running with the choker partly closed.
Insufficient preheating of mixture after leaving carburetor.
Surplus gasoline going into the intake manifold caused by defective vacuum tank.
Connecting rods out of alignment.
Bent connecting rods.
Leaky valves and valve seats.
Burned valves and seats.
Badly worn valves and valve seats.
Cracked valve seats.
Badly burned valve stems.
Excessive wear in valve guides.
Insufficient valve tappet clearance.
Valve grinding compound left in valve chambers causing rapid wear to piston rings, pistons and cylinders.
Dirty crank-case causing rapid destruction of ring faces.
Abrasive left in cylinders.
Cracked cylinder head.
Broken valve spring.