POCA Technical Articles

Introduction

These articles were originated by POCA member Ted Mitchell and were designed to be inserted to the Ford Pantera Shop manual, also known as the Pantera Technical Information manual originally produced by Ford, for the Pantera. All of these articles are from the early days of POCA and do not include any of the latest technical articles as currently found in the newsletter. The authors are credited in each article.

Index

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Comments

GROUP 00

INTRODUCTION

As you can see, we are trying something new with the Tech articles. They are designed to be three hole punched and inserted into the appropriate section of your Shop Manual or kept in a separate notebook. The Group numbers and Group headings will be consistent with those used in the Shop Manual with the addition of a Group 60 for MISCELLANEOUS. I will follow up with an Index page, listing the Group numbers for those of you that want to keep a separate book instead of the Shop Manual.

With a little luck and some help, I will try to start reprinting some of the past Tech articles in the new format. I am excited about this and I believe that it will produce an excellent technical reference manual.

I would appreciate any comments, suggestions, etc. before we get too far along.

Group 00 will be used for comments such as this, and can be discarded instead of cluttering up your reference.....TM

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Wheels and Tires

GROUP 11

WHEEL OFFSET - PART I

by Ted Mitchell

The term "**offset**" as used regarding wheels, is often misunderstood, and is very important when matching non-stock wheels to your Pantera. When you order a non-stock wheel you must (or should) specify the desired offset. This is important for both looks and handling characteristics.

First, we need to define a few terms, so we are all talking about the same things.

1. **BEAD AREA**: The area where the bead of the tire seats. See figure 1 below.
2. **RIM WIDTH**: The distance between the INSIDE bead areas of the rim.
3. **RIM DIAMETER**: The diameter of the bead area.
4. **BACKSPACE**: The measurement from the mounting flange to the rear bead area.
5. **OFFSET**: The distance from the mounting flange to a point midway between the front and rear bead areas.

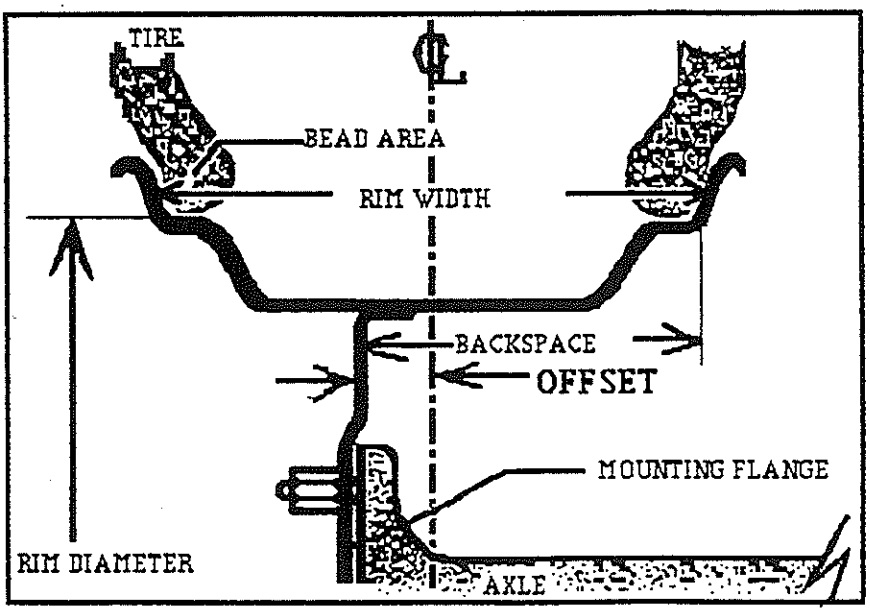

FIG. 1 WHEEL CROSS SECTION

You may have noticed that all of the above measurements involve the bead area of the wheel which is impossible to get to when a tire is mounted on the wheel. Even when the wheel does not have a tire on it, the bead area is very difficult to measure in relation to the other areas, such as the mounting flange. One hint is that on cast wheels, the metal thickness near the bead is approximately 1/4 inch; therefore if you measure 8 1/2 inches across the outside of the bead area, your **rim width** is 8 inches (8 1/2 -1/4 -1/4). Steel wheels are about 1/8th metal thickness, so a 8 inch rim would measure about 8 1/4 inches across the outside.

Now, the PANTERA came with 7 inch rims on the front and 8 inch rims on the rear. With the proper **offset** and tires, you should be able to run up to 8 inch on the front and 10 inch on the rear with no real problems; BUT what is this **offset** jazz?

Offset is defined as the distance between the mounting flange and the rim centerline. This distance is termed positive when the mounting flange is outboard of the rim centerline, and negative when inboard. In other words, deep dish wheels (sometimes called "reverse rims") have negative **offset** Stock PANTERA wheels (7 and 8 inch rims) have positive **offset**.

The difference between positive and negative **offset** is so confusing to most people, that many dealers and manufacturers will ask for the desired **backspace** instead. This, with the **rim width** defines the design of the wheel. Looking again at FIGURE 1, you can see that **backspace** is one half of the **rim width** plus (or minus) the **offset**.

OFFSET IS IMPORTANT

Why? For looks, it determines where your tire fits in the wheel opening; but more importantly, it determines if your tire and wheel will clear other parts of your car, the load on your wheel bearings, and the handling characteristics.

Since I have covered this point before, I won't get too involved in the explanation. The steering geometry of your car was designed to work with a certain offset in your front wheels so that the steering axis would intersect the ground ideally at the point of tire contact. When we change the **offset** of the front wheels, we usually go to a negative **offset** for looks and/or clearance. We then move the tire contact out away from the steering axis. This causes the car to be extremely sensitive to forces on the tire, and we wonder why our beloved Pantera is darting all over the highway, following ridges, or when we brake. At the very worst it could even jerk the steering wheel right out of our hands when we hit a pothole.

So, when you change wheels, whether for a different make or a different **rim width**, try to keep the stock **offset** or very close to it, OR pay the consequences!

O.K.! What is the stock **offset**? I just went out and measured a set of early wheels, which should be the same as the later wheels, and came up with the following measurements.

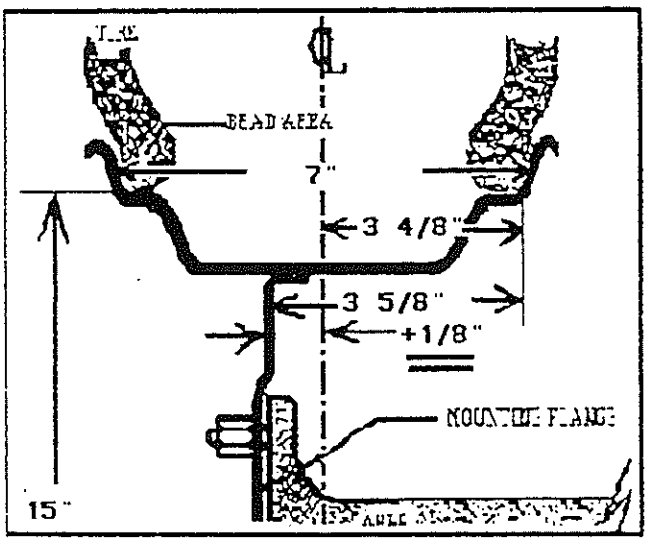

FIG. 2 PANTERA FRONT WHEEL

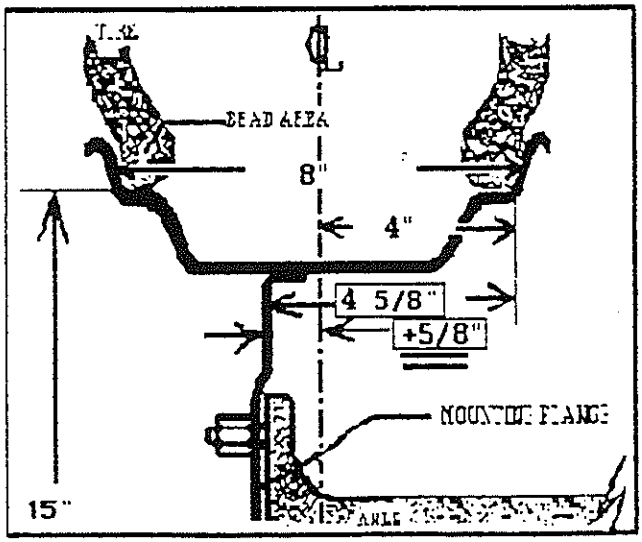

FIG. 3 PANTERA REAR WHEEL

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Wheels and Tires

GROUP 11

BIG WHEELS AND TIRES

by Bill Mason

I ran across this older article written by Bill Mason, which I thought fit in well with the recent articles on Wheel Offset. MM.

I don't know any Big Wheels worth writing about, so from here on, we'll call them wide wheels.

Wide wheels on the Pantera can be a great advantage they can also be a terrible disadvantage.

Nearly everyone agrees that the stock wheels on the car are not what we'd call great looking--but for getting the job done, they are the best. (We've all had girl friends like that.) The reasons they get the job done are the design and the material from which they're made.

Design wise, the shapes and spacing of the holes in the web (center) pump a phenomenal amount of air to the caliper and disc. This high cooling rate coupled with the 99% magnesium construction really gets the job done to help the handling. When the wheels are replaced by a set of spokes, or big heavy aluminum dudes, the braking action is hurt because of reduced airflow over the brake units, and the offset of the centerline is usually too much in the Brand X wheels, resulting in screwy handling.

We are all aware of the final results of High brake fade, but how about too much offset in the wide wheels? And having them both at the same time?

Going into graphs and charts at this point is useless, because if we all knew how to translate their results and apply them to the car we wouldn't need this article.

The centerline of the wheel should not be moved either way. The wheel alignment cannot be done, because centerline offset puts the scrub radius 6" to a foot below the pavement. This results in handling like the car had two seemingly flat tires in front and hockey pucks in the rear.

Besides ruining the braking and handling, the popular beauty wheels will also pound the suspension bushings out of the A-arm pivots. These are expensive to replace, and they also are responsible for excessive tire wear.

Gran Turismo has DeTomaso Campangola Mag wheels of the proper centerline dimension available up to 14" wide, for the racer, and 10" wide for street and race.

I feel sorry for any of you out there in Pantera land who have disposed or your original wheels.

Depending upon the manufacturer, there are many wide tires available in 7 and 8 inch rims. I used 11" wide Dunlops on my stock wheels and it was something else.

Ask anyone who rode with me in "01' Yaller", number 2049.

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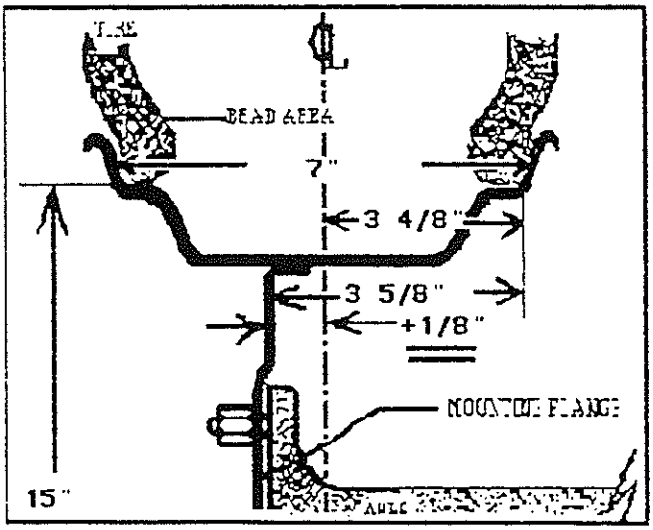

FIG. 2 PANTERA FRONT WHEEL

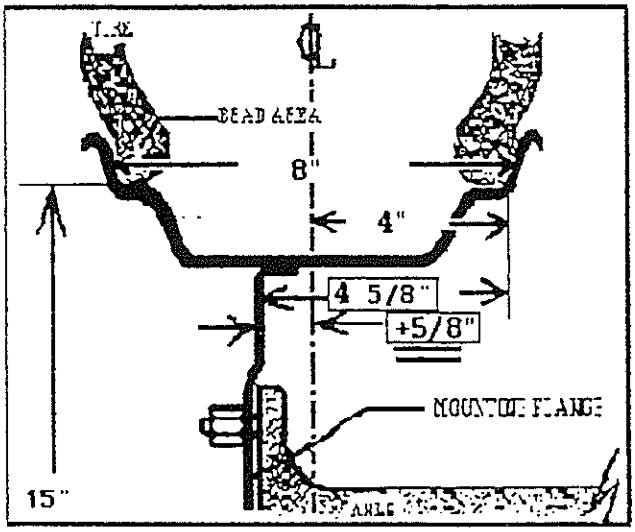

FIG. 3 PANTERA REAR WHEEL

The front wheels (Most important) have a positive **offset** of about 3/8th of an inch. So you should be O.K. with a 0 inch **offset** wheel. If you go to a negative **offset**, your car will handle like an untamed beast.

The rear wheels have a positive **offset** of about 1 1/8 inch. This is very kind on the outer rear axle bearing, and may have something to do with the bearing problems many of us with MONSTER rear tires, and their necessary negative **offset** wheels, are having. The negative **offset** in the rear wheels should not have any adverse steering characteristics like the front, but DOES effect the axle bearing and other suspension component loads.

I hope this article will spur some of you to submit measurements on the wheels for other applications, and I plan to follow up with the measurements I used for Darth Vader with the Group IV flares and the super wide Perelli's.

TM

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Brakes

GROUP 12

ABOUT PANTERA BRAKES - PART I

by Jack Richards

(M.M. Note: This is the beginning of a complete revision of Jack's series of articles on the Pantera brake system, so replace the original Part I, Part II, and the out of order Part IV.)

THIS IS NOT ANOTHER RACE CAR SYSTEM: These brakes are intended as an option to the original Pantera brakes. So, the replacement brake rotors are the same size and in the same location as the original equipment rotors. The new parts will not create problems fitting stock wheels, etc. And, these parts will not over-stress other stock parts such as axles, spindles, bearings, and the like.

These brakes are All-American. Every part is better than the O.E.M. item that it replaces, and the American pieces cost less than new original parts. Are you interested? Well then, read on!

The brake system is described, and can be installed, in "stages" of development. This step by step approach allows the car to be used and tested at each stage.

WHAT IT TAKES TO MAKE GOOD BRAKES: Good brakes alone will not bring a speeding car to a quick controlled stop. Everything on the car must work in harmony. The tires, spring rates, shocks, and suspension geometry are very important to good brakes. Also, the way the car is balanced must be in tune with the braking forces. A front heavy car requires quite different brake proportioning than a rear heavy car - like a Pantera.

And, there are still many other factors affecting brakes. Brake discussions can easily get lost wandering through this maze, and I don't want to do that. Even so, I must talk briefly about wheels and tires, about brake fluids, and about Pantera peculiarities. After that, I'll spend the remainder of my words on the brake parts that will work best on your Pantera.

THE RUBBER AND THE ROAD, ON TIRES: The distance from the center of the wheel to the outside of the tread where it touches the road is called the "rolling radius" of the tire. The rolling radius acts just like a lever on the brake caliper and rotor - a larger diameter (taller) tire therefore has more leverage than a smaller (shorter) tire.

Modern chemists have produced rubber compounds that give tires wide range of adhesive abilities, and - particularly with the very soft compounds - this characteristic changes as tires age. As you might imagine, any change of the adhesion between the tire and the road surface (the coefficient of friction) changes the braking balance of the car.

Pantera's are especially sensitive to wheel and tire changes for two reasons. (1) Pantera design is very much like a world champion race car. It's weight distribution, it's suspension, and it's rotational

axis are all completely different from traditional road cars. In fact, it's probably different from any other car driven by most of its owners. (2) Pantera has another similarity to modern race cars - taller and wider tires on the rear wheels than the fronts - and for the same reason. The rear tires are larger because they must take more scuffing, and they must dissipate more heat than the fronts.

Early Pantera GOODYEAR Arriva's are: LOCATION - SIZE - HEIGHT - TREAD R/ tire . H60V15 = 26" X 9" F/ tire C60V15 = 23-3/4" X 7"

Similar new GOODYEAR EAGLE VRs are: LOCATION - SIZE - HEIGHT - TREAD R/ tire P255/60VR15 = 26-1/2" X 8-1/2" F/ tire P225/60VR15 = 25" X 7-1/4"

These tires certainly are BIG & little enough. But, many Pantera owners use big fender flares to mount tires with even greater differences to create a JUMBO & tiny look. Tires effect handling and braking more than any other single item. Yet some owners make such changes with no thought about braking. As the difference in tire size increases it produces an even greater disparity in the braking balance of this car.

PANTERA DESIGN PECULIARITIES: For those of you who really haven't already noted them here is a brief list conditions that must be considered in working on Pantera brakes: (1) A Pantera's weight distribution is about 40/60, front/rear. (2) Hard braking shifts this weight forward. In front heavy (front engined) cars over 60% of the braking load goes to the front wheels. But, place a Pantera under hard braking, and the force loads tend to even out the weight of the car, so the load on the front and rear brakes is also nearly equal. So a Pantera's peculiar (for a non-race car) weight distribution means that the rear brakes do as much work as the fronts - that's why race cars are balanced like this. However, the rear brakes must be weakened, just-a-little, so that the rear tires never slide before the front tires, and that's where brake proportioning comes in. (3) Like Pantera rear tires, the rear rotors are larger than the front rotors -just as they should be. But the original rear brake calipers are much smaller than their front counterparts - and this is not as it should be. (4) The original Pantera hydraulic proportioning valve reduces pressure to the front brake cylinders so that the weak rear cylinders will work - again not as it should be.

MY PANTERA WAS EVEN WORSE THAN STOCK: As I have mentioned in previous articles when I bought Pantera #5272 it had front end damage, and I rebuilt most of the car before I drove any Pantera. So when I put this car together I installed a Ford/Courier master cylinder. I replaced all of the original brake lines with stainless steel hard lines and braided-stainless steel soft lines. I also took the front proportioning valve out of 5272s brake system. This left the car with a brake balance that was just awful. If you know anything about Pantera brakes you know the results - the front brakes locked up before the rears even took hold.

But, the ridiculously small rear calipers are reason that a stock Pantera brake system is so poorly balanced. Reducing front hydraulic pressure to compensate for these weak rear calipers just robs the car of its true stopping potential. I wanted to beef-up the rear calipers.

BRAKE FLUIDS, GLYCOL / SILICONE: The "life blood" of any brake system - the hydraulic fluid. Automobile manufacturers nearly all use glycol base hydraulic fluids, as does the stock Pantera. But some after market suppliers tout the silicone base fluids.

Pantera owners who have had old glycol fluid go bad and freeze brake pistons may want to try silicone. So, let's spend a few words on this subject. I have used silicone brake fluid for years in some cars with good results. It has several advantages over conventional brake fluid. Silicone fluid does not absorb water which causes oxidation, rust, and brake piston seizure in systems using glycol fluid. Silicone fluid boils at a much higher temperature than glycol fluid. And, unlike glycol fluid, silicone fluid is harmless to paint when that inevitable spill or leak occurs.

But Silicone fluid has other characteristics not desired in a brake fluid: (1) Under normal running conditions silicone fluid is slightly more compressible than a good glycol fluid. (2) As brake fluid temperature increases silicone fluid becomes progressively more compressible while glycol fluid remains fairly constant. However, in race cars heat builds up rapidly, and in anything longer than a twenty minute sprint the compressibility of silicone brake fluid is just not tolerable. So, most racers hate silicone brake fluid. (3) Silicone fluids can also create problems when used with some types of rubber often found in brake systems. Silicone fluid users have complained of swelling rubber O-ring seals when switching to silicone fluids. I haven't had any problems of this kind, but I've used these brake fluids only in American brake systems, and I suspect that American rubber is less susceptible to this problem than is the European variety.

In my opinion, silicone brake fluid is not practical for most Pantera owners -only those who totally change brake systems to American parts, and who are willing to accept a little softness in the brake pedal. But, this compressibility makes all silicone fluids totally unsatisfactory for the Pantera clutch system.

HYDRAULIC BRAKE SYSTEMS, BASIC PHYSICS: In any given hydraulic system the hydraulic pressure is measured in pounds per square inch / p.s.i., and that pressure is the same throughout a system (forget proportioning valves for a minute). Anyway, differences in hydraulic piston sizes, (measured in square inches of surface area) create predictable mechanical advantages just like levers. Reducing the piston size at the brake pedal end means that less foot pressure is needed to produce the greater brake piston pressure on the brake pads. Leverage is calculated simply by finding the surface area of the master cylinder piston as related total surface area pistons in any particular caliper - remember the formula from your high school math, the area of a circle = 3.1416 X (radius X radius).

In comparing brake parts, or drawings of brake parts, you may find one brake caliper with small pistons and large brake pads, while another caliper has large pistons and small brake pads. Don't let these differences confuse you. Remember that a caliper's power comes from its total piston surface area as related to the master cylinder p/s/a. Pads relate to the rotors in a brake system like tires relate to the road. Pad & rotor size, type of material, and design, in combination, determines the cooling efficiency and wear characteristics of these brake parts, just as those same factors determine tire wear. All other things being equal, small pads and rotors will over-heat, fade, and wear out quicker than larger ones. But, braking or hydraulic power comes from hydraulic pressure / psi, and that results from the relative piston surface areas of the parts in the hydraulic system.

MASTER CYLINDERS: In modern hydraulic brake systems the brake

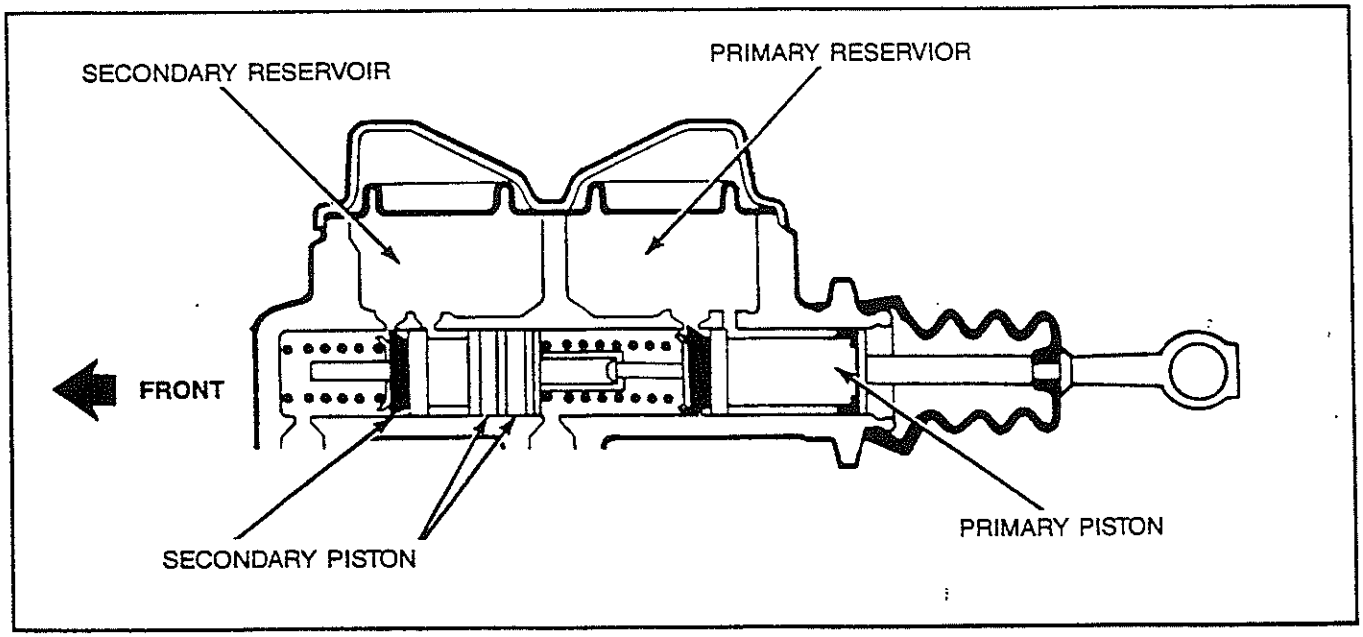
pedal actuates a dual piston, called a "dual master cylinder" (see drawing on next page). The dual master cylinder separates the hydraulic fluid into two systems, with each system serving two wheels. These can be split front / rear, side / side, or diagonally. For Pantera purposes the front / rear division is the obvious choice because of the rear weighted car and the built-in weak rear brakes.

