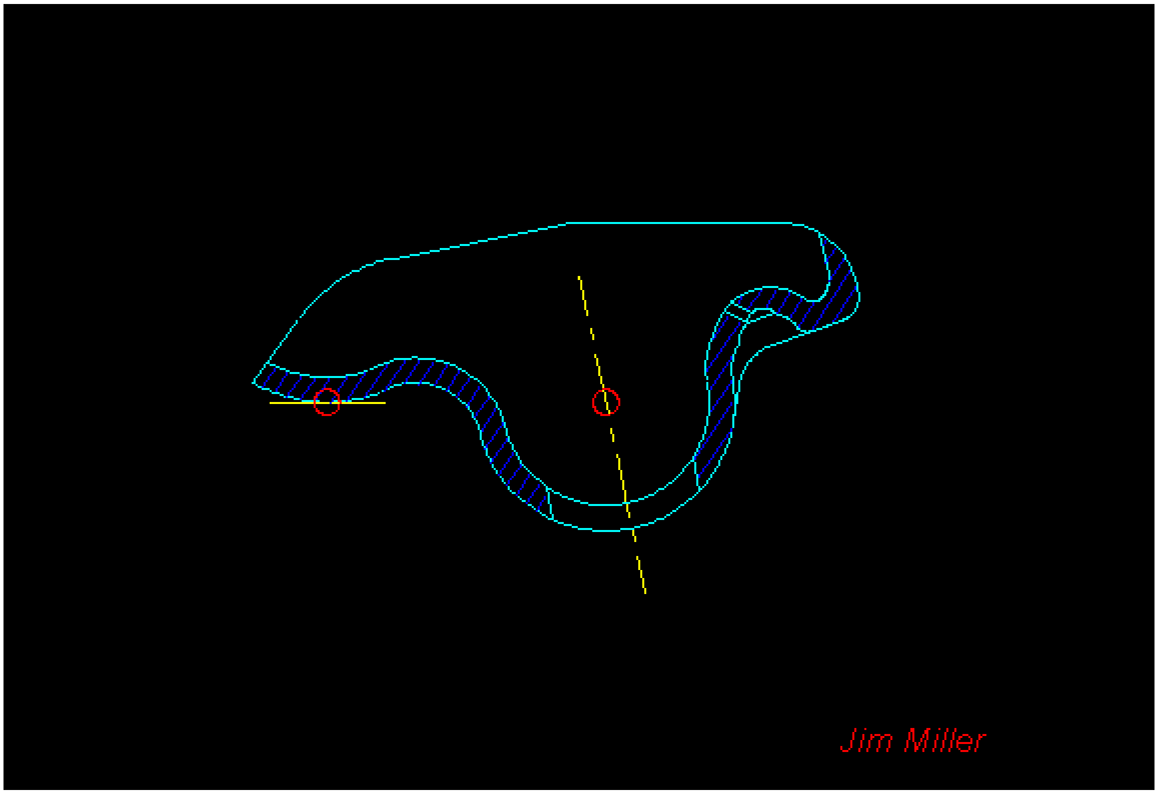
HISTORY OF MID-LIFT

WHAT IS MID-LIFT?



DESIGN and **INSTALLATION**. These two simple perspectives of rocker arm function must be understood separately. Because you can have one and not the other. If the "design geometry" isn't correct, then your "installed geometry" can only be set for the lesser of two evils, either setting the pivot points for a **MID-LIFT** relationship on the "valve" side of the rocker arm, or the "push rod" side of the rocker. Not both. On a stud mounted system, this is done by changing the pushrod length. On a stand (shaft) system, this is done by adjusting the stand's height.

> **From the above two perspectives we establish that there are TWO kinds of geometry:**
>
> The first is: "***Design Geometry***™."
>
> The second is: "***Installed Geometry***™."
>
> Understanding the difference between **DESIGN** and **INSTALLED** geometry is one good example; and it is not only critical in choosing the right parts for your engine, but also installing them correctly.

