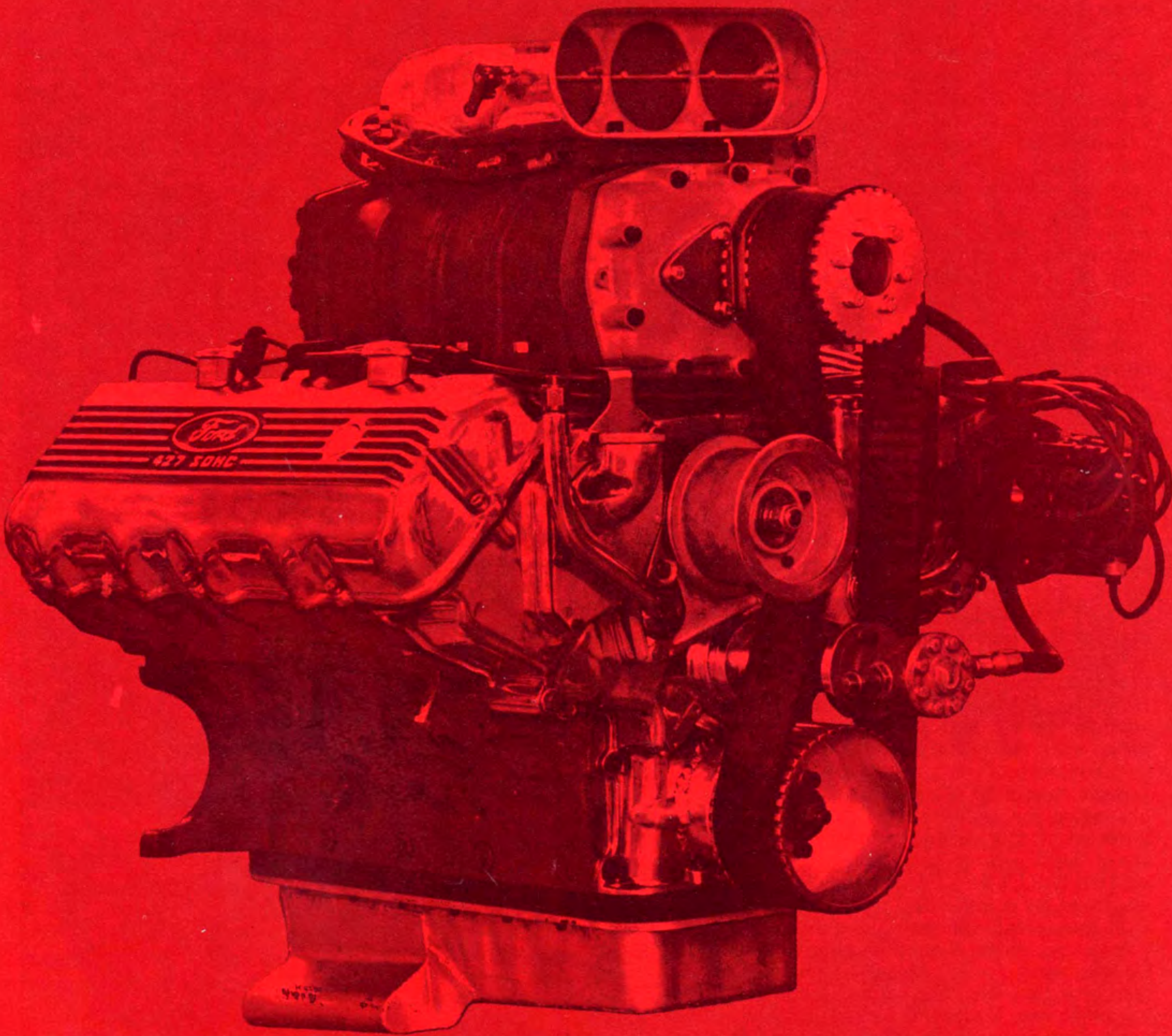
SOHC Magical Mystery Tour



BY A. B. SHUMAN

"The Old Master," Ed Pink, guides us on a journey through the exotic, never-before-revealed world of the Single Overhead Cam Ford engine