A QUICK CURE FOR THE WEAK REAR BRAKES: Some owners are doubling up on rear calipers by adding another set of stock units to the extra mounting lugs on the front side of the rear suspension uprights. And, they report that this change makes a great improvement. All that is required to make this "quick fix" is a "Y" fitting in the hydraulic line so the extra flex lines can be hooked up, one to each of the four rear wheel cylinders.

WHAT I DEMAND OF A BRAKE SYSTEM: The "quick fix" solution doesn't appeal to me. Too many things about the O.E.M. brakes offend me. The original rotors are large, but unvented rotors on a 3400 pound car are not efficient heat radiators. And, those heavy steel Pantera calipers with asymmetrical pistons and those bleed screws that require a power bleeder. However, the calipers I liked made no provision for a parking brake (required by California law). The extra mounting lugs on the rear upright helped solve the parking brake problem. Using those as a starting point I kept the original parking brakes, while I replaced other brake parts in stages until I was rid of most of the unwanted parts. The trick was determining which parts would work well together, and then adapting them.

Next month we'll get into the actual choices of the new parts.

J.R.



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Brakes

GROUP 12

ABOUT PANTERA BRAKES - PART II

by Jack Richards

I'm a long time member of the local Cobra club, and I take one of my cars to a road race track with this group twice a year. During these times I flog around the circuit in ten or twelve lap sprints - sometimes for thirty minutes at a time -and then I come in to check on things, rest, and pet the beast. The brakes that I'm describing in this article are not racing brakes, but - based on this experience - these brakes should perform well in similar circumstances, and much better than stock Pantera brakes in any event. They will certainly take more hot laps than five or six [illegible] of uncooled oil in a stock pan [illegible] read on the street radials.

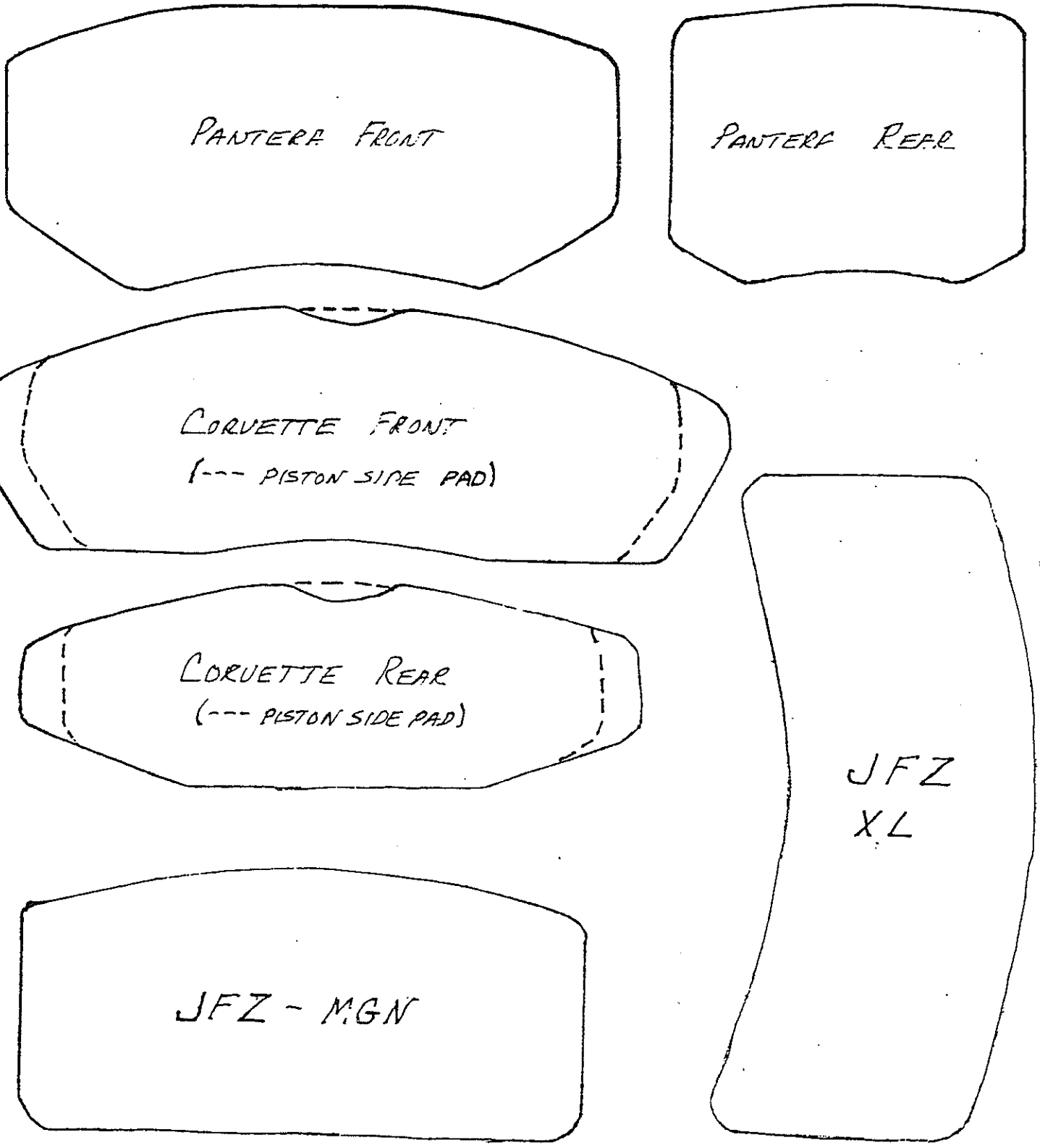
I believe that the brakes on a high performance car should work just as well when the engine is not running, and that means eliminating the vacuum booster. But, I know that many owners like the light braking effort that the booster allows, so I have tested this system first with a booster. Later, I'll eliminate the booster, go to a better master cylinder and pedal assembly system, and test some more - you'll read about this when I get to it.

About that Pantera vacuum booster -think about this little scene. You're attending a POCA event at your local road race circuit. You and the Pantera are traveling at about mach-1, the engine sounds like rolling thunder, and your ears are blocking your smile, as you arrive at your normal braking point. There's this bang, and the thunder becomes silence. You nail the brakes - but the engine has quit - there's no vacuum assist -AND ALMOST NO BRAKES! It's bad enough to blow an engine, but what about the rest of the car when that on-rushing turn arrives and your brakes don't. I repeat, I want brakes that work at all times.

SELECTING WHICH BRAKE PARTS TO TRY After a thorough inspection of the Corvette brake parts I found most of them unsatisfactory for the Pantera. All but the newest (1988) Vettes have single piston floating calipers that I do not like - the '88s have two piston floaters. The G.M. bean counters no doubt like these calipers because one cylinder is cheaper to make than four. But, no EXOTIC GT car worth mentioning uses this type of caliper because four piston calipers are better. By the way, if you're one of those persons who must have the biggest and best, GNSC has a six piston caliper. In short, Corvette brakes would not improve the Pantera (See the drawings of caliper pads, next page).

About the Grand National Stock Car / GNSC (racing) brakes that I also proposed trying. These guys run regularly at 200 mph, and they don't run vacuum boosted brake systems. But GNSC brakes had other problems that made them unsuitable for most Pantera owners. These brakes are for real racing, and adapting them to a

BRAKE PAD COMPARISONS



Pantera would require offensive and expensive modifications or additions to other parts of the car - like larger spindles, hubs, bearings, and oversized wheels. And, all of a sudden we've got a racing system, and not what I wanted -not yet anyway. So the GNSC conversion was also eliminated from testing.

After eliminating the Corvette and GNSC brake systems, all I had was an incomplete assortment of parts from several manufacturers. But with anything automotive, hotrodders and race people are still the best sources of information and parts. So I continued contacting local purveyors of this type of hardware. And I filled in the needed parts. The completed system is still from several manufacturers, but it all fits beautifully together. And, these are American parts that any Pantera owner of modest means can adapt to his car at home in the garage.

Most Pantera owners don't have machine shops, so making these changes will require some hired machine work, but it isn't much, it isn't complicated, and it shouldn't be expensive. A machine shop is needed to redrill two Chevy rotors for the Pantera rear axles. Other machine work, such as caliper adapters and front hubs, the owner may choose to hire made, or those owners may purchase these pieces from ready made sources, because, I have a small supply of these parts, and nearby me are shops that are already set up to produce the hubs and adapters as needed.

PANTERA - AMERICAN BRAKES, THE REAR END: By using a special made adapter an excellent aluminum four piston brake caliper made by JFZ* fits the unused bracket on the forward side of the stock Pantera hub carrier. These adapters and calipers work on the Pantera original equipment rear rotors **and** with a much better rotor - one with a Corvette part number.

Because the G.M.& Pantera rear rotors are so similar the G.M. rotor can be used to replace the Pantera rear rotor at anytime, and the same calipers and adapters are all easily refitted. It's a better-than-stock balanced system - simply by adapting new calipers to the front side of the rear rotors and moving the rear hydraulic flex lines from the old calipers to the new. The flex lines removed from the original wheel cylinders easily reach the new calipers.

This G.M. part is a late model Corvette FRONT rotor. It is 11-1/2 inches in diameter by 13/16 thick, and has a cast-in hat - all very much like a Pantera REAR rotor. If you lay this Chevy (front) rotor beside the Pantera (rear) rotor you'll notice two things. The superior quality of G.M. rotor makes the Pantera part look like junk, but in overall size and shape, the two parts are almost identical.

FITTING AND REFITTING THESE PARTS: Like the original equipment rotor, the G.M. part mounts under the rear axle hub -not the best way to mount a brake rotor -it makes changing the rotor difficult -and it unnecessarily transfers unwanted heat from the brakes to the wheel bearings. Race car makers just slip the rear rotors over the outside of the wheel lugs, so that the rotors are as easily changed as tires.

Measurements of the G.M. and Pantera rotors will show some differences that must be considered. The Vette rotor-hat has a little over 1/8th inch MORE offset than the stock Pantera item. AND, the Pantera rotor actually has 1/16" larger circumference than the G.M. part. A 1/16th of an inch closer rotor edge-to-caliper clearance will usually require no change. If the edge of the rotor rubs the caliper any brake shop can quickly restore clearance by turning a few thousandths of an inch off of the edge of the rotor. The 1/8th inch offset difference is even more easily handled, and we'll

deal with that in a minute.

But first the center of the Chevy part must be redrilled to a Ford/Pantera bolt pattern, and the center hole needs to be enlarged slightly to register properly on the Pantera stub-axle. These are simple jobs for even the most rudimentary machine shop. And, considering that the result is a vented rotor that is superior to the stock item in every respect, it is well worth this small trouble. After the rotor is assembled to the axle and inserted into the upright, check for interference between the rotor inner rim and the caliper boss on the upright. Casting differences may cause conflict between the Pantera & Chevy parts where the inside rim of the Chevy rotor passes closest to the Pantera caliper mounting boss. If this happens a little filing on the corner of the caliper boss will quickly restore necessary clearance. These reworked Corvette rotors have a number of advantages over both stock parts and other more extensive brake modifications: (1) With these rotors the original Pantera parking brakes may be used. Stock calipers may be remounted in their usual place. Just insert 1/8th inch thick spacer-washers between the caliper and the mounting face on the Pantera upright. This spacer compensates for the extra offset of the Chevy part thereby reestablishing the proper caliper location. Then, hook up the parking brake cables - but not the hydraulic lines. (2) Adapters which fit JFZ calipers to the Pantera rotors will also mate them properly to the newly mounted Corvette rotors. Insert spacer washers under each adapter and mount the caliper on the front or unused boss on each rear up-right, and hook up the Pantera hydraulic line. I repeat - the flex lines from the rear-of-the-rotor calipers reached the front-of-the-rotor ones perfectly. (3) One final benefit! These rotors are available at your local Chevy dealer, and they currently retail for around 65 dollars each - and who pays retail??

REAR CALIPER PARTS AND NUMBERS: JFZ - MINI GN DUAL CALIPER. These calipers all have four pistons. The two part numbers suitable for Pantera rear brakes are: JFZ MGN 175 (B) part # 002-0057 JFZ MGN 150 (B) part # 002-0347 The first part has 1-3/4" pistons, and the second has 1-1/2" pistons. The original Pantera rear caliper has one piston about 1-1/8 inches in diameter. In other words, the JFZ pistons have 9.6 / 9.4 square inches of surface area, while the Pantera's single piston has only 1.6 s/i of area - which is really 1.6 X 2 because a floating caliper uses both the piston and the caliper back wall to apply force to the rotor.

REMINDER: Now it's time to remove that stock proportioning valve from the front brakes so that they'll get full brake pressure for the first time ever. Because, with the recommended JFZ calipers in place the rear brakes have triple their original stopping power. With that front p/v removed the system will be nearly in balance, and you will immediately notice a big improvement in the brakes. But, achieving a completely balanced system will only come with the ability to "fine tune" the brake proportioning.

There is one small trade off in adding bigger rear calipers - the brake pedal will sink an inch or so more than usual before it gets firm. This lower pedal results when more fluid must move from the master cylinder to fill the eight cylinders in those two new calipers. But when you try these brakes, I think you'll agree that a slightly lower brake pedal is easily forgiven in trade for the improved stopping power.

Restoring a high brake pedal can be accomplished by changing to a larger bore master cylinder. So far in this project we've only added new rear calipers, or "stage one", and changing master cylinders is not necessary at this stage.

FINE TUNING THE BRAKE PROPORTIONING: Race cars adjust brake proportioning by two different means: (1) The best brake proportioning device is a balance bar that has a pivot between TWO master cylinders which divide the front and rear brake systems. An adjustment allows the pivot to be moved along the balance bar until perfect proportioning is achieved. The proportioning thus established is certain and repeats exactly every time. (2) The other device is a brake proportioning valve that reduces the pressure in one end of the hydraulic system. Proportioning valves (or p/v's) were first used in production cars with front disk and rear drum brakes because of the inherent differences in these two types of brakes. P/v's worked okay for that purpose, and such a valve will also serve to make minor hydraulic pressure adjustments between the front and rear sections of an all disk brake system. It is the second best method of brake proportioning - chosen because it works with the original master cylinder and pedal assembly - and it works well enough. Just don't expect a p/v to restore order in a grossly unbalanced system. After achieving a well balanced brake system, a p/v is the simplest (and the cheapest) way to fine tune the balance between front & rear braking power to the changes in tires, using fuel, or adding luggage.

This p/v must be easily accessible for necessary adjustments, and it should be someplace relatively clean. One good location is next to the master cylinder inside the front trunk. Another good mounting place for this valve is on the drivers side of the center tunnel just forward of the shift gate - and that's the spot I chose. With the p/v mounted like that on the central tunnel, the hydraulic lines run from the valve back along the corner of the tunnel and floor through the speedo-cable hole in the fire wall.

The proportioning valve mounted in this location can be adjusted while driving, and no hydraulic lines in the car were cut to make this installation: Just inside the engine compartment these lines interrupt a factory connection in the rear brake line. A fitting near the lower front of the line from the master cylinder was loosened so that line could be rotated 180 degrees causing the "L" at the other end to face that proper direction to mate with the line from the new proportioning valve.

PROPORTIONING VALVE, PART NUMBER: Kelsey/Hayes Products** adjustable proportioning valve part number 12580. PRICE . . . . . about $65.00

PANTERA - AMERICAN BRAKES, THE FRONT END: With a strong rear braking system AND a proportioning valve to trim it properly it's time to upgrade the front stoppers.

On the rear brake modifications the rotor chosen was almost interchangeable with the Pantera part, and this allowed a lot of flexibility in applying the parts to the car. However, on the front brakes the problem was very different. So - I'm sorry but, with the this system - the front brakes must be done completely or not at all. Also these front JFZ's 9.6 / 12.6 square inches of piston surface area replaces 5 s/i in the stock front caliper, which means the front JFZ caliper grips the rotor with roughly double the power of the stock Pantera caliper

AND also the JFZ's take considerably more fluid from the master cylinder. So, when you go to this system you will also need to think about going to larger bore master cylinder - AND I'll get to that in a minute.

THE FRONT CALIPERS, PART NUMBERS: JFZ MGN MGN175 (B) part # 002-0093 JFZ XL 200 part # 002-0216 PRICE . . . . . about $100.00

NOTE: When ordering the XL SERIES caliper you must specify that this caliper be made for a one inch thick rotor.

PANTERA FRONT HUBS AND CALIPER ADAPTERS: For those owners interested in undertaking this project I can now offer either detailed engineering drawings of these parts so that you can duplicate them in any material you choose, or I can supply the parts in tempered aircraft grade aluminum from available supplies while they last.

Mild steel or 7075-T6 aluminum billet hubs may be available in the future subject to demand. I now have a few sets of hubs made from 356-T6 aluminum castings. These hubs are shipped with grade eight bolts (for mounting TCI rotors). bearing-races are already pressed in place, and new caged bearings are included the package.

AMERICAN FRONT ROTORS: TCI / Magnum Axle in Ontario, CA. makes an 11 X 1 inch rotor (the same size as a Pantera front rotor) and it is an ideal replacement part. The TCI rotor is flat and bolts to the back side of the front hub, which means that it's easily serviced and / or replaced. It is a very nice vented rotor. PRICE, about $70.00

AMERICAN MASTER CYLINDERS: When I started this brake project my car already had a 1983 Ford Courier master cylinder adapted to the stock Pantera vacuum booster via a Gary Hall adapter kit. The bore in this master cylinder is nearly identical to the stock Pantera m/c (22 mm / .866" bore). In conducting brake tests of the system described in this article I continued using this master cylinder. I wanted to see how these brakes worked before I recommended this brake system to those owners with stock system. However, I plan to change this m/c to eliminate the brake booster for reasons I've already given, and I'll report on that when it happens.

This master cylinder works, but it does not have sufficient volume for the four JFZ calipers. Moving enough fluid to fill those big JFZ's takes over half of the brake pedal, and most owners would find that a panic situation. So, "stage three" is find and adapt a suitable master cylinder.

My Pantera is at "stage two" - I have not yet changed master cylinders. But, for those of you who want to keep the original pedal assembly, I am told that G.M. makes a dual piston Corvette cylinder with a 1-1/8" bore that should be about ideal size for achieving the proper fluid volume.

At "stage three" I want to remove the proportioning valve, replacing it with two master cylinders and a new balance-bar type of Pantera pedal assembly. I don't know of anyone currently making such a part, so I plan to produce one. If this ur... proves out I'll make it available to other owners.

JFZ Products has some very nice master cylinders for "stage three" of this project. The JFZ master cylinder that I have in mind has an integral fluid reservoir, and the cover has a spring clip retainer. The working parts of this unit are all contained in a cartridge (cylinder bore and piston assembly). These inserts come in various bore sizes (5/8, 3/4, 7/8, and 1"), and they're all interchangeable within the same housing. Rebuilding this master cylinder in the car is a snap Changing pedal leverage by reducing or increasing the bore size is also simple. And the beauty of it, three compact and identical housings will operate the front brakes, rear brakes, and clutch.

More, next month. J.R.

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Brakes

GROUP 12

ABOUT PANTERA BRAKES - PART III

by Jack Richards

CONFLICTING ADVICE & INFORMATION: In my contacts with various hotrod and racing people I accumulated a lot of information and advice, and I could not have completed the work without this help. But I also met with a lot of conflicting information and advice. In this regard I considered the source. Then I tested and compared parts after which I used my own findings.

During the process of selecting and adapting these parts various people volunteered that the following facts: (1) The brake rotors I was using wouldn't be adequate for the Pantera in either size or venting ability. (2) The rotors were okay, but (3) The calipers I had would burst apart with from the brake line pressure they would be receive. (4) The calipers were certainly strong enough to handle the pressure, but (5) The brake pads in these calipers weren't large enough to transfer the heat they would receive. (6) The brake pedal would be unbelievably spongy, and (7) The only way to stop a Pantera fitted with the brakes I was considering would be to run it into a bridge abutment.

Well!! I thought, "These people are all considered brake experts, and I'm not." And, I was badly shaken. But, these are the views of specialists - like drag racers or grand national stock car racers. Their cars run under conditions which apply to very few (if any) Pantera owners, and certainly not to me. So, I invite you review these comparisons, and the results of my testing.

I have already described the replacement brake rotors. Compared with original Pantera parts the new parts are of equal size, and the cooling efficiency of the new parts is better than that of the stock parts.

The JFZ calipers are both lighter and stronger than the Pantera parts that they replace.

I've gone through the mathimatics of hydraulics and demonstrated the superiority of the replacement system from the standpoint of hydraulic power.

The only remaining items to be compared are the brake pads. JFZ provides five (5) grades of pads: soft, medium, hard, super, and metallic. Soft pads work better cold / at low speeds. The harder pads work better hot / at high speeds. The super pad is something new and is supposed to be the best of both worlds -it works well hot-or-cold and at low/high speed. It just wears out faster when hot. As I said before the size of a pad is also a factor of its ability to stand wear and heat. Bigger pads generally last longer than small ones. Pad sizes of various cars are depicted on pg 2 of Part II, so that you can visually compare them.

As of now I have only driven 5272 on the street, testing the brakes

at all speeds under 100 mph. I haven't gotten to drive this car any hot laps on a road race circuit to prove my assertions as to it's track durability. But, 5272 will certainly go to the track at our next Willow Springs event in October, and I'll give it a thorough shake down at that time.

The results of the street testing: (1) In street and highway driving when I apply these brakes vigorously my Pantera stops like it's hit a molasses lake. (2) Because the current master cylinder is small for the large wheel cylinders that I'm now using the brake pedal is lower than I would like, but it remained the same both in level and in feel during repeated hard test stops. (3) Because I'm still using the original vacuum booster the brake pedal is spongier than I like, but it is not any spongier than it was with the stock brakes before I made any changes. JR.

MANUFACTURERS MENTIONED IN THIS ARTICLE:

*JFZ Engineered Products
440 E Easy St. unit 3,
Simi Valley, CA 93065
phone 805/581-3594

WARNING! SEE LETTER, PAGE 3, PART III

**Kelsey/Hayes Brake Products
Proportioning valve
Available from:

Stock Car Products
11904 Burke St.
Santa Fe Spr, CA 90670
phone 213/698-9913

Longacre Inc.
14752 NE 95th St.
Redmond, WA.98052
phones
800/423-3110 orders
206/885-3823 tech. in WA.
818/997-8644 tech. in CA.

