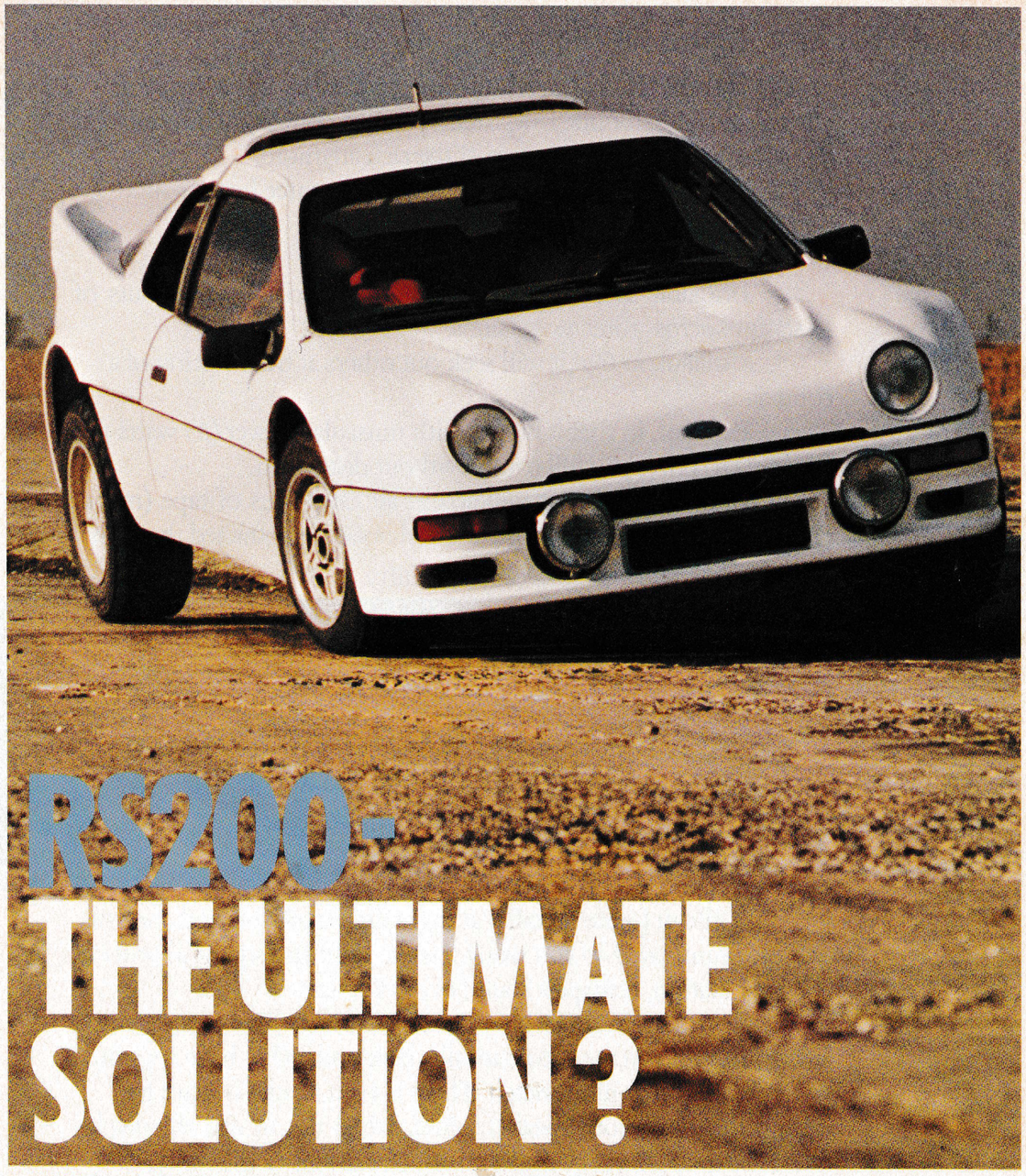
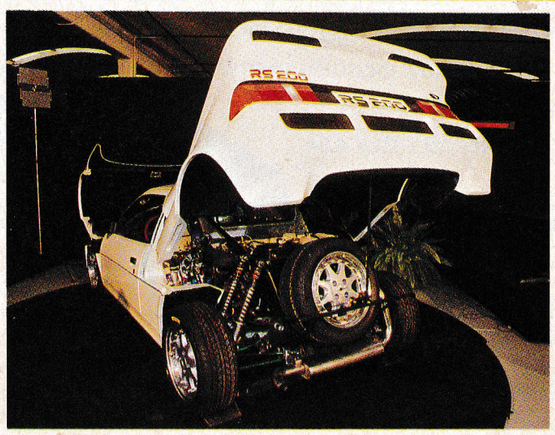