The illustration above shows the typical American OEM stamped steel rocker arm silhouette, sitting in MID-LIFT position, although the only way you'd know this is by the two small red circles: The one on the right representing the pivoting axis of the rocker, and the one on the left representing the contact pad's point atop the valve, which isn't shown. This represents the ideal "installed geometry" relationship, at exactly MID-LIFT. But for this design rocker, it wasn't originally proposed this way. This 90 degree relationship between these two points used to be achieved when the valve was 2/3 open, not half way. The result was that it "scuffed" more across the top of the valve.

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WHAT IS MID-LIFT?

All Over-Head Valve (OHV) engines have pushrods that link the cam and tappet information to the rocker arm. The rocker arm pivots about an axis upon the cylinder head, being pushed up by the pushrod, so that the opposite end of the rocker arm pushes down upon the tip of the valve. This is really "engines 101" -- but it's worth placing in perspective for our novice readers. As stated elsewhere, there are two other perspectives that need to be understood, in addition to what we call "design geometry" and "installed geometry." These other two perspectives refer to the differences in operating characteristics of the components we just spoke of. The "cam" is a rotating device, with an eccentric lobe to it, that allows anything sitting upon it to be pushed up as it rotates. This is an over simplification that is really very precise and exact in its operating characteristics. But this basic fact is true. The component that rides upon it is known as a "tappet" or "lifter" or "cam follower," depending on who's talking. Each term have their roots in the American language of engine talk, but the part is the same. Riding upon the cam follower, is the pushrod. Then the rocker arm, and finally the "valve" of our "valve train." Everything, except the cam and the rocker arm, are linear in their operating characteristics. They basically follow an in-line path. But the cam and the rocker arm are "radial" and rotate about an axis. Actually, the rocker arm doesn't rotate, it reciprocates (stops and reverses itself); but none-the-less it follows around an axis, and this has mechanical characteristics that must be understood to design and install it properly on the engine with these linear components.

What really makes a difference is the driving force of the rocker arm, the PUSH-ROD. All engines have an inherent angle with the valve, which is on the other side of the rocker arm's motion. On some engines, this angle leans away (and we call this a negative attack angle), but on most American made engines, this angle leans IN toward the valve centerline. So in keeping with a simple concept of minimum "in-and-out" motion for the pushrod, we place the axis for the top of the pushrod at a 90 degree angle, to the axis of the rocker arm itself. But to make the rocker arm truly MID-LIFT in "Design Geometry," it has to do this same thing on the opposite side, where the VALVE is.

If either side of the rocker arm does not do this, then one side or both (depending on the "Installed Geometry"), will move out of its radial path more than it needs, and the consequences will be wasted "linear" motion from the cam to the valve; excessive harmonics at high speed; extra contact heat from extra friction within the socket, and finally extra side loads being applied in the direction where the linear deviation occurs. In example, if the pushrod is too high in the rocker (a common trait of most companies for many years), then as the cam lifts the tappet and pushrod up in the block, the opposite tip of the pushrod, which is "floating" with the rocker arm's motion, will push upward and in toward the stud. As it leaves this straight up path, and begins going around and in toward the stud, it will "slow down" the rocker's motion. Because it is not following the cam and tappet where maximum velocity occurs, by being in-line with the straight line motion the tappet wants to follow. This is ONLY the pushrod side. The valve tip side has it's own chaos too, if this isn't established right, in relation to the valve tip. The height of the roller tip ABOVE the TRUNNION (or shaft, for stand mount rockers), determines it's over-arcing upon the valve. Understand though, that the best it can do, is rotate the same amount of degrees that the cam and pushrod have dictated above. So if the above hypothetical condition exists, the roller tip end of the valve will also slow down as the rocker's pushrod tip does, by following up and around the rocker axis, from being mounted too high.

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HISTORY OF MID-LIFT

HOW MID-LIFT BEGAN

The other companies designed their rocker arms in a "closed valve" state, with regard to only fitting the head, *not the engine*, thus disregarding the pushrod's influence with the valve. What Jim Miller did was to design the rocker arm when BOTH sides, the valve side and the pushrod side were in the MID-LIFT position simultaneously – but *only* when the motion was in the middle of its stroke, or “MID-LIFT.”