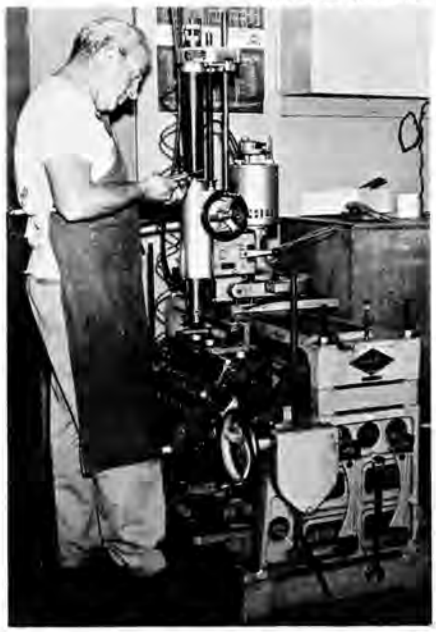
Despite an extremely impressive record in the Funny Car and Fueler ranks during the past few years, and all the attendant publicity, FoMoCo's 427 cubic inch single overhead cam engine has steadfastly maintained about it an air of deep mystery. Definitive information on the inner workings of a winning "cammer" has been more closely guarded than Bill Jenkins' home phone number. But Ed Pink recently swept away the blue veil of secrecy that surrounds the most sophisticated engine in drag racing and granted us access to both his Van Nuys shop and the small green card file where all the key dimensions are stored, computer-like, during the building of a blown fuel SOHC for Funnyman Gas Ronda. To our knowledge, this was the first time that any "outsider" was allowed to watch and record just how these engines go together.

Generally, it can be said that the problem with the SOHC is not in getting it to put out lots of horsepower, but getting it to do so with longevity. This is where Pink's handiwork really shows, as his engines are not only consistently strong runners, but they live. Ed readily admits that it took many months of racing and just plain hard work to learn the secrets that have made his big Fords successful, but herein he reveals them all.

SOHC uses same basic block as 427 wedge. Oil system must be checked, some passages enlarged, others blocked.

Starting with a complete engine (available through Ford dealers, Holman-Moody or Pink), it is first disassembled and all parts that will be used – including the block – magnafluxed. A full-length Milodon steel lower end support is fitted to the block and the bottoms of the main caps are milled to give the desired .005" crush, as measured with a dial indicator at the cap centers. The block is deburred completely and a slight chamfer ground at the bottom of each

Photos by A. B. Shuman



Concurrent with boring to 4.250", O-ring receiving grooves .080" wide and .050" deep are cut around top of each cylinder.

cylinder to provide extra clearance for the aluminum connecting rods that will be swinging by. Since the block is basically a modified version of the standard 427 wedge engine block, there are several essential operations which must be performed, chiefly to the lubrication system. The main oil gallery (which runs along the left skirt) is enlarged with an extra long 5/16" drill. The passages to the mains, oil pump and filter mount are also enlarged.

Shot peened accessory drive stub rides in #1 and #2 cam bearings; oil pump and either mag or injector pump run off it.

The engine utilizes a short cam stub for driving the oil pump and either the magneto or the injector pump. In Ronda's engine it drives the injector pump, though in most it drives the magneto. This accessory drive is in the stock wedge engine camshaft location, riding in the #1 and #2 cam bearings. These are the only two cam bearings which require lubrication, yet all five receive oil from common passages that serve the mains. Since bottom end oiling is critical, the passages to the two front cam bearings are restricted to .040" and the others are blocked completely, saving the otherwise "wasted" oil for the mains and rods, where it's needed. There is one catch though – the oil going to the heads is normally supplied from the cam bearings, via a single passage on each bank. With this supply cut off, another method must be used to get oil to all of the valve train parts in the heads. So, the rear plug on the main oil gallery is drilled and tapped to accept a .040 jet. This feeds oil to a T-fitting which transits into two 3/16" copper lines. Each line goes to the oil gallery in one of the heads. The stock oilers, which all of this plumbing replaces, should also be sealed off with Allen plugs as a precaution. This completes the oil system modifications, save for the pump.

