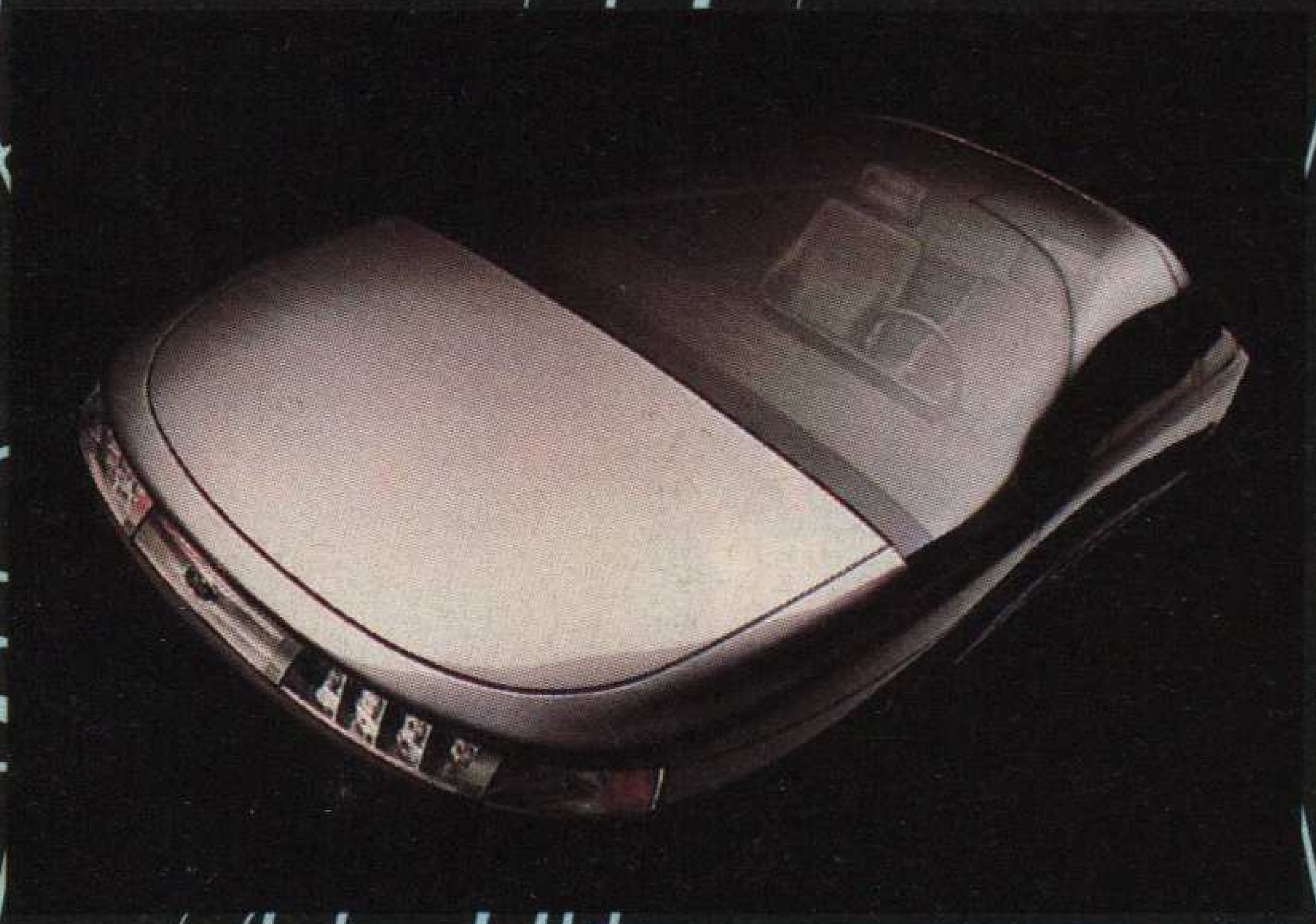
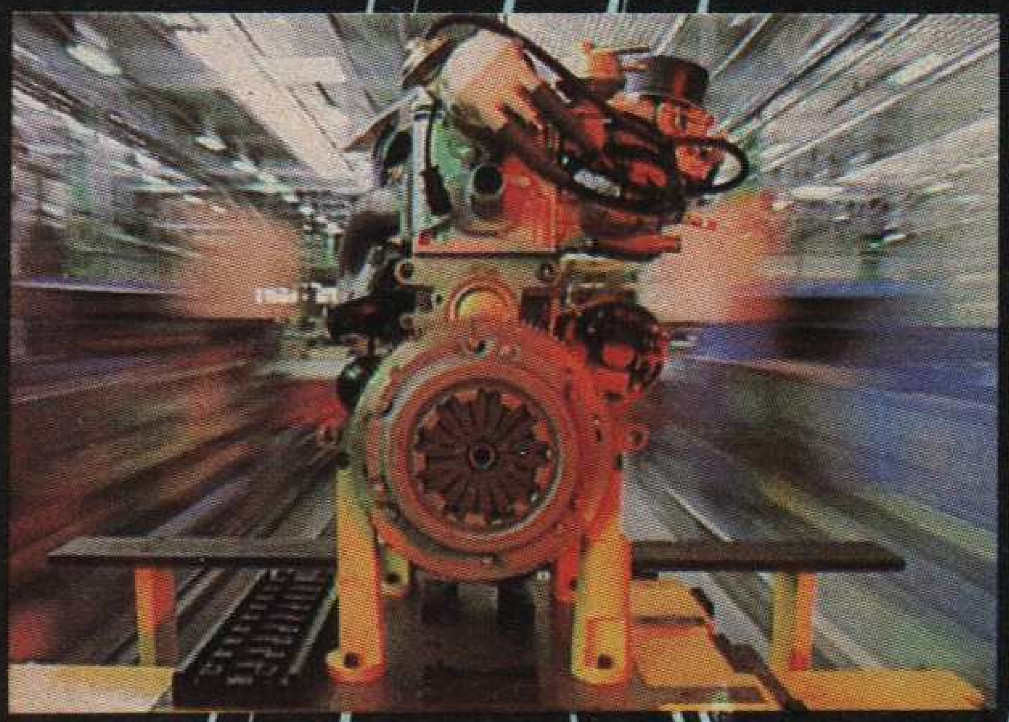
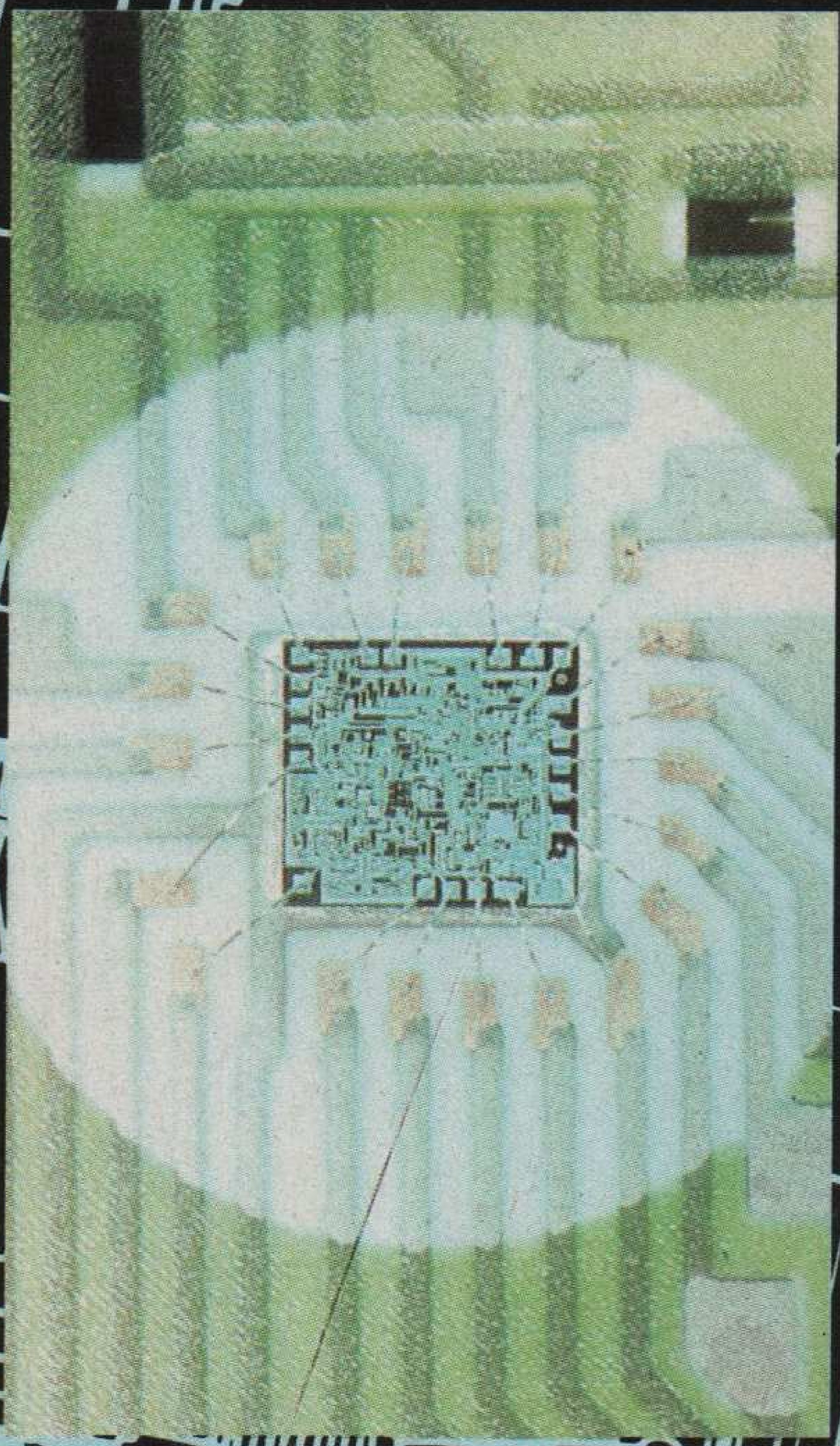
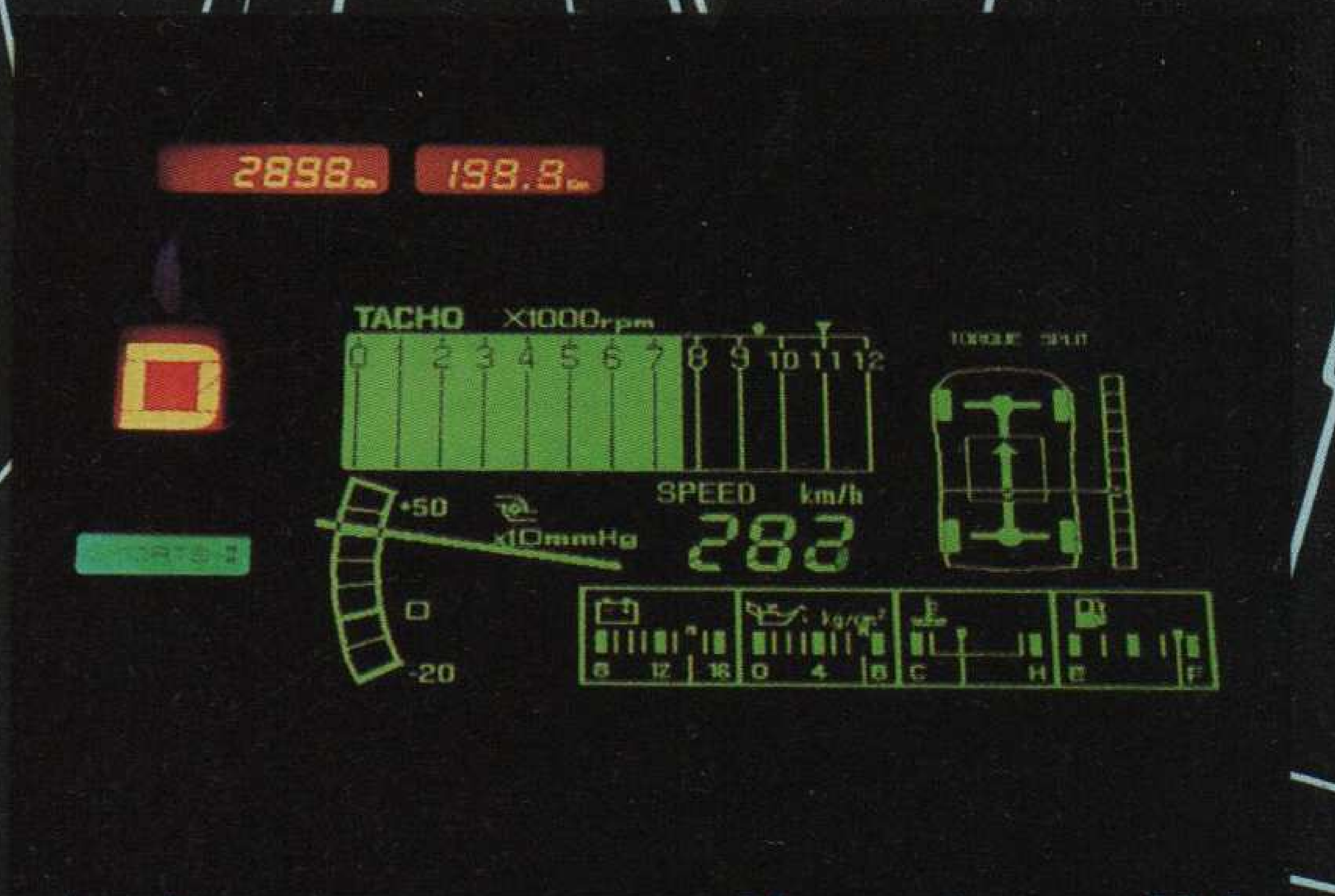
SPECIAL SUPPLEMENT