This influenced all of the critical dimensions as it equally divided the rocker arm's circular motion (arc) on BOTH sides, which Jim emphasized was critical to not only minimizing back-and-forth sweep atop the valve, but providing the maximum information of the cam dynamics to the rocker arm with the ultimate least amount of wasted motion. This additional motion, found in all previous rocker manufacturers, required the crank to turn additional degrees of rotation to effect the same amount of cam lift "at the rocker arm." Miller's MID-LIFT principle of design set in stone a formula that would apply to any valve lift, provided the engine builder set the "installed geometry" for the net valve lift of the engine, a mandatory task with any rocker. Finally, a standard! And in 1974, the phrase Jim kept using was coined: "Mid-Lift" becoming the terminology to a Patent application in 1978, that was filed in 1980 and issued in 1982. The **MID-LIFT Patent: #4,365,785**.

THE QUESTION

How could this be? How could an industry of multi-million dollar cam companies make such an oversight? Finding the answer to this confounding question became necessary. Within a year the answer would be known, but two years was spent confirming the evolution of rocker variations across several decades to bring this mistake to pass.

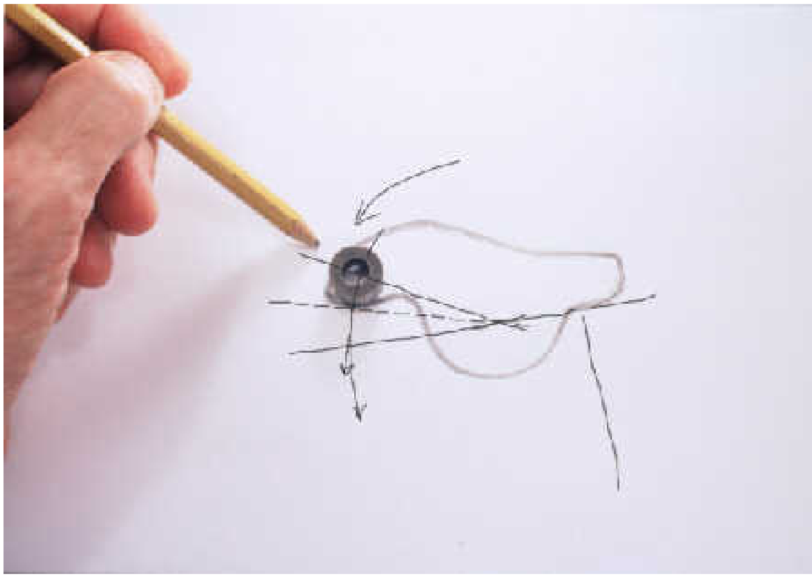
In 1958, Harland Sharp, an avid automotive enthusiast and hard working, innovative machinist, took a standard OEM stamped steel "shoe" type rocker arm and laid it on its side to trace its silhouette on a piece of paper. Knowing he wanted to place a roller tip on the end, he traced a roughly .600" diameter roller, placing the bottom of the roller's diameter on the same horizon as the shoe's contact pad of the original rocker arm. This was the mistake. He marked a center to this circle for the location of the roller pin, then using a scribe, he transferred his silhouette to a block of aluminum where he proceeded to machine his roller tip rocker body. Several years later, Harvey Crane asked Harland to make roller rocker arms for his company: CRANE CAMS. However, within a short period of time, Crane's excellent national marketing outstripped Harland's production capability, forcing CRANE to use other sources, eventually making them in-house. Having already established an identity with Harland's roller rocker arms, CRANE simply kept the same design basics which Sharp had been using, and the mistake was copied. During the 1960's, several of today's top cam companies began making their own line of rocker arms, and although many would no doubt argue that their design was unique to their own ideas, the fact of the matter is: that same mistake appears to have been copied throughout the industry... and except for some copy-cats pretending they have a "better geometry," it continues to this day. True story!