A stock '57 Ford oil pump is used, with the outlet passage to the block enlarged to match the block opening. The bypass valves in both the pump and the block are shimmed to open at 100 psi, and the pump inlet is bored out to accept ¾" o.d. tubing. This goes to a special pickup which runs to the rear of the engine and sits ⅛" off the bottom of the reworked SOHC oil pan. The pump is driven off the bottom half of a 427 Ford

(continued on page 46)

100 psi of oil pressure is supplied by a '57 Ford pump. Pickup feeds at rear of modified pan and sits ⅛" off bottom.

distributor, held in place with a 283-327 Chevy-type distributor clamp and a single ⅜" bolt, and running off the accessory cam stub. A hole must be drilled and tapped in the lifter valley for the clamp bolt, the head of which is later drilled for safety wiring to the clamp.

Next, with the bottom end support torqued in place, the mains are align bored. Following this, the support and main caps are removed and the top of each bank is surface ground to make it parallel to the crankshaft centerline. New blocks are then cleaned with an air/solvent spray, washed with Tide, blown off with compressed air and wiped dry. Old blocks get the same treatment, but are hot tanked first. All unmachined surfaces inside the block are painted with Rustoleum primer and the outside is painted with Rustoleum enamel in the desired color.

When the paint is thoroughly dry, the block is bored .016" to 4.250". One of the chief reasons for this is to correct the cylinder centerlines, so the block should be supported by the main saddles during boring. Going to a 4¼" bore also brings the engine to a more common ring size. Still on the boring machine, O-ring receiving grooves .080" wide and .050" deep are cut around each cylinder. The diameter of these grooves, measured at the groove center, is 4⅜". The grooves in the heads are the same diameter, but only .033" wide and .017" deep. Thus, with .035" stainless steel wire O-rings, the stock steel shim head gasket (C3AE6051B) is actually pushed down into the receiving grooves in the block. The ends of the wire used to make the O-rings should be filed flat so that they butt together squarely. The O-rings are cemented or glued in place in the heads and both sides of the gaskets are sprayed with Copper Coat aerosol. (This O-ring/gasket combination was arrived at only after a long process of evolution, and Pink has found it to be the only thing that works.)

Following boring, the block is honed with a #620 (medium grit) Ammco hone, using cleaning solvent or kerosene mixed with little engine oil as a cutting fluid. The honing is just for finish, striving for a 45-degree cross-hatch pattern. The top of each cylinder is notched slightly for valve clearance, all threaded holes are checked with a bottom tap and the head bolt holes are spot faced to prevent the top threads from being pulled out. The block is washed to remove all metal chips, with special attention paid to the oil galleries. Pink uses a set of cleaning rods and brushes specially made for this purpose to insure that all oil passages are completely cleared of debris. The whole block is then washed with solvent and Gunk, scrubbed with Tide, rinsed with clear water and blown dry. All unpainted surfaces are coated with WD40 if the engine isn't to be assembled immediately. To further protect the block, it is covered with a heavy plastic bag while waiting to be put together.

For assembly, the first step is the fitting of the main bearings. Ed uses Federal Mogul B-16594-32 steel-backed, soft babbit bearings. The oil hole in each upper shell is carefully matched to the oil passage in the block and both sides of the bearings are lightly buffed with #000 steel wool to remove any burrs and to insure proper seating in the block. The main caps are then bolted down, with the bearings in place. The main bolts are torqued to 100 ft/lbs, going 40, 60, 80, 100 in succession. The side bolts – which always go on last – are torqued to 45 ft/lbs (going 20-35-45) with the stock side bolt spacers being retained. Next, the lower end support is put on and torqued to 45 ft/lbs, going from side to side when tightening it down so that it sits flush on the bottom of the block.

