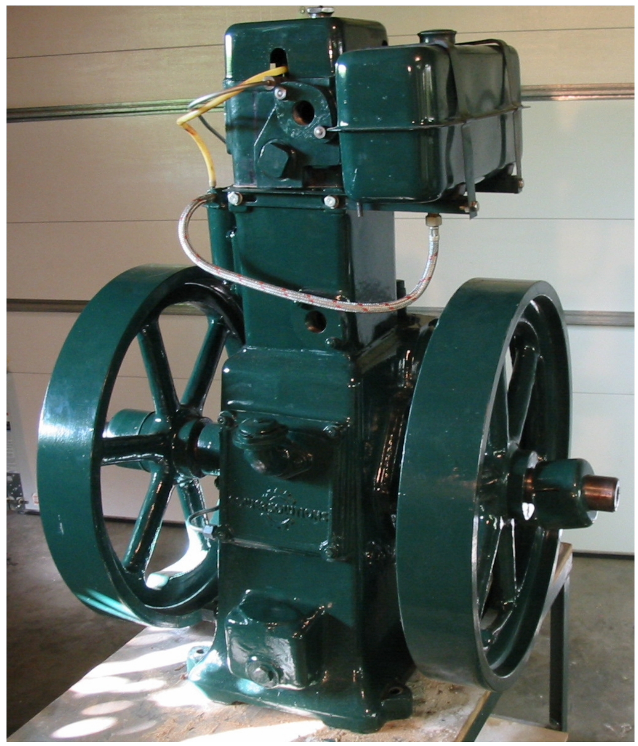
Inspection and Assembly of a Power Solutions 6-1 Lister-Type Diesel Kit Engine, Part I

The Beta Test Engine



In 2005 I purchased an Ashwamegh 6-1 from George Breckenridge at Utterpower.com. As soon as I unpacked it from its crate I heeded the advice on the Utterpower website and immediately tore it down to nuts and bolts and stripped the paint off and reassembled it. With so few parts, the task took very little time and I savored every moment.

As I worked, I took photographs and wrote some brief notes about what I saw and periodically e-mailed them to George. I hoped that my observations might be of some use to him or another customer. They evidently were because sometime later George contacted me and said he and business partner Joel Koch were wondering whether I'd be interested in documenting the receipt and assembly of a 6-1 kit engine they were considering importing. George explained that they had concerns about the quality of the parts and assembly and possible damage accrued during the initial run-in of the assembled engines they had been importing. They hoped that by importing the engine in subassemblies, intended to be assembled by serious Do-it Yourselfers (DIYers) some of those problems could be avoided. I agreed to be a sort of Beta-Tester for the concept. My task was to receive, unpack, examine, assemble and test run a 6-1 kit engine, and to keep track of the approximate amount of time each major step in the assembly required.

Following is what began as my initial e-mailed report to George and Joel. I expected that my reports would be for their eyes only, but to his credit, George posted them on the Utterpower website in their raw, unedited form, misspellings and all. Any problems that I noted appeared on the website without alteration, and at no time did either George or Joel ask me to give anything other than my honest impressions of what I saw as I assembled the engine to its working configuration. However, because of the peculiarities of the rather primitive website software that was used at Utterpower.com in those days, incompatibilities arose as the software was upgraded which caused most of the photos to disappear from the Beta Test articles and rendered them useless.

I decided that I ought to spend some time and revise and expand my original account and bring it up to date with some of the information I have learned over the last 9 years of owning two 6-1 Listeroids. And in instances where I made errors I have corrected them.

Following is my updated account of assembling and running a PowerSolutions 6-1 Lister-type kit engine. I hope the time I've spent on this project can be useful to someone, and I would like to thank George and Joel for their faith in me and their continued friendship, which I value very much.

-- QuinnF January 10, 2015

Introduction

There is a pervasive misunderstanding among people who are new to Lister engine clones about how the engines are made. It stems from the erroneous presumption that the engines are manufactured in the same way that engines are manufactured in the West.

U.S. automakers are huge conglomerates composed of individual corporations whose output is entirely dedicated to supplying their corporate overlord (GM or Ford, for example). In the early days of the last century, before economics professors taught their students about corporate management strategies, Henry Ford became frustrated by his inability to control the costs of inventory, raw materials and manufactured components which were sourced from individual suppliers. He realized his company was at the mercy of any of a number of firms, each of whom could unilaterally raise prices or halt his production by labor actions. So he took his cue from the steel baron, Andrew Carnegie, and instituted a high degree of vertical integration into the structure of his company. By the 1920s, Ford owned coal and iron ore mines, blast furnaces, steel mills, timberlands, rubber plantations, a railroad, freighters, sawmills, a glassworks, and more. Capping it all was a giant factory at River Rouge, Michigan, which manufactured parts and assembled the cars.

A manufacturing company can gain many of the benefits of vertical integration without the expense and management hassles of full ownership by engaging in lateral or horizontal integration. Consider Toyota, which has earned a reputation for good management in the same way that General Motors has not. Toyota rigorously evaluates its suppliers for quality and financial health, and then spends time and money to ensure their efficiency and survival, sometimes taking minority ownership stakes in order to exert some level of control over them. That allows the Toyota to continue to do what they do best (building cars) without taking over complete control of a company whose specialty, for example manufacturing auto glass, lies far outside the parent comany's core competency.

In the 1980s, when Toyota chose Johnson Controls to supply seats, it pressured the supplier to refrain from expanding its facility; for fear that the additional cost would harm Johnson's profits and effectiveness. Instead, Toyota's engineers worked with Johnson to streamline production, rearrange the factory floor, and cut inventories, ultimately showing that expansion wasn't needed after all.

Contrast Ford's strategy of vertical integration and Toyota's innovative twist on horizontal integration with that of, for example, a major appliance manufacturer, one that makes refrigerators. Though the refrigerator might say "GE" on the nametag, it could be powered by a Tecumseh or Copeland condensing unit, controlled by a Johnson Controls thermostat, a Danfoss thermostatic expansion valve and a Parker refrigerant drier. And the refrigerant itself may be supplied by DuPont or some other company. So the appliance manufacturer is really *an assembler* of parts made by several individual suppliers.

Like the appliance maker, Indian engine manufacturers are really engine assemblers, or erectors, to use the British/Indian term. Just as refrigerators are assembled from components made by different manufacturers, Indian Lister clone engines are assembled from parts available from a limited number of suppliers. Major components such as the engine block, cylinders, flywheels, head castings, pistons, connecting rods, etc. are available from only one or a few manufacturers. In most cases the only difference between brands is who assembles the engine, the grade of parts that are purchased from the suppliers, and the care with which the engine is assembled. Some shops assemble more than one "brand" of engine in the same workspace.

In several cases it is known that the only material difference between brands of Indian Lister clone engines is the name cast into the crankcase access plate.

Welcome to Rajkot

Just as with refrigerators , Indian engines are assembled by different job shops from parts sourced locally from foundries in and around the area of Rajkot, an industrial city in Gujarat province on the Northwest coast of India.

Rajkot lies in a region of Gujarat which (A on the map to right) specializes in foundry work and machining. The industry grew with the arrival of craftsmen from Pakistan after India was partitioned in 1947. Since then the industry has flourished and developed to integrate small manufacturers to manufacture parts for assembly by larger ones.

There are hundreds of foundries in the area which produce gray iron castings predominantly for the diesel engine industry. The infamous shipbreaking region along the beaches of Alang , 200 km to the southeast (B on the map on the next page), furnishes Rajkot with scrap metals. Only 2% of the foundries export

castings, which are used mainly in electric motors and the automobile industry. The majority of the industrial output of the area serves local and regional customers.