AUTOCAR









FAST FORWARD

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LEADING THE WORLD IN TYRE TECHNOLOGY

GOODYEAR

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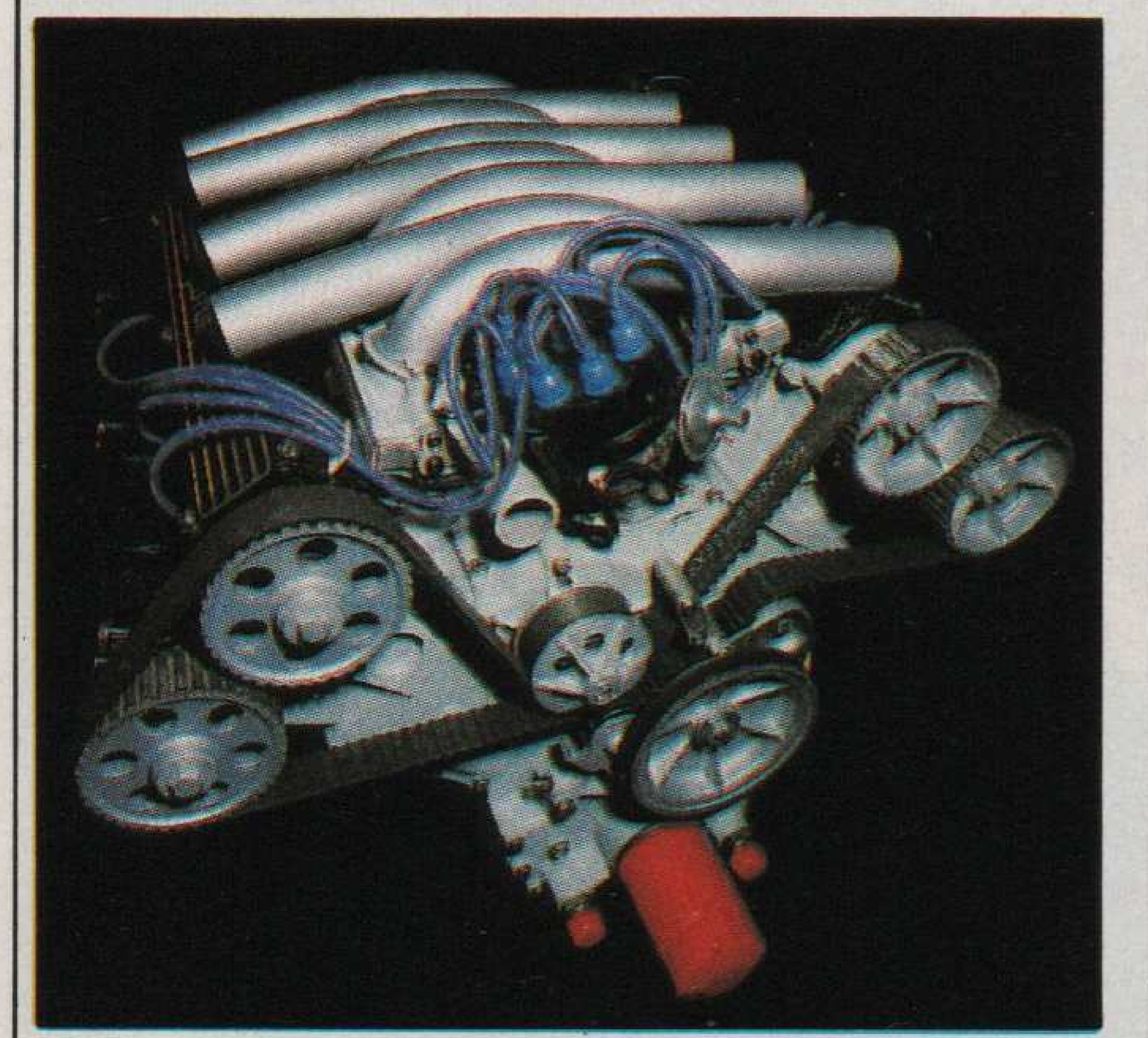

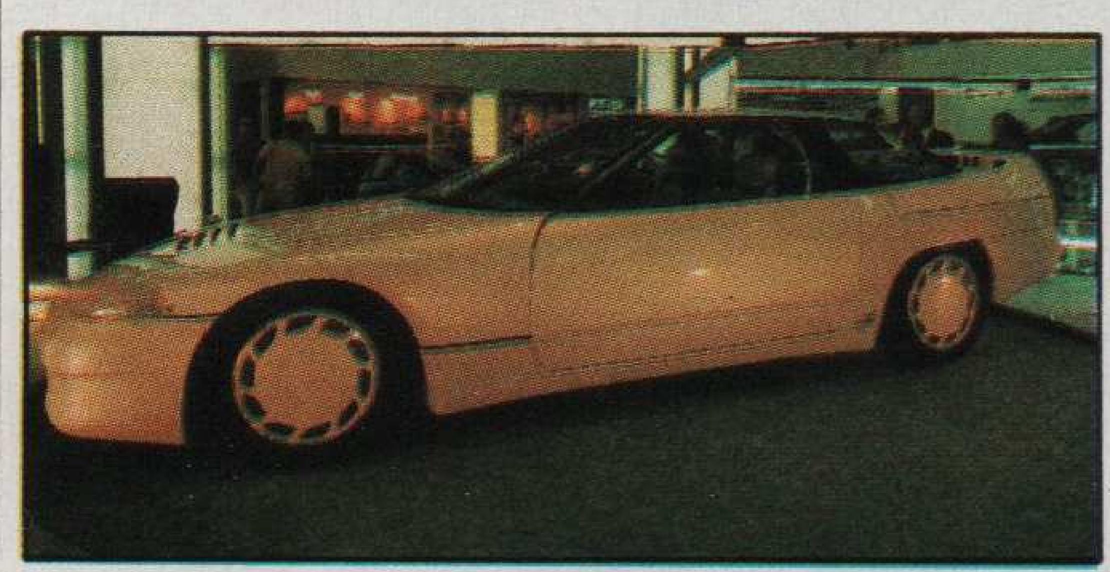

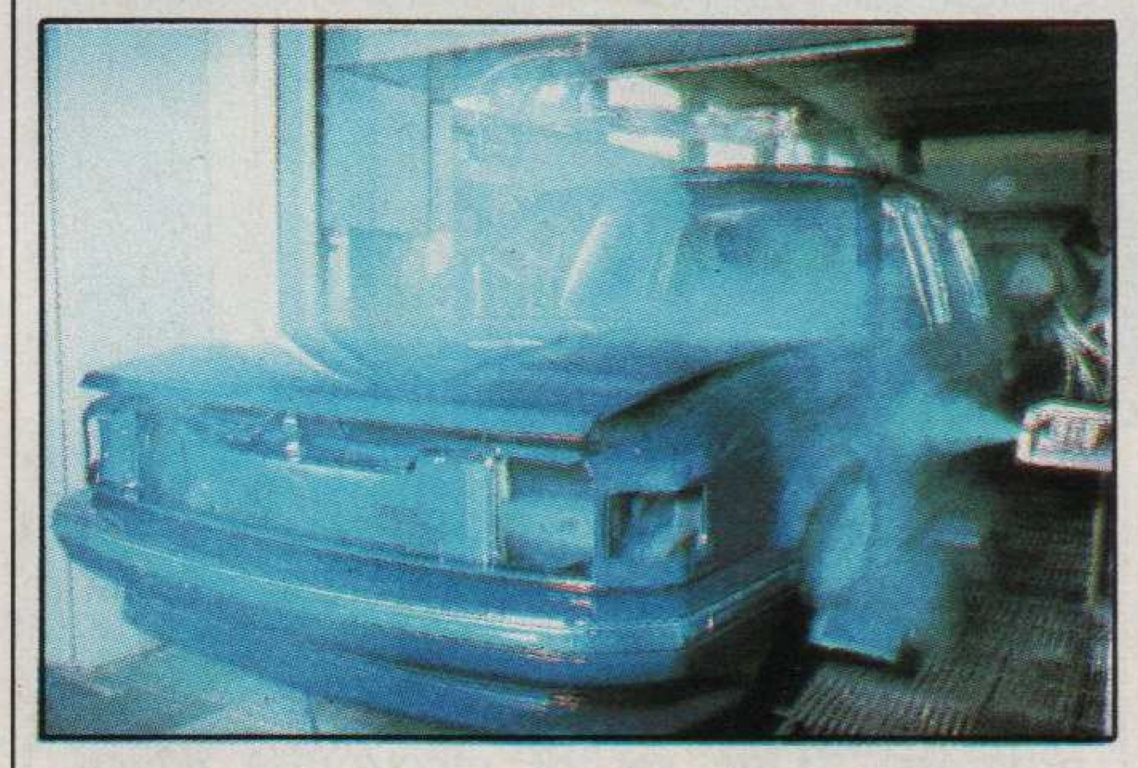

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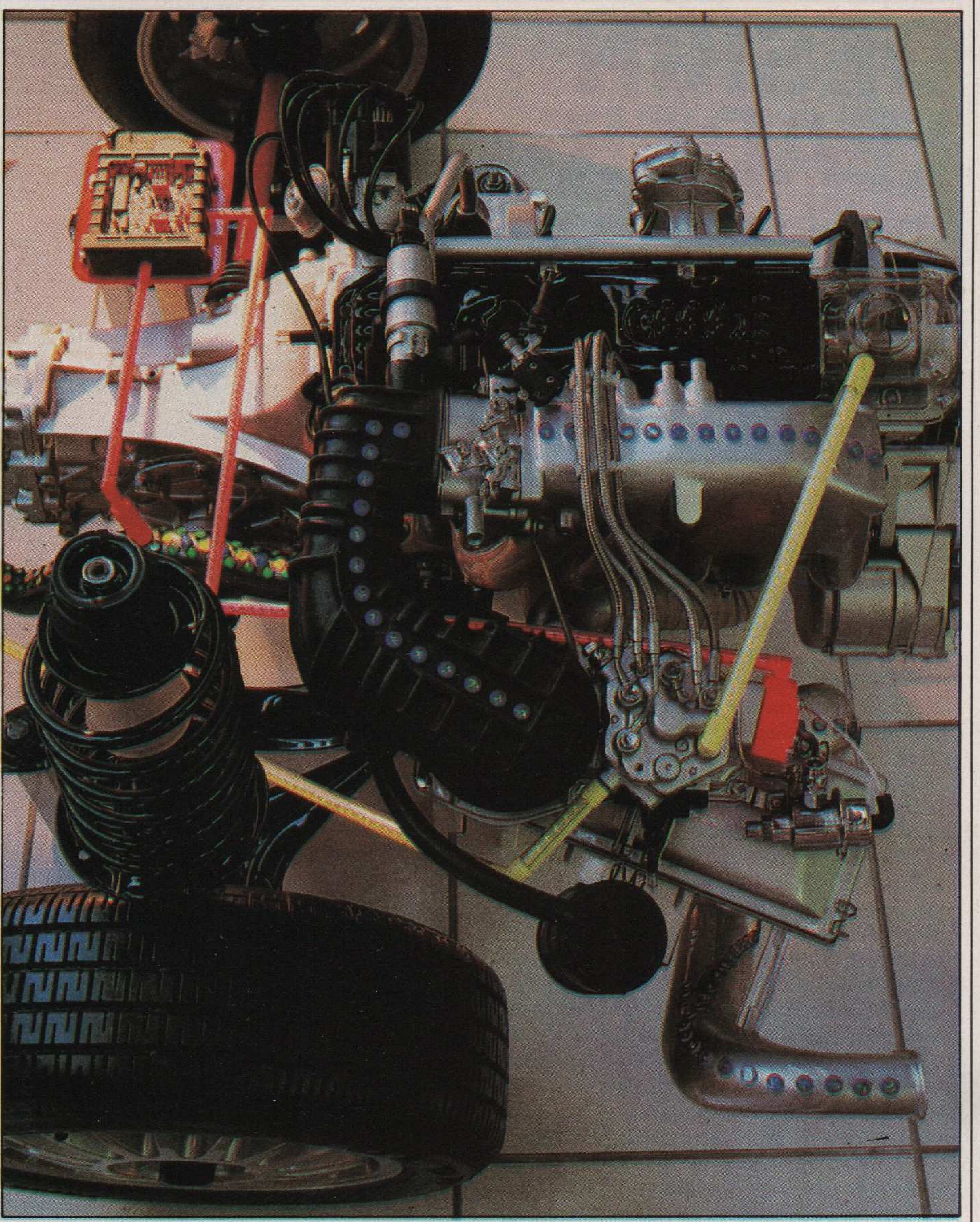


Clean machine: *efficient fuel-injected Audi engine uses catalyser technology*

TOMORROW'S WORLD

You could easily believe that all the quantum leaps in car design were made within the first half of the automobile's current 100 year lifespan.

