If you want to be competitive in international-type rallies, you'd better start by rebuilding your car from the ground up!

SCOTT HARVEY AND RALLY

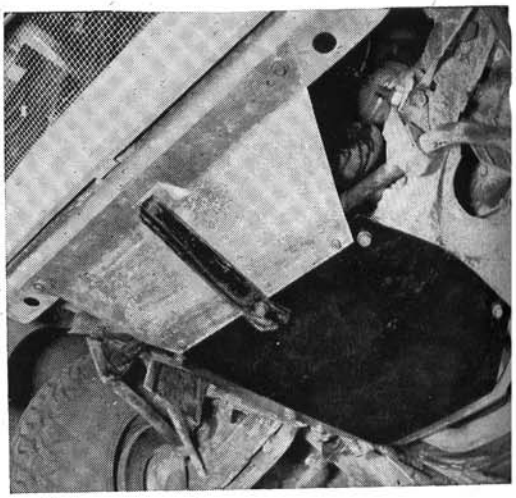
Scott Harvey, staff engineer for Chrysler Corporation, has been involved with sports cars for many years. He has twice won the SCCA National Rally Championship, the SCCA Central Division Sedan Racing Championship, and the big car class on the Shell 4000 Rally. In 1966 he took the award for best aggregate performance on closed sections on the Shell Rally and directed the Star-Fish Racing Team of Barracudas on the Trans-American circuit. He has built cars for several different types of events. Many of the performance items described below, although helpful, would be unnecessary in any competition in North America except the FIA Championship-status Shell 4000 Rally.

CAR PREPARATION FOR ANY COMPETITION IS USUALLY A COMPROMISE. Preparing a car for an international rally is no exception. In fact, the variables involved may require having the best all-around prepared car of any event in the world. For example, the roads used on the Shell 4000 rally in Canada range from the deep-rutted, twenty-mile-an-hour log-

ging roads of Ontario to the near ideal surfaces of the St. Jovite and Westwood race circuits to the deep sand and gravel trails of the Sandilands 'closed section' in Manitoba, where big-engined cars hit 130 down the long straights. Temperature conditions may vary from an eighty-degree afternoon in British Columbia to a near-zero, pre-dawn start in the Prairie Provinces.

Pre-rally preparation is becoming most important in North America, because regulations concerning 'service crews' have become quite restrictive over the past few years. In most cases, the service crew, at best, can provide tools, parts, and verbal assistance.

The first decision one has to make in order to compete is: with what car, and what engine size? For many people there is no choice, but if you are fortunate enough to have several cars or engine sizes available, look over the regulations for the chosen event, because they change from year to year. For instance, the use of studded tires was banned on the 1967 Canadian Winter Rally (see pages 31-34), severely handicapping the larger cars.



In the rally office, watches and odos replace the glove box, driving light switches replace the ashtray, extra cables and fuses are within easy reach. The Halda and compass are positioned so both of the crew can read them, and magnetic clips on the dash have unlimited purposes.

Photos: Chrysler Corporation

One very important consideration is the inherent strength of the car. Some cars are just not physically capable of absorbing the beating they will have to take in a European-style rally.

Preparation

Once you have decided on the 'winning' car, strip it as if you were starting to prepare for a season of racing. Get rid of all excess weight, within the limits of Appendix J or applicable rules, of course. (International Rally regulations require all cars to conform to the rules of Appendix J of the FIA code under Group 1, 2, or 3.) Get rid of all undercoating and insulating material and, while you're doing this, look for places that may require welding or additional reinforcement to take the pounding of a grueling cross-country drive.