The slow speed Lister engines were brought to India during the years of British colonial rule, sometime in the 1930s. The Lister engines were mainly used to pump water and for other agricultural tasks and they became very popular because they could be run continuously under rather primitive conditions and they were not difficult to keep running. However, in 1947 the British suddenly left India (some maintain that they were kicked out). The new Indian Government and the public were unwilling to maintain ties with any British company or its products and most of the merchandise which had been imported from England was suddenly banned. However the need to keep their Lister engines running was so great that local people started manufacturing parts to replace the old worn out ones. Eventually entire engines were assembled from locally made parts. By the early 1960s entire Lister-type engines were being made from indigenous parts.

Packaging and Shipping

The components and crankcase/cylinder subassembly arrived at the ABF freight yard in separate wooden crates which had been strapped together with the spare parts kit on a 4' x 4' wooden pallet for transport. The straps holding the heavy components to the pallet passed over the spares kit, which were packaged in chipboard outer cartons with Styrofoam liners. A careless forklift handler could have torqued the package enough to crush the gas tank contained in one of the chipboard boxes. Since they are lightweight, I wonder if it would be worthwhile to ship them separately.

The forklift driver at the ABF Freight dock kept commenting about how heavy such a small crate was. I told him it contained diesel engine parts and that seemed to make sense to him. I tied the load in place to the lumber rack on my pickup with every sailor knot I knew, but as I drove home the crates slid around on the slippery bed liner, so I took corners carefully. It seemed no matter how I lash stuff down, heavy items slide on the plastic bed liner. However, that makes getting the crate out the back onto the tailgate that much easier.

I cut the nails holding the crates together with my sawzall and was impressed by the packaging job. The engine was sealed in a saffron (Curry?)-yellow plastic bag with a bag of silica desiccant hung from the governor linkage.

The parts inside stayed very clean that way. And the yellowish "curry dust" insecticidal powder that was everywhere inside the crate stayed in the crate where it belonged, and not on the engine.

The Flywheels

I opened the second crate which contained the flywheels and bar-curled one flywheel out of its box by hand, feeling very much The Man, because I could do that. Then when I got halfway across the garage it suddenly dawned on me that that nobody was watching, so what was I trying to prove? I'm not bagging groceries after school anymore, nonchalantly grabbing 50 pound sacks of Morton rock salt in each hand and carrying them out to a customer's car while my coworkers stare at me in rapt awe and admiration. (Testosterone is a mixed blessing. It makes you feel invincible, but it also makes you do stupid things.) So I set the flywheel down gently and rolled it the rest of the way to the workbench, and lifted the second flywheel out of the crate with a chain hoist.

The flywheels each have two drilled holes 5/8" diameter in the web, indicating that they may have been balanced. The holes were drilled in different locations on the web of each flywheel.

Unlike the flywheels on my Ashwamegh 6/1, these flywheels were drilled in the web supporting the rim, and not into the rim itself. Drilling the web to be preferred because the rim of the flywheel is already under considerable tension which was induced while the rough casting cooled. Tension is increased further while turning at speed. Any removal of metal from the rim weakens the flywheel and invites failure. There are enough surprises in Indian castings without making more of them. If metal must be removed to achieve balance, and I don't believe that should be done, it should be removed from the web and not from the rim. A flywheel can more easily be balanced by adding lead weights to the rim without removing metal and weakening it.

Engine Crankcase and Cylinder Assembly

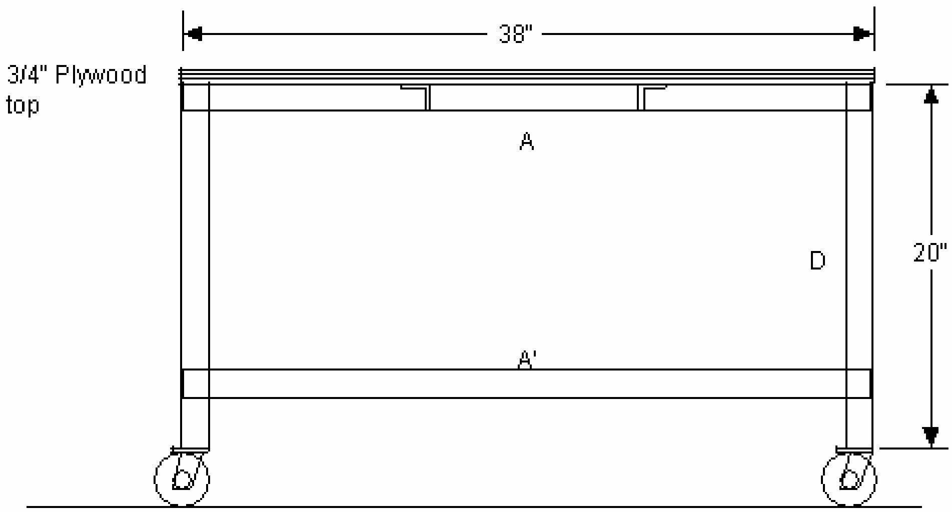
Next step was to hoist the block out of its crate. Doubled nuts on the base hold-down bolts made for easy removal. My other engine was bolted to the pallet and I had to reach under the top deck of the pallet with a wrench in order to loosen the nut and lockwasher to free the mounting bolt. By placing the hold-down bolts upward from beneath the pallet deck, doubled nuts provide better security for the engine, while allowing for easier removal.

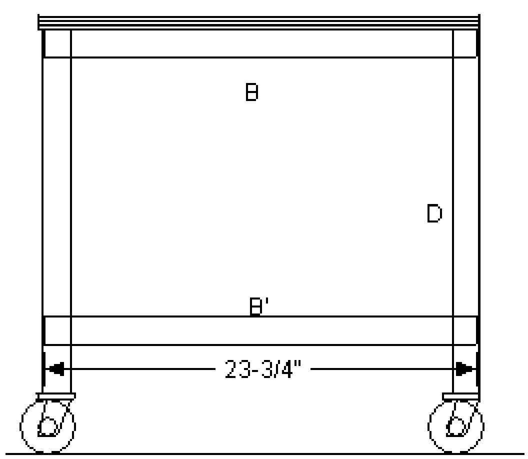
I kept noticing little things that, by themselves, don't mean much, but when taken together they give one an impression of the overall quality of the engine. The nuts, studs and bolts used on this engine are of much better quality than the ones that were used on my other engine, which might have been made in-house by the engine assembler.

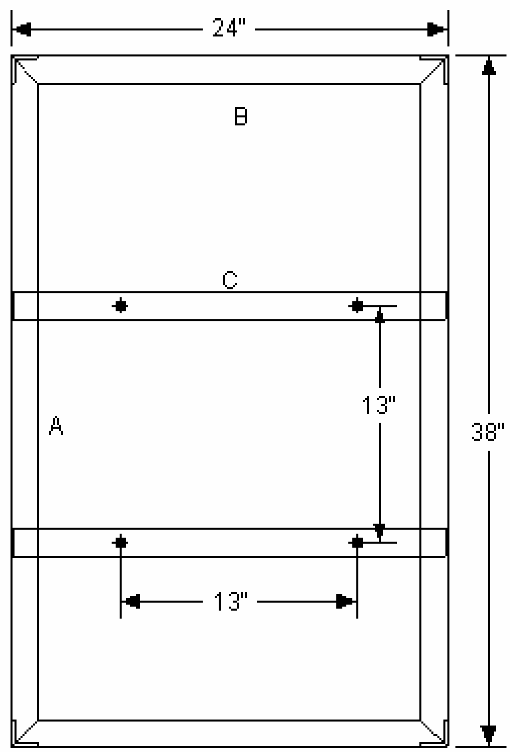
I made a lifting bar from a piece of 3/8" steel bar and attached it to the cylinder studs with a couple of short ¾" x 10 tpi bolts screwed into two coupling nuts threaded onto the studs. The coupling nut arrangement provides enough height so that the engine can be moved with the cylinder head in place. I connected a chain hoist to the lifting bar and lifted the engine out of the crate. The engine came out of the bed straight and level. The center of gravity of these engines is centered on the cylinder bore. I then drove the pickup out from beneath the engine and set the engine on top of a steel-framed 38" x 24" work table I made especially for the task.

