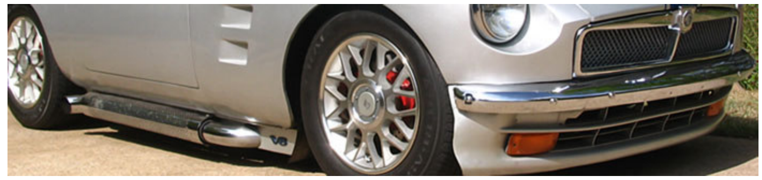

'80 MGB with Rover 4.0L V8 (owner: Mike Cook)

The British V8 Newsletter - Current Issue - Table of Contents

British V8 Newsletter January - April 2007 (Volume 15, Issue 1) — 175 pages, 494 photos

the editor's car

In The Driver's Seat (Volume XV Issue 1, April 2007)

by: Curtis Jacobson

Welcome readers! Welcome car enthusiasts, tinkerers, inventors, and hot-rodders! Whether you're an old-timer around here, or new to our newsletter and our rapidly growing branch of the old car hobby, I'm hopeful and confident you'll find both entertainment and useful information in this publication.

How did you spend your winter? When you weren't turning wrenches, did you catch any good car movies? Several movies I enjoyed this winter seem to echo the content of this newsletter issue.

I don't know if there's ever been a better car movie than "Grand Prix" (1966)! It's especially awesome in the new two-disc DVD special edition. Keep control of the remote so you can freeze-frame on construction details... it's almost as good as actually spending "A Day At The Races", as Greg Myer discusses in his column.

Note: "Grand Prix" is a special favorite among our crowd for a couple reasons. MGB V8 pioneer Ken Costello was one of the drivers employed in creating its groundbreaking footage. Also, if the Brabham cars shown in the film were perfectly authentic they'd have our favorite aluminum V8 engine block, the Buick/Olds 215. It won the championship that year.

You should also check out "Le Mans" (1971). I really enjoyed seeing the streamlined endurance racers. While you ponder them, you might find yourself contemplating how you might streamline your own car. We've included a few ideas for you in "Practical Automotive Aerodynamics for MGB V6 and V8 Builders".

Are you a fan of "B" movies? Check out Roger Corman's "The Fast and the Furious" (1955)! Okay, the acting and dialogue are just plain bad... but the real stars are the cars. The protagonist is a Jaguar XK120 and the antagonist is a Jowett Jupiter. A Triumph TR2, some Allards, and some MG's appear too. (The movie has lots of little "continuity problems" - it's fun to watch just for that!) This movie also provides a lot of footage of mid-fifties California road racing. The California racing culture inspired a young Tom Schnerk to put a 1949 big block Oldsmobile engine in his 1954 Healey. Tom Schnerk's "How It Was Done" article describes the earliest engine swap to appear so far in The British V8 Newsletter. It was completed FIFTY years ago this June!

To survive and thrive another fifty years our hobby needs to be shared with kids. I recently had the pleasure of viewing "Chitty Chitty Bang Bang" (1968). It's aged MUCH better than I expected. For maximum enjoyment, I recommend viewing it with a six year old. The movie starts with surprisingly cool recreated race footage of the 1907 through 1909 Grand Prix seasons! According to the credits, the vintage race cars were provided by The Henry Ford Museum.

Note: Chitty Chitty Bang Bang was written by Ian Fleming (of James Bond fame) for his son. Go figure!

Of course the star and title role of Chitty Chitty Bang Bang is a lovingly rehabilitated old racecar that transforms itself into a speed boat, an airplane, and a helicopter. It also navigates and drives itself. You know what? Given a couple more years I think Jim Blackwood's car may equal these marvels. Like inventor Caractacus Potts, Jim also started with an old race car. You'll want to read "The Story of One Ultra Radical V8 MGB" to learn more about the transformation.

This new issue contains more of everything: more articles, more top-quality color photography, more "shop tech" advice, more writers representing more perspectives, and more of our extremely popular "How It Was Done" articles. We've got an especially broad spectrum of cars this time too, including our very first Lotus, a 9.65 second MGA, a unique V8 Spitfire, and another MGA with suicide doors. In fact, all the cars in this issue are exceptional - don't miss any of them!

The British V8 newsletter and website are a volunteer effort. They represent the work of many people. I want to take a moment to recognize and thank all the folks who've contributed articles, photos, and information. Returning readers will probably recognize some familiar names including Jim Blackwood, Martyn Harvey, Greg Myer, Jeff Schlemmer, and Larry Shimp. I also want to thank brand-new writers Joe Schafer and Bill Young, plus all the folks who've contributed "How It Was Done" write-ups.

Now it's your turn. Click here to learn how easy it is to submit an article or photos.

I continue to be amazed by the generosity of readers. Since December we've been blessed with financial support from readers Jeb Blanchard, George Cooper, Steve DeGroat, Paul Fitzpatrick, Herb Gundy, Scott Harris, David Maples, Les Matthews, and Richard Morris. You guys are wonderful! Your contributions will be put to good use, expanding the depth and breadth of our coverage.

As editor, I'm committed to keeping the Newsletter FREE for all readers, but I still need money to invest in growth. Financial contributions will be very gratefully accepted. Click here to make a contribution.

Finally, I want to assure everyone that the next issue of The British V8 Newsletter will be even bigger and better than this one. How can I keep promising that? I know people JUST LIKE YOU have valuable ideas to contribute, and I know you're a generous bunch of people. Besides, we're coming up on another annual meet. Don't miss out on the fun - GET INVOLVED!

Very best regards,
Curtis Jacobson

Annual British V8 Meets:

NOW is the time for YOU to firm up your plans for attending the 2007 British V8 Meet! Your first two steps are:

(1) pre-register with event organizer Kurt Schley, and
(2) reserve your room at the Days Inn in Willoughby Ohio. (Phone 440-946-0500 and mention "British V8".)
Click here to download the British V8 2007 registration form!

Kurt Schley and his lovely fiancée Sue (CONGRATULATIONS!!!) are planning a full schedule:

Wed. Aug. 1st:	Plan to arrive, check-in, pick up registration forms, and socialize.
Thurs. Aug. 2nd:	Kurt has arranged our exclusive use of Nelson Ledges race track and Pete Mantell of Mantell Motorsport will be underwriting the track-time so we can all play for just $75-per-car! (Even if you don't care to drive the track, this will be a fun day for spectators and impromptu pit crews.)
Fri. Aug. 3rd:	We'll be autocrossing in the morning...
Sat. Aug. 4:	We'll be racing high-performance valve covers in the morning and weighing modified cars after lunch. We'll also have a banquet and auction in the evening.

Of course, one of the great highlights of British V8 Meets is the expert "tech sessions". Kurt has reserved seven hours in the schedule for tech sessions and is recruiting a team of experts to assure they're especially valuable and informative!

So far, at least eight vendors have confirmed plans to participate in the meet. Some will offer discounted merchandise.

Additionally, there'll be a plethora of diverse social activities (for example, a spa outing is being planned by some of the ladies...) There will be vineyard tours and spirited country drives - British V8 meets are great fun for couples! - plus free time is being left for kicking tires and telling stories. Don't forget to bring your camera.

British V8 2008 is also now being planned by volunteers Paul & Mary Schils! The meet is scheduled for July 12-16.
A host hotel has not been named yet, but the event will be held near Elkhart Lake in the beautiful southeastern corner of Wisconsin, near the Road America race track. The "International Vintage Race" will be held immediately after our meet. If you can spare the full week you should certainly plan to stay over. We also anticipate enjoying spirited drives near The Kettle Moraine Glacier Area and a visit to the Experimental Aircraft Association's museum in Oshkosh. I'm looking forward to cheese, beer and bratwurst... and especially a traditional Wisconsin "Fish Boil".

Notice: ALL fans of modified British sports cars are welcome and encouraged to participate in our meets. Don't let our old "V8" name discourage you! We're happy that our participants and their cars are increasingly diverse. The meets are especially recommended for people who contemplating, planning, or engaged-in performance modifications of their cars.

Nifty New Website Features:

There's now a "Google" search box at the bottom of every page of the website. You can use it to search through almost 400 pages and articles. You can also search the broader internet by selecting "web" instead of "site". We're experimenting with Google-provided ads too. In a nutshell, the way they work is that we only get paid if readers "click" on them. Typically it's only a few pennies per click. If the ads interest you, by all means please click to get more information.

Please don't forget to support our advertisers - and thank them for sponsoring this FREE newsletter!
In fact, you should use British V8 sponsoring businesses exclusively whenever possible. These folks are the best.

We welcome sponsors that are new with this issue:

Glen Towery British Cars	24 years of engine conversion experience. Complete line of MGB-V8 components.
The Motorway Ltd., Fort Collins CO	restoration, customization, race preparation and performance.
The Sports Car Shop, Eugene OR	sales, service & restoration of fine British enthusiast automobiles.

And familiar companies that have renewed and increased their sponsorship:

Advanced Distributors, LLC	distributor rebuilding and re-curving for all vehicles.
All British Car Repair	MGA and MGB V8 conversions. Quality restorations and repairs.
Classic Conversions Engineering	MGB V6 specialists, including kits, plus MGB chassis upgrades.
Fast Cars Inc.	British sports car chassis and handling. Conversions, modifications and brakes.
Mantell Motorsport	Ford V8 engine conversions for MGB, plus powder coating.
Pieces of Eight!	struts to hold open the bonnet and the boot lid or GT hatch of your MGB.
Roadtronics Automotive Technologies Co.	(aka: "RATCO") Triumph frames & performance chassis upgrades.
Reborn Company LLC	Rover engine specialists. MGB V8 conversions and big brake kits.
Richland Motor Cars	turn-key aluminum V8 motor cars. Custom interior and electrical.

A complete list of sponsors can be found here: SPONSOR DIRECTORY
Are you in the British sports car performance trade? If so, you should be supporting the newsletter too!

Canadian Corner   (Volume XV Issue 1, April 2007)

by: Martyn Harvey

Shhhhhh...! Martyn's cars are still hibernating. His column will be back in the next issue. Maybe sooner.

"Banner Class" Example - Photo Submitted by Bob Elwin

Update: The British V8 Newsletter Photo Contest!

One benefit of moving The British V8 Newsletter online was to facilitate sharing colorful photos of the cars we love. If you poke around on this website you'll find about 3000 photos so far, and we add more almost every day. Cool! But frankly, in my humble opinion, two things could improve. Number 1: I'd really like to see more photos of PEOPLE HAVING FUN with their cars. Number 2: I could really use some help finding glamorous photos to keep the main pages of the website looking "fresh" for frequent visitors and to spice-up general-interest newsletter columns.

These two selfish desires are the impetus behind the two classes of our first-ever **British V8 Newsletter Photo Contest**! The rules will be simple, the judging will be arbitrary, the prizes will probably be almost non-existent... but there's still a big reward for participating: we'll all have some great photos to look at! Interested?

Here Are The Rules

"General" Class:

The theme for this class is "People Having Fun With Performance-Modified British Sports Cars." To be a winner or runner-up in this class, photos must include both people and cars. No exceptions. Second rule: it must be possible for a "reasonably knowledgeable enthusiast" to spot some detail of the car that's modified from "original". Either the people or the cars can be the emphasis of the photo. Points will be given for composition and craft... but also for how much fun the people are having and for how cool the performance mods are. Winners will be selected at the discretion of the judge or judges.

Most of the photos on our website are displayed 600 pixels wide by 450 pixels tall. The photographer needn't be concerned about this, but the judge or judges will be asked to give preference to photos that look good when re-sized or cropped to this size. (Please see the General Submission Guidelines.)

"General Class" Example - Photo Submitted by Bill Young

"Banner" Class:

The theme for this class is "Performance-Modified British Sports Cars." To be a winner or runner-up in this class, photos must show the modification in a glamorous way. Showing a badge, decal or painted logo that indicates or suggests the existence of a modification counts too. The photo doesn't need to contain people. Points will be given for the photographer's creativity, composition and craftsmanship. Winners will be selected at the discretion of the judge or judges.

Photos submitted for the Banner Class should look great when cropped or resized to 700 pixels wide by about 200 pixels tall. (See above for an example.) The photos may be cropped before submission, or the actual cropping may be left to the judge's imagination. (From my personal perspective, as editor and not as judge, the latter is actually preferable. Please see the General Submission Guidelines.)

General Submission Guidelines

You may submit your photos however is most convenient for you, including e-mail. Our contact information can always be found here: http://www.britishv8.org/British-V8-Contact-Info.htm If you're submitting the photos as digital files, then "the higher the resolution the better". If you submit the photos by physical mail, please indicate whether you want them returned. (It wouldn't hurt to include return postage.) You may submit however many photos you like. If you submit a photo that meets the criteria of both classes, it will be judged separately in both classes.

No matter how you submit your photos, we ask that you document them as follows:
a) Please specify your full name, how we should credit you, and how we may contact you.
(Include this with all submitted materials.)
b) Please only submit photos that you took yourself.
c) Please advise us the names of any people who appear in the photo, if you know their names.
d) Please advise us the owners of the car/cars that appear in the photo, if you know their names.
e) Please advise us the make, model, and year of the cars. (Generally, the more info the better!)

Some photographers like to develop their own film. Others like to alter their photos digitally. The contest rules neither restrict nor prohibit this, but we don't particularly want to encourage it either. Generally, high resolution un-altered images are what we prefer to receive. Please note, however, that we routinely modify photos before showing them on our website. For example, we use several optimization tools and techniques to reduce digital file size. We also frequently crop, re-size, and brighten photos. We have a weird habit of airbrushing out at least one or two digits from license plate numbers (unless they're vanity plates).

Participating in this contest implies that you're making the photos available to The British V8 Newsletter for use at our discretion. We will credit you as the photographer, but we will claim copyright rights on any and all photos that appear on our website or in our newsletter. If you don't own a photo or if you're uncomfortable with our having the right to display it, please don't submit it.

Judging, Awards, and Deadlines

Breaking news! I've recently recruited two impartial, well-qualified and thoroughly fun-loving judges: Dreama and Robert Milks! Based on my interview with them, I know they're looking forward to making up additional categories to judge photos by. If you're the "competitive type", that means MORE CHANCES TO WIN!!!

We're still working on identifying potential prizes. (Contact me if you'd like to sponsor the contest and provide awards!)
The deadline for all entries is July 15, 2007. Winners will be judged and announced at the British V8 Meet in August!

DO NOT PUT THIS OFF ANY LONGER! SEND IN YOUR PHOTOS NOW!

I wish everyone good luck and hope everyone who participates enjoys this informal competition!

Sincerely,
Curtis Jacobson, editor

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A Day At The Races

The British V8 Newsletter, Volume XV Issue 1

by: Greg Myer

First of all, this isn't a review of a Marx Brother's movie. I enjoy their movies, but this isn't the place for it. Rather, it's a suggestion. Spend a day at the races! Grouchos Marx's "Dr. Hackenbush" would agree - for a different reason of course - but he'd agree!

If you're considering an engine swap for your British sports car, the best place to get information is right here at The British V8 Newsletter. Just keep clicking and reading! Also, make plans to go to our annual British V8 Meet. At our meets you'll see completed swaps motoring around and you can ask their owners questions. We're a friendly crowd, and you'll probably get offered a few rides. Warning! These will kick your desire into high gear.

OK, but why go to the races? Because at the races you'll find a whole different world of ideas that could be incorporated into your ride. All sorts of races are good for this, but especially races where you can get up close to look at the cars carefully. There are plenty of very inventive people out there. Most are willing to talk about their 'Pride and Joy' too. Beyond inspiration, talking to racers is a good way to find out what works and why. Quite often you can find out what doesn't work very well too.

The Bentley Speed 8 (powered by an Audi V8 engine)

One of my personal favorites is the Sebring 12 Hour Race. I know, high end Porsches and Aston Martins and their crews seem like the dark side of the moon from where we are. Well, the overall winner in 2003 (when we most recently went) was a British V8! That's right: the Bentley Speed 8 is a British produced car with an Audi V8 engine. I haven't seen that swap tried here....yet.

TVR (with Rover-derived V8 engine)

The GT class cars are even better in my book. A 7 liter race motor breathing through open exhaust on the side of a Corvette is FANTASTIC! (Even with ear plugs... and you'd better have them in!) You won't get that from a magazine, web site, or even cable TV no matter how good your sound system is. This may not be a "useful idea", but it's another incentive to go to the races.

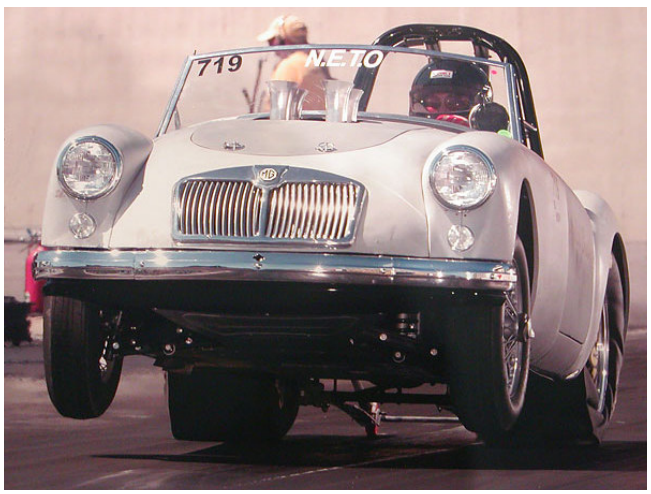
Take your own camera! Endurance races like Sebring (and the 24 hour race at Daytona) are particularly laid back about providing fans opportunities to take detailed photos of the cars.

There's a lot more going on at these races besides exotic "prototypes" or fantastic GTs. There are several races each day leading up the big day. Vintage sports cars and a variety of others get out on the track too. Before and after these sprints, the owners are in the pits tinkering. Most of the competitive cars are well prepared long before heading to Sebring, so the owners are usually just fussing: polishing chrome and hoping someone will notice. If you're observant and ask the right questions, you'll be amazed at what you can learn. Look at the little details: linkages, bulkhead fittings, plumbing and wire routing, fastener selection... the possibilities boggle the imagination!

Thunderbolt (with Triumph I6 engine)

I approached one owner who was polishing something that didn't need it, and I inquired about the car. It turns out that it's a "Thunderbolt". A hand-formed body mounted on a Triumph chassis with Triumph drive train. Seems there were 8 or so built and this was the only example in the US. There were lots of interesting details to take note of on this car! As I walked away he was polishing again and looking over his shoulder, waiting for the next person to show interest.

Road races, hillclimbs, and autocrosses are among the very best places to get ideas that are directly applicable to our British V8 engine swaps - regardless of what class the cars compete in. Look for Sports Car Club of America (SCCA) and historic race events. Many of the cars are very well sorted out, and by asking a few questions you may save yourself a lot of time and expense. Suspension settings and steering with larger tires and stiffer springs can be tricky to set up properly. These guys have answers! At least you can sort through information from first hand experience. Quite often you'll find they know tricks about parts we would never even think about.

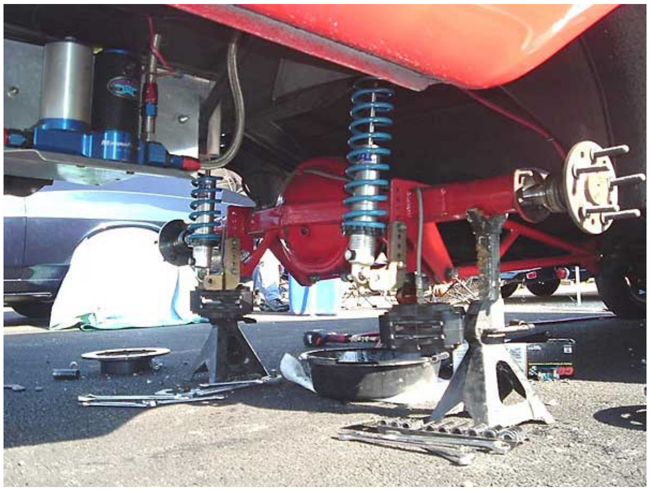


Bob English's MGA (with Chevy V8 engine)

Another type of racing that can be informative is the Drags. With just 1320 feet to get their work done, these cars have to be well thought out. Whichever sanctioning body the particular strip works with (NHRA, AHRA, or IHRA), all the cars must conform to rules which are put in place for safety first and foremost. You can feel confident using these ideas. Some won't be applicable for a British V8 car, but some are worth your consideration. For example, many classes are required to have a battery disconnect on the outside of the car so the starter (the man who controls the tree) can reach over and kill the electrical power in case of trouble. You may not want it accessible to the public, but a switch like this can save a car when there's an electrical problem. Many of these cars have the battery hidden in the trunk so pulling the cable would be difficult. Same with our cars.

Battery Charger Studs

How about being able to charge the battery without having to do gymnastics? Check out the access under the former gas door for just that purpose. Maybe transfer that idea to the engine compartment and there are all sorts of possibilities; a power source for your timing light would be just one.



Axle

Look under a drag car. Since these cars launch hard, strong components are needed. They will still fail at times. If the owner is out of eliminations and working on the rear you might find out what went wrong. Knowing the weakest link can help you prevent using something unsuitable. The suspensions on drag cars are interesting too. While not intended for cornering, they work coming off the line and their geometry can help you in setting up your car as it's light and has more power than the suspension was designed for, or at least it will soon.

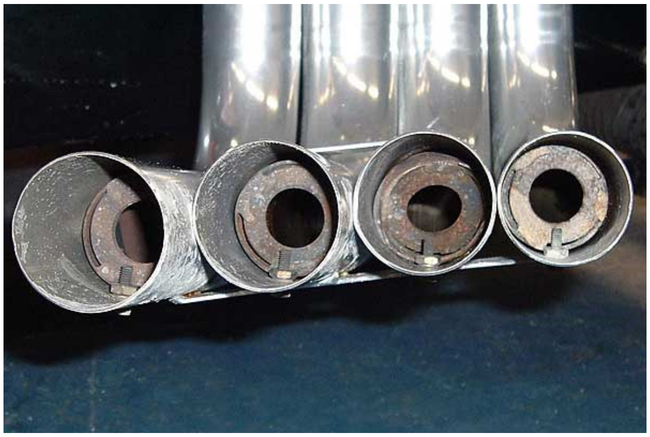
Induction Tract

Thinking of turbo charging or super charging your little aluminum Buick? Here's a good place to reduce the learning curve as drag racers have been using them for years. Intercoolers, waste gates, and handling the underhood heat are all part of what's going on. So much to learn, so little time. Remember, "Engine parts: Good. Engine pieces: Bad."

Paint

Time to re-spray your ride? It doesn't have to be British Racing Green you know. There's nothing wrong with that! (Hey, my MGB GT

V8 is getting Jaguar Racing Green metallic!) but there's a multitude of options. Look around at the races.



Zoomies

Other sources of info are car shows. Here the cars are on display so you can take your time and even take pictures if you like. Motorcycle baffles in zoomies may not be appropriate for 4 into 1 headers... or could they be used? No mufflers to find space for under that tight area below your bucket seat. Hmmm......... Notice how these zoomies have been installed so they can be turned for straight-through flow when desired. Street rods are fun cars and these guys use lots of imagination.

Swap

Many races and car events have swap meets included. Keep an open mind here. You can score useful items if you know what you're looking for. I picked up a set of Ford 302 long tube headers for a truck for $10.00. Good price if you have a truck, but how does that relate to a British V8 swap?

Headers

It's just such a set of headers that I cut and welded to put a 5.0 in Larry Nicholas' MGB. The long tubes and bends give you plenty to work with. The flanges are formed and the tubing already welded in. The set on my garage wall is waiting the next Ford / MGB swap I'll do. The motor is waiting under the bench and the heads are apart getting GT-40 valves and porting right now.

My Buick-powered GT isn't finished yet and I already know it won't have enough HP to keep up with Larry. That just may be another lesson; build what you want the first time.

The idea of this article is to stimulate ideas. Go to the races! You'll have a great time. And remember: if someone asks why you go, tell them you're doing research. It works for me!

Oh yeah... when you go to the races, take your wife along. She'll enjoy it just as much as you did when she took you along for "A Night at the Opera".

Disclaimer: This page was researched and written by Greg Myer. Views expressed are those of the author, and are provided without warrantee or guarantee. Apply at your own risk.

