PROJECT X1/9

The Complete Guide to Racing Preparation of the Fiat X1/9


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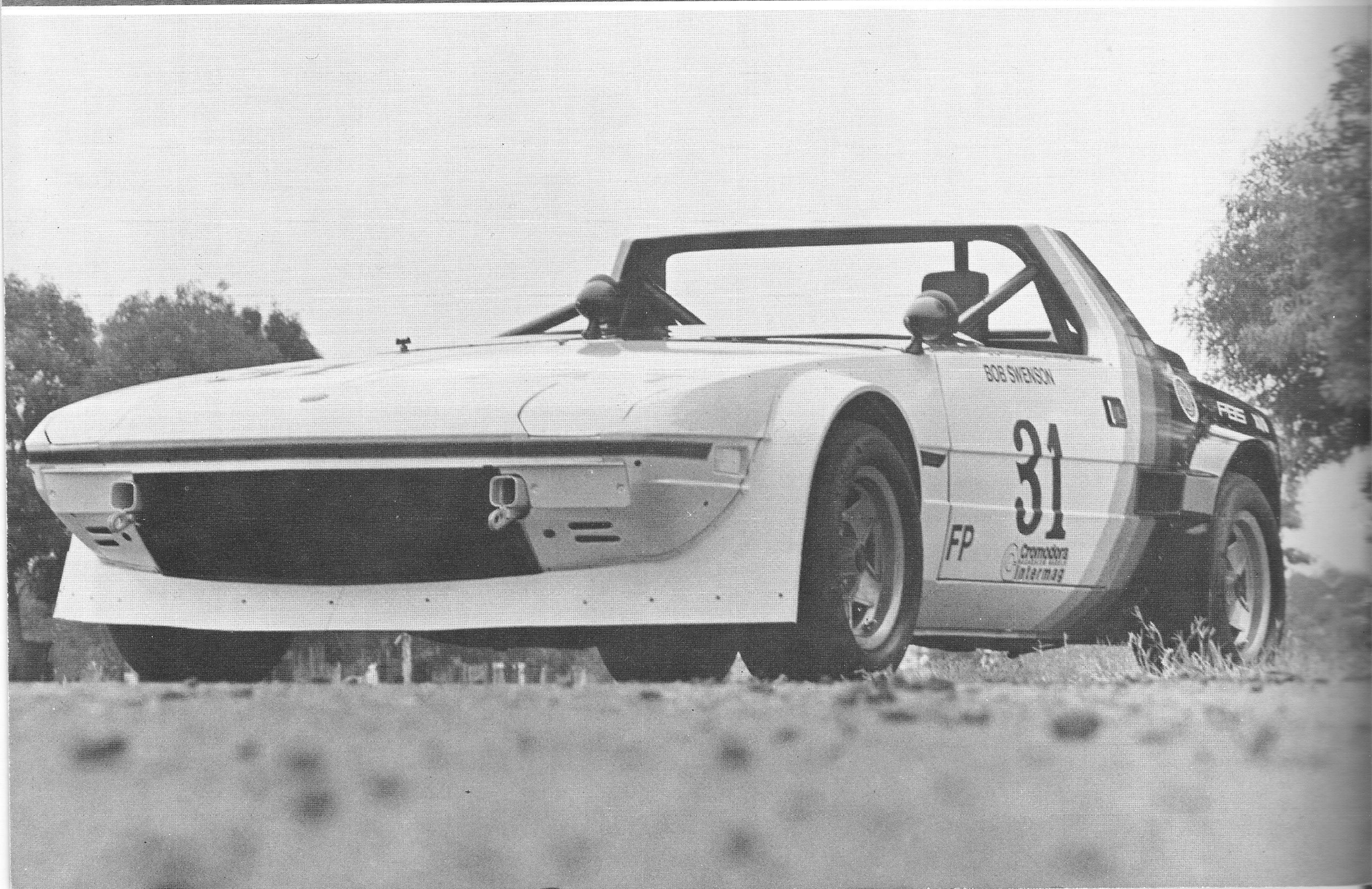
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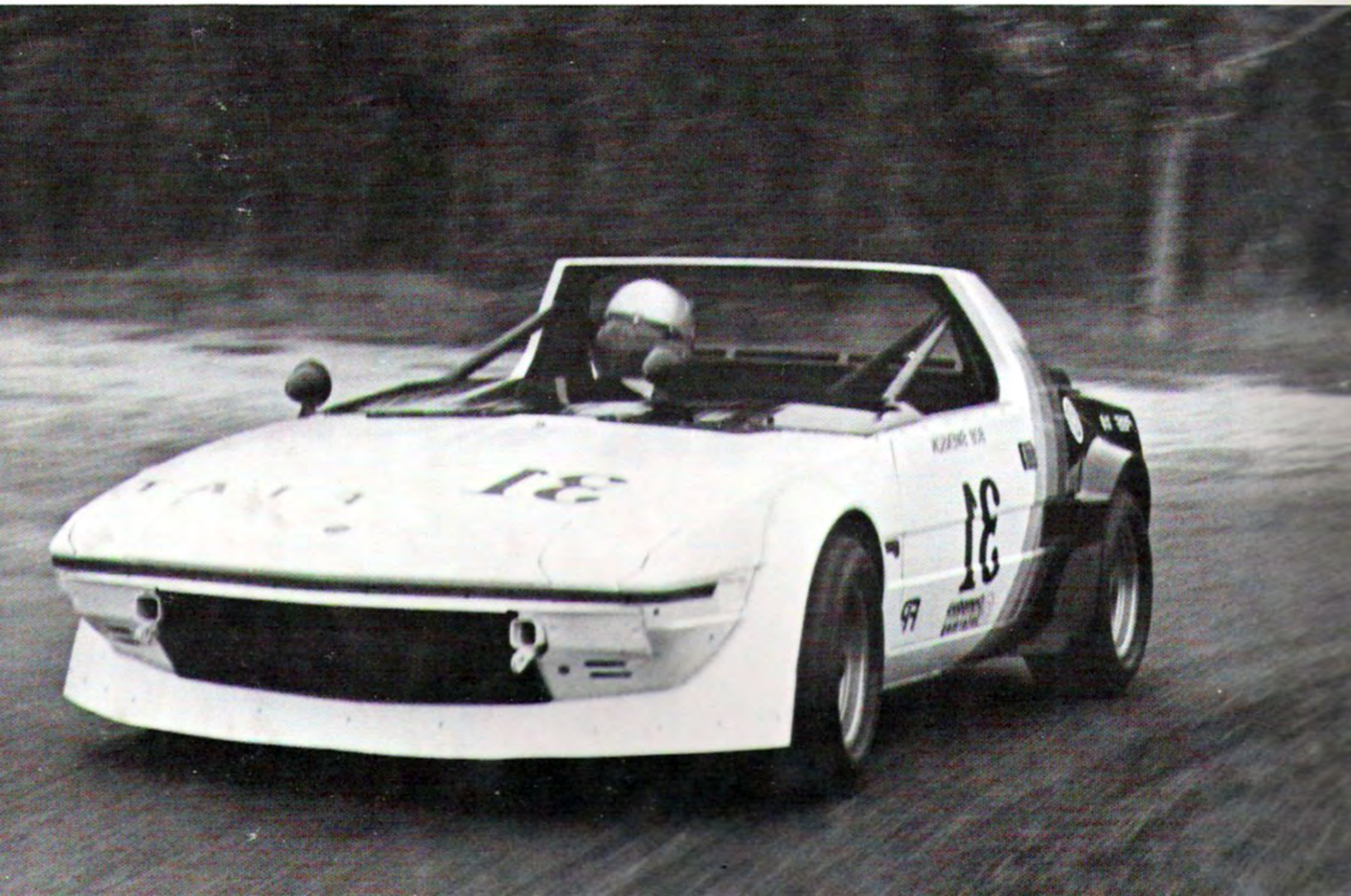

$5.95

PROJECT X1/9

The Complete Guide to Modification for Competition of the Fiat X1/9

IMPORTANT NOTICE

Modifications of the type described herein are not suitable for vehicles licensed for street use. They will also render the vehicle illegal for street use, as Federal law restricts the removal or modification of any part of Federally required emission control systems. Further, many states have enacted laws with various penalties for tampering with, or otherwise modifying, any required emission or noise control system.

Though SCCA General Competition Rules have been taken into account in the preparation of these recommendations, it is the responsibility of each individual owner or driver to ensure that his car conforms to the SCCA rules. Neither Fiat Motors of North America nor its dealers can be held responsible in connection with any protest or disputes resulting from illegal modification of parts.

Fiat vehicle and parts warranties are voided if the vehicle or part is used for competition or if they fail as a result of modification. Competition parts or assemblies described herein as offered by PBS Engineering or any other vendor are sold "as is" without any warranty whatsoever. The entire risk as to quality and performance of such parts is with the buyer.

INTRODUCTION

The information contained in this volume has been prepared by PBS Engineering of Garden Grove, California at the request of Fiat Motors. In it, PBS makes available to the SCCA competitor the sum total of many years of experience in the preparation for racing of Fiat cars. It is our hope that this information will be of value to those who compete with Fiat X1/9 automobiles. Clarification on the methods described, if needed, should be obtained directly from PBS Engineering.

This book is not intended as a substitute for the shop manuals and guides that Fiat Motors makes available for the servicing of its products. It is written to be used in conjunction with such manuals and guides.

Fiat Motors wishes you the best for success in your competitive efforts with the X1/9.

FIAT MOTORS
Fiat Motors of North America, Inc.

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First Edition—1979

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CHASSIS/BODY

To prepare the X1/9 for SCCA production racing, the car must first be stripped down completely to the bare body structure. Then it can be modified and re-assembled. All non-essential parts are left out in order to reduce weight, unless required by SCCA rules. The suspension is modified to lower the car and optimize suspension geometry within rules constraints. The brakes are modified to improve efficiency and heat rejection, and to allow front to rear brake bias adjustment. A complete roll cage is incorporated into the body structure to comply with SCCA safety rules and to stiffen the body structure. Fiberglass fender flares are added to cover the wider racing wheels and tires and to comply with SCCA rules.

REAR SUSPENSION

The SCCA production rules allow a number of suspension changes including relocating the position of the inboard suspension pick-ups, substituting shock absorbers and springs, eliminating the rubber in suspension bushings and the addition or modification of anti-roll bars. Working within these rules, the car should be lowered as much as practical and suspension pick-ups modified to regain acceptable suspension geometry control in the lowered condition.

Rear Suspension Body/Frame Modifications

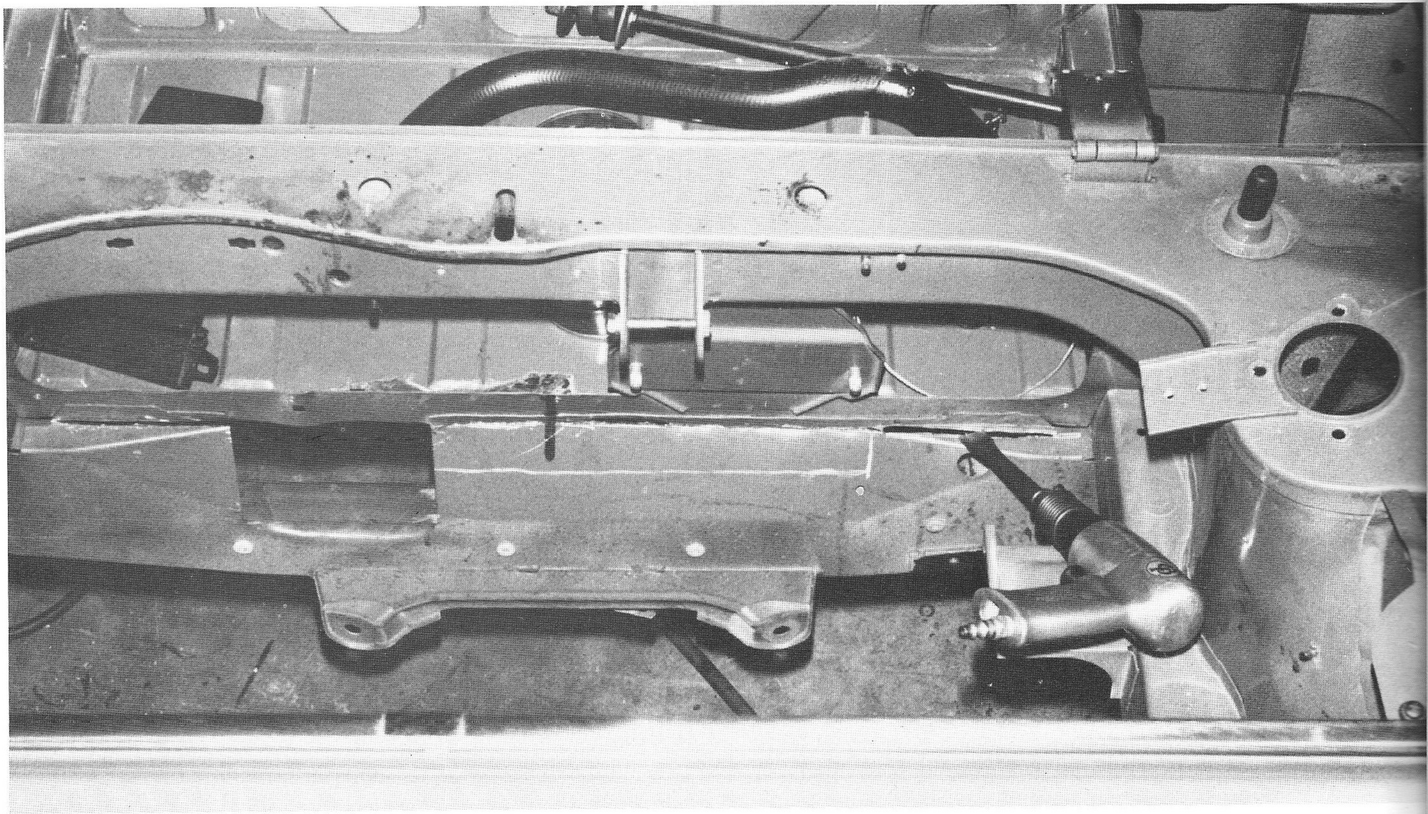
After stripping the car down to the bare body/frame structure and setting it on stands, the rear suspension modifications can be started. The object of this modification is to lower the rear of the car 1-1/2 inches, in addition to the drop in height achieved by using smaller diameter tires, and to end up with approximately stock camber change as a function of wheel deflection.

A simplified discussion of strut suspension geometry will explain the need for relocating the inboard suspension points to maintain good geometry control with a lowered car. First it is necessary to remember that, neglecting the effects of camber change as a function of wheel deflection, when the car leans to the outside in a corner, the wheels will lean with it and the outside wheels will go to positive camber. This reduces the effective tire contact patch and loses lateral adhesion. Thus, it is desirable to have the camber change in a negative sense, when the wheel is deflected upward from its normal static position. This effect plus the initial negative camber adjusted into the suspension will help to compensate for the positive camber introduced by chassis lean in cornering.

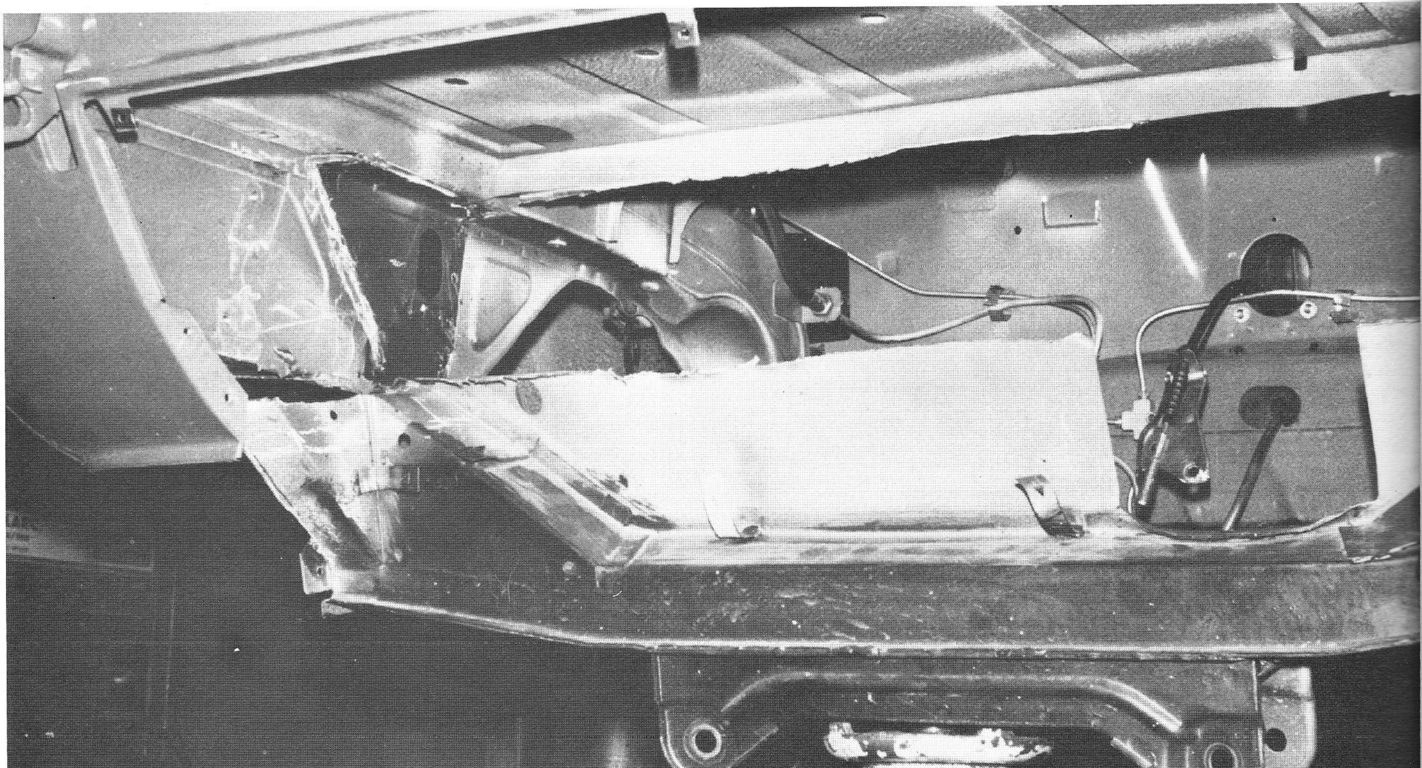
With the strut type suspension, negative camber is induced by moving the bottom of the strut outward as the wheel is deflected upward. This can be accomplished by having the outer attach point, of the lateral control arm, lower than the inner attach point, at the chassis. Then, when the wheel moves upward, the outer end of the control arm will move outboard, in an arc about the inner attach point.

The effective kingpin inclination, towards the inside at the top, also helps induce negative camber as the strut gets shorter. Lowering the car to achieve a lower center of gravity by using shorter springs increases the effective kingpin inclination, which is desirable; however, it also lowers the inboard pick-ups of the lateral control arm relative to the outboard pick-up at the strut. This is undesirable because it reduces the gain in negative camber as the wheel deflects upward. However, by relocating the inboard transverse pick-up point at the chassis, this undesirable effect can be alleviated. The inboard pick-up should be raised the same amount as the car was lowered by shortening the nominal working length of the struts.

The rear transverse control arm has two inboard pick-



Cutting Out Rear Crossmember



Removing Complete Rear Crossmember

up points. Lateral position is primarily controlled by the rear inboard pick-up point while the foward pick-up primarily controls fore and aft location. For this reason, primary effort should be directed toward raising the rear inboard pick-up.

The first step in modifying the rear suspension is to scribe a line on the rear engine bay panel above the rear crossmember and parallel to a line through the rear inboard suspension pick-ups. Measure the vertical distance between the line and the rear suspension pick-ups and record it for reference in relocating these suspension points.

Cut the rear crossmember out of the car as a unit with the rear inboard suspension pick-ups intact. This can be accomplished by drilling out the spot welds on either end from inside the fender wells and cutting as shown with an air chisel. This operation should be done carefully so damage to this unit is not sustained while removing it.

While the rear crossmember unit is removed from the car additional T.I.G. welding on the suspension brackets and associated panels is recommended to supplement the existing spot welds. Also, 1/2 inch washers should be welded on the suspension tabs.

Cut the rear crossmember as required to allow it to be raised vertically in the car by 1-1/2 inches. Use the scribe marks made previously.

The forward inboard pick-ups of the rear suspension are less critical, but they should be raised also as much as practical. These pick-up points are drilled after the body is assembled at Bertone, so there will be some variation from side to side in the amount of clearance above the existing hole. Typically, these holes can be raised about 9/16 inch and just redrilled in the existing bracket. Check your car on *both* sides to be sure how much you can raise the holes and still clear the suspension arm.

Centerpunch the foward brackets 9/16 inch above the existing hole, or other dimension (as determined above). Drill a small pilot hole through both sides of both brackets.

Weld the original holes shut in the forward brackets and grind them flush.

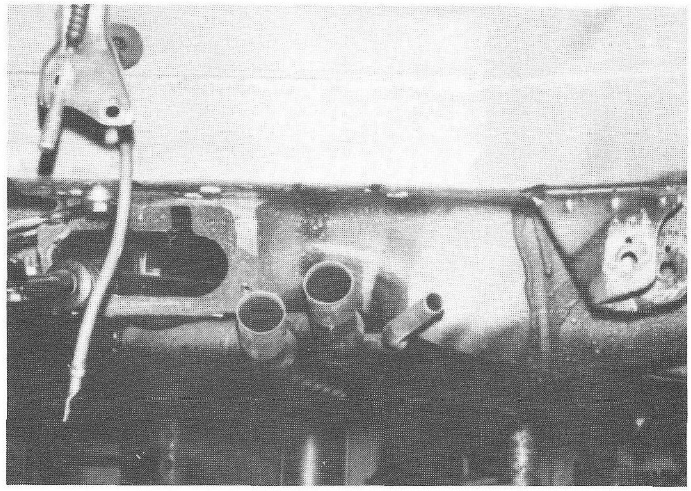
Drill the new holes to size. In order to change the inboard rear suspension bushings to 1/2 inch spherical joints, these holes should be drilled to 1/2 inch.

Clamp the modified rear crossmember in its new position and install the two transverse rear control arms in place with bolts through all 4 inner pick-up brackets to insure proper relative alignment.

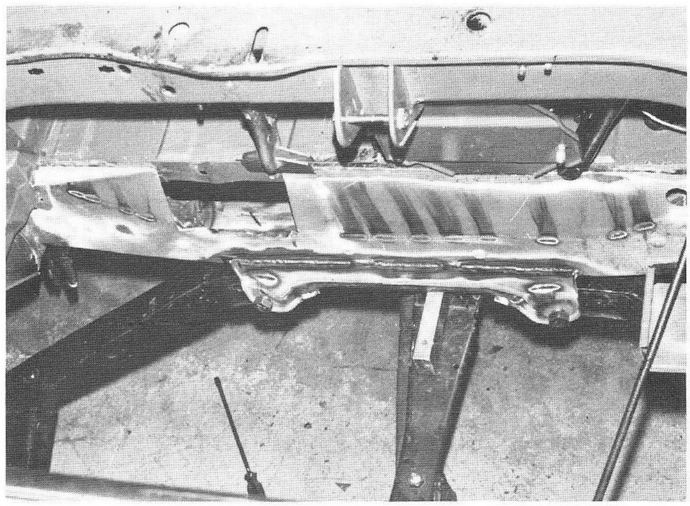
T.I.G. weld the rear crossmember in place.

Rear Strut Modifications

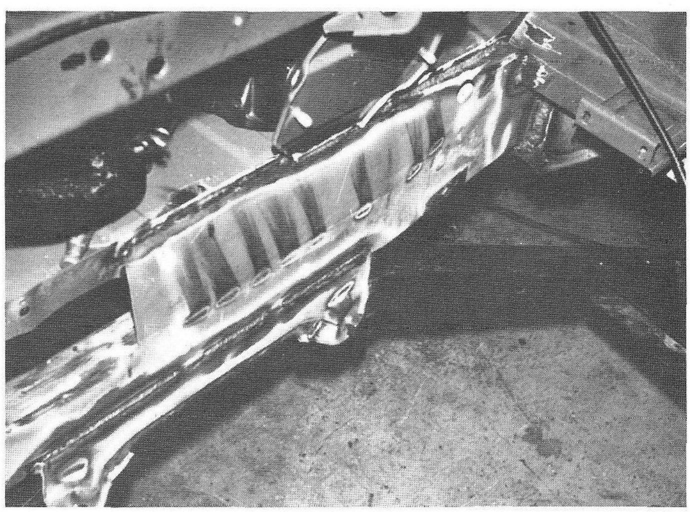
The function of the rear struts includes provision of a suitable spring and damping unit as well as part of the suspension geometry control as discussed earlier. The spring and damping function is a compromise, which must be stiff enough to limit deflections and resultant geometry changes and to prevent suspension bottoming under normal racing conditions, and yet be soft enough to minimize



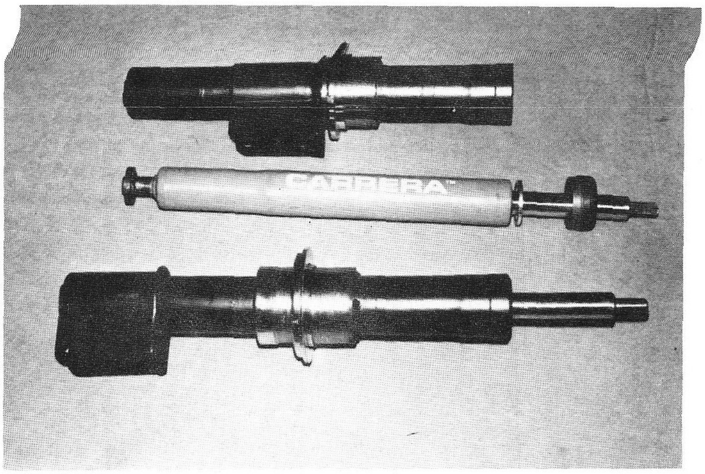
Pilot Holes Drilled In Forward Rear Suspension Brackets



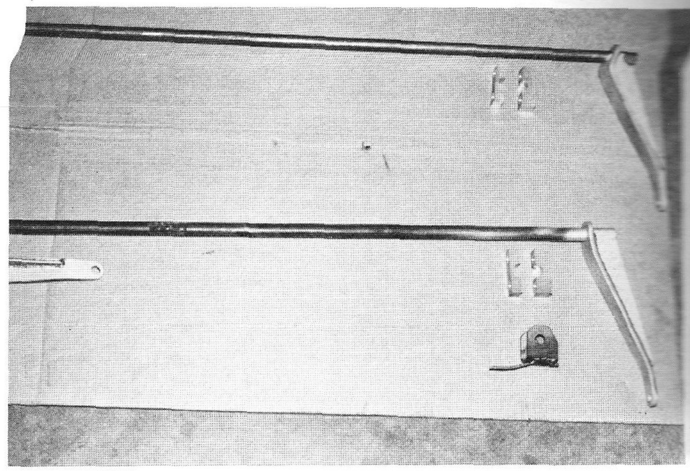
Modified Rear Crossmember Clamped In Place For Welding



Modified Rear Crossmember Welded In Place



Modified Front and Rear Strut Housings and Carrera Insert



Front and Rear Anti-Roll Bars

wheel loading changes which can cause loss of adhesion in the presence of bumps during cornering. The optimum compromise will be somewhat stiffer for a smooth track than for a rough track, in general. However, making changes in spring rates gets rather complex for the typical SCCA racer and should not be necessary in most cases. Adjustable shocks sound like a relatively good idea, but in practice they are not practical, particularly with a strut type suspension. Shocks which must be collapsed in order to adjust them require removal of the spring in order to collapse them. Also, most adjustable shocks are only adjustable for rebound damping. This works fine for ride control, but for racing they should be relatively loose on rebound in order to let the spring push the tire back down onto the ground. In racing the compression stroke on the shocks becomes more important, in order to keep the tire from leaving the ground on the upward stroke. Thus, a shock absorber which works well for street use will not necessarily make a good racing shock, and vice versa. Also, it must be remembered that the primary suspension element is the spring and radically altering the damping will not compensate for the wrong selection of spring rates. Thus, for SCCA production racing a good quality, non-adjustable racing shock, which is calibrated for the approximate load and spring rate of the X1/9, should be adequate for most racing conditions. The springs should be changed to a higher rate spring, with an adjustable lower spring perch, to allow ride height adjustment and balancing of suspension loads from corner to corner. The following paragraphs will describe rear strut modifications required to use Carrera 1974F coil-over shock conversion kits and Carrera 32635-F strut inserts. The modified parts are included in PBS Kit Number 2.

Completely disassemble the rear strut assemblies. The only part which will be used is the outer strut housing.

Cut the stock spring perch off from the strut housing.

The heavy walled threaded tube supplied in the Carrera coil-over conversion is longer and hence heavier than necessary. This tube can be cut to a length of 2-7/8 inches.

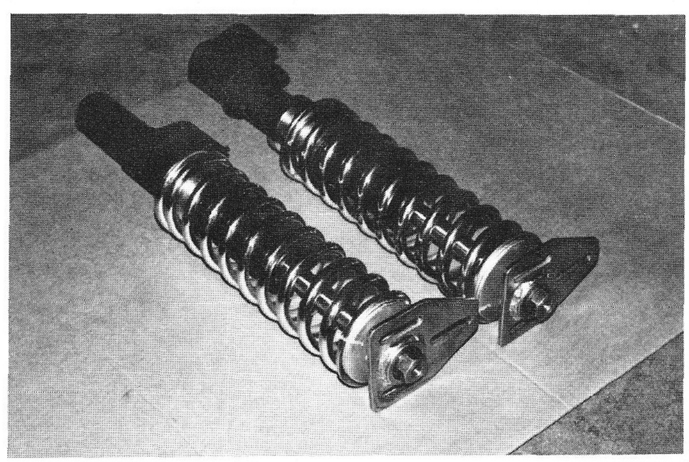
Mount the threaded tube 3 inches above the suspension bracket on the strut housing.

If Carrera 32635-F strut inserts are used, it is recommended that an indexing washer be welded on the bottom of the insert per Drawing 1. This indexes positively inside the bottom of the strut housing in the same fashion as the stock insert and precludes any possibility of undesired motion at this point.