I MIG welded the table from 1/8" x 1.5" steel angle (bed frame material would work fine, too) for working on the Ashwamegh engine. In retrospect, I have come to really like that little rollaround table, and have used it for all sorts of projects. And, in deference to George's preference for the color green for all things Lister, I painted it with a rattle-can of Rustoleum Deep Hunter Green enamel.

Listeroid Assembly/Disassembly Cart







Cut List

1.5"x 0.125" Steel Angle

A. 2 ea 38" 45 ends
A' 2 ea 37 3/4" 45 ends
B. 2 ea 24" 45 ends
B' 2 ea 23 3/4" 45 ends
C. 2 ea 23 3/4" 90 ends
D. 4 ea 20" 90 ends

The engine smelled of the same odd-smelling green paint, that I noticed when I unpacked my Ashwamegh. The paint covered everything including the control linkages, which can cause a problem with governor operation and throttle response. The oil pump and nicely formed steel oil lines with silver-soldered connections are an interesting change from the other engine.

I removed the cylinder cover and peered into the bore. The temporary aluminum gasket and plywood backing kept the cylinder very clean, and thick red oil covered the top of the piston, so whoever did the assembly did it right. No dirt, no rust, plenty of lubrication. The cylinder bore was nicely machined and honed with hone marks crossing at 90 degrees in the middle of the stroke, as they should. A wipe with a white cloth indicated no residue from the honing operation.

My overall impression was very favorable, compared with my other engine. The Beta-Test engine arrived much cleaner and had been packed with more care and better materials and fasteners than was the case with the Ashwamegh.

Spares and the gas tank arrived in boxes with formed Styrofoam inserts, which indicates that the manufacturer took some precautions to avoid damaging the components.

While waiting for the cylinder head, which had shipped separately, to arrive, I decided I would do some basic inspection and mount the flywheels on the crankshaft. First I had to clean the red anti-rust compound off the crankshaft ends.

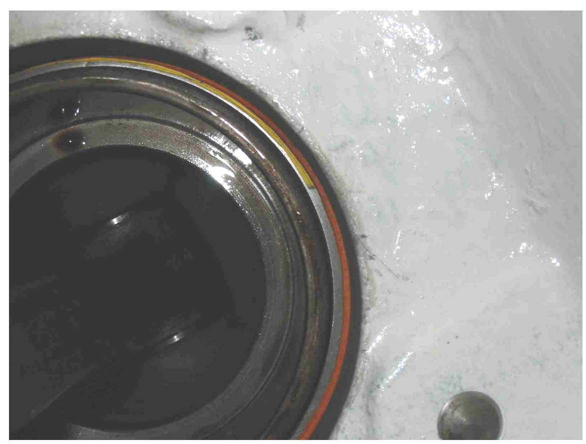
Acetone applied with a natural bristle paintbrush melted the red compound immediately but didn't affect the green paint. I was careful to keep the acetone away from the crankshaft oil seals.

The flywheels slid on without a hitch.   The gib keys fit as tight in the keyways as last summer's swimsuit. I had to insert the keys in the outboard end of the crankshaft keyway and tap them lightly with a hammer to move them along toward the flywheel hub.

My other engine had a cumulative total of 0.029" clearance between the crankshaft keyway and the gib keys and the flywheel keyway which was causing the engine to sound like it had rod-knock.   Brass shims applied between the sides of the key and the keyway in both the shaft and the flywheel fixed that problem, and that engine now runs like a watch.

The Sump

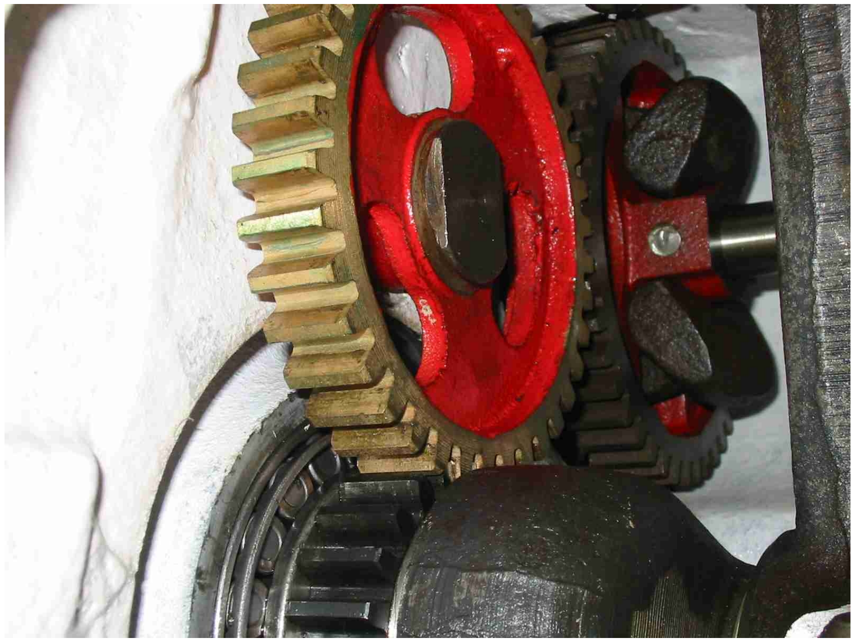
I pulled the crankcase access cover and took a close look inside. Whoever painted this crankcase took his time and did a nice job. An even thick coat of white paint coated all the right surfaces and didn't coat the wrong ones. Some red assembly oil appears to have leaked through the rings and dribbled on to the floor of the sump. A few chips of paint that fell off the tappet guides as they were being removed can be seen on the left side of the sump. Other than that, the sump was clean. No grit, no dirt, no metal particles, but of course this engine hasn't been run yet. At least this shows that the guy who assembled the engine had clean hands.



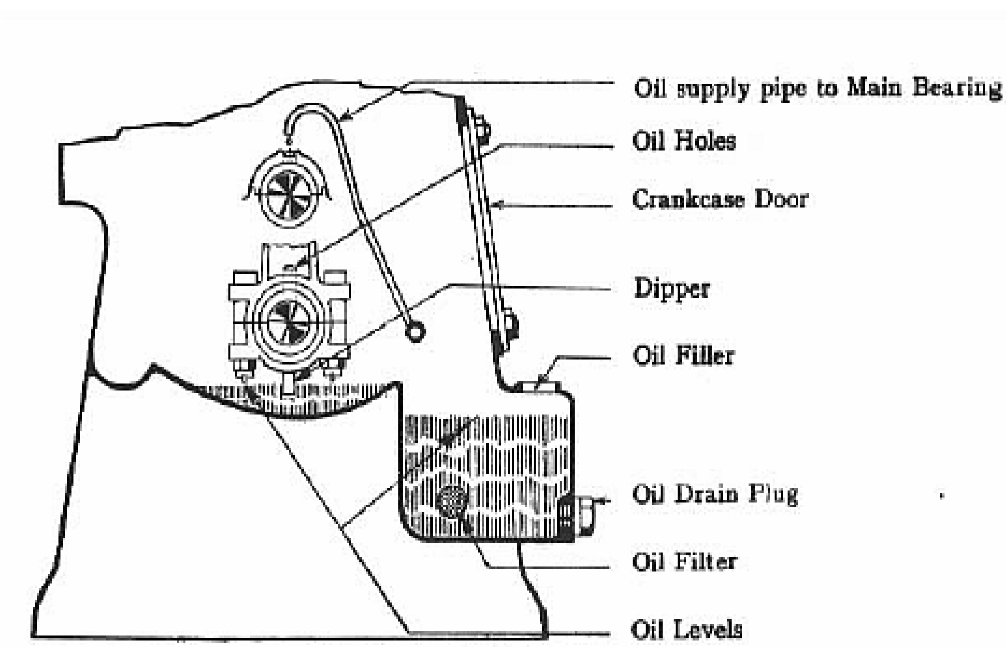
One area that the painter missed on my other engine was the area under the cylinder deck. Inspection with a mirror indicated this engine had been more carefully painted. Unlike my other engine, it's almost certain that the crankcase was turned upside down to paint all the surfaces. The "holidays" evident in the paintwork inside my other engine indicate it was probably painted while it was standing vertically and the painter didn't bother to turn it over to get to the underside of the cylinder deck.