RS200 - THE ULTIMATE SOLUTION?



Ever since the Audi Quattro made its rally debut, designers of competition cars have been changing their views on four-wheel drive. First Peugeot, then Austin Rover and now Ford have all turned to different mechanical 4x4 concepts in the search for a guaranteed winner. Is four-wheel drive the answer or will this be a technically blind alley? **Peter Jefferson** gives a revealing insight into the strategy and details of the RS 200 and future high performance trends.

When Ford launched the new front-drive Escort in 1980 they gave the competition engineers an insurmountable problem: How to develop a rally winner based on a production model? There were only a few choices, none of which stacked up to provide championship material. One: Go with front wheel drive and develop specialised driving techniques that would be hard on machinery and driver over a full international event. Two: Move up a class to the Sierra or Capri, using rear wheel drive with size handicaps. Three: Build a purpose-built rally car based on the new Escort bodyshell.

They started along the third route with the RS 1700T, but abandoned it two years ago in favour of a fourth option: Start from a clean sheet using the most advanced technology with everything optimised to the limit. The reason was simply that the inevitable compromises of any other approach would not be competitive enough in all types of event. So they designed a Group B special, something that would reign supreme on tarmac and on gravel, something that stretched vehicle dynamics into a new dimension which was already being explored by Porsche and VW in the search for the ultimate. They wanted a machine with race-car adhesion on the track and rally-car balance on the loose, two totally opposed sets of conditions that usually produce two different kinds of winners.

Ford studied in detail the criteria that makes a rally car fast, easy to drive and controllable. On the majority of events in the world championship calendar, that meant four-wheel drive to handle the power/weight ratios needed to be competitive on the poor surfaces of special stages. Audi were proving time and again that 400bhp with the extra traction of four-wheel drive was a winning formula, although they were demonstrating at the same time the difficulties of handling a larger car with a heavy front-end weight bias.

To the rally driver on a special stage, traction and balance is everything. In the forests there are often twin wheel tracks offering more grip than the surrounding surfaces, which means too much oversteer with two much tail-out puts the rear whels out of their best position. Yet some oversteer is needed to scrub off speed and generate the swinging instability that allows unknown corners to be handled in either direction at the last moment. The sliding dynamics, which are totally different from cornering characteristics on surfaces like tarmac with good grip, are therefore critically sensitive to both the static weight distribution and the polar moment of inertia about the front wheels.

Fiesta-based workhorse

Friction is governed by the most simple physics laws of all, as any student can so easily prove to himself by practical experiment. Once the coefficient between two surfaces is fixed, the limits of grip depend entirely on the load acting between them. And, of most significance in the case of vehicle dynamics, the total limiting force is the same in any direction. This means that traction or braking can only be at the expense of cornering force and vice-versa.

When the total limit is exceeded and you lock the front wheels under braking, for example, steering control is lost. And a front wheel drive car cannot be steered effectively with its wheels spinning. Reduce the braking effort or the wheel torque, and steering is restored — as every driver of a front-drive car has found out at some time or other.

For investigation into these factors Ford cobbled together a workhorse in 1981 based on a Fiesta bodyshell and powered by a front-mounted in-line BDA engine driving the rear wheels through a five-speed transaxle. Its behaviour made an interesting comparison with the Boreham experience of four-wheel drive in Rallycross Capris 10 years before and with Ford studies of Quattro dynamics, which were explored in minute detail.