MM Note: After Jack Richards excellent article was prepared, and part of it published, a letter from JFZ' President, Mr. John F. Zufelt, was recieved warning that some of their calipers that were being proposed by Mr. Richards were not suitable for the application. I felt that the article contains great information for the Pantera owner in understanding his car's braking system, and in evaluating alternatives. With the revised pages, indicating warnings, and the inclusion of the next two pages reprinting the original letter from JFZ, and Mr. Richards' reply to him, we are continuing Part III of the series.

I would warn all of you that any change or modification of original parts in any car, should be checked out thoroughly with the manufacturers of the proposed parts, and even then may involve an element of risk to the safety of the automobile.

PREMIUM QUALITY DISC BRAKES

440 E. Easy Street, #3
Simi Valley, CA 93065
(805) 581-3674

September 1, 1988

JRM Inc.
5148 Cape Tenez Dr.
Whittier, Ca. 90601

Re: Pantera News Letter

Dear Sirs,

An article in Pantera News Letter (copy enclosed) has come to our attention.

In particular I call attention to the use of JFZ Mini GN or MGN Calipers. These calipers have extremely high brake torque for their size as they are intended for racing applications where weight and size play an important role. These calipers in my estimation are extremely undersize and unsafe for this particular application. We have been involved with a few Pantera customers over the years as well as having very diversified experience with high performance street vehicles of all types and in my professional opinion this kit should not be marketed and in fact any kits already installed should be removed at once.

While we appreciate your consideration at JFZ we feel we have a responsibility in this case to point out the possible hazards that could result in the use of these undersize calipers. This could result in a crash, or death of the driver or occupants of the car.

If I can answer any questions regarding this matter, please contact me.

Sincerely,

John F. Zufelt
President

JRM Inc.
5148 Cape Tenez Drive
Whittier CA 90601

September 6, 1988

JFZ Engineered Products
440 E. Easy Street
Simi Valley, CA 93065

Mr John Zufelt:
Thank you for your letter directing my attention to the possible misuse of the JFZ MGN Brake caliper.

While developing the Pantera brake system I conferred with a number of people - both hotrod and engineering types (including some of your people). And during that process I received some conflicting advice. But I'm an old hot rodder myself, and - as you well know - hot rodders have often proved engineering dogma wrong in the past. Because of these experiences I often try something that looks right even when "experts" tell me it won't work.

During such experimenting the brakes pictured in the JRM ad were tested on the street, and I found that they perform very well with no sign of any weakness whatever. Your calipers must be better than you believe. However, these tests were limited to only a few miles, and the brakes have NOT been tested to the point of failure. Therefore, I will respect your advice.

I AM IMMEDIATELY WITHDRAWING THE PRESENT JRM SYSTEM USING THE JFZ MGN CALIPERS. ALSO, I WILL NEITHER SELL NOR RECOMMENDER THESE CALIPERS AS SUITABLE REPLACEMENTS FOR FACTORY EQUIPMENT CALIPERS.

Parts manufactured for racing are often not DOT approved for use on public highways, so this also may be a problem. But. the objects of my activities are to find parts that make the Pantera a better car and provide Pantera owners with alternatives to the factory parts - which have so often proven disappointing.

I would like to meet you soon to work out a solution.

Sincerely

Jack Richards
c.e.o. JRM inc.

cc: Monique Erickson, Ted Mitchell, POCA officers.
JRM/jr

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(714) 981-4807

Brake System

GROUP 12

PANTERA BRAKES IV, AND THERE'S STILL MORE

by Jack Richards

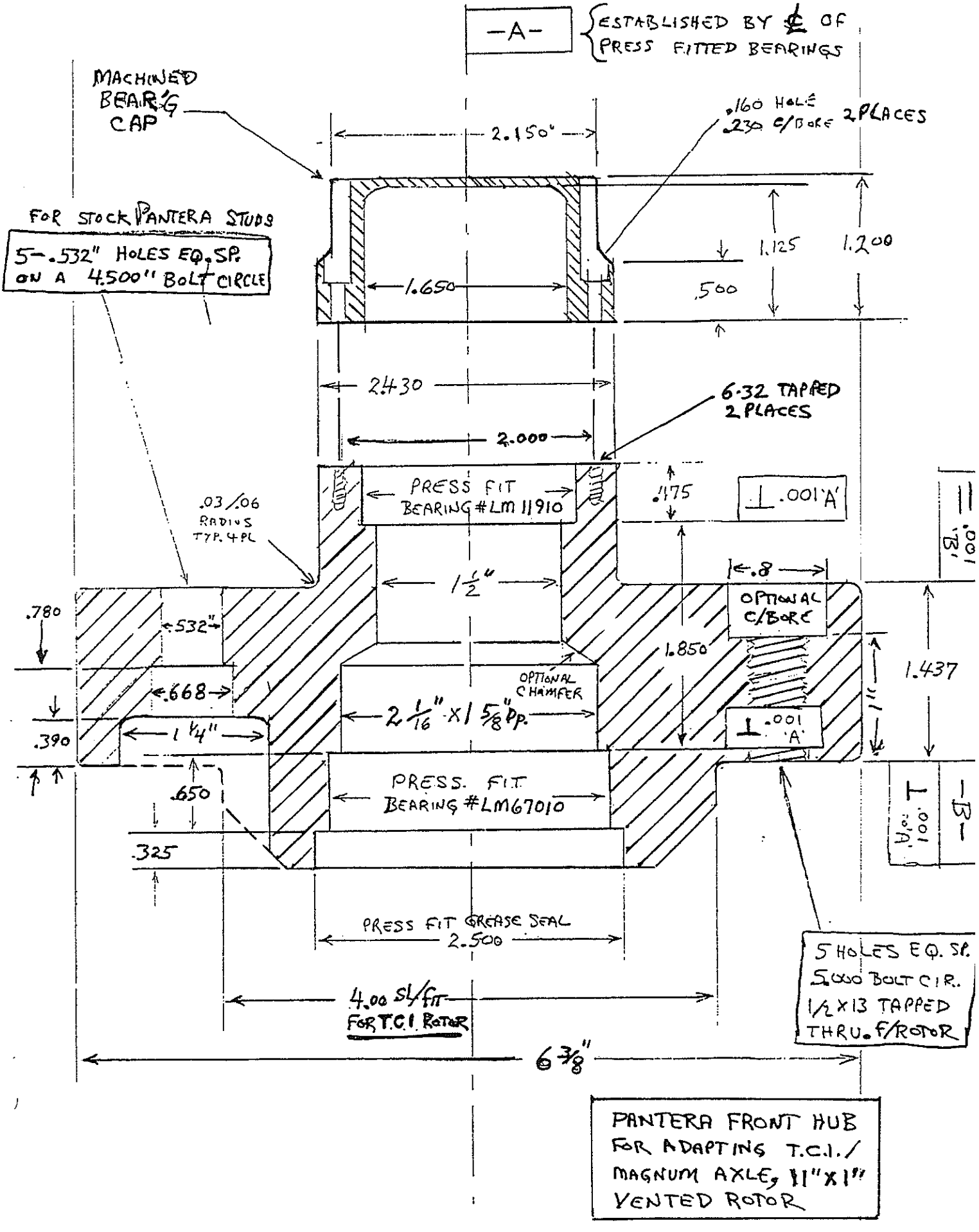
I thought that I could handle Pantera brake revision in just three articles. I was wrong. What's more, some of the previous information that I published was not entirely correct. The drawing of the Pantera front hub in my previous article was based on my inspection of a stock hub and the assumption that I could use the same rotor/wheel spacing for my replacement hub. The drawing (with only minor errors) accurately shows those stock dimensions, so you may want to keep it that reference. However, for machining a revised hub those specs served only as a starting point. SEE NEW DRAWINGS.

ALSO, since many of you have different tastes, as well as different resources, and budgets, I want to provide several options in braking revision. I'd like to include specifications for using: (1) TCI rotors /JFZ calipers, (2) GNSC rotors and calipers, (3) GNSC rotors /Corvette calipers to the Pantera. I say that I want to do this. I'm not sure it's all possible. But keep reading these articles and we'll find out what can be done.

So far this month I have machined prototype front hubs and caliper adapters to fit group one (1) parts to the stock Pantera front spindle. THESE ITEMS FIT PERFECTLY. The only modification necessary to the Pantera is the cutting off of the old stock Pantera caliper mounting bracket from the aft end of the steering arm. See the drawings on the attached pages.

For those of you who don't have machine shops available, I also hope to soon have a source where these hubs and adapters can be had for a reasonable price.

NOW, about the rear hub carrier and brakes, I've torn mine apart, and I've conferred with Master . Mechanic T.M. about the problems with the stock items. Some exciting things are brewing that might solve a lot of problems on this end of the car. But, I don't want to get ahead of myself again and give out bad information. So, it'll have to wait 'til I finish the front brakes.



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Steering

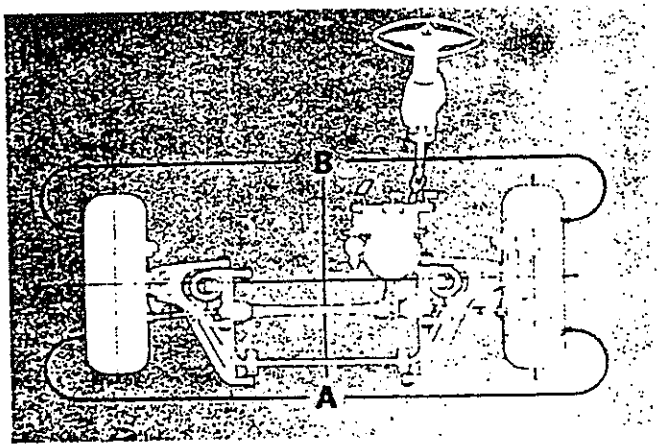
GROUP 13

STEERING SYSTEM ACCESSIBILITY

(MM Note: The following article is from the original Pantera Factory SERVICE HIGHLIGHTS and I thought it would be of interest to some of you.)

The Pantera has a highly responsive rack and steering assembly, the approximate turns lock to lock being 3:1 and a turning circle curb to curb of approximately 39 feet.

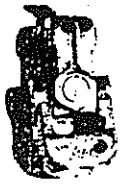
The basic principle of this type of gear is that the pinion which is driven by the steering column shaft, transmits a linear motion to the rack which through a simple tie-rod system, actuates the steering arms which are fixed to the vehicle front stub axle.

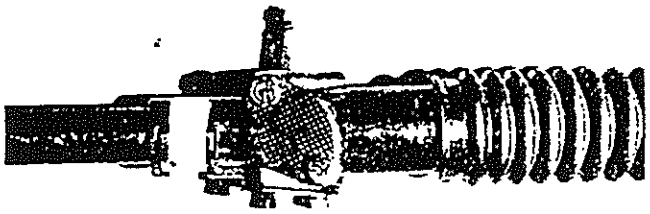


The rack inner ball joints are protected by rubber bellows. Oil is introduced into the assembly during manufacture and there should be no further lubrication required unless damage to the bellows is encountered.

The initial intent is to supply the steering assemblies as complete assemblies with the steering ball joints and rubber bellows, the only two service items currently available.

It is possible however, that at some time in the immediate future, individual steering assembly components may become available, and with this thought in mind we will include for your personal edification, full service instructions for the rack and pinion steering gear.





SERVICING INSTRUCTIONS FOR STEERING GEAR

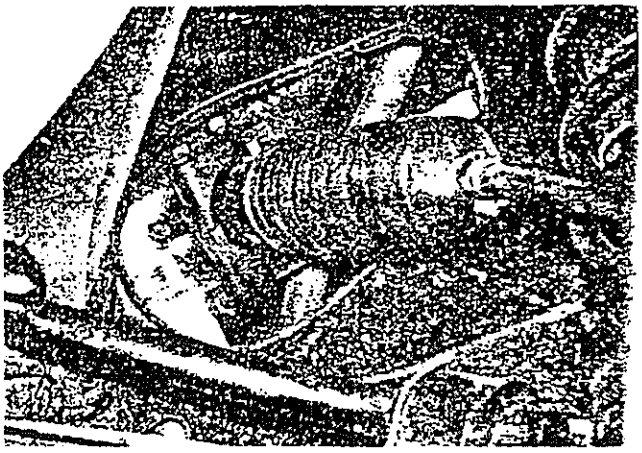
1. **Symptoms of Need for Adjustment**

   Need for adjustment will show itself as free play at the steering wheel together with lack of precision and steering wander; if the free play has a spongy feel it is probably due to wear in the suspension units or wheel bearings. Wear in the steering gear itself will usually produce a certain amount of lost motion which takes up very cleanly as the wheel is turned and the free play absorbed. This action will probably be accompanied by a knock which is transmitted to the steering wheel.

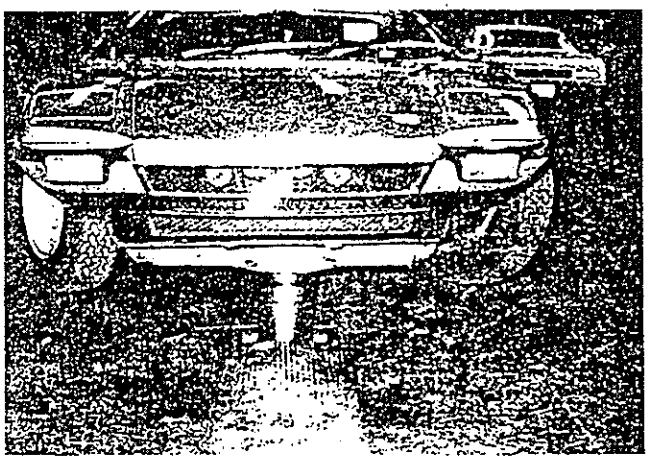
2. **Probable Causes of Excessive Wear**

   Loss of oil due to accidental puncturing of the bellows is the most common reason for excessive wear and the bellows should be checked for leaks during routine servicing. Providing the bellows are not

damaged by stones thrown up from the road, but remain oil tight, no topping up of the oil is required.

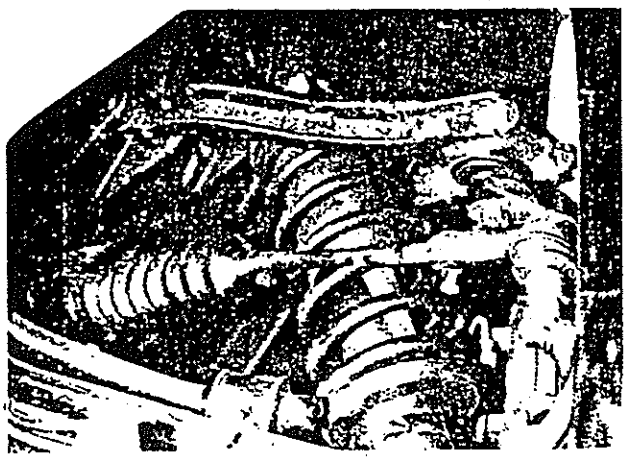


When the vehicle is jacked up the road wheels must never be swung rapidly from lock to lock. This im-



poses shock loads far greater than any produced by the most violent driving and may cause cracking and chipping of the pinion teeth, which in turn could cause seizure of the steering gear at some later date.

Removal from Vehicle



Remove the bolts securing the rack pinion to the lower column universal joint. Remove the left or right front wheel. Remove the nuts securing the ball joints to the steering arms and withdraw the ball joints from the steering arms. Remove the four (4) bolts, two each side securing the steering reinforcement bracket to the chassis front extensions. Remove the four bolts securing the mounting brackets and rack housing to the No. 2 cross member. Withdrawn the complete steering assembly.

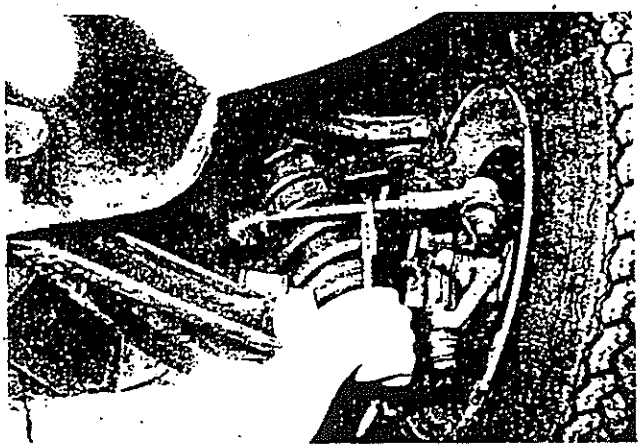
REPLACEMENT IS A REVERSAL OF THE REMOVAL INSTRUCTIONS

Checking for Wear and Damage and Dismantling

a. Bellows. Before removing bellows, deform them in various directions, checking for cuts and punctures.

Remove the ball joints and locknuts from the end of the tie rods, then the bellows may be removed.

Check the rubber covers of the ball joints for cuts and ensure that the ball pins move freely.



b. **Tie Rods.** Tie rods should articulate freely in any direction without being so slack as to fall under their own weight.

The spherical end of the tie rod is held between the housing and a spring loaded pad. A locknut is threaded onto the rack before assembly of the housing and flanges on this locknut are deformed into slots in housing and rack. When these deformations are pried up the housing may be unscrewed from the rack and the tie rod dismantled.

Check that the tie rod shank is not bent and that the portion immediately behind the head is not bruised. Check spherical seatings for signs of wear or fretting.

c. **Rack Support Yoke.** The yoke is held against the back of the rack by means of a helical compression spring.

Removal of the two bolts at the side of the main housing will permit removal of the yoke and spring. Shims will be found between the cover plate and housing (see adjustment).

Unless the unit has been allowed to run dry, excessive damage or scoring on the yoke is unlikely.

The yoke should not bind in the housing, and no excessive side clearance should be present.

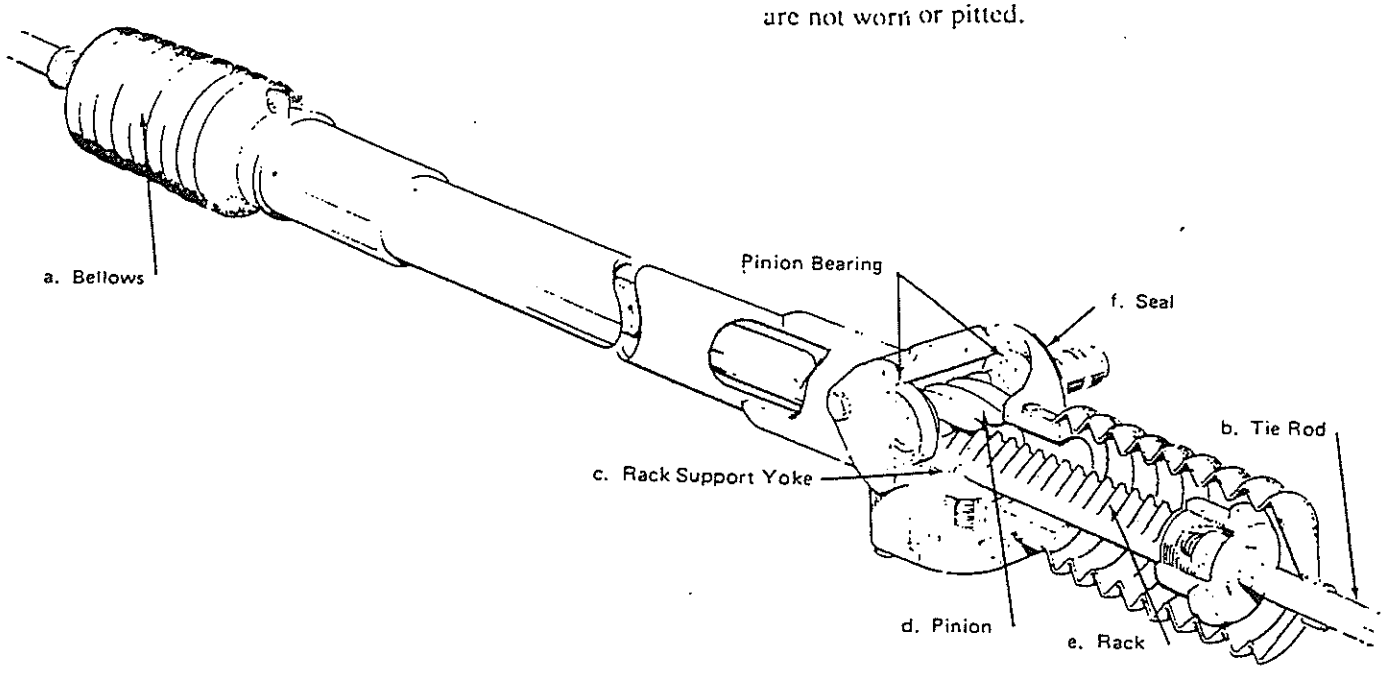
d. **Pinion.** After the rack support yoke has been removed the pinion may be withdrawn for examination. First wipe clean the pinion shaft in order to prevent damage to the seal. Remove two bolts and the cover plate above the main housing, then the shims will be found between the pinion bearing and the cover. (see "Adjustment").

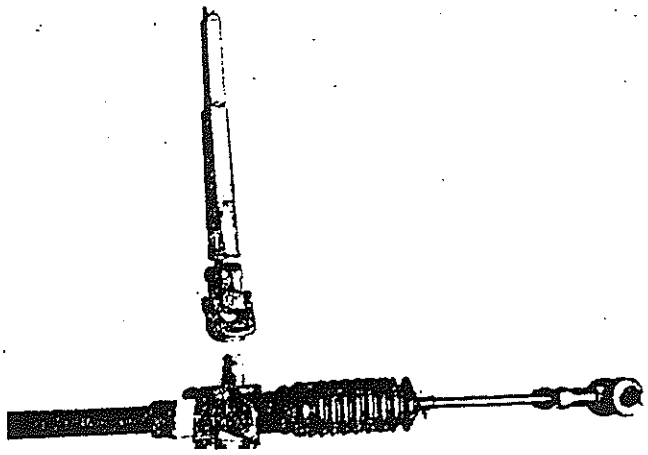
The pinion is supported between two ball races. Each race comprises an inner and an outer ball cup between which runs a set of balls.

After the end cover has been removed, the pinion and one ball race assembly may then be threaded past the rack and removed.

Tapping of the main housing should dislodge the second ball race assembly after removal of the rack.

Examine the pinion teeth for signs of wear and chipping and check carefully for signs of cracking towards the end of the teeth. Should the unit have been over-stressed as described in "Probable Causes for Excessive Wear" the pinion teeth may have been cracked without actually chipping. Check that the ball and the ball cups are not worn or pitted.





e. **Rack.** The rack may now be withdrawn from the main housing. Check the bearing and support surfaces for signs of scoring or excessive wear. Check the flanks of the teeth for wear and also for bruising due to excessive shock loading. Check that the threaded ends of the rack are in good condition and ensure that no burrs have been raised near the keyways during removal of the tie rod housing and the locknuts.

f. **Pinion Shaft Seal.** The seal is a press fit in the housing casting and may easily be removed. Undue wear of the sealing lip is unlikely unless the oil has become contaminated with foreign matter, but the lip may have been chipped or damaged and should be carefully examined.

g. **Rack Support Bush.** It will be noted that the resilient material for this bush is carried in a steel tube. The tube is necessary because the cast housing incorporates three grooves which permit the oil to be circulating when the steering gear is in operation. The steel sleeve is located by means of a self-tapping screw.