Engine

The engine will be out of the car, of course, and it should be torn down, thoroughly inspected, and reassembled with proper care, including proper torquing of all bolts and nuts. Port matching, head milling, etc., can be done while the engine is down. Bearing clearances should not be increased, because you will probably be using 10W-30 motor oil (remember the zero-degree cold starts). Compression ratio should be eleven-to-one as an absolute maximum. Good gasoline is usually available at scheduled stops, but an occasional stop

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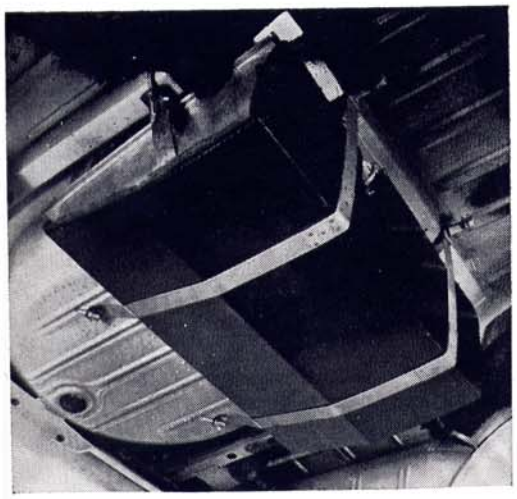

Protective plating also helps keep debris from the engine, screen keeps rocks out of the radiator. Gas tank shield is 1/16 hard aluminum plate, and held on by straps bolted to floor pan and shock absorber studs. Driver's seat is made for comfort not concours; fold down rear seats are a handy spot to carry spare wheels.

may be necessary at a gas station in the back country. The octane rating of gasoline obtained at the unscheduled stop is always questionable.

A performance camshaft should be fitted, but not the grind that would be used for racing. There will be times during the rally when you will want to idle gently through a slippery gumbo field or across glare ice at 1000 rpm in top gear, so install a camshaft that will allow this.

Appendix J allows a lot of freedom in carburetors. Be sure the carburetor you fit doesn't have an icing problem, won't vibrate apart on washboard roads, and can be fitted with a good, adequate air-cleaner. We use a large, dry-element air cleaner and change it if the day's run has been dusty. The stock carburetor may, in many cases, be the best compromise.

Prepare the engine for maximum power output without reducing its durability or flexibility. How's that for a compromise?

Clutch, Transmission, and Rear Axle

The clutch disc should have a competition lining and the pressure plate should be modified for higher loads that most production cars incorporate.

The transmission should be checked and well broken-in before the start of the rally. If optional ratios are available, it is nice to have second, third, and fourth gears close in ratio, but first gear should be a 'stump-puller.' A reverse lockout is a 'must' on the shift linkage. Driving the gravel 'closed sections' requires a lot of third-to-second downshifts and just an instant's delay at the cross-over gate could be disastrous.

The rear axle should have a limited-slip differential. The proper ratio should be determined by several factors: maximum allowable engine revs, tire revolutions/mile (tire manufacturer technical data), and estimated top speed needed on the rally. If you decide on 6000 as maximum revs, 800 rev/mi on tires, and 100 mph, then the ratio should be:

$$\frac{800 \text{ rev/min} \times 100 \text{ mi/hr} \times 1/60 \text{ hr/min}}{6000 \text{ rev/min}} = 4.5$$

Suspension and Tires

Handling is obviously one of the basic considerations. The car should be as near neutral steering as possible so it will go around corners properly on ice, gravel, or pavement. The variables that can be readily manipulated to arrive at this desired characteristic are weight distribution, spring rates, and tire characteristics.

Weight distribution can be juggled quite a bit on a car properly outfitted for rally work. The placement of auxiliary gas tank, spare tires, tools, winch, spare parts, and protective plating can make quite a difference in weight distribution. To reduce understeer or increase oversteer, shift weight toward the rear. Conversely, to reduce oversteer or increase understeer, the weight should be shifted forward.

A consideration that ties in with spring rates is ground clearance. This is a real compromise since maximum ground clearance is desirable in deep snow or high-center logging roads and minimum ground clearance (very low center of gravity) is desirable for some closed sections, especially the race circuits. Probably the best compromise on car height is to raise the car one to two inches above standard. Most major manufacturers offer a heavy-duty suspension which lifts the car about one inch and a 'station-wagon, heavy-duty suspension' which lifts the car a little higher. Spring rates usually go up about twenty percent for heavy duty and an additional twenty percent for heavy-duty station wagon. Ground clearance can also be increased by using larger tires.

To reduce understeer or increase oversteer, increase rear-spring rates more than front. In an extreme condition, reduce size of the front sway-bar or add a rear one. For an American compact car, I would suggest a starting point of heavy-duty, station-wagon rear springs and heavy-duty front springs.