The cam lobes are located correctly to ensure tappet rotation. Note that the painter was careful to wipe paint from the machined surface above the TRB carrier at lower right. Note the tapered pin which holds the cam lobe on to the camshaft has been peened (sigh). If the hole was drilled correctly and assembled dry, the pin should hold without being peened as if it were a rivet.

This engine came with a bronze idler gear, thanks to the time and money that Joel Koch spent with a U.S. grear manufacturer in order to determine the best material and tooth profile to specify for the gear. I wiggled it back and forth, but could not discern excessive backlash. But once the tappets are re-installed and the valve train loads the cam lobes that may change. Many (most?) of these engines appear to have a problem with the location of the idler gear shaft, causing excessive gear train backlash and ultimately broken timing gears.

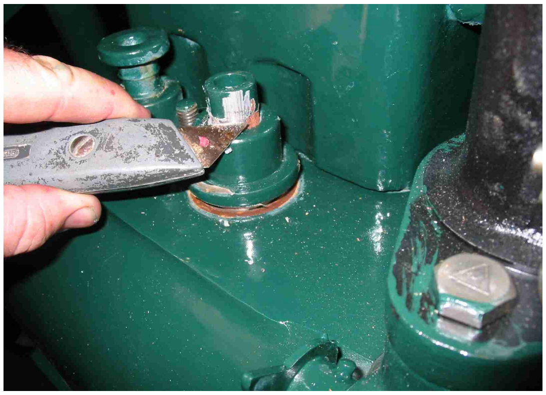


Unlike my other Indian engine, this one has the “kangaroo pouch” upper/lower sump arrangement like the original British engines had. It should provide enough isolation from the goings-on upstairs to allow large particles to settle. More so if one uses non-detergent oil such as is still used by owners of vintage automobiles. Amazon.com sells non-detergent engine oils. However, modern lubricants are better than those from the 1930s, so maybe it’s best to use a diesel rated lube oil and plan on installing a spin-on oil filter instead.



As seen in drawings from the original British manuals, there was a screened strainer on the end of the intake line to the oil pump, which was wrapped with soft cotton fabric. I'm thinking a rectangular piece of old sock or terrycloth wrapped in steel screen and held down against the bottom of the lower sump with a few magnets might be a good way to trap ferrous nasties during break-in before they get sucked up by the oil pump. I felt around in the sump and discovered that the black specks that look like dirt particles in the photo above appear to be black paint droplets. Don't know where they could have come from.

Removing the Tappet Guides



The tappets and guides were pretty well glued together with paint. I could have gotten them free by just oiling them and scraping a little paint away with a knife, but since I was waiting for more parts to arrive, I thought I'd pull them and do a more thorough inspection and cleaning.

I pried the tappet guides free of the deck with a set of round jaw Vise-Grips. Just a slight twist and the paint seal broke and the guides came free of the deck. I didn't squeeze too hard, so didn't scar the flanges. If you're squeamish about using Vise-Grips on a part of the engine that will show, you can wrap a soft rag around the part to keep from scarring the paint.

I scraped the paint off the lifter stems, which revealed some minor surface rust beneath the paint that made removing the tappet guide from the lifter difficult. A touch with a ScotchBrite pad will fix that. If one didn't feel the need to do all this, it's a simple matter to just scrape away the paint from the tappet stems to ensure that the lifters rotate properly.

I ended up using a small 3-jaw gear puller to pull the intake guide past a rough spot of rust on the lifter stem. The lifters were then removed from inside the crankcase.

The heat treated lifter faces are flat or slightly concave with concentric machining marks.
After I took my first swipe at the face with the paper I noticed three small punch marks near the center of each lifter. The marks indicate that they had been tested for surface hardness following heat treatment. That's encouraging evidence of quality control in Rajkot.

I stopped by my friend's machine shop after work. I chucked each lifter stem in the Rockwell lathe and turned it on. Both lifters spun true. There was no visible runout. I also placed a straight edge across the lifter faces and was able to fit the tip of a 0.003" feeler gauge between the center of the tappet face and the straight edge. It has been reported earlier that the lifter faces are machined ever so slightly concave.

The cutter used to face the lifters appears to have been sharp. I saw no compelliing reason to polish the surfaces further to a mirror finish, though I decided I'd lightly face them with 220 grit paper on a flat plate, then smooth the sanding marks on a buffing wheel with rouge.

My other engine had lifters that were cut the same way, and George wrote about seeing that, too. I suppose they are all made by the same manufacturer. Whether the slight concave face was deliberate or the result of their being faced on a worn lathe by a machinist in a hurry to finish the part is difficult to say. The concavity is very slight and likely would have little or no effect on the operation of the lifter.

I reinstalled the lifters and guides with a little dab of my favorite assembly lube (STP Oil Treatment – slimier than a politician's kiss). The lifters now spin freely in their guides.

Next, I unpacked the spares kit. It contained:

- 1 old-fashioned pump-type steel oil can
- 1 set rod bearings and shims
- 1 set intake and exhaust valves
- 1 pair gib keys
- 1 pair steel flywheel hub covers
- 1 pair pre-formed high-pressure steel fuel lines with ferrules

The last item is a vast improvement over the chromed steel fuel lines that came with my Ashwamegh. The ferrules were nicely machined and silver soldered onto the steel lines. The ferrules on the Ashwamegh were roughly finished by hand on a grinding wheel, leaving facets which caused the connection to leak like a newborn until I touched up the surfaces.

The fuel tank was packed in a separate box that contained mounting hardware, braid-covered fuel line and fittings for connecting to the tank mounted fuel shutoff valve and the engine-mounted fuel filter.

The last of the parts, the head assembly, arrived today via UPS.

The head was packed securely and the Styrofoam did its job keeping the heavy head from destroying the plastic shipping box.

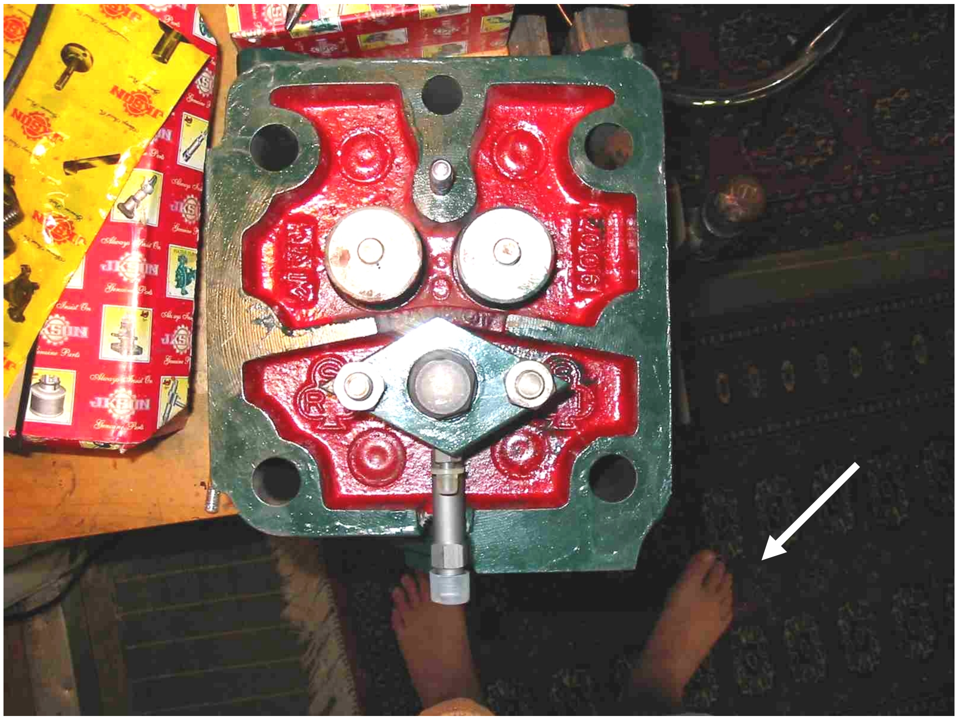
Contents of the head assembly. Someone in India placed the Power Solutions nameplate in a plastic bag with the mounting rivets dropped in loose. Then the sealed bag was placed on the bottom of the box, then the head was placed on top of the bag. The loose rivets did a good job of mangling the nameplate and registered every bump in the road from Rajkot to its final destination.