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Please take a moment and have a detailed look at John's work: John Mangles' Buick V8 Powered MGA

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Jim Blackwood's 1971 MGB V8 Roadster

The British V8 Newsletter, Volume XV Issue 1

by: Jim Blackwood, Blackwood Labs LLC

The Four-Cylinder Days

I began this write-up using the British V8 submission sheet but considering the unique character of the vehicle and the path it has traveled I felt a bit of literary license was warranted.

My car was ordinary enough in the beginning. It was a standard North American spec red MGB convertible, but by the time it reached me the car had already differentiated itself. It had acquired a racing history.

The racing was not at all what you would expect from an MG, as it had run on the dirt tracks of southern West Virginia. I don't know with what success, but the remarkable thing was that it hadn't been beat up as you might expect though it had been repainted about a year before I bought it due to minor dings and deterioration of the original paint. The carpet was gone, the seats were worn and the car had about 50,000 miles on it. We pulled the engine, installed new bearing shells, and serviced the clutch. Overall it was sound.

After paying the princely sum of $1100 for it, I swapped in the lowered suspension of its twin (which was ultimately to be a parts car) including a GT sway-bar, Delrin(tm) bushings and competition shock valves. I was ready to head off to Los Angeles, stopping for a couple months in Florida and reinstalling lever arm shocks in the rear along with oversized U-bolts on the axle. (Ride quality improved noticeably.) With a short stop in Louisiana to replace a bad U-joint and a brief visit in Texas to see my young son and ex-wife, I was soon on the west coast.

In LA I de-arched the rear springs and added a leaf, bringing the car down level and stiffening it, and then using a pair of shortened front wire wheel hubs, cut off the flange and welded on a new one drilled for a 4-1/2" 5 lug pattern. To these I mounted Mach-I Mustang ventilated rotors, 14 x 8" Cragar SS wheels and 265/50-14 BFG radial TA's and mounted the Mustang calipers using a bracket I welded up and machined out of steel plate.

To get the back to match, I used a pair of wheel adapters, figuring I would either change the axle out later or make up new rear hubs. (Note: a couple of years later I made and fitted a new set of axle flanges similar in construction to the front hubs. The gears finally started making noise after driving The Tail of the Dragon during the 2003 British V8 meet so I swapped those axle shafts into the replacement axle. I had been planning on a Currie 8" Ford axle with limited slip differential and disc brakes, but they didn't have a suitable brake package (I wanted discs with an integral parking brake) and besides, I didn't have the money.

In order to fit the rear tires, the fenders needed to be modified and as the only appropriate tool I had to work with was a cutting torch that's what I used, which left a rough edge and turned the paint yellow where the flame hit. In this condition, I next headed east up into Utah, visiting friends for a few weeks through Christmas and then headed over Vail Pass on the leading edge of a huge winter storm.

Knowing the storm was coming, I stopped at Checker Auto in Provo and bought the biggest set of tire chains they had, and then shortened them to fit the rear tires. About a quarter way up the mountain range the wisdom of this foresight was proven. With several inches of snow accumulated, I pulled over and put the chains on. On up the mountain we went. Eventually I hit interstate and as we neared the summit I was keeping up a steady pace driving along two ruts in the snow in the slow lane, the snow dragging on the bottom of the car constantly and passing lumps in the fast lane which I figured to be cars that stalled, though you really couldn't tell.

At one point there was a hitchhiker out in the middle of nowhere and I stopped and gave her a ride, but when we got to Vail conditions were so bad that I stopped in the traffic lane rather than risk not being able to get started again. Luckily that didn't get me stuck and I was soon headed down the mountain into Colorado, once again back to the front of the storm with the snow turning to rain and then finally stopping altogether. I was the last car down the mountain that night before they closed down the highway!

I had the entire highway all to myself coming down the mountain into Denver. As you might imagine for a guy who dearly loved drifting the turns, I was having quite a time. (The chains were back in the trunk of course.) Developing a miss, I drove into Denver looking for a set of points for the Mallory dual-point distributor I had installed a month or two earlier but it being very early in the morning no parts places were open. So pulling back on the interstate I hoped to drive awhile and then get parts.

Mistake! The engine quit and I had to stop. It was cold, and I mean really cold. It was clear to me that the only reasonable chance I had at survival was to fix the distributor and I wasn't going to get any extra chances at it before my fingers got too numb to use. So using every means at my disposal to conserve warmth, I climbed out and quickly removed both the distributor and the external ballast resistor I had installed with it and got back in the car. Inspecting the distributor and finding one set of points burned beyond use, I removed the bad set and adjusted the other and turned my attention to the ballast resistor which had tested "open".

Using a small screwdriver, I broke out the ceramic and unwound the ni-chrome wire. Finding it burned out in three places, I twisted the ends back together, wrapped the length of it around the housing and looped the ends under the lug screws and was ready to reinstall. Luckily the MGB distributor only goes in one way so once I had it back in and hooked up with the cap back on I was real glad to be back in the car, even though my hands were shaking so bad from the cold it was hard to turn the key.

The engine fired right up and I was able to head on back to West Virginia without further incident, having spent just about a year making the loop.

More Modifications

Once back home I began making some further changes: finishing the rear wheel-wells, building the adjustable brake bias assembly, and reworking the dashboard, then moving on to building the first forward tilt hood assembly and finally doing the V8 swap.

To form the rear fender flares, I spliced a 3" strip of sheet metal into the inner fender by splitting it at the seam. Then bent a length of half inch conduit around a 55 gallon oil drum to get the curve I wanted for the opening. Next I shaped sheet metal to match that to the outer fender. Once it was all welded and brazed together I bumped the inner and outer fender out as one to give more tire clearance and a more aesthetically pleasing curve. (Shortly thereafter, a friend who was a body man informed me that brass continues to outgas for about a year, so I quit using brazing rod and gave it plenty of time to cure before final paint.)

I worked up the brake pedal assembly mostly from parts lying around, reshaping and using arms from an extra pedal assembly and a few other parts. A half inch hardened jackscrew provided the adjustment shaft along with a spherical bearing for the pivot and some custom made swivels. The pedal box was widened to accommodate three single piston cylinders. To allow adjustment while driving, a flex shaft was run through the firewall and dashboard where a large custom made walnut knob was placed and a rubber shifter boot sealed the cable connection to the cover.

The dash pillow had developed a crack, so I removed it, stripped off the vinyl and the pad and made a few changes there before re-covering it all in black leather. Early gages were substituted and the square hole welded up. Provision was made to mount a 7-band graphic equalizer, and 5 round gage holes were added, one of which was used for the brake adjuster knob. Further to the right, an early glove box opening was grafted-in as well as a map light and switch. Part of the original pad was retained as a brow, and the center console below the dash was reworked as well. I found a molded-plastic glove box liner out of a compact GM that fit the opening nicely.

I had long admired the easy accessibility of the Spitfire and GT6 and felt this was possible with the MGB, but it wasn't until after a mishap left me with a damaged fender that I felt there was no loss in trying my hand at making one. (Had I known the cost of MGB fenders I might have thought better of it!)

I set to with hammer and dolly and when I was done I had what was then a very "unique" design. Unbolting the fenders and cutting them at the rear hood line, I welded the fenders to the hood, did a bit of reinforcing, cut out the headlight buckets, flattened the bulge and spread the sheet metal out to cover the tires. When finished, it had a continuous line that followed the curve of the hood out to the edge. Again conduit provided the lip. A set of quad rectangular headlights were procured and mounted, two in the fenders and two in the grille space.

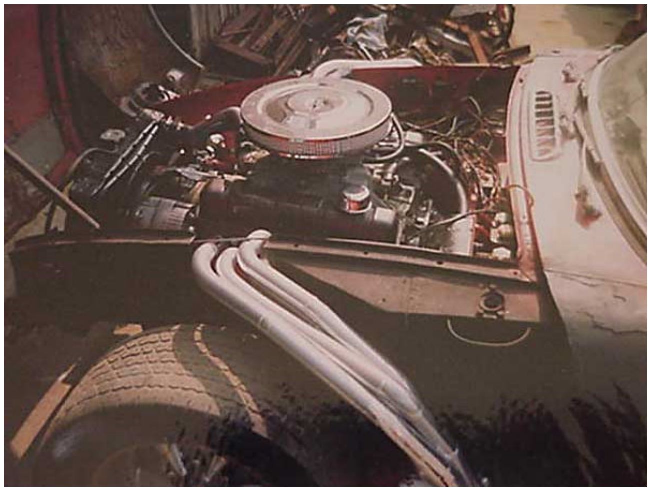
I built a pair of simple hinges and spliced together a pair of old bumpers. A center section for the front spoiler was built which served double duty as a radiator guard. Two cut-down MGB hood latches were positioned at the rear, and were operated by the standard hood release cable. No bumper over-riders were fitted at that time (due to the tilt geometry). A stock hood prop kept it off the ground when open. This design is shown in the included photos and though very rough, I was happy with it for a time due to its unique character.

My First V8 Conversion!

Some time later I'd expended all of my engine spares and with the last remaining engine giving up the ghost, I was determined to proceed on my V8 transplant, even though I had only heard rumors that it had been done before at the factory. I had learned of a disused junkyard where 215's might be found, and arriving tool bag in hand climbed the hill, fought through the multi-floral roses, and discovered several cars with the desired engine. Picking a 2 barrel F-85 automatic as the easiest one from which to remove the engine, I spent an hour or two unbolting it, then climbed into the engine compartment and physically wrestled the engine out and onto the ground. I then rolled it onto the hood of the car, looped a couple of fan belts together and attached them to the hood and dragged the works back down the hill like a sled, a distance of probably a couple hundred yards through brush and ruts so deep it was impossible to get a vehicle up there.

Once broken down and at the machine shop two things became apparent. There was a crack in the water jacket, and this wasn't the best engine choice. So back I went and between me and a buddy we ended up hauling 4 or 5 engines down off that hill. I began test fitting. I found that if a small diameter oil filter was used, it could be positioned to fit between the steering rack and sway-bar. This determined the engine position, giving just barely enough room between the steering shaft and rear header bolt, just enough starter clearance, and no need to cut the firewall. The one thing in the way was the slam panel, but since the latches would be in the rear that wasn't much of a concern, and I simply cut it out. Using stock Buick engine mounts, I fabricated bosses onto the cross-member for them to bolt into. These were made up of a couple different sizes of black pipe and some gussets, test fit a few times, tacked in place and welded up.

Being the mid 80's, the transmission I selected was a Warner T-50 5 speed. With just a little bending the shifter came up through the hole in the stock MG shifter plate. So far this had all been done very cheaply, but the big expense was the engine. I used a Buick 215 4bbl. which had about 20,000 miles on it. I tore it down, cleaned it up and put it back together with new rings, bearings, etc. along with a 600 Holley mounted on a modified stock intake and the hottest cam I could find.



The next job was to build that wild set of headers you can see in the photo. I used parts from "Headers by Ed", and completed the job in 80 hours. The finished headers have 34" x 1-3/8" primaries all of which were within 1/8" in length; swirl scavenged into 2-3/8" collectors. This was followed by glass packs housed within flared rockers (to simulate "ground effects" and blend nicely with the front and rear bodywork). The exhaust dumped in front of the rear tires. The exhaust was sent out for coating, which was still a very new process at that time, and the total cash outlay was around $750 for the exhaust and $1400 for the engine. There were other conversion costs, of course, but nothing on that order of magnitude.

I originally used an external slave cylinder for the clutch. I shortened the clutch fork as much as I could get by with, made a box in the floor under the gas pedal, and shortened the pedal. For the driveshaft, I found a junkyard GM shaft and had a local shop splice the two together. (I later replaced it with a small diameter heavy-wall driveshaft.)

The radiator had been re-cored with a 4" longer core a few years earlier so some modification of the necks was all that needed. Exhaust tubing was welded up into coolant lines. A stock aluminum-nose 215 starter was found and the nose modified to reposition the solenoid by welding on new ears and cutting down the snout on a belt sander. (I still use the same starter today, though it has been rebuilt!)

That was really about it except for cutting a big hole in the hood for the air filter. I found a JC Whitney scoop to cover the hole and painted the whole car flat black and it looked like something out of a Mad Max film, but it ran like a scalded dog. I first got it running with the V8 in '88 and estimated about a 240hp output. Finally I had the power to go with the handling, and the mountain roads of West Virginia once more found me power sliding around the turns the way I had been doing with my 1970 Olds Cutlass back in the early 70's, but going a good bit faster.

In fact, the MGB had at this point gotten so fast that, as I often told people, "If it's a blind turn and the tires are squealing, there'd better not be anything in the road because I'm going to hit it." It had become faster than my reaction time which was really quite good, and I found myself no longer at the point of tire adhesion in those blind turns purely for reasons of self preservation.

Have you ever crossed the New River Gorge Bridge on Rt. 19 in Fayetteville, West Virginia? (Editor's note: a "must see", it's famous for bungee jumping!) From a dead stop at one end, I once hit 130mph about 2/3 of the way across. I had to back off the throttle due to the front end getting light. It was after this run that I added the front spoiler. It wouldn't do to float over the guard-rail 900 ft up!

Upgrades and Interior

I drove the car like this for a few years, trading the Cragar wheels for polished Centerlines as soon as the old BF Goodrich's needed replaced, which didn't take long, and thus began a long period of incremental upgrades.

A buddy sold me a close ratio T-50, and it proved a much better choice than the (ex-V6) wide-ratio box I was using. Years later I sold the original T-50 on eBay. It was bought by (fellow MGB V8'er) Jake Voelckers out in Utah. Regrettably, I'd damaged the transmission before removing it and forgotten about it, so I had a mess on my hands. I refunded Jake's money and let him keep the remains in exchange for his shipping costs. He found this acceptable as he was able to use some of the parts in his first transmission for his V8 swap, but it would have been better for us both if I'd checked out the tranny before listing it! That's hindsight, so an apology is the best I can do.

Next up was a better radiator. Having moved to Cincinnati to attend UC law school, I found a local shop that would build me a custom brass radiator along with fitting a crank-driven fan and I soon thought I had the answer to my intermittent overheating problems. That helped, but was not the complete answer and I continued to fight this bugaboo for a long time. I tried several different electric fan setups, two different crank fans, a correctly engineered fan shroud, re-coring the custom radiator with the most efficient core possible, adding a surge tank and overflow tank, re-plumbing to automatically remove all air from the system, and finally learning to tune the engine for temperature control, but I'm getting ahead of myself.

During this period I made new wooden interior trim which really improved the inside appearance and comfort. To match the brake balance knob, I carved a black walnut "T" grip for the shifter and shaped new cap rails for the doors. I bought some thin Birch plywood and cut new door and trim panels. I carved thick walnut planks into door-pocket/speaker-mounts. This was a pretty big project, done with a Forstner bit, a Skilsaw, a large hole-saw, and small belt sander. The end result has allowed me to ditch the foot-well pocket. I finished the doors out with chrome window cranks.

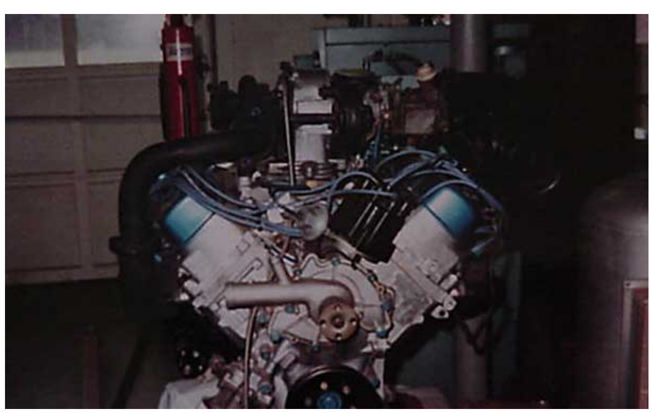
After stripping and polishing the rear cockpit surround, modifying the top frame for speedy removal by utilizing the tonneau brace sockets and reconditioning a Parish Plastics hard top for winter use, I was satisfied for the time being.

The Turbo

Then the engine blew up. This was entirely foreseeable as I had been winding it to 7 grand frequently and it still had the original cast pistons. Still, losing power, overheating, blowing out smoke and rapidly slowing to a stop was not what I wanted that particular afternoon. I got a buddy to tow it back to my place and I had an alternate plan already in the works.

When my old friend Harry Johnston moved to Virginia he sold me the Olds 215 that we'd built in his basement. (The same engine I'd sledded down the hill a couple years before.) Harry had impulsively bought a set of low compression Buick pistons and there was no way I could talk him out of using them in the engine. With the 2 bbl Olds heads, the resulting compression ratio was probably around 6.5:1. Although this was exceptionally low, the motor still ran and made better power than you might expect. It was still a very significant improvement over the 4 cylinder engine. I knew this because I'd swapped it into the MG temporarily while I did a cam change on the Buick engine a year or two earlier.

In the meantime I'd been scouting for an Olds Jetfire turbo and found not just the turbo unit, but also the engine, mounted in, you guessed it, an MGB. The car was toast. The previous owner had hacked up the sills and tranny tunnel extensively, but I bought the works for a thousand bucks and began adapting the turbo to the ultra low compression Olds engine.



Why not the fresh Jetfire? I was saving it for later after all the bugs were worked out. I set to work making up a set of turbo headers, some adapters, linkages and such, and making it all work in the MG. Once it was back together, I began tuning the 2" SU carb I had feeding the turbo. I lathe turned new needles and drilled out the main jet but midrange tuning was tricky. In order to get it right, I enlisted the aid of a fellow whitewater guide and motorcyclist who I've been close with ever since the early 80's named: "Cosmic" John Janzen. I knew I could count on him to be comfortable in the wind! I had John stand up, lean over the windshield, and with a screwdriver adjust the main jet of the SU while we drove up and down Clifton Hill in Cincinnati. (Unlike the 1-3/8" SU of the MGB, this 2" version had a rocker linkage on the jet with a top adjustment.)

John still ribs me about that ride (exaggerating the speed and such) but we got the adjustment right after a few tries and with the turbo putting out 7 lbs of boost the engine ran nearly as well as the Buick until it started gasping for air around 5 grand. Fuel mileage was poor, but response was pretty good if you could overlook the turbo lag. It wasn't a lot of lag, but it was near impossible to time it accurately and it put me sideways so often that I had two freeway collisions because of it in a period of just a few years. I began to look for another option.

Along about the same time as the turbo swap, I grew weary of being asked by looky-loos if the car was a Porsche. The front end was never going to be right anyway and besides, I had recently seen another car in the area that looked suspiciously similar. Commonly nick-named the "Clown Shoe". That was just too much for me! I decided my car needed to look more like an MG.

I thought up a brilliant scheme to make a new front end out of fiberglass. I envisioned it as being basically similar but having a raised snout with an MG grille that was tall and narrow, like a cross between a TD and an MGB. I began building this apparition and actually drove the car with it in place for a number of weeks before deciding that my free-form fiberglass skills were not up to the task. The fiberglass hood followed my first homemade hood into the dumpster in favor of more traditional sheet-metal.

I had a set of fenders and hood from the Jetfire car, so I mounted them and cut a line from the cowl to the inside of the headlight bucket. Then I spread the fender 3" to the outside at the front edge, and spliced in some steel to close the gap. The resulting design looked more "MG", so I was very satisfied with it. I drove with this prototype until the turbo shaft bearing began to wear. At that point I was fortunate enough to be in a position to buy new sheet metal as well as a new Eaton M-90 blower form Magnuson Enterprises in California. M-90's had not yet appeared on production cars, and I actually had to call and twist their arms to have the boys ship me one, but at last the final plan was set into motion.

The car was torn down to the basic shell and prepped for paint. At the same time, I finished up some details. The rockers were trimmed for new perforated stainless grilles that would allow some of exhaust heat to escape. I decided not to remove the box section under the gas pedal at that time as the hydraulic throw-out bearing would be new and was as yet untested. Along with the new sheet metal and the blower equipped engine it would be getting an experimental heat-pipe based intercooler, distributor-less ignition, and sequential fuel injection, plus the wing from the Cutlass would at last be mounted. Other changes were in the works as well, meaning that this time the car would be down a couple of years.

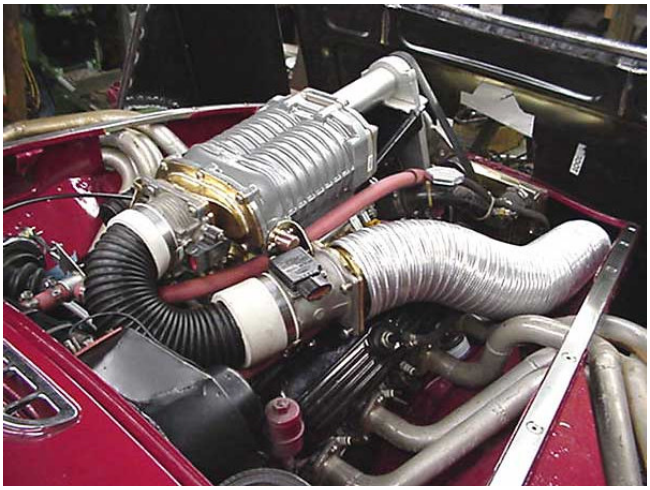
I made a point to do some work on it every day, even if it was a tiny step. In this way, the project kept moving forward. I highly recommend this approach to anyone doing a conversion. It keeps the project foremost in your mind, gives you a constant feeling of accomplishment, and prevents the car from languishing in the corner. Tasks that seem insurmountable become much easier when you tackle one part at a time.

Clearly you have to sort out some of the largest issues before you start though. What kind of blower, what kind of intercooler, how to make sure there was space for both, and things like that. If you're a CAD wizard so much the better, but I am not. What I'm saying is that you don't necessarily have to know where every bolt will go before you begin. "Anything worth doing is worth doing twice!" Keep that in mind as you work on your conversion and you will find the entire experience much less frustrating. You will be less tempted to walk away from it.

Turbos are great but a Blower is Better

It was along in here somewhere that I met Kurt Schley and attended the Indianapolis V8 meet. With the car down for redesign, I felt a little out of place, as many new participants do. I felt as if there had to be some doubt as to whether I really even had an MGB, much less a fire breathing monster like the one I eventually showed up with. So be sure to show extra consideration to the new guys.

Skipping the intimate details of how the ports were machined or the rivet nuts installed, in more general terms I next proceeded to mount the blower to the Jetfire engine by modifying the old Offenhauser dual port intake. I chose this one because of the large plenum space, which after all internal dividers were removed gave me room for the intercooler.



Originally a Ford EEC-IV SEFI/EDIS system was used for injection and ignition by cannibalizing a Crown Vic. The Delco distributor was cut down and used only as an oil pump drive and cam sensor, thereby leaving room for the blower drive. 5/8" aluminum plate was used to make the front drive support, which also serving as the tensioner and alternator mount. (It supported the front of the intercooler as well.)

A brass plenum box was built to house that unit and raise the blower above the fuel rail. The fuel rail turned out to be a very tight fit, but there was enough room to install and remove it with everything else in place. I learned to cast silicone rubber in the process and have made good use of that skill several times since.

I know some people will want to know more about that intercooler! I had a special custom 2 row brass radiator made up, I forget the exact dimensions but something like 4-1/2 x 18" long with a 1/16" NPT thread in each of the end caps which were intentionally kept as small as practical. The outer cap was fitted with a Schraeder valve and the inner with a tube connected with another Schraeder valve through the wall of the plenum. In this way when assembled I was able to completely fill the intercooler with ethanol thereby determining the internal volume, and then with a vacuum pump and recovery chamber draw out half of the volume, leaving only ethanol and ethanol vapor in the intercooler. Set at an angle and at vapor pressure only, any heat introduced to the liquid in the lower half immediately upsets the equilibrium, causing production of more vapor which rapidly transfers the heat to the cooler end where it is radiated.

How effective is it? I don't know yet, but I now have sensors in place and a means of measuring it, so it's just a matter of setting up data-logging to record the outputs. It was never my intention to try to keep the blower concealed beneath the hood. With the already radical bodywork and extremely wide tires it was not going to be mistaken for a stock MGB by anybody so the cat was out of the bag. No, I *wanted* that blower to stick through the hood, mostly because of an image from my adolescence. There was a TV commercial with a kid who had an AMX Javelin with a GMC blower fitted and an Enderlie intake. When his dad ragged on him for some unremembered crime, he casually blipped the big red throttles of that Enderlie, drowning out all possibilities of conversation. That made a statement that stuck with me through all the years and that was what I wanted. But nobody made an Enderlie for the M-90 and the EEC-IV was a hotwire system so that would have to wait. Nonetheless when the time came the hood was cut to fit. A lot of details are going to be skipped in the interest of brevity, but eventually I designed and manufactured an Enderlie intake for the blower which would fit through the hood cutout, had three big red butterflies, a throttle position sensor, and an internal K&N air filter.