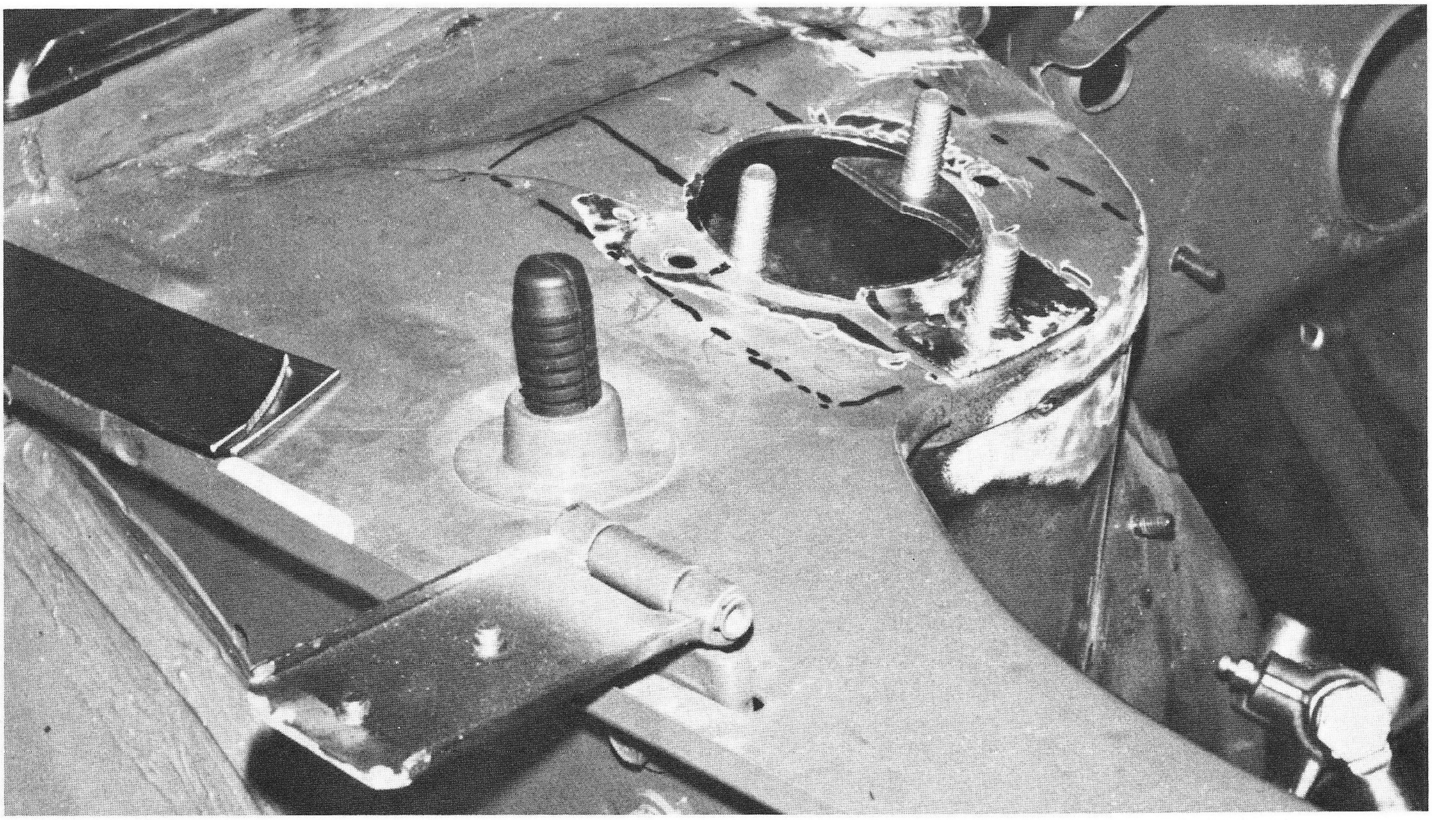
Rear Adjustable Camber Plates

Adjustable camber plate assemblies are recommended for the X1/9 for racing because they allow relatively simple camber adjustment which will be useful in chassis tuning. Also, the camber plate is thinner than the stock attachment and allows the car to be lowered farther without limiting travel. The following paragraphs describe the installation of a Carrera 1875HF camber plate assembly. These are included in PBS Kit Number 2.

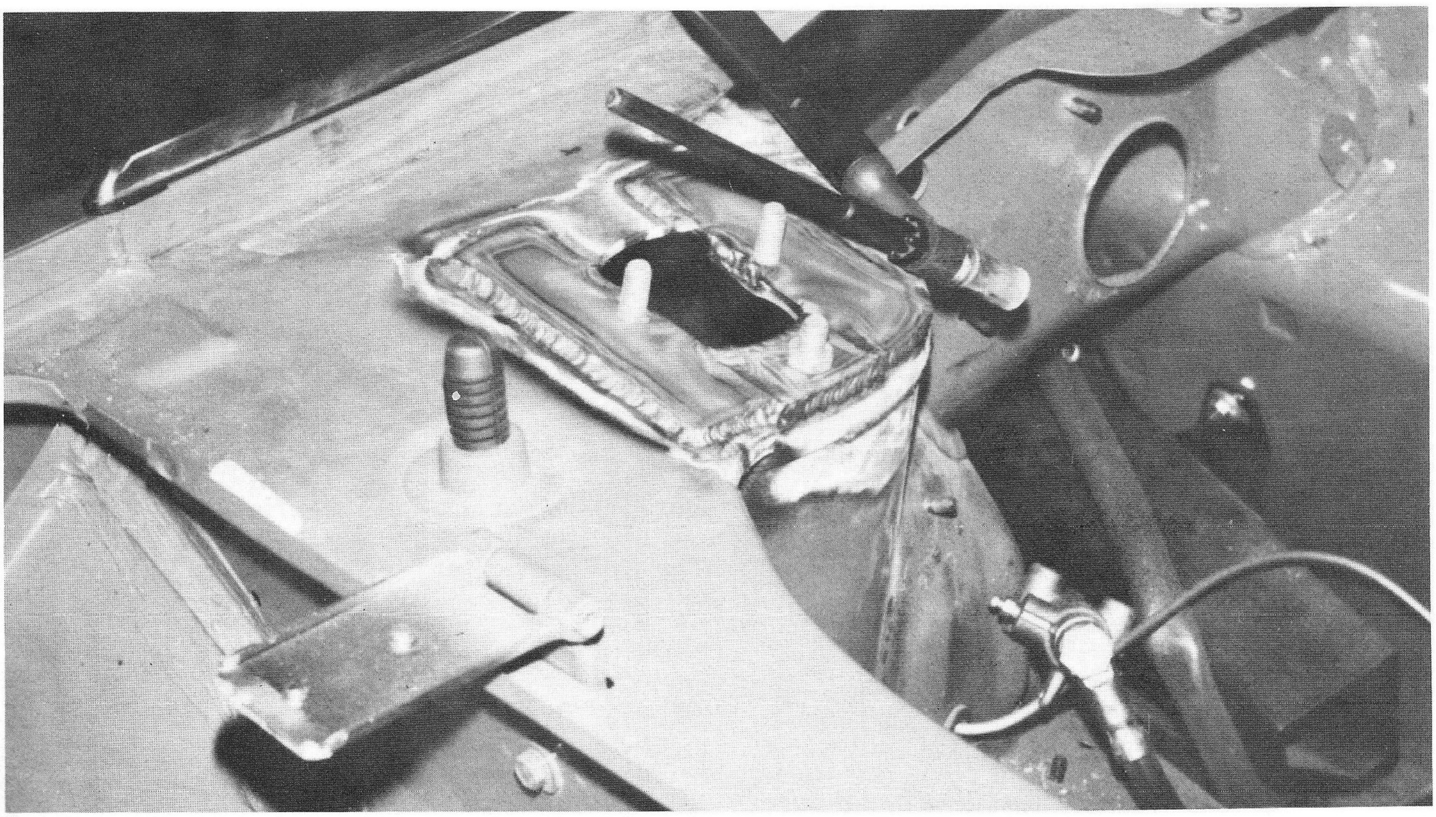
Referring to the pictures, cut and fit doublers from 1-1/2 inches wide by 1/8 inch steel, on top of the strut



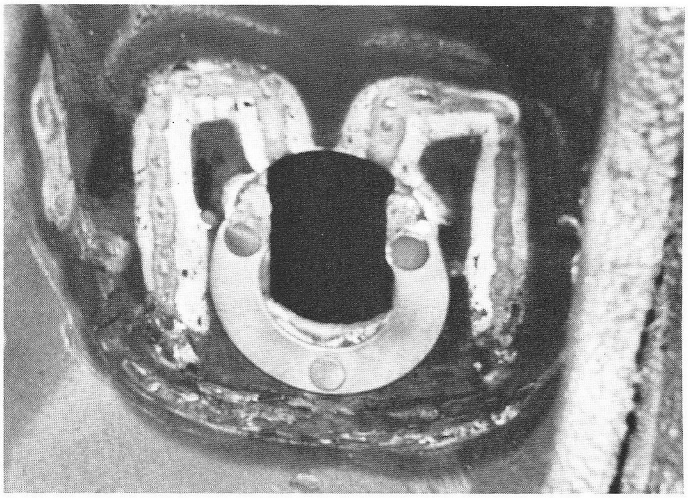
Complete Strut Assemblies With Carrera Coils and Camber Plates



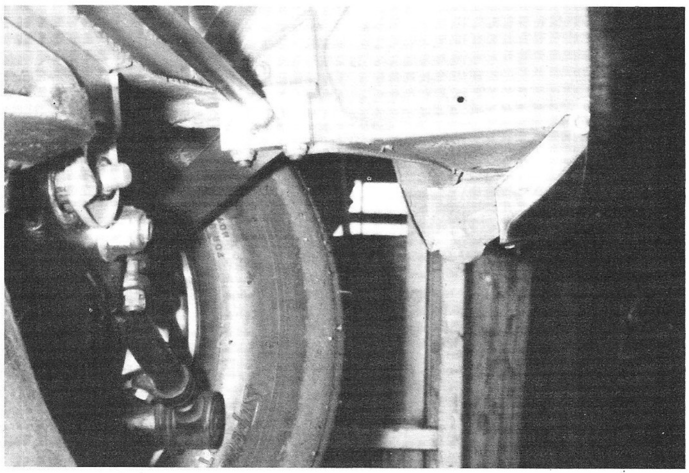
Camber Plate Installation



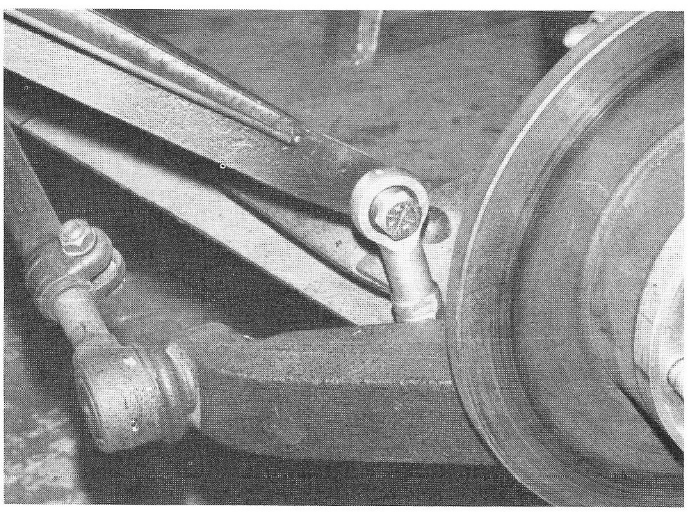
Doublers Welded In Place For Camber Plate



Camber Plate Installation Inside Strut Tower. Front Is Shown, Rear Is Similar



Rear Anti-Roll Bar Installation



Rear Anti-Roll Bar Installation

towers. Note that the two studs adjacent to the slot in the lower stud plate fit in the center of the existing hole in the strut tower. Drill a hole for the third stud.

Weld the doublers to the top of the strut tower with the stud plate in place to assure proper alignment. Note that the stud plate assembles from underneath the strut tower.

Install the moveable camber plate per Carrera instructions.

Rear Anti-Roll Bar

The X1/9 doesn't come with anti-roll bars on either front or rear. In order to minimize chassis roll in cornering, which couples into a reduction in negative camber, it is desireable to increase suspension roll stiffness substantially from stock. This is partially accomplished by using stiffer suspension coil springs. Anti-roll bars are recommended on both ends to increase roll stiffness further. Altering the anti-roll bars to vary the respective roll stiffness, between the front and rear of the car, is also a valuable tool in chassis tuning for controlling the degree of under or oversteer.

Drawings 2, 3, 4 and 5 show the suggested rear anti-roll bar configuration. The size can be altered to suit the driver and individual car. Increasing the diameter of the rear anti-roll bar will increase the oversteer. A 5/8 inch diameter rear bar works well with the other modifications described here.

Fabricate the rear anti-roll bar mounting brackets per Drawing 3 and weld them to the chassis as shown in the pictures.

Fabricate the threaded blocks and weld them to the rear control arms as shown in Drawing 5. The rear anti-roll bar can be purchased as PBS Kit Number 6.

Rear Suspension Bushings

Alinabal CBC-8-B2, or equivalent, 1/2 inch spherical bearings can be adapted to replace the rubber bushings in the rear suspension arms. PBS Kit Number 11 contains the required parts for this conversion.

Remove the stock rubber bushings and their steel jackets by pressing them out of the inboard ends of the two rear suspension arms.

Since 14mm spherical bearings are not readily available, the 1/2 inch Alinabal CBC-8-B2 units are recommended. These have an outside diameter of 1.312 inches. This diameter must be ground to 1.260 inches so they can be pressed into the suspension arms.

Press the spherical bearings into the center of the openings in the suspension arms. Fabricate locating spacers from 1-1/4 inches O.D. 16 ga. mild steel tubing. These are inserted on either side of the spherical bearing to retain it centered in the arm. Weld the locating spacers to the outer edge of the arm, being careful to seat them squarely on the outer race of the spherical bearing.

Fabricate spacers for the 1/2 inch bolts from 3/4 inch O.D. x .120 wall mild steel tubing. These are used to make up the distance between the suspension mounting brackets and the spherical bearing ball.

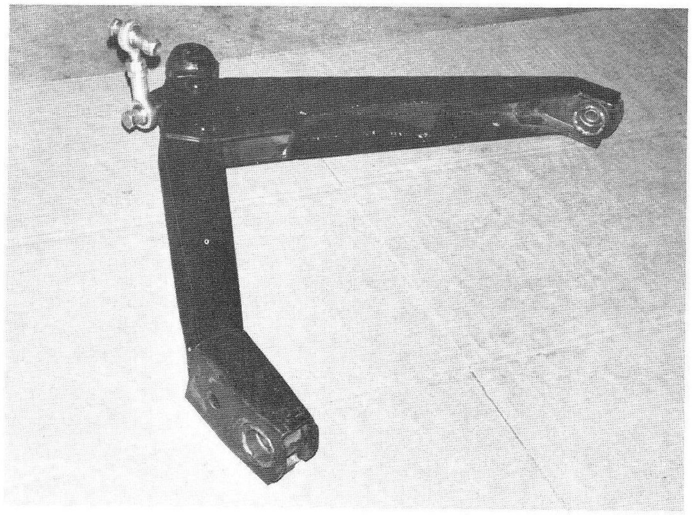
Weld heavy steel 1/2 inch washers onto the rear suspension brackets concentric with the stock 14mm holes. This can be done while the rear suspension crossmember is removed from the car (see page 5). The forward brackets should be drilled to 1/2 inch when they are relocated in position.

Assemble the arms to the chassis and fit-check all of the spacers. Use high strength 1/2-20 bolts, 3-1/2 inches long, and self-locking nuts. Be certain that the bolts clamp the spacers and spherical balls securely between the mounting bracket ears so that the bolts will not work loose and wear the mounting holes.

Left Rear Control Arm Modification

The left rear suspension arm must be modified for clearance if the 5-speed transmission is used.

Cut the arm for clearance as shown and box it in locally with 16 ga. mild steel T.I.G. welded in place. This operation is best performed with the engine and gearbox installed and the suspension, less the coil spring, in place so that proper clearance can be ascertained by moving the suspension throughout its travel range.



Left Rear Control Arm

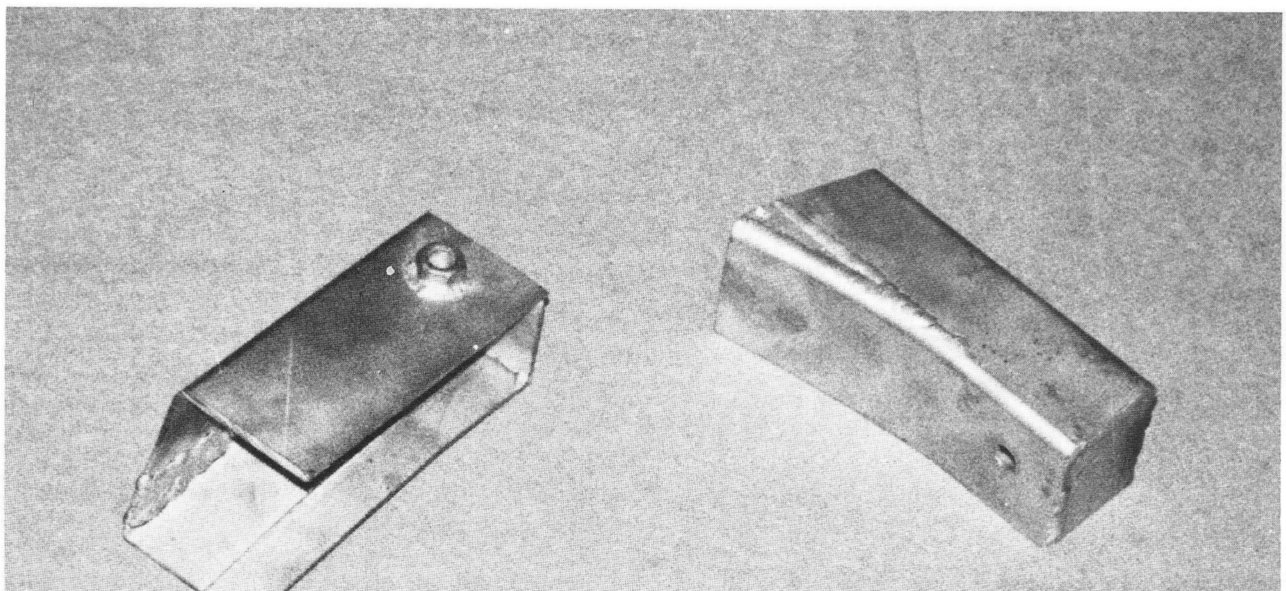
Also, the steering function requires additional modification in the front. The stock X1/9 actually is higher in front than in the rear. In order to improve aerodynamic penetration and stability the front should be lowered more than the rear of the car. Dropping the front about 2-1/2 inches in addition to the change in tire diameter works well with respect to the 1-1/2 inch lowering of the rear.

FRONT SUSPENSION AND STEERING

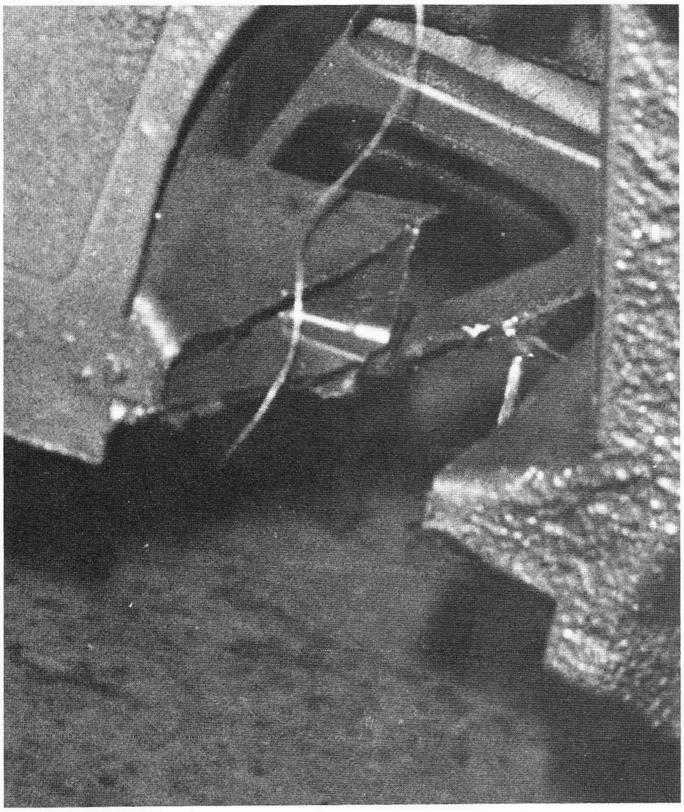
Modifications to the front suspension parallel those to the rear suspension in general, but the details are different.

Front Suspension Body/Frame Modifications

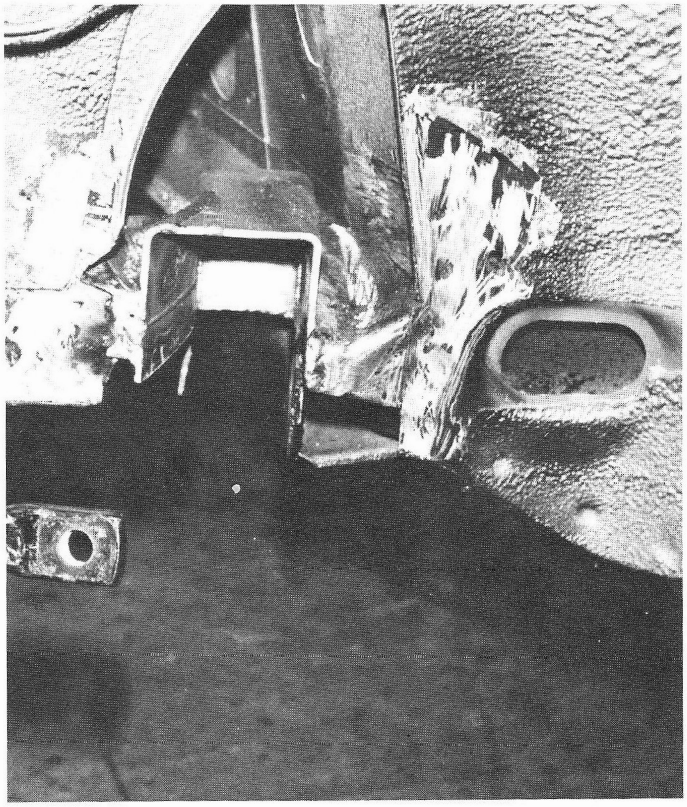
In order to lower the front 2-1/2 inches, it is desirable to raise the inboard transverse suspension pick-up at the



Front Inboard Suspension Brackets

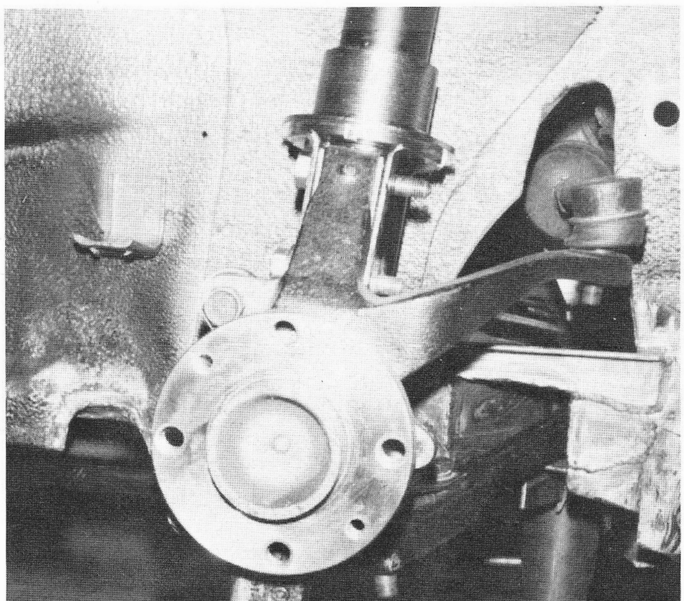


Cut-Out For Front Suspension Brackets



Front Suspension Bracket Welded In Place

Box In Suspension Bracket



Completed Front Suspension Bracket
(Note Trailing Arm Clearance Notch)

chassis 2-1/2 inches so that the transverse control arm will maintain approximately stock geometry. The rationale for this follows that given on page 4 regarding the rear suspension. This requires extensive cutting and fabrication of new inboard suspension brackets.

First fabricate the new front inboard suspension brackets per Drawing 6. These are included in PBS Kit Number 9.

The body/frame must be cut out above the stock inboard suspension pick-up to accommodate the new brackets. Refer to the pictures for guidance. Leave the rear stock mounting ear intact for a location reference for the new bracket. An air chisel and a small abrasive cut-off disk, in an air-driven die grinder, will be useful tools for cutting and fitting the new bracket.

When the new bracket has been fitted so that the suspension pick-up is moved directly upward by 2-1/2 inches, the bracket can be T.I.G. welded in place.

Fabricate and fit the additional doublers and stiffeners as shown in the pictures and weld them in place.

Fabricate new front trailing arm attachment brackets as shown in Drawing 7. PBS Kit Number 7 has these parts.

Modify the trailing arm and the front transverse control arm per page 14 and temporarily install them.

Cut the body/frame locally to clear the trailing arm in its maximum upward travel. Weld up the notched area, piecing in the hole as required.

Modifications to the Front Struts

The front struts are basically the same as the rear struts and are modified in similar fashion. Since the front will be lowered more than the back, it is necessary to move the suspension bracket up on the strut housing in order to retain adequate deflection capability. The following instructions assume that Carrera coil-over shock conversion kits will be used. PBS Kit Number 2 contains the modified parts.

Disassemble the stock front strut assemblies. Only the stock housing will be used.

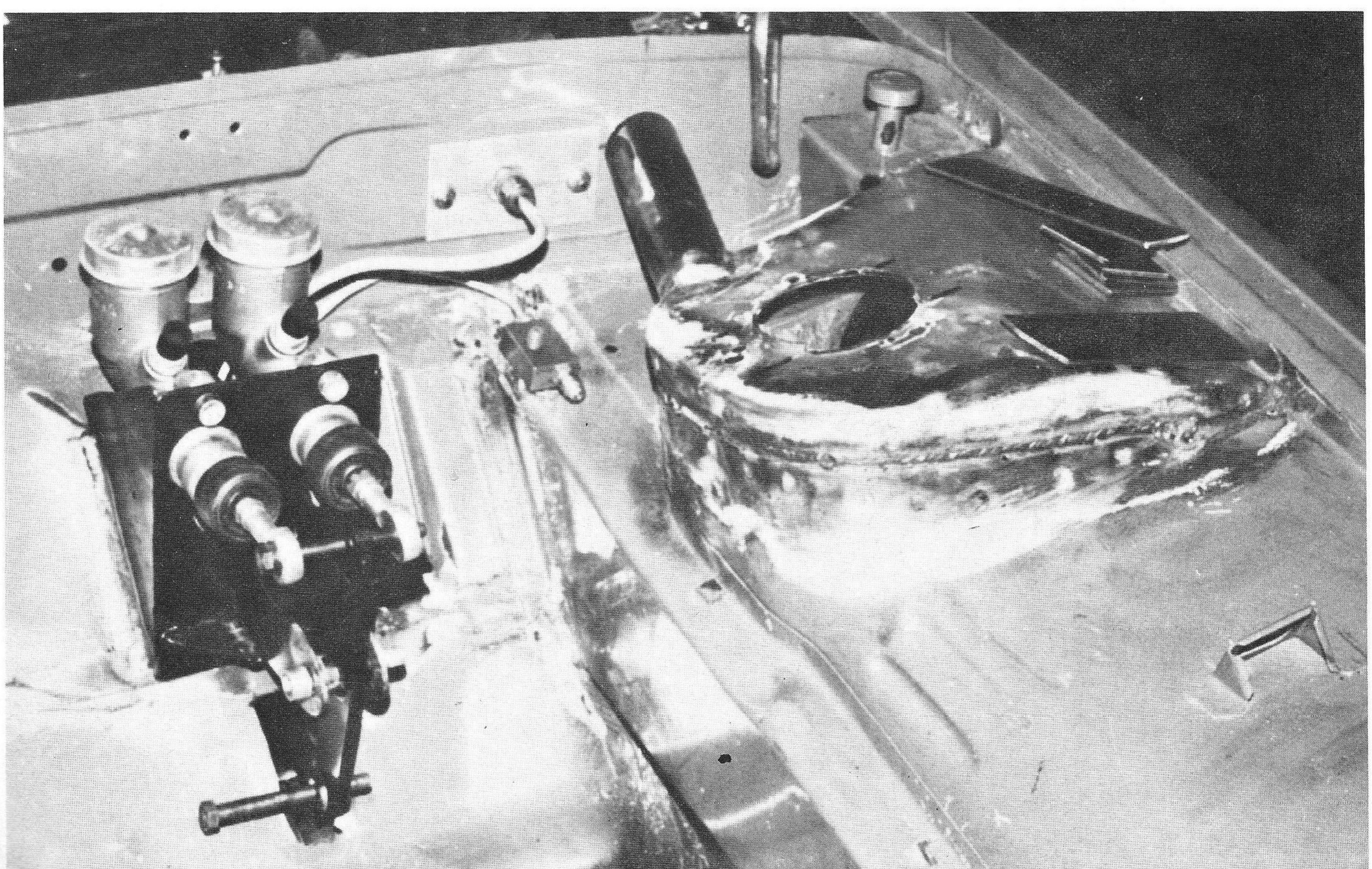
Cut off the stock front lower spring perch.

Using a lathe, cut the weld off of the bottom of the suspension bracket so the bracket can be moved up on the strut housing. Raise the bracket 15/16 of an inch and re-weld it to the housing.

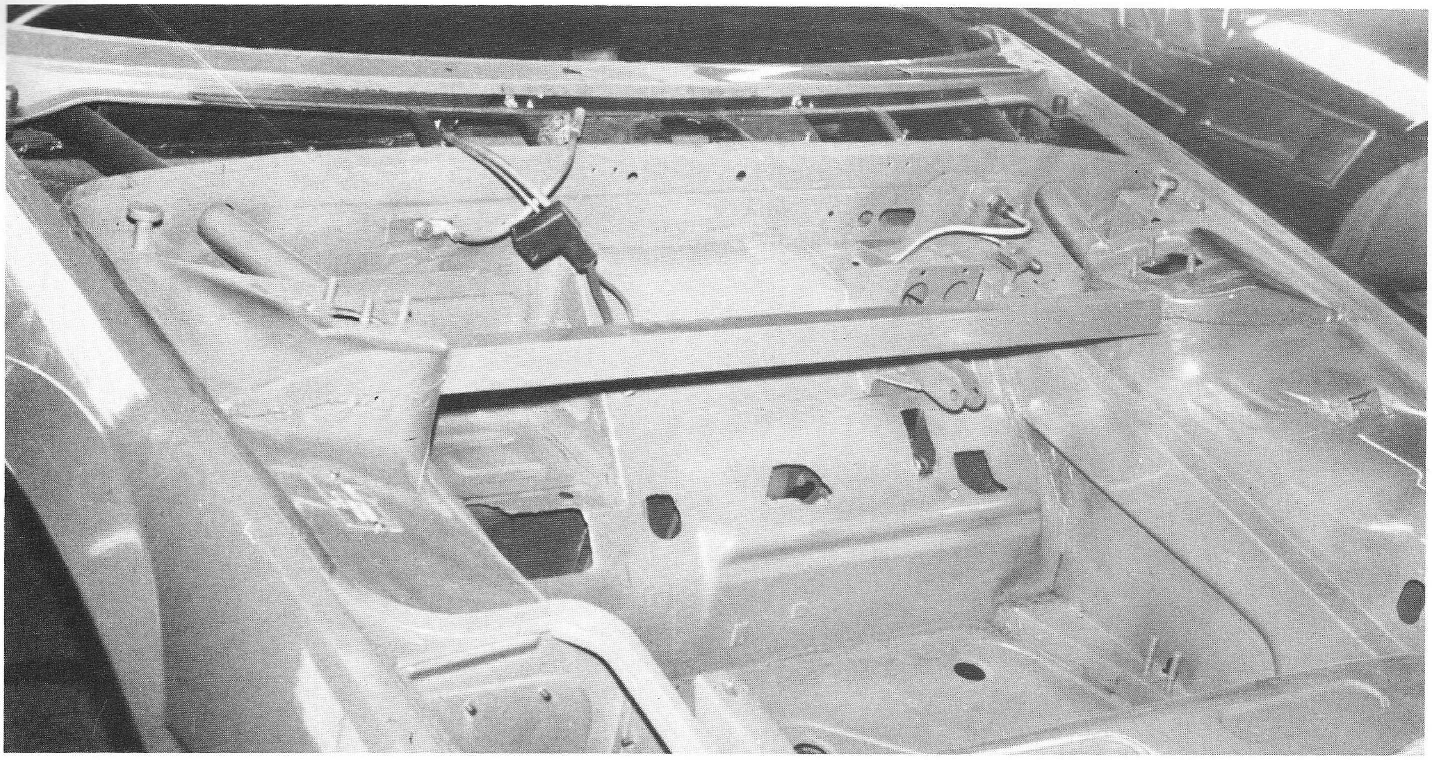
Install the threaded collar for the coil-over kit down against the suspension bracket.