The mating surface of the head was covered with red transparent sealer that was easily removed with a little acetone and a paintbrush. Lacquer thinner, spray carburetor or brake cleaner would work just as well.

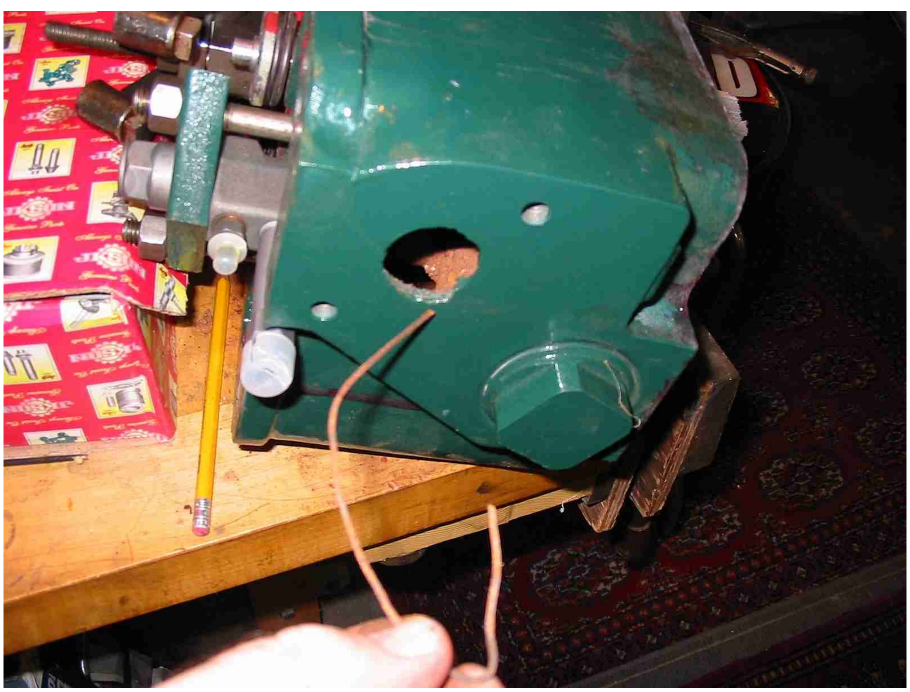
Once the anti-rust coating had been wiped off it was clear that the head had been nicely surfaced. The camera flash makes the surface dirt and rust in the water galleries appear much worse than it did visually.

I removed the valves in order to check their fit in the guides and to see whether anybody bothered to lap them into their seats. I was sort of surprised that I didn't need a spring compressor to remove the keepers. I expected the springs to be stiffer than they were. But then, when an engine turns only 650 rpms, valve float isn't really going to be a problem, is it?   One has to keep one's assumptions based on high rpm engines in check.

The valves were beautifully machined. They were fully the equivalent of anything you'd find in the West (who, perhaps, source their valves from India, just like they do their piston rings). They fit their guides and seated tightly. Close examination of the valves and their seats indicated that they had been lapped.

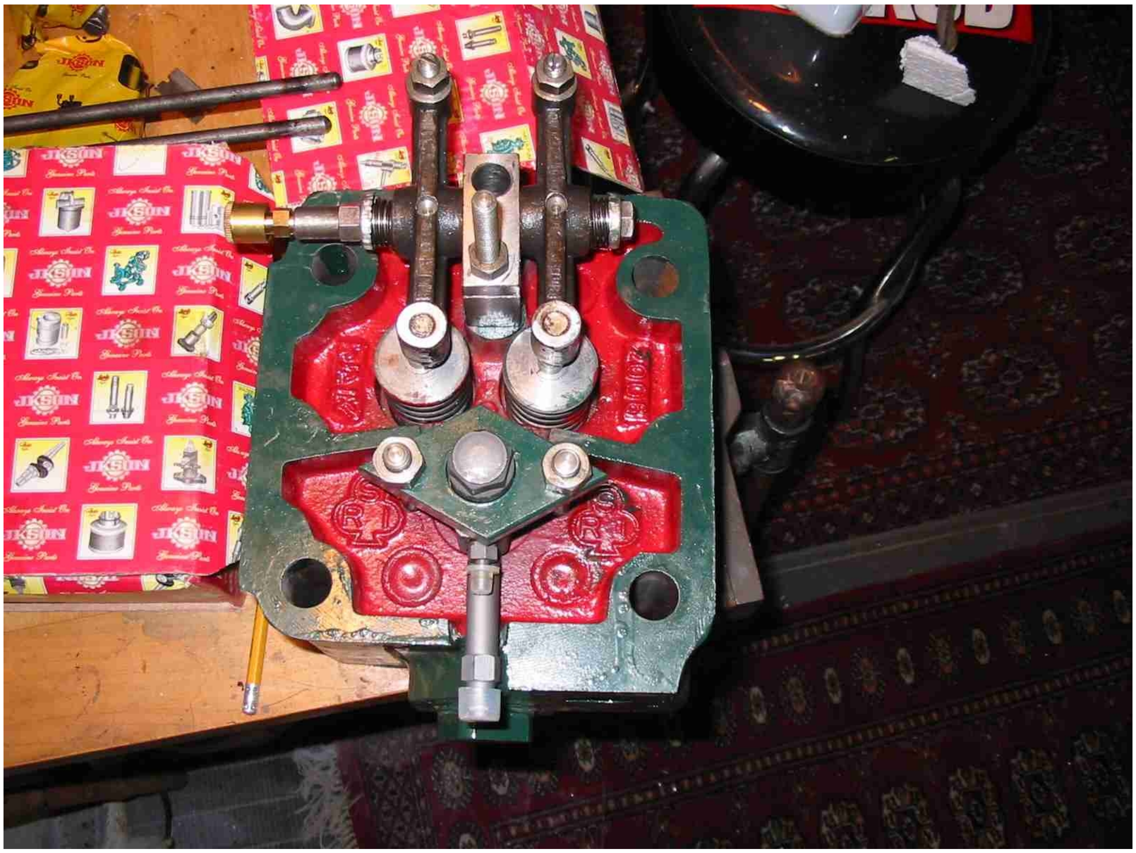


I replaced the valves, valve springs and keepers and installed the fuel injector. Again I have to say that the hardware that came with these parts was far superior to that on the Ashwamegh. Nuts, bolts and studs are thoroughly the equivalent of anything you'd find on an engine built in the West. And, yes, those are my bare size 13s. It's the middle of summer and I kept telling myself that I'd stop assembling after the next part and put some shoes on, but I was having too much fun.