More Bodywork

Taking the best features of the first tilt assembly and the final prototype hood, I made new revisions and built the front end assembly that's on the car today. It uses a double-hinged gas-assisted mechanism, secured by the stock latch in the stock location on a forward mounted slam panel that was installed with the last hood. UHMW (Ultra High Molecular Weight polyethylene) "fingers" secure the rear. Stainless steel inner fender braces to prevent cracking of the inner fenders replace the white oak ones from my first forward-tilt hood, and tie into the fender stubs for crash-worthiness.

The steering shaft was modified to give more room at the header location, and a completely new forward cross-member was designed and built combining the functions of skid plate, spoiler center section, and hinge mount into one extremely stiff but lightweight piece. As before, the fenders were widened by adding a wedge of sheet metal. The bumper was widened by MIG welding sections from two new bumpers together. To avoid discoloration of the chrome (from the welding heat) I first made a jig. Some dry ice was procured and sliced into slabs about an inch thick and shaped to fit the bumper contour. I secured it in place with springs holding it against the chrome side. The dry ice providing a gas shield and cooled the metal so that the discolored zone ended up being only about a quarter inch wide, and the weld picked up some chrome as well (making it more resistant to corrosion). These welds were positioned behind the bumper over-riders, the new hinge geometry allowing them to be retained. As a result, they are well hidden and most people would mistake it for a stock bumper.

The end portions of an LE spoiler are bolted to the ends of the bumper and are attached on the inside to the cross-member assembly which makes up the center section.

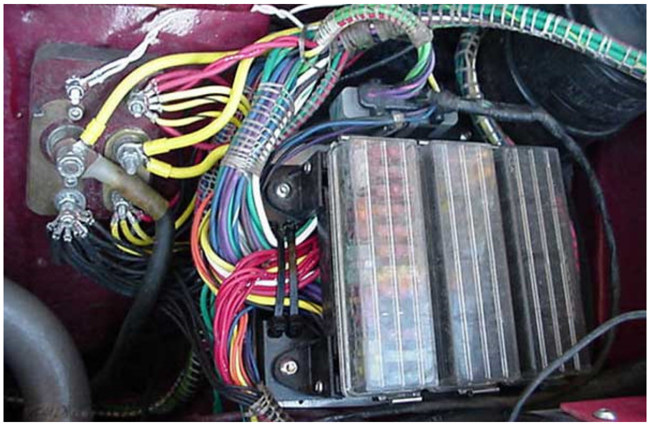
In the rear, the right side leaf spring mount was lightly reinforced by adding a channel section and the rear spoiler (wing) was mounted using aerodynamic struts sourced from Aircraft Spruce and Specialty. The wing I chose to use had been with me since 1973. While driving my 1970 Cutlass Supreme I was stopped by a 442 owner and asked if I wanted to buy a fiberglass spoiler and hood. I kept the wing even after the car was long gone because in the early 70's Hot Rod Magazine did a test of spoilers on cars of the period and concluded only two were effective: the Olds 442 and the GTO "Judge". The difference between them was in the end treatment. I had always favored the Olds-style turned-up ends, and after buying the MG I was constantly scheming to mount it. The struts provided the answer. I also incorporated an idea from a college buddy's radio control racer by tying the leading edge to the car's differential, so body movement would be offset by wing angle. The resultant down-force holds the car to the road but decreases drag when not needed.

Finally, the car was ready for paint. I selected a dark red metallic after much searching for just the right tone, hue and shade. At last it was a Ford color that caught my eye. On the car, I highlighted it by laying out some black flames around the blower. All this was done on a carport, with tarps on the sides to keep out debris. The results were pretty good, but not professional. I can live with it though, having long tolerated a hot rodder's wax job (e.g. rattle can flat black.)

After final assembly, start-up and registration I was once more ready to drive. Although the car ran, there was some tuning to do and my first step was to buy a TwEEcer unit to interface the EEC-IV controller with a laptop. To say I was overwhelmed by this experience would be a gross understatement. The learning curve was the steepest I've ever seen anywhere, and to make it worse, with the proprietary controls and software most of the tuning parameters were unknowns. The sheer number of tuning settings was daunting. But I set to, and I was able to eventually get a tune that worked well, had good power, started easily and was generally smooth to drive except there was a surge at 2000 rpm that I simply could not get rid of. I tried different controllers, swapping out components, and verified every input, all to no avail. Finally, having learned of the MegaSquirt controller, I built one, experimented with it, and I decided to get rid of the hot-wire system. (MegaSquirt is a manifold-absolute-pressure based system.) The hot-wire system wouldn't work with an Enderlie scoop anyway.

Wires, More Wires, and Spaghetti

By this time, Dan Masters had developed an excellent wiring kit for the MGB and with his son Mike had set up the company Advance Auto Wire (AAW) to sell it. One of the distinctive features of their wiring is that they specify cross-linked polyethylene cable insulation instead of vinyl insulation. (Editors note: this kind of insulation is commonly available in several insulation thicknesses: "SXL" has a very thick wall. "GXL" has a medium thick wall. "TXL" has a relatively thin wall.) Although their kit wasn't what I wanted for my wiring harness, they agreed to sell me bulk SXL cable. Dan and Mike continuously upgrade their kits and are now offering a new variation with thinner insulation and lighter gage signal wires while still retaining their signature oversized wires for load carrying conductors, meaning it's now possible to completely rewire the car and have a more compact wiring bundle. In my opinion this is an excellent development and greatly simplifies the rewiring task.



For power distribution I chose modular snap-together fuse and relay bases with clear o-ring sealed covers from Furneaux Riddall & Co Ltd Relays in the UK. These are more expensive than the domestic selection but can be combined in any order or quantity to give a neat and tidy appearance. I machined a black nylon base to keep the wires organized and used the new LED equipped blade fuses, another wonderful innovation. Relay selection is a bit particular as heights vary but I found that half of my selection of stock Ford relays fit, if somewhat snugly. This panel was located on top of the passenger side shelf for easy access. I had previously fitted a phenolic terminal block nearby on the inner fender at the old coil location and retained that as well as adding new ones behind the glove box and in the trunk.

I used a great many ring terminals, and learned that an open barrel-crimp similar to those used by automakers is perhaps the most secure means of terminating wires for general connections. However there is great variation between various brands of crimpers and terminals. AAW and others sell a crimper for automotive terminals which does an excellent job with the matching terminals, but it does not work well with industrial terminals. This might not be an issue if automotive open barrel ring terminals were readily available. Practically every other type is, such as the terminals for various EFI connectors but I had great difficulty sourcing ring terminals and ended up with industrial ring terminals which are made of a thicker material and require a different crimper.

I really like sealed connectors. Unlike the bullet type we all know and love (NOT!) they seal out air and last indefinitely. I had a surplus of the Ford type left over and found a source for most of the pins. Some are carried by auto parts stores but another good source is: RJM Injection Tech. I replaced all bullet connectors with sealed connectors, including the steering column wires. This was a good deal of trouble, but worth it in the long run as I shouldn't have any more connector troubles. Now I know some say all you need to do is keep the bullet connectors clean and use good dielectric grease, but I have just eliminated that maintenance item from my schedule and am very happy about it.

At the same time I replaced the light bulb sockets with the newer blade type, except for the dashboard lights, and had already gone to Bosch 100 watt headlights. I should have probably done the dash lights as well, but am still not satisfied with what is available and will wait for new developments, hopefully in the form of durable high intensity LED type bulbs at some point. It appears I may change to a newer type electronic speedo anyway with the impending transmission upgrade.

Switches and Such

I never liked the MGB headlight switch. It seems a poor design to begin with, and it's only reliable when used to drive a headlight relay rather than powering the lights directly. Besides, I wanted an indicator to remind me not to leave the lights on, and I wanted to be able to switch on the headlights independently of the running lights. (It's an old street racer thing, don't ask.)

Anyway, I found that commonly available lighted rockers would fit in the dash cutout stacked three high, which gave me an additional switch for fog lights. I also wanted a 3 speed fan on the heater so the same thing applied to the heater switch. (Relays were in place for both.) Originally, I had epoxied the switches together and used standard spade connectors but this meant that one switch could not be replaced independently and making the connections was tedious, confusing, and not terribly reliable. So putting my silicone casting skills to use I had a solution. By now I had learned to mix copier toner (carbon black) with the silicon resin for color, durability, and a harder cure, so I devised molds to hold the switches with connectors in place and encase them in silicon rubber, resulting in 9 pin connectors that the individual switches could be plugged into, and in the process sealing out the air except for where the blade was inserted. This was a dramatic improvement and should be very reliable. I used the same method for the transmission reverse switch and the brake light switch (which was a Chrysler item and a direct fit in the cover). I substituted a toggle switch with a metallic red hinged guard for the emergency flashers. Since I had installed an electronic cruise control unit, I used one of the remaining console openings for a compact pushbutton package to control that, and the other for an auxiliary back-up light switch.

The Marantz graphic equalizer was replaced with a more modern one, the radio with a CD player head unit, amps front and rear, and poly cone 6x9 speakers in the doors and rear bulkhead. The MegaSquirt harness, purchased as a semi-finished kit also had been installed before the main harness was in place and all the wiring bundles were laced with flat lacing twine, an old aircraft technique. A wide-band O2 sensor from Innovative Motorsports was installed, and a knock sensor circuit was added to the controller.

The rest of the gauge package consists of an exhaust gas temperature gauge, ammeter, voltmeter, vacuum/boost gauge, '67 vintage dual water temp/oil pressure gauge and fuel gauge, and the early MGB speedo and tach.

Upholstery

By now the MG seats had gotten pretty ratty even with parts store slip-covers. I wanted to re-cover them in leather and had even gotten the seat foams one year for Christmas but buying the leather was not looking cheap and stitching them up was going to take a lot of time. Buying custom covers would be even more expensive. I went looking for an alternative and found it in a set of swap meet seats from a Mercury Marauder. They're black leather with adjustable lumbar support and electric rails, all for $100. But they wouldn't fit. I removed the electric rails. They still wouldn't fit. What to do? Removing the covers, I found I could combine the MG seat base and recliner mechanism with the Marauder seat back, lumbar and head rest. Soon they were in the car and looking good. I won't claim it was the easiest swap, and it did take significant cutting and welding, but in the end I was satisfied and the ride was improved, to say nothing of the appearance.

What's Next

The immediate concern is the transmission. I have now demolished my second T-50. (I wouldn't recommend one for an engine over 200 hp.) It's beginning to look like the replacement may be a T-56 six speed or perhaps a TH200-4R overdrive automatic with lock-up converter, but the details are yet to be determined. With perhaps the most forward engine position of any MGB V8 swap, there appears to be room for it. But it looks like a replacement T-50 may need to be fitted in order to give me time to mate the replacement tranny to an upgraded engine, the Buick 340. The money is an issue, as always.

Then a roll-hoop is needed so I can play with it on the track, but of course an off-the-shelf product just won't do and I want one that can be raised for track days and lowered to fit under the top, and still comply with SCCA rules.

New carpet would be nice.

Finally, I hope to finish the IRS project in a few years. As planned, it will use T-bird components and geometry, inboard brakes, and tubular lower control arms with long suspension travel and extremely low un-sprung weight. However, there is a relatively new GM SUV IRS that also looks promising. An adjustable-height revision of the suspension design may be in the works as well. If my income has increased by then I may even buy one of Ted Lathrop's fantastic ("Fast Cars") front suspensions, though I'd probably have to modify it some.

The gas struts for the front clip will probably be modified into hydraulic units to give positive control of hood movement using a Mercruiser trim pump, which is reasonably light and compact. Most of all, I just intend to drive it!

What I'd Do Differently

If I was starting over? Everything! Possibly a normally aspirated SBC engine or a (surprisingly lightweight for its size) early Buick 455... Everything else is up for grabs, but I would find a way to include air conditioning, which I may add to my '71 at some point. If re-doing a '71 padded dash, I would also entirely discard the pillow and use other materials to build up the right side brow before re-covering. I'd use a glove box lock that could be keyed to match the door and trunk locks. The headlight buckets should probably have been pointed inwards slightly as well, as I had done on the previous fenders. Another thing I meant to do but misplaced the parts was to install the early type air doors on the foot-well vents. Maybe some day I'll find them.

Disclaimer: This page was researched and written by Jim Blackwood. Views expressed are those of the author, and are provided without warrantee or guarantee. Apply at your own risk.

Fast Cars, Inc.

Ted Lathrop Explains the New **Fast Cars** MGB Front Suspension During a Tech Session at British V8 2003

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(above: Ted's Chevy 350 powered TR6)

Typical installation of an oxygen sensor for an aftermarket air/fuel meter.

Ignition Tuning 201

How To Use an Air/Fuel Meter to Optimize Your Ignition Timing Curve

as published in British V8 Newsletter, Volume XV Issue 1, April 2007

by: Jeff Schlemmer, proprietor of Advanced Distributors, LLC

When it comes to selecting an ignition system, most people are left with more questions than answers. The main goal of improving any ignition system is to get your car to burn fuel as effectively as possible and thus create the most power your cylinders can provide. But how do you test that?

Air/Fuel Monitors are a great place to start! Onboard air/fuel meters can be installed in less than a day by virtually anyone, with little damage to your pocketbook. One example is the Edelbrock unit pictured below in a custom MGB application.

Retail prices for Air/Fuel Monitors range from $130 up to $1500. At the upper end of this spectrum, you're looking for a wideband O2 setup that can be used in conjunction with a chassis dynomometer. When trying to make a decision on what to purchase, be aware that the oxygen sensors that come with the kit can be heated or unheated. A heated oxygen sensor will display data much faster than an unheated sensor and will provide more accurate feedback. A heated sensor can be quickly identified by three (or sometimes four) wires feeding into its connector. Early kits came with single-wire sensors, but I believe these kits have become obsolete.

The gauges used in these kits can be found in varying degrees of accuracy and scale. The inexpensive gauges will get you in the ballpark with readings to the nearest 0.5 AFR (air/fuel ratio), typically in a range of 12:1 up to 15:1. For base tuning this is great, but for more advanced tuning a wideband sensor and gauge will be required. Wideband kits, such as the LM-1 portable digital meter, are certainly more expensive but they offer the advantaged of 0.1 AFR accuracy in a range from 10:1 up to 20:1 while taking 12 samples per second.

Installation varies from brand to brand, but they all have a few things in common. They all use a similar oxygen sensor that needs to be mounted in the exhaust system. It is recommended that you install the sensor as close to the engine as possible, but after the collector where the branches of the manifold join. In the case of tubular headers, this would be near the coupling flange or clamp in the header collector itself. In the case of dual exhaust, whichever side offers more room will be suitable.

A small steel bung needs to be welded into the pipe. It's typically a 14mm non-plated ring, made to be welded over a three-quarter inch hole drilled into the exhaust. If you don't have access to a welder, most exhaust shops will be happy to perform this task at a minimal cost.

After the sensor is installed, you can run the remainder of the wiring. Be sure to route and secure the wires away from the hot exhaust or your system will be short lived! Most on-board O2 meters simply have two wires to connect. There will be one ground wire, attached to the engine or transmission if possible, and an ignition-fed power source (such as the "green circuit" on most British cars). A test light will help you verify power is only applied when the ignition switch is turned on.

The gauge can be mounted temporarily or permanently.

Before engine tuning, make sure you've filled-up with the same quality and octane of gasoline that you plan to continue using.

Now that you have everything installed, go ahead and start your engine. Allow the engine to warm up to normal operating temperatures and verify that the meter works. Take a few minutes to make sure your engine is idling smoothly at a comfortably low rpm. In most cases this will be anywhere from 600-850 rpm. You may want to verify or set your ignition timing to achieve a smooth, steady idle.

The following tuning procedure is for wide open throttle (WOT) operation ONLY, so please find a safe place to drive where you can keep an eye on the gauge or find a driver to help you out while you watch the meter and take notes. You are looking for an air/fuel ratio of 12.5-13:1 at WOT. You can replace carburetor jets and needles until you are somewhere in that general ballpark. You may see your fuel mixture go slightly leaner as RPM rises - that's excellent!

Make a few runs from 1500-2000 RPM in second or third gear up to 4000 RPM or so. Take close notes regarding your air/fuel ratio (AFR).

2000 RPM --- _______ : 1,

2500 RPM --- _______ : 1,

3000 RPM --- _______ : 1,

3500 RPM --- _______ : 1

4000 RPM --- _______ : 1

You should have very consistent AFR readings from run to run unless the driving conditions have changed markedly. (Make a note if there are any unexplained inconsistencies between runs.) Repeat each run on the same stretch of road if you can. Once you've established this baseline, you can start making changes to your ignition timing.

The next step is to begin "mapping" the optimum timing curve for your engine. But how? The idea is to determine the amount of advance your engine likes at each RPM range (i.e. 500 RPM increment). The trick is to do this by methodically taking AFR readings at incrementally adjusted initial timing settings. In principal, you might like to test from about 2 degrees BTDC to about 20 BTDC, in 2 degree increments. In practice, you won't have to take that many test runs to get what you're looking for!

Initial timing? Yes, initial timing. You're not looking for the initial timing setting that gives you the best performance across the RPM range, and you don't really have to be concerned at this point with the existing mechanical or vacuum advance mechanisms (so long as they're behaving consistently). Instead, you're looking for data points or "spots of perfection" that taken together can be used to create a "perfect distributor". Changes will be made to your distributor's curve to match the total amount of timing needed at each rpm.

So, as you're making test runs and writing down notes, how will you know when you've found the best timing settings? You're looking for the timing adjustment that will provide the leanest observed AFR (at WOT) for each engine RPM range! The best amount of ignition advance will show on the gauge as a **leaner** mixture, with no engine pinging. (Pinging? See below.)

If your AFR gauge readings get richer after making a timing adjustment, you've either gone in the wrong direction or you've gone too far - and your engine isn't burning fuel efficiently.

Just keep repeating the testing process until you find the best timing settings at 2000, 2500, 3000, 3500, & 4000 RPM. Don't worry if any given initial timing adjustment causes a flat spot or hesitation somewhere, as long as it improves performance in one given spot. Disregard any off-throttle or part-throttle information for now. If you change your timing enough to go leaner than 13:1 at WOT, make a fuel mixture change between runs.

Don't worry about drawing an actual map. You don't need to plot out an elaborate "curve". Typically you will see results that entail setting the base timing higher and gradually removing advance from the distributor up to the point where the cam falls off. Your notes at the end of the session might be as simple as this: "16 degrees BTDC at 2000 RPM, 14 degrees BTDC at 2500 and 3000 RPM, and 10 degrees BTDC at 3500 and 4000 RPM."

It's fairly typical to gain 10 percent power (or considerably more in some cases) by going through this process and making subsequent adjustments. While a stoichiometric rate of 14.7:1 is great for fuel mileage, it is too lean for high load conditions such as wide-open throttle. Once you get the basics down, we can move on to tuning for fuel mileage or cruise-tuning later. After all, it's all about WOT anyway, right? But those are more advanced topics for a follow-up article.

Keep in mind that all this tuning must be done on an otherwise properly running engine. It is assumed that a basic tune-up has already been performed and all the ignition components are in good working order. This process is to enhance a good running engine, not troubleshoot a drivability issue, although the A/F meter can potentially be used for that too.

Having an air/fuel meter allows you to check critical data from your engine that you previously took for granted! That's why computer controlled cars usually run so well - they're constantly going through this same process and automatically making programmed corrections. We need to make our corrections the painstakingly difficult way - and live with the results. So take your time, set your car up right and reap the benefits!

Now you just need a good distributor guy to implement your custom ignition curve. (How is this done? Go back and review the ignition article from our last newsletter issue: Ignition Tuning 101: Mechanical Ignition Advance Curves.)

Drive fast and take chances!

What is pinging? The characteristic "pinging" (or "pinking") sound is best described as "rattling like a can of marbles" within your engine, not to be confused with the light tapping noises of solid lifters. It's pretty distinct, even if you've never heard it before! When you hear that sound, fuel is burning prematurely and explosively within the combustion chambers. That's called "detonation", and it can be highly destructive.

In some engines, pinging may be heard when too much timing advance is present in a high-load condition (such as driving up a steep hill at WOT). Pinging is aggravated by poor quality or too low-octane fuel. If you get a tank of bad fuel after setting up your timing, driving in a moderate manner or adding a bottle of octane booster to your fuel are good options. Most likely though, this problem will never affect you if you've used an Air/Fuel Meter to optimize your timing curve. If you go too far in advancing your timing, you'll actually see the mixture start to go rich again. As detonation occurs, the fuel charge usually doesn't fully combust, and that shows up on the Air/Fuel Meter. Your base timing setting can always be altered later too, and that will advance or retard the timing throughout the RPM range as needed.

Disclaimer: This page was researched and written by Jeff Schlemmer. Views expressed are those of the author, and are provided without warrantee or guarantee. Apply at your own risk.

Performance Carburetor Selection and Set Up

The British V8 Newsletter, Volume XV Issue 1

by: Larry Shimp

There is no doubt that fuel injection will give the optimum results, but a properly set up carburetor actually works quite well. The key is "properly set up".

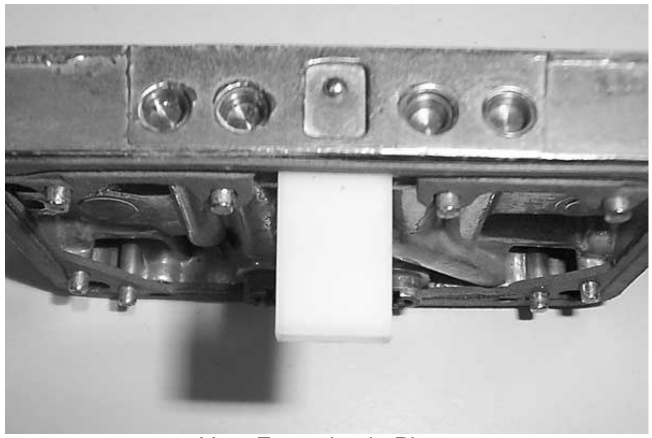
Float bowl and float setting

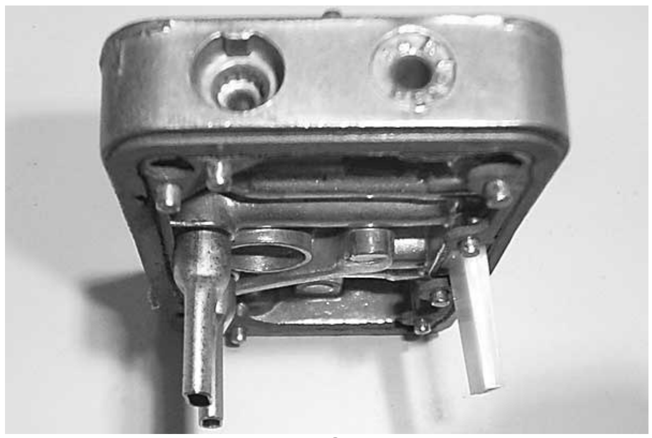
From my experience, the most important factor in carburetor selection is float bowl design. The fuel float is intended to keep the fuel at a constant level within the float bowl which permits the proper functioning of all of the fuel circuits. With an incorrect or fluctuating float level, a carburetor cannot perform properly. When the car is sitting and idling, any carburetor float/bowl works well. The key is what happens when the car is moving, especially at the extreme performance limits possible with a V8 powered MGB.

There are two basic float designs: center hung and side hung. Side hung means the pivot axis of the float is parallel to the direction of travel. Center hung means that the pivot axis is perpendicular to the direction of travel. Side hung floats tend to get upset on hard cornering. The float on the outside of the corner tends to stay closed, letting the fuel level drop, while the inner float tends to open, raising the fuel level. The result is an unequal, sub-optimum fuel mixture that differs on each side of the carburetor, leading to poor throttle response and a lower power output. Holley carburetors can be either side or center hung, but all Carter carburetors are center hung. However, because the Carter float bowls are on either side of the carburetor, they behave more like side hung floats. I first had a Carter carburetor on my car, and experienced poor throttle response on hard cornering. I could find no fix, so I went to a center hung Holley.