After all, the most popular power plant remains the petrol fuelled internal combustion engine. We still have predominantly manually selected gearing, braking is by application of friction material to a rotating surface, road shocks are absorbed by springs and the wheels still carry rubber tyres.

So, superficially, the opening premise is true. However, one needs to look back only a decade to see what progress has been and continues to be made.

Examine any area in detail, be it safety, reliability, economy or comfort, and the degree of improvement is quite startling.

In this supplement, our writers, with the help of the top people in the industry, have tried to map the way ahead, highlighting today's key development areas which will give a pointer towards the kind of cars we will be driving tomorrow.

Even without legislative pressure, we can be certain that cars will be safer and even easier to drive. Widespread applications of ABS braking systems, sophisticated transmissions which offer continuously variable gearing and drive to all four wheels, and computer controlled engine management systems for maximum performance and efficiency are all part of the future.

All the signs are that the next 100 years promise even more exciting developments — and possibly a few quantum leaps as well.

DESIGN LEADER

Uwe Bahnsen is the vice-president, design, for Ford of Europe. He reveals his thoughts on passenger car development to Graham Jones

A small plaque fixed to the wall behind the desk of Ford's design supremo, Uwe Bahnsen, reads: 'Never ask a designer to design a bridge — but a way to cross the river'. Whatever one may think of the looks of the recent Ford offerings for which he has been directly responsible — notably the Sierra, new Granada, and most recently, the Eltec concept vehicle (described in *Autocar*, 4 September 1985) — he certainly cannot be accused of design conservatism. We recently had the opportunity to question him about his views on the automobile and where four-wheeled transport of the future might be going.

Eltec, as Ford's most recent statement of its thinking on this subject, seemed like a good place to start. What conclusions, for instance, could be drawn about the Fords of the 1990s by looking at Eltec? Taking a drag on the ever-present cigarette, Bahnsen looked thoughtful for a moment and then responded, his English barely revealing his German roots: "As far as the silhouette of the car is concerned, I think Eltec describes very clearly our thinking about the changing relationship of glass area — or the greenhouse, as we call it — to the lower body of the car. We are moving closer and closer with this sort of 'greenhouse on wheels' concept, I think, to an almost integrated silhouette. I don't want to call it a one-box or one-volume car because people might misinterpret it as being a van type of vehicle, but this idea of expanding the usable space within a given platform is certainly one of the trends we will be pursuing further. I definitely see it as an element of the next generation of cars which will hit the market in the mid-1990s.

"If you look at Scorpio, for instance, the greenhouse to lower body relationship is already dramatically different from the classic three-box saloon. As a result, the interior spaciousness, or room available within the given 'footprint' of a motor car, is considerably more than if you compare it with the previous Granada."

Bahnsen acknowledges the problems inherent with this increasing use of glass in the car of the future — heat transmission which requires powerful air conditioning and ventilation systems to counteract the effect is the main one — but feels technology will come to the rescue in time for his plans to be realised: "What I'm looking for is a glass treatment which will provide better heat resistance than the glass used in today's cars. The research needs to concentrate on reducing heat transmission, and this may require some sort of laminated glass for all the surfaces whereby one of the layers reflects the bulk of the heat producing infra-red rays."

Along with a basic change in the shape of the car of the 1990s, there is also likely to be a new emphasis on the interior layout and appearance:

Uwe Bahnsen *sees Ford's passenger car development as an evolution, not a revolution*

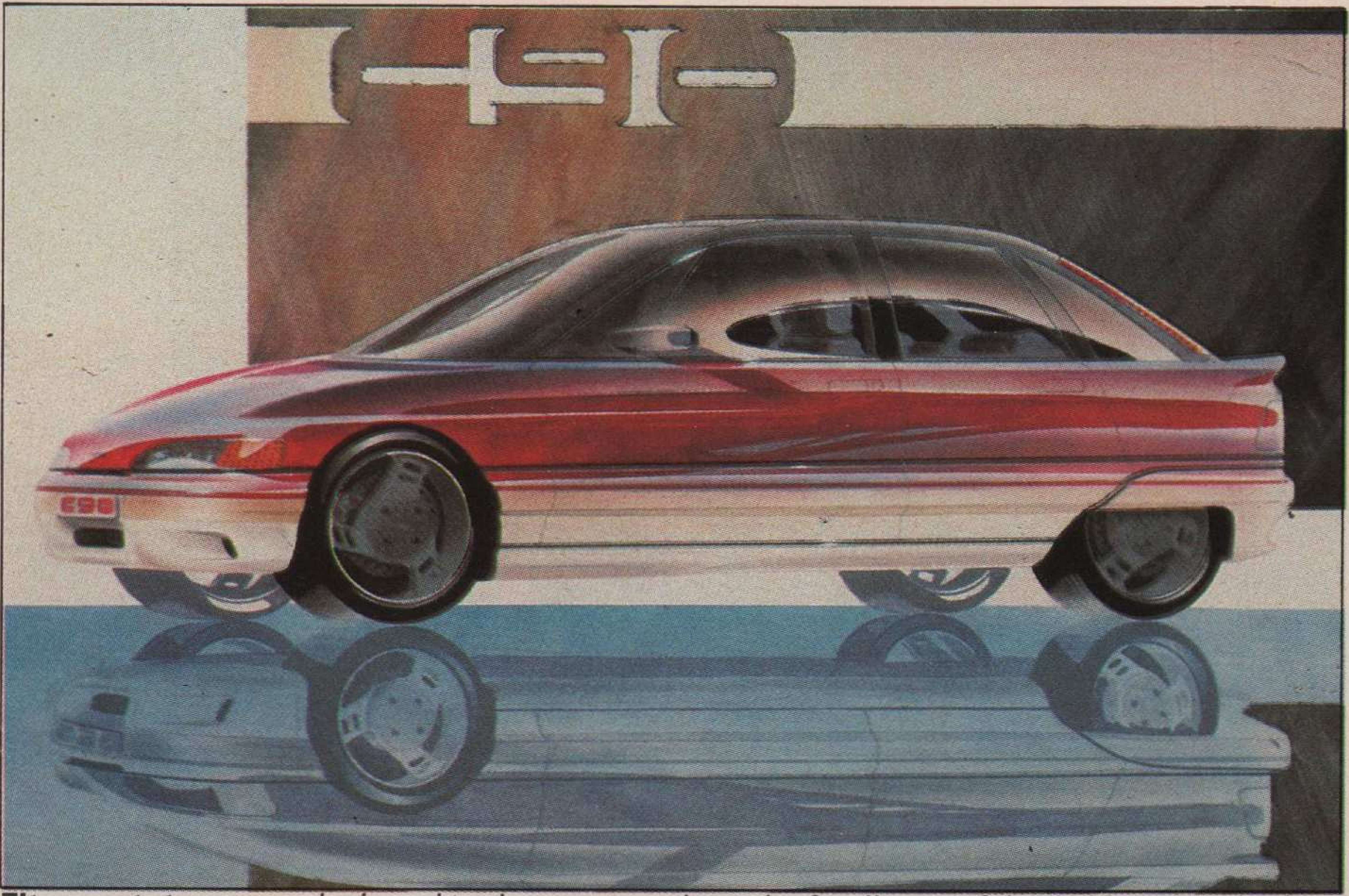
"The more we move toward designing cars for the user rather than a shape into which, accidentally, the user has to be fitted, the more stress there will be on the design and development of the interior. The emphasis will be on providing a spacious, comfortable, yet functional 'living room' in the car. I see this as a continuing, on-going development, not necessarily a revolution.

"One point that must never be forgotten about a car interior is that the controls are used in a dynamic state. In other words, they should not be below a certain size or closeness of grouping that would prevent the driver using them perfectly easily and without the need for binoculars or out-stretched fingertips. In other words, the aim should always be for a very clear, functional, well-identified layout. Where electronics will continue to help us is by providing the opportunity to group controls together and thereby make them less space-consuming."

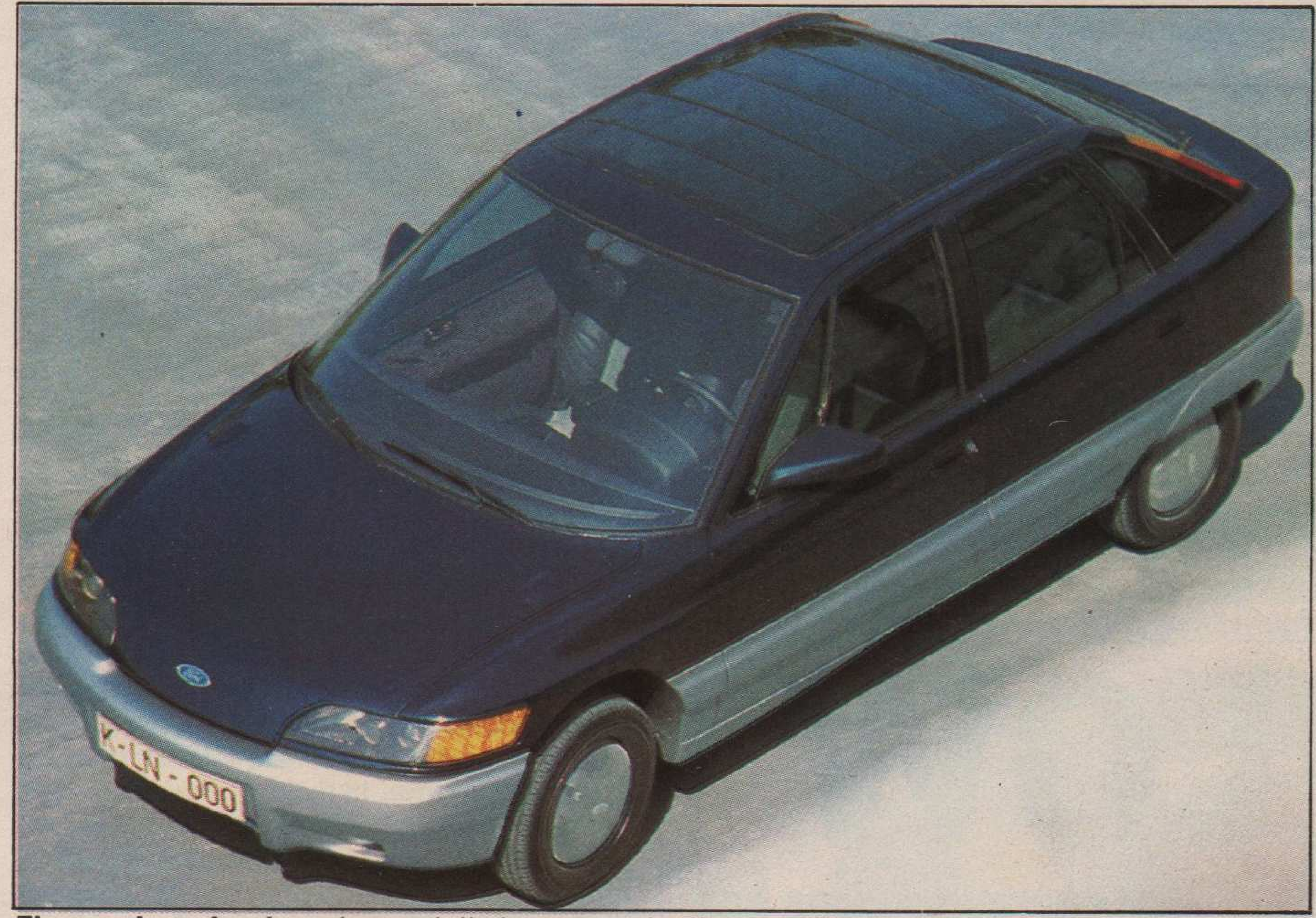
The mention of electronics, and their ever-increasing use in the motor car brought to mind the whole question of whether the average driver really appreciates such advances or would prefer a vehicle which is far simpler and more easily maintained. Bahnsen was fairly uncompromising about the importance of automotive progress: "One set of electronics which I personally view as being of great value — essential almost — is where they are applied to make the mechanical operation of the car more satisfactory or efficient, or where they are used to compensate for the inadequacies in a driver's abilities to handle a car. I do not necessarily see electronics going further into providing instrumentation for every conceivable piece of information, whether the driver requires it or not.

"At the risk of being accused of being old-fashioned, I believe that, for instance, as far as instrumentation which demonstrates a rate of change is concerned, a good analogue indicator is still the best way of providing information.

"On Eltec, there is integrated electronic control of the complete engine and transmission



Eltec prototype *was designed to demonstrate how the family car of the 1990s might look*



Electronic technology *is specially important in Eltec, reaffirming Ford's faith in high tech*

unit and I believe you can't have a more efficient system than that at the moment. That kind of thing actually does give the customer value for money. In terms of repairability and do-it-yourself, I know that a lot of car owners, and especially young car owners who start with a second- or third-hand vehicle to get themselves mobile, enjoy mechanical work. I do not, however, think that is an element which should stand in the way of progress.