Each main bearing is then checked in two places with a three-anvil hole mike, both for measuring inside diameter and checking concentricity. All figures are noted and compared with micrometer readings for each of the five main bearing journals on the crankshaft. The difference between the two sets of figures is the oil clearance. The magic number here is .006". (That's right!) To correct minor variations from this figure, different sets of bearings are tried, as normal manufacturing tolerances provide a range of sizes. In some cases the crank has to be ground accordingly. The crankshaft to use is the steel one (C6AE6303-C). After magnafluxing, it is sent to Reath Automotive and the rod throws ground to 2.3710" to accept 392 Chrysler bearings. The throws are made 2.010" wide, with a .150" fillet where the crank cheek meets the throw. The mains are given a .060" wide by .060" deep, radiused – not square – groove for better oiling, and a .125" fillet. The cranks are reinforced between #1 rod throw and #1 main, and between #4 rod throw and #5 main with welded steel plates. This is where they are prone to bend the easiest. The mains are hard chromed and ground to 2.7450", or smaller if needed, to achieve the .006" oil clearance. The nose of the crank is also hard chromed so that the crank hub won't gall itself to the crank, a common malady. To go with this, Ed uses his own 4130 chromoly hub. The crank and complete reciprocating assembly are later sent to Vic Edelbrock for balancing. Following balancing, the crank journals are masked off and the crank shot-peened, paying special attention to the fillet areas.

The aluminum connecting rods are Mickey Thompson's, ordered for a 427 Ford with Chrysler bearing size. The rods and caps are numbered and Zyglo inspected, and the bolts magnafluxed. Ed then has the rods heat-treated to his own specifications and Zyglo'd a second time. The rods are polished to remove surface stresses that might cause cracks, the big ends are resized to 2.500", the caps reserrated to match the rods and the small ends bored for wrist pin bushings (which are run with .002" clearance). After pin fitting, the small ends of the rods are made parallel to the big ends. The sides of the big

With main caps and Milodon steel lower end support torqued in place, Federal Mogul main bearings are each checked in two places with three-anvil hole mike. This gives accurate i.d. measurement and check of concentricity. Desired main clearance is .006.

ends are ground to give the desired .060-.070" lateral clearance. The pin ends of the rods are also machined so as to maintain .030" between the rod and the pin boss in the piston when the rod is against the crank cheek. A small groove is made in the outboard side of each cap where it joins the rod, to sling oil onto the cylinder walls. The thoroughly remanufactured rods get a final Zyglo inspection and check of the threads, and are then washed and deburred.

Small oil groove on outboard side of rod cap helps lube lower cylinder. Bearings must be drilled to fit on locating pin.

The pistons for this engine were Forgedtrue's newest #72 forging, with an 8:1 compression ratio. Each piston is fitted with four buttons per side – to hold it straight in the cylinder – keeping it off the wall and reducing friction. They also help the rings seat quicker and straighter, and help them last longer. The finished o.d. of the buttons is equal to the bore size, giving zero clearance. The pistons are run with a moderate .012" wall clearance. Ed uses his own hard chromed, tapered wrist pins. They're Chrysler 392 size, with a .984" diameter, compared to .975" for the stock Ford pins. Piston to pin clearance is .002". He uses Tru Arc pin locks, two per side, fitted into widened grooves. This double setup prevents the pin locks from being hammered out by detonation. Wrist pin length is 3.083", giving .002" side clearance.

For top rings, Ed uses Forgedtrue 1/16" step-seals with .012" end gap. The second ring is a cast iron 5/64" Pedrick with .025" butt clearance, and the third is a Pedrick 3/16" four-piece, with .020-.025" end gap. A small whetstone is used to remove any sharp edges where the rings butt together.

The rod bearings are Federal Mogul 2235SB (steel-backed babbit), which are actually made for a Chrysler. The lower bearing shell from each set must be drilled to accept the locating pin in the rod cap, and one side of each set machined so it won't contact the fillet in the crank. This gives a final bearing width of .840". Rod bearing clearance is .005".

Modifications to the SOHC oil pan entail cutting off the sump and relocating it at the rear. The sides are given little bubbles to increase capacity to nine quarts with filter. Two baffles are built in the pan to keep the oil around the pickup on acceleration and deceleration. When completed, the pan is sand blasted and cadmium plated, for both corrosion resistance and ease of cleaning. A high performance Fram filter is used.