Should initial examination of the steering gear show that the rack support bush is worn (as proved by sideways movement of the rack at the end remote from the pinion) **it is recommended that the whole rack housing and bush assembly be replaced with a factory built unit** in order to save time and work. If, however, the customer considers it essential to replace the bush in the housing, the following method should be followed:

(1) Dismantle gear completely by removing pinion and rack assemblies.

(2) Remove recessed head screw in side of rack housing casting.

(3) Insert bar about .98" diameter through the pinion end and drive out old bush, bush housing and backing disc.

(4) Fit new bush into a new bush housing.

(5) Drive bush housing and bush with backing disc ahead of it into the housing.

(6) Drill hole in bush housing with a .109" diameter drill through the hole from which the recessed head screw was removed, being careful not to penetrate the inner surface of the bush.

(7) Refit recessed head screw in its hole with sealing compound.

Rebuilding and Adjustment

It is assumed that all parts are clean and that new replacement parts have been obtained as necessary. If the rack support bush has been disturbed, refit as described under "Rack Support Bush."

Hold the main housing in a horizontal position, with the hole for the pinion cover uppermost. Insert the ball race assembly into the housing.

Insert the toothed end of the rack through the rack support bush from the outer end and feed it through the main housing until the toothed portion may be seen through the large aperture in the housing. It will assist if the rack is rotated whilst being passed through the bush. Turn the rack so that the teeth are towards the axis of the pinion bore and pass the stem of the pinion past the rack teeth and through the inner ball race, pressing the pinion well home against the back of the race. Make sure that spacer has been fitted in the proper place.

Fit the second ball race assembly.

a. **Pinion Adjustment.** It will be found that the outer ball race projects below the face of the housing. Apply a load of approximately 22 lbs. to the back of the upper ball bearing and measure the gap between the face of the bearing and the cover face of the casting. Select shims to give a total thickness equal to this gap plus .002" to .005", taking into account the thickness of the paper joint fitted to the casting face. One large shim .092" thick must be used and this should be fitted last, so as to bear against the cover plate.

Apply jointing compound to the face of the housing and fit the paper joint followed by the cover plate. Smear two bolts with jointing compound and tighten down. The pinion should now revolve freely without shake, although the rack will still be unsupported.

b. **Rack Adjustment.** When the pinion has been correctly adjusted, insert the yoke against the back of the rack and refit the spring. With the rack at straight ahead position (centrally disposed relative to the length of the main housing) and the rack firmly pressed into engagement

with the pinion, the yoke should stand slightly proud of the cover face on the rack housing. When the cover plate is fitted, a gap will therefore exist between it and the rack housing. This gap should be measured with feeler gauges.

Select shims to provide a thickness equal to this gap plus .002" to .005".

Apply jointing compound to the face of the housing and fit the shims and cover plate. Smear two bolts with jointing compound and tighten down.

If upon rotating the pinion through 180° either side of the straight ahead position, slight tight spots are felt, then more shims must be added to remove this feeling. In any case, however, the amount of shims must not allow a yoke clearance greater than .005".

c. **Pinion Shaft Seal.** The pinion shaft seal may now be replaced. Ensure that this is fitted with the recessed side inwards and press the seal home flush with the face of the end cover. The pinion serrations may be wrapped in this paper during this operation in order to protect the lip of the seal, but care must be taken to ensure that no particles of paper are trapped under the lip of the seal.

d. **Tie Rod Adjustment.** Screw a locknut onto the threaded end of the rack as far as it will go, ensuring that the larger diameter of the locknut is towards the end of the rack. As correct locking of the assembly is vital, it is recommended that new locknuts are fitted whenever they have been disturbed.

Hold the unit with the rack axis in a vertical position and insert the correct spring into the aperture in the end of the rack. Smear oil onto the housing, ball end of tie rod and spring pad and insert the tie rod through the housing. Lay the spring pad on the end of the spring and press the end of the tie rod against the pad. Screw the housing onto the rack until the spring is compressed and gentle nipping of the tie rod occurs and a torque of 32/52 lbs. ins. is required to articulate the tie rod. Whilst holding the housing, screw the locknut back to meet it so that the flange on the locknut passes over the end of the housing.

Prevent rotation of the housing and tighten the locknut against it to a torque of 400/450 lbs. ins. Recheck the tie rod articulation to ensure that housing has not moved during the tightening of the locknut.

Use a well rounded punch to deform one locknut flange on to the slot in the housing and the other onto the keyway in the rack. If the flange shears or splits during this operation the locknut must be removed.

Repeat for the similar assembly at the other end of the rack.

Loosely fit bellows clip to one bellows and thread this over the tie rod at the pinion end of the steergear. Tighten the clamping screews. The small end of the bellows should locate in the groove in the tie rod. Refit the other bellows in similar fashion but do not fit the smaller clip at this stage.

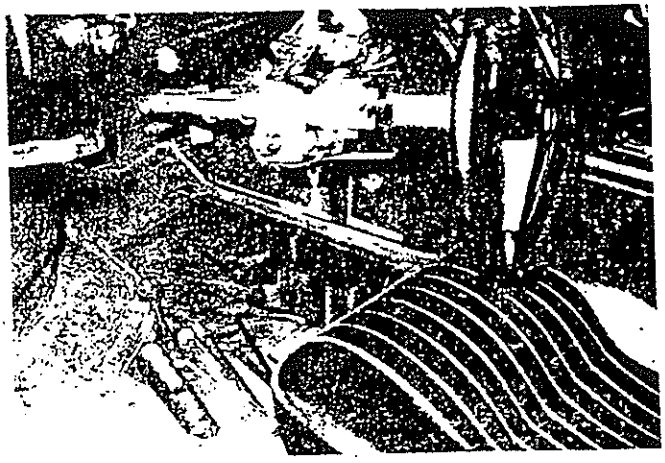
6. **Lubrication**

SAE 90 oil is the recommended lubricant. It is essential that an oil of Extreme Pressure type is used. Grease must not be used as a lubricant.

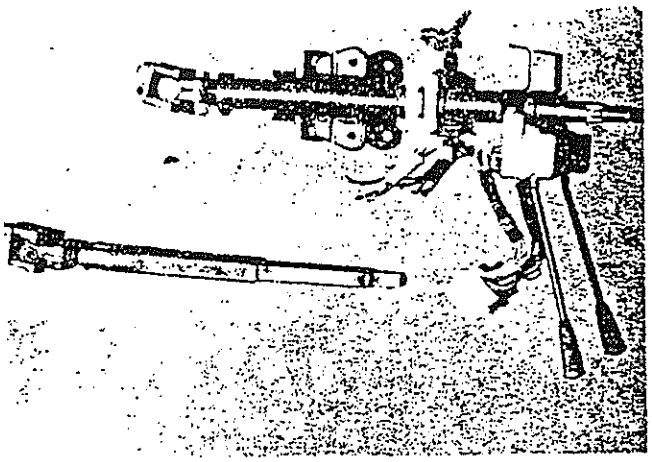
The oil capacity is 1/3 pint + 10% and this amount should not be exceeded as overfilling may cause the bellows to burst or to be forced off the main housing. An oil can of "Easijeet" type may be used for filling the unit and the spout should be inserted between the tie rod and the small end of the bellows from which the clip has been omitted. When the correct amount of oil has been instroduced, fit and tighten the small bellows clip.

The steering system components in the passenger compartment consist of:

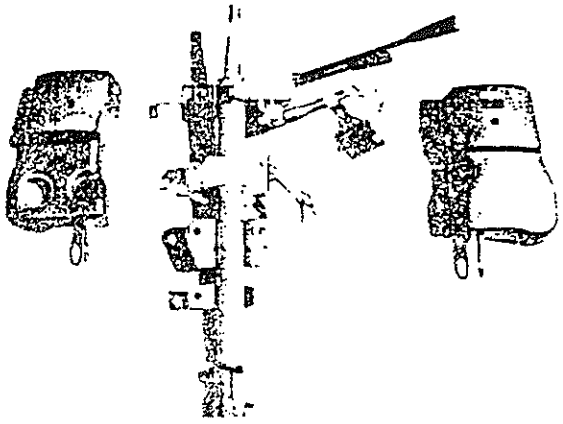
1. The steering wheel mounted on a convoluted cam designed to collapse under heavy load and secured by a retaining nut.



2. The collapsible spring.
3. The upper steering column shaft with outer tube and attachment bolts.



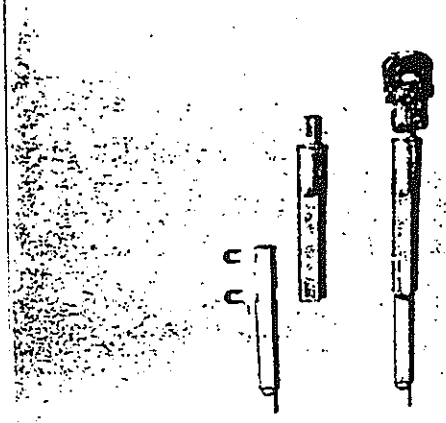
4. The turn signal and horn assembly — accessible by removal of the steering column cover shield.



5. The shaft spring, bushings, washers and retaining springs.

The steering system components outside the passenger compartment include:

1. The upper and lower universal joints.
2. The lower steering column shaft.



the bottom portion of the shaft slides up the inner sion of the shaft and collapses on heavy impact. clips between the two segments of the column retain em securely, unless dislodged by impact.

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Steering

GROUP 13

STEERING GEAR FIX

by Ted Mitchell

Now that we've published the steering gear repair section in an earlier article (see group 13, Steering System Accessibility"), I thought it was time to republish the following fix.

The Problem: One of the common problems of the unit is the wearing out of the right-hand (passenger side) support bushing. This can be checked by jacking up the right front wheel and while a friend attempts to move the wheel and tire assembly back and forth slightly, look for the right-hand tie-rod moving up and down in the boot, as opposed to just going in and out. If your bushing is worn, your right-hand wheel is free to move back and forth some with your left-hand wheel and steering wheel staying straight. Not too good of a condition, is it?

The original bushing is a plastic part that allows a very small amount of movement which is normal.

One Fix: Remove the steering gear assembly from the car according to the article referred to above. This article also explains the procedures to replace the bushing. The bushing is contained in steel housing for support, and the bushing can be replaced with an oilite bushing. I actually got written approval from the engineers at Cam Gear, Ltd. to use an oilite type bushing for this purpose. They pointed out that this might lead to a "knocking" noise when the bushing became worn, but I believe that could be an advantage for diagnostic warning to the aware Pantera owner.

I have not been able to find a stock size bushing for this replacement, so it will require machining of one that is close.

An Easier Fix: I have discovered an easier fix that can be accomplished with the gear still on the car. This still requires some disassembly of the right hand tie rod assembly, but should take no more than an hour or two of your time.

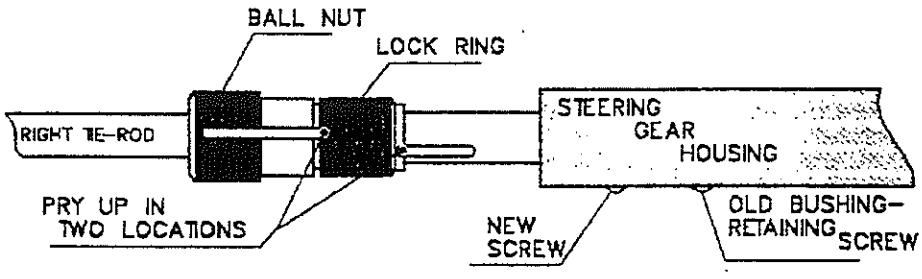
First, purchase a stock oilite bushing (Bunting #P79-6 or similar). The cost should be very nominal (mine cost $2.96). Then have a local machine shop turn the outside diameter to 1.216 inches, and the inside diameter to .845 inches

Now, jack up the right front corner of your car and remove the tire and wheel. Remove the left-hand, (driver's side), boot from the gear and with the right side of the car jacked-up, try to drain all the old lubricant out of the gear and discard it.

Remove the clamps from the RIGHT side boot, and pull it away from the gear. This will expose the balljoint on the end of the rack. There is a locking nut ring which is peened down into a slot on the rack and also a slot on the ball nut. These must be pried-up. The ball nut can now be unthreaded off the rack (it is a normal right-hand thread). Turn counter-clockwise with a spanner wrench or pipe wrench while holding the lock ring. Remove the lock ring the same way. Don't lose the ball seat and spring as it comes apart.

Remove the bushing retainer screw and find another sheet metal screw the same length (if you can't find one, you can use this one, because the new bushing will hold the old one in place). Drill a new hole in the housing about 1 inch closer to the end than the old one (same size, about 1/8 inch, depending on the screw you are going to use). Don't hit the steering rack!

Slide your new bushing over the end of



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the rack and into the housing. Tap it in, with a piece of pipe that will slide over the rack, until it just bottoms against the old bushing. Drill through the new hole in the housing just a short way into the new bushing, so that your set screw will lock the new bushing in place.

Re-assemble by turning the locking ring ALL the way on the rack. Holding the spring and ball seat in place, thread the ball nut all the way on until it bottoms (not just the spring, but metal-to-metal inside). This should be very close to the locking ring. Back-off the ball nut just slightly, about 1/16 turn. The manual says to a point where 32/52 lbs. ins. is required to articulate the tie-rod. While holding it there, back the locking ring up against the ball nut until they are jammed together (400 to 450 lbs. ins. torque). and re-stake both ends of the locking ring. Replace the boot and tighten clamps.

Replace the right wheel and tire assembly and lower the right side of your car. Jack up the left front corner of your car, and replace the lubricant in the steering gear with 1/3 pint of SAE 90 oil. The manual says to use a pump type oil can with the spout stuck in the small end of the boot (with the clamp removed, of course). Tighten the boot clamps (I hope you checked for good, non leaking boots), and lower the car.

Re-check toe-in, and you are ready to travel.

.....TM..

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Suspension

GROUP 14

WHEEL ALIGNMENT BASICS

by Ted Mitchell

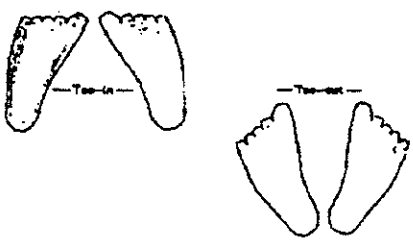
The purpose of the following is to get a little understanding into the "How's and Wherefore's," of wheel alignment, and especially the Pantera rear wheel alignment. I keep getting questions concerning rear tire wear on the inside, bay braces, different upper and lower A arms and shims, etc. To answer all of these questions, we need, as usual, to cover the basics.

First, (ignoring Caster, which is only meaningful on the front, and will not be gone into in this article), there are two specifications for wheel alignment. According to T.B.S. Number 13, article 33-S, they are as follows:

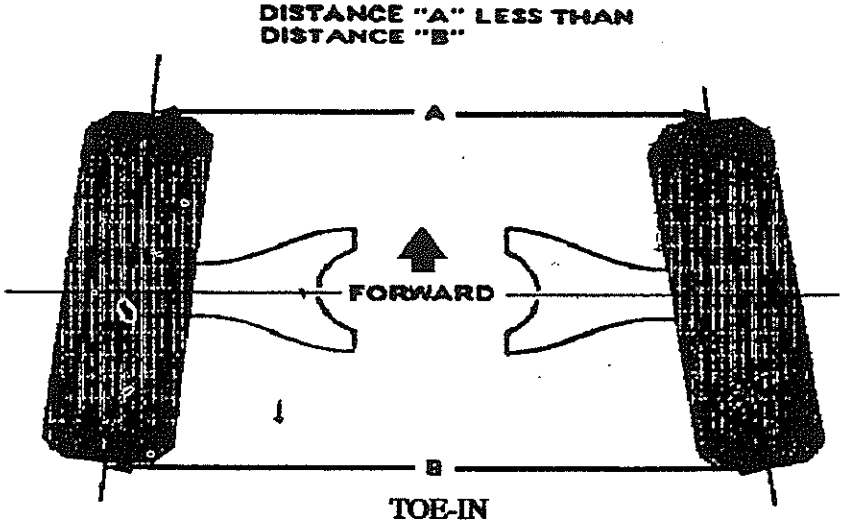
	FRONT	REAR
Toe-in	3/8 inch	1/4 to 3/16 in.
Camber	-1/8 to +1/8 deg.	-3/8 to -5/8 deg

TOE

Let's first talk about TOE. Toe refers to the direction the tires are pointed in relation to each other, like your feet. If you walk with your toes closer together than your heels, you have toe-in. If they are pointed out, you have toe-out.



This is measured in inches at the tread of the tire. So, our car should have the front of the tires closer together than the rear.



TOE-IN
TOP VIEW

Why? Normally, on the front tires, this is done so that, while driving, the drag on the tires will pull them back (because of suspension compliance -- read that rubber bushings, etc.) to a straight-ahead direction with zero toe-in. In our case, the rear wheels are driven and therefore, tend to pull in to even more toe-in. This causes drag and outside tread wear; so why do it? If we set the rear wheels to zero toe-in, or even toe-out, when we left off the throttle or worse, braked, the wheels would go to toe-out and the rear end would want to steer around the front. Very bad for staying pointed in the direction you are going.

Also, when cornering, the outside tires are doing the work. On a car with the weight biased to the rear, such as ours, centrifugal force wants to pull the rear end out. We need the outside rear tire to point slightly in to counteract this.

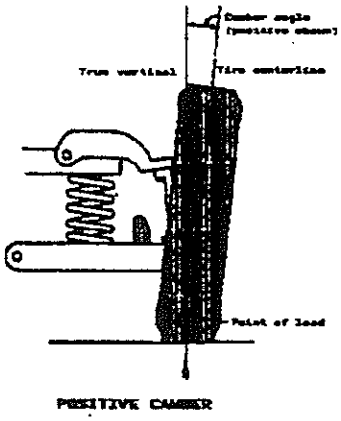
So, not enough toe-in in the rear will cause instability and wear on the inside of the tires. However, the most likely cause of wear on the inside of the rear tires is the Camber, which we will discuss next.

One thing that isn't mentioned usually,

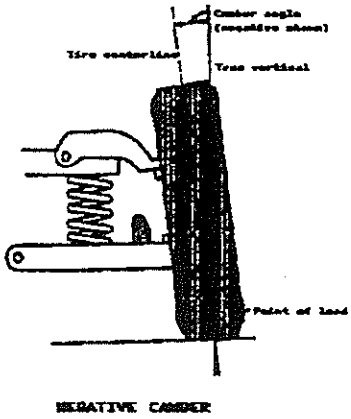
but is very important, is that the rear tires must be pointing in the same direction as the car. We could have the correct toe-in but have both rear tires pointing off the right or left of the centerline of the car. This causes a car to "crab" or go down the road slightly sideways. Not very good for handling!

CAMBER

Camber is defined as the angle of the wheel from a vertical line. Positive camber refers to wheels tilting out at the top and negative, in.

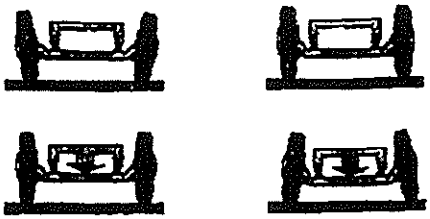


POSITIVE CAMBER



NEGATIVE CAMBER

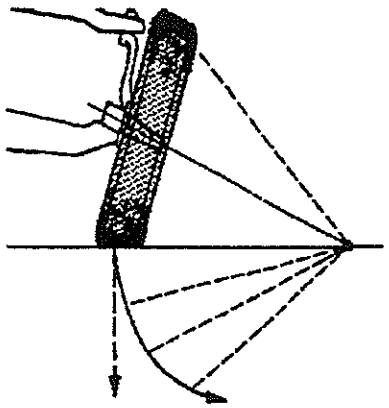
The relationship of positive to negative came from the time where this was used for wagon wheels and positive (good) camber was designed in so that the wheels would straighten out (zero camber) with a load in the wagon.



If there was no camber designed in, (a load would create a negative (bad) camber.

The effect of camber on a wheel and tire is that a tilted wheel wants to turn in the direction of the tilt. If you want to test this, try taking a wheel and tire, or even a disc of any type and roll it while tilting it to one side. It will turn in the direction of the tilt. As a matter of fact, it will turn in a circle around the point of an imaginary (or real) axle touching the ground.

Usually both rear wheels have the same camber, but remember from our toe-in discussion, the outside tire, in a turn, dictates the force. If the outside rear tire is tilted out in a turn, the rear end will steer out causing "oversteer," or a tendency for the rear end to come around. This is usually not good. All this is complicated by the fact that chassis roll, or lean, in a turn effects camber, so unless you are

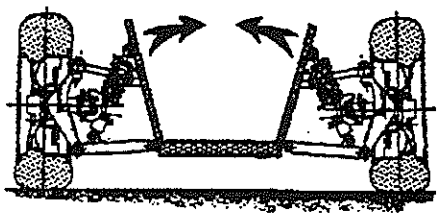


qualified to do a lot of suspension analysis, it is best not to mess too much with factory specification. For example, you may feel your car understeers too much in a corner and you modify the camber to compensate. Then one day you go around a corner on wet pavement, less body roll, and you are going backwards; or you hit the brakes in a corner and lift up the rear suspension. It is a complicated analysis.

Usually, and this is the case in our car, we want slight negative camber. Our suspension problems with the structure, eventually bending inward, results in too much negative camber. This is at least erring on the safer direction, tending to decrease oversteer, and many Pantera owners set their camber more negative intentionally.

Now, what was that about the STRUCTURE BENDING INWARD!

Essentially our rear suspension structure is "U" shaped with the weight of the car trying to bend in the legs of the "U".



If this happens (and it will), the top of the wheels tilt in, and we have too much negative camber. We take some shims out of the lower arms to shorten them and bring the camber back to specifications. Eventually we run out of shims. How can we prevent this?

Look again at figure above. If we put a bar between the two upper spring perches, this should keep them from bending inward. The stock Pantera has such a bar which is usually referred to as a "Bay Brace". Why doesn't this work? There are really two reasons. One, most of us don't understand its purpose and therefore, the need to "adjust" it, and secondly, its dependence only on friction to do its job.

This brace is fastened to the area of the upper spring perches by means of a bolt going through two SLOTTED holes for adjustment. Proper adjustment is made (How often? I don't know. Some type of mark to see if it's moved may help.) by jacking up the rear of the car, so the

suspension is hanging down, loosening the brace, and then re-tightening.