"In terms of the mechanicals themselves, I don't think they are going to change in their basic working method; it is the control of the mechanicals which will change and will be so much more efficient. Perhaps, in the long run, it may get to the point where a reasonably advanced home mechanic will be able to exchange a faulty electronic module with a new one after having diagnosed the problem."

Clearly, then, Ford designers have a reasonably detailed idea of the car of the 1990s, but how did Bahnsen perceive the changing needs of potential customers by then?

"Although I don't have a ready-made answer for that, I think what we need to observe carefully is the change in the type of customer we will have by then, and from that, perhaps we can work out the types of cars that will be required. To take just one example, as recently as five years ago, the average retirement age was 65, and 63 was early retirement. Today we are looking at age 60 as almost normal retirement, 58 is early retirement, and even some early retirements at 55 are happening. If you project that trend, you will probably be facing, in 10 years' time, a car-buying clientele of completely different composition from today's. Someone who retires at 55 is a totally different individual from somebody who retires at 65 in terms of mental and physical abilities, expectations and so forth. I believe that those elements have to enter into the concept planning of future vehicles.

"This new group of clients would be prepared potentially to spend more money on the initial purchase of a vehicle, because they normally have a working lifetime behind them and probably retired with some sort of lump sum separation, but they would be concerned that the on-going cost of the vehicle — that is, the maintenance — should be as low as possible because of their reduced, albeit regular income. I see, therefore, the idea of the reliability of cars improving when it comes to what an important emerging consumer group is likely to expect from us about 10 years hence.

"In the younger age group of drivers, it is almost the reverse pattern — the lowest initial purchase price is important even though running costs may not be quite so critical because their earning power is increasing. That said, I think we are looking at a very important new group of potential customers to whom a car, conceived and constructed around the elements which I have mentioned, will be right for the time."

Undoubtedly two of the most significant motoring developments in the last few years have been the arrival on the scene of so-called 'people carriers' such as the Nissan Prairie, Toyota Space Cruiser and Renault Espace, and the re-emergence of the two-seater sports car, so nearly killed off by American federal safety legislation. Bahnsen has some clear cut views on these two trends.

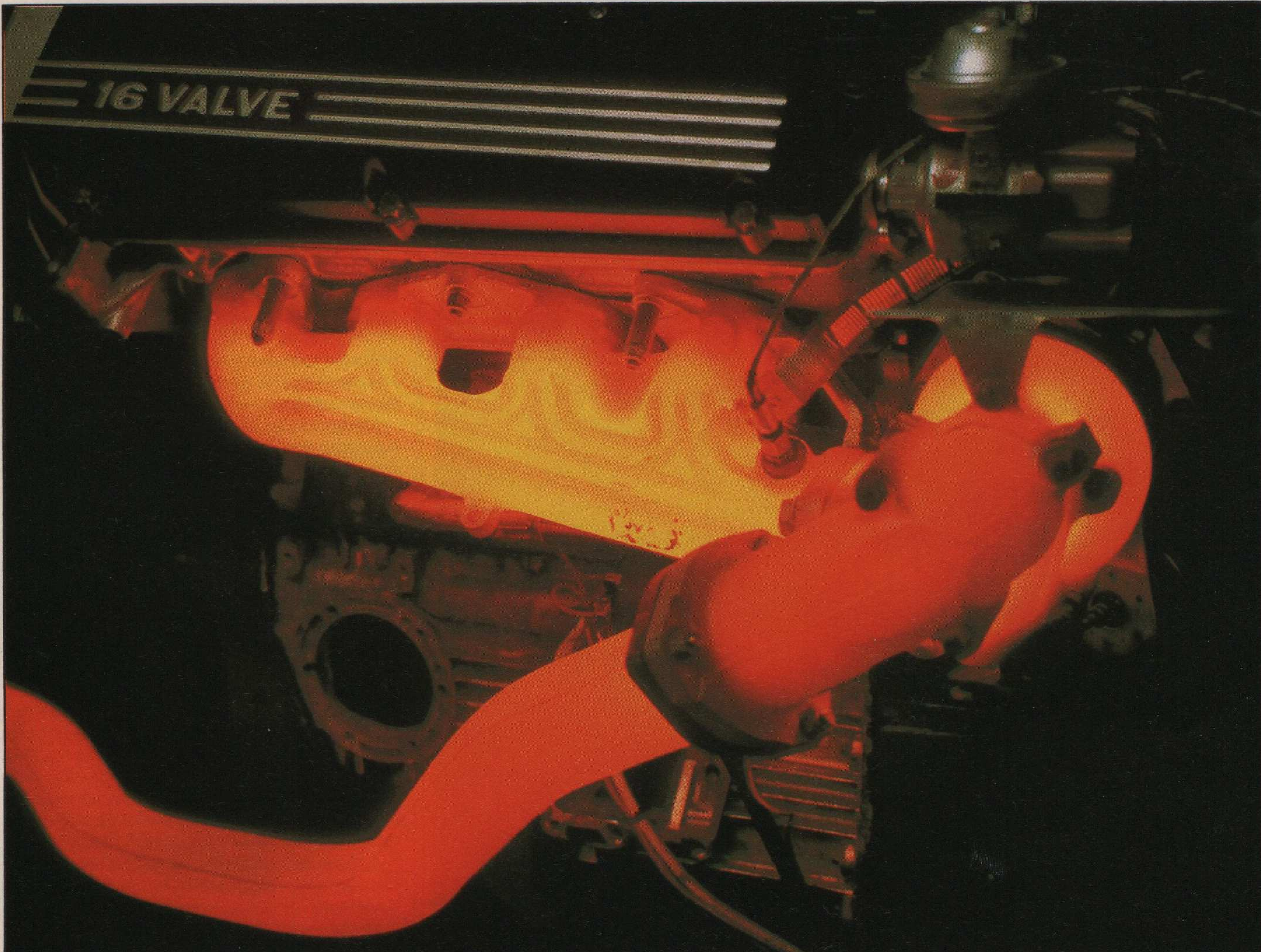
"These 'people movers' are, I think, a very interesting development and certainly not a flash in the pan. My personal projection is that they will carve out a fairly steady segment of the market since they provide, on a shorter platform, perhaps more usable convertible space than a traditional estate car. The increasing leisure-time aspect generally will support this type of vehicle, although I see it as an alternative plus an extension of the estate car rather than a replacement for the family car.

"As far as the sports car is concerned, yes, this, too, is a reasonably significant development in my view, and is in a way tied up with the tremendous increase of interest in after-market conversions — and I'm talking here about professional conversions rather than the cheap-and-cheerful bolt-on stuff — as well as sophisticated customising. I don't think the two-seater sports car, roadster type of vehicle, will ever be a large, significant volume of car sales, but certainly a fringe market which is highly attractive and can, for special low volume manufacturers, provide a very profitable market as well. I don't think it would be very easy for a large volume manufacturer, such as Ford, to integrate such specialised derivatives into mainstream production.

"As you are probably aware, we tried really very hard to find a way to build the Barchetta prototype, which we showed two years ago at the Frankfurt show at, let's say, a reasonable cost to the customer. So far, we haven't found that way. I think the large, mainstream manufacturers are probably the least likely to produce vehicles of this kind simply because the volume required would be rather limited. That is not to say that joint ventures between a major manufacturer like Ford in terms of the supply of mechanical parts, and a more specialised coachbuilder like Karmann, actually to build the car, may not occur more frequently.

"There is generally a resurgence of enjoying driving and the fun of motoring. Psychologically it is no longer anti-social to have a nice car and to show that you enjoy it."

If Uwe Bahnsen and his crystal ball are to be believed, it is good news indeed for car enthusiasts everywhere.



Engine designers *are now improving efficiency: four valves per cylinder is one way, direct ignition may be another*

FREE FLOW

With oil still abundant, talk of alternative energy sources has receded. Manufacturers are now concerned with maximising efficiency from the conventional internal combustion engine

One of the several certainties about the next 10 years is the continued survival of the internal combustion, reciprocating piston, poppet valve engine. The cynical will say, rightly, that is so because of the predominant, and vast, worldwide investment in it. It is equally true to say that it has been developed to an astonishingly high pitch of efficiency and refinement, and that as yet no one has come up with anything looking like a replacement which has a better power-to-weight ratio practical for cars.

The future for the i.c. engine is nevertheless confused. The immediate worry is making it cleaner while preserving power and improving fuel economy, rather than doing it inefficiently as in America. The full catalyst route is deplorably wasteful even if German manufacturers make catalyst cars with the same power output as their lead fuelled counterparts. The lean burn way is more attractive, but only marginally, since it is hard to see how a lean burn engine can preserve power to a respectable degree. Much work remains to be done, and one can hope only that better answers will arrive before the legislators get heavy handed.

Better breathing via three or four valves per cylinder seems likely to become more common, if only because of the way the Japanese have forced the pace at the bottom end of the market. However, in view of the cost of labour today, it can only come with an accompanying increase in the use of maintenance-free valve gear.

If Volkswagen is correct, the supercharger has a future after all, more so than the turbocharger in the below 2-litre class. It will be interesting to see if VW's spiral blower is as good as it seems, and how widely it is used in both VW's range and in those of other manufacturers said to be interested. VW maintains its case via some interesting idealized indicator diagrams which show that the power lost in driving the G-40 spiral blower versus that required for an equivalent turbocharger on a 1.3-litre engine is highly competitive, in the direct-drive blower's favour.

Turbocharging is so widespread now that it is difficult to see it spreading much further. What *is* likely to happen is that standards of turbocharging control will rise across the board, as the need to maintain a wide power band becomes more important. This, as much as cost, will determine how much further the turbocharger will encroach into the mass market, although the complications it brings are still a major drawback.

With regard to alternative energy sources, it has been a bad few years for its gurus. The reason is plain enough: oil is apparently abundant. We keep finding more of the stuff, and the world's cartel has seen its price forced steadily lower. One day, all that will probably change and once again we shall look to alternatives of one kind or another.

Five years ago, a virtual industry appeared to be building itself around three propositions. One was that engines would need to be made not only more efficient, but also able to burn a wider range of fuels in order to make the most of what there was. Another was that we needed to develop the means of turning other biological or fossil fuel resources, such as surplus sugar or wine or coal or oil shale, into liquid fuel in order to replace traditional refined crude oil. The last was that we needed to replace combustion-type engines with something else altogether — such as electric motors.

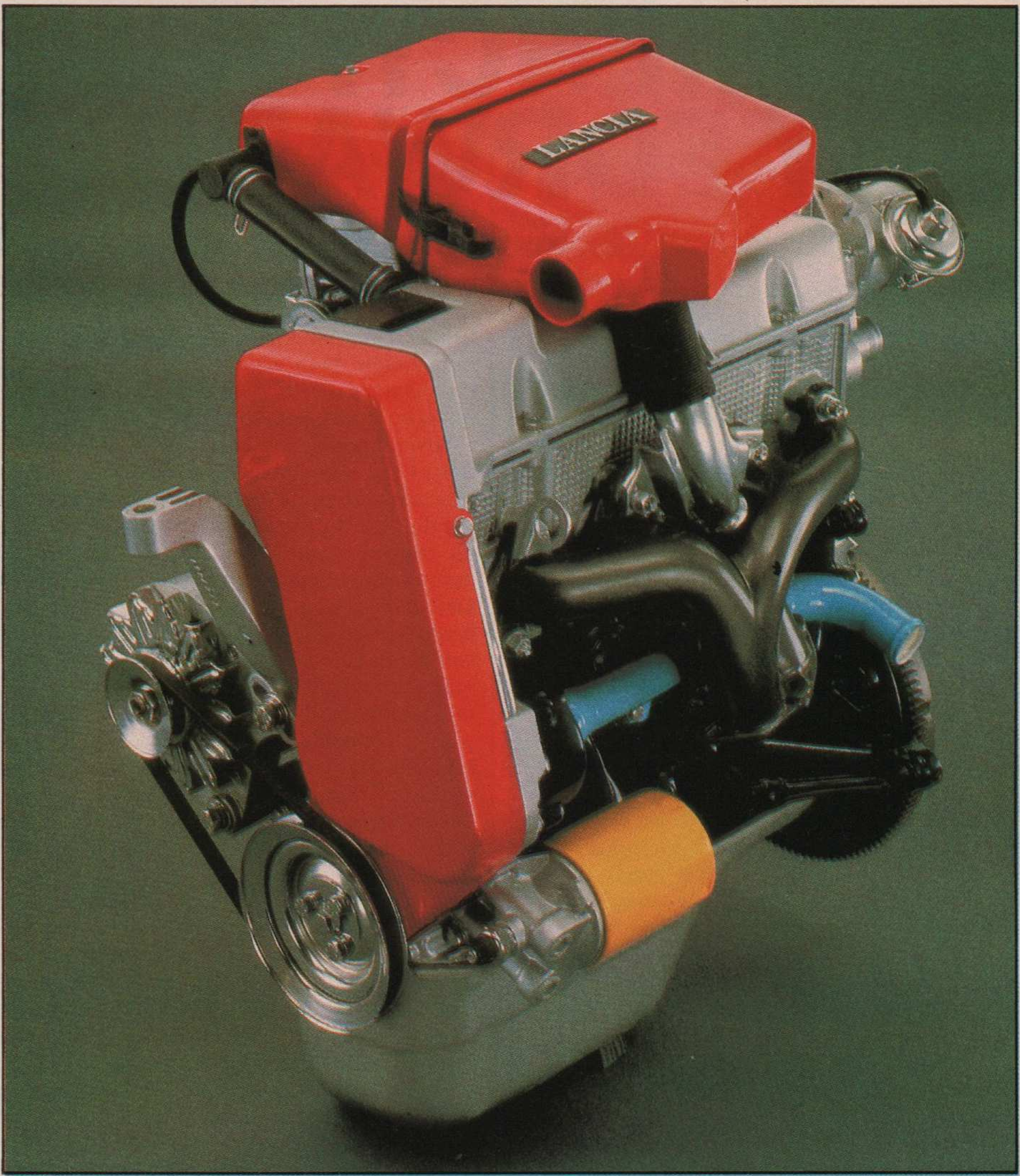
What has happened to those three propositions? The first has survived, in truncated form, mainly through other pressures. The second has largely died a death; the third may have fared even worse.