Shock absorbers are a special problem, particularly on the Shell Rally, and many people plan to change shocks daily. I have changed just one shock absorber on five Shell 4000s, and that one was because a rear shock housing was near failure from five days of rock peening. The solution is to use as low a control shock as will damp out suspension oscillations on rough roads, prevent wallowing during the transient stage of cornering, and prevent brake hop on high deceleration rates. Excessively high shock-control on extremely rough roads can cause premature shock failure, put more impact loading into the car's structure, and may cause the shock-absorber attaching brackets to fail — a very serious failure in the middle of the rally. A strategically placed 'mud flap' will prevent the rear shocks from being rock peened.

Tires have been a big problem, especially on the fast cars. In recent years, extremely good, spiked tires have been developed for use on snow and ice rallies. Generally speaking, on North American winter events, the more studs the better, for in the extreme conditions of a winter rally on the back roads they are a decided advantage. Ordinarily, average speeds on paved roads are relatively low and can be easily maintained, despite the deterioration of handling characteristics with a multitude of spikes in the tires. There has been a great difference of opinion on what constitutes the best, all-around-compromise tire for the Shell 4000, as is evident by the variety of tires used each year. Until last season, a good high-speed mud and snow tire was lacking. We now have radial-ply and low cord-angle snow tires capable of 130 mph, so I think they will be fairly universal this year. I prefer the same tire on all four corners for predictable handling on any surface. Snow treads on the front do help some on loose surface deceleration and cornering. To reduce understeer or increase oversteer, use slightly larger tires, or more tire pressure, in the front than in the rear. Using snow tires rear and conventional tires front will increase oversteer on pavement and good unpaved surface; however, in loose snow or mud understeer will be increased. It's risky to mix snow tires with conventional tires where so many different type surfaces are encountered. With all tires alike, the spare tire problem is simplified.

When preparation nears completion and the car is driven for handling evaluation, don't use an empty car in testing and then start the rally with a fully loaded car. Twenty gallons of gas, two spare tires, and all the assorted tools, equipment, and spare parts that go in the car during the rally can drastically change the handling characteristics.

Brakes

If disc brakes are homologated for the car of your choice, use them. Nothing will do as much for your peace-of-mind as knowing that, when you hit the brakes at any temperature or humidity condition, they will not be erratic. This is especially true on the one-lane, mountain roads with thousand-foot drops at the edge of the two ruts. Good competition pads should be used on the front discs. The rear drums should have a good, stable lining also. Brakes should be balanced for front-rear distribution on gravel. In case they cannot be balanced at all temperatures, be sure you don't have a 'rear wheel only' lock-up problem under any condition. Brakes can be balanced by changing wheel-cylinder size, lining

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length, lining coefficient, or, on most domestic cars with discs, by adjusting the brake distribution-valve.

A dual or tandem master-cylinder is a good thing to have. Front brakes alone would be pretty good, although I'm not quite sure what you'd do with rear brakes only. They provide about thirty percent of the braking normally, and the car is terribly unstable when only rear brakes are used. Brake lines should be re-routed to eliminate the possibilities of damage. Any line that remains exposed should be covered with coil-spring-type armor.

Fuel System

There are at least two good reasons for adding an auxiliary gas tank. It's nice to have the extra range, and the regular tank may be damaged or become contaminated. Closed-section driving causes the car to use a great deal of gasoline, as does second-gear, wide-open-throttle driving on the logging roads.

On many cars, another regular stock tank can be installed in the trunk, directly over or opposite the existing one. This is a particularly neat arrangement for several reasons. Stock gas-tanks are very light and quite inexpensive. With minor modification, the gas-tank strap probably can be used to retain the auxiliary tank. The existing gas gauge can be used to indicate the level in either tank by properly wiring the tank sending-units through a toggle switch to the gas gauge. The gas lines need to run from each tank to a fuel-selector valve – a marine supply store item – either in the trunk or inside the car. It's best not to have fuel lines running through the car because of the fire hazard, but the selector-valve handle could stick through the floor or another panel into the interior. The fuel line should be re-routed for maximum protection, and the portion of the line not fully protected should be covered with coil-spring-type armor.