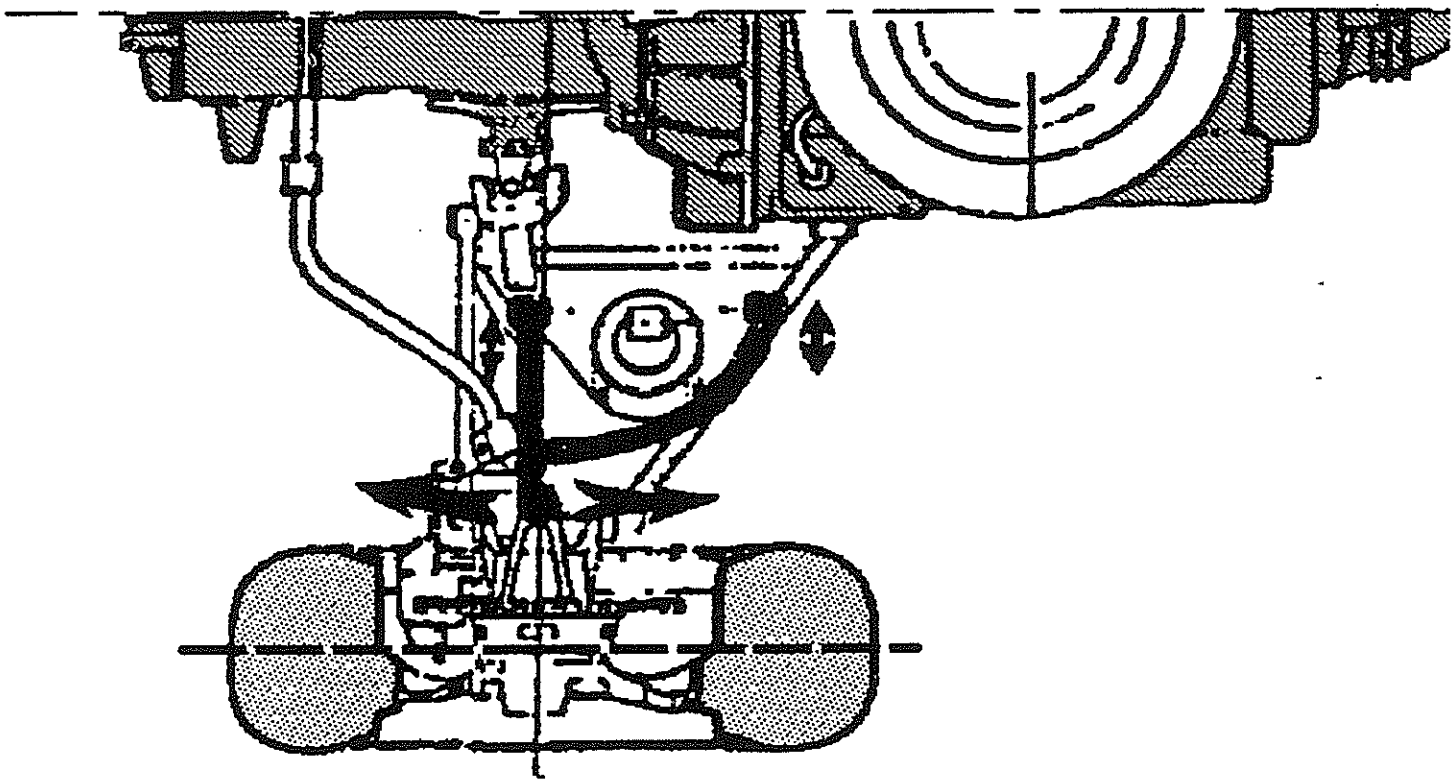
A better way, is one of the aftermarket, adjustable braces being sold by a number of our Pantera parts and service specialists. These braces can actually be preloaded to provide proper support to the rear suspension. I highly recommend these.

O.K., what if it is too late already. We have run out of shims. Can we use the adjustable Bay Brace to crank our body back out? NOT unless you want to put cracks in your car. This might work if your car is stripped and going to be re-leaded, etc.

What you need now is shorter lower, or longer top, arms. Again, various Pantera parts and service specialists can supply a longer upper "A" arm that will bring everything back to the way it was designed. There are also several makes of adjustable arms on the market but I, personally will not recommend any of these that are not designed with the adjustments at the inner ends of the arms where the loads are strictly in tension or compression.

Next, we cover how to make these measurements yourself.

T.M.



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Suspension

GROUP 14

WEIGHT DISTRIBUTION

by Ted Mitchell

Does your car corner to the right as well as the left? If you have made any modifications to the weight or suspension of your Pantera, you may have adversely affected the weight distribution. Also, if you have adjustable springs and have not checked your distribution, you could be WAY OFF!

The actual weight at each wheel is not necessarily due to mass (weight due to gravity). It is also due to chassis load caused by your suspension. You could conceivably adjust the suspension so that ALL the weight is borne by the left front and right rear wheels. If you don't believe me, drive your car up on a couple of 12 inch high blocks under the left front and right rear wheels and see how much weight is borne by the other two wheels. I am sure that your car is not this far off, but you might have enough to make a difference.

Fist let's get a couple of concepts down. Your handling in a corner depends on the weight distribution between the front and rear OUTSIDE tires. The outside tires in a hard turn are doing most of the work and the amount of weight on those tires in relation to its size, air pressure, and suspension geometry are going to determine the side or cornering force that it can exert. We can change the front to rear weight transfer in a turn with anti-sway bars, but they affect both sides the same, so we want to start with the same distribution on both sides. We can do this without moving engines and gas tanks around by using "WEIGHT JACKING".

Let's find out where we are. Weigh all four wheels. This MUST be done on LEVEL ground and if you weigh one wheel at a time, it MUST be at the same level as the other three. In other words, if you use a platform scale that is 3 inches high, use 3 inch blocks under each of the other three wheels, assuming you are on perfectly level ground to begin with. THIS IS VERY CRITICAL! If you don't do this all the time, and don't have special car scales, you can find a public scale that has a flat area around one corner of the scale. First weigh the whole car, and then jockey your car around so that each wheel can, in turn, be placed on the SAME corner of the scale. This way, any SLIGHT variation in level will cancel out.

Adding the weights of all four wheels SHOULD equal the total weight of the car. A slight variation indicates that the area was not perfectly level. Be sure you or equivalent weight is in the driver's seat and the fuel tank is about half full.

O.K., if you have weighed your car properly and have all the right numbers, let's figure it all out. As a running example, we'll use the numbers that I got for my 1973 Pantera (Darth Vader). Remember, this car is modified with Group IV flares.

L.F.= 755 lbs R.F.=715 lbs FRONT=1470 lbs
L.R.=1045 lbs R.R.=975 lbs REAR = 2020 lbs
TOTAL=3490 lbs

First add both FRONT WHEELS and divide by the TOTAL CAR (x 100) to get the FRONT DISTRIBUTION, and then both REAR WHEELS divided by the TOTAL CAR (x 100) to get the REAR DISTRIBUTION.

$$\frac{755 + 715}{3490} \times 100 = 42.12\% \text{ FRONT}$$

$$\frac{1045 + 975}{3490} \times 100 = 57.88\% \text{ REAR}$$

Now you can determine the IDEAL WEIGHT on each wheel. Remember, the right side can (and will) weigh differently than the left, but they should have the same WEIGHT DISTRIBUTION.

$$\frac{\text{L.F.} + \text{L.R.}}{100} \times \%\,\text{FRONT} = \text{L.F. IDEAL}$$
$$(\times \%\,\text{REAR} = \text{L.R. IDEAL})$$

$$\frac{755 + 1045}{100} \times 42.12 = 758 \text{ lbs L.F. IDEAL}$$
$$(\times 57.88 = 1042 \text{ lbs L.R. IDEAL})$$

$$\frac{\text{R.F.} + \text{R.R.}}{100} \times \%\,\text{FRONT} = \text{R.F. IDEAL}$$
$$(\times \%\,\text{REAR} = \text{R.R. IDEAL})$$

$$\frac{715 + 975}{100} \times 42.12 = 712 \text{ lbs R.F. IDEAL}$$
$$(\times 57.88 = 978 \text{ lbs R.R. IDEAL})$$

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L.F.		R.F.
755	actual	715
758	ideal	712
-3		+3
+3		-3
1042	ideal	978
1045	actual	975
L.R.		R.R.

L.F.	R.F.
-30lbs	+30lbs
+30lbs	-30lbs
L.R.	R.R.

Notice that all four IDEAL WEIGHTS are, and should be, off from the ACTUAL WEIGHTS by the same amount, BUT two opposite corners need MORE weight and the other two opposite corners need LESS weight. On my car, to get to the IDEAL WEIGHT the L.F. needs +3 lbs, the R.F. -3 lbs, the L.R. -3 lbs, and the R.R. +3 lbs, so the TOTAL WEIGHT would be the same. Actually, unless we are at least 10 lbs off (and with a street car maybe as high as 50 lbs) we are almost perfect and don't have a problem. (Ain't De Tomaso grand?) But let's say it was 10 times worse and 30 lbs off at each corner and we wanted to fix it.

It is time for some decisions. We can add shims to either the L.F. or R.R. springs or both, or remove same from L.R. and/or R.F. Check your car's ride height and see if it is off. If it is low in the L.F. corner, you can bring it up by adding shims to the L.F. only. You may want to lower the R.F. instead by removing some material from the R.F. spring spacer (if you you haven't already removed the whole spacer). If it is perfect(?) AND you don't want to affect your alignment, you MUST change all four corners (although small changes won't make noticeable ride height changes).

Now comes the tricky part and after reading this you may want to forget the whole thing. This takes a LOT of trial and error, and almost requires your own scales. Each change affects all four corners. THEREFORE, THE AMOUNT YOU SHIM IS DETERMINED BY THE NUMBER OF CORNERS YOU HAVE DECIDED TO CHANGE. If you have decided to raise only the L.F. corner (remembering that this will lower the R.R.), add a shim to increase the weight at that corner by the whole amount of 30 lbs. If you decided to raise both the L.F. and R.R., add a shim to bring the L.F. up to 30 / 2 = 15 lbs. This will add 15 lbs to the R.R. also (as well as take away 15 lbs from each of the R.F. and L.R.), so when you add the shim to the R.R. for an additional 15 lbs, you will be at the right 30 lbs. If you are going to change all four corners, add shims to bring up the L.F. by 1/4 the change (30 / 4 = 7.5 lbs), add the same amount to the R.R. and remove the same amount (milling some metal off the aluminum spacer for example) from the R.F. and L.R.

Another great thing about our car is that the seats are about midway between the front and rear wheels, so if you take a passenger along, it will not affect your right side distribution and handling. Yes, I know! Why did I tell you to be in the car when you first weighed it? I don't know. I guess I want to know the actual weights in case somebody asks.

GOOD LUCK! tm

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Clutch and Transaxle

GROUP 16

CLUTCH MAINTENANCE

by Ted Mitchell

I keep getting questions regarding clutch problems on the Pantera; and for good reason. 1. There are a number of different components in different year cars; 2. The maintenance parts are getting hard or impossible to get, and are expensive; and 3. It doesn't really work right when everything is perfect.

Let's start with the last point, so you know what the main problem is. Clutches should have a MINIMUM of .040 inches of air gap between the pressure plate, the clutch disc, and the flywheel, when the clutch is fully disengaged. A high performance application, should really have .060 inches.

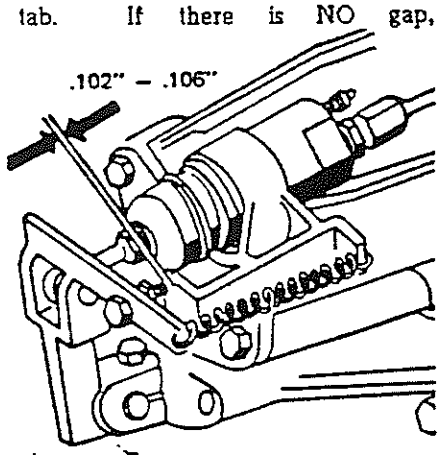
On the later model cars with the inspection hole in the clutch bellhousing, you can measure this gap by having a friend hold the clutch pedal to the floor, while you insert a feeler gauge between the pressure plate and the clutch disc. With the engine **NOT** running, the disc will stay up against the flywheel. Do not compress the Marcel springs between the two sides of the disc, with the feeler gauge. Measure actual free space. I have found this to usually be about .026 inches on most Panteras.

What does this mean? When the clutch is hot, you won't get even this much space, and when you depress the clutch pedal in your car to make a shift (especially if you don't push the pedal clear to the floor), the clutch does not fully disengage, and the Synchro Rings in your transaxle have to do extra work. And guess what? Second gear Synchro goes out first, with the others sure to follow.

What can you do about this? Not a lot, without re-engineering the system, which is not what this article is about (But we may do that later). What you can do, is make sure everything is as right as it can get.

First, the obvious things. Make sure you have plenty of brake fluid in the system: that it is **clean**: and that you have bled it to insure no air in the system. Silicone fluid is not acceptable on a stock system because it is slightly compressible, and we have enough problems as it is. As a matter of fact, the higher grades (DOT 4, 5, etc.) don't do any good, because they are ratings for heat, which is not a problem in the clutch. But you want good quality, and you are hopefully using a high grade for your brakes, so why not use the same stuff?

Now let's go to the SUPER CRITICAL slave cylinder adjustment. Note that there is a stop bolt adjustment on the linkage at the slave cylinder. Holding the linkage back toward the rear of the car without starting to compress the clutch to JUST take up the free play (If you don't have a deft touch, this is easier to feel with the spring temporarily removed), measure the air gap between the end of the bolt and the metal tab. If there is NO gap,



your throwout bearing is riding on the fingers of the clutch pressure plate and is probably not long for this world (although a number of Japanese cars run their systems like this). TOO MUCH gap, and you are decreasing the total amount of clutch disengagement. The Pantera Technical Service Bulletin No. 10, Article No. 88 calls for .102 to .106 inches. Most of our service people shoot for 1/16 to 1/8 inch, and IF you will keep an eye on this adjustment regularly, I would keep to the 1/16 side.

It is also, absolutely necessary to make sure there is free play at the other end of the system. Whether you have the clutch effort reduction system (see TSB No. 6, Article No. 49) or not, the push rod in the master cylinder, MUST be allowed to come all the way out when the pedal is released. If this doesn't happen, the piston cannot take another gulp of fluid from the reservoir if it needs it and will probably suck in some air instead, or optionally, if it wants to get rid of some fluid into the reservoir, it will just hold open the clutch slave resulting in slipping or throwout bearing wear. Our cars came with a torsionally wound spring on the pedal shaft to return both the brake and clutch pedals. MOST OF THESE SPRINGS HAVE BROKEN . You need to either replace them (A BIG job) or 'jury-rig' a conventional pull type spring from the pedal arm to some point under the dash, so THE PEDALS (BOTH BRAKE AND CLUTCH) ARE PULLED BACK UP WHEN THEY ARE RELEASED.

By the way, the Clutch Effort Reduction System does not reduce the amount of clutch movement as some people have said. How did the great powers of Ford manage to beat the laws of physics and lower effort without lowering movement? They used a linkage system that actually increases movement (and effort) at the beginning of the stroke (when clutch efforts are small) and decreases movement (and efforts) progressively, at the end when clutch efforts are greatest. Not too shabby for engineers, huh?

If you are doing major work on the master cylinder or the slave cylinder or the clutch itself, refer to TSB No. 10, Articles No. 88, 89, and 90 for the latest measurements. If you don't have the Technical Service Bulletins, order them from the POCA Store, along with the Shop Service Manual, and the Parts Book. You just can't work on a Pantera without these books.

But just in case you don't have the Parts Book, the part numbers for the actual clutch parts are as follows:

YEAR	TRANSAXLE	DISC/PRESSURE-PLATE
71-72	1031-001-060	DISC/D16Y-7550-A
	1031-001-061	PP/D16Y-7563-A
	TYPE 5DS/25-1	
71-74	1031-002-001	DISC/D46Y-7550-A
	1031-002-020	PP/D46Y-7563-A
	TYPE 5DS/25-2	

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Ignition System

GROUP 23

ENGINE IGNITION

We don't make a practice of pushing products, and the following should not be taken as an endorsement for a particular brand, but I have discovered a new ignition system which offers the best of all worlds, and so far as I know, this is the only brand that offers this particular system (If you know of any others, please let me know). I should also mention that I am reviewing only the concept at this time. I have no knowledge of how well this particular unit works, but I am familiar with the concept and I am excited about it. I have ordered one and I will follow up on both good and bad.

I also thought this would be a good time to review ignition systems in general. If you already know all about them or don't care, just skip down to the heading "ELECTROMOTIVE'S D.I.S.".

ENGINE IGNITION SYSTEM

The ignition system of most conventional engines performs a number of functions. We will concern ourselves here with two main jobs. First, the system converts the battery voltage of 12 volts (primary system), to a very high voltage that will allow a spark to jump across the spark plug gap (secondary system). This spark is what ignites the fuel mixture in the cylinder to give us power. The second function of our ignition system is to direct that high voltage to the proper spark plug at the proper time. Usually these two functions are split up with the control of the timing of the spark occurring on the primary (low voltage) side, then the voltage increased, and lastly the secondary (high voltage) directed to the proper spark plug.

Let's look how this is done with a normal distributor and coil. First, our primary 12 volts is connected (from the ignition switch) to one side of the primary side of the coil. Whoops! We better explain the coil.

The "coil" is made up of two coils of wire. The primary coil is a relatively few turns of heavy wire, and the secondary is many turns of fine wire surrounding the primary with one end fastened to the negative side of the primary. When 12 volts is applied through the primary, it builds up a magnetic field surrounding it (and the secondary also). When the current is stopped, the field collapses very rapidly and induces a voltage in the secondary. This new secondary voltage is proportional to the difference in the number of turns of the primary and secondary coils and the speed of the field collapse. If you don't totally understand this, don't worry about it, just accept that the coil "transforms" our primary 12 volts into a secondary voltage usually in excess of 50,000 volts. Just remember that the secondary, or spark voltage, is generated when we turn off the primary voltage (because it takes a relatively long time to build up the magnetic field, and it collapses rapidly).

Now, back to the positive side of our 12 volts hooked to one side of the coil. The other side of the primary in the coil is hooked up to the points in our distributor. The other side of the points in the distributor is connected to ground, so that when the points are touching, we have a complete circuit in the primary side of the coil. When the points OPEN, the field collapses, and the secondary, spark voltage is produced. The coil wire connects the top of the coil, back to the center terminal on the distributor cap. Inside the distributor, the rotor, as it turns, connects the secondary to each spark plug wire in turn according to the firing order of the engine.

Now we are sending the spark to each cylinder at the time needed to run the engine. There is only one thing left. Depending on how much power is needed and how fast the engine is running, we need to vary the exact time that the spark is produced. We normally do this by moving the plate inside the distributor that the points are mounted to and/or the cam that opens the points. This way we can advance or retard the time that the spark is produced. At higher RPM, we can have the spark sooner, so we build in centrifugal advance mechanism that uses weights acting against a spring to advance the spark. Also,

when we aren't demanding much power out of the engine, we can advance the spark even more for better fuel economy and cooler running. Since manifold vacuum is a good measure of torque requirements on our engine, we use a vacuum advance mechanism to move the plate.

PROBLEMS AND IMPROVEMENTS

The basic system described above worked just fine until we got into higher performance engines. Higher compression suppresses the spark and so we need more voltage in the secondary system. At the same time, as the RPM of the engine increases, we have less time to build the field up in the coil so the secondary voltage drops. When the voltage drops below what is needed the engine misfires. Our basic ignition system is no longer sufficient to do the job.

Now what do we do? One of the first improvements to the basic system was the use of dual points like the stock Pantera distributor uses. In an eight cylinder engine like ours, the points have to open and close eight times for every two engine revolutions (the distributor turns at one-half engine RPM). This means there is only so much time for them to be closed (coil field build-up time), and the time decreases as the RPM increases. With one set of points, the time they are closed is limited due to point bounce and point cam design. By using two sets of points working together, we can cheat and make the time the circuit is closed, longer than the time the circuit is open.

This helped some, but as performance requirements increased, the system again fell short.

A number of improvements evolved. Capacitive discharge systems were developed to "supercharge" the charge to the primary side of the coil, resulting in higher secondary voltages. Transistors were used to replace the points both to give more coil build-up time and to solve the point "pitting" problem developing from the increased current load being handled. Even more than one spark pulse being sent to the spark plug for each firing.

The increased voltage in the secondary started causing new problems. The spark would sometimes jump through the ignition wire instead of the spark plug. Or sometimes it would jump across inside the distributor cap, firing the wrong plug at the wrong time. Spark plugs, wires, and distributor caps and rotors had to be improved.

For awhile, it had been known that the distributor, being driven by the camshaft that was in turn driven by the crankshaft was leaving something to be desired in terms of accuracy, so the crankshaft triggered ignition system as born. The distributor now only had to direct the secondary charge to the proper spark plug. A sensor mounted on the crankshaft damper would trigger the primary current and electronics would build in a centrifugal advance curve. This worked great in the earlier racing fields, where the throttle was on "full" most of the time, and fuel economy was of no concern, but it didn't solve the problem of the secondary spark jumping to unwanted places.

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What we needed was a simple, trouble free, accurate system that would supply enough spark at high RPM and give us the control necessary for power and fuel economy. ENTER THE MULTIPLE COIL DISTRIBUTORLESS IGNITION SYSTEM.

ELECTROMOTIVE'S D.I.S.

Actually, this type of system has been around for a while, but not, to my knowledge, been available for our engines. A number of years ago, Buick's engineers came out with this system for their V-6. The stock unit was tied into their electronic brain and was therefore of little use to the average enthusiast. They later, came out with an "off road" version that was perfect, IF you had a six cylinder engine.

The concept developed when some bright fellow said to himself "why don't we take the positions off of the crankshaft, and fire a separate coil for each spark plug?". This way we don't have to "distribute" that high secondary voltage that likes to jump to the wrong spot. It also had the effect of giving the coil gobs of time to build up the field (in and eight cylinder engine at 8000 RPM, the coil would be running at the equivalent of 1000 RPM). Therefore no complicated voltage enhancement was needed.

There was only one fly in the ointment; the crankshaft turns twice as fast as the camshaft (and firing order of the engine), so that the plug would fire at the right time, but it would also fire 360 degrees later, near the top of the exhaust stroke. When the effect of this was studied, it showed that it not only didn't cause any harm, it actually cleaned the spark plug. It was also decided by Buick and others that the system worked good enough, and packaged better by using half the number of coils and putting two

secondary towers on each of them. Two plugs have to fire at the same time anyway.

Now there is THE system, developed for race cars by a company in Virginia called Electromotive, Inc.. The system totally eliminates the distributor (you will need to build a dummy to still drive the oil pump) and is crankshaft triggered for accuracy, and for our engine, uses four double coils. They have an electronic centrifugal advance, and optional vacuum advance. Depending on the model (read that price) you have more and more control of the advance curves, and on their biggie, you can get a KNOCK sensor, and a BOOST retard for you turbo or supercharged guys.

Everyone that knows me, knows that I think anyone who doesn't have vacuum advance on a street driven car needs their head examined. You just can't get enough advance to get full performance without throwing away all sorts of fuel economy, smooth and COOL running at cruise conditions without vacuum advance. Also, the knock sensor lets you set the advance curve for best performance with the best gas available (additives?) and still run on a trip with available gas.

These systems are priced (my latest information) at $389 (plus $50 for the vacuum sensor) for the HPV-S with a fixed advance curve. The next level up, HPV-1 with an adjustable curve and adjustable RPM limiter is $439 (+ $50). The super system is called the HPV-2. This sweet little baby is fully programmable for dialing in the perfect curves for your car, has a dash display with tachometer, shift light, manual advance lever (yes, you can tune the advance while you drive),etc. etc. etc. It costs $1050 (plus $50 for vacuum or turbo pressure sensor, and $75 for the knock sensor. $110 for both. and $30 for a remote shift light.)

A word of warning. The HPV-2 doesn't have a tachometer drive output because of their built in tachometer. A word on the phone, however, got me a pigtail out for the tachometer sensor, but it may require your friendly electronics neighbor to build you an amplifier to drive the Pantera tachometer.