Today, the late Harland Sharp’s original legacy is carried on by the kid who used to sweep floors when Jim Miller was first flying to meet Harland in the mid ‘70s, and has since been passed on to his kids, two of the three sons who work at Custom Speed. Unfortunately, the original mistakes Harland developed continue to be replicated by the second and third generation inheritors of his company; where nothing has changed.

HISTORY OF MID-LIFT

THE ERROR

What was it?...



In much the same way the designing of a flat tappet cam is measured differently than the roller tappet cam, so too is the principle of design with a roller tip rocker arm. For on a "shoe" rocker arm, it is the bottom contact pad that has traditionally been used for angular measurement with the axis of the fulcrum (trunnion or shaft), but with a "roller tip" it is the axis of the roller that is used for angular motion. By placing the bottom of the roller on the same horizon as the shoe, the measurement was off by half the diameter of the .600" roller, or .300". In angular terms on the mall block rocker arm, this works out to more than 12 degrees of error. To set this in perspective, the rocker arm only moves 24 degrees or so for a valve lift of .600" making the rocker arm wrong by 50% of its motion, regardless of the pushrod length or the rocker's height to the valve tip!

The following page illustrates the detail of the design, and the error. By flipping back and forth between this page and the next, you will see the SHIFT in critical measuring points as they occur on the valve side of the rocker. Keep in mind that this page (above illustration) is what Harland did, and the following page is what he *SHOULD* have done. What you will see is the *middle line* of three pie shaped lines will move from the BOTTOM of the roller here, to the CENTER of the roller. This simple error is what shifts the PUSHROD side of the rocker off by more than 12 degrees.

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THE ERROR

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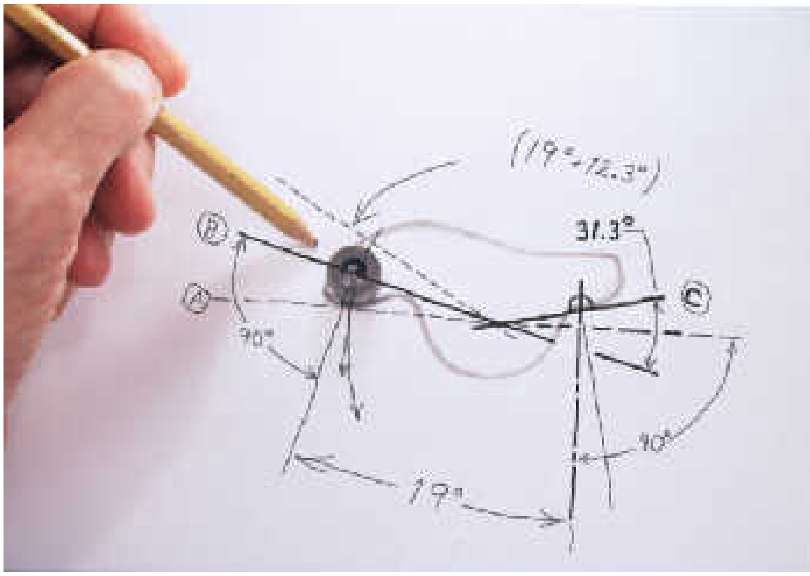

Line "A" represents the contact pad of the rocker, traditionally used for rocker design under the "**1/3 RULE.**" But with roller tappets or roller rockers it is the axis of the roller which matters, not the outer diameter, which is what Harland used, as shown. This moved the roller axis up by half of its .625" diameter. This extra .312" error had the effect of moving the push rod "cup" UP (shown as "C") by more than 12 degrees. The rocker arm only moves about 24 degrees, so no matter what pushrod length you choose, only one side of the rocker arm can be set for minimal back and forth motion, while the other end suffers. "B" represents this increased angle with "C" while the dashed line beneath "C" shows where MID-LIFT geometry should be.

Note: *The late Harland Sharp's background with racing interests dated back to the 1950's, when many of today's largest and most well known companies were first beginning. The hand written notes and drawings from Harland, during the 1970's when he made custom designs for Jim are still kept as a reminder to the simple legacy of this history*