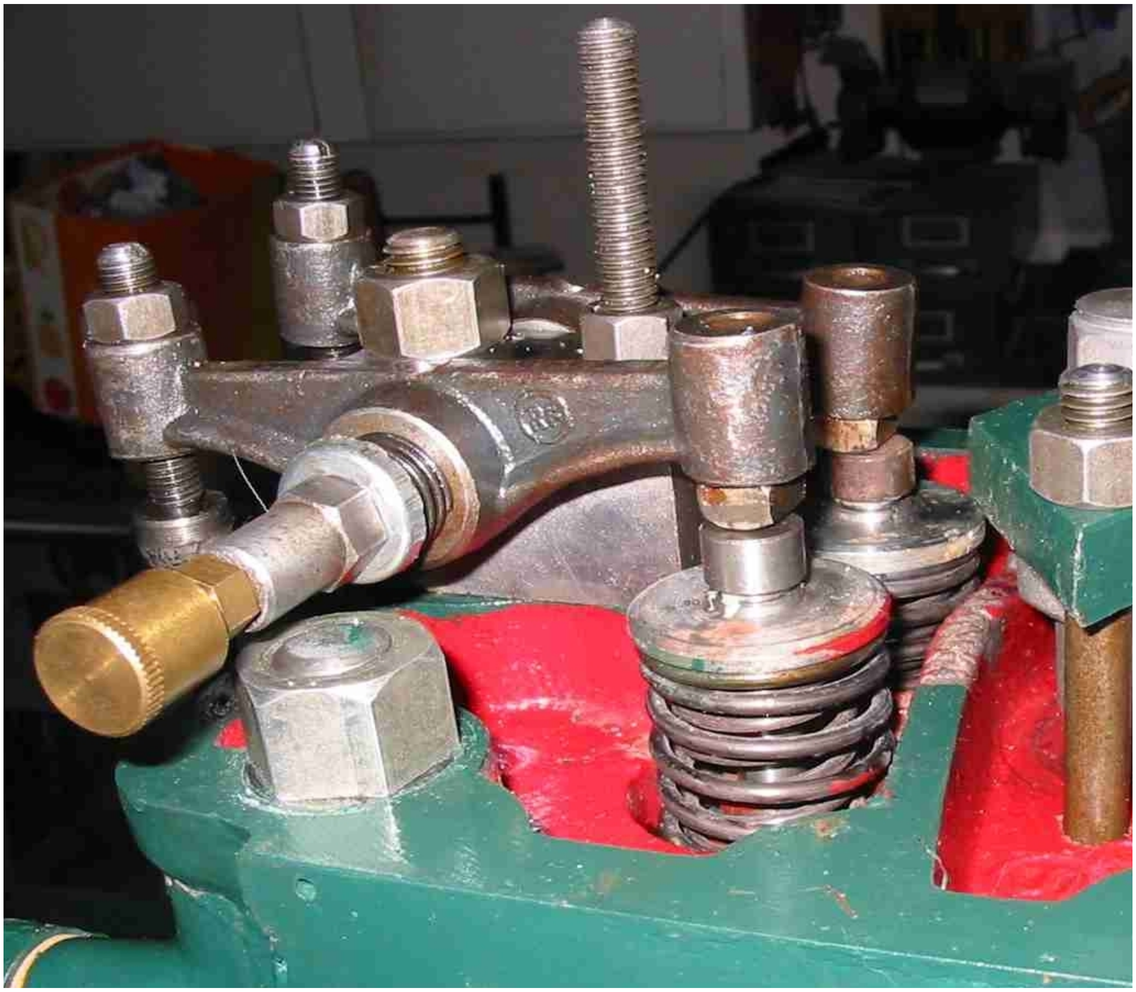


The water galleries in the head were free of casting flash and core sand, however I managed to remove a piece of bailing wire from the water outlet. The wire had probably been used to suspend the head casting from a hanger while it was being painted.

I unpacked the rocker assembly from its shipping container. The rocker arms run on a hollow shaft that is filled with heavy yellow grease similar to the "Yak fat" that the Chinese use to lube bearings in their ST generators. A capscrew in the end of the rocker shaft must be removed in order to install the knurled brass grease cup, which was pre-filled with heavy grease. A half-turn of the knurled grease cup is all that it takes to force grease through holes drilled in the rocker shaft and lubricate the rocker arms. Grease extruded through the oiling holes on the top surface of the rocker arm webs allows one to see when the rocker arm is sufficiently lubricated.



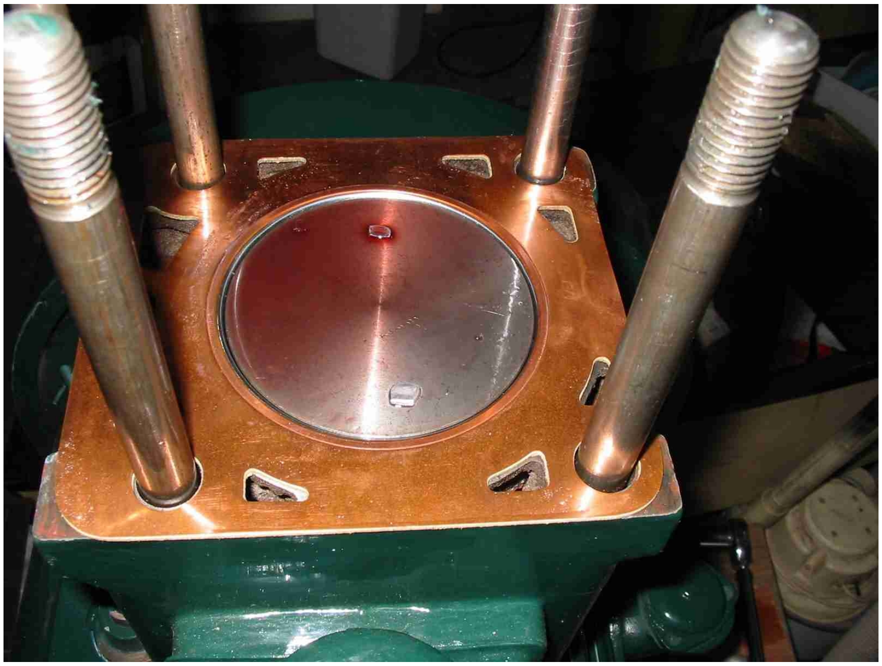
Below is a closeup of the rocker setup. Note the red and green paint on the valve springs and spring cap, which indicates the head was painted after it was assembled.



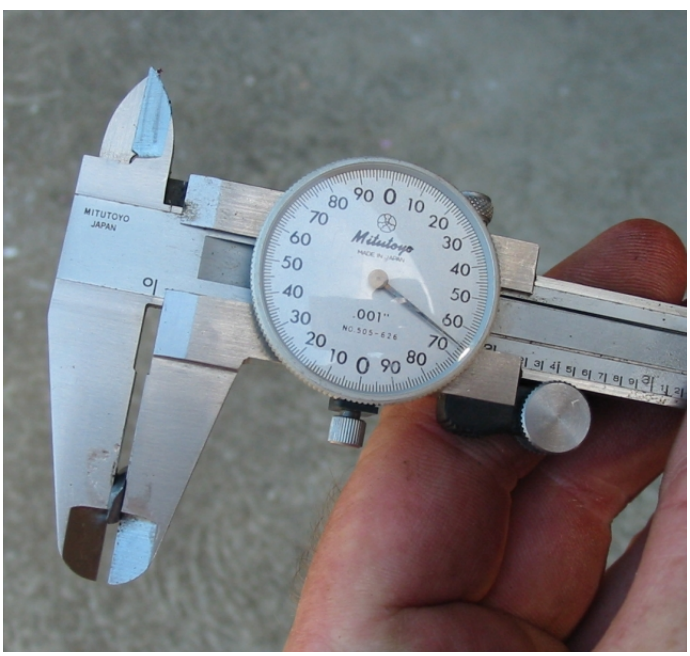
Some adjustment is called for here. The rocker arms don't register correctly on the top of the intake valve caps. That will place a small lateral force on the valve stems and wear against the cast iron valve guides.