Next come the heads. There are two types available: cast iron and aluminum. The aluminum heads are 88 pounds lighter per pair than the cast iron, but are said to be shorter-lived. Donovan stainless steel valves with hard chromed stems are used. Intake size is 2.250" and the exhaust valves are usually 1.900", but in some cases this is increased to 2.250". Valve stem diameter is 3/8". The mehenite guides are knurled and .0010-.0015" stem to guide clearance used, with PC seals installed on the intake valves only. A 30-degree angle is ground on both the valves and the valve seats. The intake seats are 1/16" wide and the exhaust seats 3/32" wide. The heads are not ported, though the ports are matched to the blower manifold gasket, and any casting imperfections are removed. For aluminum heads, Pink has a special coating process for the exhaust ports. The material used reflects heat and prevents holes from being burned in the ports. Both the aluminum and cast iron heads are O-ringed as previously described.

Small dial indicator is used to check concentricity of valve seats with guides. When using aluminum heads, Ed treats the exhaust ports with heat-reflective coat.

Pink starts with M/T aluminum rods, completely remanufacturing them. Pistons are by Forgedtrue, running 8:1 compression, and normally four buttons per side are used to steady each in bore. Top ring is Forgedtrue Step-Seal, second and third are Pedrick.

Going into the head work in a little more detail, the chambers are polished, with dummy valves used to protect the seats, with special care taken to remove all sharp edges around the spark plug holes. The valve seats are radiused, blending from one edge into the port and from the other, into the chamber. A small dial indicator is used to check that each seat is concentric with the

(continued on page 98)

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MAGICAL TOUR

(continued from page 47)

valve guide within .001". Each valve is numbered and placed in a numbered valve board. Then each is lapped in with medium grit Permatex valve compound to show the seat width. Finally, the heads are washed in Gunk and solvent and then soap and water.

Putting the heads together, Ed used his own springs and aluminum retainers. The valve stems are coated with Valvoline 60-weight before being slipped into place. Desired seat pressures are 215 pounds on the intakes and 220 on the exhausts. With Ed's springs, the installed height comes out at 1.780". Chromoly valve locks keep the valves from dropping. Finally, a special cap, drilled with several holes, is placed in the oil return hole in each head. Ed turns these out of aluminum, but steel freeze plugs can also be used. These engines use lash caps on the valve stems for changing the valve clearance, and the purpose of the "filters" is to keep any stray caps that may vibrate off due to valve float, from being carried into the sump with the returning oil. The steel lash caps that Pink uses are made by Milodon.

Chromoly exhaust rocker, left, is must for blown fuelers; gas SOHC's can safely use lightened, reworked stockers though.

As for rocker arms, the exhaust rocker is the critical one. For unblown engines, lightened, polished and shot-peened stock rockers are adequate, but for blown engines, Pink's custom-made rockers should be used. Each is machined from a block of 4130 and uses needle bearing rollers. These don't come cheap, but they are a necessity for all-out blown fuelers.

The camshafts Ed used in this engine were Crane "Nitro 612A's," which Crane Engineering recommends for Funny Cars. Running clearance is .016" on the intakes and .020" on the exhausts. Lift for both is .612". The idler cam stub used for accessory drive is magnafluxed, machined smooth and shot-peened, and a ⅜" hex is broached in the forward end for driving the mag or injector pump. This completes all the parts and block preparation, and the engine is now ready for assembly.

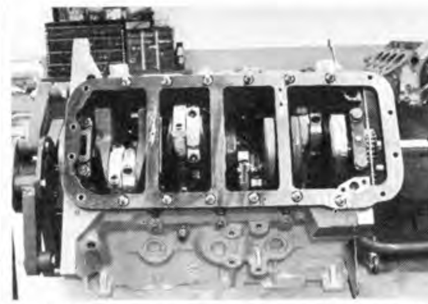
The main bearings are laid in the block and the crankshaft is installed, using Valvoline 60 as a lubricant. All

(continued on page 100)

MAGICAL TOUR

(continued from page 99)

main cap bolts are run down until the caps seat, then the side bolts and spacers are installed. Alignment of the caps is checked and corrected if necessary. The mains are torqued to 50 ft/lbs in one step, and then to 100 ft/lbs in 10-15 ft/lb increments, using the (magnafluxed) stock main bolts. Since the number three main is the thrust bearing, it is not torqued with the other four. The crank is moved so that its thrust surface is against the thrust surface of the main. Number three main can then be taken to 100 ft/lbs in the same manner as the others. The side bolts are next taken to 45 ft/lbs in two steps. Following this, the thrust clearance is checked with a feeler gauge at .008".