Front Adjustable Camber Plates

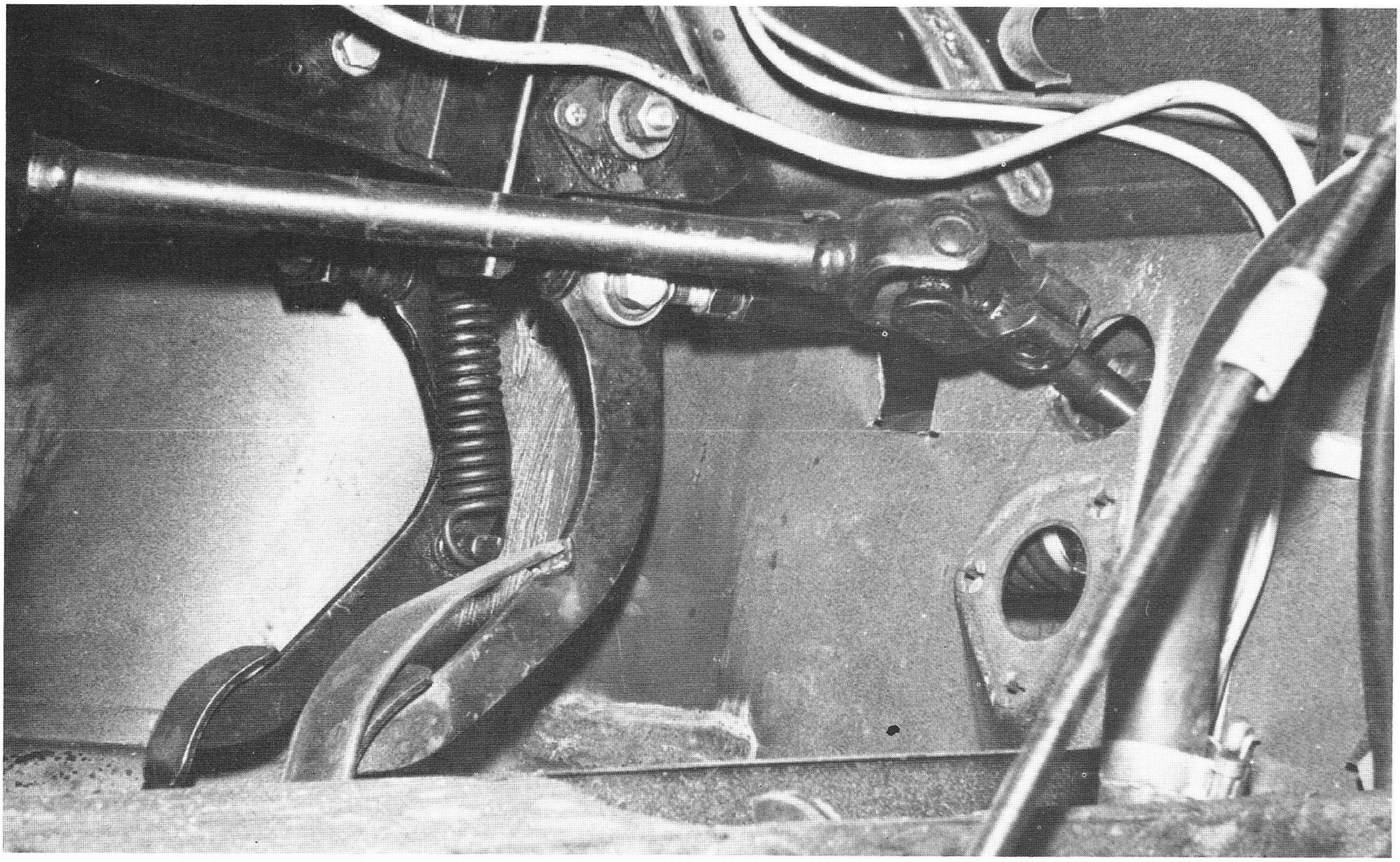
The front camber plates are identical to the rear ones and are installed in the same manner. See photo below.



Front Camber Plate Installation and Brake Master Cylinder Installation



Cut-Outs For Steering Rack Clearance and Access



Steering Shaft Location and Brake Master Cylinder Push Rod

Steering Rack and Mounting Modifications

The design of the suspension and steering is such that it is impossible to eliminate bump steering completely on the X1/9. However, raising the steering rack by the same amount as the inboard suspension pick-ups will keep bump steer from becoming a serious problem with the lowered car. The required parts are part of PBS Kit Number 9.

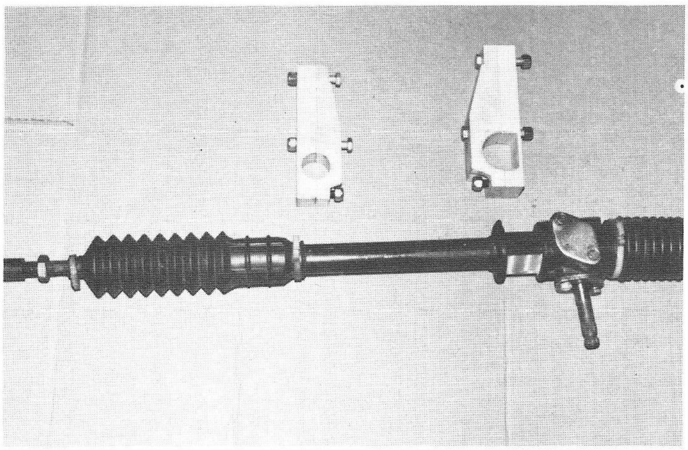
Remove the plastic bushing inside the right-hand end of the steering rack and fabricate a new one from aluminum bar. Reassemble the steering rack. Be sure to constrain the bushing from falling out by swaging over the end of the rack tube or welding a retaining washer on the end of the rack.

Fabricate the two new steering rack mounting brackets per Drawings 8 and 9. These are used to move the steering rack up 2-1/2 inches and to provide a solid mounting for the rack, rather than the stock rubber cushioned mounting.

Cut a flat on the left hand steering rack mounting boss to match the flat area on the left bracket.

The inner front trunk skin must be cut in several places, to provide access to the new rack mounting brackets, to allow vertical motion of the connecting links between the rack and the steering arms, and to allow access for adjusting the front toe. See the pictures for guidance. Don't cut the battery box back more than necessary as the floor must be left wide enough to support the aircraft battery. All holes cut must be covered to comply with the G.C.R.

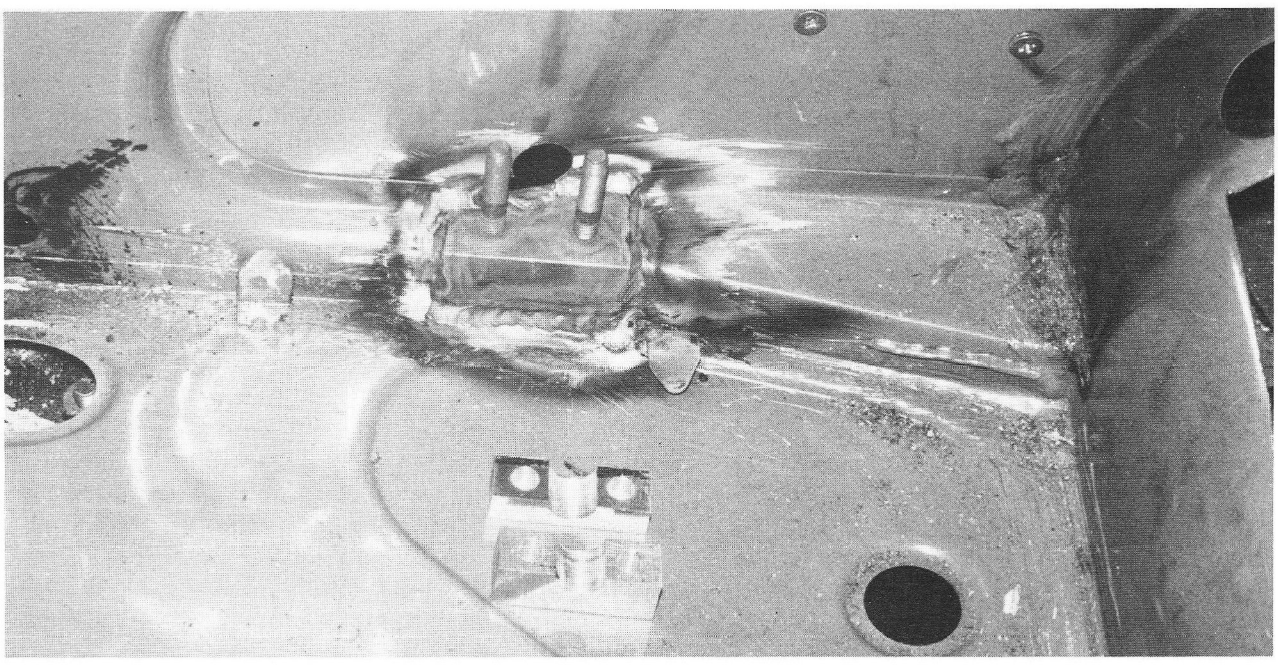
Install the steering rack after cutting a new hole for the steering splined shaft to feed through into the driver compartment. Cover the original hole.



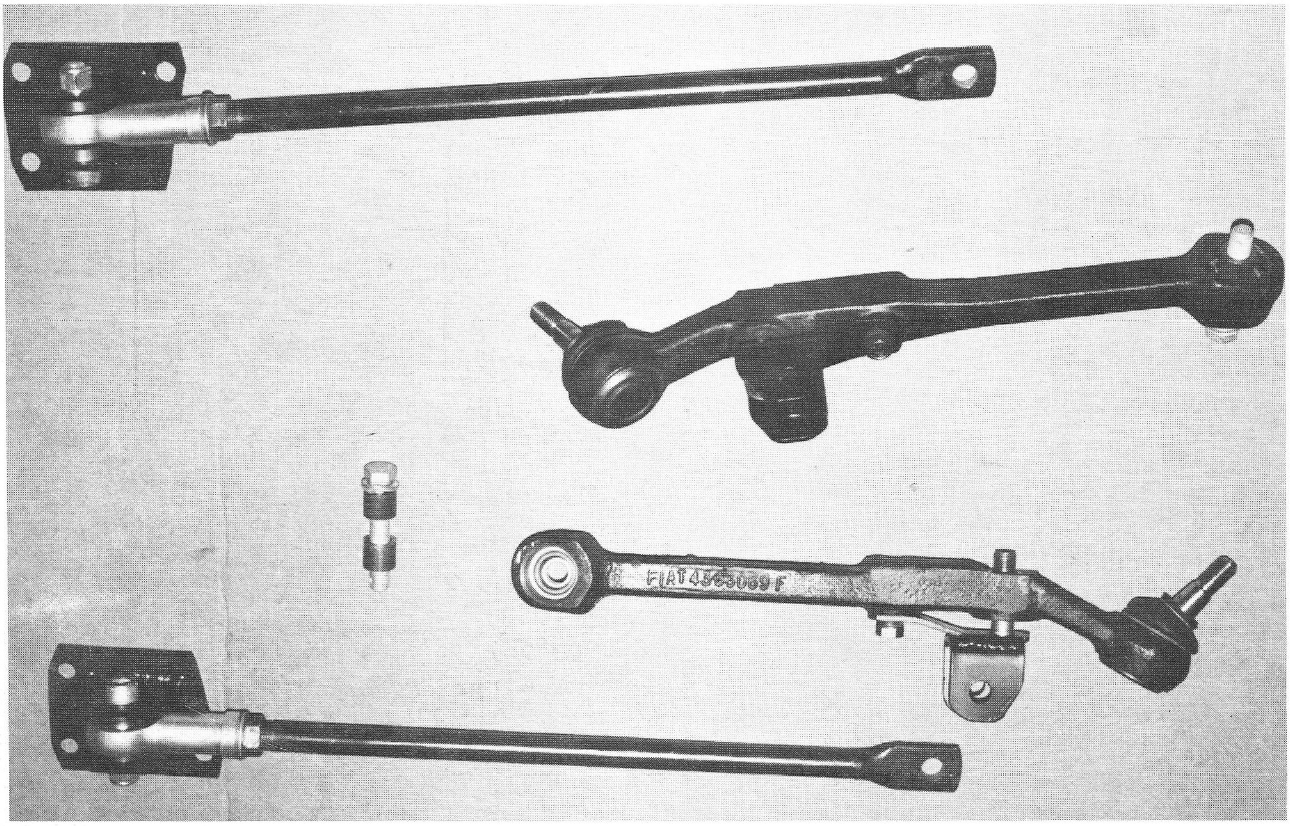
Steering Rack Brackets and Mounting Modification

Front Anti-Roll Bar

The rationale for a front anti-roll bar parallels that given for the rear bar. The front bar in general should contribute more roll stiffness than the rear bar, particularly with a mid-engined car, in order to preclude excessive oversteering. The car is low enough that it is very difficult to find adequate room for a bar and mounting brackets under the front of the car. Therefore, it is recommended that the front anti-roll bar pass through the front trunk compartment even though this creates a few problems. The front bar is essentially the same as the rear one except for diameter. A 13/16 inch diameter front bar is recommended if the suspension is modified as described in this manual. PBS Kit Number 5 includes this bar.



Front Anti-Roll Bar Mounting Bracket



Front Anti-Roll Bar Pickup Brackets and Front Arms and Trailing Links

Fabricate the front anti-roll bar per Figures 2, 4, 10 and 11. Only weld the arm on one end of the bar as the bar must be inserted through the body before the opposite end is welded in place.

Fabricate the front anti-roll bar mounting brackets (Drawing 10) and bearing blocks (Drawing 4) and install them in the front trunk.

Fabricate the anti-roll bar pick-up brackets, which mount on the transverse suspension control arms, per Drawing 11.

Install the anti-roll bar and weld the arm on the bar in the car. Align the two arms so they lie in the same lateral plane before welding.

Front Suspension Bushings

It is recommended that the rubber bushings at the inboard end of the front transverse control arms and the front end of the front trailing links be replaced by spherical joints and rod ends respectively. Note that since a line extending the axis of the bolt through the inner transverse pick-up doesn't intersect the pivot point of the trailing link, a straight bushing cannot be used without causing binding. Therefore, any non-flexible suspension bushing must have freedom in two axes. Eliminating the rubber joints and replacing them with spherical joints greatly improves steering accuracy under racing cornering loads.

Bore the inner ends of the transverse control arms to accept 7/16 inch spherical joints. Alinabal P/N CBC-7-B2 joints or equivalent are recommended. Bore in, leaving a shoulder to seat the ball joint against, such that it will be centered in the arm. A piece of thin-wall tubing can be pushed in after the ball joint and tack welded in place to retain the ball joint. PBS Kit Number 8 has these parts.

Cut and thread the ends of the trailing links as shown in Drawing 12 to accept 5/8 inch female rod ends. Alinabal PF-10-G rod ends or equivalent are recommended. Also fabricate spacers per Drawing 13. This modification is included in PBS Kit Number 7.

BRAKES

The X1/9 has four-wheel disc brakes which work quite well in stock form. However, there are a number of changes which can be made to improve their performance under racing conditions. The 1500 F-production car is allowed to use Lancia 10 inch disc brakes as an alternate. These are recommended for the front. Front X1/9 calipers can be used on the rear of both G and F cars to eliminate the hand brake mechanism. Some method of adjusting the relative brake pressure between the front and the rear systems is essential for proper brake balance. Probably the best way to achieve this is to use two separate master cylinders with an adjustable linkage between them. These can be mounted in the front trunk compartment to simplify maintenance.

Front Brakes (F-production 1500 X1/9)

Several modifications are required in order to use the alternate Lancia 10 inch discs on the front of the X1/9.

Use the rear discs from a Lancia Beta, P/N 82346816. Machine the inside of the discs to fit over the X1/9 front axle flange.

Modify X1/9 stock 3/16-inch-thick wheel spacers so one can be used between each disc and the X1/9 axle flange. The spacer O.D. should be cut to 4.380 inches and the I.D. must be relieved to clear the radius on the axle so it will seat properly.

Carefully deburr the spacer and disc and assemble them on the axle. Check disc lateral runout with a dial indicator. This shouldn't exceed about .005 inch T.I.R. If it does, correct the problem to avoid having the disc runout push the pads back in operation.

The aluminum front calipers from the 1500 X1/9 will work well with the Lancia 10 inch discs, but modified Lancia Beta front caliper mounting brackets and brake pads must be used. The Lancia caliper bracket is casting number 1419979. The caliper retaining blocks and clips and the pad retaining clips from the Lancia should also be used. The Lancia caliper itself could be modified and used, but it is a double piston unit with two separate hydraulic systems for redundancy and is large enough to cause space problems in the X1/9 front end. Thus, the use of the X1/9 caliper with the Lancia caliper bracket and brake pads makes a better installation.

Modify the Lancia caliper brackets as shown in Drawing 14.

Fabricate the caliper mount adaptors per Drawing 15 and weld them to the modified Lancia brackets.

Assemble the caliper assemblies using Lancia hardware except for the X1/9 aluminum caliper itself. Use the Lancia brake pads, P/N 82315602.

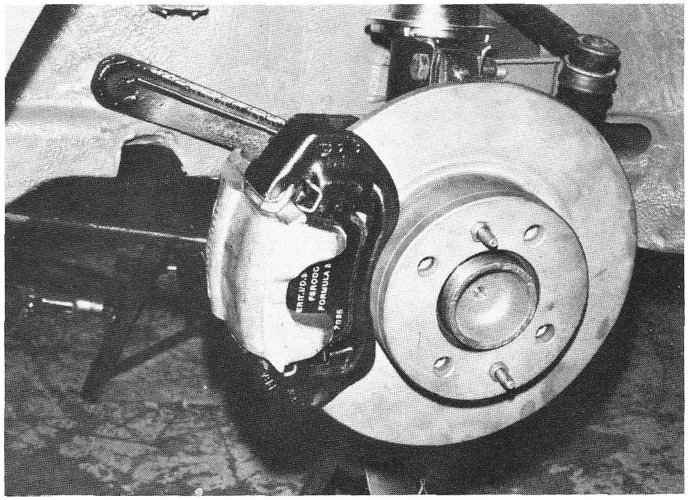
Assemble and plumb the brakes on the car. Note that the steering arm may have to be ground down slightly to clear the Lancia disc. Check for clearance between the caliper and the wheels and correct any problem areas. Leave the front dust shield off to allow more air circulation. The Lancia brakes are available as PBS Kit Number 1.

Front Brakes (G-production 1300 X1/9)

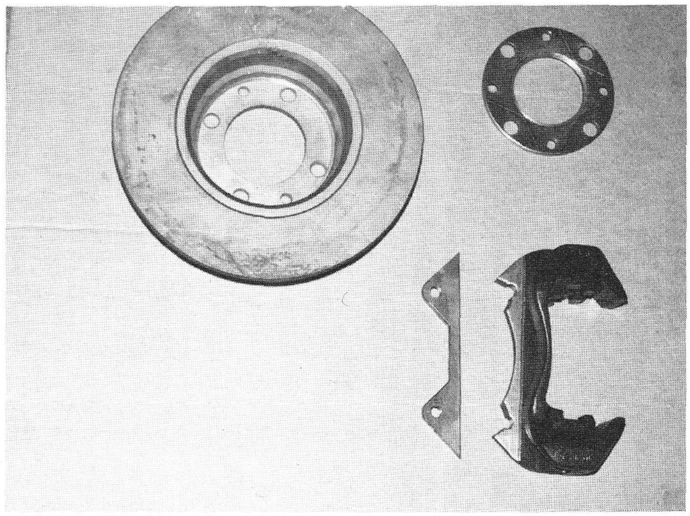
Alternate brakes are not allowed on the G-production car. Remove the dust shields and use a good grade of competition brake pads.

Rear Brakes (G- and F-production)

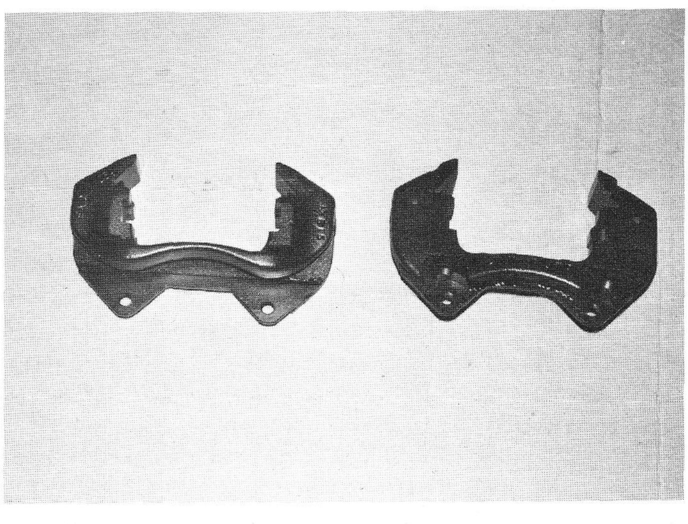
Although Lancia brakes could be used on the rear of the F-production X1/9, this isn't necessary. It is recommended, however, that stock front X1/9 calipers be used on



Front Brake Assembly (F-Production) Using Lancia Discs

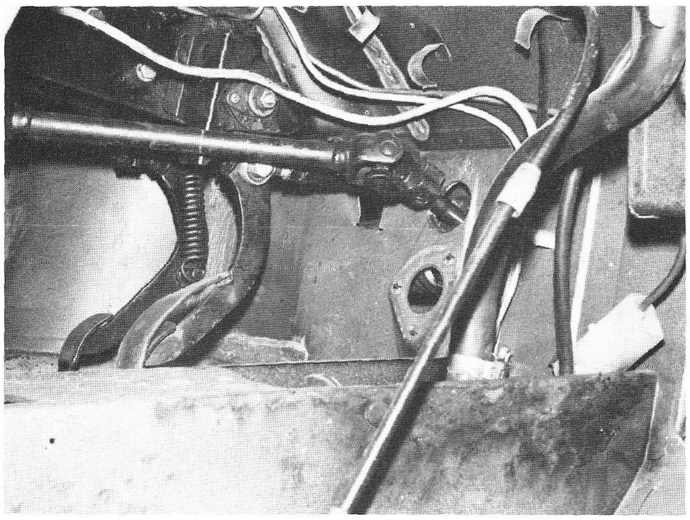


Lancia Disc, Modified Spacer, Modified Lancia Caliper Bracket

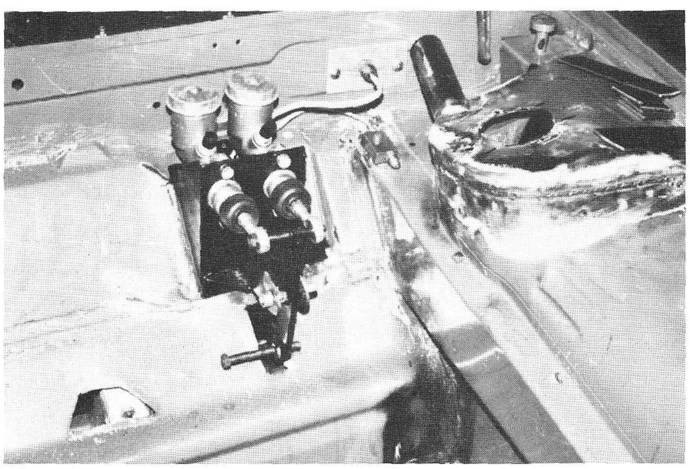


Modified Lancia Caliper Brackets

Brake Master Cylinders



Steering Shaft Location and Brake Master Cylinder Push Rod



Front Camber Plate Installation and Brake Master Cylinder Installation

the rear since this eliminates the hand brake mechanism and allows the use of the thicker front brake pads. Leave the dust shields off.

Brake Master Cylinders

The stock tandem dual master cylinder in the X1/9 is a good unit, but there is no provision for adjusting balance between the front and rear brakes. Also, the stock master cylinder is located in a very inaccessible location which complicates any maintenance on the master cylinder. It is possible to use the stock master cylinder for racing if you add a manually adjustable pressure limiting valve in the line to the rear brakes. The valve used on the 128 sedans can be used for this function if you add a screw adjusting feature to it. The preferred set-up for racing, however, is to incorporate two master cylinders with an adjustable balance bar between them. Refer to the pictures on this installation.

Use two 3/4 inch Girling master cylinders. Fabricate the master cylinder mounting bracket and linkage per Drawing 16.

The brake pedal has an existing hole, below the pivot, which can be used for the new linkage to drive the master cylinders. Cut a hole into the front trunk compartment to allow the brake pushrod to pass through.

Assemble the master cylinder bracket, rocker arm and pushrod, and locate the assembly on the rear wall of the front trunk as shown in the pictures. Weld the bracket to the car.

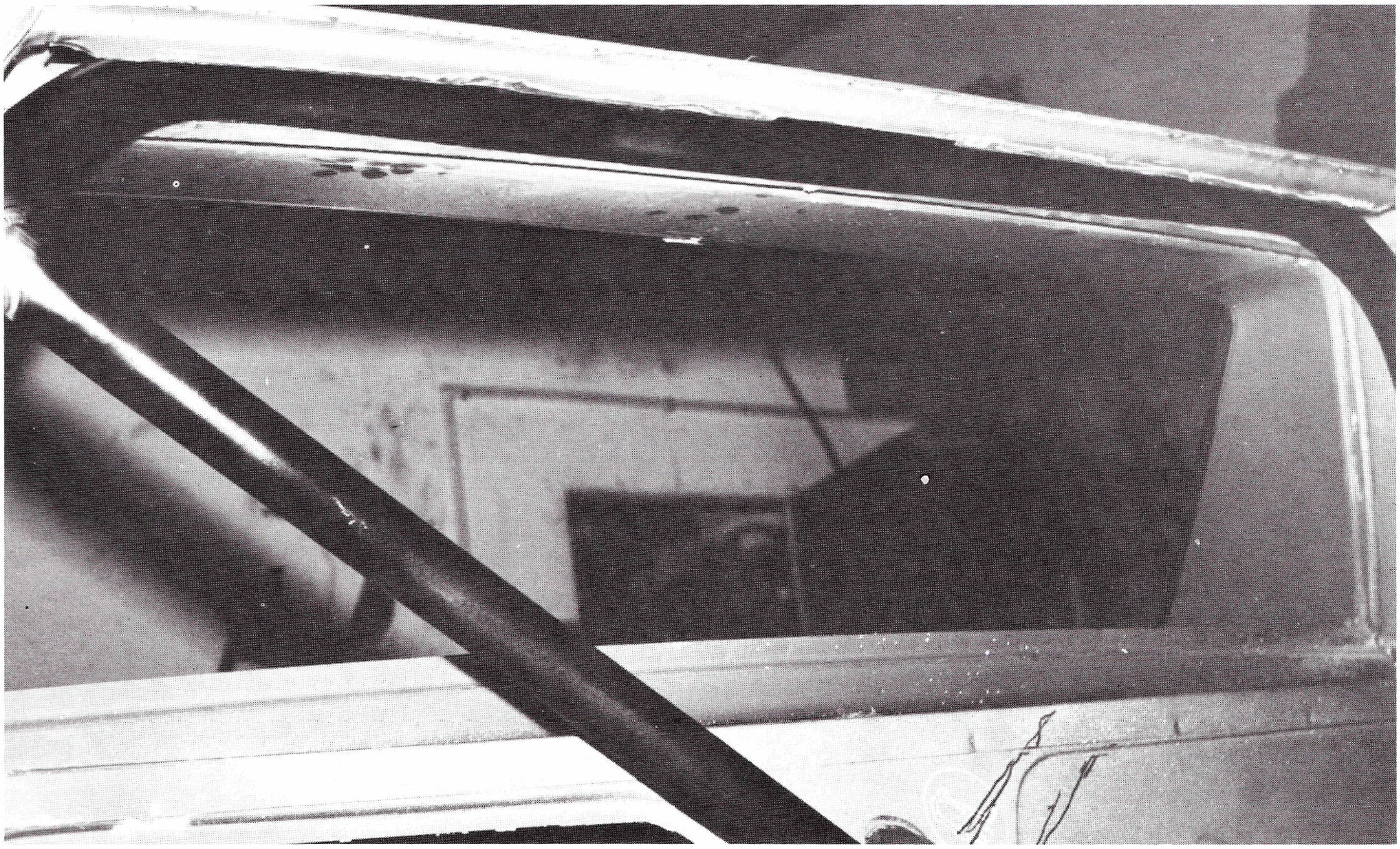
After painting the installed master cylinder mounting bracket, the cylinders and linkage can be assembled. Set up the brake balance so the rocker arm pivot is slightly closer to the front master cylinder for initial testing. Adjust this balance as required to obtain optimum front to rear brake balance under racing conditions. PBS Kit Number 12 covers the dual master cylinder parts.

ROLL CAGE

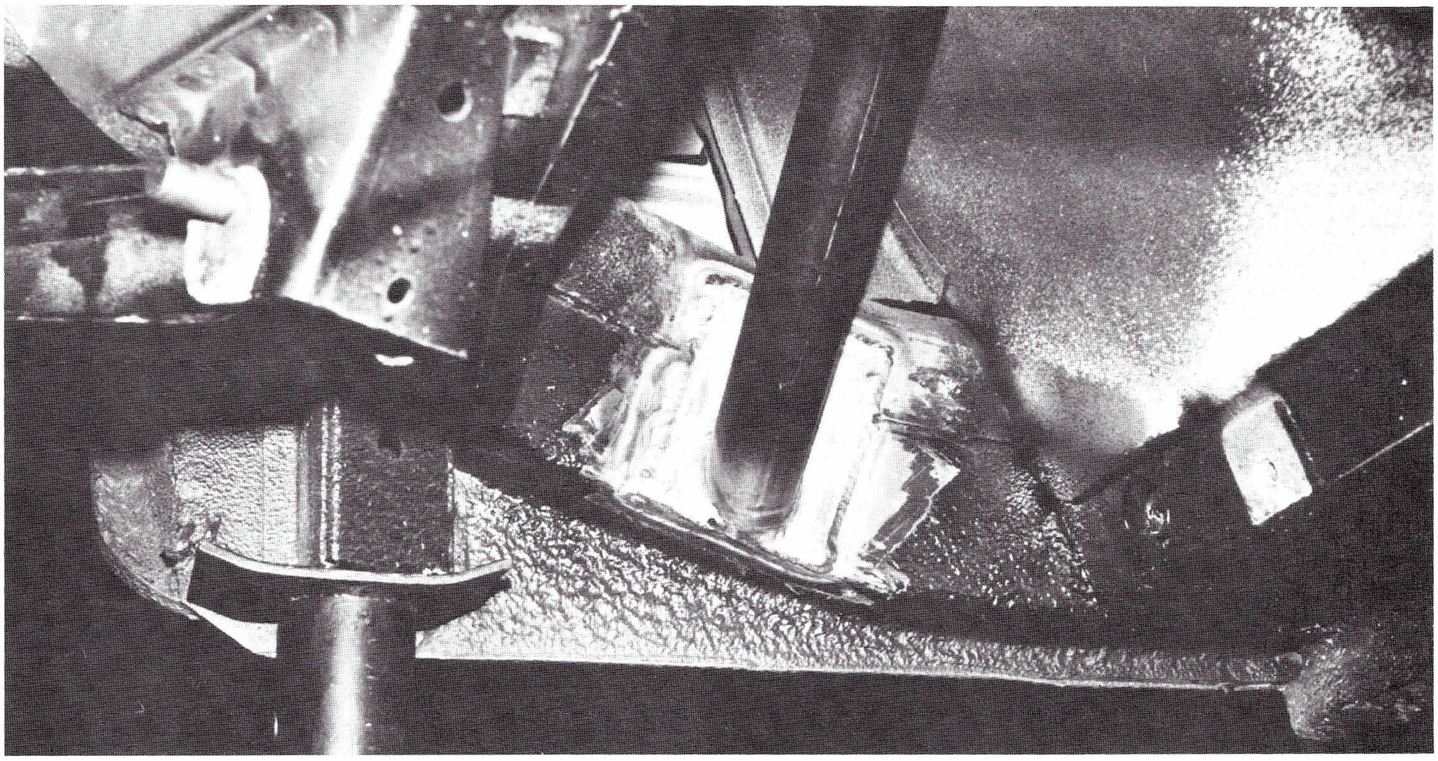
All SCCA production race cars built in 1979 and later are required to have a complete roll cage as defined in the current SCCA G.C.R. Since it is required, it is desirable to integrate the cage carefully into the basic car structure to enhance the stiffness of the chassis as well as to protect the driver. In addition, the cage should be designed in such a way as to minimize its aerodynamic drag. The roll cage described in subsequent paragraphs complies with SCCA safety criteria and the above objectives as well as being integrated into the basic styling of the X1/9.