The conclusions were clear, even before the RS 1700T exercise was aborted. Any loss of front wheel adhesion in a four-wheel-drive system, either under power or braking, caused the front end to run wide, while lifting off not only caused the front end to tuck in (front-wheel-drive style) but the rear to swing out under the drag of the drive interconnection, often resulting in a spin. With the Quattro's overhung front engine balancing the rear polar moments about the front wheels, steering responses were too sluggish.

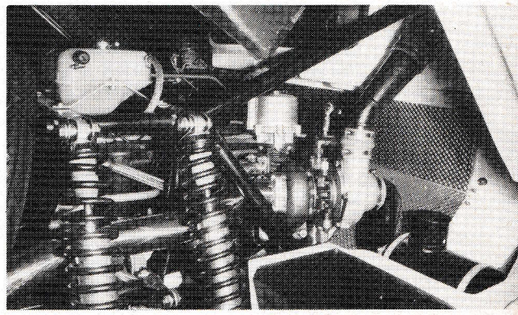
What about the Ford GT70?

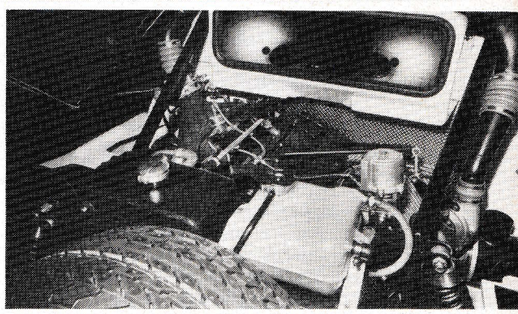
Head of the revitalised competition team in 1983 was Stuart Turner, a shrewd strategist and planner who had led Ford to more rally championships than they had ever dreamed possible for a production-based saloon. When he controlled Advanced Vehicles Operations at Aveley in 1973, there was already a well established programme to go up the purpose built rally car route with a neat little mid-engined coupe, the GT70.

Looking back now to where Ford might have been without the Oil Crisis and its knock-on effects there is an ironical logic which merges the Rallycross Capri experience into the GT70 and evolves into a machine just like the RS 200 that could have appeared well before the Quattro and changed the whole course of competition history. Instead, AVO was axed, the Escort went on and Ford faced a design vacuum.

Out of those ashes now comes the RS 200 using a similar GT70 mid-engined concept combined with an advanced selectable four-wheel drive transmission which unusually puts the gearbox in unit with the front axle and utilises all the best Formula 1 construction technology in a shape originally conceived by Ghia and honed closer to its functional purpose by Dunton designers. It uses carbon-fibre, Kevlar and aluminium honeycomb with steel and magnesium in a composite structure that breaks entirely new ground, clothed in a fibre-glass shell that will be manufactured and assembled by Reliant at Tamworth.

Chassis and structural design is the work of Formula 1 supremo Tony Southgate, developed in close association with John Wheeler at Boreham, who really deserves most of the credit for the drive and layout concept. Basically, the engine is in-line behind the driver, angled and offset to allow a primary drive to pass through gears which can be swapped in minutes to allow a different overall ratio to suit the particular special stage. The drive then passes down the tunnel to the gearbox and





Top: The turbocharger nestles behind two sizeable suspension units
Below: The BDT nestles against the rear bulkhead

centre differential, then back under the canted block to the rear axle and forward to the front axle.

A second short lever adjacent to the main shift for the five-speed gearbox has three positions and selects three drive systems through dog clutches. Four-wheel drive puts 63 per cent of the torque on the rear wheels, 37 per cent on the front. Two-wheel drive by-passes the centre diff and puts all the drive to the rear, while the third position locks out the centre diff and splits the torque 50:50 front-to-rear any mode can be selected at speed on the move to suit conditions. All three differentials employ Ferguson viscous couplings, like those used on the Peugeot rally car and the Ford FWD Escort RS Turbo, which are progressive and use very compact epicyclic gear sets.

This system puts four-wheel drive on loose surfaces into an entirely new category of control and on the RS 200 gives the

driver the most important option of being able to disengage drive to the front wheels at any time. On the old Rallycross Capris there was no limited-slip device in the front differential and only a 75 per cent limiter in the centre diff, for attitude control and to generate cornering power. Formula 1 experiments with four-wheel drive in the 1960s proved quite conclusively that very little front wheel cornering force could be generated with power through the front wheels. Some cars ran with less than 15 per cent of the torque passing through the front wheels and all were in serious trouble with understeer on the approach to bends.