Bottoms of main caps are milled so that torquing lower end support to 45 ft-lbs gives .005" crush on the main bearings.

The pistons and rods are then installed and torqued to 70 ft/lbs. Finally, the main support is bolted in place with 45 ft/lbs of torque, being especially careful to tighten it evenly. The oil pump and pickup can then be bolted in and safety wired. This completes the bottom end; so, after installing the reworked pan with a stock gasket, the engine can be flipped over and work started on the top side.

The accessory drive cam stub and fabricated oil pump drive can go in at this time and the hold-down bolt safety-wired to the clamp. Using a dial indicator, establish TDC for #1 piston and so indicate on a degree wheel on the front of the crank. The heads can then go on, using the stock Ford (grade 8) bolts. The gasket must be trimmed and a velu-

Shot of number 8 cylinder shows O-ring groove, small valve reliefs and rear oil drain-back hole. Note old gasket marks.

Stock 427 steel shim head gasket is one to use, but small velumoid insert must be used to seal around the drain-back hole.

moid portion added, as shown in an accompanying photo. When the gasket is installed, the crimped portions must be on top. On cast iron heads, a .060" steel washer is used under each head bolt. For aluminum heads, a ⅛" washer is required. In tightening, start at 50 ft/lbs, then go to 100 in increments of 10, working outward from the center of the head. A general rule to follow when installing heads with the camshafts installed is to have the keyway in the crankshaft facing 45 degrees to the left of straight up. This should preclude any damage to the pistons or valves.

Timing gears for the crank and accessory drive are installed, the timing marks aligned and a blued stock timing chain (indicating heat treated pins) installed. The steel portion of the front cover goes on next, followed by the gaskets for the aluminum portion. The camshafts are then placed in the heads, aligning the indexing marks with the marks on the cam hold-down caps, for approximate positioning. The stock cam bearings, with .002" clearance, are used. Next, the cam drive gears and the cam drive chain go on. Again, you should attempt to get a blued chain. The chain has three painted links – a red, a white

Six foot timing chain drives the Crane 612A cams. High rpm stretch necessitates use of the different initial cam settings.

and a blue – to insure that the two cams are in proper relation with the crank and each other. The red link aligns with the mark on the center cam stub gear, the blue on the right cam sprocket and the white on the left cam sprocket. Once the chain is installed, the aluminum front cover can go on.

The four rocker shafts and the rockers are next. Most engines use lash caps

(continued on page 102)

MAGICAL TOUR

(continued from page 101)

and non-adjustable rockers, though adjustable rockers are available. The valves are set with feeler gauges. This properly loads the cams so that they can be degreed in. For this, Ed utilizes four separate dial indicators: two on #1 cylinder (intake and exhaust) and two on #6 cylinder, enabling both cams to be set simultaneously. This next information is probably one of the best-kept secrets in the building of these engines. A puzzling characteristic of the SOHC is that a plug check will usually show the right bank running lean, while the left is quite rich. After trying to correct this through manifolding and injection changes, Ed realized that it was actually caused by variations in camshaft timing due to stretch in the six-foot-long cam drive chain. This high rpm stretch causes the right cam (as viewed from the driver's seat) to retard, while the left cam advances. It took some experimenting before Ed could determine exactly how much each cam was moving, but he was finally able to find the right combination. He uses an eight-degree timing split between the two cams. The right hand cam is set at eight degrees advance and the left at split overlap. At about 6000 rpm, the stretch in the chain puts the cams in proper relationship. The timing gears are held to each cam by one large center bolt and four outer bolts. The outer bolt holes on the gears are slotted, allowing a range of angular adjustment. A small Vernier adjusting pin is used to position each gear on its cam exactly,

Proper tightening of chain tensioner is vital. Continuously turning engine over during tightening helps eliminate slack.

by aligning one of the indexing holes in the gear with the appropriate one on the front of the camshaft. This system permits timing changes in steps of about two degrees.