The Holley center-hung design completely solved the cornering problem. However, there were some straight line effects that did not show up with the Carter. The most obvious was that the engine would flood and stall on hard braking. The cause was that the fuel in the rear (secondary) fuel bowl would slosh up the vent tube and into the carburetor throat. Holley sells a vent tube modification kit that moves the vent intake from the area by the throat to the outer edge of the float bowl (Summit part number HLY-26-89). This prevents any fuel slosh out of the vent from either bowl on either acceleration or braking. I highly recommend this modification, it solved the problem I had with the engine flooding out and stalling upon hard braking. Installing the vent is easy, but it does require a #51 drill bit to drill a small hole for a rivet/screw using the locating dimple in the metering plate body. (If you have a holley carburetor model without a secondary metering plate, this modification probably won't fit.) The #51 drill is available from Micro Mark and similar hobby suppliers. An alternative to the vent extensions is made by Moroso (Summit part number MOR-65221) which puts a foam baffle in the front of the bowl. However, it requires that the bowls be moved out with a spacer and thus it changes the spacing of the fuel inlets.

Metering Block (note the dimple that has to be drilled out for screw/rivet)


Vent Extension in Place


Vent Extension and Mr. Gasket Jetty Extensions

Another potential problem with the in-line holley fuel bowls is that the fuel in the secondary bowl can move to the rear under hard acceleration, partially starving the secondary jets. The fix for this is a kit that consists of a pair of jet extension tubes that move jets to the rear of the float bowl, and a notched float to clear the jet extensions (Summit part number HLY-116-19), or a kit by Mr Gasket (Summit part number MRG-6060) that consists of a pair of flattened sheet metal jet extensions that can be used with the standard plastic float. (Some carburetors come with a brass float, and this may be too large to work with the jet extensions.) Holley also makes plastic extensions (Summit part number HLY-55009HOL) that do not seem to need a notched float (but probably need a plastic float). Jet extensions are probably not necessary even on a very fast MGB because the drop in fuel level should be compensated for by new fuel entering the carburetor. It makes more sense for big block engines with 1000 cfm carburetors that use huge quantities of fuel during acceleration. However, it does not hurt to install the kit.

The next item to consider is the needle valve itself. The needle valve is held closed by float pressure once the bowl is full, but it must be able to flow very freely once the float level drops a small amount to facilitate keeping fuel level constant during periods of high fuel demand. A metal seat and needle is usually standard, but vibration, vehicle acceleration, and bumps can cause momentary unseating. When vibration causes the valve to bounce, running fuel level will be above the resting fuel level. A remedy for this is a needle with a rubber tip that is more tolerant of vibration and vehicle acceleration.

Naturally, all of the above steps are useless if the initial float level is incorrect. With a Holley, the float level is normally adjusted externally to the height of an inspection hole in the side of the float chamber. The best way to do this is with the engine off and the electric pump on. Holley (and others) make clear plastic plugs to replace the metal bowl plugs, but the plastic plugs cannot be left in permanently because gasoline will eventually attack them. Holley also offers replacement bowls with glass windows, but these are not really necessary. Some old Holley two barrel carburetors even had float chambers made entirely of glass. It was a neat idea, but that concept is long gone.

Remember that Holley has a long tradition in road racing competition, including Le Mans. Their success would not have been possible if the float levels were constantly being upset by acceleration, braking, and cornering!

Fuel pump and lines

The final factor in maintaining proper float bowl levels is the fuel pump. Fuel pumps are rated on a gallon per hour basis, and even the smallest pump would seem adequate for an MGB V8 (after all, no-one uses 20 gallons of fuel per hour). However, in reality, a fuel capacity of at least 75 gallons per hour is necessary to be able to provide enough fuel during high demand acceleration conditions. In general, no fuel pump meant for a 4 cylinder MGB is satisfactory for a V8 MGB because of the much higher momentary fuel consumption possible with a V8.

The pump pressure is also important. Most carburetors are set up to work with 5 to 7 psi. Higher pressure forces open the float valves, and lower pressure cannot keep the level constant under high acceleration. (The pressure needed to force the fuel forward from the fuel tank under rapid acceleration also plays a role in this.) Pumps with a capacity of 150 to 200 gallons per hour or more often have pressures in excess of 7 psi, and therefore need a pressure regulator. However, a 5 to 7 psi rated pump can be found with a flow of around 100 gallons per minute that will be satisfactory.

Electric fuel pumps can be noisy. I have tried pumps manufactured by Carter, Holley, and Mallory. The first two were intolerably noisy, even with rubber isolation mounts. The Mallory is very quiet, and I strongly prefer it for that reason.

With an electric fuel pump, in the event of an accident, fuel can be pumped from a broken fuel line at a high rate and lead to a serious fire hazard. Do not install an electric pump without some type of automatic emergency cut off! I used a standard late model MGB inertia switch. Other inertia switches are available. There are also schemes that use a oil pressure switch that cut off the pump when the oil pressure drops to zero. Whatever system you use, be sure you understand how to install it or have someone who does install it.

The best pump location is back by the fuel tank, where MG originally put it. This keeps the fuel line pressurized and so prevents problems from vapor lock. Put a fuel filter before the pump. This will protect the high speed, precision, moving pump parts from damage from debris. And, of course, follow all of the pump manufacturer's instructions and recommendations.

The fuel line should be 3/8 inch in diameter. Smaller sizes may restrict fuel flow. Use steel line, not rubber line. Rubber hoses should be restricted only to the ends of the line where it joins the pump and carburetor. Be sure to route and clip rubber fuel lines to avoid chaffing or pinching damage. (Give a thought to how vehicle components are likely to shift in an accident.) The metal pipes where the rubber hoses connect should have proper beads to help retain the hoses.

Tuning principles

All of the above preparations (in addition to making sure the ignition system is properly set up) need to be carried out before tuning the carburetor. That way, tuning will only be affected by the carburetor settings themselves. With external influences, tuning will be impossible.

The following tuning recommendations are most applicable to Holley carburetors. Carter and other carburetors may work on different principles. Much has been written about carburetor tuning, so I will concentrate on issues that are especially relevant to a street tuned MGB V8. To begin, there are two basic carburetor types: those with vacuum secondaries and those with mechanical secondaries. For small block street engines, vacuum secondaries make the most sense and there is (in my opinion) no reason to consider mechanical secondaries. The vacuum secondary carburetors have the advantage that they are inherently very adaptable to a wide range of engine sizes and states of tune, while a mechanical secondary carburetor must be carefully matched to the engine as far as flow capacity is concerned.

Any carburetor has three types of fuel circuits: idle, transition, and power (main). Most cruising is on the transition circuit, which is the hardest to tune. Idle is adjusted by the idle jets, and power by the main jets. Transition behavior is mainly governed by fixed air and fuel bleeds that can only be modified by custom fabrication or expensive aftermarket metering blocks. My advice is to find a carburetor that naturally has the "right" transition settings for the engine. Holley has a huge number of carburetor models to choose from, and I have only tried a few. Basically, I have found that the Street Avenger 670 (Summit part number ???????) has excellent characteristics for my Ford 302 crate engine. I also tried the Street Avenger 570 which would seem to be better sized, but the transition circuits were too far off. I also tried various Demon carburetors, including one that was supposed to be perfectly set up for the Ford crate engine, but none were even close. (Luckily with eBay it's possible to buy and sell a bunch of carburetors without spending too much money.)

To assess the carburetors, I used a wide band air/fuel meter installed in the exhaust so I could monitor the mixture while driving. There are traditional ways of tuning such as timing acceleration runs and shutting off the engine at full throttle, then coasting to a stop and checking the plug deposits, but these are not very practical on public roads. Dyno tuning works, but an hour of dyno time can cost over $100, and many sessions may be needed. Therefore the approximate $250 cost of an air/fuel meter seems reasonable.

The goal with the transition circuits is to achieve an air/fuel ratio during cruise of 14 or 15 to 1. Then, upon the slightest throttle opening, the ratio should immediately increase to 11 to 12 to 1 to prevent hesitation. With some carburetors, the transition mixture was very rich (giving poor fuel economy), then went dead lean upon opening the throttle. The only cure for the leanness was very large main jets that resulted in much too rich of a full throttle mixture. I gave up on these carburetors. Note: these results were obtained with small, slow throttle movements that should not involve any accelerator pump action, so increasing the accelerator pump jet size did not help.

The way to influence the richening upon small throttle movements is with the power valve, not the accelerator pump. The power valve is a vacuum operated valve that opens at high vacuum conditions to lean the mixture. It then closes as vacuum drops upon acceleration to richen the mixture. I have a relatively mild cam in my engine so I am using one of the highest rated power valves (closes at 10.5 inches of mercury). With a vacuum gauge I found my cruise vacuum is about 17 inches of mercury, so the power valve is open. Slight throttle opening drops the vacuum to 10 or less inches of mercury, and the power valve instantly closes and richens the mixture. Be aware that the standard power valve in the Holley Street Avengers is rated at about 6.5 inches of mercury, and so will be closed until relatively large throttle openings, unless you have a very radical cam that gives a low cruise vacuum. (Note: The power valve model number is equal to the value of the vacuum at which the valve closes.) This leads to a flat spot at small throttle openings and in most cases the standard power valve needs to be replaced.

Holley secondary metering systems don't normally have a power valve because the secondaries only come into play at relatively low vacuum conditions. But without the richening effect of the power valve, the secondary jet sizes need to be bigger than the primary jet sizes. That's why Holley carburetors normally come with secondary jets about 8 to 10 sizes bigger than the primary jets. If you buy a used carburetor, always replace the power valve just to be sure, and check to see what jets are installed.

Ignition timing

Ignition timing is also important to success with a lean cruise mixture, and a vacuum advance distributor must be used. This will keep the timing well advanced so the slow burning lean cruise mixture will fire properly. Then, as soon as the throttle is opened slightly, the vacuum advance drops out, and the timing reverts to a power setting. Without a vacuum advance, the engine will run poorly on a lean mixture and will almost certainly hesitate with small throttle openings, even with a properly chosen power valve. (My engine runs fine on a 15 to 1 air/fuel ratio and gets about 26 mpg on the highway.)

Power valve protection

From my experience, one problem with power valves is that they can rupture from a carburetor backfire. The Holley Street Avenger (and apparently all Holleys made after about 1992) has a check valve that protects the power valve in the event of a backfire so it's not a problem with this model series. There are also kits made by several manufacturers to retrofit older Holley carburetors with the check valve. I highly recommend this modification.

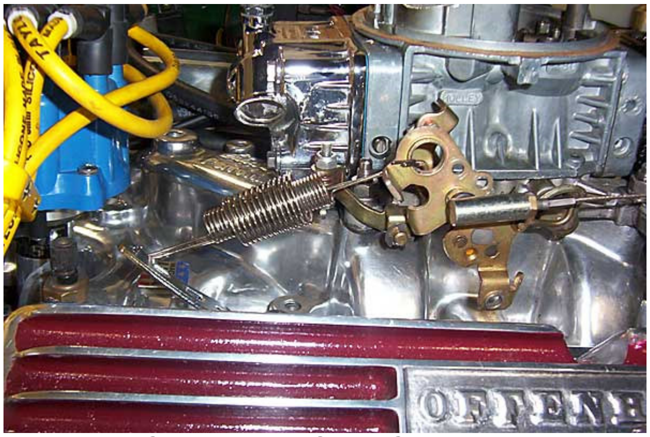
Jetting and secondary vacuum canister springs

With the carburetor properly set up and the right power valve installed, final tuning is relatively very simple. The goal is smooth throttle response with no surging or flat spots associated with rapid throttle openings. If throttle response is good, chances are that the full throttle mixture will be reasonably correct as well. First of all, if there is some hesitation upon throttle opening at low engine speeds, it is probably the accelerator pump circuit. Holley a has a number of accelerator pump cams and even a larger capacity accelerator pump itself (50 cc versus 30 cc). I have found that simply putting in the next size larger accelerator pump jets (0.033 inches versus 0.030 inches) worked fine for my car.

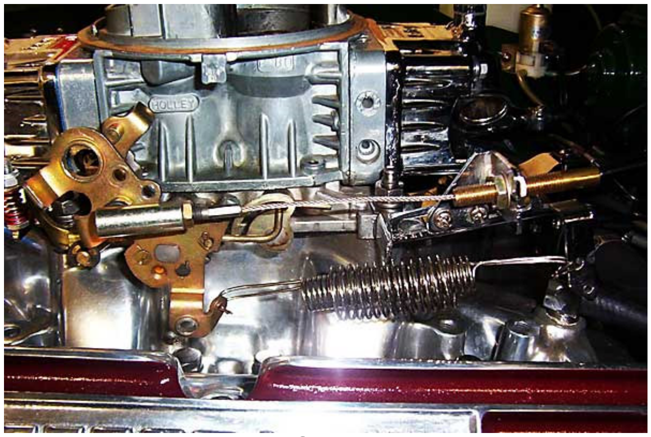
Throttle response

At higher speeds the secondary throttles open. When this occurs there should be no surging, just a smooth increase in power. Some people think there should be a surge as the secondaries open, but this only signifies a lack of power. (A surge means either the engine was down on power until the secondaries opened or there is a flat spot coming and going.) There is no accelerator pump associated with the secondary throttles, the only tuning variables are primary and secondary main jets, and the secondary vacuum capsule spring. If the primary jets are too lean, there will be a surge as the richer secondary jets cut in. On the other hand, if the secondary jets are too lean, there may be a flat spot as the secondaries open. However, too soon of a secondary throttle opening will also cause a flat spot even if the mixture is correct. This can be addressed by putting a stiffer spring in the secondary vacuum capsule. For some reason, with the Holley 570 carburetor, I had a flat spot when the secondaries opened even though the eventual full throttle mixture was fine. Installing much richer secondary and primary jets solved the flat spot, but the full throttle mixture was then too rich. Fitting a stiffer spring in the vacuum capsule worked well, but then the secondaries did not open all the way. For some reason the bigger (670 cfm) carburetor works well with a softer vacuum capsule spring. (Note: the degree of opening of the secondaries can be ascertained by putting a clip on the secondary throttle rod. The clip will be pushed down the rod during driving and give a record of how far the rod has moved. Be very careful that the clip does not jam the throttle linkage and remove it immediately after the test is finished! Note that the secondaries will never open when the engine is revved up in neutral.)

There is a major difference between Holley and Edelbrock (Carter) carburetors in when the vacuum secondaries come into action. With Edelbrock carburetors, the secondaries are interlocked so that they cannot open until the primaries are fully open. With Holley carburetors, there's no interlock and the secondaries can open whenever primary vacuum gets sufficiently high. The Edelbrock interlock is good for fuel economy because the secondaries never open unless the throttle is floored. However, this can lead to sluggish part throttle response, especially with the small primaries that Edelbrocks tend to have. The Holley allows the secondaries to open under part throttle, high RPM conditions. This contributes to a more responsive feel.



Optimal Return Spring Orientation



Incorrect Spring Position

Throttle linkage

Finally, make sure the throttle is opening fully. This is an area that is often overlooked in carburetor set up, and it can cost a ton of power, I had to drill an extra cable mounting hole in my carburetor throttle arm to get the right match between the MGB accelerator and the carburetor. To check, with the engine off, have someone push the throttle to the floor, and then see if you can open the throttle at the carburetor any further. First be sure that the carburetor is fully warmed up and the choke is off because some choke mechanisms limit the throttle opening when cold.

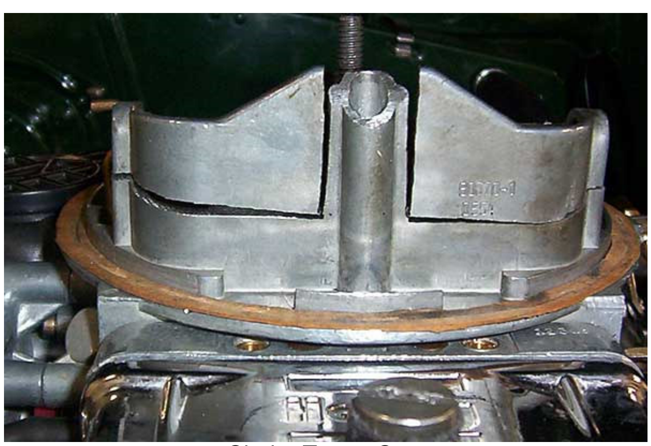
For connecting a throttle cable, I recommend cable ball joints from pegasusautoracing.com (either fixed, # 1276 or quick-disconnect, # 1274).

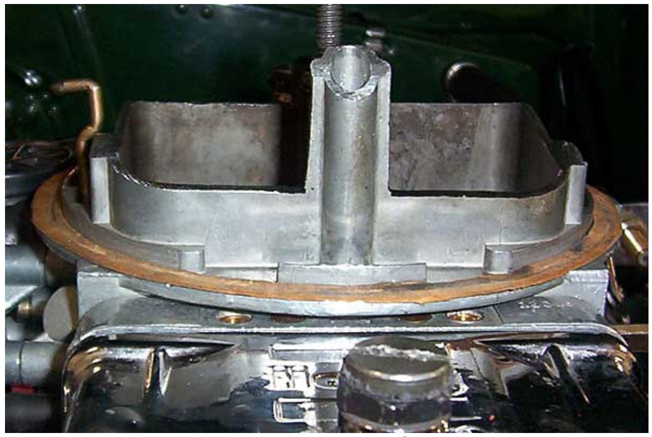
For safety, use dual throttle-return springs and make sure that at full-throttle gas pedal movement is either limited by the floorboard or "pedal stop". The carburetor-mounted linkage is NOT designed to withstand the load you can exert with your leg muscles! Read the carburetor's manual for additional installation recommendations.

The throttle return spring should be installed so that it directly opposes the throttle cable, and not on the opposite side of the throttle shaft. A spring connected to the opposite side of the throttle puts a load on the throttle shaft as the cable pulls against the spring. This creates much more rapid wear in the shaft and bushings which leads to air leaks that will cause an erratic idle and a poor transition response.

Choke

A choke is not really needed with a manual transmission car, but it is a convenience. An air cleaner is, however, essential. With limited hood clearance, often all that will fit is a triangular foam air cleaner by Edelbrock. It is, however, rather poor because it does not filter well, and can upset the flow into the carburetor. An alternative that is almost as compact is the Mr. Gasket dropped-base air cleaner, which really works much better except for one problem. The top of this air cleaner is so low that it can interfere with the choke plate. This is a consequence of the recess in the lid where the attaching nut goes. No other drop case air cleaner has this recess, and it is the main reason why this air cleaner fits under low hoods. I solved the choke interference problem by simply removing the choke plate and shaft. I left the electric choke actuating mechanism in place, as well as the rod that went to the choke shaft. The rod and its plate seal what would otherwise be a hole that would let unfiltered air into the carburetor. The choke mechanism still actuates the fast idle control, and this is enough to make the engine livable, even down to zero degrees. The air cleaner lid just touches the float bowl vent tubes. In the primary carburetor side this looked like it might provide a restriction to air flow because of the choke tower. I eventually cut off the choke tower, and it seemed to make a difference in that the engine seems freer revving before the secondaries open (but it could also be my imagination).


Choke Tower Cuts


Finished View of Modified Choke Tower

One other tip to gain space for the air cleaner is to have the carburetor mounting flange angle milled to tilt the carburetor forward. Just a few degrees will allow the air cleaner to follow the slope of the hood, and this does not necessitate any change to the carburetor mounting studs. This is a tip I picked up from Glen Towery.

Example settings

The optimum settings I found for my car are:
Holley 670 street avenger
Standard secondary spring
Standard accelerator pump and cam
0.033" Accelerator pump jets
10.5 Power valve
58 primary jets
68 secondary jets

Your results may vary because different engines, cams, etc. will influence what the optimum settings will be.

With the above settings my carburetor is "on the edge". This shows up as a slight temperature sensitivity, where below about 40 degrees there is a slight flat spot with small throttle openings (mainly in 5th gear below about 1800 rpm). This gets slightly worse as the temperature goes lower, but even at zero degrees it is still not bothersome. However, this is why car manufacturers adopted heated air supplies to the carburetor with the advent of emissions controls.

A word about manifolds

There are several types of manifolds available including dual plane, single plane and X type (or 360 degree type). One important property of these manifolds is the plenum volume. A large plenum volume is needed for optimal high rpm power. Mixture is drawn alternately from one side of the plenum and the other. The gas develops an inertia as it flows, and this inertia makes flow reversals more difficult. At high engine speeds the inertia problem is worse, and is one of the reasons why high speed cams open earlier on the intake cycle than low speed cams. A large plenum volume reduces the velocity of the gases in the plenum and so minimizes the inertial problem. Performance type manifolds (single plane and X type) already have large plenum volumes, but dual plane manifolds, because they are not intended for all out performance engines, may or may not have decent plenum volumes.

With an engine that has a mild cam and restrictive heads, such as a typical 215 V8, plenum volume of any manifold is sufficient. However, for engines with power peaks in the 6000 rpm range, plenum volume becomes important. For hood clearance reasons, I am using an Edelbrock Performer manifold on my Ford V8. This has a much smaller plenum volume than the Performer RPM manifold, but is otherwise similar. Unfortunately, the small plenum volume of the Performer manifold is probably costing me 30 to 50 hp. This loss can be somewhat mitigated by using a larger carburetor. If there is hood clearance, then a carburetor spacer can be used to increase plenum volume, although it is best to go for a better manifold. In any case, at least with a Ford engine, the availability of relatively cheap stroker kits can make up for the power loss (and more).

Manifolds can be ported. The Edelbrock performer is designed to match the standard iron Ford head port size, but the ports on the GT40X aluminum heads are considerably larger. I ported my manifold to better match the intake ports. The key is to especially enlarge the top portion of the manifold openings to reach the top of the taller ports. Most air flow down the port is on the outside of the port radius, and this starts at the top of the port, so the manifold should match here. The bottom should also be enlarged, but a perfect fit is not as essential. I also enlarged the passages back into the manifold to the point where they opened up as they approached the passage junctions. To make sure the passages were reasonably consistent, I bent coat hanger wires to use as gauges, one for the width, and one for the height. Ideally, the manifold should be flow bench tested to ensure all passages flow equally, but I did not do this.

I really do not know if the power has increased because any increase would be at higher RPMs, and the high RPM power was already really good, with the power peak arriving at 5900 RPM. In any case, there was no noticeable loss of low RPM torque or response. Eventually, I plan to get the car dyno-tested to see what difference this made. (I already have a baseline from before the modifications.)

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Read notes from Pete's **British V8 2006** tech session:
"MGB Ford 302 Engine Conversions"

How Glen Towery Installs Rover EFI on MGB V8 Conversions

The British V8 Newsletter, Volume XV Issue 1

by: Greg Myer

Glen Towery has been playing around with British cars longer than most of us and has a vast amount of experience with V8 swaps. He's also very willing to share his knowledge, experience and opinions. When I first met him several years ago I acquired a tape he had made about MGB V8 swaps and what was needed to accomplish them. In that tape he highly recommended carburetors and had nothing nice to say about fuel injection. Well, now he's been converted!

It seems he was talked into trying the E.F.I. by a friend and learned a bit about it. Now he swears by it, and not at it. Why? Because of the reliability, power and MPG improvements! The Rover "hot-wire" EFI system can be installed on any Buick or Olds 215, or on Rover 3.5L aluminum V8s. (It was factory installed on the 3.9L and larger versions of this engine.) It works with any compression ratio too. There are a few requirements, as we'll see, but nothing drastic.

Glen uses Rover's "Hot Wire" fuel injection (used from '87 - '95) as opposed to the 1980 "Federal" fuel injection system that came on the SD1. The Federal system was thrown into production by Rover to comply with tougher air pollution emission standards here in the U.S. than they were used to in other world markets. It was a decent starting point for Rover's fuel injection development program. The only real problem with it was the only part Lucas supplied: the ECU. The "Federal" has a totally different intake manifold and plenum from all the other Rover systems. Rover engineers then produced several generations of "Flapper-Valve" (Bosch L-Jetronic) based fuel-injection systems, but they weren't exported to the U.S. market.

Lucas's Hot Wire fuel injection system was state-of-the-art in 1987 when they introduced it at the same time as they finally introduced Range Rover into the U.S. market. Glen says it's a great basis for modern FI for your British V8 project as it's Bullet Proof. In fact, Glen likes it so much he refuses to build motors with carburetors any more.

Two generations of Lucas ECU. (Foreground: 14CU or 14CUX. Behind it: 13CU.)