Note that the exhaust rocker arm in the background isn't very well aligned with the (slightly rusty) exhaust valve cap. The holes drilled in the rocker arm assembly block are a little oversized and might move enough to correct the misalignment. If they don't, the holes can be drilled out a little more until the rocker assembly can be positioned properly. This is an easy fix that can be accomplished by the customer using a cordless drill with the part held in a bench vise, although a drill press is to be preferred.

The next step was to install the cylinder head assembly on the cylinder.   But first, some measuring is needed to make sure the piston is square in the cylinder and the piston/head clearance is correct.



Indian head gaskets follow the design of the original Lister head gaskets. A copper fire ring is crimped over a copper/asbestos fiber/copper sandwich. The asbestos can be expected to wick coolant, so it should be sealed. I thought of using RTV silicone glue which is waterproof and resistant to heat up to several hundred degrees.
But I decided instead to take George's advice and use his liquid floor wax trick. I submerged the head gasket in an 8" square glass baking dish filled with floor wax, then hung the gasket outside, then dried it in an oven set at 225 F. (1)



The piston-to-head or "squish" dimension needed to be verified against the specifications, so I cranked the flywheel until the piston came to near top of its travel. Then I snipped two pieces of soft lead approximately 1/8" square from a roll of lead sheet and placed each piece over the location of the piston wrist pin. I then installed the head and torqued the head bolts to 170 ft-lbs. and cranked the flywheels back and forth a few times through top dead center. Then I removed the head and measured the thickness of the lead pieces to dermine the piston-head clearance.

The thickness of the lead pieces was measured and found to be 0.065" The spec. from the Utterpower.com website says 0.060" – 0.065" is acceptable. As the head gasket gains "experience" and the head bolts are torqued again after a few hours of running, and as carbon inevitably deposits on top of the piston, the clearance will likely decrease a few thousandths.

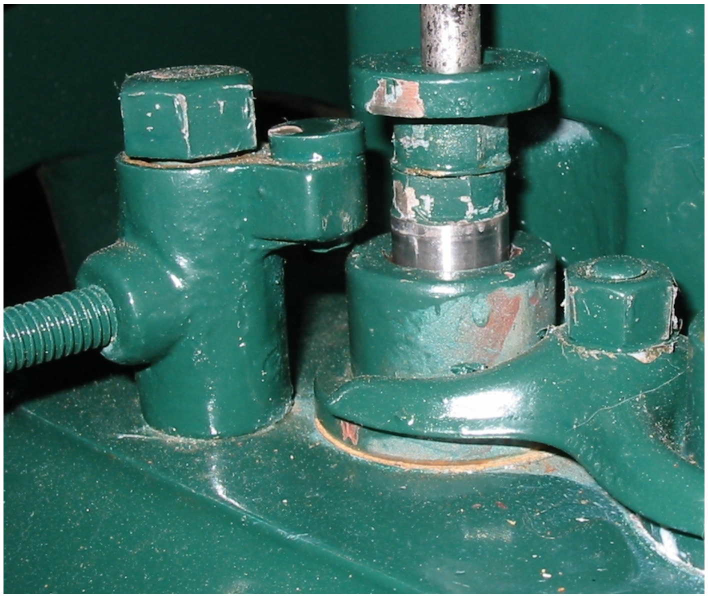
It's fortunate that the clearance was so close to spec. because the cylinder base gaskets that are used for adjusting the squish thickness measured 0.010" on the Ashwamegh, so it would have been difficult to adjust the squish distance any less than that amount. The head was replaced and the head nuts were re-torqued to 170 ft-lbs.

The pushrods were unpacked and cleaned of grease. The fact that both ends are hardened is evidenced by the discoloration that is visible at each end.   The rods on the Ashwamegh were chrome plated. These rods will need to be painted before they begin to rust.

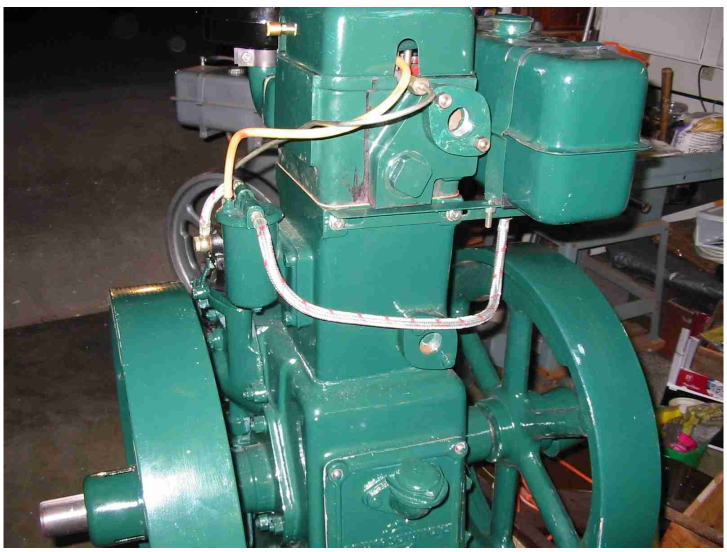
Within the cups on the end of the pushrods is frequently found a protruding point of metal, an artifact from the manufacture of the pushrods. These pushrods have no such protrusion which is fortunate since it would have had to be ground off with a carbide burr.

The pushrods were installed, then the flywheels, pepper-can muffler and air cleaner. The gib keys need to be fitted in order for them to more fully engage the flywheel and the keyway in the crankshaft. Presently, they leave about 1" of key protruding past the hub, which is too much.

Although the pepper can muffler won't be used on this engine, except at First Smoke, it was nice to see that this muffler was heavier and better made than the silencer that Ashwamegh supplied.



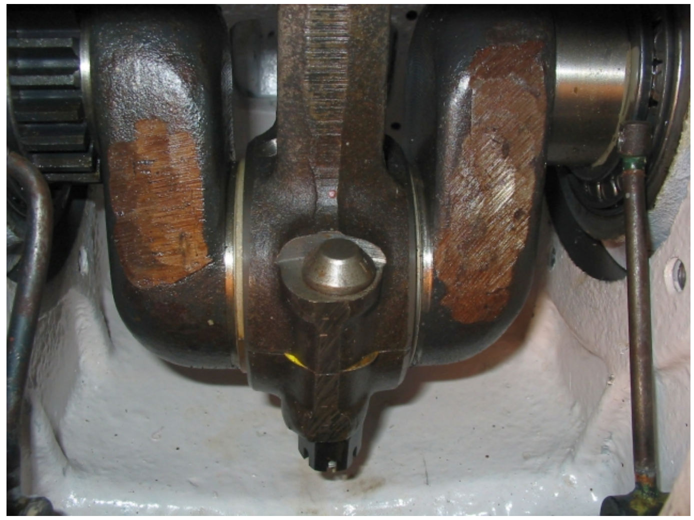
The decompressor arm which lifts the exhaust tappet seems to be a little short. It barely engages the flange on the lifter.



The fuel tank was installed and the fuel lines were connected. The fuel petcock was sealed with a piece of string which, like the head gasket, is an unnecessary throwback to the technology of an earlier day and doesn't instill confidence in the integrity of the valve. A quarter-inch ball valve adapted to the tank fitting with a quarter-inch British Standard Parallel Pipe Thread to NPT adapter, available from http://www.mcmaster.com would fix that.

This afternoon I pulled the rod bearing cap in order to inspect the crankshaft pin and measure the rod bearing clearance.

I removed the oil dipper on the rod bearing cap by loosening the lock nut and unscrewing the dipper a total of 7 turns. That is the number of turns that is required for the threaded portion of the dipper to just touch the bearing shell. There is plenty of thread in the bearing cap, so even four turns would hold it in place.