Fabricate the main hoop and the front hoop from 1-1/2 inch O.D., .120 inch wall, mild steel tubing per Drawings 17 and 18. The bottom ends of the two hoops will need to be trimmed to fit the installation.

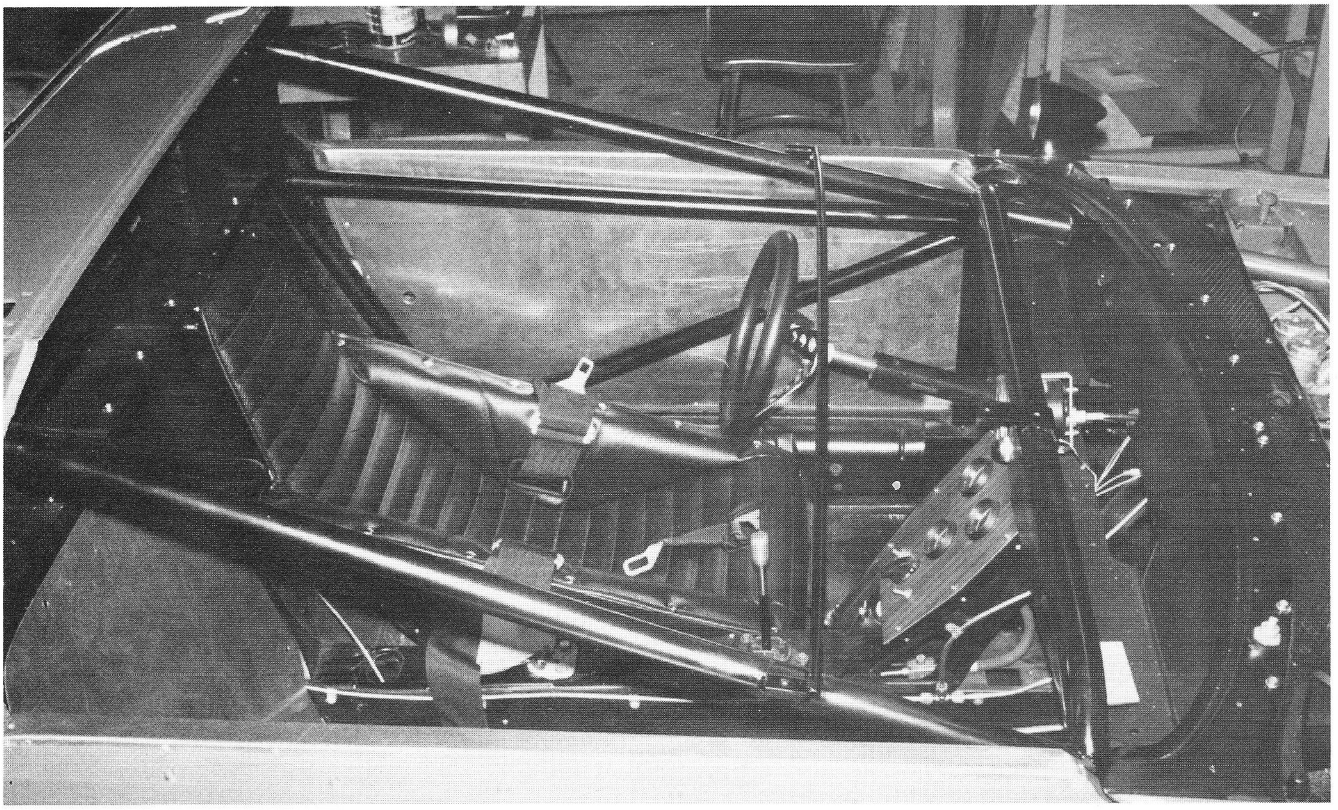
Fabricate four base mounting pads from angle iron or by bending steel plate and weld them onto the outer



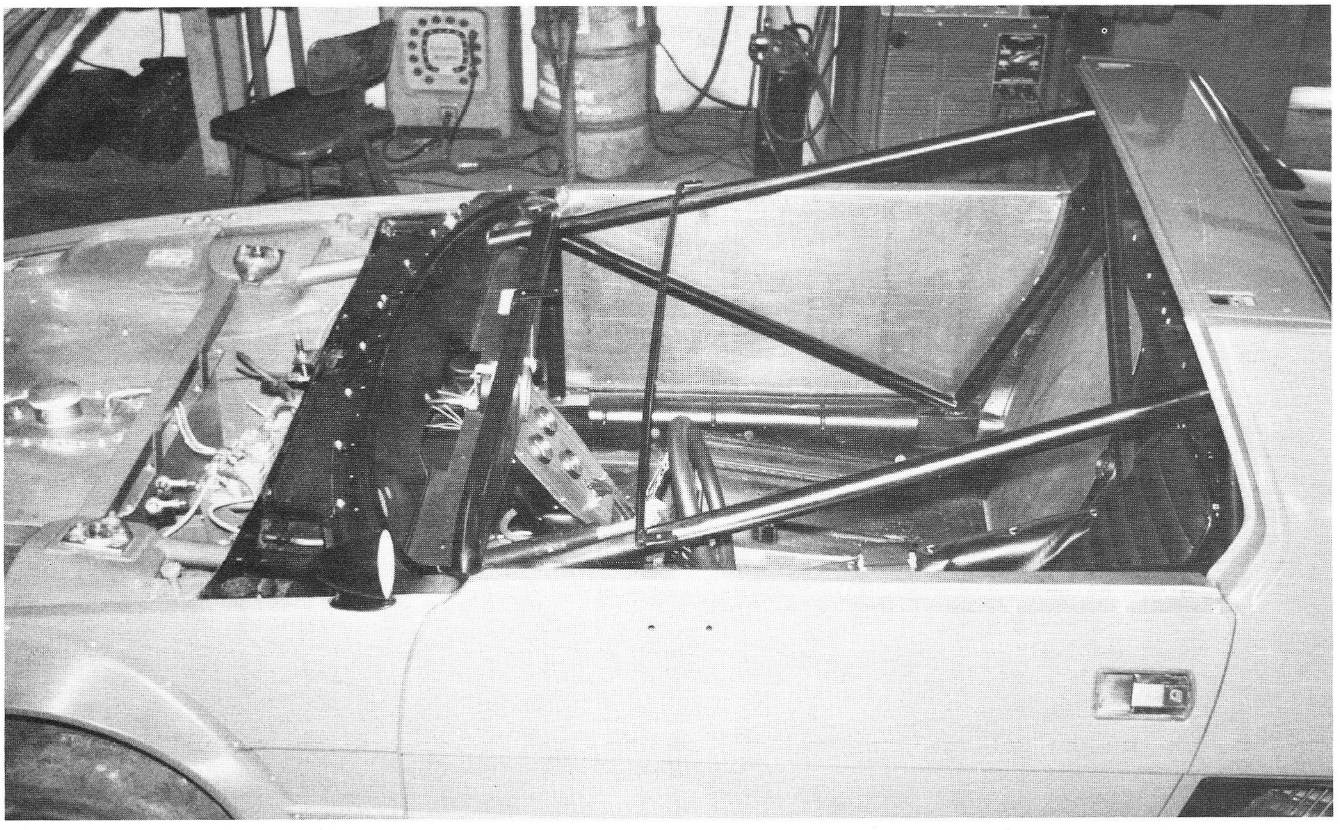
Roll Cage Main Hoop



Lower Main Hoop Diagonal Attachment



Driver's Side Roll Cage Bracing



Right Side Roll Cage Bracing

chassis box members to support the bottom of the hoops. Refer to the pictures.

Cut a slot in the under side of the targa roof panel to insert the main hoop. Cut through two layers of sheet metal, being careful not to damage the top outer skin. An abrasive disc in a pneumatic die grinder works well for cutting sheet metal.

The main hoop can be welded in place as soon as it is properly fitted. Note that the bottom of the hoop is positioned foward of the door posts to allow easy access behind the hoop for welding to the base pads. The main hoop can be welded to the door post structure at the top of the doors and to the lower skin of the targa roof section in several spots to increase the stiffness and strength of the combined structure. Do not weld the front hoop in place at this time.

Cut and fit the foward braces between the front strut towers and the front hoop. These fit through the front side air duct holes. After these are fitted, they, and the front hoop, can be welded in place.

Cut and fit the diagonal for the main hoop. Note that this passes through the cockpit rear panel and intersects the left lower chassis box member inside the original fuel tank bay. Sandwich a steel plate between the diagonal base and the box member to spread out the loads.

Cut and fit the remaining roll cage braces. It is recommended that the remaining braces in the cockpit section not be welded in place until the cockpit interior has been completed, because they make access to the cockpit more difficult. Note that a transverse tube is installed between the front strut towers. This is not part of the safety roll cage and can be made of lighter material such as 1-1/2 inch square tubing with a .06 inch wall. Its function is to stiffen the front strut towers and mount the fuel cell. The roll cage parts are contained in PBS Kit Number 17.

WHEELS, TIRES AND WHEEL ALIGNMENT

Wheels

The F-production X1/9 is allowed to use 6-1/2 inch wide, 13 inch diameter wheels. We recommend the Cromodora Daytona-style magnesium wheels in this size. These wheels have conical steel inserts to accept tapered lug nuts for centering on a 4 inch bolt pattern. Most other brands of aftermarket wheels are made to accept straight shouldered lug nuts which typically don't provide very accurate centering, especially in a racing application where the wheels are removed and replaced frequently and the mounting holes become worn. The G car can use 6 inch x 13 inch wheels. These are available from Cromodora with a 98mm bolt pattern.

For racing, the wheel lug bolts should be replaced with studs and nuts. This can be accomplished by drilling the wheel mounting flanges, brake discs and spacers to 1/2 inch. Drill the new pattern to a 4 inch bolt circle (not the stock 98mm) if Cromodora 6-1/2 x 13 wheels are to be used. Then 1/2 inch bolts can be inserted from the back side and the heads can be tack welded to the back of the axle. Some grinding is required on the bolt heads so the brake disc will clear the outer edge. It is recommended that the flange be mounted to a wheel when welding the studs into the flange. This will assure correct alignment after welding. In order to drill the axle flanges, they must be removed from the wheel bearings. In general, it is suggested that the wheel bearings be replaced with new ones when the axle assemblies are reassembled. Use matching tapered lug nuts with the 1/2 inch bolts to retain the wheel securely. PBS Kit Number 15 can be used.

The Cromodora 6-1/2 x 13 wheels have a "0" offset. A 1/2 inch positive offset would be about optimum on the X1/9. Therefore, a 1/2 inch thick aluminum spacer should be added behind each wheel. This is in addition to the stock steel spacer on the rear of the X1/9. On the front of the F-production car, a steel spacer is included under the Lancia brake discs, so no additional spacers should be added outside the discs except for the 1/2 inch aluminum one.

Tires

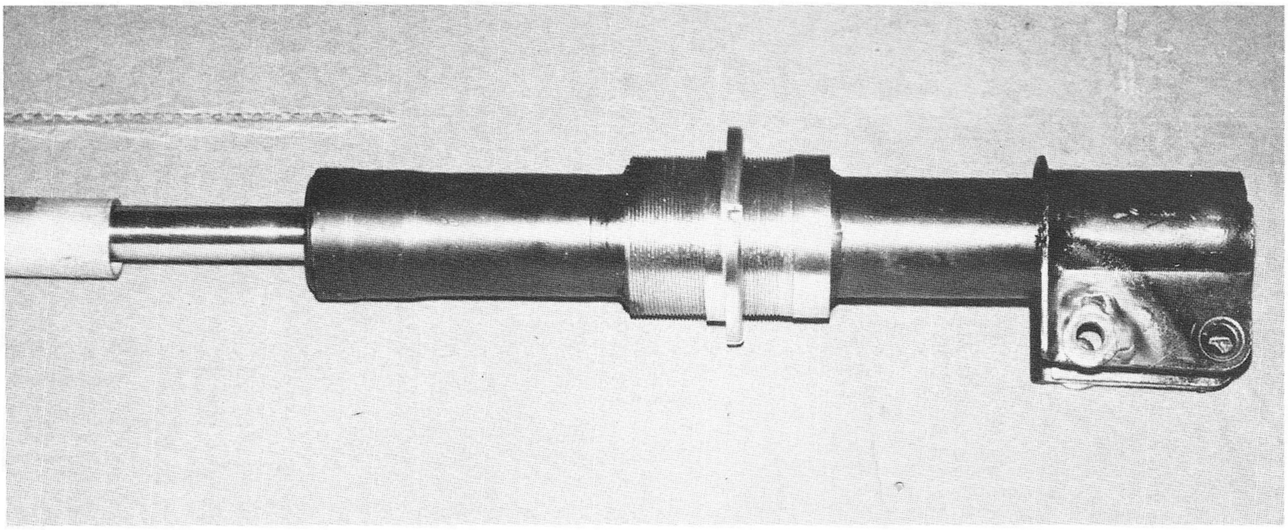
Tire technology changes so rapidly that no firm recommendations can be made, because in the next six months they would be obsolete. The chassis modifications described are intended for tires in the range of 20 to 21 inches in diameter. Clearance to the front springs is quite limited so the front tires cannot be excessively wide or they will interfere. More room is available at the rear so the rear tires can be wider than the front tires if desired.

Wheel Alignment

The optimum wheel alignment will vary somewhat depending on the tires, but a few general guidelines are appropriate.

The front caster is not readily adjustable on the stock X1/9. With rod ends on the leading end of the trailing rods it could be adjusted somewhat by changing the wheelbase, but this is not a legal modification. The trailing rods should be adjusted to be of equal length and to position the wheels foward and aft in the stock location as closely as practical. This should give equal caster on each side. Lowering the car will effectively increase the positive caster somewhat. The increased caster couples into slightly increased negative camber on the outside wheel when turning, which is okay. However, this whole effect is probably negligible for practical purposes.

The adjustable camber plates allow fine tuning of the camber angles with relative ease. After lowering the car, it may be found that the camber is so far off that the desired setting is outside or nearly outside the adjustment range of the camber plates. This problem can be corrected by slotting one of the bolt holes in the suspension bracket



Coarse Camber Adjustment

located near the bottom of the strut. After elongating the hole in a lateral direction, a heavy washer can be welded over the hole to effectively move the hole. The nominal camber settings can be coarse adjusted to be near the center of the camber plate adjustment in this fashion if necessary. The optimum static negative camber will have to be determined experimentally, but a good place to start is around one degree negative at all four corners. Note that adjusting the front camber will also change the front toe. Thus the toe must be re-adjusted each time the front camber is changed.

The front toe can usually be set very close to zero or perhaps slightly out (1/16 inch or less) to minimize rolling resistance. A small amount of toe-in is desirable at the rear in order to improve straight-ahead tracking. About 1/8 inch toe-in is a good starting point. If the car wanders from a straight line excessively, increase the rear toe-in.

The ride height and weight bias from corner to corner should also be checked. Ride height can be adjusted up or down a little depending on the race course and how much ground clearance is required. It must be kept in mind, however, that deviations from the nominal height will change the rate of camber change as a function of suspension deflection. It will also affect the static camber setting. The aerodynamics will be altered as a function of the amount of air which goes under the car below the front spoiler. Thus it can be expected that alteration in ride height will require some testing to sort out the best setting for other suspension parameters. If a set of scales is available, the weight on all four wheels when the car is level should be checked. While there is bound to be a difference from front to back and from side to side, the sum of the right front and left rear weight should be about equal to the sum of the left front and right rear weight. Also, both sides of the front should have the same ride height and both rear points should be the same height. These measurements should be made with the driver's weight and nominal fuel load. The lower spring perches can be screwed up or down as required to achieve these goals.

BODY MODIFICATIONS

Body modifications include the driver's seat, reworking the fenders for tire clearance, removing the stock windshield, lightening the body and fabricating the front air dam.

Seat

In order to keep the driver's head low enough relative to the roll bar, it is almost necessary for the driver to sit directly on the floor, unless the driver is shorter than average. With the driver sitting close to the floor, he must also sit well back in order to have adequate leg room. Drawing 19 shows a fabricated aluminum seat which is large enough for almost any driver. Average or smaller-sized drivers will need some padding in this seat for lateral support and to raise them up an inch or two off the floor. Padding can also be added to the back as required.

Cut and fit the seat supports using 1 inch square 18 ga. steel tubing. Weld the supports to the car and rivet the aluminum seat in place.

Fender Flares

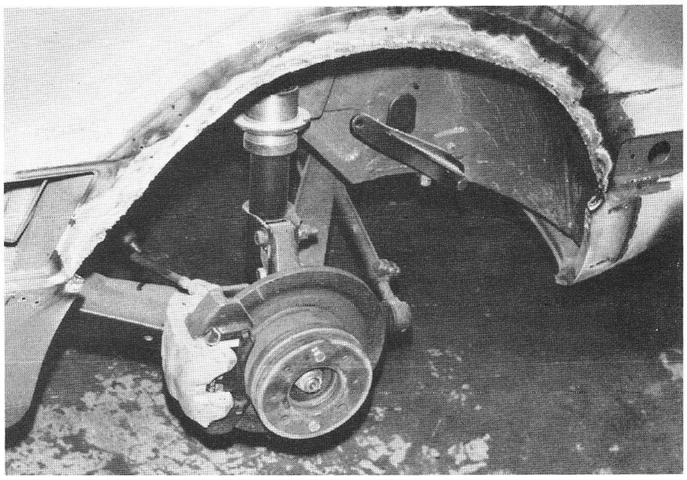
PBS supplies fiberglass fender flares in Kit Number 4, as shown in the pictures, for use on the lowered X1/9. These are specifically designed to cover racing tires on 6-1/2 or 6 inch wide rims at the legal maximum track width. They are intended for tires not exceeding about 21 inches in diameter and for a car which is lowered by 2-1/2 inches in front and 1-1/2 inches in the rear relative to the wheel centers. They are not suitable nor intended for use with street tires, nor cars which haven't been radically lowered.

Remove the fiberglass pieces and cut the front fenders out sufficiently to clear the racing tires. This should be done with the suspension assembled and the wheel and tire mounted but with the suspension spring removed. Move the wheel throughout its possible excursion range both in vertical deflection and throughout the range of steering angles to check for clearance.

Cut the rear sheet metal flares off just below the line where they blend into the body side. Cut through the inner fender panel slightly below the cut on the outer panel. An abrasive disc on a die grinder can be used for cutting the sheet metal.

Hammer the inner panel up to meet the outer skin and weld the two panels together. This is essential to retain the structural integrity of the body in the rear fender area. Check for tire clearance throughout the travel of the rear suspension.

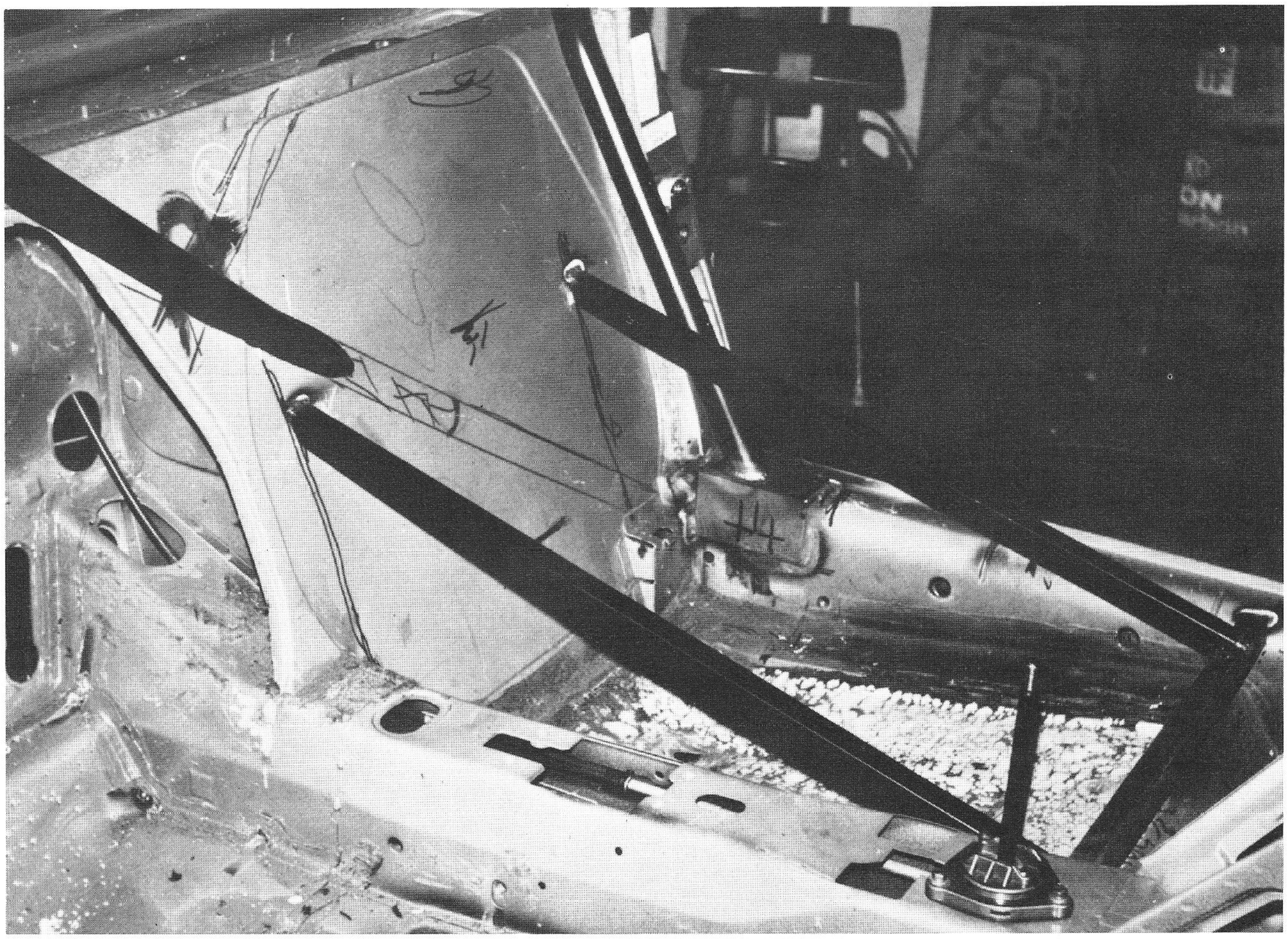
Drill rivet holes through the fiberglass fender flares and the body panels using the marks on the fender flares as a guide. Rivet the flares in place using 1/8 inch diameter aluminum pop rivets. This allows the fender flares to be easily removed, by drilling out the aluminum rivets.



Rear Fender Modification

These pieces are relatively light in construction so that they will break off before stresses get high enough to seriously damage the steel skin to which they are riveted.

Make braces for the lower leading edges of the fender flares from light aluminum sheet and rivet them in place



Seat Frame

to stiffen the flares. These should also be light enough to break or bend if damaged without inflicting damage on the body or the tires.

Windshield

The stock windshield must be removed and the posts cut off flush. Theoretically, the windshield can be removed without breaking it, but this is difficult. Two resistance wires are embedded in the molding, one in the front under the chrome strip and the other on the back under the plastic welting.

If you can find the two adjacent ends of the front resistance wire, which protrude slightly from under the chrome strip onto the glass near the upper right corner, you can apply 12 to 16 volts to them for several minutes until the area warms up. Then the chrome strip can be peeled off easily. The next step is to pull the plastic molding off around the windshield inside the car. Next, locate the two ends of the inner resistance wire near the upper left corner and apply 12 to 16 volts to them for several minutes until the molding plastic becomes warm and soft. At this point the windshield can be pushed out to the front. If this system fails, you can cut the molding all around from both sides, with considerable difficulty, and push the windshield out. If you don't wish to save the glass, the easy way to remove it is to saw the posts off with a hacksaw and push back on the windshield until it breaks off.

After removing the windshield and cutting the posts off flush, a small cover plate must be welded over the posts.

Fabricate a racing windscreen from acrylic plastic and rivet it to the body just ahead of the original windshield leading edge. The windscreen should extend back as far as the stock windshield did. The plastic windscreen should be flat enough that the driver can look over it without losing any vision not already blocked by the body. Fabricate a support for the trailing edge of the windscreen and attach it to the roll cage braces.

Grill

On the 1500 X1/9 the front bumper, grill and spoiler are all integrated together. It is recommended that this all be removed and a stock spoiler and grill from a '75 through '78 car be installed. The mounting points for the earlier grill and spoiler are still in the later bodywork with the exception of the upper grill mounting tabs. The 1500 grill mounting tabs must be removed and replaced with some to fit the earlier grill. Using a stock grill as required by the G.C.R. is greatly facilitated by this minor modification to incorporate the earlier grill. If the bumper and assorted plastic bumper ends and plastic spoiler parts are removed from the 1500 car, the grill is left standing out in front of the car with large gaps above and to the sides. In contrast, the early grill is nicely integrated into the basic front end sheet metal since the early cars were designed with minimal bumpers. Using the early grill also allows the same fender flares and spoiler to be used on either the early or late cars, and makes it possible to use any year car as either a G-production or F-production car by using the appropriate engine and drive train but without the need for extensive bodywork modifications. The car styling is such that the grill is not a predominant feature, since it is in black plastic and is sloped back at the bottom, and covered by the front sheet metal overhang. Thus, there seems to be little reason for attempting to integrate the late grill design into a race car when it is much easier to substitute the early grill. This early grill is homologated for the 1979 car.

Air Dam

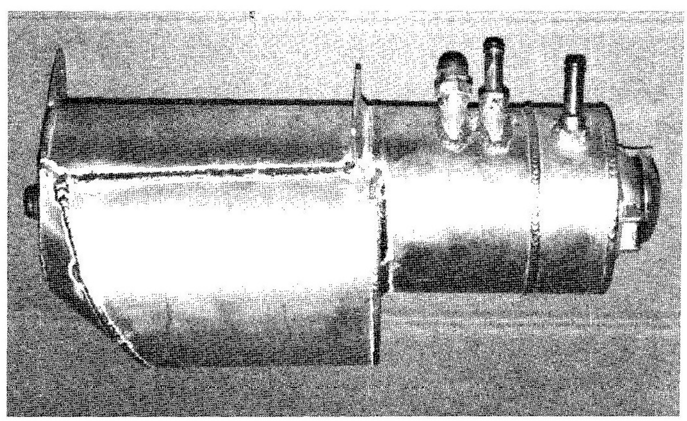
The front air dam should be made for easy replacement because it will probably be damaged frequently due to its close proximity to the ground. It can be fabricated from soft aluminum sheet or plastic and attached with bolts and nut plates. It may be more convenient to remove the spoiler each time the car is loaded on a trailer, also.

PLUMBING, ELECTRICAL AND INSTRUMENTATION

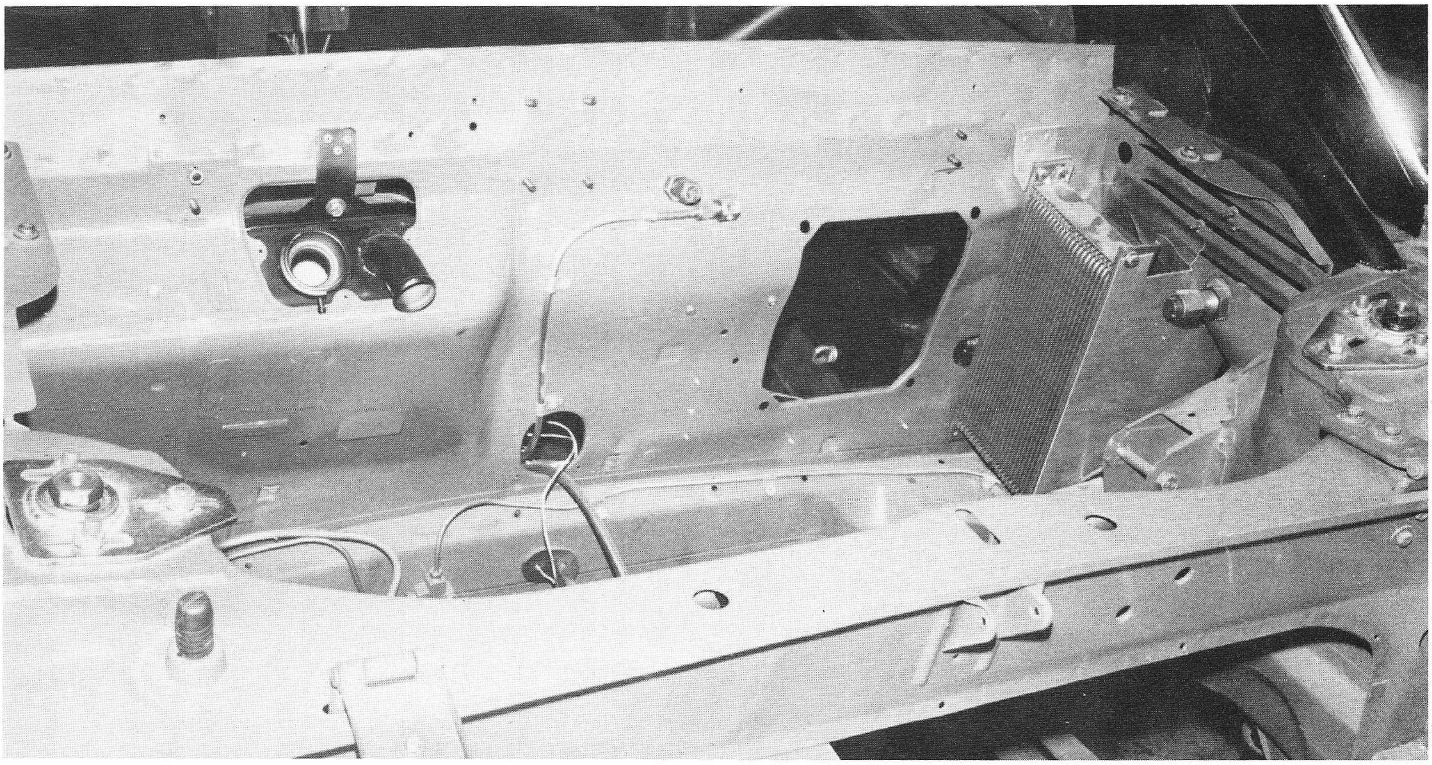
Oil System

A dry sump oil system is essential to maintain oil control under racing conditions with the X1/9. The oil pump and other engine mounted oil system components will be discussed in the engine section. This section deals with the chassis mounted portion of the oil system including the oil tank, oil cooler and remote oil filter and the lines connecting them. These parts are included in PBS Kit Number 13.

The dry sump oil tank is a critical part of the oiling system and can cause serious problems if it isn't designed and fabricated properly. Drawing 20 shows a suggested design for the tank. The dry sump tank can be mounted in



Dry Sump Oil Tank



Oil Cooler and Water Tank Installation

the right rear corner of the rear trunk bay. This location is reasonably close to the oil pump and allows enough vertical height to keep a good head of oil above the tank pick-up under all racing conditions. The oil tank inlets from the scavenge oil pump and from the engine breather should be tangential to the vertical cylindrical wall of the oil tank. This allows the incoming oil to swirl around the tank and spiral down, forcing any entrained gases to the center where they can escape through the oil tank breather. This breather must be located where oil will not be forced out of it along with escaping gases. A baffle must be located between the oil tank inlets and the tank breather.