Advanced Structural Composites

It's in the choice of chassis materials that the sophistication of Formula One techniques shows through most strongly. Although a steel outer skin is used under the floor and over outer sill panels to provide impact protection, the floor section, front and rear bulkheads and sills themselves are actually constructed from Ciba-Geigy aluminium sandwich sheets, (the same sort of material used in single seater racing car monocoques or 'tubs') which are bonded and rivetted to clamp sections together while curing takes place. Similarly bonded and rivetted to this floor section is a central tunnel and central cross beam which are manufactured from carbon fibre and Kevlar. Either end of this central section are front and rear subframes conventionally manufactured from mild steel sheet, which provide good impact absorbtion and are easily repaired during service halts. These support the front and rear transmission and drive assemblies while tubular space frame sub-assemblies bolt to the front and rear of the monococque and provide suspension pick-up points. The main subframes meanwhile are again bonded and rivetted to the front and rear bulkheads.

To achieve the required component change times necessary in competition (20 minutes maximum per major item), a stressed central superstructure was added and full-length underbody access is provided to the tunnel and transmission attachments. The roof panel and upper door openings are fabricated in a composite of carbon-fibre and Kevlar and integrated with a tubular roll cage to form a stressed structure which bolts to box-member uprights incorporated in the front bulkhead as door hinge posts and at the rear of the cabin. The whole lot weighs in at a kerb weight of 2,315lb ultimately giving the rally car a power to weight ratio of over 400bhp per ton.

Adjustable wishbone suspension

Again, racing car technology is employed, this time for the suspension. Like the Peugeot mid-engined car, the RS 200 gets double wishbone suspension which typically supports cast magnesium uprights. The use of this format allows easily adjustable geometry (castor adjustment is incorporated in an angled tie-rod which forms the leading edge of the lower front wishbone). The double unequal length wishbone format also reduces camber angle variation during dynamic ride height changes on the move.

At the front, twin concentric spring and damper units are mounted outboard of the chassis and act on the lower wishbone. The springs themselves sit on adjustable screw collars which means that ride heights can be easily adjusted and so can the individual corner weights of the car. An adjustable blade-ended anti-roll bar connects to the lower wishbones by means of short vertical struts, or in racing parlance, 'drop-links'. The car is steered using a modified Sierra rack mounted behind the front wheels and to the bulkhead, plus a universally-jointed steering column.

At the rear the wide-based tubular lower wishbones are braced by a welded diagonal reinforcing member, with twin spring and damper units again mounted above the A-shaped upper wishbone. Twin springs allow mixed units to be installed for an increased range of rate and damper settings with less parts complexity. Two alternative chassis mounting attachments at each pick-up point provide two ground clearance settings for on or off road running.

A particular feature of the suspension is the long wheel travel available within the chassis layout and body design, for proper wheel control under rally stage conditions. For road versions normal compliant rubber bushes will be specified, developed as part of special noise control programme to be undertaken on the RS 200 for Ford by the Structural Dynamics Research Corporation.

The central body section of the RS 200 is based on a Sierra driving environment, modified for this specialist application. A standard Sierra windscreen is used, attached in a rubber moulding — instead of being directly glazed — to allow faster service replacement. Modified Sierra doors are also used, cut down below the waist and reskinned in glass-fibre to a new profile.

From the standard Sierra 60 deg windscreen angle, a purposeful new wedge-shaped coupe has been developed with minimum front and rear overhangs, the distinctive character of a dedicated rally car and strong Ford overtones. But one thing is for sure, though Ford might be on the way to bringing Formula One to the Forests, their chosen tool is no beauty. Sierra, rounded type lines combine with seven inch headlights and the various lumps and bumps sprouting from the curvaceous profile to give the machine a front view closely akin to a bullfrog. Huge arches ready themselves for the slicks which will replace the road tyres shown, when the order of the day is to be a tarmac stage.