We have, of course, made our engines more efficient in a variety of ways, including turbocharging and multiple valves per cylinder. Soon, one suspects, we may see some fundamental re-thinking of the means of igniting the mixture: a pointer, perhaps, is Saab's SDI, and we may witness a return to two plugs per cylinder. All the time, electronics enable us to run engines on the edge of disaster without actually blowing up.

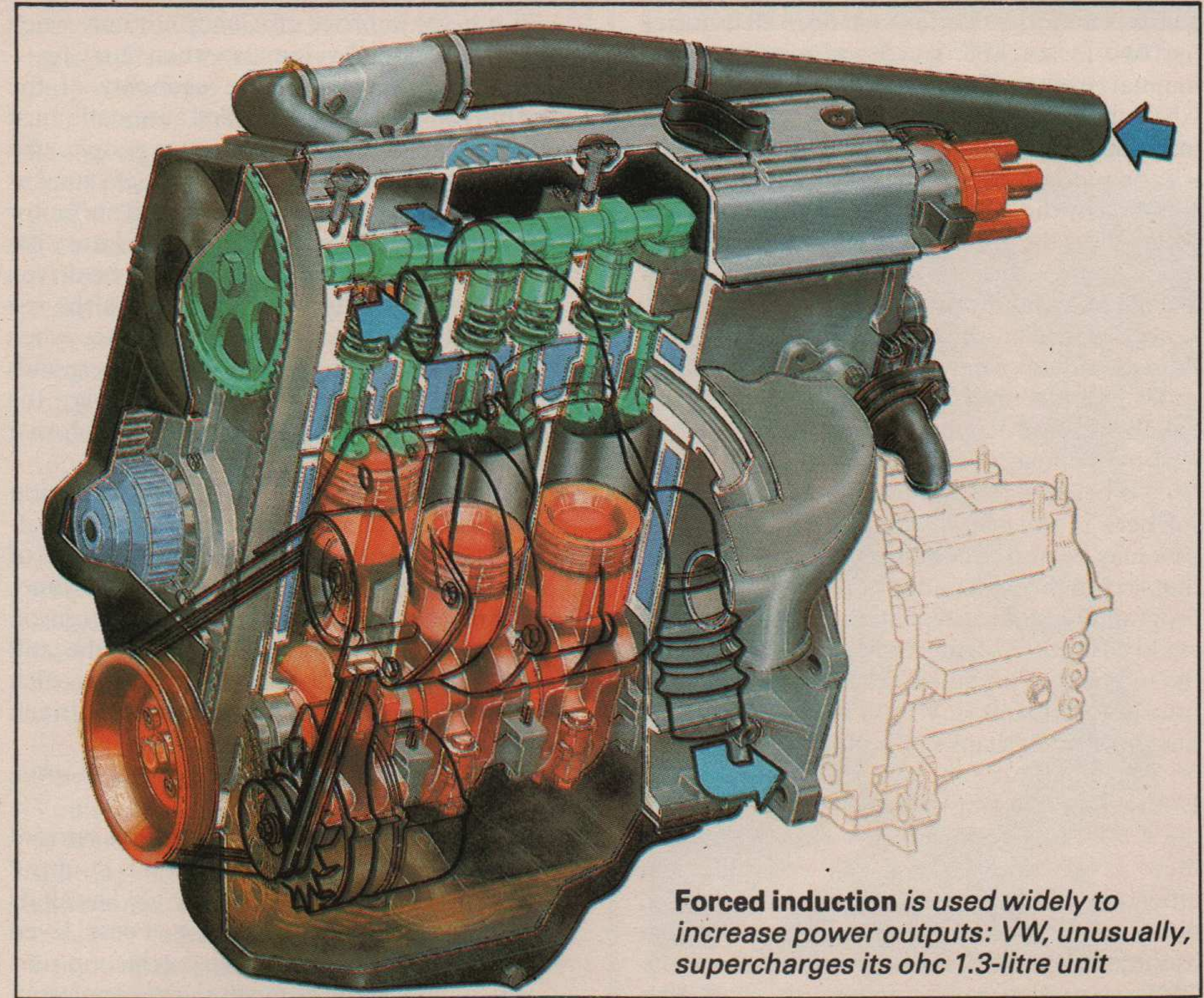
Yet this is merely the most logical of developments. One should look also at those engines which exist already and can run on anything from kerosene to 4-star. It is evident that the direct-injection diesel (such as the one Perkins and Austin-Rover are jointly developing for passenger car use) is more tolerant of varying fuel quality: with 'spark assisted ignition' some such unit might fill the multi-fuel bill. Like all things, though, it will only happen when we need it, and for the time being, we don't. The same kind of argument seems to apply to alternative engines such as the external-combustion Stirling.

Alternative fuels are in trouble. Look back to the 1970s and you discover the enthusiasm that existed for methanol-fuelled cars, for the Brazilian venture into sugar-derived ethanol, for engines that ran on cunningly-stored hydrogen, for the refining of the Athabasca tar sands and the production of oil from coal by the SASOL or LURGI processes. Today, economics have written a halt to all those ventures, even though small scientific teams may still be working towards long-term goals. Our rate of oil consumption has dropped, the geologists continue to discover more, and those who confidently predicted an oil run-out in the first half of the 21st century have gone very quiet.

As for the electric car, we have seen the brave venture of the Sinclair C5 apparently wither at birth: one suspects that it has taken with it the prospect of anyone else seriously proposing an electric car for several years. The C5 was bold thinking, a genuine attempt to unwind the vicious circle of battery weight breeding power requirement breeding battery weight which had cursed previous projects. That it seems to have failed was due to many factors, ranging from determined antipathy in many predictable quarters down to the odd decision to launch an open single-seat vehicle in the middle of a bitter winter. The fact remains that if something as logical, carefully thought-out and solidly backed as the C5 could not be made to work, the prospects are grim for other electric car hopefuls. The miracle battery, we should all now know, doesn't exist and never will; fuel cell technology advances slowly and sundry small hybrid projects spark the inevitable question: what happens if you throw away all the electrics and connect the engine direct to the wheels? Until some legislator changes the rules quite dramatically — by almost forcing a city-centre system like Amsterdam's prophetic (maybe) 'Witcar' project — the electric car seems more than ever likely to languish.



FIRE engine *from Fiat/Lancia uses the most up-to-date production techniques and design*



Forced induction *is used widely to increase power outputs: VW, unusually, supercharges its ohc 1.3-litre unit*

EFFICIENCY: THE WAY FORWARD

All-wheel drive and electronic control are some recent transmission developments. There are more in the pipeline

As long as cars are internal-combustion-engine powered, we are going to need the gearbox and clutch, or its various automatic equivalents.

It looks as if the manual gearbox itself can only be refined slightly in the next 10 years. The general standard of gearchange quality could continue to rise to the level set by most Japanese cars, although the majority of Western manufacturers have now got fairly close. It is only some of the surviving older gearboxes that need gears of better quality and design to reduce noise.

Concerning ratio choice, it has been cheering to see how *Autocar's* persistent calls in the past for the widespread adoption of overdrive five-speed gearboxes have been answered by virtually every manufacturer. It was, of course, the price of fuel rather than our unsolicited advice that made it happen, but it was pleasing nevertheless. As we said then, it is as much the cheaper, less powerful car that needs wide-range gears that include an overdrive as the larger, faster luxury car. One hopes that frustrating abomination of the cost-cutting product engineer, the so-called 3+E gearbox, will die with the old gearboxes the guilty manufacturer did not want to replace properly. Greater-spread engine torque delivery will make wider ratio range gearboxes even more essential.

The interesting thing to watch will be how far the various future forms of automatic transmission are adopted compared to the manual gearbox majority. The automatic in all its forms has two inescapable handicaps relative to the manual gearbox. The first is its inevitably higher cost, which is one reason why you still don't find many small automatics. The second is that one way or another, the energy used to change gear, supplied by the driver with a manual unit, has to be taken by the auto transmission from the only other source, the power plant, in the form usually of hydraulic pressure from an oil pump. It need not be much, but it is always there. It is false to imply as a newly formed general rule, as some manufacturers do, that automatics are equally or more economical than manual cars — in some famous cases where this appears to be so, it is because the automatic is geared higher.

There is one way in which future two-pedal cars may be more economical than before, and that is with the wider adoption of electronically programmed choice of gear: the gear concerned could be one of a set of fixed ratios or the ratio of the moment in a stepless continuously variable ratio transmission (CVT). The CVT is a long time a-coming, thanks to problems, in the case of Fiat and Ford, in production of the Van Doorne steel pushing belt. Everyone involved in the CVT in its various forms assures you that there is no doubt about the economy and efficiency advantages of these gearing systems, but not everyone is convinced about the cost problem. Something no one mentions about the CVT car is that public acceptance would be helped if interior engine noise could be reduced rather more than usual, since the undeniably fussy nature of a CVT car needs to be played down by good insulation.

Several people are keen about the possibilities of the automatically controlled spur gear transmission, using electronics as the 'brain' — in other words, the automatic manual. Electronic control of automatic clutches can provide easily a very high standard of gearchange speed and smoothness, which makes six speed gearboxes a practical and useful proposition, and in cost terms can make such arrangements a very real alternative to the CVT. As with the CVT, this is only really worth doing in conjunction with a control system sensitive of the most efficient way of using the engine — when efficiency rather than performance is wanted. Such systems are close at hand now, and it is solely the cost question which holds the manufacturer back.

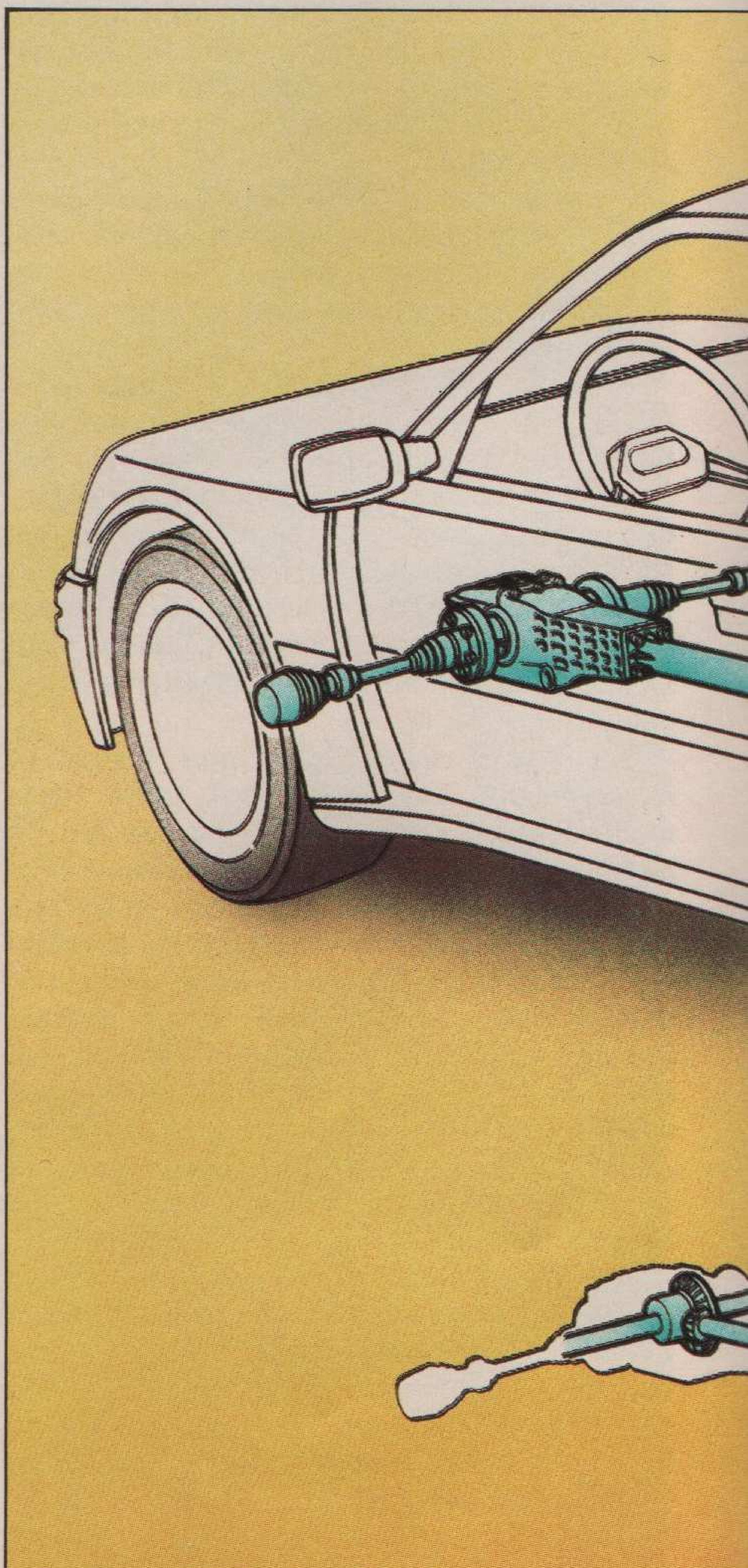
What about the conventional automatic — the epicyclic gearbox allied to a very common existing form of limited-ratio-speed CVT, the torque converter or hydrodynamic coupling? There is no doubt that when the driver uses an intelligently controlled automatic — electronics again, programmed to change gear to suit the engine's more economical ranges — he can get fair results. But even more important is the ability of the gearbox to short-circuit mechanically the torque converter, to do so smoothly, and as often as possible in all the gears.