Protective Plating

Underneath the car, several components must be protected. The engine oil-pan needs protection more than anything else. It's probably best to provide a sturdy steel plate, at the cost of some extra weight, to assure the oil pan will not be damaged. We use a one-eighth-inch steel plate, curled up enough at the front so that there is no chance it can become hooked on anything. This plate should be bolted to brackets which will hold it at least a half inch from the oil pan to allow for some elastic deformation without touching the pan. The purpose of this plate is not only to deflect stones, but also to distribute the load over a large area of the frame structure in case of a more solid collision of this part of the car. It should be bolted on so it can be removed and straightened periodically. In the case of smaller cars, a hard aluminum plate may be able to do an adequate job of engine protection, but this is a poor place to skimp for any reason.

The gas tank also needs protection on most cars, but not to the same extent as the engine, especially if the auxiliary tank has been fitted. Use a one-sixteenth-inch, half-hard aluminum plate to cover the front and bottom of the gas tank. Felt or a similar insulating material should be used between the plate and the tank, just around the edges, to prevent stones from getting trapped there and causing a punctured tank. Straps fabricated from stock-tank retaining-straps can be used to hold the protective plate in place and will also serve to retain the tank itself more securely.

The rear axle should have some protection, but, since it is unsprung weight (unless you have independent rear suspension), the weight should be kept to a minimum. We use one-eighth-inch steel plate, but trim it so it is no more than a skid plate for the bottom of the axle center-section.

Underneath the car, all lines and cables should be re-routed to assure they won't snag anything. Already mentioned were the fuel and brake lines, but such things as parking-brake cables and their brackets, shift linkage, mufflers, suspension control-arms, etc., should be checked and modified, or plated, to prevent a blunt edge which could be snagged on a high center and damage the car.

The radiator should be protected from stones and mud-caking by a hardware cloth (coarse, wire screen). The area under the fan should be shielded by an aluminum plate to prevent rocks from being thrown up into fan-belt pulleys, or snow, dust, or water being sucked up into the engine compartment by the fan.

Road Lights

The most versatile light of all, the roof spotlight, is sometimes prohibited by regulations. It can be used as a back-up light, a navigator-controlled beam to illuminate apexes of turns, a sign-reading light, or the headlight least likely to be mud-covered when the going gets rough.

Appendix J allows us only six lights on the front of the car, so we must be selective. A book could be written about the pros and cons of different lights for special conditions, but it would need to be updated nearly monthly because of development work being done in Europe. What we need again is the best compromise. A pair of fog lights is necessary for snow, rain, dust, or fog. To be effective they must be mounted low to the road, but past experience on rough roads indicates that fog lights mounted under the bumper never last through the first day's run. Several makes of European headlights have a very flat, top cut-off on both beams. These lights are as good in snow or fog as any fog lights I have used. Also they have relatively low current-draw, so their bulbs have quite a long life. They are not sealed beam, so they continue to function even if the lens is cracked. These headlights double as good fog-lights and reliable lights for unannounced safety inspections.

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TIJUANA ROAD RACE

The other four lights should be driving lights. A good combination is a pair of quartz-iodine pencil-beams for straight roads and a pair of aircraft landing lights for the logging roads and mountain switchbacks. Headlight and driving-light covers can be purchased or fabricated at a trim shop. Materials required consist of a foam-rubber pad, upholstered with vinyl or plastic, and an elastic shock-cord sewn in to hold it in place. There is a great deal of overtaking on the gravel closed-sections and, whether you're passing or being passed, you're going to have rocks hit your lights and windshield as well.

A back-up light is essential where a roof light cannot be used. An instrument-panel pilot-light should be installed to remind drivers to turn the back-up lights off after use.

Interior

Two people will be virtually living in

"No, Mam . . . it isn't that Mr. Shelby has anything against electric cars or Senior Citizens . . ."

the car for the duration of the rally, so spend some time on creature comfort. The weight of the front seats cannot be reduced, according to Appendix J, so put the weight saved in the driver's fiberglass bucket-seat into a comfortable reclining mechanism on the navigator seat. An old Porsche-coupe seat with recliner is an excellent choice here, but there are many other possibilities. Studebaker, Chrysler, Saab, and others have offered reclining seats.