Glen uses a stock computer or Electronic Control Unit (ECU). They change by motor size so he'll need that info from you if you want one. There were some changes through the years. The first generation was called "14CU", followed by the "14CUX" which work for the 3.5 and the 3.9. They can be re-chipped for a 4.2 if needed. In the 1991 and newer 14CUX units the chip just unplugs making that modification easy. RPI in Jolly Olde England has them. It's difficult to tell in the photo, but the plug for the wiring harness is the same. Glen likes to mount the ECU in the passenger-side footwell where it's out of the way but easy to access.

The fuel injectors that came on Rover 3.9L, 4.0L, 4.2L and 4.6L engines are all interchangeable. The injector O-rings are GM listed part numbers, making them easy to locate if the need should arise.

Glen mills 0.800" off the bottom of the Plenum Base to add hood clearance.

The Rover EFI intake manifold, partially assembled.

The fuel rail can be lowered slightly by tweaking its mounting feet.

The manifolds changed very little over the years. Some bosses were tapped for sensors, but not always, so they may appear different but still be the same. To make the plenum fit under an MGB hood Glen has a couple tricks up his sleeve. He has 0.800" of aluminum milled off the lower-half of the "plenum" (as shown) where it mates to the actual manifold. On some tight-fit situations the upper portion may also be machined. You can see in the photo of the two manifolds side by side the difference between the stock and modified units.

Modified motor mounts (shown upper-left and lower-right) put the engine about a half inch lower than "normal".

This gets close to the clearance needed but Glen also makes lowered motor mounts too. You can again see the difference in the photo of them side by side. This will clear most hoods. Speaking of hoods, the steel hood has more clearance in the plenum area than the aluminum one has.

Mass Air Flow (MAF) sensor. (At left, a "tamper proof" plug has been removed to reveal the idle speed adjustment screw.)

The Mass Airflow (MAF) Sensor used by Rover were all the same for these motors. What Glen is pointing out in the photo is the adjustment for the voltage for the idle circuit. Speaking of idle quality, computer controlled fuel injection units need some specifics with regard to cam timing. (The factory cam is fine.) Glen called up Woody Cooper at The Wedge Shop and put him on the speaker phone for a quick refresher course. It seems that too much overlap in the camshaft wreaks havoc with the FI at idle. A cam with 112 degree lobe separation angle or greater is needed. More lift and duration is no problem however. Woody can supply a custom grind for your application. Check out The Wedge Shop for cams, lifters, springs and timing chains. (They've got a beautiful set of headers for a TR8 too.)

Jaguar inline fuel pump.

Glenn recommends Jaguar XJ6 inline fuel pumps, because they can support the high pressure and fuel flow needs of the fuel injection system. Some people have trouble with these Bosch pumps because of where they mount them. Glen mounts them close to the tank and has no problems with fuel pick up. If you need a fuel pump, Glen keeps good used ones in stock. The fuel is routed to the fuel rail, and a bypass allows what isn't used to return to the tank.

Glen's also offers brand new gas tanks with swirl-pots installed. (Editor's note: unlike water, gasoline has very high "vapor pressure" and low "surface tension". This can cause us problems. First of all, compared to other liquids, gasoline doesn't siphon very well to begin with. Secondly, while being pumped and passed through the engine compartment the fuel heats up, and as it heats up it produces vapor bubbles. If these vapor bubbles accumulate in the fuel pump, the pump will "cavitate" and be temporarily unable to supply the engine. The swirl pot helps the bubbles come out of suspension in the liquid fuel.)

Oxygen sensors should be mounted as far forward in the exhaust flow as feasible.

There are two oxygen sensors too. Because their accuracy improves with heat, they should be installed as far forward in the exhaust system as feasible.

The wiring harness complements your car's harness, but obviously doesn't replace it. To integrate it into the car, you must hook up four wires. A "hot" lead is easily gotten from the starter. Another lead goes to the coil, plus one to the ignition to sense when it's "ON" and one for the fuel pump inertia switch to cut off power in case of emergency. That switch is also a GM part, available at many local auto parts stores. There are also a couple of grounds to connect. Note: you may need to shorten some grounds. While discussing wiring, Glen recommended soldering new terminals onto the wires. Solder is cheap insurance for hand-crimped terminals. The only problem he ever had was from a crimp-on connector working loose.

Glen doesn't use the Rover vehicle speed sensor, keeping things simple. He gets good mileage and emissions without it.

All of this sounds very good. Are there any drawbacks? Well, depends what you want to do. The stock E.C.U. has a rev limiter of 5200 RPM. If you have a lot of 'gear' in the rear, and/or a race cam, you may need to re-chip. Glen likes "torque motors" and they give great gas mileage too. His MGBGT with a 3.5 gets 30 MPG and the one with a 4.2 has gotten 25 MPG in Wisconsin while cruising at between 65 and 85 MPH on 87 octane. Now that was a purpose built motor with 6 inch long P76 connecting rods and Isuzu pistons, but that's another story. This does demonstrate the possibilities, however.

Fuel Injection is fun to drive! There's no lag time or hesitation. There's never any fuel starvation in the corners, making it ideal for autocross or road racing.

The proof is in the pudding as they say. Glen took me for a ride in converted car in the rain. It had been a 3.5L with carburetor and now is a 4.2L with FI. More power and better gas mileage, period! On this car, Glen reports that he's getting fully five (5) miles-per-gallon better fuel economy with the more modern induction system. Compression, cam timing, and other factors affect the outcome, but this swap was of similar types of streetable motors. The increased efficiency of the F.I. was the main reason for the MPG gain.

We went out and Glen started the cold car. It was in the 30's and raining, and some snow and sleet were mixed in. Not a good day for displaying horsepower and cornering ability! I knew this when I left home and didn't bring along my G Tech Pro for data acquisition. What the day did do was provide an environment that would challenge many engines to start and idle and drive smoothly. This car didn't sputter once. No bogs or hesitation. Not a moment's fuss. In fact as we headed out and the car was still cold (the windshield hadn't defrosted yet) Glen was cruising along in 4th gear at 1500 RPM and got into the throttle. The engine pulled well even with the 2.79 gearing out back. I've got to get back there when the weather breaks!

If this sounds good to you and you'd like more information; call Glen. You can also e mail him, but he's a little slower at responding to that as he usually has a wrench in his hand and that can be hard on the keyboard. He'll discuss your needs and make recommendations.

Glen's offers a complete Rover hot-wire electronic fuel injection system, complete and ready to install for less than a thousand dollars. That's certainly something to keep in mind as you plan your next build.

Glen Towery

Disclaimer: This page was researched and written by Greg Myer. Views expressed are those of the author, and are provided without warrantee or guarantee. Apply at your own risk.

ADDITIONAL INFORMATION

If you like this article, you'll probably also like: "Hot To Service Rover 14CUX Electronic Fuel Injection" by Curtis Jacobson.

You may also like to review how Rover EFI systems have been installed on these sports cars:	
1	Evan Amaya's Rover powered 1964 MGB
2	Neil Brown's Triumph powered 1968 Triumph TR-250
3	Bob Edgeworth's Rover powered 1972 MGB
4	Scott Miller Rover powered MG RV8
5	Nick Nicholas's Rover powered MGB
6	Jim Stuart's Rover powered 1966 MGB
7	Glen Towery's Rover powered 1974 MGB/GT
8	Edd Weninger's Rover powered 1977 MGB

A Rover 14CUX Electronic Fuel Injection Installation (Installed by Glen Towery. Photo by Greg Myer.)

Service and Troubleshoot Rover 14CUX Electronic Fuel Injection

The British V8 Newsletter, Volume XV Issue 1

compiled by: Curtis Jacobson

INTRODUCTION

For those considering updating a carbureted Buick, Oldsmobile or Rover aluminum V8 engine to electronic fuel injection, the Rover "hot-wire" system is the most logical starting point. The hot-wire mass air flow (MAF) system automatically adapts to conditions such as temperature, humidity, and altitude. The system also automatically adapts to vehicle modifications, such as changes to the air filter or exhaust system, and to differences in fuel quality. No more carburetor jets and no more guesswork! Unlike carburetors, MAF-based electronic fuel injection is automatically self tuning.

The goal of this article is to provide general background information on these systems. This article will focus specifically on the "14CUX" version of Rover electronic fuel injection because it's the newest, most developed, and most widely available of the three generations of Rover hot-wire systems that are feasible to retrofit.

A complete 14CUX system can be bought second-hand quite economically because many Range Rovers are being retired, and because many people in our community of engine swappers prefer the simplicity of carburetors. But what on Earth are they thinking!?! The Rover system will typically provide a more "drivable" engine, a little more horsepower, significantly less pollution, and certainly better fuel economy. Some carburetor designs and installations are negatively affected by acceleraton (including cornering and braking.) EFI installations typically have no problems with radical acceleration. Finally, EFI provides fresh new technical challenges to keep us geeky tech types learning and growing, and it opens up whole new performance opportunities for us to play with.

What about finding information for troubleshooting and tuning? Or the unknown cost and availability of spare Range Rover parts? Those are fair questions... so this article compiles and presents a whole lot of troubleshooting and tuning information, and even includes tips about economical spare parts and alternative sources.

BACKGROUND INFORMATION

The Lucas/Hitachi hot-wire MAF sensor was used on Range Rovers from their introduction in the US market in 1987.

Range Rovers built for other world markets (to 1990), Rover SD1 cars, and non-carbureted Triumph TR8 cars featured an entirely different and more primative sensor technology. Specifically, they used the Bosch L-Jetronic (L for "luft") "moving flap" air flow meter in which the moving current of induction air pushes past a spring-loaded vane. The Bosch L-Jetronic sensor dates back to about 1974. Some of the mechanical parts of these systems may be interesting to engine swappers, but the sensor and Lucas's analog electronic control system generally aren't.

The Lucas/Hitachi hot-wire MAF sensor was used with three different generations of Electronic Control Unit. With each generation the control system's electronic hardware and its programming improved, so the final version is preferable. The final version of Lucas electronic fuel injection was called "14CUX". 14CUX system were installed from 1990 through 1995 on engines with displacements of 3.9 and 4.2 liters.

The 14CUX's immediate predecessor was called 14CU. This system was used on US-market 1989 Range Rovers with 3.9L engines. It's largely similar to the 14CUX system, but the 14CUX provided several new features. Most notably, the 14CUX system included an auxiliary module to assists troubleshooting by displaying numeric fault codes (as shown below). Also, the 14CUX system came with a newer generation of Bosch fuel injectors which provide more power and approximately one mile per gallon better fuel economy. (The newer injectors are easy to retrofit to 13CU and 14CU systems.)

What came before the 14CU system? U.S. (and Swiss) market 1987 and 1988 Range Rovers with 3.5L engines came with a system called 13CU. The 13CU computer is easy to differentiate from later computers because the housing is quite different. Just look for pop-rivets.

One of the coolest things about the Rover 14CUX system is that it will self-adapt to many of our cars. For example, it will work fine with a wide range of compression ratios and exhaust systems. There are a couple notable exceptions. For example, the 14CUX system has a hard time adapting to a cam with a lobe separation angle under 112 degrees.

For special applications like engines with aggressive cams or with displacement enlarged to more than about 4.2L (258cid), one should strongly consider purchasing specially programmed replacement control chips. Especially in England, there are quite a few people hot-rodding Range Rovers and TVR sports cars for off-road performance and competition. The expertise certainly exists to reprogram a 14CUX ECU for good driveability to 4.6L (283cid) and even beyond, but it's not a do-it-yourself job.

Another option for people who want electronic fuel injection on a highly modified Buick, Oldsmobile or Rover aluminum V8 is to use the basic Rover mechanical parts but select a different control system. The most obvious choice is called "MegaSquirt".

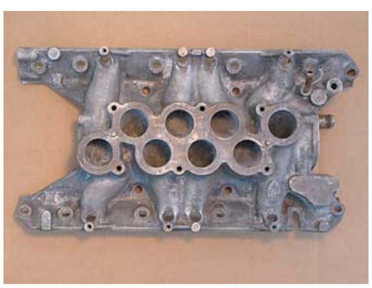
MegaSquirt doesn't require an air flow sensor because Megasquirt systems simply don't measure air flow. Instead, they use a Manifold Absolute Pressure (MAP) sensor, an Intake Air Temperature (IAT) sensor, and usually one or more wide-band oxygen sensors. (The oxygen sensors used by Rover were narrow-band.) Removing the air flow sensor has the benefit of eliminating some restriction in the induction air path, and may subsequently facilitate supercharging, turbocharging, or cowl induction.

The big downside of a MAP-based EFI system such as MegaSquirt is that it needs a complex customized "map" to relate manifold pressure to mass flow. The map can't automatically adapt to changing operating parameters. So, for example, if you change the air-filtration or exhaust system on an engine with MegaSquirt you can expect to spend some time driving around with a laptop computer to modify the fuel map based on empirical feedback from the wideband oxygen sensors. (I'm told this is a great educational exercise, but it sounds too analogous to carburetor re-jetting to appeal to me.)

The Rover 4.0L and 4.6L engines from 1995 to 1999 featured the next word in Rover engine management systems. Called "GEMS", these engines are easy to identify by the 4.0 or 4.6 cast into their intake plenums. The 4.0L and 4.6L control systems will be more challenging to retrofit to older engines because, for one thing, they control both fuel and ignition from one computer. Although many of the mechanical parts are similar, GEMS differs from its predecessors in that it's a sequential multi-port system: each injector is individually controlled instead of the injectors being batch-fired in banks of four. On the ignition side, GEMS is a direct ignition system utilizing four coils. (It provides spark to two cylinders at a time using the well-proven "wasted spark" principal.)

The Rover 4.0L and 4.6L engines from 1999 to 2002 featured the last word in Rover engine management systems. Called "Motronic", these engine management systems were designed and produced by Robert Bosch GmbH. The associated induction system is easy to identify, with prominant curved aluminum intake runners. (These were part of a twin-plenum design with longer runners than earlier Rover systems.) The Bosch "Motronic" EFI system had next to nothing in common with earlier Rover systems. Instead, they showed BMW's temporary influence on Range Rover design.

BASIC MECHANICAL PARTS



Intake Manifold

If you look closely at the Intake Manifold photographs above, you'll see that the fuel injector bosses are at the very bottom of the runners. The injectors spray right into the cylinder head intake ports.

The Rover EFI intake manifold will bolt right onto all Buick, Olds, and Rover aluminum V8 engines, but to assure that the injector spray patterns aren't obstructed it may be necessary to notch the valley pan gasket and also file small reliefs into the edges of the head ports in the immediate vicinity of the injectors. On the other hand, this may NOT be necessary. Jim Stuart reports that his 14CUX-equipped Buick 215 performed flawlessly without any head-port-to-injector clearance added. See the Fuel Injector section below for a close-up view of the manifold ports.

Next to each fuel injector boss is a short raised column. Four of these columns have been drilled and tapped for mounting the fuel rail.

The top surface of the manifold mates to the Plenum Base. It's interesting to note that the Plenum Base and the Plenum Chamber can be installed with the throttle body facing toward either the "driver's side" or the "passenger side". These three major parts are held together by six bolts, but the Plenum Base is also aligned by two steel pins pressed into the manifold.

In the left-hand photo above you can see a threaded hole where the coolant temperature sensor is installed. I've been warned that at some point Rover changed sensors from one with standard pipe threads to one with metric threads, although I've not been able to confirm this. Near the sensor hole you can see a nipple where a hose can be attached for the throttle body warmer. (See below for more info.)

Plenum Base (with eight steel "trumpets")

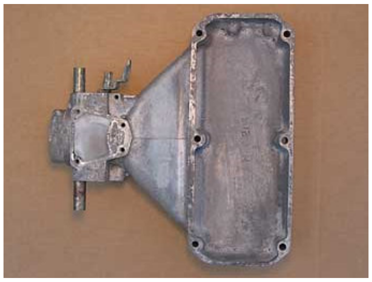
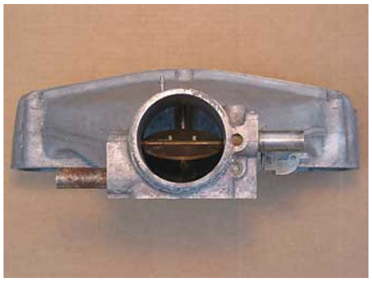
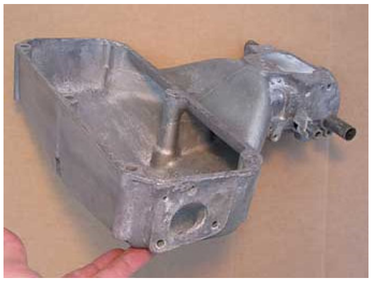
The top left-hand photo in this set shows one of the steel "trumpets" that insert into the Plenum Base and extend upward into the bottom of the Plenum Chamber. The trumpets are all the same length: 100mm. When you see them installed, as in the top right-hand photo, they appear to be two different lengths, but in fact that's just because the holes they're inserted into are machined to different depths.

When you disassemble the plenum assembly you'll find the internals are coated with oil and fuel residue, partly because the crankcase ventilation system feeds into it. To drain the resulting condensation, Rover drilled holes into the Plenum Base that drain back into the intake runners below the trumpets. Those holes can be seen in the photos.

The Rover 14CUX fuel injection system is relatively "tall", so its mechanical components typically must be modified to get it under the bonnet of a sports car. The easiest and most obvious way to reduce the system's height is by milling the bottom surface of the plenum base. In many installations, that's not sufficient and additional milling is required on the top surface of the plenum base and/or the bottom surface of the plenum chamber. Some or all of the steel trumpets may require shortening to accomodate these changes.

So, the first step is to remove the trumpets from the plenum base. You may be surprised to learn they are NOT an interference fit, and in fact they would pull out easily if they were clean. When you're ready to disassemble your plenum, it's likely that most or all of them will be stuck. Getting the trumpets loose is easy if you know the trick: heat the parts in an oven! The aluminum Plenum Base will expand more than the steel trumpets, and you'll be able to simply pull the trumpets out by hand. (Perhaps the heat also loosens gasoline/oil deposits.) Obviously you should first degrease the parts so you don't stink up your kitchen. Wear hot mitts!

From personal experience I can advise that the trumpets will come out easily if the parts are hot enough, but they cool quickly! Several cycles of going in-and-out of a 400° oven will be required. If you get a particularly stubborn trumpet you can gently cool it by wetting a thin strip of cloth in water and lowering it into the tube. The cloth doesn't have to actually contact the steel trumpet to have a dramatic and rapid cooling effect. When steel cools it will contract. Be very careful though, because the steam produced could easily burn you badly. Wear your safety goggles!

Plenum Chamber (with integral throttle body)

The lengths and diameters of runners in the intake system, and also the volume of air in the plenum from which they draw air will affect the performance characteristics of the overall system. Although we lack the resources to comprehensively and scientifically evaluate the performance effects of modifying these components, we can make a few physical measurements and see how they fit "rules of thumbs" published by others.

The inside diameter of each trumpet is 3.81cm. The cross-sections of the runners in the cylinder heads are significantly smaller, but in the intake manifold the runners quickly transition up to round cross-sections of about 3.8cm diameter each. The average total length of all eight runners measured from intake valve to open plenum is about 38.75cm. (Runners 1 and 8 are approximately 41cm long. Runners 2 and 7 are approximately 39cm long. Runners 3 thru 6 are approximately 37.5cm long.)

Based on these measurements, and on articles written by engine guru David Vizard describing the behavior of Helmholtz Resonance induction systems, we can calculate that the Rover induction tract seems to be tuned to achieve peak torque at approximately 5130rpm. Furthermore, according to David Vizard's explanation and formulas, if the runner length is shortened the induction tract's tuning will be shifted to achieve peak torque at an even higher engine speed. (If the shortened runners average 37.95cm, the system will be tuned to provide peak torque at about 5310rpm.)

A quick-and-dirty check revealed that the total air volume of the plenum (base plus chamber to the throttle plate, minus the trumpets) is in the ballpark of 3250cc.

The 14CUX system's "throttle body" is fully integrated into the plenum chamber. The throttle butterfly is 65mm in diameter.

Typically a molded rubber hose elbow is used to connect the MAF sensor to the plenum chamber. The hose flange on the plenum chamber measures 73mm diameter. (The hose flange on the MAF sensor is a little larger; it measures 80mm diameter.)

The two 5/8" O.D. steel pipe nipples are for connection to the positive crankcase ventilation valve and the idle air bypass valve respectively.

Idle speed is NOT adjusted at the throttle linkage as it would be for a carburetor. As a rule, idle speed is self-adjusted by the EFI system. For instructions on how to manually adjust idle speed, please refer to the Air Flow Sensor section below.

The photo on the bottom left shows a plate that mounts underneath the throttle and apparently is intended to warm it to prevent "icing" right at the throttle butterfly. One of the coolant hoses for this plate connects to a nipple on top of the intake manifold, near the the coolant temperature sensor. Most engine swappers discard these components and plug their holes.

The photo at right shows the thermostat housing, thermostat, and a a second coolant temperature sensor that isn't used by the fuel injection system. Incidentally, care should be taken when installing the thermostat to align the vent hole in the thermostat at "12 o'clock."

Fuel Rail and Fuel Pressure Regulator (fuel temperature sensor is also shown)

The Fuel Rail provides fuel to all eight injectors. For the fuel injectors to operate properly, a fairly constant fuel pressure is required, so a Fuel Pressure Regulator is mounted on the fuel rail at the rear of the plenum chamber. The regulator is a mechanical device controlled by plenum chamber vacuum; it ensures that fuel rail pressure is maintained at a constant pressure difference of 2.5 bar above that of the manifold. When pressure exceeds the regulator setting excess fuel is returned to the fuel tank.

To check the fuel pressure, a gauge is fitted to the supply line immediately after the fuel filter. The ignition is powered up, and the gauge is read. The pressure reading should be between 34.0-38.0psi (2.390-2.672 kgf/cm^2). Next, turn the ignition switch off and observe the pressure drop in the system. After one minute, pressure should drop no more than 10psi (0.7 kgf/cm^2). To check for a leaking injector, first check the spark plugs! (A leaking injector will typically result in a sooted-up spark plug.) Range Rover advises that all eight injectors can be removed from the manifold without being disconnected from the fuel rail (which is presumably still full of fuel.) If you can manage to get them out and inspect them for leakage, you should observe no more than two drops of fuel per minute from any injector.

The Fuel Pressure Regulator on our example system is marked "W. Germany", "Lucas", "2.5", "8RV", "84924A", and "7.21311.02".

Warning: performance tuners familiar with older fuel injection systems may be tempted to modify or replace the fuel pressure regulator to achieve fuel pressure increases at the injectors immediately upon increases in throttle opening (triggered via vacuum.) This tuning technique is not appropriate for newer electronic fuel injection systems such as the 14CUX. It's really better to avoid confusing the ECU!

THE CONTROL SYSTEM

Electronic Control Unit - ECU

The Electronic Control Unit is the "brains" of the fuel injection system. On a Range Rover, the ECU is located under the front right hand seat. Various sensors are fitted to the engine to measure and to communicate operating parameters to the ECU. The ECU uses this data to quickly and constantly adjust the amount of fuel delivered. The ECU does this by modulating pulses of the electrical current that opens the fuel injectors. The fuel injectors are divided into two banks of four, and the ECU only has two "outputs" (i.e. one for each bank of injectors.) Inside the ECU, a microprocessor and other components are mounted on printed circuit boards. The ECU is connected to the main harness by a 40 pin connector. The connector terminal/cavities on the ECU housing are not labeled.

The ECU on our example system has a sticker with the following markings: "PRC7081", "14CUX", "85007A", "Electronic Fuel Injection Control Unit", "Made in U.K.", "Date Code 3689", "Land Rover" (plus a bar-code).

A second, smaller sticker on the front of our ECU is impossible to read. It's mildewed and the print is faded. Apparently there were some hand-written marks, but they're unreadable too... All the more reason for us to have a peak inside!

First impressions? Well, it's colorful, isn't it? From my perspective though, the first thing to note about our 14CUX ECU is that it represents several generations of electronics technology. Some of the big, fat resistors, capacitors and diodes on the circuit board would be right at home in a 1960's TV set. The leads on these "discrete components" poke through holes in the board and are soldered to traces on the back-side. Interestingly, in between these large components you'll notice more modern, much more highly-miniaturized surface-mounted devices (SMD). These are mostly still individual resistors, capacitors and diodes, but they don't require through-holes so they're more economical to install, they support greater miniaturization overall, and additionally they're more resistant to vibration and mechanical fatigue. SMDs were just coming into widespread automotive use in the late 1980's. There are SMDs on both sides of the main board. Their presence means two fundamentally different types of assembly and soldering equipment were needed to build the main circuit board.