This helps improve efficiency not only when driving for economy, but also when hurrying — and those who talk of the economy of the carefully and cleverly controlled automatic must always remember that cars are for people who do not always want to drive slowly. As long as there is true freedom, of which the private motor car is one practical embodiment, no future car which dictates completely how it can be driven will sell successfully. What will sell is the car offering the best of automatic efficiency when wanted, and which equally readily responds when you want it to *go*. Fortunately, the majority of engineers who can provide such a car see the need for fun as well as economy.

We are now also in the middle of a traction revolution, with an old invention, all-wheel-drive, being adopted for an ever wider range of cars. If there is an afterlife for everyone, including tractor millionaires, Harry Ferguson must be very pleased, especially as the still mysterious coupling patented in his name is such an important part of the better all-wheel-driven systems.

What could happen on the four-wheel-drive scene in the next 10 years?

For the popular car, assuming that current world over-production continues, it is doubtful if we will see the day when every car has all its wheels powered, simply because of cost. Even with the economies of massive production runs — which must apply as much to the simplest of

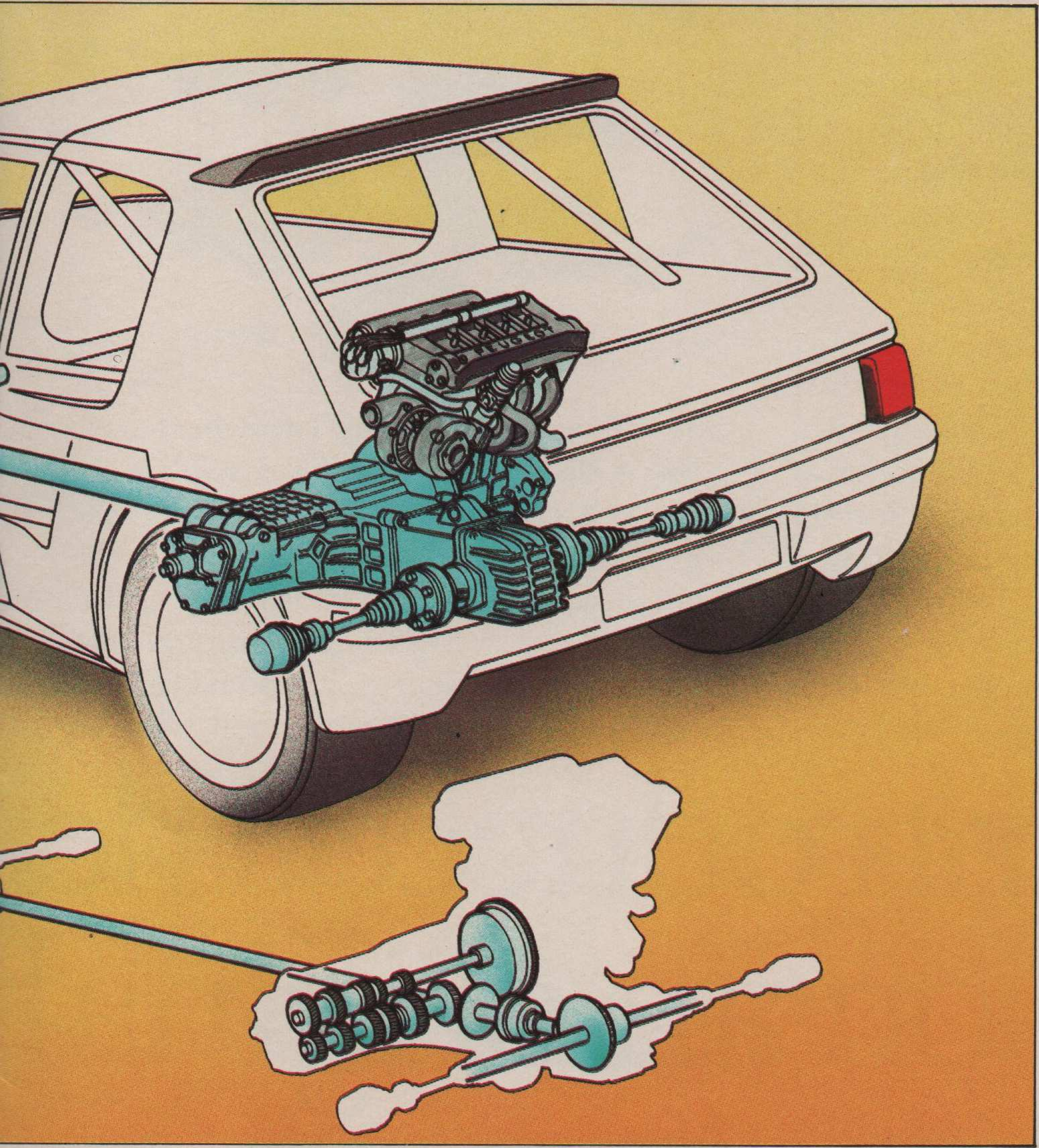


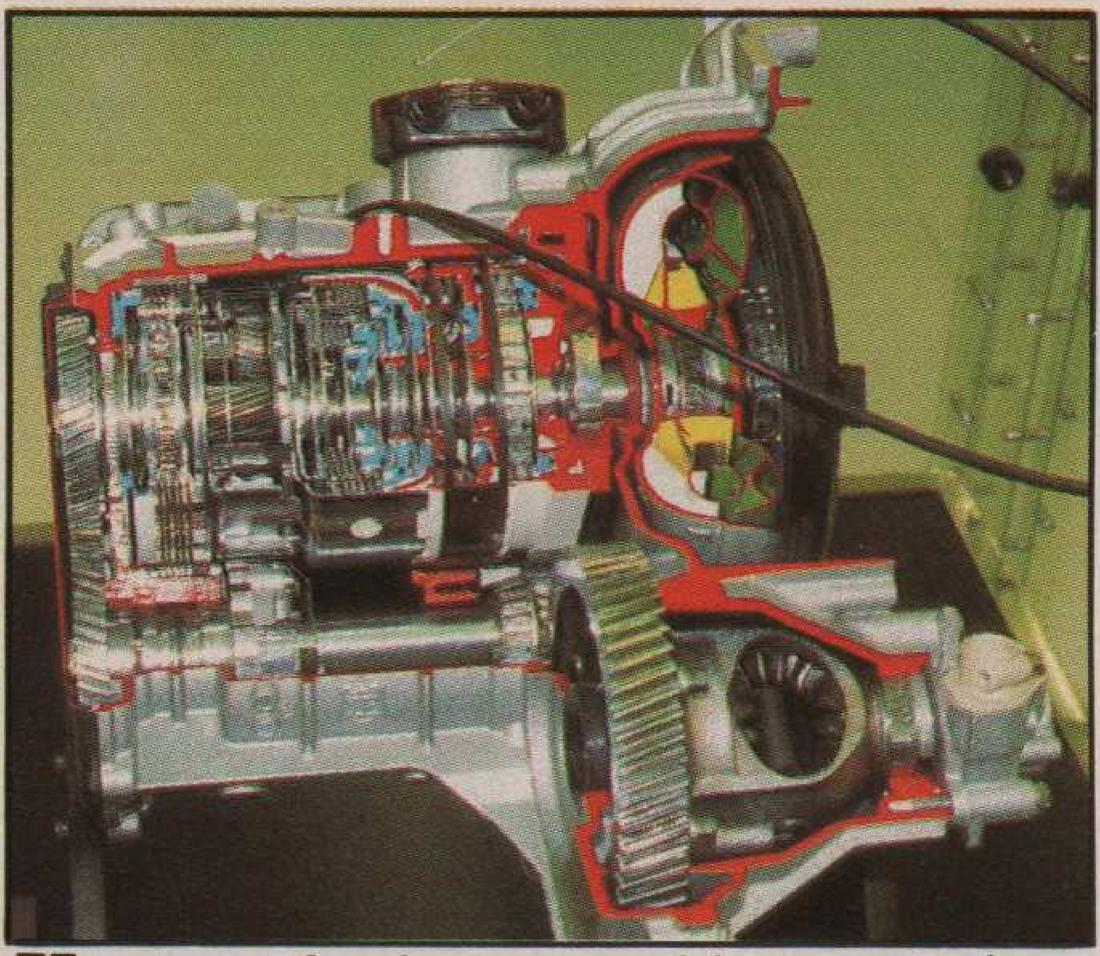
Peugeot 205 Turbo 16 *4wd layout follows current thinking, with centre differential and variable torque split*

cars as to the more complex — a four-wheel drive car cannot be as cheap as a two-wheel drive one. No major manufacturer will risk pricing itself out of popular, price conscious, markets. An additional reason for this is the popularity of front-wheel drive, for while traction is undeniably lower in hard acceleration, it is remarkably effective in allowing the driver to keep going in all but the very worst conditions.

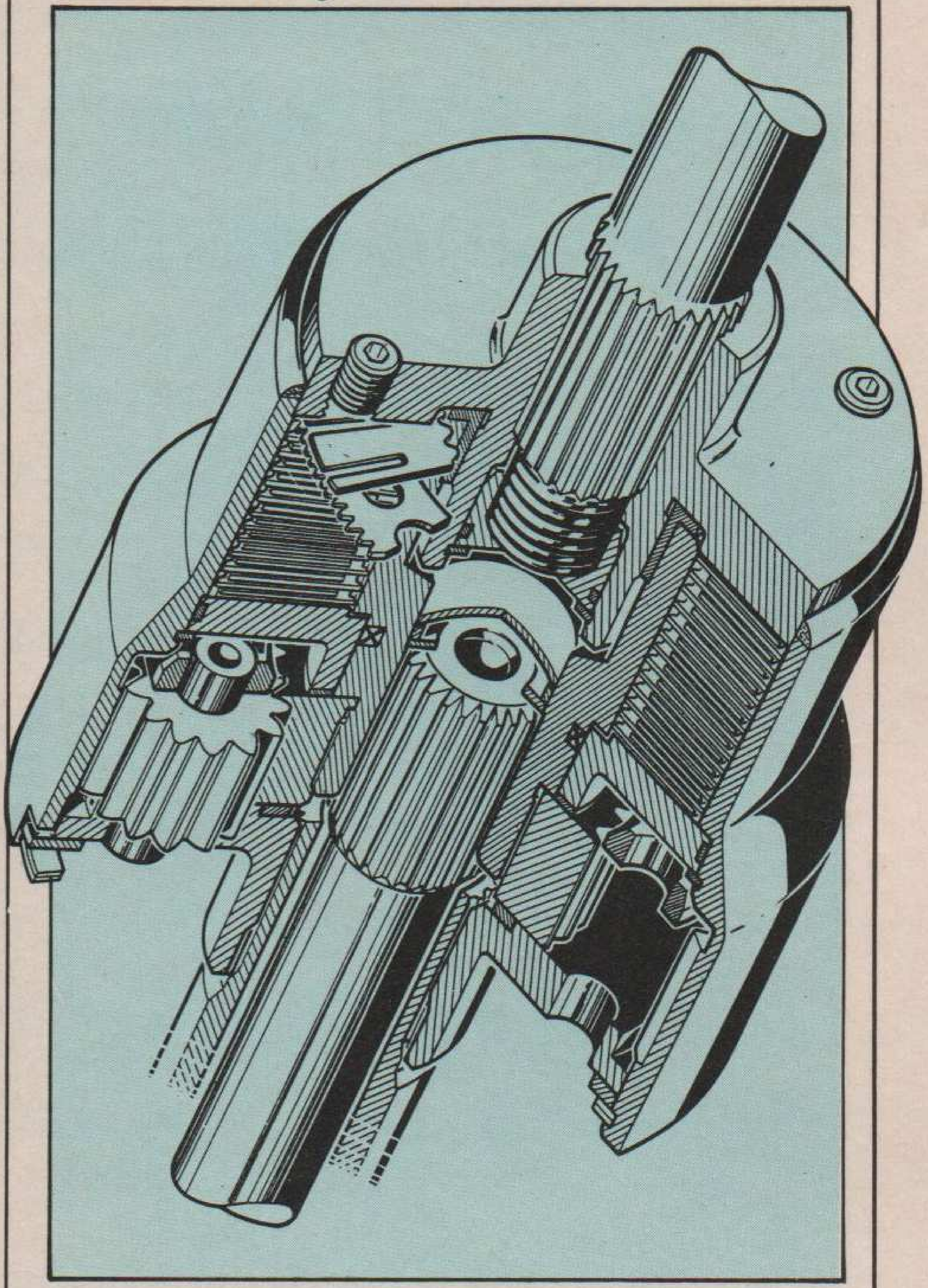
That said, how low is the border of four-wheel drive likely to fall in the popular car sector? With the application of its delightfully simple Syncro system to a 90 PS 1.8-litre carburettor Golf rather than the more obvious GTi, Volkswagen seems to have pointed the way. It remains to be seen how well this promising-looking car sells when it goes into production. Its simplicity is due to that Ferguson-patent silicone viscous-fluid coupling, which is so outstanding that Volkswagen AG, nowadays probably the most technically proficient and therefore technically proud of mass manufacturers, has chosen to pay the holders of the Ferguson rights for development and manufacture of viscous couplings.