With the cams degreed in and the timing gears bolted in place, the chain can now be tensioned. During tensioning, the crankshaft should be continuously turned over to get all play out of the chain. The adjusting bolt is torqued to 10 ft/lbs and retightened as often as necessary, so that moving the chain no

(continued on page 104)

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MAGICAL TOUR

(continued from page 102)

longer causes a drop in tension. The adjuster can then be locked in place by tightening the 9/16" bolt to 70 ft/lbs and the 7/16" bolt to 55 ft/lbs. After this, the adjusting bolt should be given an additional one-eighth turn to lock it in place.

The blower manifold is an item made by Ford, amazingly enough. It comes in either magnesium or aluminum. The aluminum model is slightly heavier than the magnesium, but it holds up better under backfiring. A groove is cut all around the inlet portion to accept a .125" runner-type rubber O-ring. No more than .007-.008" of the O-ring should be above the surface of the manifold, otherwise the blower case will be distorted sufficiently to cause rotor bind. Each manifold branch is bored and tapped for 1/8" pipe thread for the injector port nozzles. The forward three on each side of the manifold are counterbored for socket clearance and the eight blower hold-down-stud holes are spot faced to prevent thread pull-out. An M/T pop-off plate, with a vulcanized rubber O-ring, is used. The springs that come with the plate kit are tightened so that they have 1/8" clearance before coil bind. The manifold ports are matched to the stock SOHC intake gasket, which should be coated with Lubriplate on both sides prior to installation. This will prevent the gaskets from tearing, enabling them to be reused several times. Great care must be taken in torquing the manifold to the heads. Ed starts at 10 ft/lbs and builds up to 25, working outward from the center. After tightening, a straight edge should be laid both ways across the manifold top to make sure it is still flat.

The completely reworked Ed Pink 6-71 blower goes on next. A thin layer of Lubriplate is used to hold the O-ring in place. The blower is only torqued to between five and 10 ft/lbs – never more than 10, as case distortion is critical. As you tighten, go back and forth across the blower, turning the rotors to insure that no binding occurs. A Cragar Chrysler blower drive, with Ed's own idler plate and 4130 crank hub with aluminum degree ring, is used. The hub is honed to fit on the nose of the crank with zero clearance. The nose is lubed with STP and the hub knocked on with a small mallet.

Next, the fuel injector pump and magneto are installed in the appropriate locations. A Moon water inlet fitting is attached over the opening in the right side of the front cover, providing for convenient addition of the 60-weight Valvoline Racing Oil recommended by Ed. The stock breather tubes are removed from the magnesium valve covers and replaced with freeze plugs. Two small conventional breathers, or one of

Ed's own breathers with oil tube, are bolted on each cover. The Pink breathers carry excess oil away through a plastic hose which goes to the back of the car. This keeps oil off the driver's goggles in the event of an engine mishap. The covers are polished and painted with clear epoxy to prevent tarnishing.

Specially fabricated fixtures hold dial indicators in proper position for checks of valve timing and camshaft placement.

For the final touches, Packard 535 ignition wire goes to Autolite AG 403 plugs for fuel engines and AG 603's for gasoline engines. Total advance is 35 degrees, with the magneto locked out. The blower is run at 30% overdrive and the injection system distributes the fuel equally to the blower and the ports, with eight .067" nozzles used top and bottom. Ed has had equally good results with Enderle and Hilborn systems. The normal "load" is 80% nitromethane and 20% methanol, run with a blank main metering jet. Tuning the injection is usually a matter of adjusting the port nozzles to lean the rich cylinders, rather than vice versa, so that line pressure to the nozzles is kept high. The exhaust system is up to the individual and has to be constructed to meet the requirements of the specific installation.

That concludes the engine building and our journey. So, bidding thanks to our gracious host, we take leave and return to the harsh reality of our '51 Plymouth six.

"WRAP IT, PLEASE; IT'S A GIFT!"