An engine oil cooler is a necessary item for racing in order to keep the oil temperature within reason. This cooler could be mounted either at the front of the car or at the rear. More cooling air is available at the front, although this must be shared with the water radiator. Longer oil lines are required if the cooler is mounted in front, which increases weight, cost and oil pressure drop. Thus, the best compromise seems to be to locate the cooler in the engine bay and to direct the air from the right rear side scoop into the cooler. Block off any other paths for the air so that it all has to pass through the cooler. Space is rather limited so the cooler should be one which is very efficient relative to its physical size, such as the Borg Warner coolers distributed by PBS. These have about three times the heat rejection rate of the typical tube and fin cooler for a given frontal area.

A remote oil filter adaptor should be plumbed in series with the oil cooler. This can be located in the spare tire well.

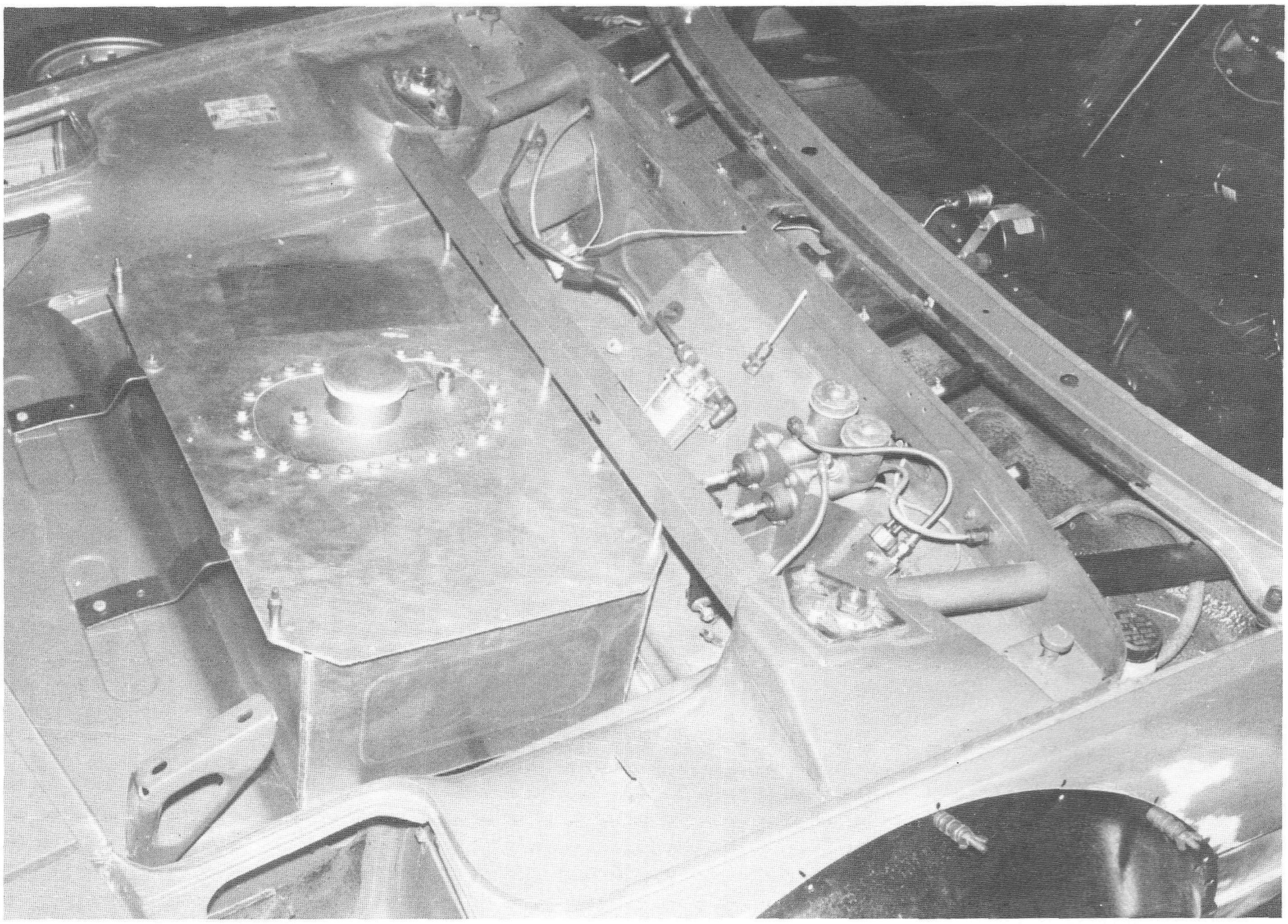
High quality, high pressure oil line should be used to plumb between elements of the oil system. The lines between the scavenge pump and the oil tank, from the oil tank pick-up to the inlet of the pressure pump, from the pressure pump to the cooler, from the cooler to the oil filter and from the filter to the engine inlet fitting should all be 5/8 inch with AN-10 fittings or larger.

Fuel System

A fuel cell is recommended for the X1/9. This can be mounted in the front trunk compartment. Drawing 21 describes a fuel cell of about 10 gallons capacity. An electric pump and fuel lines complete the fuel system.

Note that the fuel cell has a small sump at the bottom rear center of the tank. With the pick-up located in this sump, the fuel will not run away from the pick-up in cornering when the fuel level gets low in the tank, as it would with a large flat bottom. The pick-up, vent and filler cap are located in a steel plate which is bolted to the top of the cell. The fuel cell is designed to sit above the front anti-roll bar which passes through the front trunk. The integral sump drops down behind the anti-roll bar. This fuel cell is available as Item Number 16 from PBS.

Fabricate stands to support the tank above the floor from aluminum sheet. Secure the tank from shifting with



Fuel Cell

steel straps bolted to the tank cover as shown in the pictures. The bar described on page 19 is used for this purpose.

The electric fuel pump should be a good quality, pressure regulated unit. Mount the pump on the bulkhead behind the fuel cell.

Use flexible lines between the pump and the fuel cell pick-up and for the vent line as well as for the line between the chassis and the engine. A rigid steel line can be used to travel the length of the car from the pump back to the engine bay. All lines except the vent line should be a minimum of 5/16 inch O.D. The vent line should be relatively small and should incorporate a check valve to prevent fuel from escaping.

Brake Plumbing

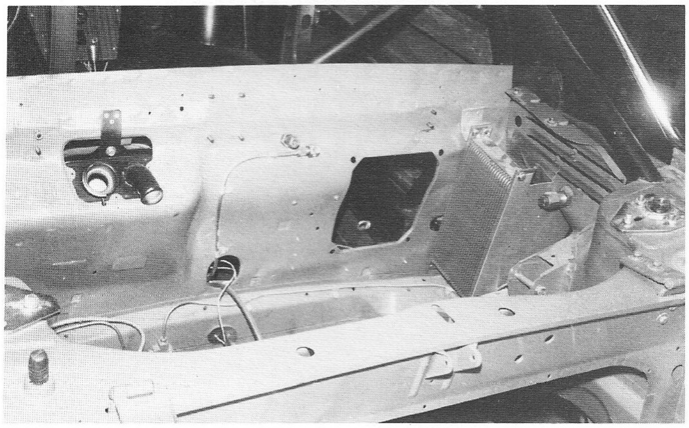
The suggested brake master cylinders can be fitted with male fittings which mate to AN-4 lines. Thus, AN-4 steel braided lines can be used to connect the master cylinders to distribution blocks. From there conventional brake lines can be used or AN-4 lines can be used as desired.

Clutch Plumbing

The stock hydraulic clutch plumbing works fine except that the location of the master cylinder makes it very difficult to work on when the line must be opened up for any reason. This can be improved for maintenance purposes by installing a length of steel braided AN-4 line between the master cylinder and a bulkhead mounted fitting in the front trunk area. This is accomplished by removing the output fitting from the end of the clutch master cylinder and tapping it to 1/8 inch female pipe. Then an 1/8 inch pipe to AN-4 male adaptor fitting can be installed and the flexible line used. This alteration makes it unnecessary to make and break hydraulic connections up under the cowl when the clutch master cylinder must be removed for maintenance.

Cooling System

The cooling system plumbing is modified somewhat in the engine bay to eliminate the heater system, to simplify maintenance and to improve reliability for racing. The stock radiator is marginal at racing speed in high ambient temperatures and should be replaced with one having a more open fin spacing and a slightly thicker core to improve cooling at high speed. The radiator should be sealed along the edges so all air is forced through rather than going around the edges. PBS supplies a special radiator as Item Number 3.



Oil Cooler and Water Tank Installation

The coolant header tank interferes with access to the engine and transmission for maintenance in its stock location. Since the stock fuel tank is removed for racing, the coolant tank can be moved to the original fuel tank location with the filler cap protruding through the existing opening in the firewall as shown in the pictures. The header tank is modified so that one hose fitting points out the bottom and the other arcs out of the top adjacent to the filler cap.

The left hand water tube under the car can be shortened at the rear and connected to the bottom outlet on the header tank with a formed steel or aluminum connecting tube and two short lengths of radiator hose. This tube leads foward to the bottom left of the radiator.

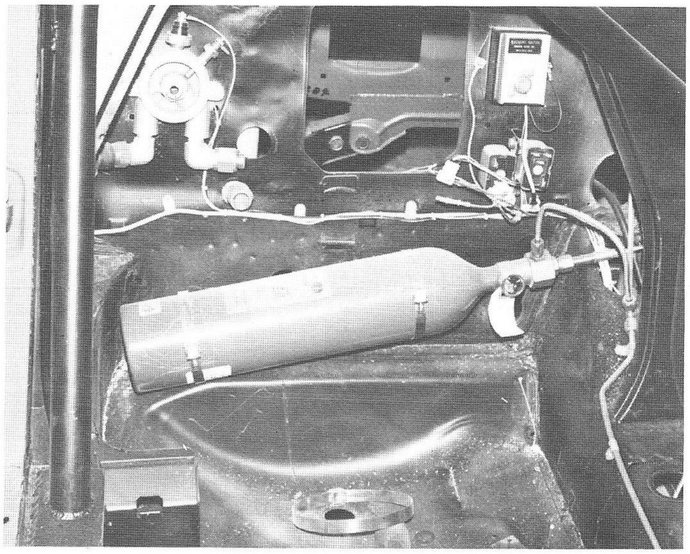
Fabricate a straight water outlet for the cylinder head from aluminum tubing welded to an aluminum plate. This eliminates the stock thermostat housing.

Radiator hose is used to connect between the new cylinder head outlet and the upper hose fitting on the header tank. A Mercedes-type inline thermostat is installed in this hose. The side bypass fitting on this thermostat is connected to the water pump inlet with 1/2 inch heater hose.

Connect the water pump inlet pipe to the right hand water tube under the car with a formed metal tube which passes over the bell housing and two short lengths of radiator hose. Tee the thermostat bypass line into this tube. Note that this line comes from the top corner of the radiator to the suction side of the water pump. Thus the pressure side of the pump forces the water into the bottom corner of the radiator while the suction side connects to the top corner of the radiator. If any air is present in the radiator, it will rise and be pushed through the radiator and back through the pump and engine and finally escape into the top of the header tank which is the highest point in the system. By forcing the flow upward through the radiator, the radiator will bleed itself rather than trapping air in the top of the radiator as it would if the water flow was reversed through the radiator. Use springs inside the hoses on the suction side of the pump to prevent collapsing.

Fire Suppression System

While it isn't currently required for production racing, an approved fire suppression system using Halon 1301 is recommended as cheap insurance against catastrophic fire damage, both to the driver and the car. The gas bottle for this system can be mounted in the spare tire well. Nozzles for the system should be located in the engine bay, the passenger bay and in the front trunk. Follow the manufacturers' instructions for the installation details. PBS Kit Number 18 contains this system.



Fire Suppression System

Wiring

The entire original wire harness should be removed with the exception of the main battery cable leading from the battery to the starter motor. Rewire as required, keeping wiring as simple as possible.

It is suggested that the stock battery be replaced with an aircraft 12 volt battery. These batteries come in several common sizes. The one which works well for the X1/9 measures about 9-3/4 inches long, 5-1/4 inches wide and 7-1/2 inches tall, including caps and posts.

Mount the master electrical switch on the right hand cowl just ahead of the windscreen. This switch must be able to handle the full starter current. Lucas P/N 76606 is one switch which is suitable for this application. Redrill the ground battery cable terminal and run it to the master switch. Add a short additional length of cable from the switch to the ground.

Wire the rest of the car using high quality wire. Pay particular attention to avoid situations that may cause the insulation to be cut or worn away.

Instrumentation and Switches

Recommended instrumentation includes a tachometer, an oil pressure gauge and water and oil temperature gauges.

For best results, the tachometer should be a mechanical unit. The Jones tachometers have proven to be accurate and reliable for racing. The early X1/9 speedometer cable can be reworked on the ends and used for a tachometer drive cable. It is necessary to fabricate a tachometer drive adaptor as part of the end cover for the camshaft housing. A tachometer drive kit is available (Number 10). If an electronic tachometer is preferred for ease of installation, be certain that it is compatible with any electronic ignition system which you choose to use.

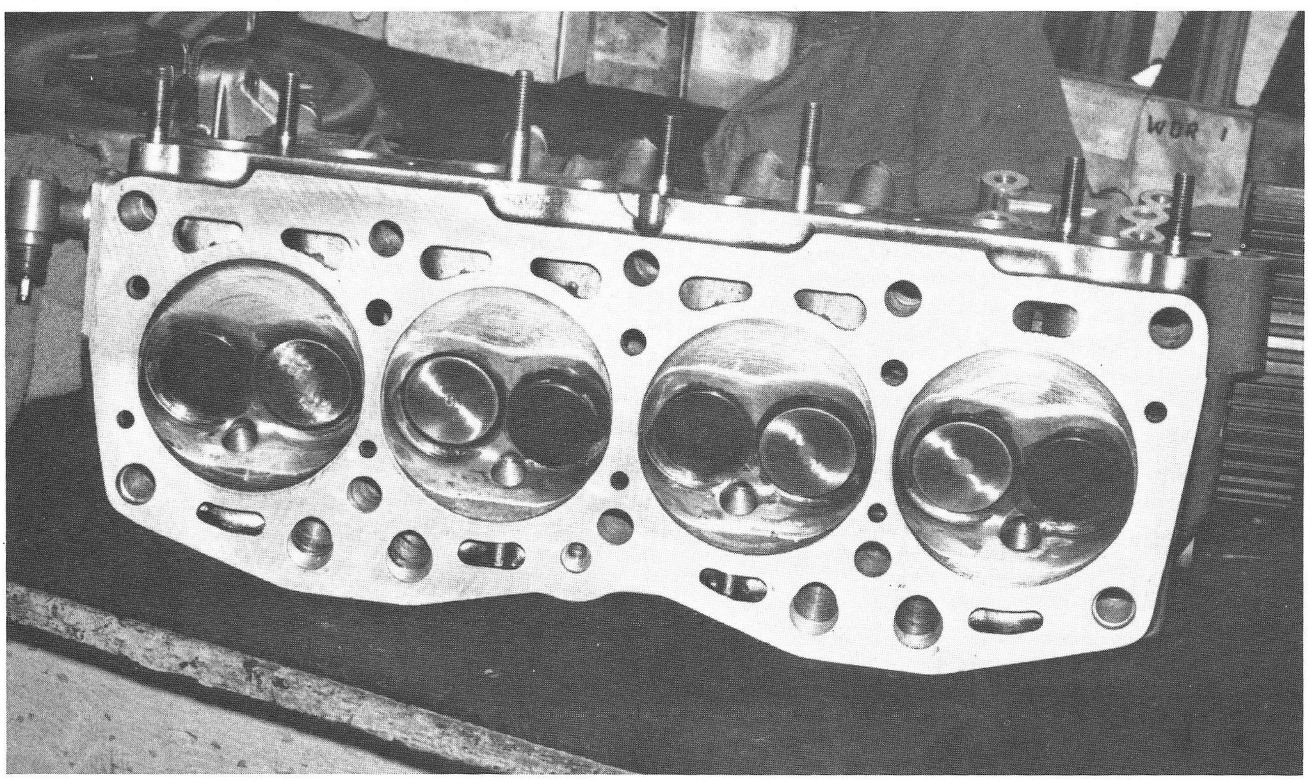
A mechanical oil pressure gauge is preferred for accuracy and reliability. Tap the oil filter block for the oil pressure fitting. This is done to prevent needless handling of the oil pressure line when the engine is removed. This block is also drilled and tapped to install the oil pressure light switch and the oil temperature sending unit. A Stewart Warner 0-200 psi mechanical oil pressure gauge works well in this application.

Stewart Warner electrical temperature gauges are recommended for the oil and water temperature functions. The water sending unit should be installed in the water outlet for the cylinder head. Put the oil temperature sending unit in the remote oil filter adaptor as indicated above.

In addition to the cowl-mounted master switch, the instrument panel should have an ignition switch, an electric fuel pump switch and a starter switch. The starter switch should be a spring-loaded switch which must be held on. A parallel starter button can be installed in the engine bay to facilitate cold starting. A large bright "idiot" light connected to an oil pressure sensing switch should also be installed in a prominent position on the instrument panel.

ENGINE

For SCCA production class racing, allowable engine modifications are strictly limited. However, a number of detail changes are allowed and necessary to obtain optimum performance within the rules. In general, these modifications fall into two categories, those which increase power and those which improve reliability under racing conditions. The following paragraphs describe these modifications in sufficient detail that the competent mechanic



Cylinder Head

can choose an appropriate assortment of stock and modified or special parts and assemble them into a reliable and competitive production racing engine for the X1/9. This manual is not intended as a detailed guide for actually machining modified and special engine parts. Refer to the parts list for engine parts which are available from PBS.

CYLINDER HEAD AND VALVE GEAR

The major effort in performance improvement for the production X1/9 racing engine is directed towards improving flow through the head and valve gear.

Ports

The cylinder head ports should be enlarged as much as is possible without intersecting the water jacket. The ports are machined from each end with a milling machine and then blended in using a hand-held pneumatic die grinder. This work is done with the valve guides removed. Although the valves are not enlarged, the inside diameter of the valve seats can be bored somewhat and the valves reseated toward their outer periphery.

Combustion Chamber

The cylinder head combustion chamber should be modified to increase the compression ratio and the turbulence while maintaining optimum flow around the valves and preventing anything from interfering with rapid flame propagation. The design of the head chamber and the piston crown must be compatible and must both be directed toward achieving these goals together.

The PBS piston design has a very shallow dome on the crown and pops up above the block and head gasket into the head area. Two valve clearance reliefs are cut in the piston crown to clear the valves.

The squish part of the head is flycut deeper than stock to clear the pop-up pistons. The relative shape of the piston crown and the head squish area is such that the piston to head clearance is minimal at the periphery of the piston and is slightly greater at the center of the piston. This causes the mixture to be accelerated toward the spark plug by a wedging action as the piston approaches top-dead-center. Thus the pop-up configuration increases mixture turbulence as well as raising the compression ratio. At the same time, the chamber around the spark plug remains clear of protusions and has a relatively small surface to volume ratio. This, coupled with the high turbulence, promotes very rapid and complete combustion. Furthermore, proof of this is the fact that the dyno testing shows that the minimum spark advance for best torque, at high engine speed, is about 30 degrees crankshaft when using this combustion chamber design on the Fiat X1/9 engines. This is significantly less than is required with the stock chamber and verifies that the combustion process is more rapid.

Valves

SCCA production rules don't allow changing the size of the valves. The stock valves should be lightened and reshaped to improve flow, however.

Valve Springs

PBS supplies special racing valve springs for high rpm use with high lift racing cams. These special springs are necessary to accomodate the lift of cams used on the production racing engines without experiencing coil bind problems.

Cam and Cam Timing

In general, the cams which work best in the X1/9 production racing engine have moderate duration and relatively high accelerations. These allow adequate flow without excessive overlap. The end result is a broad usable torque curve. A number of different profiles are being experimentally investigated at PBS to determine the optimum production racing cam. The cam data in subsequent paragraphs pertains to the best performance obtained at this writing.

The cam currently in use in the 1500 X1/9 F-production engine is the PBS F-2 cam. This cam has a duration of 287° when measured at a gross lift of .020 inch. Lobe centers are at 107.5°. The peak rate of lift is .009 inch per degree. The maximum lift is .453 inch measured at the valve. Valve clearance is set at .010 inch on both the intake and exhaust. Cam timing is set for split overlap. This gives a lift, measured at the valve, of .125 inch at top-dead-center on valve overlap for both the intake and exhaust cams.

At the time of this writing, the F-2 cam as described in the above paragraph is also being used in the G-production engine.

Tappets

Stock tappets and valve adjusting shims are adequate for use in the production racing X1/9 engine. The tappets should be visually inspected for cracks and other damage, particularly if the engine has experienced any failure in the valve gear area which might have overstressed the tappets.

Valve Guides

The stock cast iron guides and the stock valve seals work well on the X1/9 engine. Bronze guides can be used, but experience indicates that the cast iron guides last longer and are less expensive as well.

Head Gasket

The currently available stock head gasket is not recommended for racing as it isn't strong enough for the combustion pressures generated. The older stock gaskets were stronger. PBS can supply high quality racing head gaskets for the X1/9.

ENGINE SHORT BLOCK

Dry Sump Oil System

The engine oiling system is modified extensively to improve reliability under racing stresses. Oil control is achieved with a dry sump system and a special oil baffle between the crankcase and the oil pan.

PBS manufactures a special two-stage, cog-belt-driven dry-sump pump which mounts on the engine block in place of the stock alternator. The alternator is not used, of course, for production racing due to the short duration of the races. The oil pump is a gear-type pump with a larger scavenge stage than pressure stage. The pressure relief bypass valve is built into the pump to provide a pressure outlet of about 10psi per 1000 crankshaft rpm minimum.

The dry sump oil pump is crankshaft-driven by a 1/2 inch wide, 3/8 inch pitch timing belt. The pump is driven at 1/2 crank speed. The same belt also drives the water pump which is fitted with a drive sprocket. The 12-tooth, crank-drive sprocket replaces the stock crankshaft V-belt pulley.

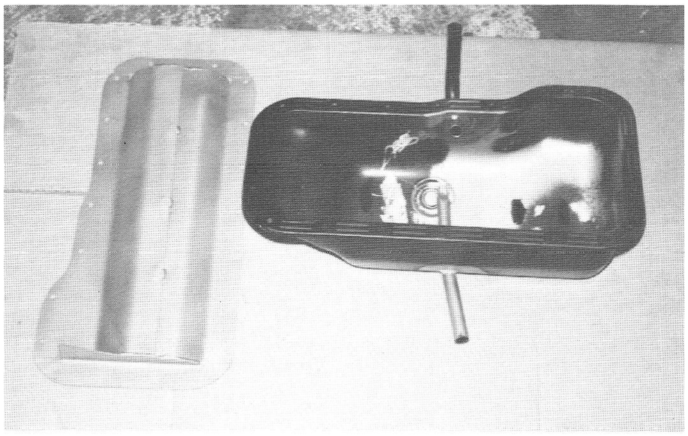
The dry sump oil pan is fabricated from a steel Fiat 128 oil pan. This pan has less depth than the aluminum X1/9 pan and hence provides a little more ground clearance. The stock baffles are removed from the 128 pan and the dry sump pick-up tube and the engine breather tube are brazed to the pan.

A special baffle is fabricated to allow oil to pass into the pan but prevent it from climbing back up into the crankcase or being churned up by the rotating crank. This baffle has a longitudinal slot lapped in such a way that it peels off any oil rotating with the crank and forces it through the slot into the pan. The baffle sandwiches between the block and the pan, with a gasket on each side, and completely blocks any oil trying to climb up the walls under cornering, braking or acceleration forces.

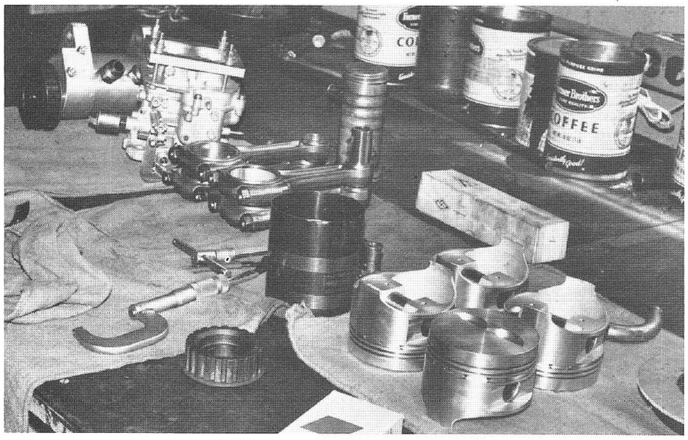
An in-line filter screen is recommended for the scavenge pump. This should be located in the line between the oil pan pick-up and the inlet fitting on the bottom of the scavenge pump. The filter screen will prevent the pump from ingesting any large pieces of debris in the event of engine failure. The scavenge inlet line should be a minimum of 5/8 inch or AN-10 in size.

The fitting on the block, which the stock filter is screwed on to, is modified by welding a steel male AN fitting on the end of it. This should be an AN-10 fitting or larger. The engine pressure inlet line coming from the oil filter (oil filter output) is attached to this fitting.

The original oil filter input port, at the block interface with the stock oil pump, should be plugged. The stock dip stick hole and the stock engine breather hole are also plugged. The new breather is located in the pan under the oil baffle. This location allows the normal breathing of the engine to help force the oil down through the baffle into the pan. It doesn't matter if oil is blown into the engine breather because the breather hose is directed into the dry sump tank where the oil is separated out and recycled.



Dry Sump Pan and Baffle



Pistons, Rods, Carburetor and Oil Pump

Cylinder Bores

SCCA rules allow the cylinders to be bored up to 1.2mm oversize. This gives a bit more displacement, but a bore size must be selected which matches available piston rings. The 1300 X1/9 engine has a stock bore of 86mm. 87mm rings are readily available so that is a good size to use for the G-production engine. The 1500 engine has a stock bore of 86.4mm. Ring availability is not as good for oversizes for this engine but some rings are available at the maximum limit of 87.6mm.

Crankshaft

The stock crankshafts are reliable up to about 9000 rpm on the 1300 engine and 8500 rpm on the 1500 engine. They don't have adequate counterweight for higher rpm. This causes the center main bearing to be overloaded and results in premature failure if excessive rpm is used. Other than this problem, the stock cranks are adequate for racing use. Investigation is being done on an alternate counterweighted crankshaft for improved durability.

Pistons

As noted in the cylinder head discussion, the piston design has a great effect on the combustion process. PBS pistons for the racing X1/9 engines are machined from Cosworth forged aluminum blanks. These blanks are of the highest quality material available and are heat treated for optimum hardness and stability. They can be fitted significantly tighter in the cylinder bore than most forged pistons without problems of galling or seizing. About .004 inch skirt clearance is adequate with these forgings compared with roughly twice that much for most forged pistons in the X1/9 size. The tighter clearance keeps the piston straighter in the bore and significantly improves ring sealing and hence engine performance. The stock diameter piston pins are retained by snap rings. The piston crown design is discussed on page 27.

Connecting Rods

The 1500 X1/9 connecting rods are suitable for racing if they are lightened, balanced and shotpeened. The 1300 stock rods are marginal for racing. Alternate forged steel rods are recommended for the G-production engine. Do not attempt to lighten and polish the stock 1300 rods as they will warp out of shape due to relaxation of residual stresses when the outer skin is broken.

Bearings

The stock Fiat main bearings and rod bearings are suitable for racing use as long as the oil pressure is raised to about 10 psi per 1000 rpm and adequate oil control is provided by a dry sump lubrication system.

ENGINE ASSEMBLY

Basic engine assembly is the same as with the stock engine and the reader is referred to the Fiat shop manual for general information on engine assembly. This section will cover details which are different from the stock engine and which are particularly critical for the racing engine. The primary areas of concern involve clearances between the pistons, the head and valves, and cam timing.

Checking Piston, Head and Valve Clearance

A trial assembly is recommended to check piston to head clearance and valve to piston clearance.

Bore and hone the cylinders to get the desired piston skirt clearance (.004 inch if Cosworth forged piston blanks are used).

Assemble the rods, pins and pistons being certain that the flat side of the piston pin retaining circlips face outward.

Check piston ring end gaps in the bore before installing them on the pistons. End gap must be .012 inch minimum. The rings should be off the pistons for the trial assembly.

Assemble the pistons, rods, crank and bearings into the block.

Verify that side clearance exists between the connecting rod small ends and the piston pin bosses in the assembled condition.

Install the head assembly using a used (compressed) head gasket. Put modeling clay on the piston crowns. Two narrow strips across the piston crown at right angles will be sufficient to monitor clearances. Torque the head down.

Time the cam as described below. Rotate the crank through top-dead-center on all cylinders to compress the clay between the head and the piston crowns.

Check the exhaust valve to piston clearance at about 10°(crank) before top-dead-center (TDC) on valve overlap. This can be accomplished by monitoring tappet motion with a dial indicator while the valve is pried open with a screwdriver until it touches the piston. This will be easier to do if light springs are used on the valves during this trial assembly phase. The exhaust valve to piston clearance should be a minimum of .100 inch when measured this way.

Check the intake valve to piston clearance at about 10° (crank) after TDC on valve overlap. The clearance should be .070 inch minimum.

Remove the cylinder head and check the thickness of the compressed modeling clay. The minimum head-to-piston clearance at the piston crown periphery should be between .025 and .035 inch.

Checking Cam Timing

The cam timing must be checked and adjusted to the optimum position as defined by the cam supplier or dyno testing. If not otherwise specified, a symmetrical timing pattern (split overlap) will generally give good overall performance for racing. The cam can be advanced slightly (up to 4° crank) to enhance mid-range torque with some loss in top end power. Or it can be retarded slightly to give a small increase in top end power with a significant loss in mid-range torque.

The easiest way to check for split overlap on the cam timing is to check the lift at TDC on both intake and exhaust lobes during valve overlap. First, set the valve lash to the same arbitrary value on both the intake and exhaust lobes on one cylinder such as number one. .010 inch clearance would be acceptable, for example.

Install a dial indicator so that it monitors the lift of one of the tappets, for example the intake tappet. The piston should be near TDC and the two valves on overlap. Note that an accurate indicator for TDC will be required. This should be carefully checked for accuracy before the cylinder head is installed by monitoring piston travel with a dial indicator and verifying that the TDC mark does accurately determine the point where top-dead-center occurs.

To check intake lift at TDC, the crank must be rotated CCW, from the front, until the indicator stops moving, showing that the cam is on its clearance ramp. At this time, zero the dial indicator. Now rotate the crank CW until TDC is reached. Read the dial indicator.

Move the dial indicator to the exhaust tappet. Rotate the engine CW until the indicator stops and zero it. Rotate the crank CCW past TDC and then CW to TDC, to take up any slack in the CW direction, and again read the indicator.

If the two readings at TDC are the same, the cam is set for split overlap. If the intake lift is greater than the exhaust at TDC, then the cam is advanced. The cam is retarded if the exhaust lift is higher. These conclusions assume that the cam has identical and symmetrical intake and exhaust lobes.

If the cam timing is in error and an adjustable cam sprocket is being used, the timing can be adjusted and rechecked until the desired setting is obtained. If something other than split overlap is desired, a degree wheel is suggested for use on the crankshaft. Then the split overlap point can be dialed in to any desired crank angle. For example, setting the cam for split overlap as described in the previous paragraphs, but with the crank at 4° before TDC, will result in the cam being advanced by 4°. Also, the degree wheel can be used to check opening and closing events and calculate the lobe centers.

If a stock, non-adjustable cam sprocket is used, a new dowel pin hole can be drilled in the sprocket. First it is necessary to determine how much the timing must be changed.