Air is exhausted from the radiator by means of a duct just behind it which combines with deep circular recesses in the bumper to contribute to the ugly frontal appearance.

The rear is businesslike though with a large spoiler on the engine mounting which accommodates twin hot air exhaust grilles below its upper edge. A large duct is mounted at the back of the roof (where the air flow is unbroken and moving at the highest speed across the body) and conceals a full width intercooler.

Following the initial design work by Filippo Sapino at the Ghia Studio, extensive modifications were made as the result of aerodynamic development which have been integrated into the final shape by John Hartnell at the Ford Design Centre, Dunton. Using the Motor Industry Research Assocation's wind tunnel at Nuneaton, some 30 body details were tested and modified to generate downforce with minimum increase in aerodynamic drag. The production car will have a Cd of abut 0.40 with 4.5kg negative lift at the front and 6kg negative lift at the rear.

The interior layout follows the general Ford concept of grouping instruments and equipment into function-related panels, with an instrument pack in front of the driver, auxiliary gauges and switches in the centre and either an open glove box or navigator's aids on the passenger side. Both left and right hand drive layouts are being developed, so the car can be sold in all Ford's world markets if required.

Provision is made for full-size spare wheels to be mounted at either end of the car, to give weight distribution trimming for individual events. On the road version a detachable luggage bin replaces the front spare wheel. Twin aluminium fuel tanks are installed inside the rear cabin cross-beam, with 75-litres capacity in one and 42-litres in the other.

Engine installation

The engine of the RS 200 boasts an impressive heritage and is of the 16 valve BD series type immortalised in the seventies by the works Escort rally cars. The first was the 1600 BDA which appeared in the original RS1600. The new RS is fitted with a BDT enlarged from 1,780cc (as it was used in Ford South Africa rally cars and 1984 group C2 racing) to 1800cc. The engines are being developed by Brian Hart who was responsible for the works engines in the 'seventies. They have alloy blocks with Nikasil-treated aluminium bore surfaces, are turbocharged have a Cosworth 16 valve twin-cam head.

The turbo unit itself is mounted in a cooling duct moulded to the rear engine cover, by means of a stainless steel exhaust manifold. The turbo version of the BD alloy block also has a revised cooling system with a larger capacity water pump and coolant passages.

The turbocharger is a Garrett AiResearch T.04 which boosts at up to 0.8 atm with a geometric compression ratio of 8.2:1 on the road car and at up to 1.2 atm on the rally car with a compression ratio of 7.2:1. The wastegate is finned and, unusually, separated from the turbine to reduce underbonnet temperatures.

The problem of intercooling the boost charge of a mid-engined car is overcome using the roof location for the aluminium air-to-air intercooler while the price of this solution is inordinately long inlet tracts. A Ford EEC 1V microprocessor is a fully mapped system and handles up to a million commands a second enabling it to control both injection and ignition.

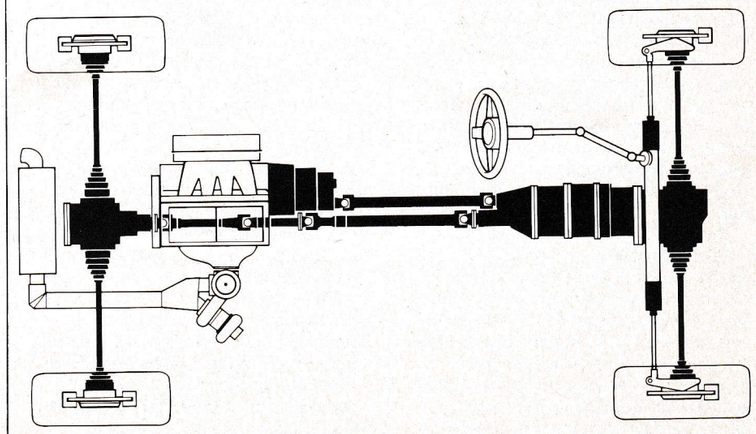
The engine in the road version will develop 225bhp at 6,500rpm, while output of the rally version will be around 380bhp initially rising to well over 400bhp later on.