The address for anyone interested is:
ELECTROMOTIVE INC.
14004-J Willard Road
Chantilly, Virginia 22021
(703) 378-2444
.....TM

TECHNICAL BULLETIN

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Fuel System

GROUP 24

CARBURETOR JETTING

by Ted Mitchell

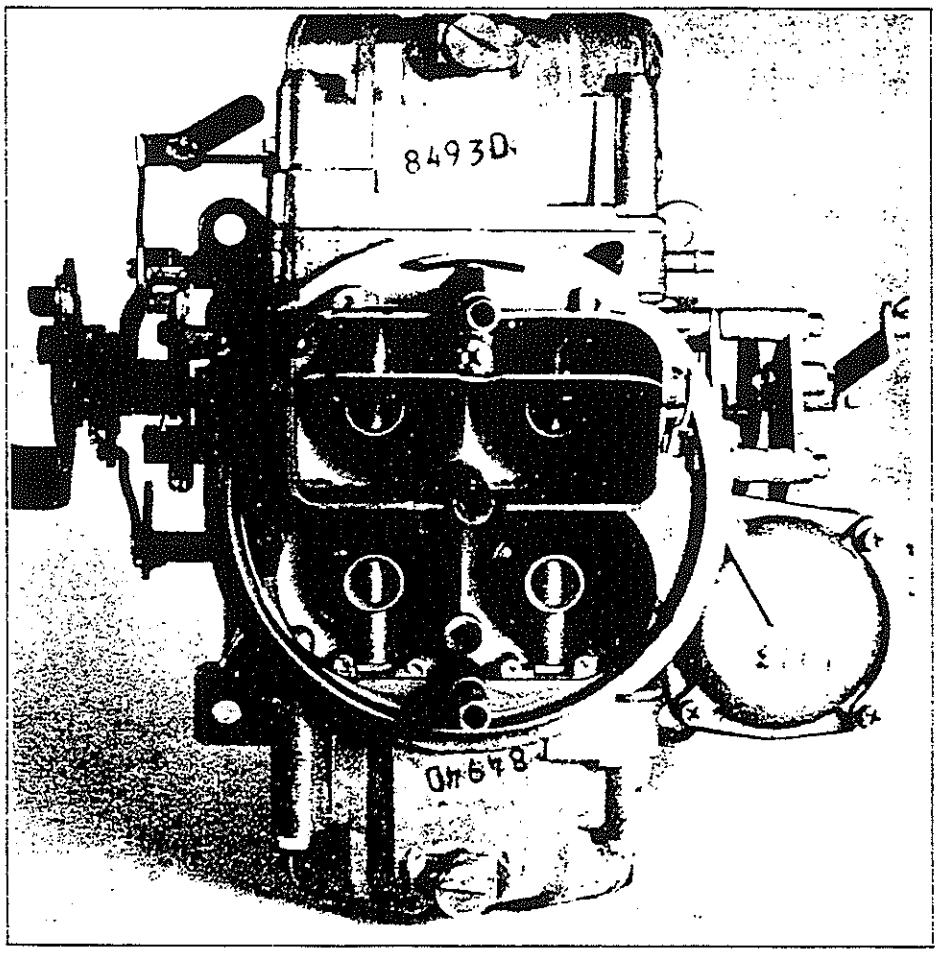
This article will attempt to remove some of the dark clouds of mystery surrounding carburetor jetting for those of you so inclined, with the warning that although not as complicated as you might think, it is still a long, time consuming job. I will talk primarily about the Holly carburetor, although the principles can be applied to the Ford.

First, a very brief primer on some of the functions of a carburetor. The carburetor serves two main functions:

1. To mix the proper amount of fuel with the proper amount of air.

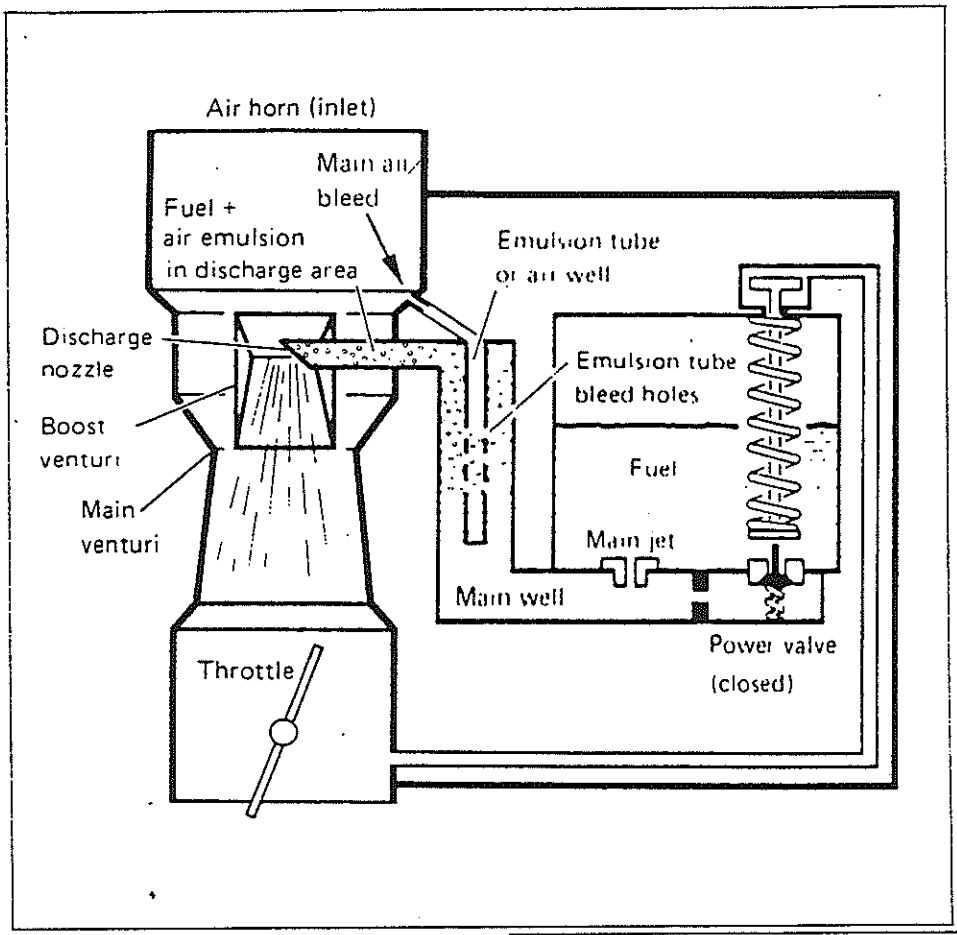
2. To control the amount of air-fuel mixture introduced into the engine.

Let's look at the second function first. The throttle "butterflies" in the base of the carburetor. accomplish this control. We would use just one big throat and butterfly valve to do this, but the first function of mixing fuel with the air doesn't work very good unless the air is flowing very fast through the carburetor throat or venturi. So, we use four throats and don't even open the second two until the engine speed and load is enough to flow the proper amount of air. Contrary to popular belief, a 4-throat or 4-barrel carburetor is more efficient if properly jetted and sized, and will get better fuel economy than a two barrel (unless, of course, we are using the extra power available).



Now, the first function. Gasoline does not burn (it will extinguish a match thrust into the liquid, but take my word for it and don't try it because there is vapor all around). Only gasoline vapor in the proper mixture of air will burn. In an automobile engine, this can range from around 8 parts of air to 1 part of fuel (8:1), to about 17 or 18:1. Best power is about 12:1 and best economy is about 14:1.

Believe it or not, you can actually run an engine by holding a sponge over the intake manifold and pouring a small



Notice the sequence of effects. This is the way we must determine our needs; and on an engine that is used on the street, we are interested in economy as well as power. We can have our cake and eat it too!

The different circuits do a primary job, and then effect everything afterwards. In other words, the **Secondary Jets** effect **high speed power.** The **PVCRs** effect **low speed power** and **high speed power.** The **primary jets** effect **cruise, low speed power, and high speed power.** Therefore, unless you are setting up for "all out" race-only, the primary jets should be adjusted for best cruise and fuel economy.

PRIMARY JETS

1. Isolate the primary system by wiring the secondary throttle plates firmly closed. If you don't have vacuum operated secondaries, you must disconnect the secondaries and wire them firmly shut.

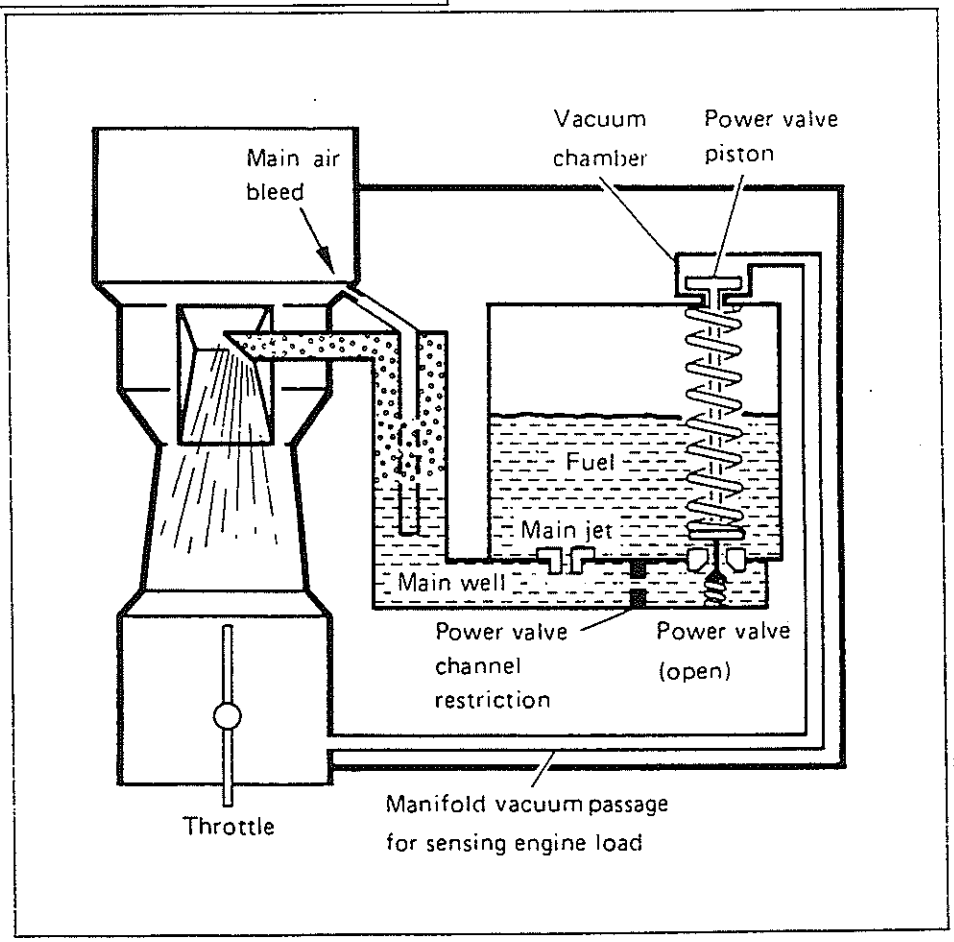
amount of gasoline on the sponge. Not very efficient, so we want our carburetor to not only mix the air-fuel for us in the correct amounts, but also to know when we want power or economy.

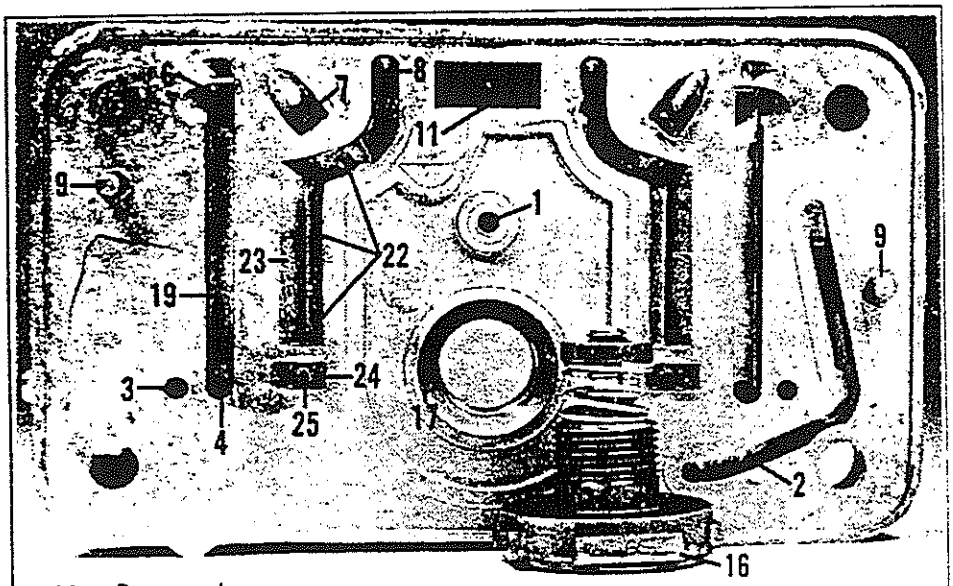
Our modern Holley four-barrel carburetor, with vacuum operated secondaries (the rear two throats) does this fairly simply.

1. Under cruise conditions, the air-fuel mixture is determined by the primary main jets (there are 2 of these for the front two primary throats).

2. Under full throttle, low engine speed, the air-fuel is determined by the primary main jets and the power valve channel restrictors (PVCR's).

3. Under full throttle, high engine speed, the air-fuel mixture is determined by the primary main jets, the PVCR's, and the secondary main jets. The secondary main jets look just like the primary main jets, except they are located in rear float chamber for the rear two throats.





16 — Power valve
17 — Power valve channel restriction (connects to main well 21)

2. If you have an Exhaust Analyzer, operate the engine in the range of 2000 to 4000 RPM at a steady speed looking for approximately 14:1 air-fuel, changing primary jets to get this. This will get you a close approximation.

3. Now run the car on a straight and level road. Keep changing to a smaller jet until you get a "Lean Surge". This is a feeling of the car surging back and forth while the accelerator is held steady. Rich'n back up (larger jet) until lean surge is completely gone. Put these jets aside, temporarily.They will be your primary jets, eventually.

POWER VALVE

1. Now put in the next larger number primary jet, temporarily. The power valve on the Holley is replaceable, but only effects **when** the valve opens, not how much is flowed (assuming it doesn't restrict the flow). The actual flow is determined by the Power Valve Channel Restrictors (**PVCRs**). Unfortunately, the PVCRs are not interchangeable jets, so they must be drilled out. This is why I told you to put one set richer **primary jets** in temporarily.

2. Make full throttle acceleration runs up to about 4000 RPM and drill out the **PVCRs** until you can determine no more improvement. Since you will go "too far" by perceiving no more improvement, you should be "right on" by going back to your "right" **PRIMARY JETS**. (BE CAREFUL! Over-drilled holes "can" be plugged up with lead in the event of a mistake and re-drilled, but it is a **very** poor fix.)

3. Put your correct **PRIMARY JETS** in the carburetor.

SECONDARY JETS

1. Now, you can un-wire your secondaries, and change the **secondary jets** to get best acceleration overall, paying most attention to over 2000 RPM.

The above procedure will give you your "cake and eat it". Most procedures have you change primary jets for power. This is wrong, unless you are interested in "race-only" with no interest in economy, and will still give you no more power. This is a long procedure but if used, can give you the best performance possible, with fuel economy in the range of twenty or more miles per gallon on a trip, EVEN IN A PANTERA. For more information, I recommend the "H.P." book on Holley Carburetors & Manifolds, below.

T.M.

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Fuel Systems

GROUP 24

FUEL INJECTION SOURCES

PANTERA UNITS

HALL PANTERA
15337 Garfield Ave.
Paramount, CA 90723
(213) 531-2629

PANTERAS BY WILKINSON
16237 Illinois Ave.
Paramount, CA 90723
(213) 804-4321
(213) 634-3434

PANTERA SPECIALISTS
2824 S. Willis
Santa Ana, CA 92705
(714) 250-1797

GENERIC UNITS

AIRSENSORS, INC.
Special Applications Group
708 Industry Drive
Seattle, WA 98188
(206) 575-1594
(800) 654-6775

B & M
9152 Independence Ave
Chatsworth, CA 91311
(818) 882-6422

KINSLER FUEL INJECTION INC.
1834 Thunderbird
Troy, MI 48084
(313) 362-1145

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Fuel System

GROUP 24

FUEL INJECTION

by Ted Mitchell

There seems to be a lot of interest in fuel injection on engines lately and since I mentioned that I am going to install an injection system on my new Pantera engine, I have received a couple of questions from POCA members regarding these systems. I know that Lance Nist of Pantera Specialist is currently building a fuel injected turbo-charged engine, and Steve Wilkinson of Panteras by Wilkinson has built at least one and maybe more fuel injected super charged engines, so I thought that this might be a good time to explain some of the in and outs.

What is fuel injection? Well, first of all as the name implies it is a means of injecting fuel into an engine, and therefore every engine must have some sort of fuel injection to run. A carburetor does this by using the flow of air going past a venturi to "pull" a proportional amount of fuel from a reservoir, into the air stream where it mixes with the air with varying degrees of efficiency. Normally a fuel injection system is thought of as a system that injects the fuel under pressure into the incoming air stream at some point. Actually the carburetor does inject the fuel under pressure because the principle of a venturi, as used in a carburetor, causes a low pressure area at the venturi and fuel is then pushed from the reservoir by atmospheric pressure into the low pressure area.

However, our typical fuel injection system uses a high pressure pump to inject the fuel into the air stream and the amount of fuel is controlled by varying methods. Both fuel injection systems and carburetors (except on some diesel engines) use a THROTTLE VALVE to control the amount of air going into the engine. This is the part you control with your foot, and is usually a simple butterfly valve.

What then are the advantages of "fuel injection" over a typical carburetor. Well, first of all, depending on the injection system type and the carburetor type that it is being compared to, there may be no advantages and possibly even disadvantages. The normal advantages of fuel injection are: 1. The ability to inject the fuel at a more advantageous point in the inlet system. 2. A more precise metering of the amount of fuel. 3. A more even distribution of the fuel to the engine.

Typical fuel injection systems available today can be broken down into a number of types. First of all there are two main classes, timed and constant flow. On a timed system, each injector or nozzle is activated in sequence with the engine firing order. The advantage obviously is that the fuel can be injected in the port to a particular cylinder at precisely the correct time to mix with air going into that cylinder. Constant flow is just that; the injector flows contant fuel.

Fuel injection types are broken down primarily by where the injection takes place and these different types can sometimes be either timed or constant flow.

DIRECT CYLINDER INJECTION

This type of injection system places the injector directly in the combustion chamber of the engine and is primarily used only in diesel engines. In this type of injection system the fuel does not have to pass through the valve system or ports and runners and the valve timing affects only the airflow into the cylinder. This type of unit must be timed and as in the case of a diesel engine can actually control the ignition timing of the cylinder.

The cost is quite high due to the requirement for a timed system, and also for an injection nozzle that can withstand the temperatures and pressures of the combustion chamber. It is also extremely difficult to retro fit an engine not designed for this as the injector nozzle must be placed in the combustion chamber and extensive modifications of the cylinder head are necessary.

We'll concern ourselves more with the next two types of fuel injection systems which are much more appropriate to modify our Pantera engine.

THROTTLE BODY INJECTION

In this type of system the injector nozzle or nozzles are located in the throttle body mechanism that is usually located on a manifold similar to the carburetor on a conventional system. The air sensor control which determines the amount of air coming through the system (so that it can regulate the amount of fuel being injected into it) is usually, but not always, part of the throttle body assembly.

Typical air sensors in use today can consist of three types. The first and oldest type is a venturi similar to a carburetor that senses the low pressure area caused by air flowing over the venturi. This signal is used to regulate the flow through the injector. The combination of the throttle body type of injector along with this type of sensor, still requiring a venturi, results in very little if any advantage over the typical carburetor.

The second type of sensor, used on some Bosch fuel injection systems, used a floating paddle. The airflow coming through the throttle body would move the paddle according to the amount of air and the position of this paddle was used to regulate the amount of fuel to the injector.

The third and newest sensor for airflow is called a "hot wire". A very thin wire is stretched across the incoming airflow. Electrical current is passed through the wire causing it to heat up. The amount of air flowing over this wire regulates the temperature of the wire and this changes the resistance, in proportion to airflow. The beauty of this system is that it automatically compensates for air density and gives a much more consistent air/fuel ratio for the engine. All these systems are usually modified by other input signals such as the RPM of the engine and the actual position of the throttle valve.

I almost forgot; there is another method which is sometimes used called a MAP. The MAP is a manifold absolute pressure sensor. This signal in combination with the RPM of the engine can essentially tell the fuel injection system just how much fuel is needed by the engine. The MAP sensor is very seldom used by itself in a fuel injection street engine, but sometimes it is used as an additional sensor along with the others to more precisely

regulate the amount of fuel being injected.

As of today, the hot wire sensor system is proving to be the best all-around type and is used on the latest Bosch fuel injection systems as well as a number of after-market systems such as the B&M and the Air Sensors systems.

The throttle body type fuel injection is usually a constant flow type as there is no reason to time the injector firing by sequence of the engine. There are however, some after-market type systems, such as the ones mentioned above that are essentially using the Bosch port-injection injectors. Since these are fired electrically, it was an easy adaptation of the system to use four injectors in the throttle body and fire them sequentially only for regulating the amount of fuel and having nothing to do with the specific firing order of the engine.

PORT INJECTION

The Port injection system works the same as the throttle body system except the injectors are placed in the individual intake ports of the cylinder heads or the intake manifold. This system obviously requires the same number (or multiples) of injectors as cylinders.

There is a lot of "magic" to the placement and aiming of the injector nozzles. The original, and still favorite position is at the end of the intake runners and aimed at the base of the intake valve. During my experience at Ford back in the early 60's, it was found that the horsepower could vary as much as 40 h.p. just with slight variation of this aim.

Some of the newer thinking in very high output engines with tuned intake runners, is to place the injectors at the very beginning of the runners so that the fuel has time to "be conditioned" before it gets in the combustion chamber.

The throttle body and air flow sensors used with port injectors are essentially the same as with the throttle body injection systems. Port injection systems may be either timed or constant flow, with the main advantage over the throttle body system being near perfect cylinder distribution.

I hope helps in giving you a clearer understanding of Fuel Injection.

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Fuel System

GROUP 24

FUEL FLOW

by Ted Mitchell

Afer my article on Fuel Injection, I got some questions concerning actual applications to the Pantera. One of these questions concerned the determination of FUEL FLOW for OUR engines.

I am usually razzed about getting too technical in my articles, but instead of just saying that you need to flow about 27 gallons per hour for your almost stock Pantera, I want to give you a little more information so you can match the flow to YOUR Pantera.

WHY?

First, why do you need to know about fuel flow? Fuel provides the energy to produce POWER. I don't care what you do to your engine, you CAN'T PRODUCE ANY MORE POWER THAN THE AMOUNT OF FUEL WILL PROVIDE. O.K., why don't we just flow massive amounts of fuel? For fuel to provide power it must be BURNED, and it can only be burned in the presence of oxygen. We usually get the oxygen from air (except for use of an oxidizer such as Nitrous Oxide), and the amount of air that our engine can get is determined by the size in cubic inches, and the breathing efficiency (porting, camshaft design, supercharging, etc.).