The steering wheel can be modified in any way. Install one with the dish you desire for comfortable driving position. All bright work on the instrument panel, wiper blades, etc., should be painted flat black to reduce glare and resulting eye fatigue.

Pedal layout should be given careful consideration. Pedals should be modified, if necessary, to simplify the heel-toe operation of brake and throttle. The importance of being able to synchronize engine speed with road speed during a downshift while hurrying through a gravel closed-section, cannot be over-emphasized.

The interior lights for the navigator should be red, because this color interferes less than any other with the driver's ability to adapt to darkness. The navigator must also have white lights for reading maps, but not while the driver is trying to 'go fast' for the existing conditions. Aircraft cockpit-lights make excellent interior lights. They are available from local aircraft supply houses.

Be sure to use relays, circuit breakers, and/or fuses for each separate auxiliary circuit in the car. The car will be bouncing around so much, that a wire could be cut by bending sheet metal, a flying rock, or any number of unpredictable sources. A burned wiring-harness or a small electrical fire usually means the end of the rally.

A console between the seats is very useful for holding fuses, bulbs, Curta cases, candy, gum, etc. It will always be full. Small boxes for folded maps, insurance papers, etc., can be bolted to the kick panels ahead of the door and on the interior, rear quarter-panels. When you live in a car for days, you need to have a place for everything, and everything in its place.

In the trunk a pair of readily accessible tires should be held firmly in place by elastic shock-cord. A plain old ratchet-type bumper-jack is probably the most useful, quickest, lightest jack to carry for emergency tire changing. It's nice to have a regular hydraulic floor-jack, but normally it's too heavy to carry in the rally car. A small, aluminum winch for de-ditching is a useful tool to carry. A tow rope, a couple of entrenching tools, lug wrenches, a tool-roll with carefully selected items, and a few spare parts should complete the payload.

Odometers, Watches, Calculators

A front-drive odometer (on a rear-drive car) is very important, since a good portion of the roads are slippery and many turns are called out by mileage only. The best way to route a front-odometer cable is through a drilled

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spindle, like on the Volkswagen. On many cars this is impossible due to front suspension ball-joint location, king-pin location, or questionable strength of the spindle after drilling. There are many ways to rig a cable from the front hub-cap or wheel cover to the odometer. If an external cable is used, an alternate odo-drive from the regular speedometer cable should be used as a stand-by unit. Some roads are rough enough to fail most of the external, odo-drive cables.

Timing on all regularity sections is to the minute. All the good navigators have short-wave radios and an accurate watch, and know where they stand "to the second." They don't merely run to the nearest minute, but, rather, they use that minute tolerance to their best advantage.

Halda Speed Pilots are quite popular because of the adjustable odometer feature. The average-speed indicator is used only on the easy highway sections, and then only as a rough guide. Other types of adjustable odos are quite common also. The Curta Calculator is standard equipment for nearly all serious competitors.

Conclusion

As you add all the equipment mentioned in the above paragraphs, keep reminding yourself to 'keep it light.' Let one bracket do the job of two, and make it out of aluminum whenever possible. Every pound you save will help you accelerate faster, reduce the load on the brakes, and reduce the impact loading on the car's structure every time it comes crashing down after that unexpected hump you didn't see in time to slow for – and it will make it easier to winch out of a snowbank or a ditch, should the occasion arise.

Be sure your car is fully prepared before you leave home for the rally. You'll find it's a lot easier to work with familiar tools and facilities. The last-minute details will require enough of your time the last day or so before the rally. Also, it is nice to be somewhat rested when you start, and not dead tired from an all-night work-session.

There are many items I have not covered here, such as the need for fire extinguisher, flares, roll bar in convertibles, etc. Before ever considering competition, study the rally regulations, the FIA homologation for your car, and Appendix J. If you wish to run this rugged type of rally, but don't want to do all this preparation, buy a Mercedes, a Volvo, or a Valiant 6 and go. There is a good chance you could finish with one of these cars with minimum preparation. If you want to have a chance of winning – it's a different story! If you want to optimize your chances of winning, then start by preparing your car as outlined here, and develop it from there as your own particular choice of car demands.