If the exhaust lift at TDC is greater than the intake lift, the cam is retarded and vice versa. To determine the magnitude of the timing correction needed, first subtract the smaller lift from the larger one. Then divide this difference by two and add the result to the smaller lift. This will give you the approximate desired lift for both valves assuming that split overlap is desired. Now, watching the indicator, rotate the crank as required to bring the lift to the calculated value. Note that all indicator positions should be approached while turning the crank CW so that any slack will be taken out as it is during normal engine rotation. At this point, the relative position of the calibrated TDC marks on the degree wheel and pointer will show how far the cam timing must be corrected in crankshaft degrees.

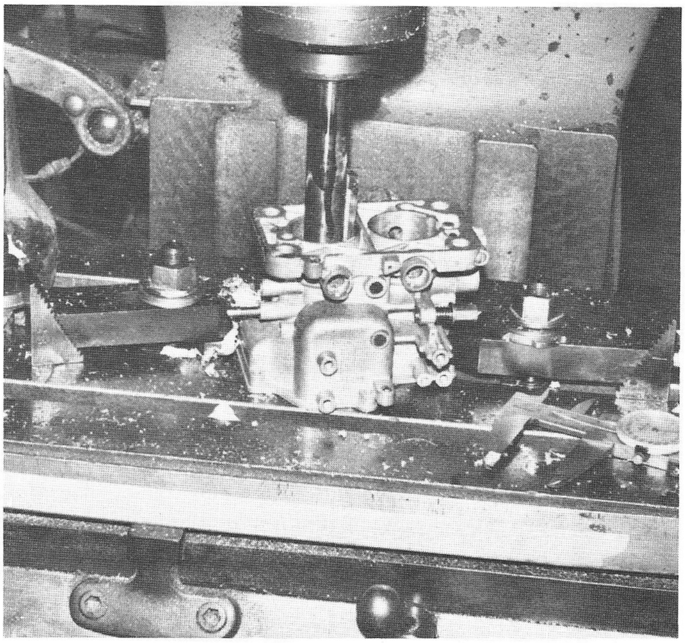
Leave the indicator set up to verify that the cam stays in position. Carefully remove the cam drive sprocket. The cam sprocket has 42 teeth. Thus the angle from the leading edge of one tooth to the same edge of the next tooth is 8.57°. Since the cam runs at half crank speed, this is equivalent to 17.14 crank degrees. The tooth pitch is .375 inch, so 1° (cam) or 2° (crank) is equivalent to .044 inch at the sprocket pitch diameter.

A simple drill jig is required to redrill the cam-sprocket-index-pin hole. This can be made by cutting the nose off an old Fiat X1/9, 128 or 124 cam. Or a short piece of bar can be machined to simulate the nose of a camshaft. In either case, bolt the sprocket onto the end of the dummy cam stub. Then drill the index pin hole through the full length of the stub.

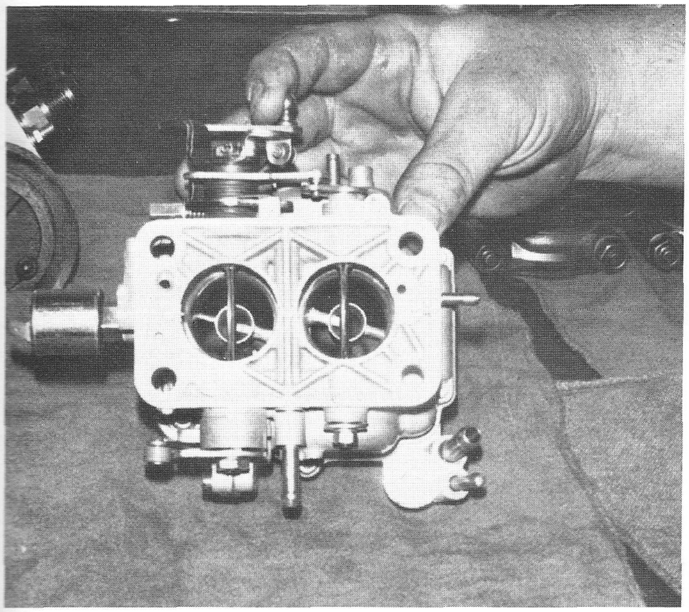
Clamp the cam stub in a vise with the sprocket installed on it and the index pin holes aligned with a pin or drill. Fix a pointer to some stable object such as a magnetic base attached to the vise. The pointer is then aligned with an edge of any tooth on the sprocket. Being careful not to disturb the cam stub or the pointer, the sprocket should be rotated through some arbitrary angle, such as 180°, and roughly realigned to the same edge of a different tooth. Knowing the desired timing correction angle and the direction of rotation of the cam timing correction, the sprocket can be rotated through the desired fraction of a tooth relative to the fixed pointer and cam stub. The sprocket is then bolted to the end of the cam stub to fix their relative positions and the assembly is removed from the vise. Use the cam stub as a drill jig to drill a new index pin hole through the sprocket.

As an example of this operation, suppose it has been determined that the cam is retarded 3° at the crank. Since the belt will remain in a position fixed by the crank sprocket, the cam sprocket will have to be rotated CCW relative to the camshaft in order to advance the cam. Thus in order to compensate for a 3° (crank) retarded cam, the sprocket must be rotated 1-1/2° CCW with respect to the fixed pointer and the dummy cam stub. If the pointer was initially set at the lower edge of a tooth with the index holes aligned, the sprocket would be rotated CCW a distance of (.044) (1.5)=.066 inch at the surface of the sprocket outer diameter.

After the new index hole has been drilled, the crank should be set at TDC and the sprocket and belt assembled on the engine, using the new index hole, without



Boring The Carburetor



Carburetor Butterflies

moving the cam appreciably. Now the lift at TDC measuring process can be repeated. If the above operations have been performed accurately, the lift should be nearly equal on both the intake and exhaust tappets. Very small adjustments can be made by rotating the sprocket within the clearance of the index pin.

Once the cam timing has been adjusted, the proper index holes should be marked permanently. Also, corresponding marks should be scribed on the sprocket outer rim and the cam box with the crank at TDC for future reference.

Head Bolts

If the cylinder head has been milled, the head bolts must be shortened. In fact, it is a good idea to cut about 1/8 inch off the threaded end even if the head hasn't been milled. This will ensure that the bolts won't bottom out in the block threads and give a false torque reading before the head is seated properly

Pan Baffle

Trial fit the oil pan baffle, which fits between the block and the oil pan, and rotate the engine to check for clearance. If it touches any place, bend the baffle as required to ensure a small amount of clearance to the crank and rods.

CARBURETOR AND INTAKE MANIFOLD MODIFICATIONS

The carburetor and manifold must both be opened internally as much as possible to allow maximum air flow through the engine.

Carburetor

The 32DMTR carburetor allowed on the 1300 engine and the optional 34DMTR carburetor allowed on the 1500 engine are virtually identical except for the butterfly sizes and some minor jetting differences. Thus, unless otherwise noted, the described modifications apply to either carburetor.

Disassemble the carburetor completely. Bore the venturis to about 28mm. (At about 28.5mm they will frequently break through to the outside).

Reshape the bottom of the venturis to blend into the throttle bore with a form tool.

If desired, the throttle shafts can be ground, along the section which fits the throttle bore, to about 1/8 inch total thickness, normal to the throttle butterflies. Smooth the edges down to feather them into the throttle plates.

If the throttle shafts are ground thin, the throttle plates can be soldered in place and the screw holes filled with solder by placing a large wood dowel behind them to prevent the molten solder from running through. Countersink the screw holes somewhat on each side of the throttle shaft, so that the solder plugs will be locked in place and won't fall out from vibration.

Plug the fuel return fitting and the vacuum fittings on the outside of the carburetor with solder. If the carburetor is fitted with a float bowl vent tube, don't plug it.

For the 1300 engine, use a 175 needle and seat (Weber P/N 79507.175). On the 1500 engine a 200 needle and seat is suggested (Weber P/N 79507.200).

The fixed idle jets can be opened up to about 1mm on both the primary and secondary. 1.35mm main jets and 1.40mm air correction jets can be used on both sides. This combination will be close enough to allow fine tuning. Set the float at 7mm. To minimize fuel starvation problems during cornering, the floats should be cut off at an angle on the outboard lower corners. Cut them off from the mold parting line, on the outboard surface, to about 5/16 inch from the inboard lower corner. If this isn't done the fuel climbs the outer wall during hard cornering and lifts the outboard float high enough to shut off the needle and seat and hold it shut off until the fuel level drops too low to feed both main jets. Thus the engine will start to lean out and die part way through the corner. Cutting the floats will help minimize this problem but may not completely cure it.

When using the 32mm carburetor, the superjet air bleed in the carburetor cover must be plugged by soldering it shut. Also, the superjet fuel jet must be drilled to 1.30mm. The 34DMTR comes with a blank (undrilled) air bleed jet and a large fuel jet. This richens the mixture at the top end when the superjet comes in.

On the 32mm carburetor, when the venturis are bored, a bleed hole is opened up into the idle circuit. This must be plugged. The idle circuit should not be plugged, however. A small lead plug on the outside of the carburetor (primary side) can be removed for access to this bleed hole. Tap this hole through into the primary venturi bore.

Select a screw the proper length to end up flush with the inner venturi bore. Grind down the center threads on the screw to allow fuel to pass in the idle circuit. Install the screw with Loctite sealant.

An air inlet plate can be fabricated from 3/8 inch aluminum plate if a smoother inlet horn is desired. This is machined out to match the carburetor inlet opening and then radiused to a smooth inlet shape with a die grinder. If this is used, the main jets must be increased to 1.45mm on both sides.

Duct air from the left side air scoop to the carburetor, but don't attempt to pressurize the carburetor with this air as this would adversely affect the air/fuel ratio.

The original choke valve shaft holes in the carburetor air horn can be plugged by tapping them with a 1/4-28 tap and screwing bolts into them. Seal the threads with Loctite.

Intake Manifold

A number of different intake manifolds have been used on the X1/9 cars. The best stock manifold is the Fiat P/N 4425193. This manifold should be used as the engine is quite sensitive to the available intake flow area. Match the manifold to the enlarged intake ports in the modified cylinder head.

IGNITION SYSTEM

Several options are possible for the ignition system. The 1300 X1/9 engines have a conventional type ignition system with points and a standard coil. This system can be modified in several ways to improve its racing performance. The 1500 X1/9 has a Bosch electronic ignition system which works well up to about 7000 rpm. For higher rpm use, the electronics must be changed.

1300 Ignition System

The stock point-type Ducellier distributor is basically a good unit if it is in good condition. But a few changes are necessary for racing.

The vacuum retard unit should be disconnected for racing. However, if the vacuum retard diaphragm assembly is physically removed, the stationary point holder must be tack welded in place.

The stock coil should be replaced with a higher energy coil. If the replacement coil requires a series, primary resistor, this must be added since the Fiat system doesn't have one.

If desired, a high quality electronic ignition and a matched coil can be added to the system. Don't attempt to use a stock point-type Fiat coil with an electronic ignition. If an electric tachometer is used, check the compatibility of the electronic ignition and the tachometer.

The stock distributor has 14° of mechanical advance built in or 28° measured at the crankshaft. If the PBS modified production racing head and pistons are being used, the total advance required will be between 30° and 33° at the crank. Thus, a static advance of 2° to 5° should be about right. The actual advance curve is not critical for racing since the useable power curve is all above the rpm where full advance is reached. However, starting may be enhanced somewhat by restricting the total amount of advance in the distributor so that an initial static advance of 10° to 12° can be used while not exceeding the 30° to 33° at full speed.

Another approach which can be taken is to build a special distributor with no advance mechanism. This distributor can be fitted with two sets of ignition points which are timed 10° to 12° (crank) apart. Then the retarded set of points can be selected by a relay which is triggered from the starter switch. This way retarded timing is used to start and as soon as the starter button is released the ignition switches to full advance. The fixed mechanical advance distributor has a more stable timing pattern than the stock distributor, but this advantage is somewhat offset by the added electrical complexity plus the extra set of points required.

The stock radio suppression secondary (plug) wires should be replaced with high quality wire core leads.

1500 Ignition System

The stock Bosch magnetic-pick-up-type distributor has an excellent timing pattern but the electronics box with it is not suited for racing.

The stock Bosch distributor can be used without modification other than disconnecting the vacuum advance unit and restricting the total advance to enhance starting. This should be restricted to 10° total advance at the distributor by welding up the inboard advance weight stop. This allows a static timing setting of about 14° advance (crankshaft) for a total advance of 34° maximum at the crank.

The Bosch electronics limit the spark voltage at high rpm (above 7000 rpm). This is adequate for the stock engine but not for racing. PBS offers a replacement electronics unit which has been specifically matched to the Bosch distributor and coil. This unit works flawlessly to 10,000 rpm. The electronics package can be located in the spare tire well which will protect it from engine heat and be close to the distributor.

EXHAUST SYSTEM

Four branch tuned exhaust headers are necessary for either size X1/9 engine for racing. Exact dimensions don't seem to be extremely critical, but they should be large enough in diameter to minimize restriction and long enough to make the effective tuned length occur at a useable rpm. Primary pipes of 1-3/8 inches O.D. by about 26 inches long seem to work well. The collector size should be about

2 inches in diameter. This can be followed by a length of 2 inch pipe a couple of feet long.

TRANSMISSION, FINAL DRIVE, CLUTCH AND FLYWHEEL

The 1500 5-speed transmission is allowed on both the G- and F-production X1/9 cars. However, a great number of changes were made to the cars when the 5-speed was incorporated. This makes installing a 5-speed in an earlier car rather difficult. Regardless of whether the 5-speed or 4-speed transmission is used, the gear ratios, including the final drive ratio, must be optimized for racing. Some form of locked or limited-slip differential will improve cornering speeds in general. The clutch and flywheel must be modified to handle high-speed down-shifting as well as the extra power and abuse of the race car application.

Changes Associated With The 5-Speed Gearbox

There are numerous changes, besides the addition of a 5th gear, associated with the 1500 5-speed gearbox.

The gearbox has been lengthened with a cover over the extra gear set. This requires an indentation in the frame and one in the left rear suspension control arm for clearance.

The universal joints have been changed to identical constant velocity joints on each end of each half shaft. These bolt onto flanges, so the two half shafts and their C-V joints can be removed by taking out the 24 bolts (6 per C-V joint). This change requires a completely new final drive setup with new stub axles, bearings and seals. Also, the stub axles in the wheels have been changed and larger wheel bearings are incorporated.

The flywheel and clutch have been changed in order to use a larger diameter clutch disc. The ring gear on the flywheel has a larger pitch diameter, and a new starter is incorporated in a different location than on the earlier cars.

Inside the gearbox, reverse gear has been relocated and the shift mechanism has been changed to select the 5th speed.

From the above list of changes, it can readily be seen that adding the 5th gear to the 4-speed car is not a simple job. In fact, it is probably more trouble than it is worth for G-production racing. There are 5-speed conversions (such as Colotti) available from Italy, but these are not legal for G-production racing, since the rules specify the same transmission as is homologated for the F-production car.

Close Ratio Gears

Following is a list of available close ratios for the 4-speed and for the 5-speed transmission. Final drive ratios are also listed. More ratios will be added to the list as they become available.

GEAR RATIOS

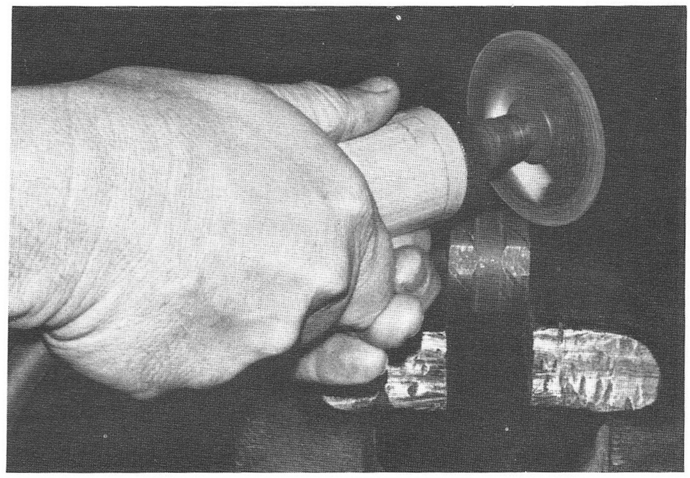
	4-SPEED	5-SPEED
1st	1.82	2.24
2nd	1.37	1.82
3rd	1.17	1.46
4th	1.00	1.17
5th		1.04

FINAL DRIVE RATIOS

4-SPEED	5-SPEED
4.077	4.077
4.417	4.417

Bearing Sleeves

For racing, the bearing sleeves on the driven gears must be modified to allow more oil to flow through the bearing. If this is not done, the gears have a tendency to sieze onto the bearing sleeves. This typically results in the transmission effectively locking in two gears at once. This modification is easily accomplished by cutting spiral grooves in the bearing surface with an abrasive disc.



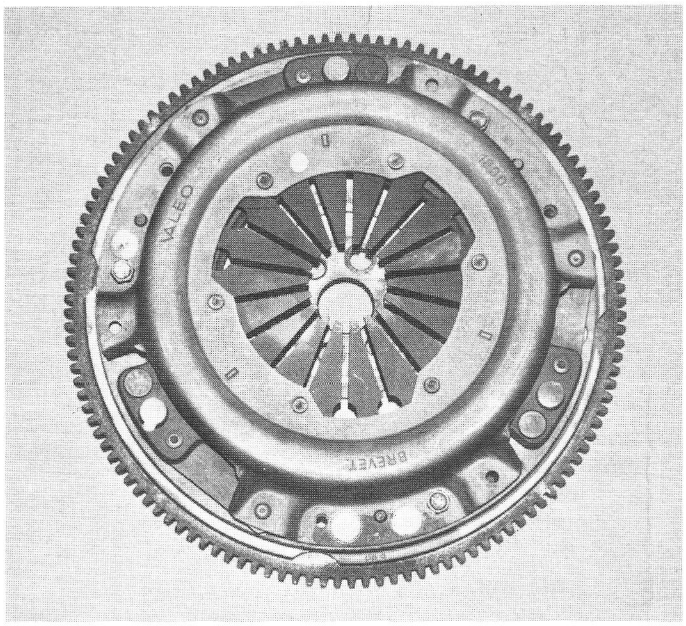
Modifying Transmission Bearing Sleeves For Oil Flow

Differential

The differential should be modified to prevent loss of traction during hard cornering. Either a limited-slip can be installed, or the differential can be locked completely, such as by welding.

Flywheel and Clutch

The flywheel and the clutch must be modified so that downshifting at high speed will not damage the clutch pressure plate. If this is not done, the reversed loads when the engine is used for braking (either intentionally or in-



Flywheel and Clutch Assembly

advertently) will buckle the drive straps on the pressure plate and cause a severe unbalance. This is immediately followed by the flywheel shearing off the flywheel attaching bolts.

The 1500 clutch pressure plate and flywheel, and the later 1300 pressure plates and flywheels as well, are not suitable for modification. An early X1/9 pressure plate (Fiat P/N 4309909) and a flywheel from a '74 X1/9 must be used on either the G- or F-production car.

The flywheel is modified by installing 3 large dowel pins. The pressure plate has 3 bosses which are drilled and reamed to fit over the 3 dowel pins. These pins provide drive torque in both directions and prevent the clutch drive straps from buckling under reverse loads.

The flywheel can be lightened by machining material away on the back side. Sufficient material must be left to provide adequate support for the large dowel pins.

The flywheel and pressure plate must be balanced after modifications are complete.

The 1500 flywheel ring gear must be used for the 1500 car (or any car which uses the 1500 5-speed transmission). This ring gear has the same I.D. as the 1300 ring gear and can be fitted on the 1300 flywheel.

A sintered metallic clutch disc is recommended for racing. This and the modified flywheel and pressure plate are all available as an assembly from PBS.

1500 C-V Joints

On the 1500 X1/9, the bolt arrangement for the axle C-V joints must be modified to prevent loosening under racing stresses.

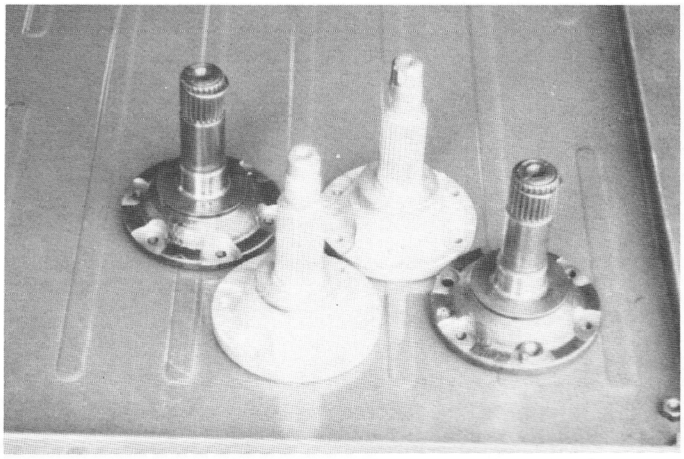
The threaded holes must be drilled out, in the companion flanges, to the body size of the bolts (5/16 inch). The companion flanges are then spot faced on the back side.

Assemble the outside stub axles to the C-V joints using 5/16-24 bolts 2.17 inches long. Use aircraft quality bolts and lock nuts. The nuts must be on the inboard side of the outer C-V joint. This assembly is done with the axles out of the car.

Insert 5/16-24 aircraft bolts 2.06 inches long through the inboard stub axles with the heads toward the inboard side. Insert the stub axles into the final drive.

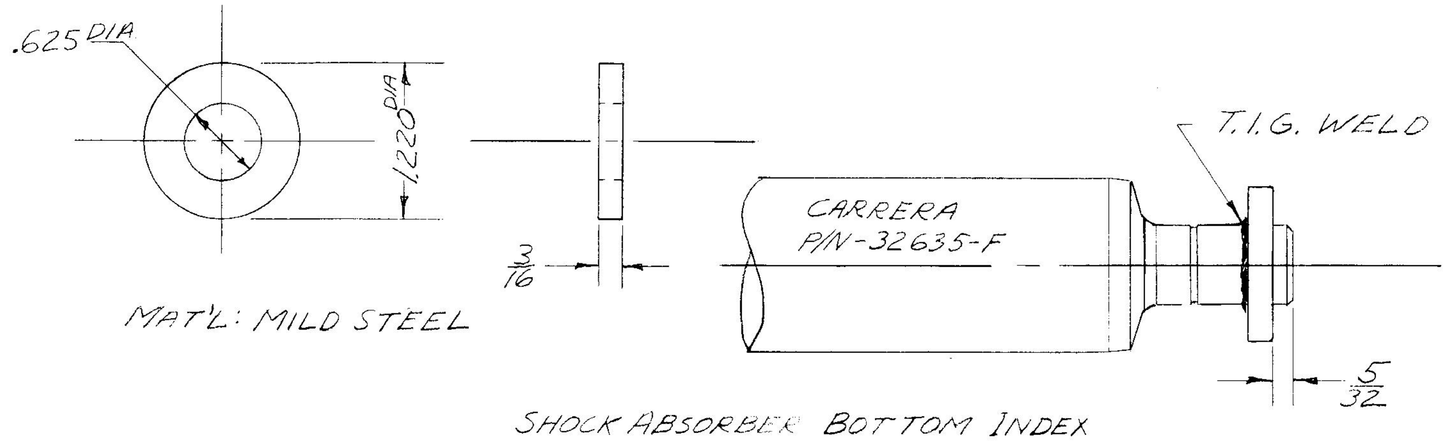
Remove the two bolts which attach the strut to the rear hub carrier and rotate the hub carrier outward about the lower ball joint. Insert the outer stub axle and half shaft assembly into the hub carrier.

Slip the inboard C-V joint onto the bolts, previously installed in the inboard stub axles, while the hub carrier is rotated back to its normal position. Assemble lock nuts onto the inner bolts. Replace the bolts which fasten the struts to the hub carriers.