Road car developments

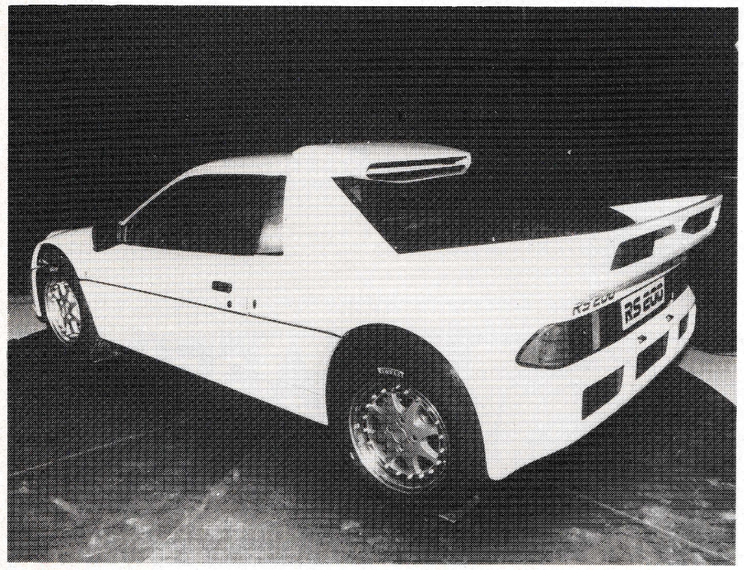
Apart from the potential of 200 road versions of the RS 200 and a more conventional 4WD Sierra option in the Spring, there are many general signs of four-wheel drive becoming increasingly established for production road cars, as pioneered by Audi, promised by VW and expected in 1985 from Porsche, Mercedes, Lancia, BMW and several others. Is this a growing trend for high performance machines, or will design find a way of reverting to two wheel drive again?

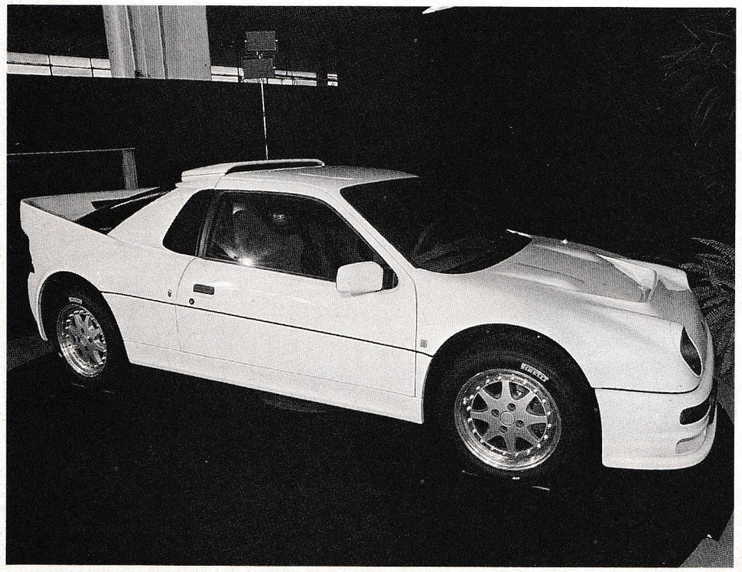
Ten years ago any technical expert would have said that front-wheel drive would reach a limit at 100-120bhp in a small/medium family sized car, that the market would split at this breakpoint and that front-wheel drive would cease to grow much in popularity. Now we have 130bhp hot hatches, 150 and 160bhp FWD models imminent and some very fine examples of advanced FWD design changing the total technical perception of limiting factors (like the Ferguson viscous-coupling diff).

My guess is that by 1990 we will have some very advanced and acceptable 200bhp FWD saloons, probably with electronic wheel controls, and that 4WD will only be an expensive option on really high performance and restricted machines, like the Ford RS 200, the Audi Quattro replacement and a new version of the BMW M1. Car design is a moving target to aim at and there is a lot more to come yet before FWD reaches its limit.



The complex driveline design affords a 50/50 weight distribution





Top: The ill fated RS 1700T, the RS 200s predecessor, contrasts with the advanced styling of its successor

RS200-THE ULTIMATE SOLUTION?