For the benefit of anyone not clear what a viscous coupling is or does, it boils down to something similar to a wet multi-plate clutch. You have a closed cylinder, the inside of which is splined to fit corresponding splines on the outside of a considerable number of thin steel

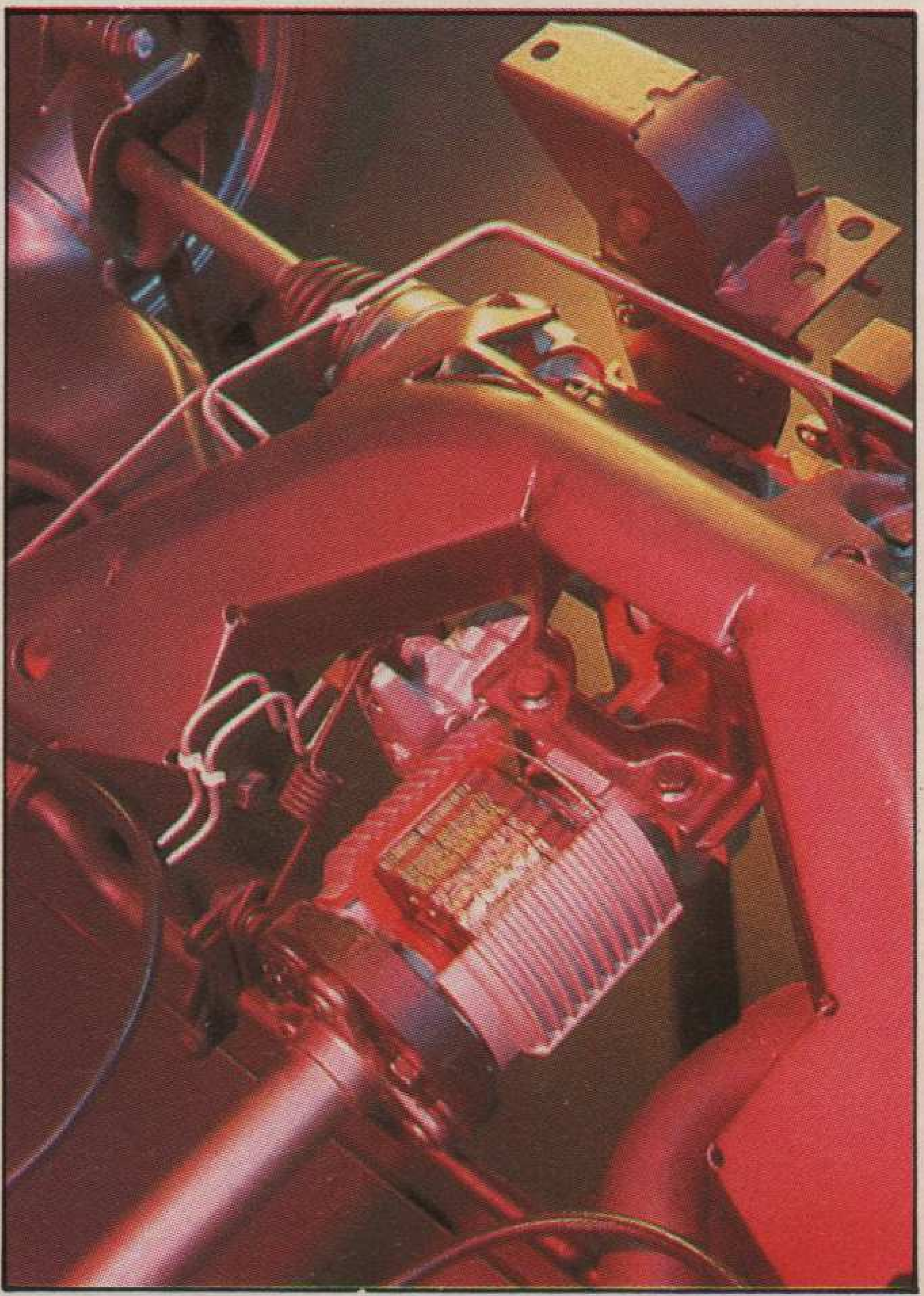




ZF automatic *gives more driver control*



Viscous coupling *from FF Developments now plays an integral part in some transmission systems: it effectively operates as a limited-slip differential*



VW Syncro *uses viscous coupling for 4wd*

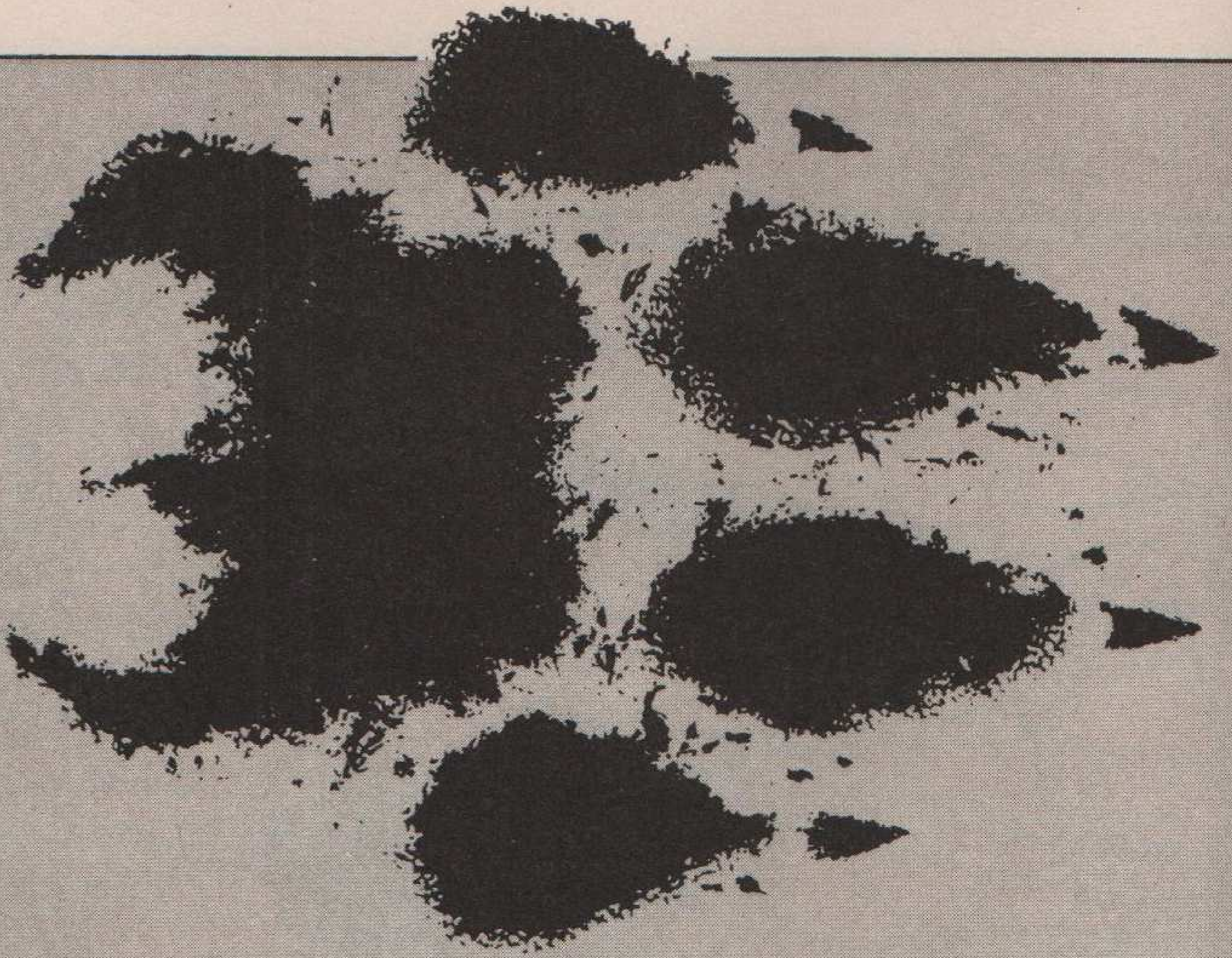
plate discs in which are cut radial slots. In between each pair of the slotted discs there are similar thickness, slightly smaller diameter discs pierced by a pattern of axial holes. These inner discs — slotted and holed — are splined to a shaft running out of one end of the cylinder through a seal and bearing. The cylinder is almost filled — the air space varies between 7 and 12 per cent of the total volume — with a Dow Corning silicone fluid. Its odd property is that its viscosity (its thickness) does not vary as much according to temperature as other fluids; it does not 'thin' so much as it warms up.

When you turn the central shaft slowly relative to the cylinder, a small amount of that twist is transmitted through the plates and fluid to the cylinder. If the relative speed between shaft and cylinder, and therefore between holed plates and slotted ones, is increased, the torque transmitted between the two increases greatly, as the fluid between the discs increasingly resists the motion. The effect is speed-proportional. The extreme end of the coupling's behaviour, where the cylinder is full of fluid, except for the 7 to 12 per cent air space, is responsible for the 'hump' effect, when the coupling locks solid.

You now have a variable torque transmitting clutch, of ideal and constant proportionality according to speed difference between the outer cylinder and inner shaft, which will progressively become solid if the speed difference becomes high and tries to continue. The smoothness and progressiveness of this behaviour makes a marvellous, silent, jerk-free, self-protecting limited slip differential — with the added bonus that if one wheel finds itself too lightly loaded to grip, or it its driveshaft breaks, the coupling will soon 'hump', and put *all* and not just some of the power through the other wheel. Use such a coupling in place of the centre differential of a four-wheel-drive car, and you have an ideal mechanism of great simplicity. It will transmit torque to the wheels furthest from the drive unit when the wheels nearest begin to lose grip, but not too much otherwise. It will go solid if one end loses grip for any length of time, so that the car still has traction.

It is worth rehearsing the principles of the VC when looking at possibilities in the near future because such couplings are certain to become the rule rather than the exception in 4wd cars. One must point out quickly that VCs have virtually always been found in permanent 4wd cars designed on the Ferguson layout, where they are used less arduously than in the Volkswagen Syncro case — in other words only as limited slip additions to an unequal torque-splitting epicyclic, still, in our opinion and experience, the best way to balance a 4wd car's handling character. It is certainly the thinking behind all the modern 4wd rally cars subsequent to the Audi quattro.

Audi introduced thei
based on an original



The concept of power, mobility, grip and control on each corner of a moving body, is far from being an idea on which Audi have sole copyright.

Nature's reproduction line runs off perfect models each and every day.

The challenge was, how to find a way of giving today's driver the very same sensations?

Audi

Audi looked first at how far the car had gone, then considered where it ought to go.

When four-wheel braking was introduced to Grand Prix racing in 1914, it pushed car technology a long way forward.

Everyone now takes it for granted that all four wheels of a car are used to brake it. So surely shouldn't it follow that all four wheels ought to drive it?

One advantage of four-wheel drive is obvious. It's taken heavy, lumbering vehicles over every kind of terrain in virtually every country in the world.

Because, irrespective of load, the traction developed by a vehicle with four-wheel drive is up to twice as great as with any car with just two-wheel drive. But it also carries with it a drawback.

Traditionally the transfer case positioned behind the engine and the gearbox unit, took up space, added weight, and wasted power through the movement of bearings, gears and oil.

In March 1980 tradition was not only broken, but shattered. Many thousands of hours of research and even more thousands of Deutschmarks investment, paid off.

With a car featuring a unique system of permanent four-wheel drive.

A car with a lightweight, economical, transfer differential in a conventional gearbox.