What we are usually concerned with is minimum fuel flow so that we have enough for MAXIMUM H.P. We want to make sure that we are able to flow enough fuel to support the Horsepower that our engine is capable of producing. We don't want to flow TOO much more than we need, because: 1. the equipment costs more, and 2. like any device, fuel pumps, injectors, carburetors, etc. work best in a relatively narrow range.

So if we only need about 27 gph (gallons per hour), and we bought a fuel injection system capable of 100 gph when there was a system capable of 50 gph, we would be wasting money, AND it probably wouldn't work as good (especially when you consider we would be using something more like 3 gph while cruising down the freeway).

CALCULATING FUEL FLOW

First, the hard way! Gasoline will produce about 126,000 BTU's (a measure of thermal energy) per gallon. One horsepower is equivalent to approximately .7 BTU's /second. Therefore, 300 horsepower would require 300 x .7 = 210 BTU's/sec or x 3600 = 756,000 BTU's/hour. WOW! If we divide this by our 126,000 BTU's per gallon of gasoline we only need 6 gallons of gas per hour, right? WRONG!

Unfortunately, our beautiful Pantera engine (along with other internal combustion engines) is VERY poor at converting gasoline into horsepower. It uses only about 22 % of the energy of the fuel. CAN YOU BELIEVE THAT? 22%! Most of the thermal energy turns into the unwanted heat that we have so much trouble getting rid of in the Pantera.

Anyway, if we divide the

756,000 BTU's we needed, by .22, we see that we really need 3,436,364 BTU's / hour! Divide this by our 126,000, and we get 27 gallons / hour.

Now I mentioned that I was starting with the hard way. That was so you would see where it all comes from.

THE EASY WAY

There is a number called Brake Specific Fuel Consumption, or BSFC. This stands for the pounds per hour of fuel burned for each horsepower developed. So if we know the BSFC of an engine and multiply it by the horsepower, we get the pounds per hour of fuel we need. Since gasoline weighs about 6lbs per gallon, we can calculate the fuel flow.

Let's go back to our 300 H.P. Pantera engine. The BSFC of our engine will probably be somewhere around .5 to, at worst, .6. I usually assume a .54. If we multiply 300 H.P. x .54 = 162 lbs. Divide this by 6 lbs/gal and we get 27 gallons per hour. So you better make sure your fuel pump can pump that much fuel through your fuel filter and into your carburetor. (By the way, that's .45 gallons in a minute, which is easier to measure.)

MODIFIED ENGINE

O.K.! Now let's figure out that new engine you want to build, and order a fuel injection system for. Let's say we are shooting for 550 H.P. 550 x .54 / 6 = 49.5 gallons per hour of fuel. Easy?

Now if someone tells you their injection system can flow 24 gpm of fuel, and they got 450 H.P. on the old dyno, don't buy a bridge from them. 450 x .54 / 6 = 40.5 gpm! About the best BSFC you can get AT MAXIMUM H.P. (and this is usually a small engine) on our kind of engine, is .43. So 450 x .43 / 6 is still over 32 gallons per hour!

SUPER EASY

If you take our .54 BSFC and divide it by 6, you get .09, which is almost .1. If you want a rule of thumb you can remember, take the H.P. divided by 10 and you'll be safe! 500 H.P. is 50 gph, etc.

TECHNICAL BULLETIN

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GROUP 27

Cooling System

THE PANTERA COOLING SYSTEM, FAULTS AND FIXES

by Jack Richards

WHAT'S WRONG AND WHY:

The water pump: The stock Ford water pump was designed for a front-engine car. When the engine is warm and the thermostat is open this pump pushes coolant into the top of a radiator (that is only a few inches away) and gravity takes it down the "water fall" through the radiator and into the bottom of the engine block, where the heat helps it rise to the water pump. The thermal and gravity forces at work in this type of system create such a natural coolant flow that some early front-engine cars didn't even use water pumps.

Automotive water pumps have single centrifugal "high-bypass" impellers that allow fluid to cavitate / tumble around the blades - and for a good reason. When an engine is cold the thermostat is closed, and fluid cannot flow through the cooling system. But the impeller (like the agitator in a washing machine) mixes the coolant to maintain an even temperature throughout the engine and against the thermostat.

The Pantera was designed and built in the era of the first mid-engine race cars, and its cooling system suffers the same maladies as those early racers. Coolant flow in a mid-engine & front-radiator car is not aided by thermal or gravity forces. The coolant must be pumped through about sixteen feet of lines and a remote radiator before it gets back to the engine. Water pumps as described were not built for such work, and in a Pantera this pump's open, high-bypass design allows coolant to flow backward around the impeller even when the thermostat is open and the engine is overheating. Current mid-engine race cars have cooling systems with twin radiators in side pods much closer to the engine.

Also, in a Pantera the coolant flows contrary to systems that we're used to seeing - hot water enters at the bottom of the radiator and must be pushed up that two gallon "water fall." Again, the stock Ford water pump was just not designed for this kind of work.

The radiator & fans: In a Pantera these pieces are improperly mounted - air leaving the back of the radiator has no adequate escape. Also, the main coolant fittings on the radiator are both attached in the middle of the side tank - probably because the way that this radiator is mounted left no space between the radiator and the chassis for positioning these connections at the top and bottom of the radiator. Air bubbles in the coolant are trapped inside of the radiator in the large area left above the top hose, and since there's no escape, periodic manual bleeding is required.

Other materials & equipment: In L.A. smog European rubber hoses rot instantly. The OE Pantera coolant tubing is so bad that I think it must have left the foundry rusty. These materials are inferior for coolant lines by U.S. (or any other) engineering standards.

WHAT TO FIX AND HOW:

Some of the modified Pantera cooling systems on the market "kill" the car's engineering faults with giant radiators. However with the modifications I'm suggesting I believe that all of these problems can be fixed without great expense or serious changes to the car - and even using a stock radiator.

The water pump: First determine if your Pantera has a high-bypass water pump. Remove the stock pump to expose the rear of the impeller. If it is stock you will see a star shaped impeller that is formed from a sheet steel stamping (see the drawing). The trailing edge of each star-point is bent inward forming the impeller vanes that move the coolant when the star is turned. But, as you can see, water is free to flow between the points of the star and around these vanes. And your Pantera may be overheating because of poor water pump performance in a cooling system with internal resistance that causes too much coolant to flow around these vanes.

There's a quick way to find out - a pump that allows less fluid to bypass will flow more through the cooling system. So

pop-rivet a flat round disk to the impeller star closing off most (but not all) of the space between and around the outer edge of the blades. Leave 1/4 to 3/8s inch around the outside of the new disk so that the pump can bypass coolant as needed when the engine is cold, but it will bypass less when the engine is warm. Install the modified stock pump and see what effect the change has on your Pantera's temperature gauge. If there is an improvement with this simple trick then you should consider a permanent fix.
(MM Note: I wouldn't leave the pop-rivoted plate on permanently; due to the corrosion of the parts, and subsequent possibility of the plate coming loose in the pump.)

Installing a Ford Motorsport / SVO impeller. These impellers are cast steel, and the back is not star shaped but round. And the SVO impellers have spiral shaped vanes to generate greater water pressure at a lower flow rate.

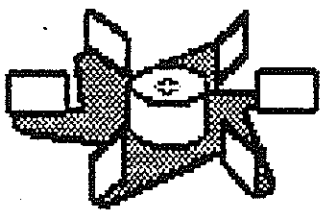
SVO impeller,
part number: M8512-A302
prices: $34 retail / $26 dealer

Water pump shaft and bearing assembly,
part number: M8530-A351
prices: $9 retail / $7 dealer

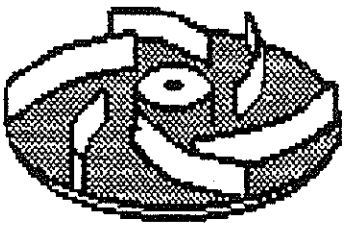
Water pump seal and seat,
part number: D4AZ8564-A
price: $9

For a complete job you may also want this
351 cleveland aluminum water pump housing,
part number: N8505-A331
prices: $131 / $100

NOTES These prices are L.A. CA. area as of Sept. '88. All of these parts are listed in the current Ford Motorsport catalog available at your local Ford dealer. But be cautioned, these are Ford Motorsports pieces, not production car parts. This means that Ford Motor Company has no obligation to continue producing them, and can stop without warning at any time. (Many of you will recall the old FOMOCO HI-PO catalog and the parts produced in the sixties). What I'm telling you (Pantera dealers and owners) is that if you want to keep these cars running you'd better buy now what you need for the future.



STAMPED STEEL



CAST

WATER PUMP IMPELLERS

(MM Note: The earlier 302 impellers were of the cast design and are interchangeable. I have found that many water pump rebuilders have cast impellers on hand and will install them on your rebuild for no extra charge if you request it.)

If you want to convert your water pump to SVO specs or build a complete new 351 Cleveland / SVO water pump here are the Ford parts and part numbers for the job.

There are several brands of rather flat electric radiator fans on the market. Most are made to attach to back of the radiator. The fans I prefer have many blades and shrouds built into the impeller that run very near the radiator cooling fins. These are much more efficient than the "shroudless" stock fans that were mounted ahead of the radiator.

These fans are distributed by:
Flex-a-lite Corporation
4540 S. Adams, Tacoma WA. 98409
phone: 206 / 475 - 5772
(MM Note: They are available from most auto parts specialty shops.)

I took the radiator out of the car, removed the unneeded stock fans and cut away all of the original fan brackets. This left a lot of space in front of the radiator. On lowering the radiator into the chassis I sat it on top of the cross brace instead of into its original mounts, and I inclined it forward to about a 50-60 degree angle. The radiator in this position cleared everything beautifully, and it allowed for the correction of several of the cooling system flaws that were noted earlier in this article.

With the radiator canted forward the fans now drew air into a large cavity under the hood. I bought and installed a set of Pantera hood vents. (These are little aluminum grills that come with very good instructions and are easily installed.) And hot radiator air was directed out these vents.

There was now space for coolant lines at the top and bottom of the radiator. So I had a radiator shop remove the original fittings and solder short American fittings in the proper corners of the right hand tank.

There was also enough space in front of the remounted radiator for an air conditioner condenser, and even space left to service, remove, or reinstall this unit without removing the radiator.

I fabricated brackets to remount the radiator in the new position (see the scale drawings on page 4).

NOTE These brackets will fit and work equally well with either a stock Pantera radiator or a Phoenix unit. Just

replace those stock Pantera fans with the flat type rear mounted fans.

Installing these new radiator brackets required drilling some holes in the chassis lower cross member and also snipping little extensions in the sheet metal cut-outs for clearance of the top fittings. On the underside if the lower cross member. I used a 1-1/2 inch hole saw to make an opening near each end. Through these holes nuts for the four radiator bracket bolts were placed inside of the cross member.

After trial fitting, everything was removed and disassembled for paint and polish. Then I touched up the bare metal edges on the Pantera chassis.

Other American parts and materials used:

The first thing I did when I bought my Pantera was take it completely apart. On reassembling the car I replaced all the lines and tubing. For hard lines. I used seamless brass or stainless tubing of appropriate sizes. The common hardware store is a great source for most of these items. For example. I found that household brass plumbing lines were exactly right for the heater lines.

You may also want custom formed hard lines to reduce resistance in the coolant flow. With these custom formed tubes all kinks in the coolant system were eliminated. Short rubber hoses between these tubes tied up the system and kept internal resistance to an absolute minimum.

I accomplished this job with the engine in place. the radiator remounted in the new position, and the coolant surge and catch tanks in the car. Then I had a header manufacturer - working directly with the car - bend four special coolant lines from

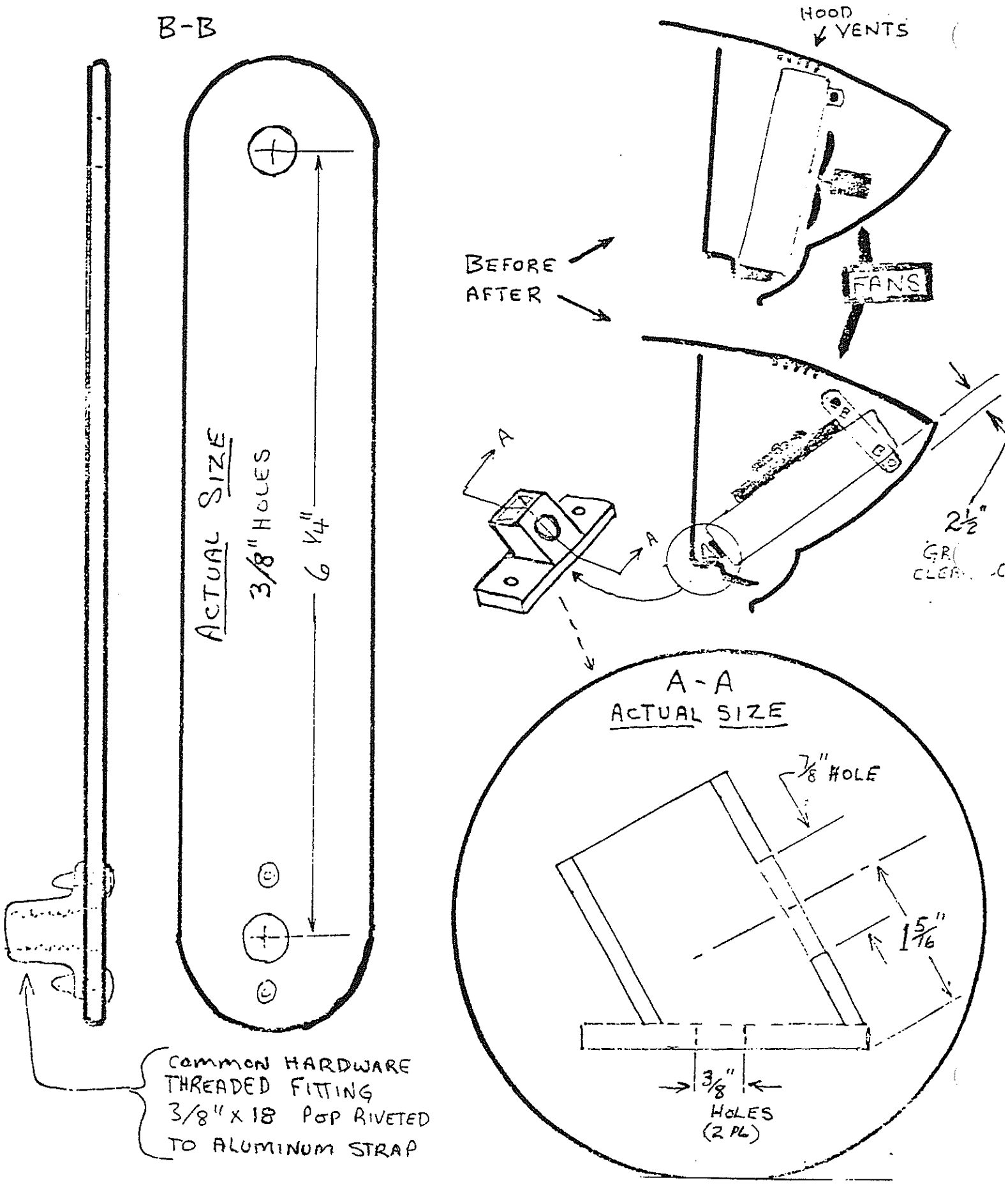
1-3/8 inch header tubing. One line goes from the engine to the surge tank. A second carries coolant from this tank to the rear of the long line that leads to the front of the car. The third tube takes the fluid from other end of this line to bottom of the radiator. And the forth hooks the top of the radiator to the return line. The line from the other end of this return tube to the bottom of the water pump is the only stock line that I retained.

HIGH FLOW / LOW RESISTANCE THERMOSTATS:

Another interesting part that I found on the hot rod market is a thermostat that is designed especially to eliminate resistance and promote greater volume of coolant flow.

*(MM Note: Remember that any thermostat used in the 351 Cleveland ***MUST*** have the small "hat" section on the lower end of the moveable part, to close off the bypass hole in the block!)*

J.R.



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Cooling System

GROUP 27

A PROBLEM THAT REACHED THE BOILING POINT

By Russ Britschgi

Sure Panteras run hot, but what can you expect from a car that has no way of moving cool air through the engine compartment, that is designed to use a 192 degree F. thermostat and that expects the hot air that has passed through the radiator to sink to the ground rather than rise through the hood. I have owned my '73 Pantera for about four years now and have not put very many miles on it, because I have avoided hot days and stop and go traffic.

I reached my boiling point, and so did my Pantera, on the club's last trip to Lake Tahoe. After that trip I decided to do a little investigative research into the cause of the embarrassing green puddles my otherwise beautiful car was leaving whenever it stopped moving for more than a minute or so.

The first bit of research was to ask other club members what they know about overheating problems. "Bad radiator cap", said one. "Use a 160 degree thermostat", said another. "Missing bypass restriction plate", said a third. "Baffling", said a fourth. "Baffling indeed", I said to myself. I only had one problem, why should there be so many answers?

I then turned to the Ford Technical Service Bulletins, Service Manual, Master Parts Book, and all the POCA and Pantera International articles I could find. After all, if a little knowledge is dangerous, then a whole lot should really get you in trouble.

One of the first things I did was to check out the thermostat and bypass restriction plate. With the coolant drained down to the water pump level and the engine discharge tube removed (the pipe attached to the block right next to the distributor), the thermostat can be lifted out. Just below the thermostat in the block should be a brass disk about 2 inches across and with a hole of about 11/16 inch diameter in its center this is the bypass restriction plate. On the base of the 341 Cleveland thermostat should be a piece of brass tubing flared out to 11/16 inch outside diameter. The theory here is that when the thermostat is closed (cold engine), the water will be allowed to circulate through the block and return to the water pump through the bypass disk, thus allowing an even heating of the water and an even cooling of al the metal surfaces within the engine's water jacket. As the engine warms up, the thermostat opens and the bottom part of the thermostat moves down to close off and a thermostat with a flared end are installed to prevent the flow of hot water directly back into the engine when th correct operating temperature is reached. Both parts were correct in my engine.

While I had the thermostat out, I did a simple test to see if it was operating correctly. By placing a pan of water on the stove with a thermometer and the thermostat

in it, I was able to watch the action of the thermostat with changes in the water temperature. I did this test with two 192 degree thermostats and found that one opened at 185 degrees and the other at 193 degrees.

I had ordered a 160 degree thermostat from Hall Pantera because the local parts stores did not have any listed as an option for the 351 C engine. The hall unit is fine except it does not have the extra flare to plug off the bypass orifice. I installed the thermostat that opened at 185 and the Hall thermostat is sitting on my work bench.

While the access panel was removed, I took the opportunity to replace the fan belt and check the water pump action. The bearing sounded O.K. and the shaft did not appear to be broken or disconnected from the pump impeller.

I then turned to the radiator. After refilling the coolant tank and bleeding as much air as I could get from the radiator, I removed the right front wheel which allowed me to reach the radiator inlet and discharge tubes. With the engine idling, I watched the coolant level in the open pressure tank. When the level started to drop, I knew the thermostat was opening. I quickly added more water and went to the front of the car to check the radiator temperature. The inlet tube was quite warm, close to 185 degrees no doubt, and the outlet very close to the same temperature. I quickly checked the left hand end of the radiator and found it to be cold. "Baffling", I said.

Upon draining and pulling the radiator, I removed the two fan control sensors and was able to shine a light into the opening for one sensor while looking into the opening for the other. This revealed two things: 1) that this was the late style radiator with the horizontal baffle, and 2) that the baffle was about 3/8 inch from contacting the header plate of the tube bundle. When the tank was removed at the local radiator shop, it was discovered that the "horizontal" baffle was actually about 30 from horizontal and that most likely the core had been replaced by a previous owner. Because the "new" core had all the tubes in parallel rows, the slanted baffle which was fixed to the top and sides of the tank had been bent out of the way so that it would not interfere with the tubes when the tank was replaced. All of this meant at slow engine speed the flow rate was low enough that most of the coolant was going around the baffle and right back to the engine. Whereas at higher engine speeds, 2000 rpm and up, the flow rate was higher and enough coolant would flow through the core and keep the engine temperature within the correct range.

A new baffle was cut and soldered to the tube header. The slant baffle was removed from the tank and the top of the tank was slit to allow the new baffle to protrude through when the tank was replaced. After resoldering the tank to the core, the protruding baffle was bent over the tank top and soldered. Pressure testing revealed no leaks and the radiator, which now has a horizontal "horizontal" baffle, was reinstalled.

While I was waiting for the radiator shop to finish their part of the job, I checked out both fan sensors in much the same manner as I used to check the operation of the thermostat. An ohm meter was used to detect the opening and closing of the contacts. One sensor closed at 182 degrees and the other at 195 degrees. These settings seem a bit low for an engine that calls for a 192 degree thermostat, however, they are nonadjustable and I was running

out of time to locate any others.

The radiator cap was the next item I looked at. The importance of a good cap is this: at fifteen pounds pressure (15 P.S.I.G.) water boils at about 248 degrees F. and a 50/50 mix of Prestone Anti Freeze at the same pressure will boil at 265 degrees F. On the other hand at say 6000 feet of elevation (i.e., Lake Tahoe), water boils at only 200 degrees F. or just about 8 degrees above the point at which the engine thermostat is supposed to open. Thus a cap that does not seal can be a major problem.

There appears to be a dimensional difference between the filler necks used on Pantera pressure tanks and those used on standard American radiators. For the system to work correctly, the spring loaded portion of the cap must seat on the surface just below the overflow tube and the top of the cap must seal on the surface just above the overflow tube. As th engine warms up, the pressure from the expanding coolant will build up to the point at which it unseats the lower seal (i.e., the cap rating). The pressure in the system cannot build any higher and the excess coolant flows through the overflow tube and into the overflow tank. When the engine cools and the internal pressure drops, coolant is then drawn back into the pressure tank: (1) if the seal at the top of the filler neck is good, (2) if the reverse flow check valve in the center of the cap is working correctly, and (3) if there is adequate coolant in the overflow tank.

By comparing the distance from the upper seal to the lower seal of a new Stant #BSP-18 radiator cap with the distance from the top seal surface to the lower seal surface of the pressure tank filler neck, I found that the lower seal needed about 1/8 inch more travel to really seat on the lower seal surface.

I was now left with two choices: either have the filler neck on the pressure tank replaced with one that meets the cap dimensions, or modify the cap. Because the tank had been chrome plated, I did not want to have any work done on it, so I modified the cap. This was easier than one may think. The BSP-18 cap is one of the lever type caps that allow the pressure to be released by lifting the lever on top of the cap. After removing the roll pin which attaches the lever to the rest of the cap, the lever was redrilled to allow for the 1/8 inch lowering of the seal. Also the roll pin had to be shortened to allow for clearance through the slot in the cap. Upon reinstalling the shortened roll pin in the new hole in the lever, I had a cap that worked.

(MM NOTE: Unfortunately this fix to the cap doesn't really solve the problem. Lowering the pin hole ONLY insures that the cap seal is REACHING the bottom of the neck. The AMOUNT that the spring is compressed, determines the amount of the pressure that the cap maintains, and this distance remains the same no matter where the lever pin is located. Because of this great article, I made some tests, and discovered that the difference in the Pantera tank and an American tank is good for about 1 pound of pressure. Therefore a 15 PSI cap will hold about 14 PSI in a Pantera. It would therefore seem that we should all be running at least 15 PSI caps. It is interesting to note that the Ford TSB calls the stock RS-40 cap a 13 PSI cap when all the specs I can find indicate that it is rated at 14 PSI.