See the bright green jumper wire? It represents some designer's embarrassing mistake, or at least a last minute design change. I bet that was one expensive piece of wire!

Finally, note how everything (including the wire) has a glossy protective coating of varnish over it? That's called "conformal coating", and from my experience it's not very common on automotive electronic components anymore, except on commercial trucks. Good for Rover!

Look a little closer, and find the mysterious black component on the board that's labeled "Lucas". Okay, it's not THAT mysterious: it's a cover over top of the chip that holds the fuel map programming for the ECU. Before removing the cover, I noticed that the conformal coating on the square chip to its right is scuffed up... someone has been here before me! (And they were prying against delicate electronic parts with a screwdriver.)

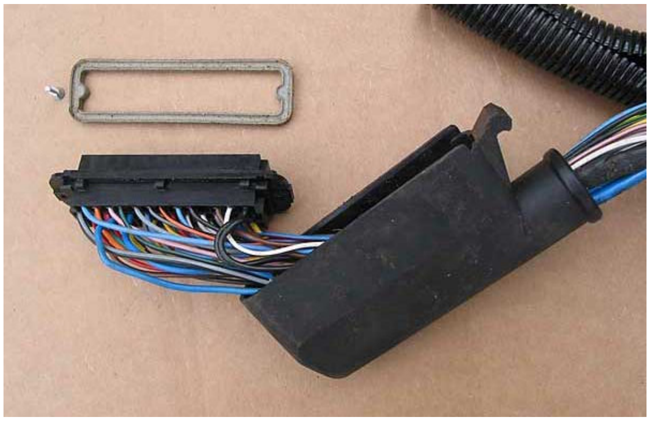
The "Lucas" cover can be pulled off with your finger tips (or with pliers). Take your time... a gentle rocking motion is called for.

Look what I found under the cover! I bet this ECU didn't leave the Rover factory with a hand-written label ("R3362") on its fuel-map chip. Someone has already "re-chipped" this particular ECU!

Many people have reported that the chip isn't socket-mounted on early 14CUX ECUs, but our example ECU seems to argue otherwise.The quality of soldering on the IC chip socket, and the fact that the conformal coating covers both socket and soldering, indicate that the socket was NOT added after board assembly.

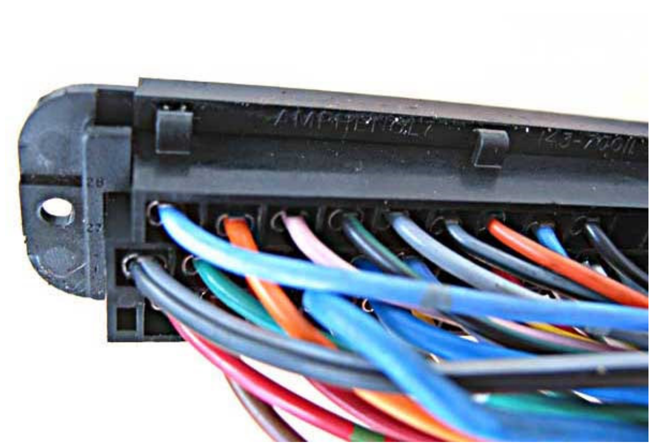
Gently peeling back the hand-written label reveals the date code "9348" and the chip part number "M27C256B-20B3". The date code indicates that this chip is about four years newer than all the other dated components in the ECU (and of course newer than the Range Rover the ECU came out of.) The part number identifies the chip as a 256 Kbit (32Kb x 8) EPROM. What's an EPROM? The acronym stands for "erasable programmable read-only memory".

The next questions are: (1) who programmed this chip and (2) what were the characteristics of the program they selected?



EFI Cable Harness Assembly

The EFI Cable Harness Assembly is connected to the ECU by one 40-pin Amphenol connector (part number 143-70011). The connector is sealed, but can be disassembled by removing two hidden screws from the ECU-side (they're hidden under a rubber seal.) Cable pin positions are labeled on the side of the connector that is hidden by the plastic cover. Pin positions correlate to cable insulation color codes as follows:



"Bottom Row" - pins 1 to 13 (they're numbered from left to right as shown in the photo)

1	Red/Green	Idle bypass valve - circuit 1
2	Brown/Orange	Power feed to the fuel injection main relay
3	Yellow	Throttle position sensor output/reference - see also 20 and 25
4	Black	Oxygen sensors (ground) and to the relay that powers their heater coils
5	Grey/Black	Tune resistor (through VIN LA451517 only)
6	Yellow	Road speed input
7	Green/Blue	Coolant temperature sensor (input) - see also 25
8	Purple/Yellow	Windshield defroster input, if fitted
9	White/Light Green	Diagnostic connector output
10	Black/Yellow	"Check Engine" lamp
11	Yellow/White	Right bank of injectors - cylinders 2, 4, 6 and 8
12	Blue/Red	Main relay "request"
13	Yellow/Blue	Left bank of injectors - cylinders 1, 3, 5 and 7

"Middle Row" - pins 14 to 27 (they're numbered from right to left as shown in the photo)

14	Black	Ground
15	Brown	"Battery" supply
16	Blue/Purple	Fuel pump relay "request"
17	Grey/Yellow	Purge control valve output
18	White/Pink	Diagnostic connector output
19	White/Grey	"Ignition" supply
20	Red	Throttle position sensor (input) - see also 3 and 25
21	Yellow/Black	Air conditioning thermostat input, if fitted
22	Blue/Red	Air flow sensor (input) - see also 25
23	Blue	Signal from the LH oxygen sensor
24	Blue	Signal from the RH oxygen sensor
25	Red/Black	Ground side of coolant, fuel, airflow & throttle-position sensors
26	Green/White	Idle bypass valve - circuit 1
27	Black/Grey	Ground

"Top Row" - pins 28 to 40 (they're numbered from left to right as shown in the photo)

28	Blue/Grey	Idle bypass valve - circuit 2
29	Orange	Idle bypass valve - circuit 2

30	Black	Fault display data
31	Black/Green	Diagnostic connector "request" input
32	Grey/White	Fuel temperature sensor (input) - see also 25
33	Black/Grey	Air conditioning compressor clutch relay, if fitted
34	Orange/Black	Transmission gear switch signal
35	Blue/Green	Air flow sensor (input) - see also 25
36	Black/Green	Air conditioning condenser fan output, if fitted
37	(Not Used)	
38	Brown/Black	Fault display data
39	White/Black	Engine speed signal cable (harness includes 6.8k ohm resistor)
40	Black	Ground

Note:
1. Where two colors are given, the first is the basic color and the second is a "stripe" or "tracer" color.
2. Pins 4, 23, 24, 30, and 31 were NOT USED on vehicles that weren't equipped with catalytic converters.

(This is NOT a "Tune Resistor".)

When visually inspecting the EFI Cable Harness Assembly, one unusual component that's particularly conspicuous is the resistor that Rover included on the Engine Speed sense circuit. This resistor should NOT be confused with the Tune Resistor. This circuit is the only connection between the ignition system and the fuel injection system. A damaged or loosely connected resistor would likely result in an open circuit, leaving the ECU wondering about engine speed.

In our example system this resistor is marked "Lucas", "RD953066", "83630A", and "892Q". The resistor should provide about 6.8k Ohm resistance.

Tune Resistor

A Tune Resistor was originally specified in the wire harness so that one ECU part number could serve multiple vehicle markets. (Multiple computer programs could be stored within the ECU, and the ECU could "decide" which one to use based on what resistance it sensed.) One leg of the Tune Resister was wired to terminal 5 of the ECU, and the other leg was spliced to ground.

At some point during 14CUX production, Rover apparently decided to eliminate the Tune Resistor. (According to Rover service literature, this started with VIN number LA451517.) It isn't clear from the literature whether any US-market 14CUX systems would be effected by having an incorrect or damaged tune resister. The example system we photographed and described for this article NEVER HAD A TUNE RESISTOR!

The following information on Tune Resistors is based on Rover service literature.

Visual inspection of wire color codes will allow you to quickly differentiate between resistors.

White	3900 Ohms	USA and European vehicles with catalytic converters
Green	470 Ohms	UK and European vehicles without catalytic converters
Yellow	910 Ohms	Saudi vehicles (without catalytic converters.)
Red	180 Ohms	Australia and "the rest of the world."

Note: all four types of Rover Tune Resistors were rated for 0.5 Watts.

When fitted, the Tune Resistor was connected to the ECU through terminal position 5, and it was also connected to terminal position 27 through a splice. If you wish to check the resistor, first disconnect power to the system, second disconnect the EFI Cable Harness Assembly from the ECU, and finally simply measure resistance (using an Ohmmeter) from pin 5 to pin 27 on the main ECU connector. (Resistance isn't polarity dependent.)

Injectors

Fuel injectors are the precision valves that meter fuel delivery. The eight fuel injectors are fitted between the pressurized fuel rail and the inlet manifold. Each injector comprises a solenoid operated needle valve with a movable plunger rigidly attached to the nozzle valve. When the solenoid is energized the plunger is attracted off its seat and allows pressurized fuel into the intake manifold.

Minimum fuel flow per injector is 160-175cc per minute using alcohol (for testing), or 180-195cc per minute using gasoline, when tested at 36.25psi (2.54kgf/cm^2) at 20C +/- 2C.

Wiring faults on the injector circuits (and within the injectors) can be tested for at the ECU connector. Turn the ignition off and disconnect the ECU connector. Check the right bank of injectors by measuring resistance between terminals 2 and 11. Check the left bank of injectors by measuring resistance between terminals 2 and 13. In both cases, an Ohmmeter reading of 4-4.5 Ohms is expected. If the reading is 5-6 Ohms, suspect one bad fuel injector. A reading of 8-9 Ohms could indicate two bad injectors, and a reading of 16-17 Ohms could indicate three bad injectors. In any case, if the overall circuit resistance isn't 4-4.5 Ohms, proceed to checking for wiring faults or for open-circuit injectors.

The Injectors in our example system are marked with a green stripe painted around their circumference.

Purchasing original Bosch fuel injectors (part number ERR722, rated 23.67 lbs/hr) from the Rover dealer isn't inexpensive. In fact, even at your local discount auto parts store you can expect to pay almost $100 per injector. (Auto Zone lists GP-Sorenson part number 800-1151N at $96.99/ea. They come with a one year warranty.) Mainly for this reason, Range Rover owners have been seeking cross-references to other usable injectors for years. The internet message boards contain several (typically dramatically less expensive) cross-references (e.g. Bosch/Ford 0280150561, Accel 158021, etc.)

Since injector failure is far more likely to be from obstruction than from electrical problems, you may want to consider having your injectors professionally cleaned. One of our readers, Tony Bates, advises that this can be done for as little as $90/set. (He recommends "Affordable Fuel Injection" in Elsie Michigan.) Fuel injector service should include thorough electrical testing, ultrasonic cleaning, installation of new filter baskets and pintle caps, new o-rings, leak-down testing, spray pattern analysis, and flow testing. (Ask for the test results and make sure all the injectors are performing similarly.)

Bypass Air Valve

The purpose of the Bypass Air Valve is to provide a mechanism by which the fuel injection system can alter the amount of air delivered to the engine, especially when the engine is at idle. The "Bypass Air Valve" is actually a solenoid motor with a plunger that acts as a valve in conjunction with an aluminum casting that it mounts into. The valve-body casting is mounted on the rear surface of the plenum chamber by three bolts. The valve is connected by a rubber hose to the intake tract ahead of the throttle butterfly. The valve includes an integral stepper motor, featuring two windings that are controlled by the ECU, so the ECU can control the valve aperture. For example, the valve provides extra air to maintain idle speed when the engine is under increased mechanical load such as when the air conditioning compressor is engaged.

The Bypass Air Valve has four terminals, but on our example valve they aren't marked on the valve housing. To identify them, refer to the mating connector. You may verify continuity in the windings by measuring across terminal pair cavity-A (orange wire) and cavity-B (blue/grey wire), and then by measuring across terminal pair cavity-C (green/white wire) and cavity-D (red/green wire); in both tests Ohmmeter readings should show 40 to 60 Ohms resistance. If you prefer, you may take these measurements from the ECU connector by measuring at terminal pair 1 and 26 or terminal pair 28 and 29.

Reportedly, the Bypass Air Valve is one of the weakest links of the Rover 14CUX system. It can stick, and we're told that the most typical symptom of this is a fast idle of about 1,500rpm, and also "searching" idle speed when descending hills. WD40 can sometimes un-stick the valve temporarily. The Bypass Air Valve on our example system is marked "73312A" and "82494". The first marking is certainly a part number, and I suspect that the second marking is a date code that indicates the valve has been replaced at some point. If you're familiar with automotive wiring, you'll probably recognize that the connector and terminals for this valve are Packard Weather-Pack components. ("Packard Electrical Division" was part of General Motors, and was spun off to become part of "Delphi Automotive Systems".) The valve itself bears a striking resemblance to AC Delco part number 25527077, which was used on all 4.3L GM V6 engines and most 5.7L GM V8 engines. If you need one of these valves, purchasing the General Motors spec part from your local parts counter will be considerably more economical than dealing with Range Rover.

Fuel Injection Fault Display

The fuel injection fault display provides two-digit diagnostic codes in a way that's very easy to read: the display has a dark red, transparent, molded plastic case. Light emitting diodes can be seen through the side of the case when a fault code is displayed. Nifty!

If multiple faults exist, the display shows the one that the ECU thinks is highest priority. Higher priority faults need to be "cleared" before lower priority faults will be displayed. A "blank" (dark) display usually indicates there are no faults.

Use this procedure to clear faults:
1. Switch "on" the ignition.
2. Disconnect the serial link mating plug, wait five seconds, and reconnect.
3. Switch "off" the ignition, and wait several seconds.
4. Switch "on" the ignition. The display should now reset.

Note: It should either show a lower priority fault code or appear dark.

Rover Diagnostic ("Fault") Codes

12	Mass airflow (MAF) sensor or MAF sensor circuit
14	Coolant temperature sensor (CTS)
15	Fuel temperature sensor (FTS)
17	Throttle position sensor (TPS)
18	Throttle position sensor (TPS)

19	Throttle position sensor (TPS)
21	Tune resistor (open circuit)
23	Fuel system pressure
25	Ignition misfire
28	Air leak
29	Electronic control module (ECM) memory check
34	Injector (or its wiring) - cylinder bank "A"
36	Injector (or its wiring) - cylinder bank "B"
40	Misfire - cylinder bank "A"
44	Oxygen sensor - cylinder bank "A"
45	Oxygen sensor - cylinder bank "B"
48	Idle air control valve (also check the idle speed and road speed sensor)
50	Misfire - cylinder bank "B"
59	"group fault" (it's either an air leak or a fuel supply problem)
68	Vehicle speed sensor (VSS)
69	Gear selector switch
88	Carbon filter solenoid valve ("purge valve") leak

Note: Fault code "02" will appear after a disconnected ECU is reconnected. Simply switch on the ignition to clear the display.

The Fuel Injection Fault Display on our example system is marked "Land Rover", "Range Rover On Board Diagnostic Display", "PRC", "7067", "17EM", "85008A", and "3589". It has a 4-lead pigtail on it that's about 18" long, and the 5-pin connector on the end of the pigtail is unmarked except for terminal cavity numbers.

The wires are connected as follows: 1 - Brown/Orange, 2 - Black/Grey, 3 - Pink, 4 - Not Used, and 5 - Brown/White.

SENSORS

Mass Air Flow Sensor

The Mass Air Flow (MAF) Sensor consists of a cast aluminum body through which air flows. A proportion of this air flow is ducted off from the main air stream to the side into an aperture in which two wire elements are situated: one is a sensing wire and the other is a compensating wire. An integral electronic module controls a measured current of electricity through the sensing wire to produce a heating effect. The compensating wire is also connected to the module but is not heated. Engine intake air passes over the two wires causing a cooling effect, and as they're cooled their electrical resistance slightly changes. The electronic module monitors the change in resistance (and current) through the wires, and by comparing them is able to provide an output signal that is proportional to the air "mass flow rate."

As air flows through the MAF Sensor and specifically over its wire elements, inevitably some dirt accumulates. Although the mileage between cleanings seems to vary widely, the MAF Sensor will need to be cleaned occasionally. It's possible to buy "MAF Sensor Cleaner" in a spray can. Regular old "electrical contact and tuner cleaner" will work too. If cleaning as part of routine maintenance, disassembly of the sensor body isn't generally required.

The MAF Sensor provides a provision for manual engine idle speed adjustment. This provision is not widely discussed, and is certainly not intended to be any part of routine maintenance, because the electronic fuel injection system can and will automatically adjust idle speed on its own. Manual adjustment has potential (if not likelihood) of negatively affecting performance of the whole system. However, what's appropriate for your neighbor's Range Rover may not be so appropriate for your little hot-rod. Manual adjustment of idle speed may be particularly helpful if you aren't running a Vehicle Speed Sensor.

By design, under ECU managment the Bypass Air Valve automatically holds hot idle speed within a range of 665-735 RPM. (The ECU is also programmed to raise idle speed slightly higher when the air conditioning system is operating.) If the idle seems to be surging or providing an out-of-spec idle speed, the following problems are most likely:

1. Defective Bypass Air Valve.
2. Defective/disconnected Vehicle Speed Sensor.
3. Incorrect throttle plate/throttle lever position.
4. Incorrect Throttle Position Sensor adjustment.
5. Incorrect accelerator cable adjustment.
6. Ignition timing not within specification.
7. Vacuum leaks.
8. Incorrect fuel pressure.
9. Inadequate seal at the oil filler cap or dipstick.

If basic repairs or adjustments don't solve the problem, base idle speed should be adjusted. Read and understand all the instructions that follow before you start. Adjustment is made by turning a set screw that's normally hidden under a tamper-resistant plug on the MAF sensor. (The plug in at the end of the cylindrical projection you see in the upper right-hand corner of the first photo above.) To access the screw, first drill a small hole (typically 1/8") in the tamper-resistant plug. Thread a sheetmetal screw into the hole, and then pry the screw & plug out together.

Adjusting Idle Speed : The following steps must be taken in the proper order, even if they seem dumb.

1. Verify once again that the throttle, timing, and TPS adjustments are to spec.
2. Start the engine and operate the vehicle until it reaches normal operating temperature.
3. Attach an accurate tachometer.
4. Switch the ignition on. (Don't start the vehicle!)
5. Disconnect the electrical connector on the Bypass Air Valve.
6. Switch the ignition off.

7. Listen for a "click" sound from the main EFI relay. (On Range Rover, it's under the right front seat.)
8. Reconnect the electrical connector on the Bypass Air Valve.
9. Switch the ignition on. (Don't start the vehicle!)
10. Disconnect the electrical connector on the Bypass Air Valve.
11. Start the vehicle out-of-gear (or in "neutral") without touching the accelerator.
12. Adjust the "base idle speed" screw on the MAF with a 3/16" Allen wrench to 550-650 RPM. Turning counter clockwise will raise the speed and vice versa.
13. Reconnect the electrical connector on the Bypass Air Valve.
14. Switch the ignition off.
15. WAIT for main relay "click" sound.
16. Switch the ignition on, start the engine and rev briefly to 2000 RPM.
17. Note the idle speed. It should stabilize at 665-735 RPM.
18. Install a new "tamper proof" plug.

The Air Flow Sensor on our example system is marked "Lucas", "3AM air flow meter", "Made in Japan", "Service No. 73242A", "Mfg Date 2389", "AFH55-1" and "Hitachi". It has a 6-pin connector on it, with terminal positions labeled "12", "9", "8", "7", "6", and "36" (from left to right).

Throttle Position Sensor

The Throttle Position Sensor is mounted on the side of the plenum chamber inlet neck and is directly coupled to the throttle valve shaft. The potentiometer is a resistive device supplied with a voltage from the ECU. Movement of the throttle pedal causes the throttle valve to open, thus rotating the wiper arm within the potentiometer which in turn varies the resistance in proportion to the valve position. The ECU lengthens the injector open time when it detects a change in output voltage (rising) from the potentiometer. In addition, the ECU will weaken the mixture when it detects the potentiometer output voltage is decreasing under deceleration and will shorten the length of time the injectors are open. When the throttle is fully open, the ECU will detect the corresponding throttle potentiometer voltage and will apply full load enrichment. This is a fixed percentage and is independent of temperature. Full load enrichment is also achieved by adjusting the length of the injector open time. When the throttle is closed, overrun fuel cut off or idle speed control may be facilitated dependant on other inputs to the ECU. The throttle position sensor is designed to be self-adaptive. (At least in theory, adjustment is neither possible nor necessary. This is one small advantage of the 14CUX system over the 14CU system.)

To troubleshoot the Throttle Position Sensor, first disconnect system power and then disconnect the EFI Cable Harness from the ECU. Using an Ohmmeter, verify that resistance between terminals 3 and 25 is between 4000 and 6000 Ohms. Next, reconnect the EFI Cable Harness to the ECU, and turn the ignition key switch "on". Take voltmeter readings from pin 20 to ground. With the sensor in the throttle-closed position, you should read 0.085 to 0.545 volts. With the sensor in the throttle-open position, you should read 4.2 to 4.9 volts. In between these extremes, turning the throttle position sensor should produce a smooth sweep of voltage readings.

The Throttle Position Sensor on our example system is marked "215SA", "84925A", "Lucas", "Made in UK", and "2499". It has a 3-lead pigtail on it that's about 6" long, and the 3-pin connector on the end of the pigtail is marked "Rists". The three cables to the pigtail are color coded "yellow", "red" and "green" respectively.

Road Speed Transducer (photo not yet available)

On Range Rovers, the Road Speed Transducer is mounted on a bracket on the left hand frame rail adjacent to the motor mount. The transducer provides road speed data to the ECU (and on Range Rovers it's also needed by the speedometer). Based on input from the Road Speed Transducer, the ECU selects an appropriate fuel map. When the Road Speed Transducer is omitted or inoperable, the ECU never leaves "idle mode". It isn't clear from the Rover literature we've found exactly how many other modes the ECU might enter if it had an operational Road Speed Transducer. You can actually drive in idle mode, especially if you manually re-adjust idle speed at the MAF Sensor, but cruise fuel economy should be better with a Road Speed Transducer signal properly reaching the ECU.

For safety reasons, Range Rovers have a "kill-joy" function built into the ECU program. If the Road Speed Transducer provides too fast a signal, the vehicle will stop accelerating.

Our example system didn't come to us with a Road Speed Transducer, but we'd like to have one so we can analyze how it functions and determine how feasible it is to provide a road speed signal to the ECU from another source. (For example, anyone who fits an aftermarket electronic speedometer also fits an aftermarket speed transducer. We don't know if an aftermarket speedometer sender can be used for the fuel injection system also.)

Oxygen Sensors (aka: "Lambda Sensors" or "O2 sensors")

The Oxygen Sensors provide a feedback loop. Based on their signals, the ECU is able to determine whether the air/fuel ratio is lean, rich, or okay. The sensors are located on the exhaust pipes just downstream of the exhaust manifolds. Because oxygen sensors are more accurate when they're hot (i.e over 600° F), the oxygen sensors are equipped with integral heater elements.

Oxygen Sensors were an invention of Volvo Car Corporation in the mid 1970's. The sensing element that Volvo pioneered consisted of a "zirconia" (zirconium oxide) ceramic bulb coated with a thin layer of platinum. Over ninety-five percent of all cars that use Oxygen Sensors use zirconia, but the Rover 14CUX system DOESN'T use zirconia sensors! Instead, it uses "titania" (titanium dioxide) sensors. Although they're technically more accurate and faster reacting, titania sensors carry a premium price. Many Nissan's and some Toyota's have also been equipped with titania sensors.