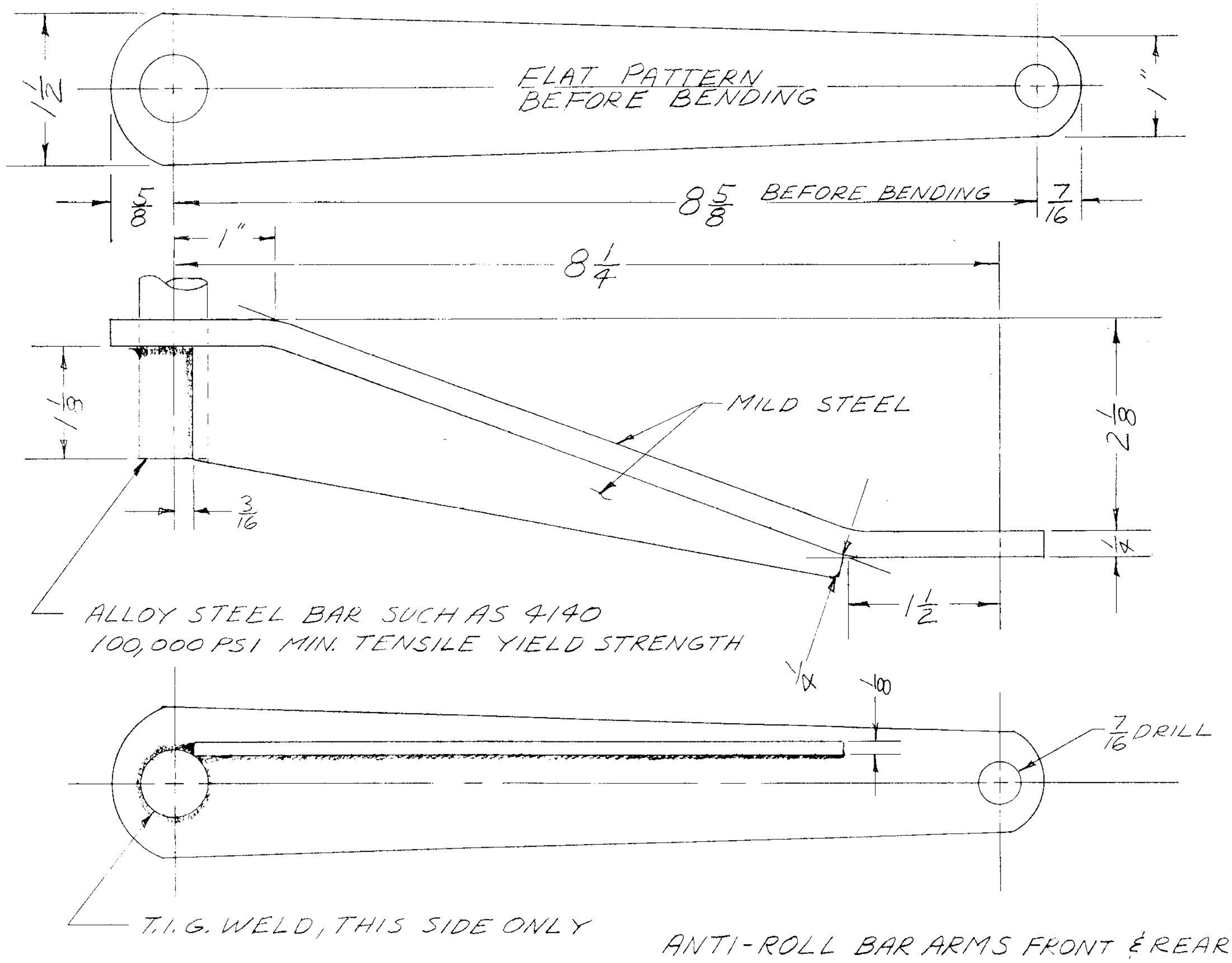


Modified Axle Flanges

DRAWINGS

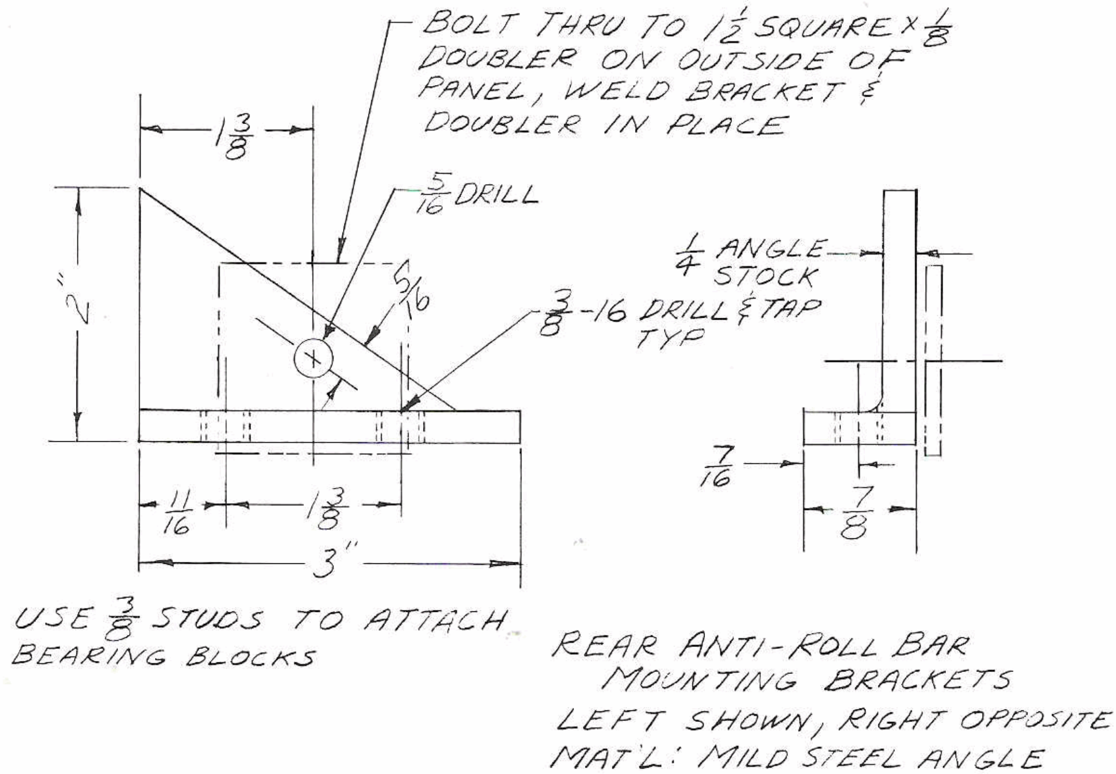


DRAWING 1

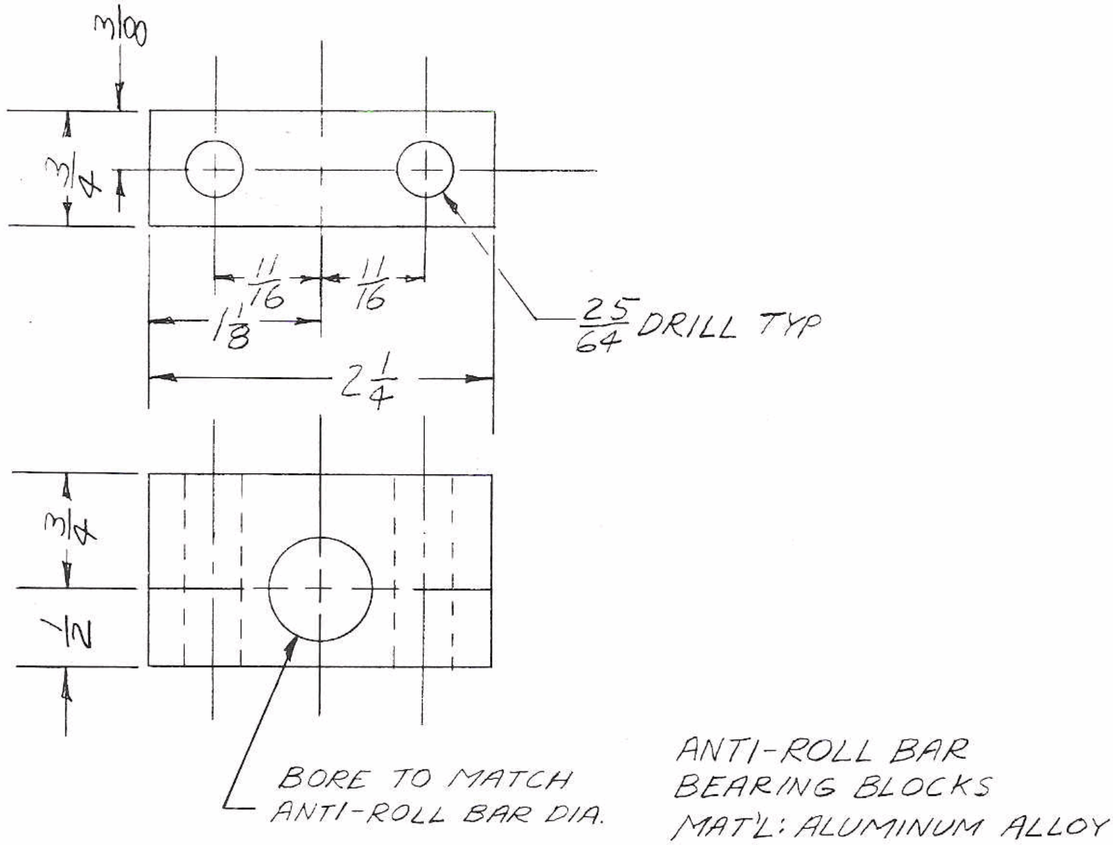


DRAWING 2

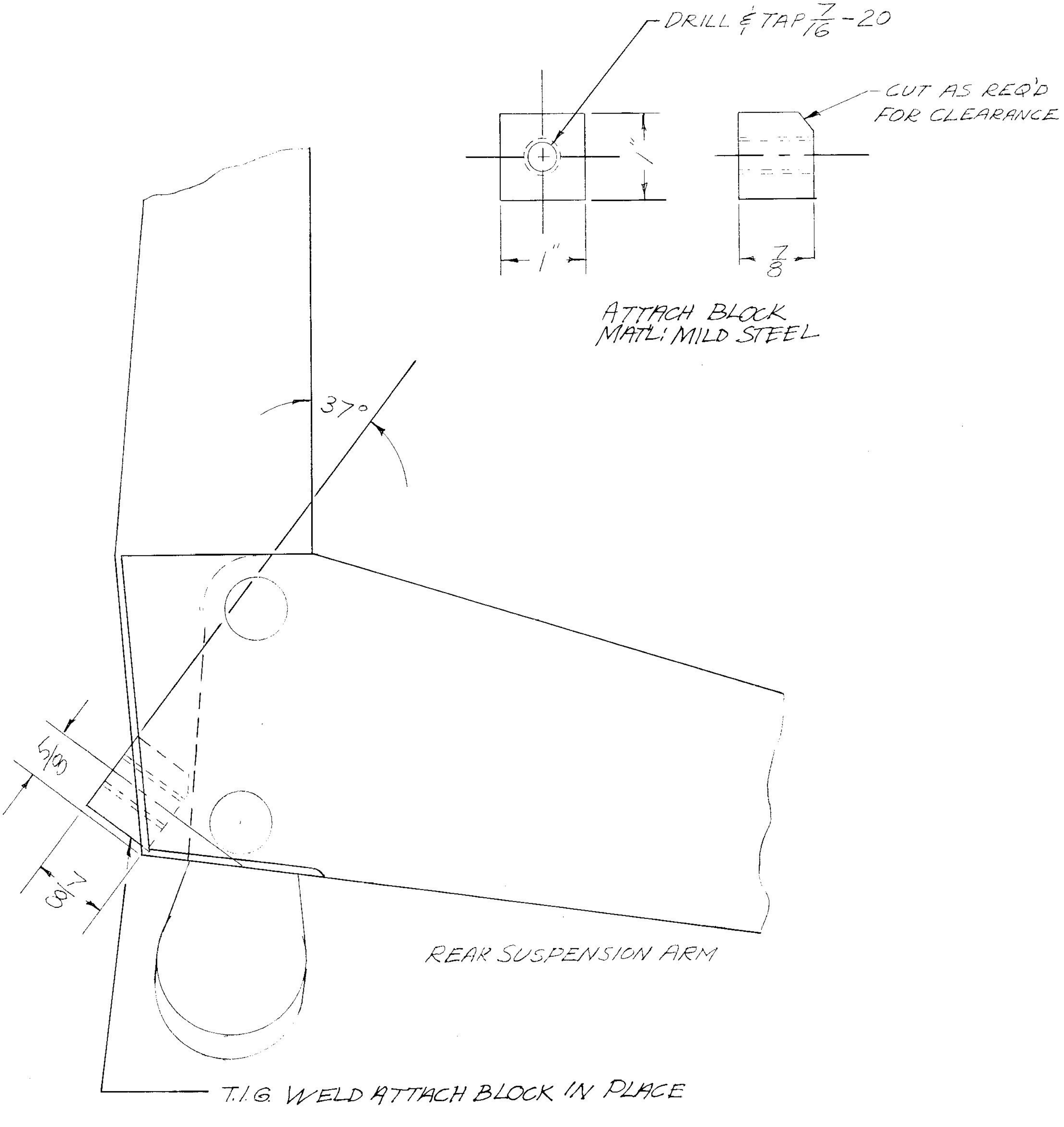
Drawings by C. F. Adams



DRAWING 3

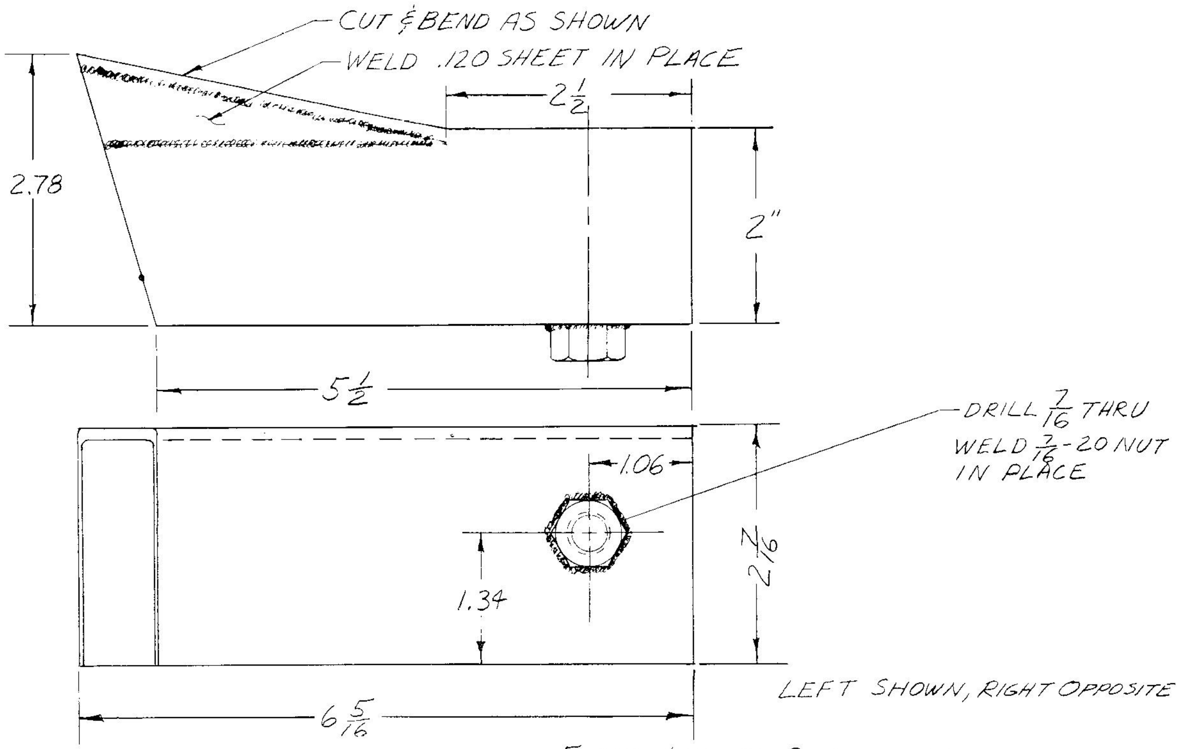


DRAWING 4

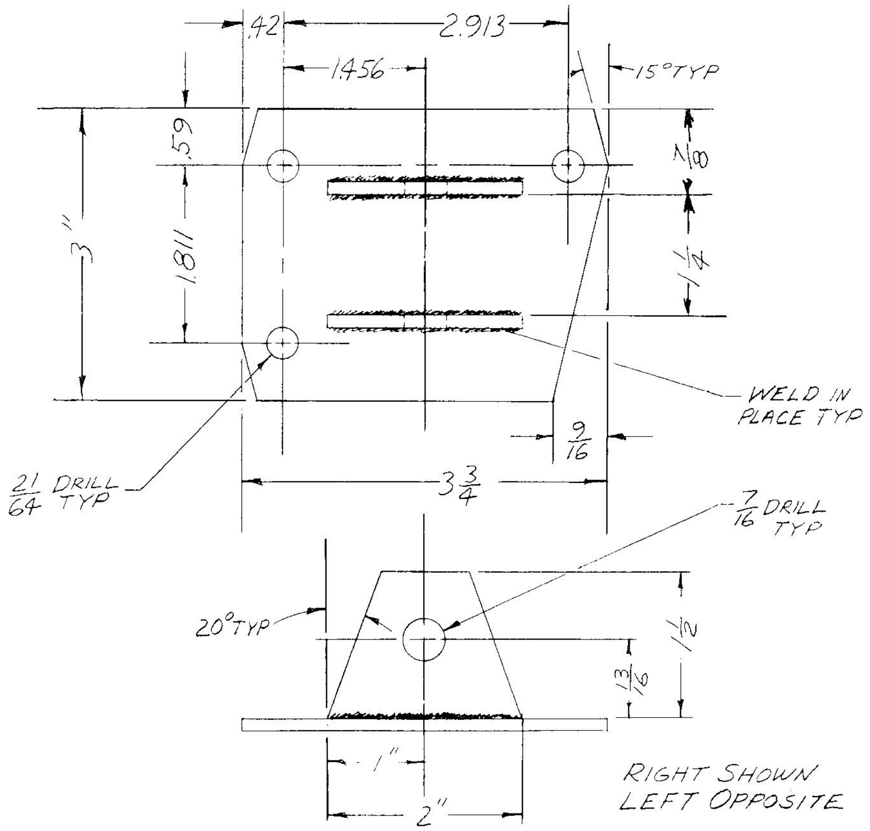


REAR SUSPENSION ANTI-ROLL BAR ATTACHMENT
RIGHT SHOWN, LEFT OPPOSITE

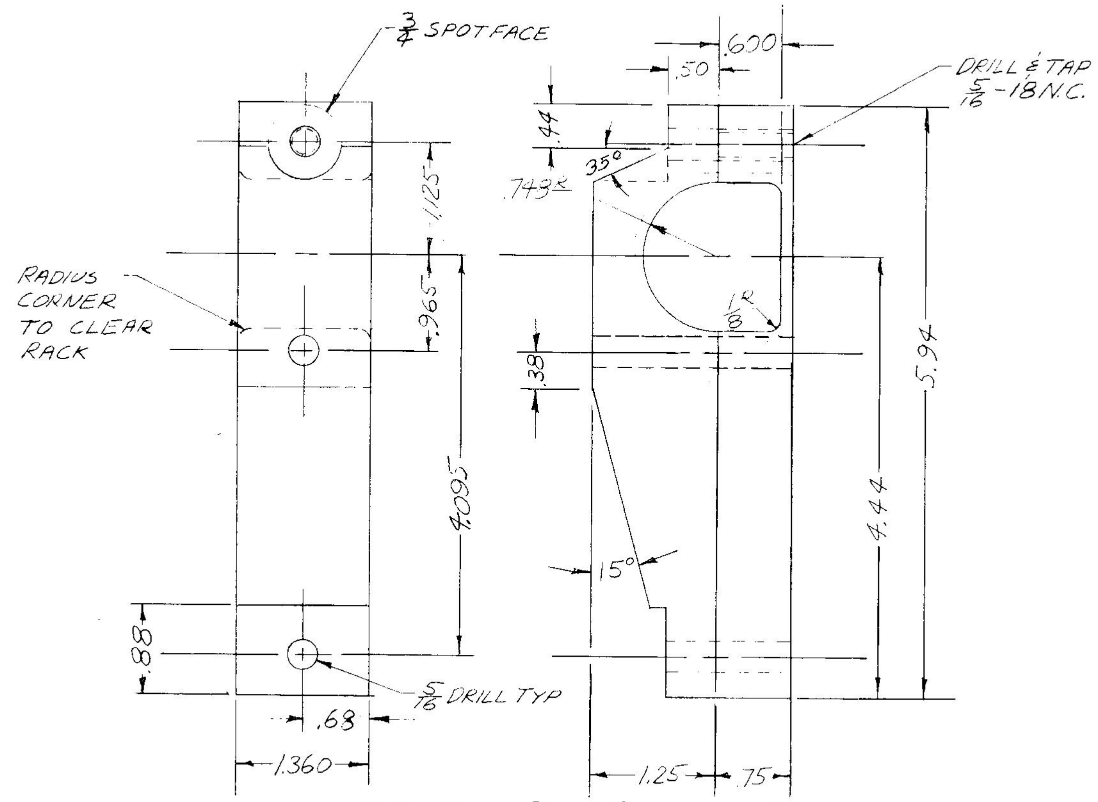
DRAWING 5



DRAWING 6 FRONT INBOARD SUSPENSION BRACKETS
MAT'L: 2X3X.120 WALL MILD STEEL TUBE

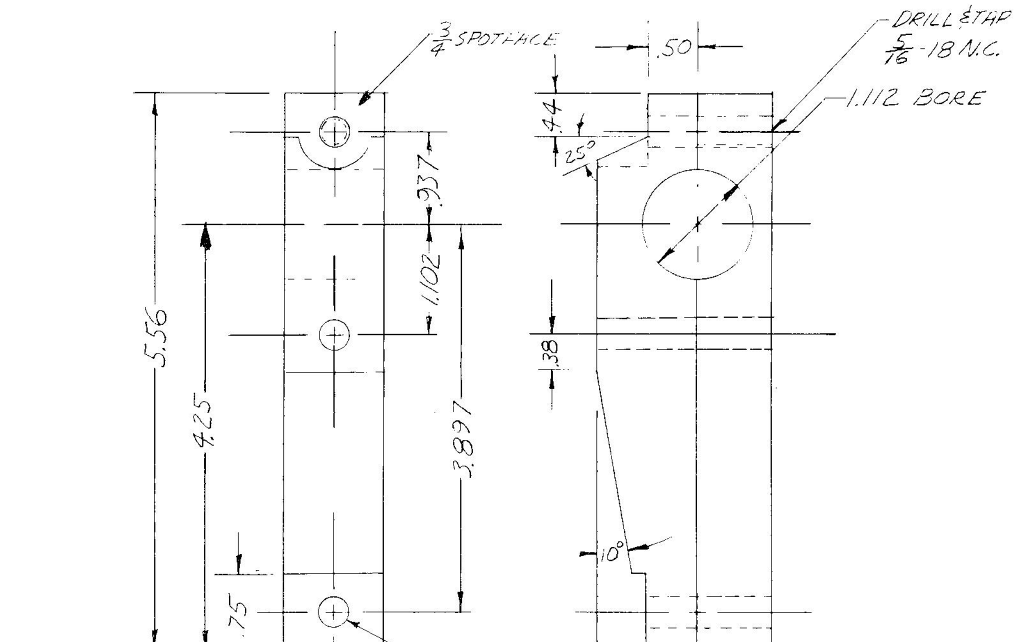


DRAWING 7 FRONT TRAILING LINK BRACKETS
MAT'L: 1/8" MILD STEEL



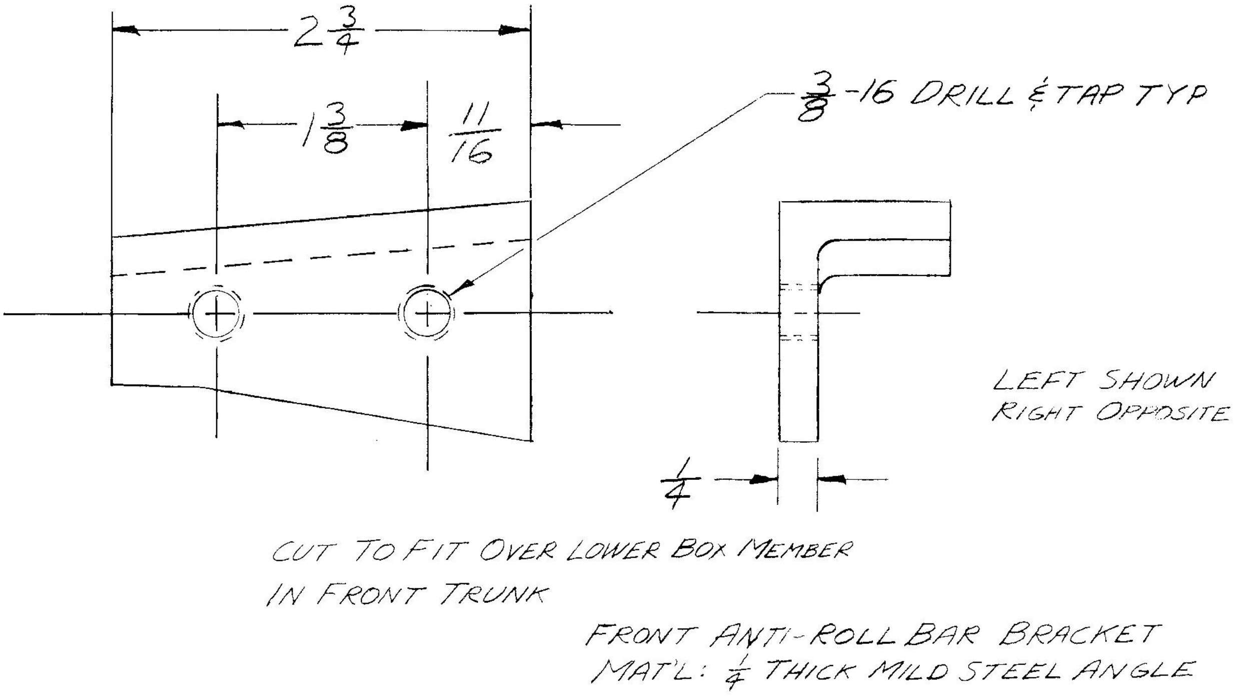
STEERING RACK BRACKET, LEFT
MAT'L: 6061-T6 ALUMINUM

DRAWING 8

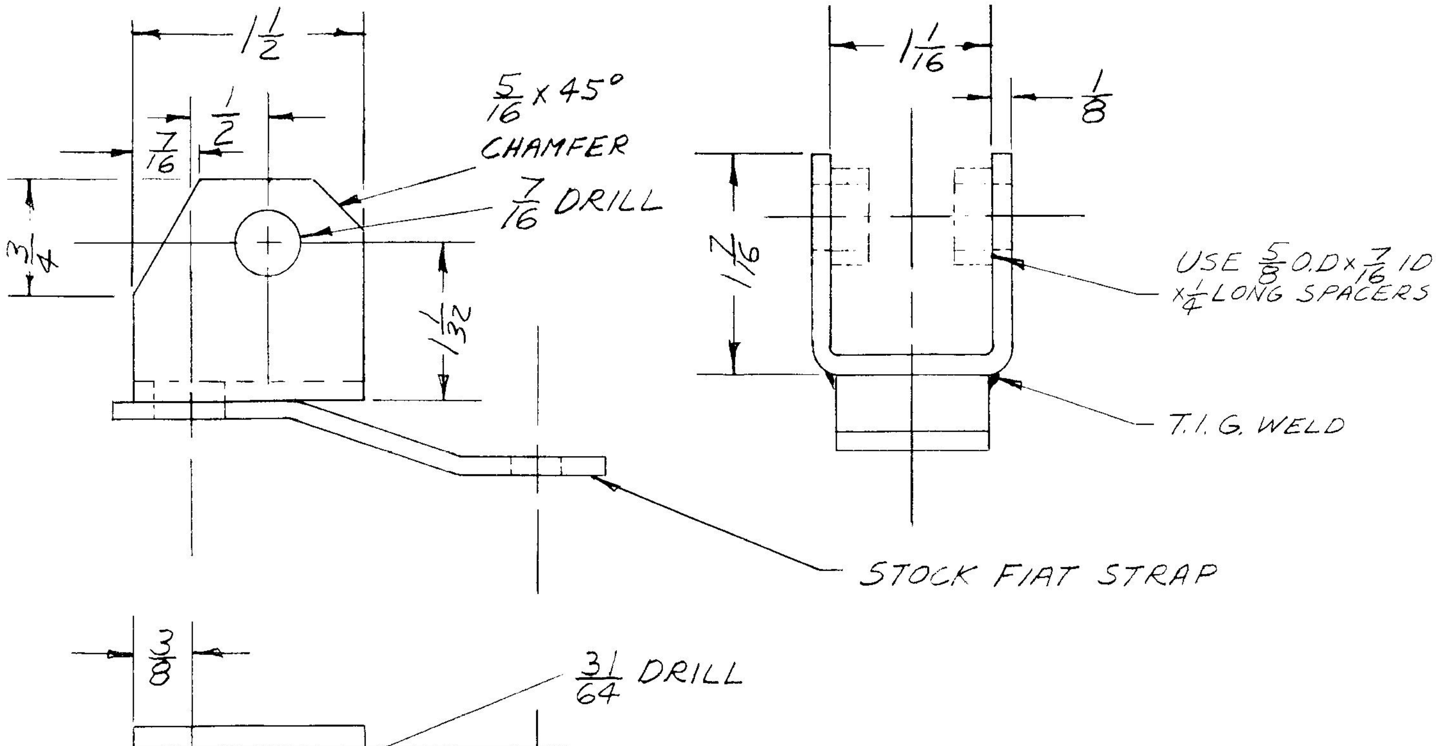


STEERING RACK BRACKET, RIGHT
MAT'L: 6061-T6 ALUMINUM

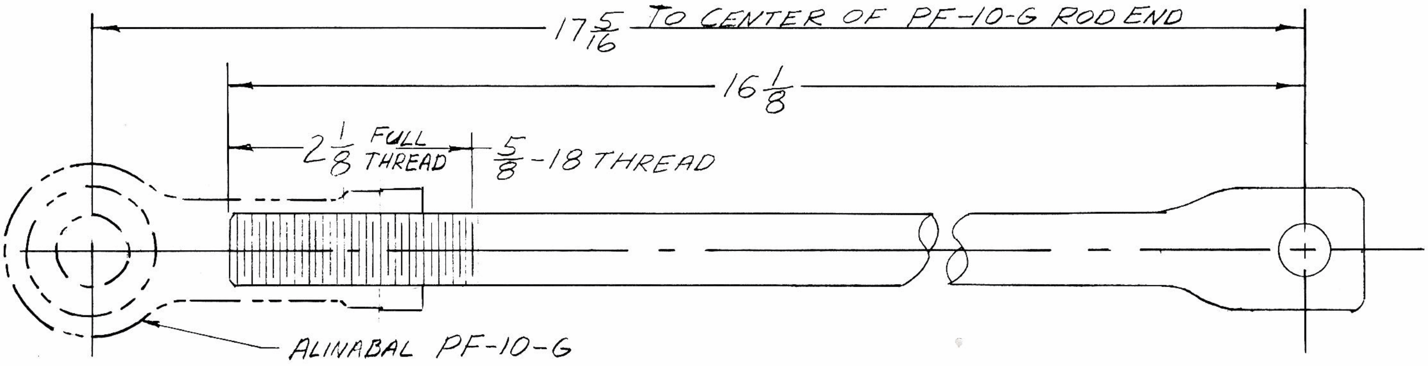
DRAWING 9



DRAWING 10

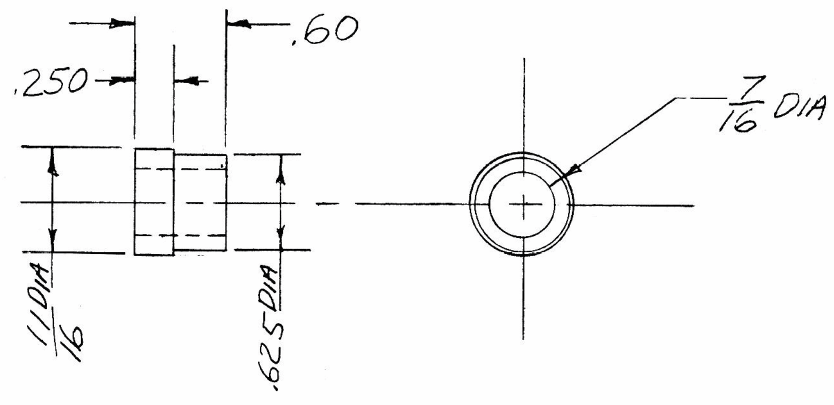


DRAWING 11



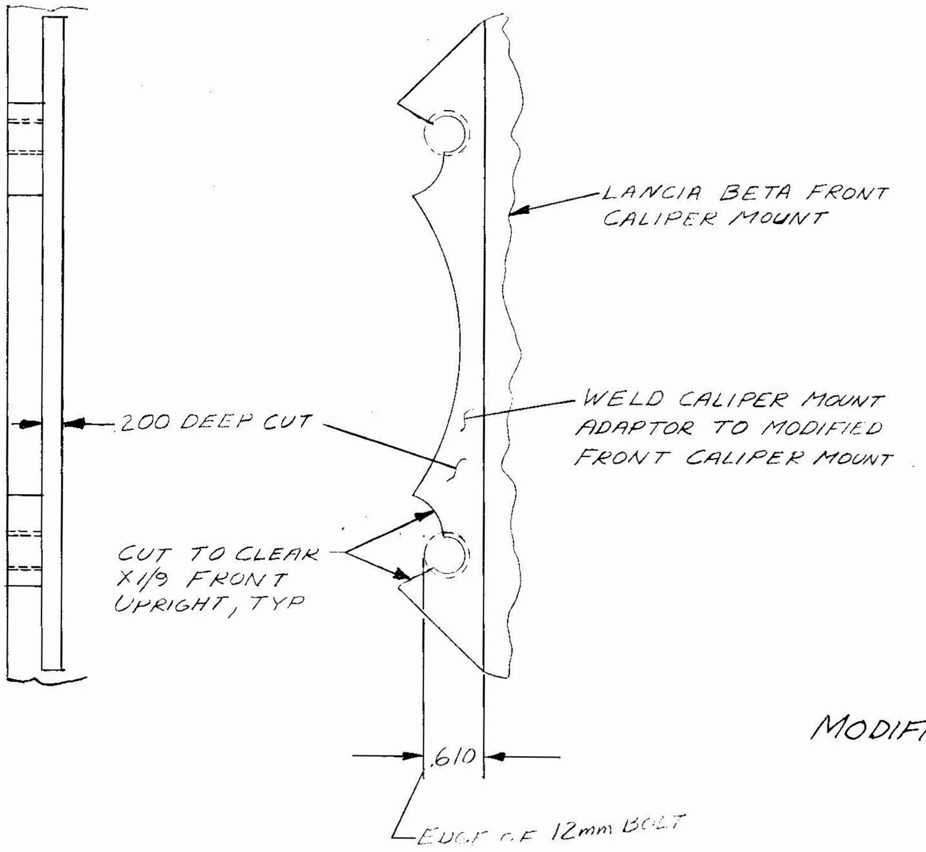
FRONT TRAILING LINK MODIFICATION

DRAWING 12



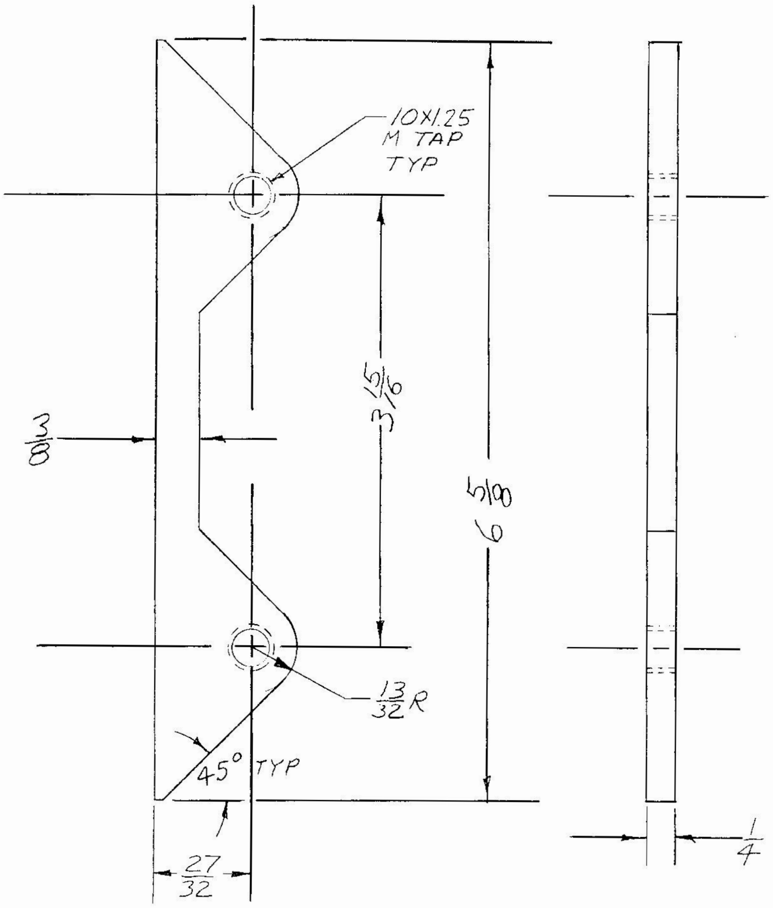
FRONT TRAILING LINK SPACERS
MAT'L: 11/16 O.D. x .125 WALL MILD STEEL TUBE

DRAWING 13



MODIFIED FRONT CALIPER MOUNT

DRAWING 14

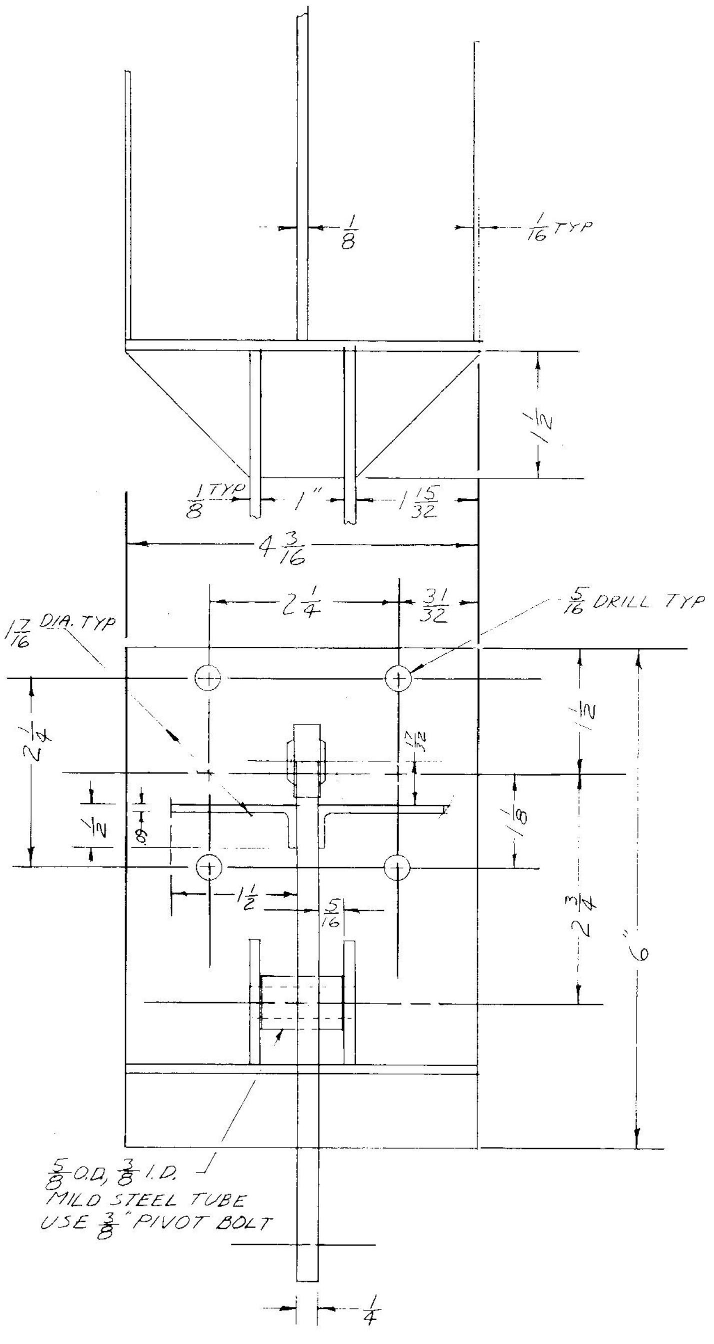


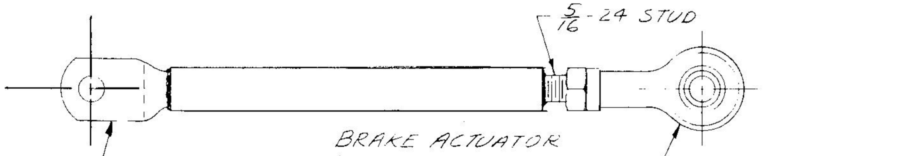
FRONT CALIPER MOUNT ADAPTOR
MAT'L: 1/4" MILD STEEL PLATE

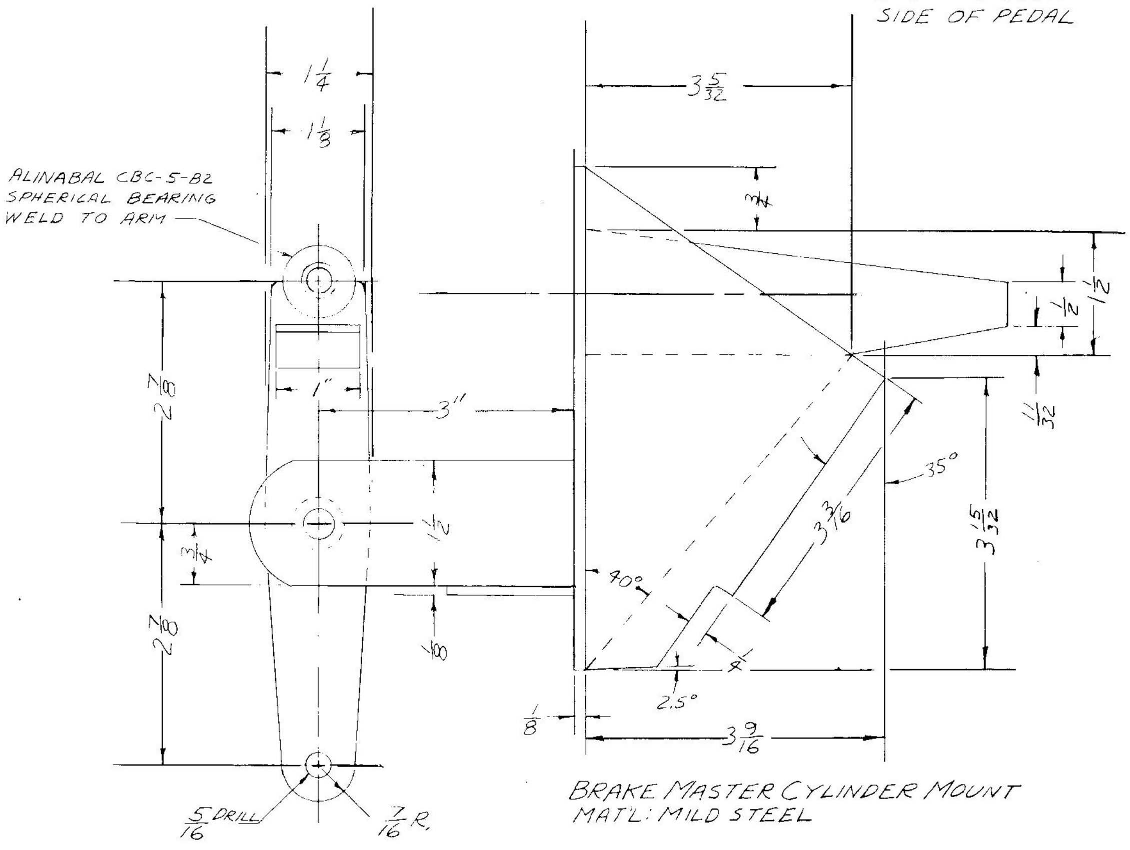
DRAWING 15

NOTES:

1) USE TWO GIRLING P/N 64067801 MASTER CYLINDERS
2) FIT TWO ALINABAL PF-5-G ROD ENDS ON MASTER CYL. PUSH RODS
3) USE $\frac{5}{16}$ BOLT FOR BALANCE BAR, CHANGE SPACER LENGTHS BETWEEN MASTER CYLINDER ROD ENDS AND ROCKER ARM BEARING TO ADJUST FOR OPTIMUM FRONT TO REAR BALANCE
4) WELD ASSEMBLY TOGETHER AND INTO CAR
5) ADJUST MOUNTING INTERFACE AS REQUIRED TO FIT CAR

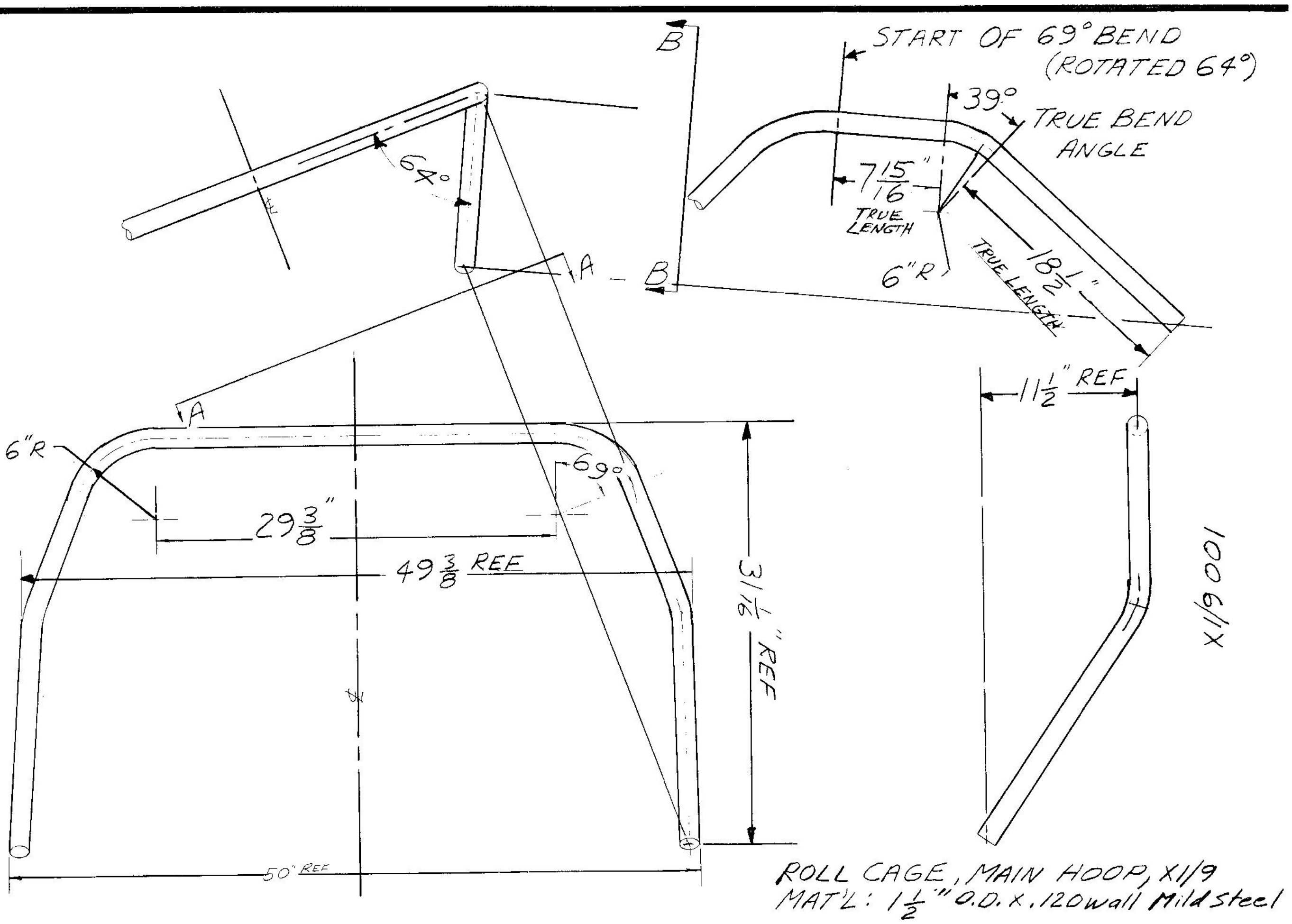




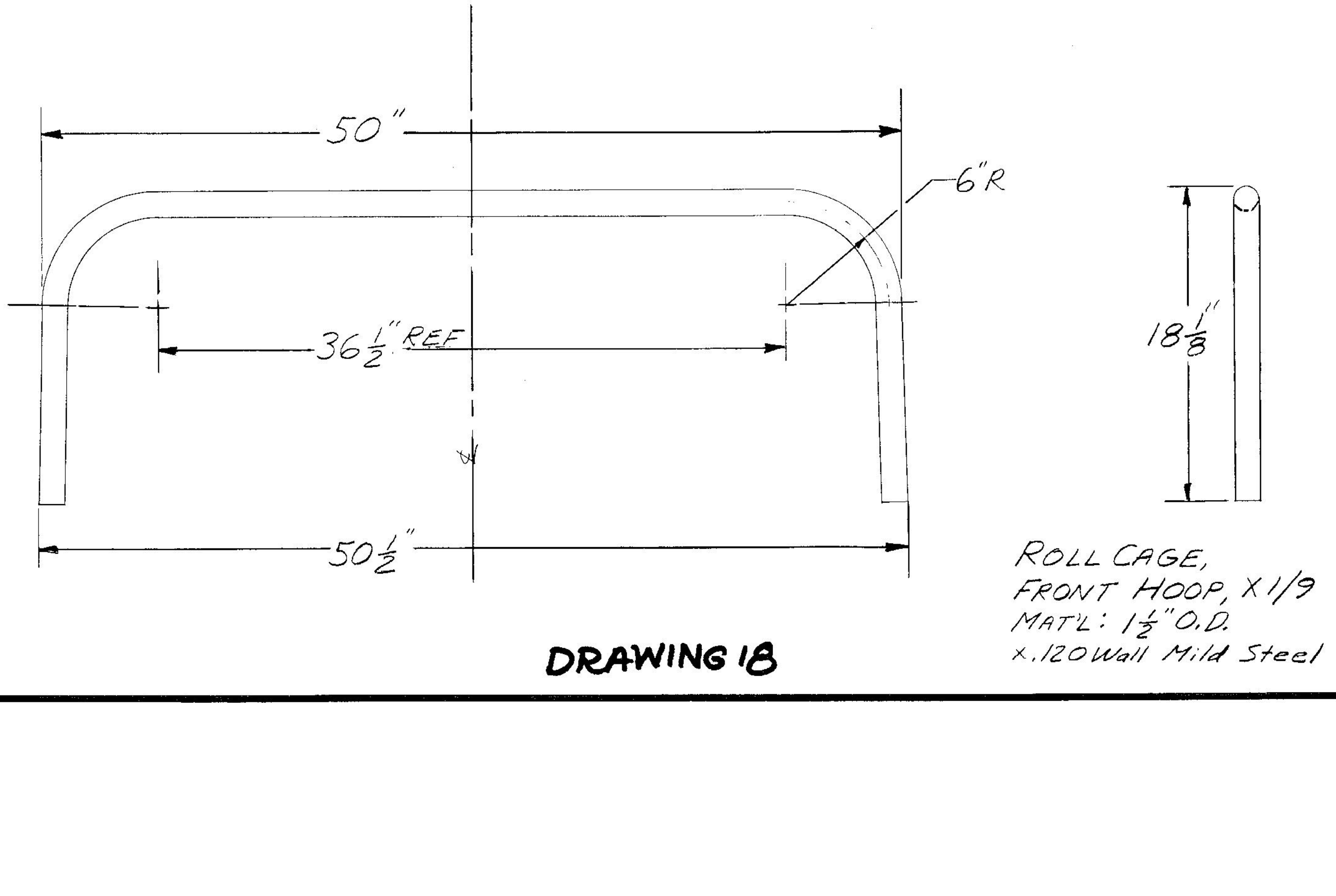


BRAKE MASTER CYLINDER MOUNT
MAT'L: MILD STEEL

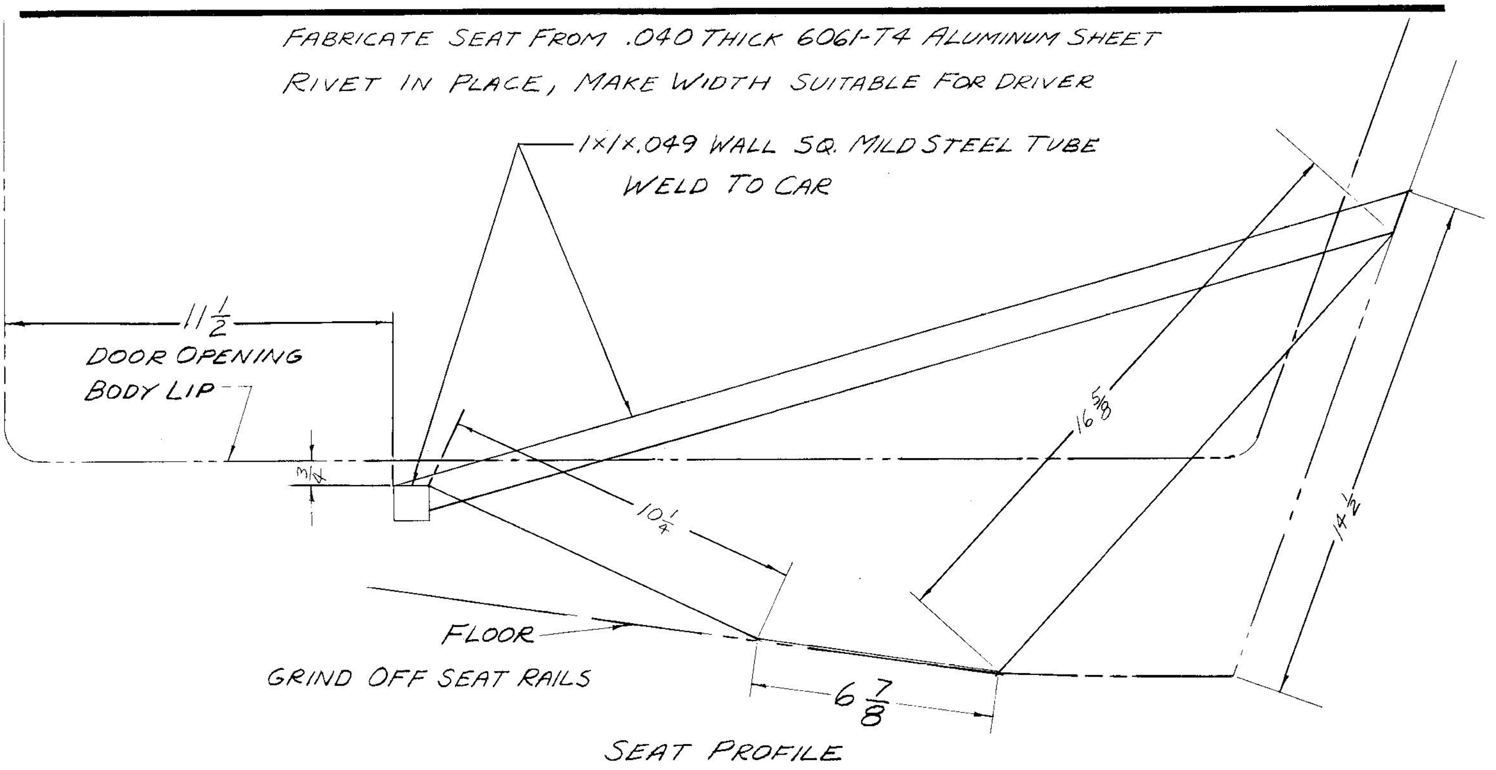
DRAWING 16



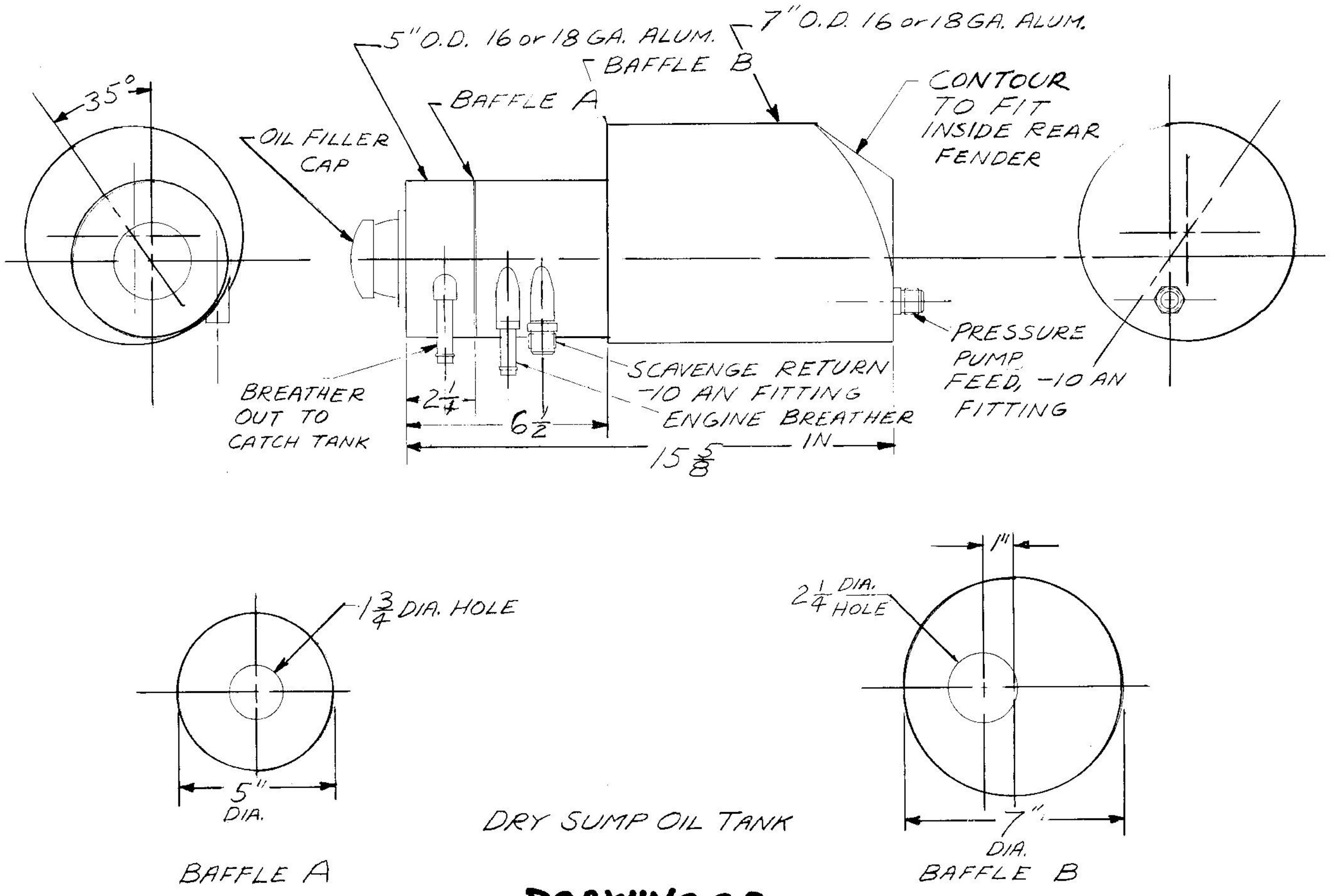
DRAWING 17



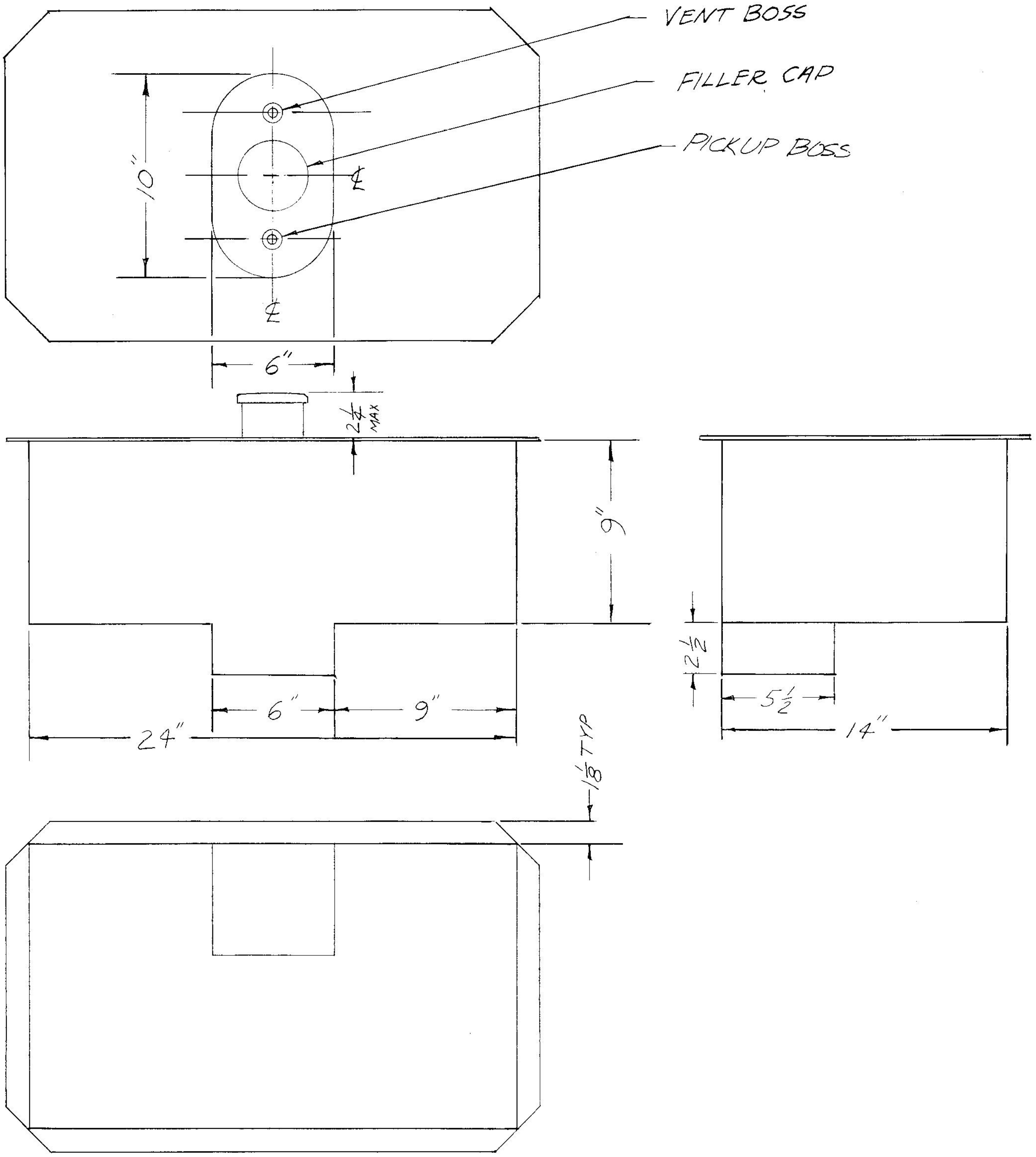
DRAWING 18



DRAWING 19



DRAWING 20



FUEL CELL OUTLINE

DRAWING 21

PARTS LIST

1. LANCIA FRONT BRAKE KIT
   a. Modified caliper bracket (2) P/N 82313845 LF, 82313846 RF
   b. Modified Lancia rotor (2) P/N 82287786
   c. Modified 3/16 spacer (2)
   d. Alum.(79) X1/9 caliper (2) right and left
   e. Lancia brake pads and retainers P/N 82315602
   f. Flex lines and fittings
   g. Instruction sheet
2. ADJUSTABLE CAMBER PLATE AND COIL OVER STRUT KIT
   a. (2) each Carrera 1875HF adjustable camber plate kits (front and rear)
   b. (4) each Carrera 10-220 springs
   c. (4) each 1974F coil over conversion kits
   d. (2) each modified front strut housings (exchange)
   e. (2) each modified rear strut housings (exchange)
   f. (4) each Carrera 32635 shock inserts
   g. Instruction sheet
3. SPECIAL RADIATOR
4. FENDER FLARE KIT
5. FRONT SWAY BAR KIT
   a. Bar (13/16 diameter)
   b. Arms
   c. (2) male and (2) female rod ends and jam nuts (7/16")
   d. (2) lower pick-up brackets
   e. Body mounting brackets, pillow blocks, studs and nuts
   f. Instruction sheet
6. REAR SWAY BAR KIT
   a. 5/8 bar with both ends welded on
   b. (2) male and (2) female rod ends and jam nuts
   c. (2) lower pick-up blocks
   d. Body mounting brackets, pillow blocks, studs, bolts and nuts
   e. Instruction sheet
7. FRONT TRAILING LINK ROD END KIT
   a. (2) modified trailing links (threaded 5/8)
   b. (2) 5/8 female rod ends P/N PF-10G
   c. (2) pick-up brackets (right and left) with spacers
   d. Instruction sheet
8. FRONT TRANSVERSE ARM SPHERICAL BEARING KIT
   a. (2) modified transverse arms with spherical bearings installed
   b. Spacers
   c. New arms or modify customer's; no exchange
9. FRONT INBOARD PICK-UP BRACKET AND STEERING RACK MOD KIT
   a. (2) inboard front suspension pick-ups (right and left)
   b. Miscellaneous sheet pieces to box in pick-ups