REGARDLESS of rating, I failed to find one tank, out of four tested, that the seat area would even hold a constant pressure. They all had a dip in the seat next to the overflow tube. This is why I

have always advocated replacing your cap EVERY spring. At the least, you should reface the sealing seat in the tank, and at best replace the neck!)

The net result of all this is with a properly sealed system and a correctly baffled radiator, there should be no problem with boiling over. Also because a radiator must dissipate as much heat as the engine puts into it, merely changing the thermostat from 192 degrees to 160 degrees will not solve the problem of a slowly rising temperature gauge. It just means that it may take a little longer to get the same high temperature as before. Besides, the greater the temperature differential, the greater the heat transfer. Thus more heat is dissipated by a given radiator if the inlet temperature is 192 degrees than if the inlet temperature is 160 degrees.

In any event, my Pantera has now been house broken. No more puddles on the garage floor, long periods of idling don't seem to send the temperature gauge into orbit, and there are no deep mysterious rumblings from the engine compartment when the ignition is turned off. You know, it's amazing how much cooler the driver stays now, too.

R.B.

TECHNICAL BULLETIN

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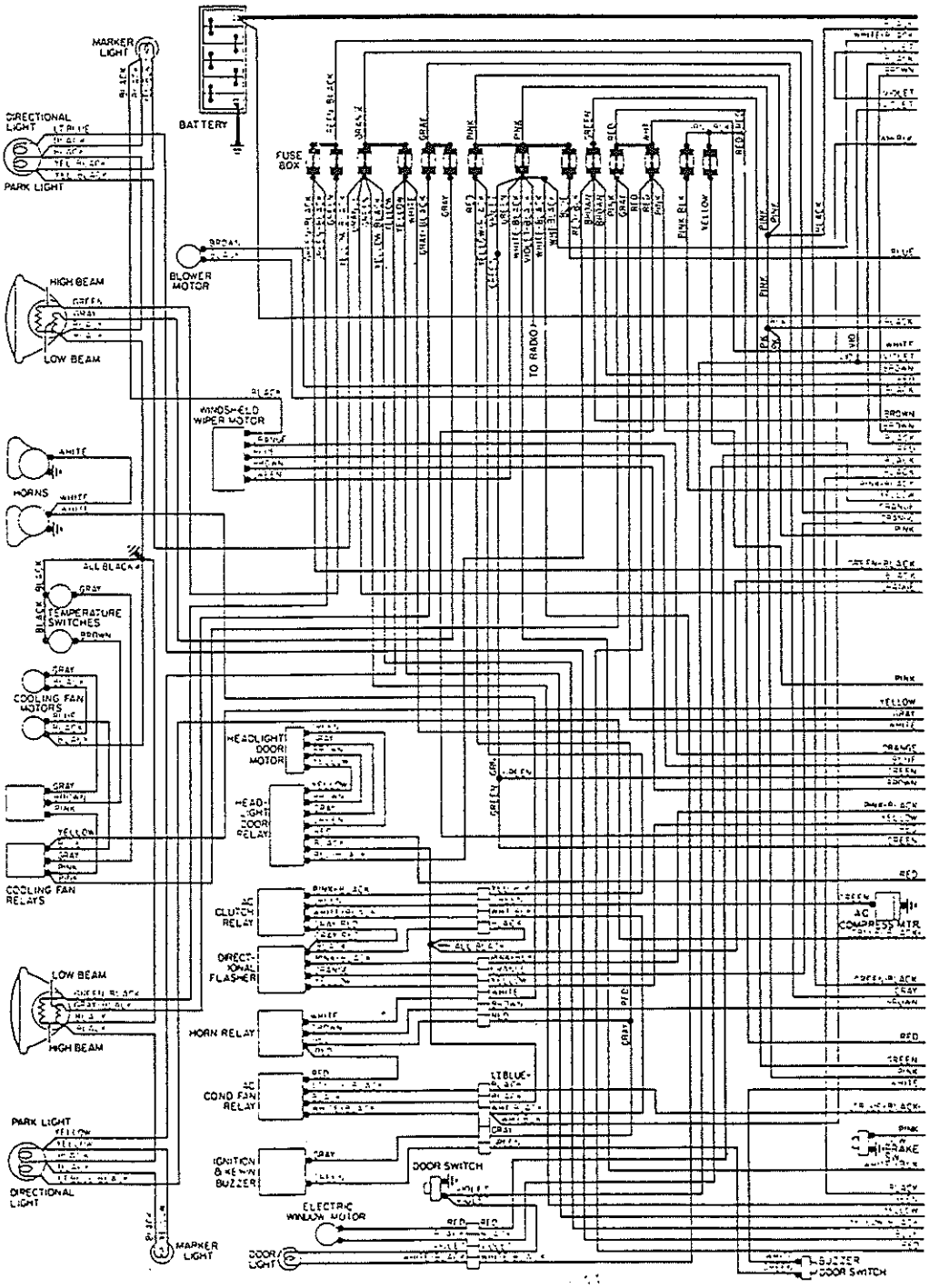
Main Wiring Harnesses and Circuit Protection

GROUP 34

1973 & 1974 PANTERA WIRING DIAGRAM: FRONT HALF THIS PAGE



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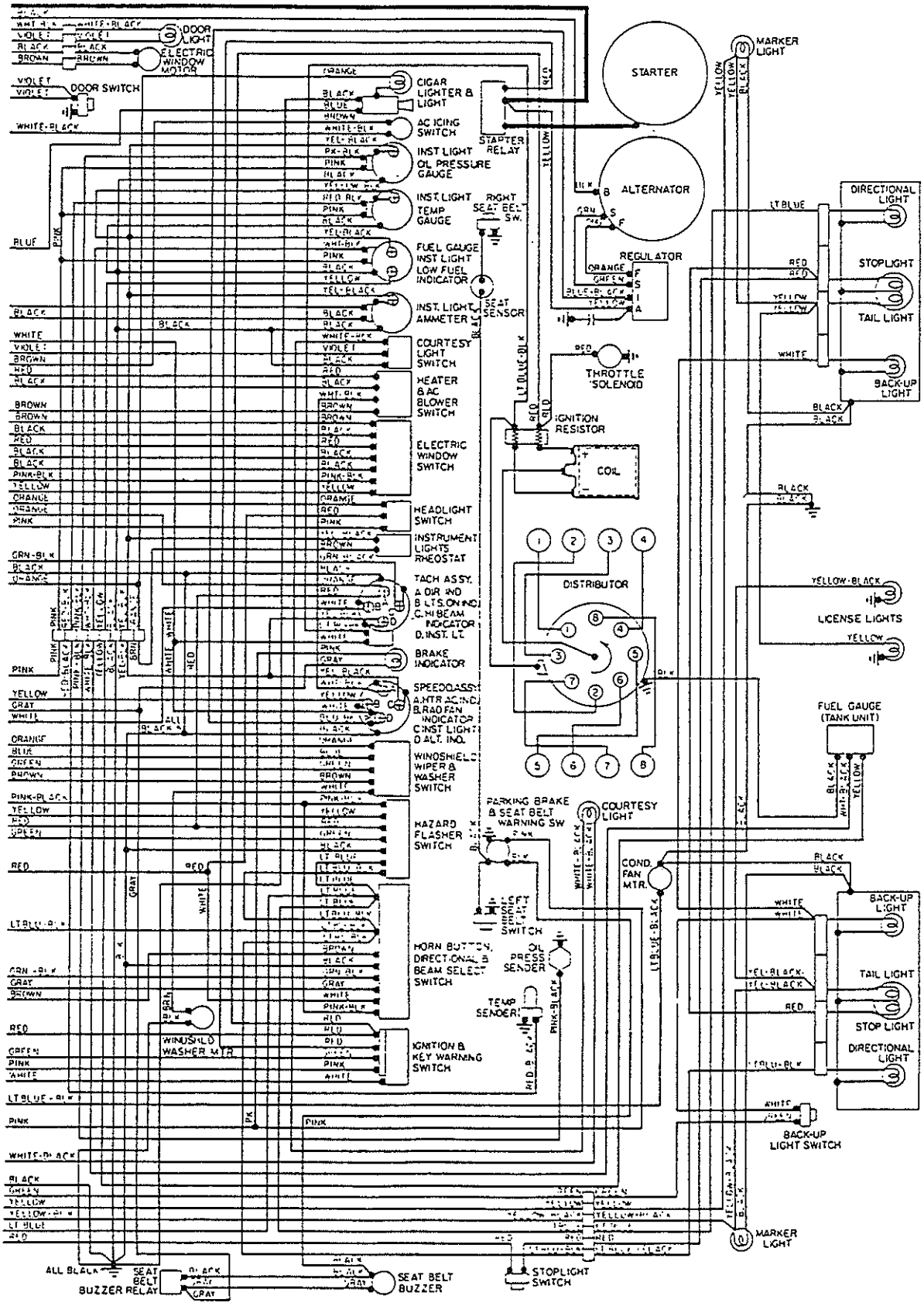
1973 & 1974 PANTERA WIRING DIAGRAM: REAR HALF THIS PAGE



POCA = TECHNICAL BULLETIN

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Ventilating and Heating

GROUP 36

HEATER HOSE SHUTOFF VALVE

by Ted Mitchell

We have talked about the heater hose problem before, but with the continuing influx of new POCA members, the questions of why and how to install the heater shut- off valve continue.

The heater system consists of a heater core up under the dash which is fed hot water by the engine. There is a control valve under the center of the dash which allows you turn the flow on or off, as well as vary it to control the heat put out by your heater. (This control valve seems to work from barely to bad.) The hot water comes from an outlet on the front of the engine block by way of a rubber hose in the engine compartment, to a steel line on the firewall in early cars, and into the tunnel in later cars. It ends up connected to another rubber hose at the heater control valve on all cars. After going through the heater core, the water returns the same way, ending up at a tube on the water pump of the engine.

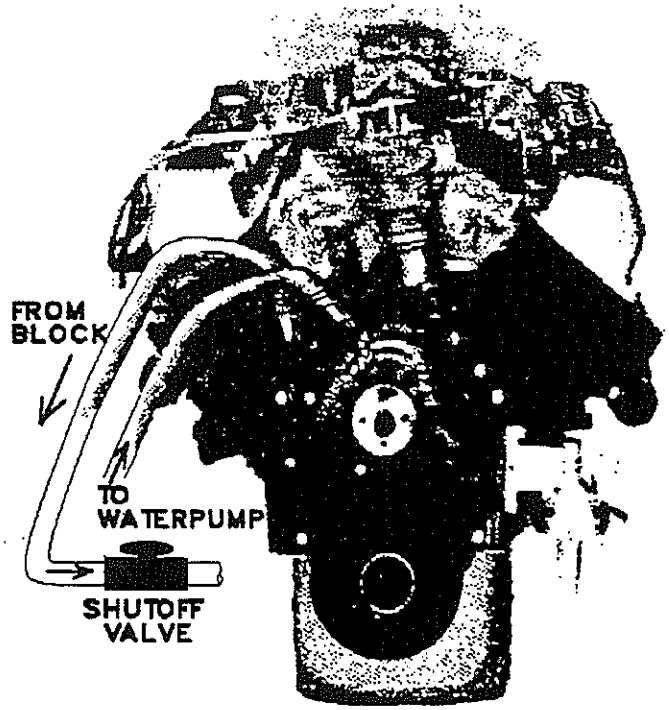
THE PROBLEM

Hoses eventually deteriorate and fail. Very few people change these hoses often enough, and even less ever change the hose under the dash until it fails. AND OH HOW IT FAILS! If the hoses in the engine compartment fail, you see steam on your rear window or out the rear view mirror. If you don't stop, the engine overheats and may even freeze up. BUT, if the hose fails in the car, the INSIDE of the car can be instantly filled with scalding steam, making visibility impossible. This can be a little disconcerting while your road racing down a mountain road, or on the course at Riverside! If you don't crash, you may end up with a scalded right leg and foot. All of the above HAS HAPPENED!

THE CURE

O.K. How do we prevent this rather nasty problem (and gain some benefits to boot)? First, aircraft type braided lines will not only make the repair "bullet proof", but make a difficult job relatively obsolete, both inside and in the engine compartment. Most of your local Pantera parts and repair dealers carry a kit to do this. Unfortunately, it is not realistic to check for this during POCA speed event tech inspections, but I highly recommend you do this as well as the next item. Second, a water shut-off valve OUTSIDE the passenger compartment prevents the dangerous problem, is easily checked for tech inspection, and has the added advantage of cutting down heat in the passenger compartment.

The new heater shut-off valve is installed in the heater hose, at the front of the engine, before it connects to the steel line at the firewall or tunnel. It MUST be installed in the hose bringing water from the front of the engine block to the heater,



as shown in the picture. A second valve MAY be installed in the return line going

to the water pump, but THIS IS NOT REQUIRED FOR TECH. The valve in the return line will prevent the hose from rupturing in the car after you shut the engine off. This could prevent a bad burn.

While the engine is running, we have found that there is NO pressure in the return line, so we only require the valve in the line TO the heater. Two valves makes it a little more difficult to use a remote control cable, if you desire to operate the valve(s) from the passenger compartment, which can be handy on a cold night in the summer when you have the valve(s) shut off.

There are dozens of heater shut off valves that are made to attach hoses to both sides (as compared to a valve made to screw into a fitting for example). Your local parts store should be able to help you. I have found two valves which are identical except that they mount in opposite directions to the flow (and are designed to be controlled with a cable), so that pulling or pushing will shut or open both valves the same. The valves are "EVERCO" #H1931 and #H1999. In 1982 they had a list price of $18 each. You might run the cable through the firewall down low, next to your seat, so that you can operate the valves while driving.

T.M.

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Lubrication & Maintenance

GROUP 53

PARTS & SERVICE SOURCES

ARIZONA

PANTERA PERFORMANCE ENGINEERING
22 North Perry Lane
Tempe, Arizona 85281
(602) 894-9636

CALIFORNIA

FANTASY RACING
P.O. Box 431
Sierra Madre, CA 91024
(818) 445-4116

GTS SPECIALTIES
6250 University Ave.
San Diego, CA 92115
(619) 582-7161

HALL PANTERA
15337 Garfield Ave.
Paramount, CA 90723
(213) 531-2629

JB'S AUTOMOTIVE REPAIR
21710 S. Western Ave.
Torrance, CA 90501
(213) 328-3787

LOMA PRIETA PANTERA
24355 Loma Prieta Ave.
Los Gatos, CA 95030
(415) 876-4200

MARK'S PANTERA PLACE
11782 Western Ave.,Suite 9
Stanton, CA 90680
(714) 895-5872

MAYBERRY LINCOLN MERCURY
4437 Lankershim Blvd.
No. Hollywood, CA 91602
(818) 984-3123

PANTERAS BY WILKINSON
16237 Illinois Ave.
Paramount, CA 90723
(213) 804-4321
(213) 634-3434

PANTERA SPECIALISTS
2824 S. Willis
Santa Ana, CA 92705
(714) 250-1797

PERSON FORD
2855 Foothill Blvd.
La Verne, CA 91750
(714) 593-7411

COLORADO

PANTERA PERFORMANCE CENTER INC.
13749-A E. Smith Dr.
Aurora, CO 80011
(303) 360-9848

FLORIDA

PANTERA MIAMI
12017 S.W. 114 Place
Miami, FL 33156
(305) 251-2591

KANSAS

ATWOOD AUTO SPECIALISTS
504 Pearl St.
P.O. Box 72
Atwood, KS 67730
(913) 626-3144
(913) 626-3272

THE PANTERA PARTS CONNECTION
406 South 5th Street
Atwood, KS 67730
(913) 626-3353

MICHIGAN

TOTAL PERFORMANCE
44020 Goesbeck Hwy.
Mt. Clemens, MI 48043
(313) 468-3673

This list is supplied by the **Pantera Owners Club of America** as a member service only. This listing does not imply or express any positive or negative endorsement by the **Club**. **POCA** reserves the right to include or disclude any organization from this list at it's sole discretion. Some of the owners of these organizations may belong to **POCA**, and some do not. We encourage you to compare prices and service.

NEW JERSEY

MEADOWLANDS CAR IMPORTS
608 Tonnelle Ave.
North Bergen, NJ 07047
(201) 866-4448

NEW YORK

M & D ENGINEERING
111-30 Van Wyck Expy.
Jamaica, NY 11420
(718) 529-2323

OHIO

AMERISPORT
1369 Shoop Ave.
Wauseon, OH 43567
(419) 337-5872

TEXAS

NEAL & ASSOCIATES
10725 Sandhill
Dallas, TX 75238
(214) 340-1464

PANTERA OF HOUSTON
1403 Cedar Post Ln.
Houston, TX 77055
(713) 781-9267

WASHINGTON

BELLVIEW AUTO SPORT
303 12th
N.E. Bellview, WA 98004
(206) 455-9575

WISCONSIN

STAUFFER CLASSICS
10967 Division St.
Blue Mounds, WI 53517
(608) 437-3000

WYOMING

GRIENER FORD
3333 Cy Ave.
Casper, WY 82604
(307) 266-1680

MASTER MECHANIC
TED MITCHELL
1822 WEST 9TH STREET
UPLAND, CA 91786
(714) 981-0796

Lubrication & Maintenance

GROUP 53

PARTS & SERVICE SOURCES

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PACTRAN
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San Marcos, CA 92069
(619) 726-8372

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(913) 626-3272

THE PANTERA PARTS CONNECTION
406 South 5th Street
Atwood, KS 67730
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MICHIGAN

351 CLEAVELAND PERFORMANCE PARTS
contact: Mike Crawford
2905 S. Cambridge
Lansing, MI 48911
(517) 485-8353

SHARPS SUPPLY
contact: Bruce Sharp
104 Grand Ledge Hwy.
Mulliken, MI 48861
(517) 482-6382

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OHIO

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Maumee, OH 43537
(419) 825-2324

TEXAS

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10725 Sandhill
Dallas, TX 75238
(214) 340-1464

PANTERA OF HOUSTON
c/o Ray Pringle
1403 Cedar Post Ln.
Houston, TX 77055
(713) 781-9267
(713) 461-8881 ????

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Lubrication & Maintenance

GROUP 53

PARTS INTERCHANGE

NOTE: THE POLLOWING LIST IS THE FIRST TRY AT PRODUCING A PANTERA PARTS INTERCHANGE LIST. I HAVE NO VERIFICATION OF THESE PARTS, AND WOULD APPRECIATE INPUT FROM THE MEMBERS CONCERNING THIS LIST. IT WILL BE REVISED AS OFTEN AS POSSIBLE. Master Mechanic

GROUP - PANTERA PART	*INTERCHANGE PART #*	*COMMON APPLICATION*	*MOD. REQ'D ?*
12 -Rear Brake Pads	D-105	Front pads for: 1964-70 Ford Cortina 1972-76 Jensen Healy 1971-73 Plymouth Cricket Wagon	
12 -Rear Caliper Seal Kit	F.A.G. KC 14000	Use 1 kit	
12 -Parking Brake Lever		1971-73 Mercury Capri	
13 -Steering Column/Ignition Assembly and Housing		1971-73 Mercury Capri	
16 - Clutch Master Cylinder Kit	BAP/Geon 26-06300	Use 1 kit. 1978 Alfa Romeo Sports 2l Sedan	
16 -Clutch Slave Cylinder Kit	BAP/Geon 26-16101	Use 2 kits; 1 seal from each Also Early Chevrolet Truck-1 inch slave cyl kit. Use 1 kit.	Some parts discard
27 -Radiator Fan Brush Kit	LUCAS WKB102	Board contains 3 brush unit: remove center one.	X
32 -Tail Lights		Maserati Ghibli, Bora, Indy: Bricklin: Late '60 Alfa Berlina 4dr Sedan	
35 -Window Motors		Most early 1970's Maserati and Citroen	
47 -Side Marker Lenses (not bezel)		1971-73 Mercury Capri	
47 -Ghia Badges		1978 Fiesta Ghia	

POCA

TECHNICAL BULLETIN

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Lubrication & Maintenance

GROUP 53

PARTS INTERCHANGE

GRP/PANTERA PART	INTERCHANGE PART NUMBER	COMMON APPLICATION	MODIFICATIONS
12 Rear Brake Pads	D-105	Front pads for: 1964-70 Ford Cortina 1972-76 Jensen Healy 1971-73 Plymouth Cricket Wgn	
12 Rear Caliper Seal Kit	FAG KC 14000		Use 1 kit
12 Parking Brake Lever		1971-73 Mercury Capri	
3 Steering Column/Ignition Assembly and Housing		1971-73 Mercury Capri	
16 Clutch Master Cylinder Kit	BAP/Geon 26-06300	1978 Alfa Romeo Sports 21 Sedan	Use 1 kit
16 Clutch Slave Cylinder Kit	Beck Arnley 0713438 BAP/Geon 26-16101 ???	1980-84 Alfa 2000 ??? Early Chevrolet Truck w/1 inch cyl.	Use 1 kit 2 kits/1 seal from ea. Discard boot
27 Radiator Fan Brush Kit	Lucas WKB102		Board has 3 brushes Remove center unit.
32 Tail Lights		Maserati Ghibli/Bora/Indy Bricklin Late '60's Alfa Berlina 4dr Sedan	
35 Window Motors		Most early '70's Maserati & Citroen	
47 Side Marker Lenses (not bezel)		1971-73 Mercury Capri	
47 Ghia Badges		1978 Fiesta Ghia	

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TECHNICAL BULLETIN

Lubrication & Maintenance

GROUP 53

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CALIFORNIA

CALIFORNIA FLASH
Contact: Jeff Price
3305 E. Miraloma, Suite 169
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(714) 993-5977

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LOMA PRIETA PANTERA
Contact: Jonathan Long
24355 Loma Prieta Ave.
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(213) 634-3434

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(714) 250-1797

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La Verne, CA 91750
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FLORIDA

PANTERA EAST
7165 30th Ave. North
St. Petersburg, FL 33710
(813) 381-1151
FAX (813) 343-4410

KANSAS

THE PANTERA PARTS CONNECTION
Contact: Bill Welch
109 S. Colley, P.O. Box 38
St. Francis, KS 67756
(913) 332-2824

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351 CLEAVELAND PERFORMANCE PARTS
contact: Mike Crawford
2905 S. Cambridge
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SHARPS SUPPLY
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PANTERA SPECIALISTS
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Roy Butfoy (ZF Transaxles)
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(714) 250-1797

PERSON FORD
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La Verne, CA 91750
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MICHIGAN

351 CLEAVELAND PERFORMANCE PARTS
Contact: Mike Crawford
2905 S. Cambridge
Lansing, MI 48911
(517) 372-3080

SHARPS SUPPLY
Contact: Bruce Sharp
104 Grand Ledge Hwy.
Mulliken, MI 48861
(517) 649-8550
(800) 869-9505 Orders Only

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Cleveland Engine Parts
44020 Groesbeck Hwy.
Mt. Clemens, MI 48043
(313) 468-3673

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M & D ENGINEERING
Contact: Michael Bigonis
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Jamaica, NY 11420
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