Zirconia Oxygen Sensors provide a fluctuating voltage output between 0.50V and 1.00V. Titania sensors don't create a voltage signal - instead they provide a resistance signal between about 20 kilohm (for a lean mixture) and about 1 kilohm (for a rich mixture). The Rover 14CUX ECU provides the sensors a low-current 5 volt supply and measures the resulting voltage drop across the sensors. So, if you measure DC voltage across the Oxygen Sensors while the vehicle is running (by connecting a voltmeter between terminal 4 and terminals 23 and 24 respectively) you should expect to see voltage readings that vary between 0.50V and 1.00V. Very interestingly, the voltage reading will look similar to what you'd see with zirconia Oxygen Sensors. There's a subtle difference, however. On a Rover 14CUX vehicle, a 0 volt reading means "lean" and a 1 volt reading means "rich", which is the reverse of what you'd expect on most other vehicles.

Unexpectedly low average voltage readings may indicate an air leak, a contaminated injector, or low fuel pressure. Unexpectedly high voltage readings may indicate too high fuel pressure, a leaking injector or injectors, or a saturated carbon canister. If your meter has a "min-max" feature, you can also use it to check the range of oxygen sensor readings - which is actually a better test. Replace a sensor that doesn't go below 0.300 volts or above 0.700 volts.

Note: Oxygen sensors need to heat up before they can be tested meaningfully.

Of course, exhaust gases are released by the engine in rapid pulses. When working properly, an oxygen sensor should be able to sense and report changing oxygen levels very rapidly. How fast an oxygen sensor switches from high voltage to low is measured in "cross counts" (per second). The higher the number of cross counts the better. EFI computers typically expect to see eight to ten cross counts at 2000 RPM. If they don't see enough cross counts they typically throw a "check engine" light.

You can also visually inspect the tip of an oxygen sensor much like you would inspect a spark plug. Black sooty deposits indicate a rich mixture. White chalky deposits indicate silica contamination. (This is often caused by using the wrong type of RTV gasket sealant when reassembling an engine after a repair. The sealant emits a gas which is cycled into the combustion chamber by the PCV system.) White gritty deposits (or green deposits) indicate antifreeze contamination as can be caused by a blown head or intake manifold gasket. Dark brown deposits are an indication of excessive oil consumption (either from a defective PCV valve or from a mechanical problem such as worn valve guides or piston rings.)

The Oxygen Sensors on our example system are marked "Lucas", "3LS", and "NTK D3G". They have 3-lead pigtails that are 17" long, and the 3-pin connector on the end of the pigtail is unmarked. The three leads are color coded "red", "white", and "black" respectively.

Lucas 3LS sensors are actually made by NTK Technical Ceramics; apparently the only parts manufacturer in the world making oxygen sensors with 12mm X 1.25 threads. Totally interchangeable NTK sensors are available from Nissan for a much lower price than at the Rover dealer - the only difference is that you must modify your wiring to connect them. No problem! You're going to get used to modifying the Rover wire harness. Any of the following Nissan part numbers will work: "22690-88G01", "226A0-40U60", "22690-61A00" or "22960-M210". (The various Nissan sensors have different pigtails.)

My local Auto Zone cross-indexes the Rover/Lucas sensors to Bosch (part number 13946) at $138.99. They're not stocked in the store, but they can be ordered.

If you're welding new sensor bungs onto your headers anyway, a few more oxygen sensor options are open to you.

Engine Coolant Temperature Sensor (aka: "thermistor" or "thermal resistor")

The Engine Coolant Temperature Sensor is threaded into a boss on the intake manifold. Note: this sensor contacts the coolant fluid, and thus its threads need to be sealed appropriately. When the engine is "cold", as determined by this sensor, the ECU richens the fuel mixture by lengthening the time injectors stay open. The ECU reduces the length of fuel pulses as the engine reaches normal operating temperature.

The Coolant Temperature Sensor should change resistance with heat, per the following specs.

10C	(14°F)	9100-9300 Ohms
0C	(32°F)	5700-5900 Ohms
20C	(68°F)	2400-2600 Ohms
40C	(104°F)	1100-1300 Ohms
60C	(140°F)	500-700 Ohms
80C	(176°F)	300-400 Ohms
100C	(212°F)	150-200 Ohms

The Engine Coolant Temperature Sensor on our example system is marked "73355A", "Lucas", and "Made in UK". It has a 2-pin integral sealed connector. My local Auto Zone lists this sensor as part number SU5133 at $26.99, and they keep it in stock. Although I haven't been able to verify it, I've also been told this sensor is interchangeable with the sensor in a late 1980's VW Golf.

I'm told that these sensors are a relatively frequent cause of trouble on older Rover fuel injection systems. One installer told me he replaces the Engine Coolant Temperature Sensor whenever he does an engine swap.

Fuel Temperature Sensor (aka: "thermistor" or "thermally sensitive resistor") (see fuel rail photo above)

The Fuel Temperature Sensor is threaded into a boss on the fuel rail, forward of the plenum. (See the fuel rail photograph above.) Note: this sensor does NOT contact fuel, and thus it can be removed without gasoline leakage. The information provided by this sensor is mainly of interest when the engine is being started. If the fuel in the fuel rail is already hot, the ECU "knows" a hot engine is being re-started, and can adjust the mixture accordingly.

The Fuel Temperature Sensor on our example system is marked "Lucas", "Made in UK", and "73273D". It has two terminals.

ADDITIONAL INFORMATION

If you like this article, you'll probably also like: "Glen Towery's Method for Installing Rover Hot-Wire EFI" by Greg Myer.

You may also like to review how Rover EFI systems have been installed on these sports cars:

1. Evan Amaya's Rover powered 1964 MGB
2. Neil Brown's Triumph powered 1968 Triumph TR-250
3. Bob Edgeworth's Rover powered 1972 MGB
4. Scott Miller Rover powered MG RV8
5. Nick Nicholas's Rover powered MGB
6. Jim Stuart's Rover powered 1966 MGB
7. Glen Towery's Rover powered 1974 MGB/GT
8. Edd Weninger's Rover powered 1977 MGB

A WORD OF THANKS

This article wouldn't have come together without a very generous gift from one of our newsletter's readers. Alex Manelis of Lindenwold, New Jersey kindly gave us the Rover fuel injection system that you see photographed here. Alex is simply a very nice guy with a passion for our hobby. He didn't ask us to promote his shop, but we'll give him a "shout out" here anyway! Lindenwold is in the eastern suburbs of Philadelphia. If you're anywhere near Philadelphia we hope you'll consider having your cars serviced by: R.A.M. Auto Repair, Inc. 110A N. White Horse Pike, Lindenwold, NJ 08021. Phone: (856) 435-2200

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Reborn Company LLC

Innovative Solutions

Since 1998, Evan Amaya and his staff at Reborn Company LLC have specialized in service, repair and restoration of both English sports cars and Land Rover four-wheel-drive vehicles. The two vocations have resulted in a unique and complementary skill set. The Reborn team provides expert support for MGB conversion to Rover V8 power!

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Reborn's New Location

(New shop shown. Soon expanding to 6000 sq ft!)

With more room, Reborn Company is expanding its automobile and parts importing businesses. In addition to MG and Rover repair and restoration, Reborn Company can provide Land Rover models that aren't otherwise available in the U.S. Looking for English performance parts? Reborn can help!

Take a moment & have a detailed look at Evan's work!
Evan Amaya's Rover V8 Powered MGB

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Practical Automotive Aerodynamics for MGB V6 and V8 Builders

The British V8 Newsletter, Volume XV Issue 1

by: Curtis Jacobson

In 1957 Sterling Moss piloted "The Roaring Raindrop" (aka EX181, as photographed by Bob Elwin at the "Goodwood Revival"), to a 1.5L Class world-record speed of 245.64mph, averaged over a "flying kilometer", on the Bonneville Salt Flats. Two years later, after engine modifications, Phil Hill set a new speed record in the car at 254.91mph.

None of my readers are likely to see those speeds in a modified MGB, even with three times EX181's engine displacement. The most obvious limiting factors are: "coefficient-of-drag", "frontal area", and "availability of salt flats". Syd Enever's design is exceptionally sleek, with a coefficient-of-drag of just 0.000292. Also, it only stands 39.25 inches tall at the top of the driver's "bubble". (It's about 30 inches tall across the body. I haven't found a width or area measurement.) At just half EX181's record speed, our little cars exhibit scary "light steering" due to aerodynamic lift. If you ask MGB V8 owners what aerodynamic modifications they've made, the answer you're most likely to hear is "I fitted an air dam."

That's well and good. Some air dams have proven effective at improving high speed stability. Some reduce drag. Some duct air better into the cooling system. Some air dams even provide holes from which you can duct air to help cool the brakes. But this article isn't about air dams. That would be an excellent topic for a future article.

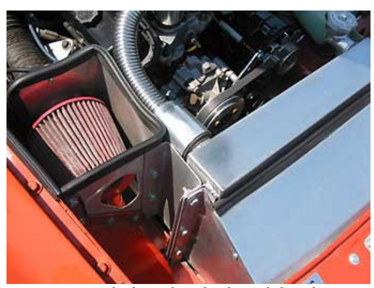
There are many other practical, inexpensive aerodynamic improvements to consider for our cars. This is The British V8 Newsletter's first article on aerodynamics, intended to present a little background plus some measurement and analysis techniques, but it's certainly not a sweeping overview. Rather, it started and remains a response to one deceptively simple little question. Someone asked me: **"How much power can you get from cowl induction?"**

I would have been the first to concede there's probably not much power to be made from cowl induction. Still, it's an interesting question. Answering it properly requires breaking the question into two:

a) What benefit can be gained by pressurizing charge-air via air ducting alone?
b) What additional benefit can be facilitated if the ducted-in air is cooler (and thus more dense) than un-ducted air?

A Few Alternative Places to Draw Air for Your Engine

Kelly Stevenson's air intake is ahead of the radiator.



Bill Guzman's air intake is beside the radiator.

Jim Strait experimented with drawing air from the wheel wells. Curtis Jacobson's air intake is through the MGB cowl vent.

Cowl Induction and Ram Air Effect

When cars move relative to the air around them, air is inevitably pushed around. If it can smoothly slide away without much turbulence, so much the better, right? If we had a "wind tunnel", we could put our cars in it and experiment with various body modifications. We might like to observe how smoke-streams flow over surfaces. Are they "laminar" or turbulent? Where and how do they "detach"? Forget about it! No one I know has a wind tunnel, so we just do the best we can.

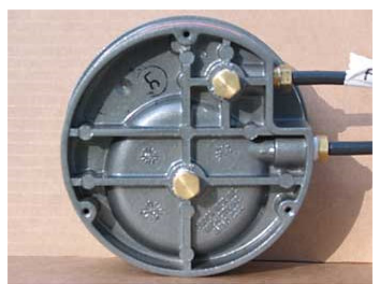
My friend Bill Wardlow at "The Motorway Ltd." in Fort Collins, Colorado told me about an experiment he once did with an MGA. He taped short pieces of thread along the hood and fenders and observed how they behaved as he drove the car. (Magnetic tape from an old cassette tape works well for this too.) One surprising observation was that air seemed to flow OUT of the oval-shaped MGA fender vents at low speeds (say under 25mph) - but at higher speeds, air was sucked INTO them!

Why does air flow? The short answer is that air is constantly being pressurized or depressurized. Air flows as a "fluid" from areas of higher pressure to areas of lower pressure.

Cowl vents like the ones MGB's use for cabin ventilation work because, when the car moves, turbulent air builds up pressure at the base of the windshield. Cowl induction, as historically promoted on Chevrolet muscle cars, is an old trick whereby high pressure air at the base of the windshield is ducted into the carburetor to achieve some pressure boosting effect. Cowl induction is essentially just a variant of "ram air effect", a term more often associated with forward-facing grilles and "hood scoops".

How effective? As a starting point, a physics or fluid dynamics teacher would tell you ram air effect is a function of vehicle speed. Applying Bernoulli's Equation, one can easily calculate the maximum pressure stationary air can apply to a moving object. Drive faster, and the pressure goes up, and in fact it goes up increasingly quickly. The real-world problem is that Bernoulli's Equation only gives us a theoretical maximum. To know how much ram air effect is achievable on a given induction system, it's easiest and best to take actual measurements.

Dwyer-Magnehelic Differential Pressure Gauges are simple, economical, mechanical tools with which one can test the potential efficacy of various kinds of vents. The gauge is most useful for "non destructive" preliminary testing - we don't have to actually install the vents to get a good idea how well they would perform. One could also use this gauge to optimize placement of vents, to analyze pressure drops in ductwork, to check dirt level in an air filter, or to compare heat exchangers (such as radiator cores.)



Magnehelic gauges are 4.5" in diameter and have two sets of 1/8" NPT ports.

I purchased a Magnehelic Differential Pressure Gauge to play with. They're quite expensive if purchased new, but surplus gauges routinely sell on eBay for less than $25. These gauges are made and calibrated for use at many different pressure ranges, so it's important to pick one with an appropriate range and scale. I've found that a gauge that reads from 0 to 2 "inches of water" is convenient for measuring pressure differences around the body of an automobile.


1/8" I.D. crush-resistant PVC hose is routed from the gauge to areas of interest.

To help evaluate potential places to draw air for MGB engine installations (and also to learn more about cooling system airflow) I routed hoses from the dashboard area to four areas of particular interest: (a) in front of the radiator, (b) inside the engine compartment, (c) under the wheel well, and (d) above the cowl vent.

The gauge can only compare two pressure levels at one time, and the user needs to plumb the higher-pressure area to the "high" port on the gauge. (Versions of the gauge are also made with a centered-needle which can read positive or negative differentials.) For these tests I would need to disconnect and reconnect hoses at the gauge multiple times. I chose to start by comparing all four "areas of interest" to cabin pressure. All tests were made with my MGB-GT's windows rolled-up (and with duct tape sealing a few known air leaks). Primarily to make sure my data wasn't screwy, I also made test runs with the gauge connected for direct comparisons between front-of-radiator vs. engine-compartment, cowl-area vs. engine-compartment, and engine-compartment vs. wheel-well. The columns of hand-written data were a little overwhelming, but they proved reassuringly consistent.

The air pressure test results below are the actual measurements made while driving my 1971 MGB-GT on Interstate 25 in Colorado between Longmont and Fort Collins. Our elevation is in the ballpark of 5300 feet above sea level. Air temperature was in the low sixties and humidity was very low. See below for further details about the test vehicle.

There was only light traffic while I was testing. I was careful to avoid following other vehicles because their presence tended to make gauge readings erratic. In a couple areas the highway crests small hills or ducks into small valleys. These also tended to cause erratic readings. Although the gauge needle was never completely still, I tried to only record relatively stable readings.

	60 MPH	**70 MPH**	**60 MPH**	**70 MPH**
Raw Differential Pressure Readings	(inches of water)		(converted to p.s.i.)	
Cowl Vent vs. Cabin	0.90	1.15	0.033	0.042
Radiator Front vs. Cabin	1.45	1.70	0.052	0.061
Engine Compartment vs. Cabin	0.15	0.30	0.005	0.011
Wheel Well vs. Cabin	-0.25	-0.35	-0.009	-0.013

	60 MPH	**70 MPH**	**60 MPH**	**70 MPH**
Calculated Pressure Differentials	(inches of water)		(converted to p.s.i.)	
Cowl Vent vs. Engine Compartment	0.75	0.85	0.027	0.031
Radiator Front vs. Engine Compartment	1.30	1.40	0.047	0.051
Wheel Well vs. Engine Compartment	-0.40	-0.65	-0.015	-0.024

Calculation of Ram Air Induction Performance Benefits

Consider the formula: $hp_2 = hp_1 * (d_2 / d_1)$

where: hp_2 = the new horsepower at density d_2
hp_1= the old horsepower at density d_1

Although "density" and "pressure" aren't interchangeable terms, they are closely related and for practical purposes we can cheat a little...

To quickly <u>estimate</u> what power gain might be feasible from utilizing ram-air to achieve a modestly pressurized air/fuel mixture, we can simply look at a ratio of relative induction air pressures. Standard air pressure at sea level is defined as "one atmosphere", which is commonly measured and agreed to be 14.7psi. However, I took my pressure differential measurements near Denver Colorado, the "mile high city". At our altitude ambient air pressure is only about 83 percent of that at sea level - approximately 12.2psi.

Remember, I measured the "boost" pressure in front of the radiator (at 70 MPH) to be 0.051psi.

p_1 = 12.2psi

p_2 = 12.2psi + 0.051psi

p_2 / p_1 = (12.2psi + 0.051psi)/12.2psi = 1.0042

This quick calculation indicates that the maximum realistic horsepower benefit one should expect from ram-air effect on an MGB at 70MPH is in the ballpark of 0.42 percent.

Disappointing.

A few words of meager consolation: some people have criticized cowl and ram-air induction systems on hot-rods because they believe these systems might cause the engines to run very lean at high road speeds or very rich at low road speeds, depending on how you tune the engine. In practice, these concerns are unwarranted for British sports car enthusiasts precisely because cowl and ram-air induction systems simply aren't that effective. Ram-air induction certainly is highly effective on purpose-built race cars that achieve much higher speeds than I tested.

On the other hand, a legitimate concern with cowl and ram-air induction systems is they can cause engine damage in the rain or when driving on wet roads. They MUST have an effective air-water separator. A very little bit of water won't hurt most engines (and it might even help sometimes,) but a big gulp of water will cause catastrophic engine failure! Water can also damage air filters.

What does the gauge say about cooling system design?

Like Bill Wardlow's test with bits of thread (described above), a Differential Pressure Gauge can be used to demonstrate clearly that vents in the rearward section of an MGB hood change from "exhaust vents" into "air inlets" as the car accelerates beyond a threshold speed. When they're behaving as inlet vents, they increase air pressure in the engine compartment and thus they probably become counter-productive to cooling. Vents further forward on the hood might look weird, but they'd probably perform better because they would increase airflow through the radiator as the car travels (regardless of speed).

The test results indicate vents in the inner fenders would enhance airflow through the radiator at cruising speed because air pressure is significantly lower in the wheel wells than in the engine compartment.

I was curious to see whether electric cooling fans help or hurt at various speeds. My fans are switched on-and-off at the dashboard, not with a thermostat, so it was easy for me to test this. With the Differential Pressure Gauge I didn't see a noticeable effect at 60 MPH, but at 70 MPH switching "on" the electric radiator fans slightly reduced pressure-drop (and thus airflow) across the radiator core.

Standard Disclaimer: your results will vary. Results will vary from car-to-car based on factors such as roadster-vs.-GT (windshield rake and height are different), early-vs-late model (for many obvious reasons), whether an air dam is fitted, and by the amount of air resistance provided by various different radiator cores.

Cold Air Induction

All car enthusiasts know that cramming more air into an engine will allow the engine to produce more power. (You've heard of superchargers and turbochargers, right?) And, we pretty much all accept that cool air is denser than warm air, and thus contains more oxygen per unit volume, so it's possible to produce more power on a chilly day. How much performance benefit can an MGB realize by installing a simple cold air induction system?

If you have a good grasp of algebra, it's possible to estimate an answer based on the classic work of Charles, Boyle, and Avogadro. You may recall from physics class that the "Ideal Gas Law" is usually expressed as: `PV = nRT`
where: P = pressure, V = volume, R = the gas constant (about 287.05 for dry air), T = temperature ("absolute"),
and "n" = number of moles... which is related to the number of air molecules, an indication of the mass of the air.

I'll stop right there! If you want to know more about applying the Ideal Gas Law, I strongly suggest you drink two cups of coffee and go to Richard Shelquist's exceptional explanation of air density calculation techniques. I found Richard's website while running down a tip from British V8 contributor Greg Fast (an engineer at Valeo Climate Controls) about "SAE J1349".

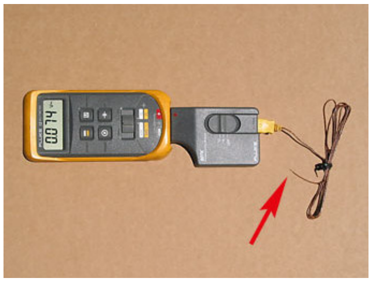
I learned from Greg that the Society of Automotive Engineers (SAE) has published industry standards for normalizing dynamometer measurements so that engines and related systems tested in one set of atmospheric conditions can meaningfully be compared with tests taken under different atmospheric conditions. The SAE J1349 standard provides us with a powerful tool: a mathematical formula into which we can enter air temperature, "altimeter setting" (which we can get daily from online aviation weather reports), dew point (a measure of humidity), and altitude. If we provide these four measurements, SAE J1349 will allow us to calculate "relative horsepower" as a percentage of "rated horsepower". If we plug in two different temperatures, we'll get out two different relative horsepowers. Comparing them should be one reasonable way to estimate the potential benefit of cold air induction.

So, conveniently, Richard Shelquist's website also provides a handy SAE J1349 Engine Tuner's Calculator! While playing around with the calculator, I noticed that Richard is my neighbor here in Longmont Colorado. I called him up to discuss how to properly use the tool. Richard advised: "For proper comparison with the established standards, the air temperature should be the actual air temperature going into the engine (that is, the air temperature immediately after any air filter)."

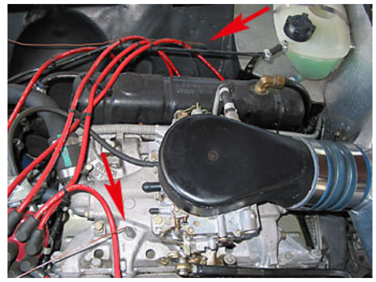
I plugged a bunch of number combinations into the calculator. For example, assuming ducted-in air at 64° F, a 30 in-hg altimeter setting (suggested by Richard), 45° dew point and 5100 feet elevation, the relative horsepower would be 82.9 percent. Substituting an engine compartment temperature of 160°, relative horsepower would be 75.3 percent. Applying these percentages, an engine with an SAE rating of 200 hp would actually produce 165.8 hp when fed cool air versus 150.6 hp with warmer air. **That's an impressive 15.2 horsepower increase, and a full ten percent improvement!**

I can already anticipate some of the questions... How hot is the air under the hood when the car is actually moving? How much temperature rise occurs in the cold-air induction system pipe? Just because you supply the carburetor cooler air, can you prove the air is still cooler below the carburetor? Don't you have to put the carburetor in an insulated box? What about the temperature of the fuel supply? Isn't the denser air going to screw up your stoichiometric equilibrium? Etc.

I decided to scratch a little deeper. To get started, I first bought some relatively inexpensive tools. A dynamometer would have been very nice, but I don't know anyone who has one. For that matter, a "G-Tech Pro" would be helpful... but even that's outside my budget right now. I chose instead to go on eBay and pick up a couple Fluke K-type thermocouples and an adapter for reading them with my trusty multimeter. Although they won't measure power, they might help us understand the system.



Thermocouples are tough, and have very little mass. They're smaller than the thin cable that goes to them! (In this photo the multimeter is reading 74° F.)



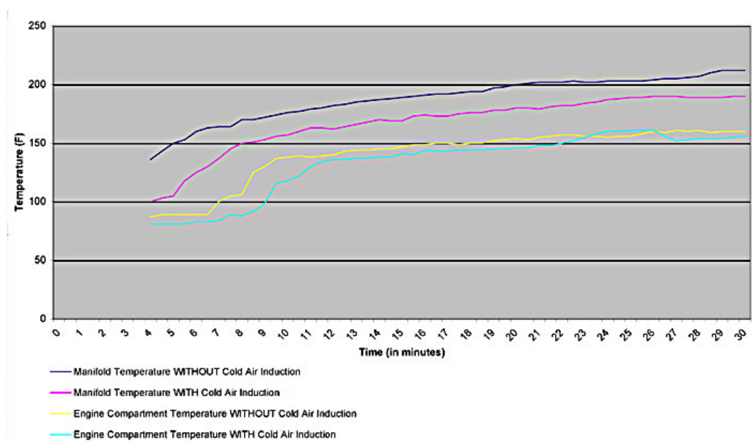
I positioned two thermocouples, as shown here. One is actually INSIDE manifold runner number "1". (The cowl-induction system is shown installed.)

If you've ever used a digital indoor/outdoor thermometer, you've used a thermocouple. The main advantage of the thermocouples I bought is that they aren't encased in plastic. Their low mass means gauge readings change quickly and accurately. Also, thermocouples can be placed in tight places. I'll find lots of uses for these little jewels!

The initial temperature measurements below were made in Longmont Colorado on two mornings in March. Ambient temperature was about 64° F on both days, and humidity was very low. (The NOAA website reported dew point was 28° F.) Our elevation is in the ballpark of 5100 feet above sea level. Due to differences in conditions, your results would probably vary. For further details about the test vehicle, please see below.