   c. (2) steering rack mounting brackets (right and left)
   d. Mod steering rack; no exchange
   e. Instruction sheet
10. MECHANICAL TACH DRIVE KIT
    a. Modified cam end cover
    b. Cable drive adaptor for end of cam
11. REAR SUSPENSION SPHERICAL BEARING KIT
    a. Modified 1/2" spherical bearings (4 each)
    b. 3/4 O.D. x 1/2 I.D. spacers (8 each)
    c. Step washers (4 each)
    d. Flat washers (8 each)
    e. 1/2" bolts and nuts (4 each)
    f. Instruction sheet
    g. Customer part modifed only—arm Number L 4343538, R 4343539
12. BRAKE MASTER CYLINDER KIT
    a. (2) Girling master cylinders
    b. Mounting bracket and bell crank
    c. (2) 5/16 rod ends for cylinder push rods
    d. Pedal push rod with clevis and rod end
    e. Instruction sheet
13. COMPLETE DRY SUMP KIT
    a. Two stage pump
    b. Oil control baffle
    c. Dry sump pan
    d. Dry sump tank
    e. Remote filter block
    f. Oil cooler
    g. Oil pump bracket, adjusting link, sprockets, belt and block inlet fitting
    h. Scavenge inline filter

i. AN lines and fittings
j. Instruction sheet

14A. 5-SPEED KIT FOR EARLY CAR
(Less transmission, special order only)
a. Special half shafts
b. 1500 ring gear P/N 4384195
c. 1500 starter P/N 4392459
d. Instruction sheet
e. Modified rear arm (no exchange, modified customer part)

14B. STOCK FIAT PARTS KIT FOR CONVERSION OF '74-'78 X1/9 TO 5-SPEED TRANSMISSION

Qty.	*Part Number*	*Description*
1	4428990	transmission
1	4381308	sheet metal spacer
1	4412832	clutch slave cylinder
1	4404472	half shaft right axle
1	4395940	half shaft left axle
2	4311711	stub shaft
1	4377787	left rear arm
1	4343536	left rear upright
1	4343535	right rear upright
2	4314976	
2	4318965	
2	4311721	
2	4352900	outer wheel bearing and
2	4314976	flange hardware
2	4314976	
2	4352899	
2	4307324	
2	4307325	
1	4384195	ring gear
1	4392459	starter

15. WHEEL MOUNTING HUB KIT
a. (4) hubs with studs installed (specify 98mm or 4 inch B.C.), modify customer's hubs

16. FUEL CELL MOUNTING KIT (Special order)

17. ROLL CAGE KIT (Special order)
a. Front hoop
b. Main hoop
c. Straight tubing
d. Angle mounting plates and diagonal flat plate
e. Instruction sheet

18. FIRE SUPPRESSION SYSTEM

19. IGNITION KIT
a. Modified distributor (breakerless ignition) (Exchange)
b. Electronic ignition module (breakerless) P/N MIDI-MP
c. Modified distributor, point type (exchange)
d. Ignition coil and ballast resistor for point type ignition
e. Electronic ignition module, point type P/N MIDI-DX
f. Silicone wires with fittings

20. CLOSE RATIO GEAR KIT, 4-SPEED OR 5-SPEED

21. LIMITED SLIP UNIT
a. 4-speed special order
b. 5-speed special order
c. Weld customer's differential solid

PBS ENGINEERING (714) 534-6700
BOX 667 11602 ANABEL STREET
GARDEN GROVE, CALIFORNIA 92643

FIAT X1/9 COMPETITION KIT PRICES

1.	Lancia Brakes	
	Complete Kit	$ 525.00
2.	Carrera Shock Absorber	
	Complete Kit	$1,040.00
	(Requires Strut Housings to Modify)	
3.	Racing Radiator	$ 175.00
4.	Fender Flare Kit	$ 160.00
	($45.00 corner)	
5.	Front Sway Bar Kit	$ 168.00
6.	Rear Sway Bar Kit	$ 168.00
7.	Front Trailing Link	$ 180.00 outright
8.	Front Transverse Arm Kit	$ 120.00 modified
9.	Front Inboard Kit and	$ 226.00 outright
	Steering Rack Modifications	$ 160.00 modified
10.	Mechanical Tach Drive Kit	$ 45.00
11.	Rear Suspension Spherical Bearing Kit	$ 100.00
12.	Brake Master Cylinder Kit	$ 150.00 plus modified cylinders
13.	Dry Sump Kit	
	Pump	$ 325.00
	Hardware, Mounting	$ 115.00
	Dry Sump Pan	$ 175.00
	Oil Control Baffle	$ 95.00
	Remote Filter Block	$ 9.95
	Scavenge Line Filter	$ 30.00
	Hoses and Fittings	A/R
14.	5-Speed Kit for 1974-78 X1/9	Special order only
14A.	Order Only	
15.	Wheel Mounting Hub Kit	$ 20.00 each
16.	Fuel Cell	Special order only
17.	Roll Cage Kit	Special order only
18.	Fire Suppression System	Order only
19.	Ignition Kit Parts	
	A.	$ 35.00
	B.	$ 74.00
	C.	$ 35.00
	D.	$ 25.00
	E.	$ 74.00
	F.	$ 20.00
20.	Transmission Ratios	$ 110.00 per ratio
21.	Limited Slip—4- and 5-Speed	Special order only
	Weld Differential	$ 20.00