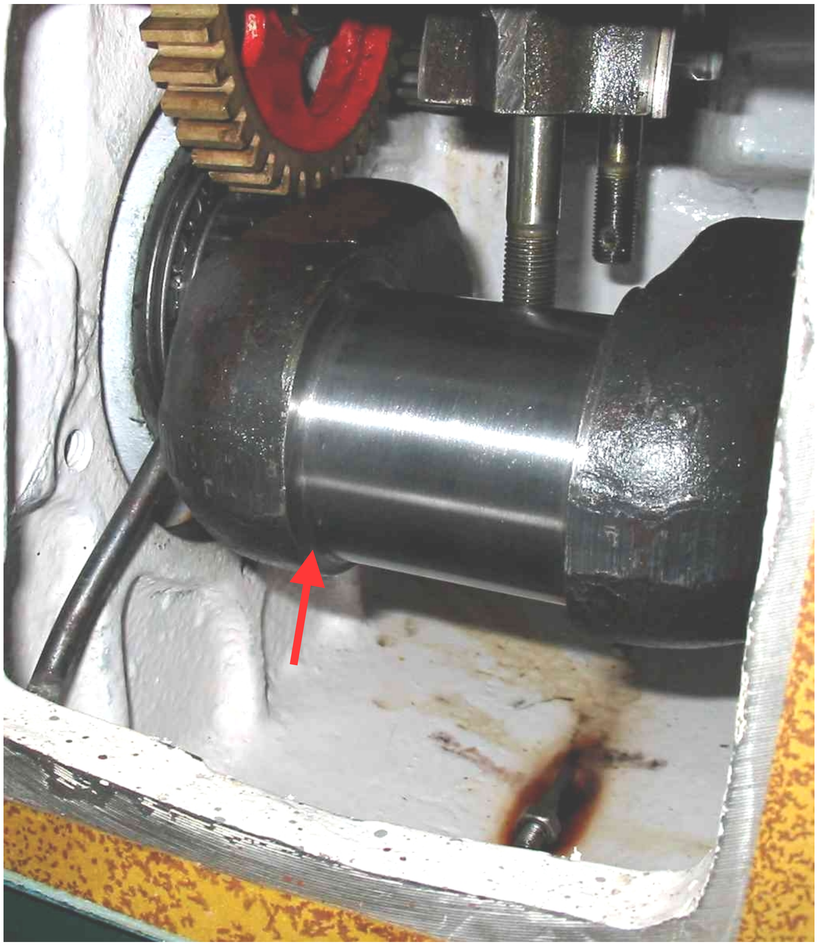


Next, I removed the cotter pins from the castle nuts on the rod cap bolts. This is never a fun job because the cramped quarters make accessing the back-side cap nut difficult, and there is very little room to swing a wrench and there are plenty of sharp edges to skin knuckles on. Last time I did this, the pin on my metal watch band let go, dropping my watch into the sump full of black oil. I removed my watch this time.

I knew the bearing cap nuts would be tight, the spec. calling for 50-60 ft-lbs., but it turned out they were *way* overtightened. I ended up needing to use an impact socket on a breaker bar with a 2' pipe slipped over the end to give me enough leverage to loosen the nuts. I was relieved when the nut loosened just as the wrench handle was approaching the side of the crankcase access hatchway. That's not usually my luck.

The bearing cap with the lower bearing shell was removed and I was pleased to see that the bearing had not been installed dry. The bearing and crank pin were wet with assembly lube. Two thin shims were sandwiched between the bearing caps which indicated someone must have determined it was necessary to place those shims there.

I wiped off the crank pin and bearing shells with a paper towel and inspected both shell halves carefully. The bearing shells were, of course, new so there wasn't much to see. The crank pin was well machined with none of the chatter marks that were evident on the pin of my Ashwamegh.



The pin appeared to have been carefully machined and polished to an appx. 400 grit finish. Low-level incident light indicated that the pin was cylindrical with no dips or grooves or visible machining marks and there was a generous fillet machined into each side of the pin. See red arrow in photograph. The importance of that fillet is discussed in the endnote. (2)

I polished the poorly finished crank pin on my Ashwamegh engine by smearing lapping compound on an old cotton sneaker shoelace passed around the crank pin two times. Pull back and forth on the ends of the lace for 10 minutes or so and the pin gleamed like Great Aunt Edna's prized silver teapot. No need to do so on this engine. The pin was nicely finished.

I reassembled the big end with a few pieces of Plastigauge stuck with grease to the bearing shells and torqued the nuts to 60 ft-lbs. When I removed the bearing cap the Plastigauge had squished evenly to a rectangular shape, indicating the oil film thickness will be constant across the pin. The clearance measured 0.0025" across the width of the bearing shell in three locations around the perimeter of the crank pin.

While reassembling the big end, small parts inevitably found their way into the lower sump. A magnetic retrieval tool is a must-have for working on this engine.

Well, here it is. The engine is ready to start. I found no evidence of casting sand, metal particles or even dirty fingerprints.

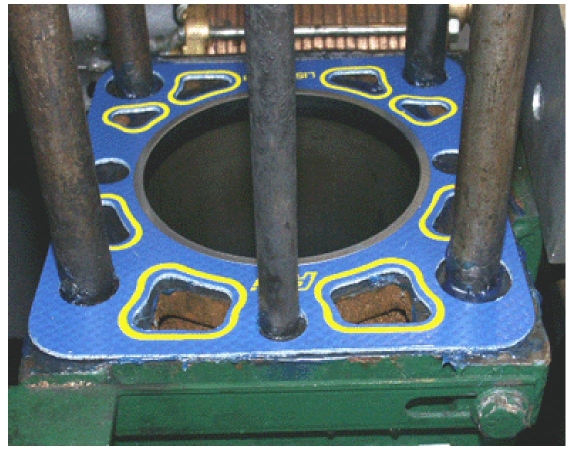
I think this indicates that many of the quality problems inherent to Indian assembled Listeroids might be attributed to the assembly process and not so much to the parts themselves. An experienced person assembling one of these engines can end up with a quality prime mover.

The engine is not pretty (yet) but there's lots of time for that nonsense. I know George is partial to Dark Hunter Green, but I'm sort of thinking Ferrari Red with brass acorn nuts on the covers.

Quinn

Endnotes and Updates

A lot of water has flowed under the bridge since I sent this report to George and Joel in the Summer of 2006. Here are a few items that are worth knowing about.



1. Updates: I'll admit, the old head gaskets were hokey, as was the method of rendering them leak-proof, but at the time it's all we had to work with. These gaskets are prone to leak and should be upgraded. A few years subsequent to my submission of these observations to George and Joel, superior quality gaskets became available for these engines from ex-patriate John at www.GasketsToGo.com. The company is located in Thailand and produces high quality gaskets at a reasonable prices. Even if they have to be made one-off by hand, John ships them stateside very quickly. John says he now keeps a stock of common Lister gaskets in the U.S. which are available for immediate shipment, and he has an e-Bay store GASKETNATION which ships from the U.S. Word has it that those who have purchased his gaskets have been very pleased with the quality, price and timely delivery. While I was revising this report contacted John and bought two gaskets that I intend to replace my originals with. The gaskets come in a package that says Lister 8-1, but the gaskets will work fine on the 6/1 with either the common Indian 5-stud, or the British 7-stud cylinder/head configuration.

2. Recently two cases of broken crankshafts have come to light. In each case, the crankshaft snapped at the junction of the crankshaft pin and the throw; a point of great stress on the crankshaft. And in each case, there was not much, if any, radius visible at that junction. It appears that whoever machined the crankshaft pins took the cutter right up to the throw and stopped, rather than taking the extra step to machine a slight radius at that point which would have prevented stress from concentrating at the junction.