The initial test procedure was pretty simple (if arbitrary)... the "cold" engine was started and allowed to idle normally. Temperature readings were recorded at thirty second intervals for thirty minutes - long enough for everything to reach steady-state temperatures. Since the electric cooling fans are manually operated on my car, I turned them on when the coolant temperature gauge read "190".

For the first morning's test the cowl induction system was intact. For the second morning's test I removed the blue hose, so air was drawn from the engine compartment, and I blocked off the air filter aperture in the firewall.



What does this graph mean? First of all, it shows that the underhood temperature of a stationary MGB V8 will come to a stable temperature over time. That temperature (e.g. about 160°) is a realistic starting point for discussion, although the air temperature under the hood will certainly drop when the vehicle is in motion and (jumping ahead) it will certainly spike higher when a working engine first comes to a stop.

This chart also shows that the temperature of the air/fuel mixture (aka "charge air") inside the intake manifold runner can be significantly and reliably lower on a car with cold air induction. From the nine-minute mark onward, the charge air presented for combustion was consistently about 18° F cooler when cold air induction was fitted. Depending on your perspective, the temperature differences may be more or less than expected.

We clearly demonstrated something important: **"Colder air in" results in "colder air out".**

Considering that under-hood air temperature rose to over 150° F (i.e. 86° over ambient), I expected to see a bigger difference between the two charge air temperature curves. At the end of the first morning's test, air was rising from 64° F to 190° F within the induction tract - an increase of 126°. At the end of the second day's test, air was only rising from 160° F to 212° F - an increase of only 52°!

MGB V6 builder Scot Abbott provided some explanation: "The cooler air will not so readily vaporize the fuel and hence will be cooled less by evaporation than the warmer air, which will evaporate the fuel more readily and hence be cooled more in the process. This would cause a leveling of the temperatures of the differing temperature air masses."

Disappointing. By this time, I was starting to wish this article had been about air dams.

I decided to take a drive on rural roads east of town.

I actually ended up taking two drives to road test the same two induction configurations as before. Each drive was about 30 minutes long and included rural roads with speeds up to 60 MPH and occasional stop-signs and traffic lights.

My first observation was that engine compartment air temperature drops steadily when the car is moving, and rises quickly when the car is stopped, within predictable limits. During the two test drives I never saw the engine compartment air temperature go below 90° or above 210°. On average it was about halfway in between. (Notice that the sensor was located at valve cover height but above the exhaust headers. This location was chosen because it's approximately where a round drop-base air cleaner or Holley "Hi-Tek" air cleaner would draw air from. For road testing the sensor cables were re-routed, through the hole behind the master cylinders, back into the cabin.)

Charge air temperature readings behaved more interestingly. Downstream of the carburetor, air temperature is clearly and directly affected by fuel flow. (You might expect higher engine RPM and resulting increased airflow would noticeably reduce charge air temperature, but that effect is overshadowed.)

The first drive was with cold air (cowl) induction. Temperature swung quickly between 90° F and over 180° F. Readings dropped like a rock during acceleration, and rose immediately when the throttle was released. They were much more steady at cruise, typically between 120° and 150°, although they varied with speed and engine load. At stoplights, charge air temperature went to about 170° or 175°, and then crept slowly upward toward 190°.

The second test drive, with cold air induction disconnected, was more surprising. Even though engine compartment air temperature was sometimes quite moderate, and even though I tried all sorts of acceleration rates and throttle positions, in this drive I never once saw the charge air temperature go below 128° F.

Temperatures observed during the two drives are summarized in the following table:

	With Conventional Induction	**With Cold Air (Cowl) Induction**
Temperature Inside Intake Runner	Fahrenheit	Fahrenheit
Full Range Observed	128° - 205°	90° - 180°
Cruise (approximate)	145° - 165°	120° - 150°
Idle (stabilized)	195° - 200°	170° - 190°
Wide Open Throttle (best observed)	128°	90°

Bottom line? The MGB cold air (cowl) induction system reduced the temperature of the air/fuel mixture (measured about halfway between carburetor jets and intake valves) in all tested situations, summarized as follows:

		Conventional Induction vs. Cold Air (Cowl) Induction		
		Temperatures (measured)	Temperatures (absolute)	Difference
Test 1	stationary steady-state operation (like when you're waiting at a long stoplight)	200° vs. 182° (F)	660° vs. 642° (R)	18°
Test 2	accelerating at wide-open-throttle (like when you're racing to the next stoplight)	128° vs. 90° (F)	587° vs. 550° (R)	37°

Calculation of Cold Air Induction Performance Benefits

What do all these ramblings and numbers mean? Pragmatically, we're just looking for a realistic estimate for expected power gain from the charge air temperature reductions we actually observed. To that end, my suggestion is to return to SAE J1349 and to the correction factor it prescribes for dynamometer calibration.

Even though SAE J1349 was developed for comparing temperatures UPSTREAM of the induction system - substituting the wide-open-throttle temperatures we observed INSIDE the number "1" intake runner is instructive if only because it provides a very "conservative" system performance estimate to contrast against the preliminary numbers we started with (above).

You can use Richard Shelquist's nifty calculator... or just go straight to the SAE J1349 correction formula:

$hp_2 = hp_1 * [1.18 * (T_{2a}/T_{1a})^{0.5} - 0.18]$

where: hp_2 = the new horsepower at temperature T_{2a}
hp_1 = the old horsepower at temperature T_{1a}
T_{1a} = the absolute temperature of the fuel / air mixture provided by cold-air induction
T_{2a} = the absolute temperature of the fuel / air mixture provided by conventional induction

When accelerating at wide-open-throttle:

$T_{2a} = 587° R$

$T_{1a} = 550° R$

$1.18 * (T_{2a} / T_{1a})^{0.5} - 0.18 = 1.18 * (587° R / 550° R)^{0.5} - 0.18 = 1.038$

This quick calculation, based on actual measurements on a typical spring day, indicates that cold air induction on my V8-powered MGB should be providing **at least 3.8 percent power increase at wide open throttle**.

Cold air induction systems provide their maximum performance advantage after leaving a stop, when engine compartment air is relatively high, and when the vehicle is accelerating at wide-open-throttle.

In combination with ram-air effect at high speeds (e.g. at the dragstrip) the potential performance benefit may temporarily be higher. (Add the 0.47 percent "boost effect" estimated above to the 3.8 percent estimated here.)

On a car like Kelly Stevenson's Ford 5.0, fuel-injected, V8-powered MGB (shown above), a 4.3 percent gain translates to over eleven horsepower. That's a lot of benefit from simply fitting a straight, foot-long aluminum tube!

It would be wild over-selling to call cold air induction a "poor man's supercharger" based on the benefits we observed, but the benefits are real and they are significant. We'd be hard-pressed to identify a cheaper, easier, or lower-risk way to improve engine performance.

There will be some readers who won't believe the benefits of cold air induction until they see dynamometer results. To them I'd point out that a typical dynamometer installation would have difficulty modeling how temperature changes under the hood as a vehicle moves through air. It would be best to more fully instrument a car and do additional road testing. Perhaps we'll be able to revisit the question in the future with a proper (continuously monitoring) data acquisition system.

To be fair, it shouldn't be forgotten that efficiently venting heat out of the engine compartment would reduce the relative advantage of cold air induction.

The cold air induction system itself seems to provide a modest benefit to engine cooling. In our stationary tests we found that engine compartment air temperature was consistently about six degrees lower with cold air induction operating. Once up to operating temperature, the engine should operate slightly more efficiently. On the other hand, the engine's rise to operating temperature will be slower, which is undesirable from an engine wear, fuel economy, or air pollution point of view.

Larry Shimp suggested a potential way to increase the benefit of cold air induction further:
"One other interesting possibility with a cold air intake is that if it is in the form of a long tube to the front of the car, and the tube isn't too big in diameter, it could be refined into an intake tuning device. It would have a natural resonant frequency (like a tuned exhaust) of relatively low frequency, and if properly tuned it might help low speed torque."

What About Stoichiometry?

In theory, a "stoich" mixture has just enough oxygen for complete combustion of the available fuel. Basic stoichiometry tells us that in order to produce more power, we need to maintain the correct air/fuel ratio. How do ram-air effect and cold air induction effect stoichiometry? I was surprised to learn that the answers to this question are pretty similar for both carbureted and electronically fuel injected engines.

Quite a few people believe that cooler air flowing through a carburetor doesn't automatically drag more fuel into the intake, and therefore they assume that cold air induction must make carbureted engines harder to tune for maximum power. The fundamental belief is wrong, and so is the associated conclusion.

Although carburetors don't have a "brain" or sensor to measure temperature, all carburetors function similarly in that pressure drop across a venturi is the mechanism that pulls fuel into the venturi. The pressure drop itself is a function of air density. Temperature and ram air effect both play into that equation. In other words, carburetors are largely self-adapting.

Carburetors are surprisingly effective at adapting within the limited range of operating conditions we subject them to. Without cold air induction, your carburetor must accommodate a significantly wider range of air temperatures than if you supplied air from outside the engine compartment. In other words, the term "cold air induction" is misleading; we're really talking about "less preheated induction"! (Still skeptical? If you start your engine on a freezing-cold day and allow it to warm up, the temperature inside the engine compartment rises from about 32° to at least 100°, and probably higher. On a 100° day your engine compartment starts at 100° and rises to over 160°. Obviously outside air doesn't vary 130°, even with global warming. With cold air induction, your car sees a narrower range of air temperatures both season-to-season and minute-to-minute.) On modified British sports cars, cold air induction generally simplifies carburetor tuning and reduces common carburetor maladies such as "boiling" or percolation.

Larry Shimp added the following insights:
"In general, for a port fuel injected engine, the colder the air the better. Fuel goes almost directly into the cylinders. But for an engine with a carburetor, (especially a central carburetor as opposed to one barrel per cylinder Weber carburetors) the fuel must stay in the air stream all the way to the cylinders, and so a certain amount of manifold heat is needed for economy and drivability..." [Larry also pointed out that exhaust-heated intake manifolds can aid throttle response, and particularly enhance the functionality of carburetors that use accelerator pumps (which don't fully atomize the fuel they add). - editor]

Larry continued:
"In the early days of emissions controls, auto manufacturers found that they had to keep the intake air to the carburetor at as constant a temperature as possible. They did this by thermally controlled air valves on tubing off of the air cleaner. One tube went to a cold air intake in the front of the car, the other to a spot just above the exhaust manifold. The air valve mixed the cold and hot air to give a reasonably constant intake temperature. With this, they were able to use leaner mixtures without throttle response problems.

"Carburetor icing can be a serious problem with a cold air intake. This condition occurs under high humidity conditions when the air temperature is between about 32° and 40° F. Evaporation of the fuel in the carburetor will cool the air to below freezing, and the water vapor in the air will condense out and freeze in the carburetor, blocking jets or even jamming the throttle. In Colorado, there is almost never enough humidity to cause this, but it is a real problem in other places."

If you do a lot of cold weather driving, cold air induction may not be a good fit for you. But frankly I believe most V6 and V8 MGB conversions see decreased usage as weather approaches or crosses the freezing mark. I've used cold air induction on my V8 conversion since 1992. From my point of view the system has performed very well. Your expectations and results may vary.

If your engine is equipped with electronic fuel injection, cold air induction is a "no-brainer"! Your engine's control system is already equipped to automatically adjust to and benefit from cooler air when it's available. Furthermore, it's typically easier and cheaper to fabricate (or purchase) simple tubing or ductwork to provide cool air to fuel-injected engines.

The newest "electronic" engines can benefit even more from ram-air and cold air induction because they automatically fine tune ignition timing based on air density, as typically measured by a MAF sensor. Cooler intake air means ignition timing can be advanced slightly more, because tendency for potentially damaging preignition ("pinging") is reduced.

If your car tends to "ping" when driven on hot days, installing cold air induction may help. Furthermore, if a car with conventional ignition is converted to cold air intake, it might be a good idea to see if a little more timing advance can be used - to realize even more performance improvement!

The Test Vehicle

My 1971 MGB-GT "test vehicle" is fitted with a fairly mildly tuned Buick 215 V8 engine. For people who aren't familiar with the Buick 215, it's an all-aluminum engine where the aluminum intake manifold is not heated by any exhaust passage and the manifold is also entirely unconnected to the engine block. (The lifter gallery is covered by a "valley pan" which also serves as a gasket between the manifold and the cylinder heads.) My engine breathes through an Edelbrock 1404 four-barrel downdraft carburetor and a panel air filter (mounted flush to the firewall).

The car has an air dam, and it rides on low profile 14" tires. The original grille and oil cooler have been removed. The radiator core is stock MGB (although the mounting is modified). Before testing, I added foam rubber between the top of the radiator and the hood to block air from bypassing the radiator. Stock MGBs have a seal at the radiator bulkhead and also a seal around the rear of the hood. My inner fenders are stock. I haven't fitted RV8-style headers, which would alter the test results due to the holes they require in the inner fenders.

Before starting any testing, I filled the fuel tank with "Premium Unleaded", and I didn't top it off again. No changes whatsoever were made to carburetor or ignition tuning throughout the tests. The carburetor choke plate on my carburetor was removed years ago, and the throttle linkage doesn't have a fast idle setting. Due to differences between our vehicles, your results would probably vary.

A Word of Thanks

This article wouldn't have come together without very generous contributions from three newsletter readers. I wish to thank Steve DeGroat of Lugoff SC, David Maples of Augusta GA, and George Cooper of Weeki Wachee FL. Their financial contributions paid for the new measurement tools I used in researching this article. If you think this article was too damn long, blame Larry Shimp. Larry's encouragement and thought provoking comments encouraged me to extend the article in several areas.

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Learn more about Bill's own MGB-V6 here:
www.britishv8.org/MG/BillGuzman.htm

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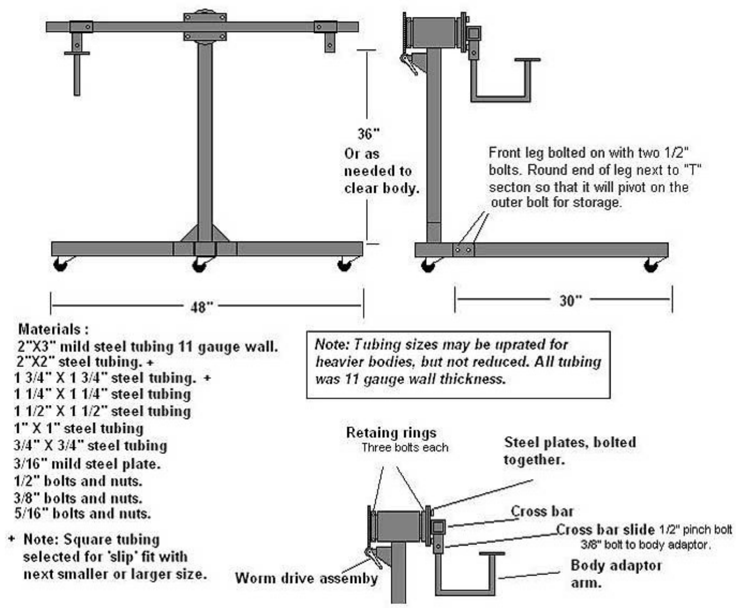
Instructions for Building an Auto Body Rotisserie

The British V8 Newsletter, Volume XV Issue 1

by: Bill Young

This rotisserie design is adaptable to a variety of different chassis and bodies by altering the design of the adaptor arms. Owning both an MGA and a Midget, I wanted something that would work for both yet break down into reasonably small pieces for storage when not in use. The photos show the rotisserie in use during restoration of my MGA, but different arms would enable use with almost any small car body, frame, or chassis.

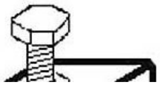


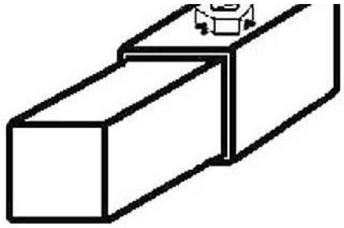
I'm not an engineer, and I won't guarantee the weight capacity of this design, but it works well for my MGA and I believe that it would be suitable for any lightweight automobile - certainly any British sports car.

As far as designing an 'offset' for the arms in order to get the best balance for the body, unless you have unusually heavy chassis components installed the center of gravity will usually be located fairly close to the actual physical center of the body. Simply measure the height of the body and make arms that will offset the mounting points one half that amount from the center of rotation.

Rotation is controlled by a worm drive from a hand winch purchased from Harbor Freight. The worm drive components were removed from the winch and adapted for use on the rotisserie. This type of drive allows for complete rotation without the need for a 'pinch bolt'. The reduction ratio is 40:1 and effort is very reasonable to rotate the body. Only one drive is necessary; the other end of the rotisserie doesn't require anything but a pivot.

I am using the term pinch bolt to indicate a nut welded to the tubing or pipe and a bolt which threads through that to contact an inner piece of tubing or pipe. This effectively acts as a positive lock to prevent movement between the two pieces.

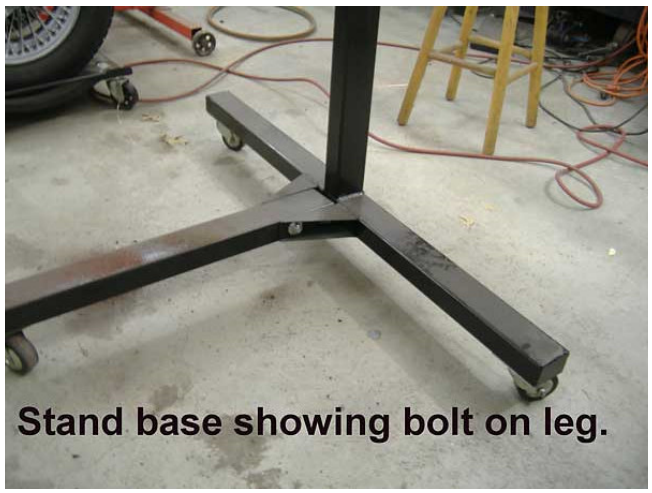




One piece of box tubing slides within another larger one, and then
is locked into position when the bolt tip is tightened against it.
(A hex nut has been welded onto the larger piece of tubing.)

The rotary heads on each stand were made from steel tubing or pipe. I did have to reduce the size of the larger pieces to make a nice fit with the inner parts. This required splitting one side of the tubing, removing some material and reforming using a hammer and vise until a good fit was achieved, then welding. I added a grease Zerk to each head for lubrication. The inner sections of the rotary heads are removable for maintenance. They are retained by rings with three 5/16" bolts drilled and taped into the inner pieces. The large gear for the worm drive is welded to one of these rings for the drive end.

The unit is designed to break down into pieces for storage or transport. The largest piece will be approximately 4' X 4' X 10". The cross pieces to which the adaptor arms are mounted are removable. They are welded to rectangular pieces of steel plate which are bolted to matching pieces on the rotating head. The adaptor arms are of a two piece design consisting of cross bar mounts and the actual body adaptor arms. The cross bar mounts are designed to slide on the cross bar and be held in place by half inch pinch bolts. This allow for use on different width bodies, or if necessary, offsetting the body on the rotisserie. The body mount arms are designed to give as much body clearance as possible in order to facilitate access to the body for repairs or even painting. The body mount arms are bolted to the cross bar slides for ease of assembly and making changing adaptors easier.



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Shop Tech: An Alternative Approach to Building Car Dollies

The British V8 Newsletter, Volume XV Issue 1, April 2007

by: Joe Schafer

After seeing Greg Myer's article "Shop Tech: Constructing a Car Dolly" in the December newsletter I figured I'd share my setup - not to be better or worse - but just to show a different approach with different advantages and disadvantages.

I started with a set of car roller dollies that you can purchase almost anywhere (Harbor Freight, Sears, Tractor Supply, etc.) and I extended them 14" using 2" angle and then installing a cross brace. (The cross brace is very important!)

I can't imagine having built my car without them. They are the perfect height for me on a creeper. The engine and transmission were in and out of my car at least 20 times, and the stands were perfect height to help with that. When you need room in the shop for something else, just roll the car into the corner.

The unique drawback of this approach is that you can't work on the suspension or even have one wheel off. Also, like a traditional car dolly you wouldn't want to get in a hurry pushing the car because as Greg Myer mentioned, a stone or a wrench could make for a bad deal.

Setting the car on the dollies takes less than 20 minutes. (I have an extension for my floor-jack that I cut on a lathe to raise the saddle 6"). I just raise the car one end at a time and set it on jack stands. Then I put my extension on the jack and raise the car the rest of the way. Finally I substitute the dollies for jack-stands and lower the car down onto the dollies.

I can honestly say that my car would not be halfway done had I not come up with something like this! If you are short on shop space, you can keep the car in the corner. Then when you have an hour or two to tinker with it, simply pull it out and in five minutes you can be working on it. It only takes five minutes to put it away again. It is easy to move and for me the perfect height for doing 99 percent of my 302 conversion.

What would I do differently next time? I might only go 8 or 10 inches, because reaching over the fender to work on the engine requires standing on a milk crate.

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At Richland Motor Cars we specialize in building turnkey and bespoke MGB-V8 conversions based on Rover aluminum V8 engines. These engines provide a great deal of power while improving the MGB's legendary character, balance and handling. (The aluminum V8 engines weigh significantly less than MGB cast-iron four cylinder engines.) Parts are readily available and it's easy to upgrade to more power.

We usually mate the Rover engine to Borg Warner T5 gearboxes (as used in Camaros in the 1990's) and modified Chevy S10 rear axles (because they work well with the T5, have excellent brakes, and can economically be set-up with appropriate gear ratios.) For even better performance, we're quite skilled and experienced at rebuilding, narrowing and installing Jaguar independent rear suspensions (IRS) in MGB's.

We offer turnkey MGB-V8 cars for sale, or we can complete projects to your specifications. We're expert at integrating all aspects of the conversion process, including detailing the engine compartment, customizing the vehicle interior, and upgrading the car's electrical and climate control systems for vastly improved safety, comfort and reliability.

We don't offer conversion kits or parts... that's a big advantage to our customers because it means we can provide more objective advice and more concentrated service. We have excellent working relationships with all the important V8 conversion parts specialists because we're not competing with them.

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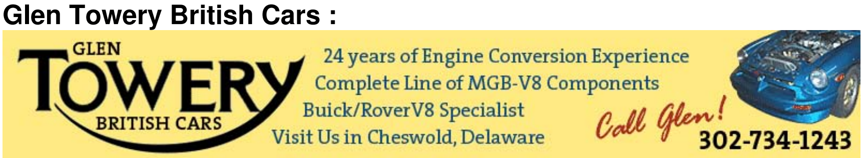

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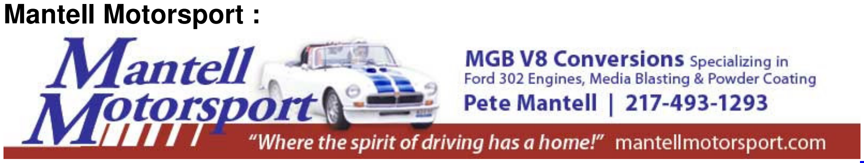

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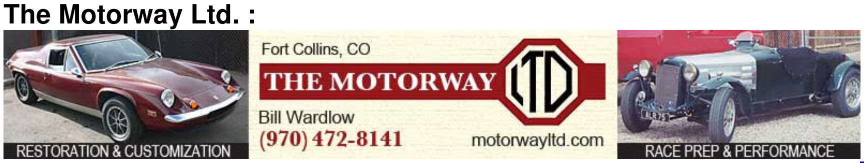

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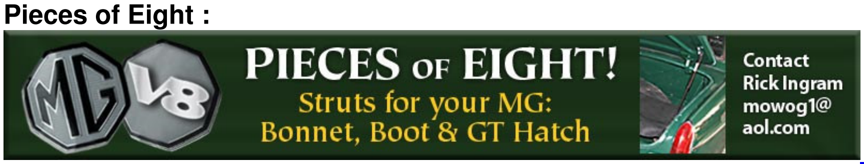

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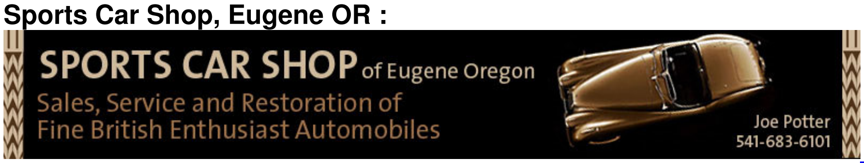

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