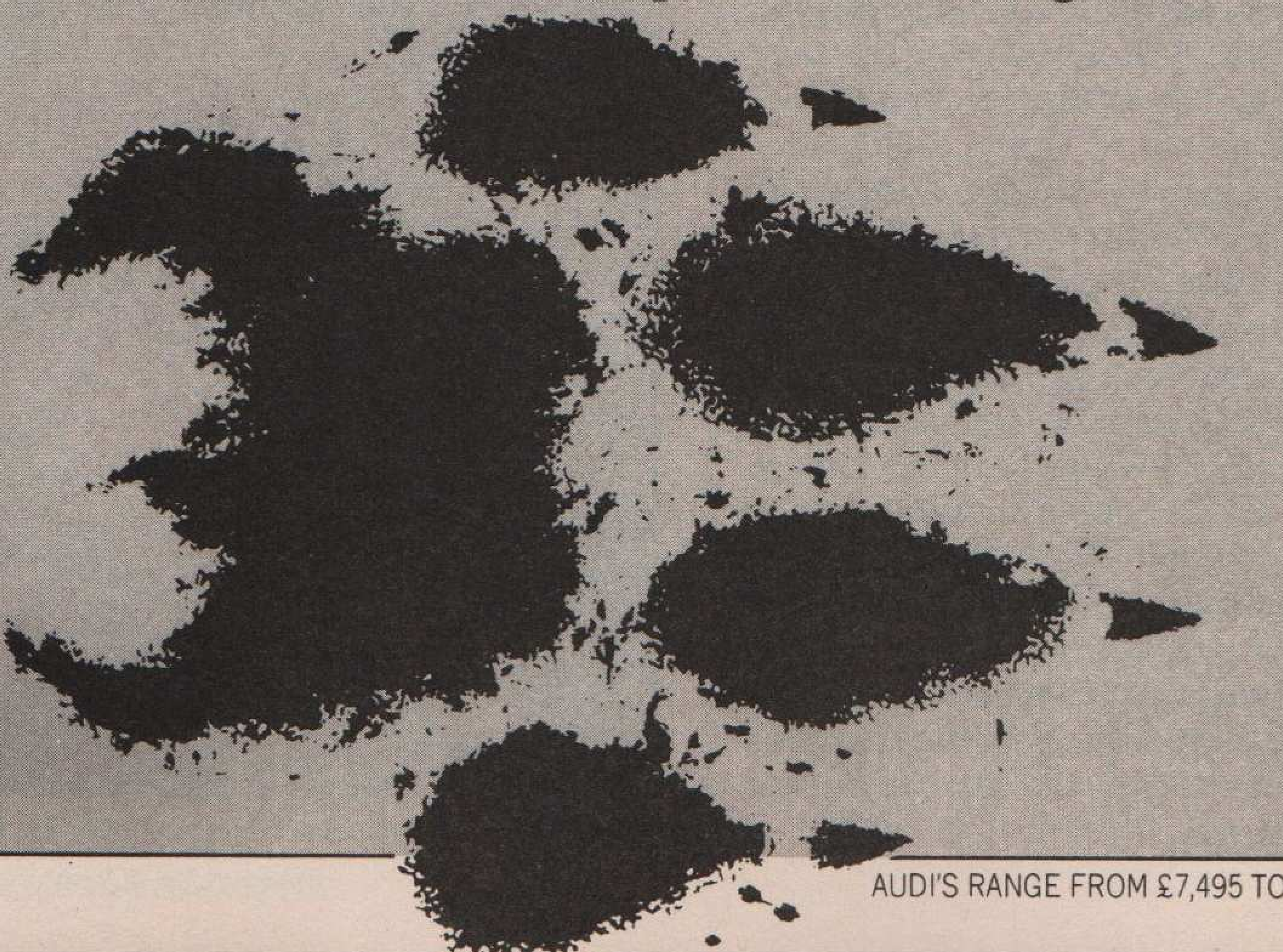
A car capable of staying superglued to the road at 135 mph.

The Audi quattro.

As you'd expect, the quattro delivers up to twice the traction when compared with a two-wheel drive car.

But not just on ice or in snow.

Its even distribution of power means lesser demands on tyre adhesion



AUDI'S RANGE FROM £7,495 TO OVER £50,000. BROCHURES AND PRICE LIST FROM AUDI INFORMATION SERVICE, YEOMANS DRIVE.

even when the road is dry.

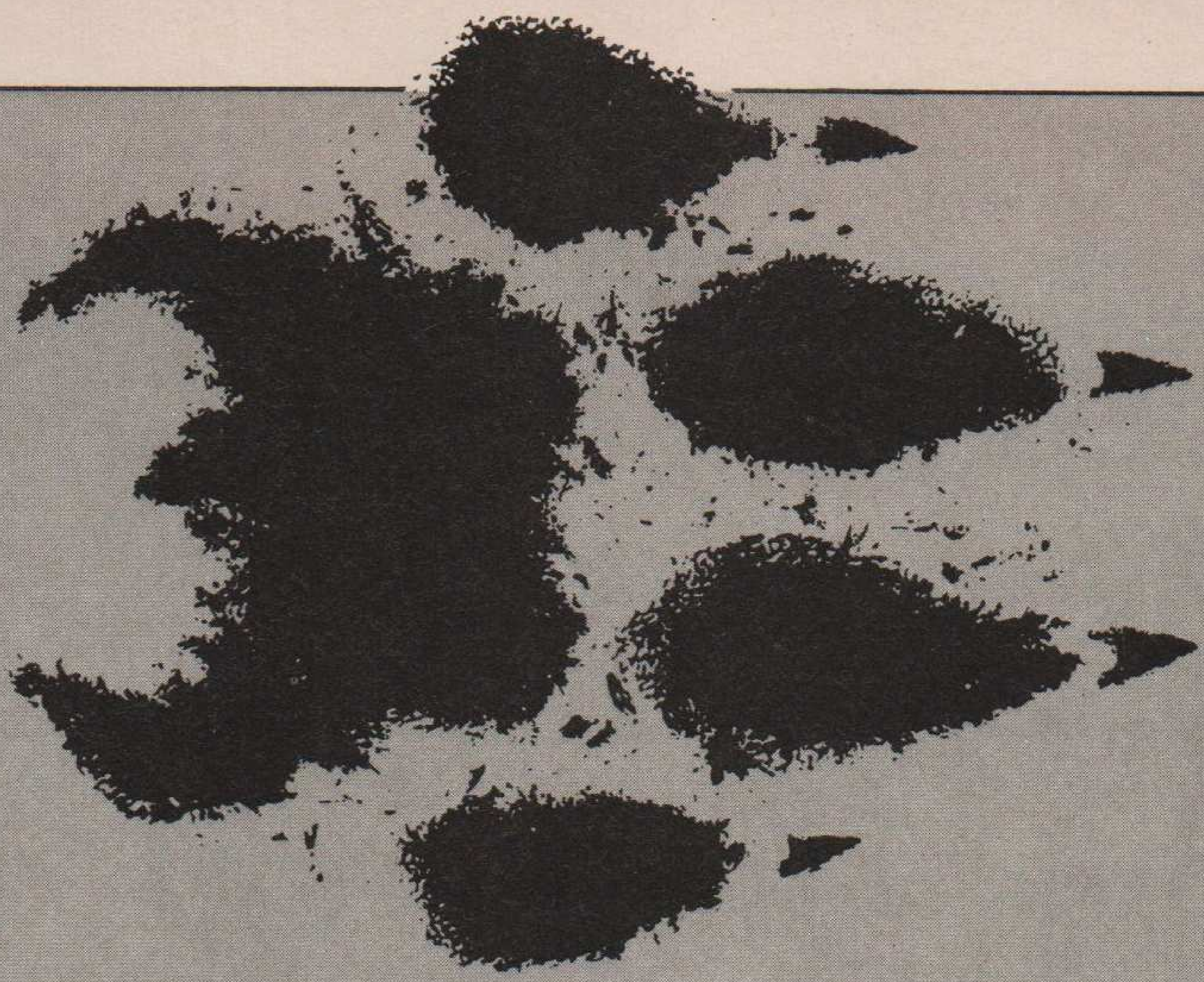
There is no longer any need to maintain speed for fear of losing traction, even on steep gradients in wet or snow covered conditions.

Being set up for slight understeer, its cornering radius increases if speed is excessive, and is tightened as the throttle closes.

You can accelerate out of corners faster, with the confidence of complete control and stability.

(However, just be aware that you can only brake as quickly as you can accelerate.)

And the back bar motoring correspondent's claim that, "You won't need brakes, you'll run out of petrol first," for once isn't true.



drive car on a perfect surface, an Audi quattro appears to use a marginal amount more fuel.

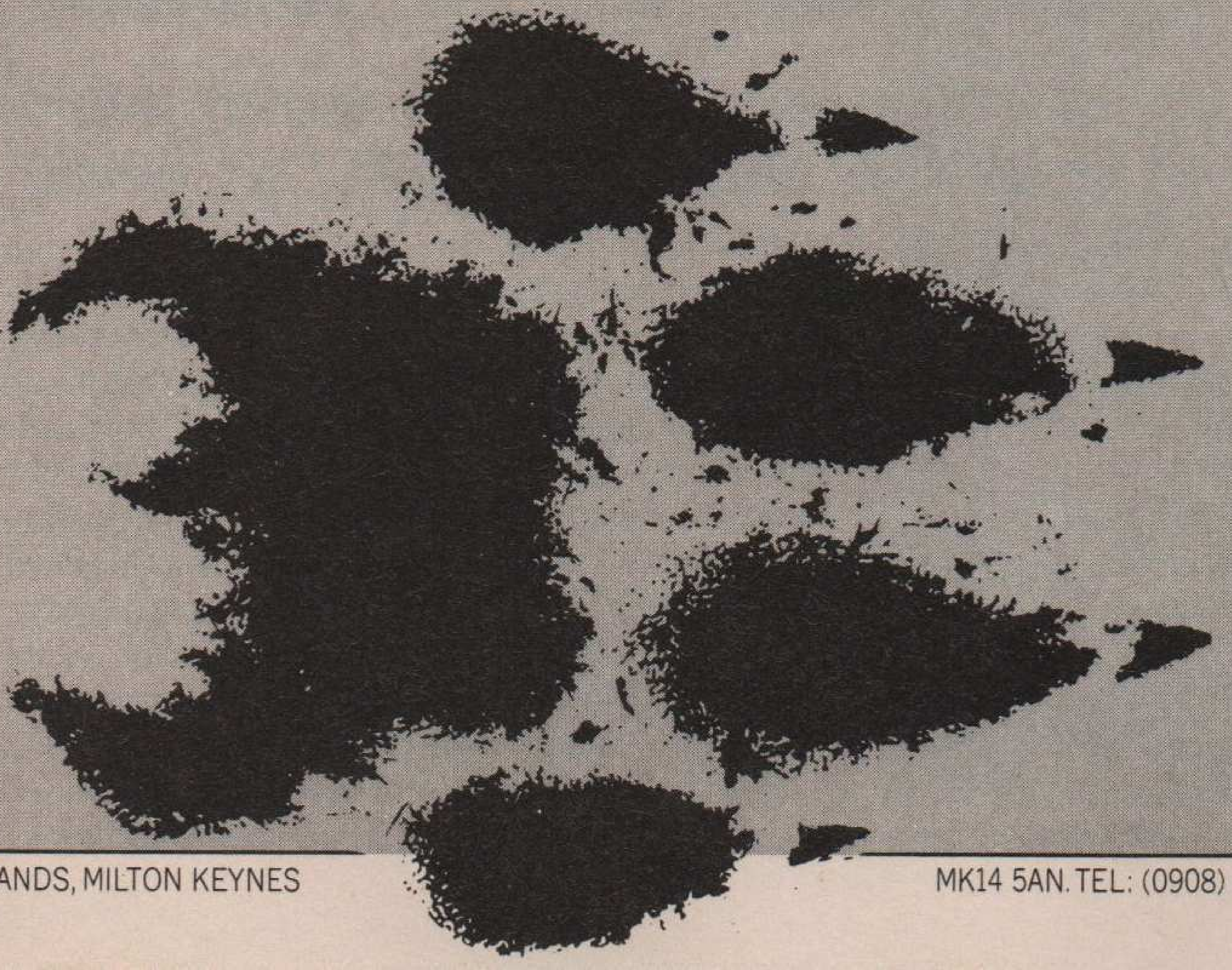
But remember this: with every car, otherwise identical engines can vary in consumption by plus or minus 5%.

A six cylinder engine can use more than a four cylinder. Most automatic

r four wheel drive car idea by someone else.

In our own tests, when an identical four-wheel drive Audi was converted to front-wheel drive, there was only 2.5% more fuel saved when both were driven at a constant 100 kph and 130 kph. Taken up to a constant 160 kph, there was a fuel saving of only 1%.

So yes, compared with a two-wheel



transmissions are thirstier than a manual gearbox.

By comparison, the additional consumption of the four-wheel drive Audi is so minimal it's virtually impossible to measure.

Given that, it's not surprising Audi has put so much faith in its performance. So much so, that for 1985 permanent four-wheel drive will be available in every model group.

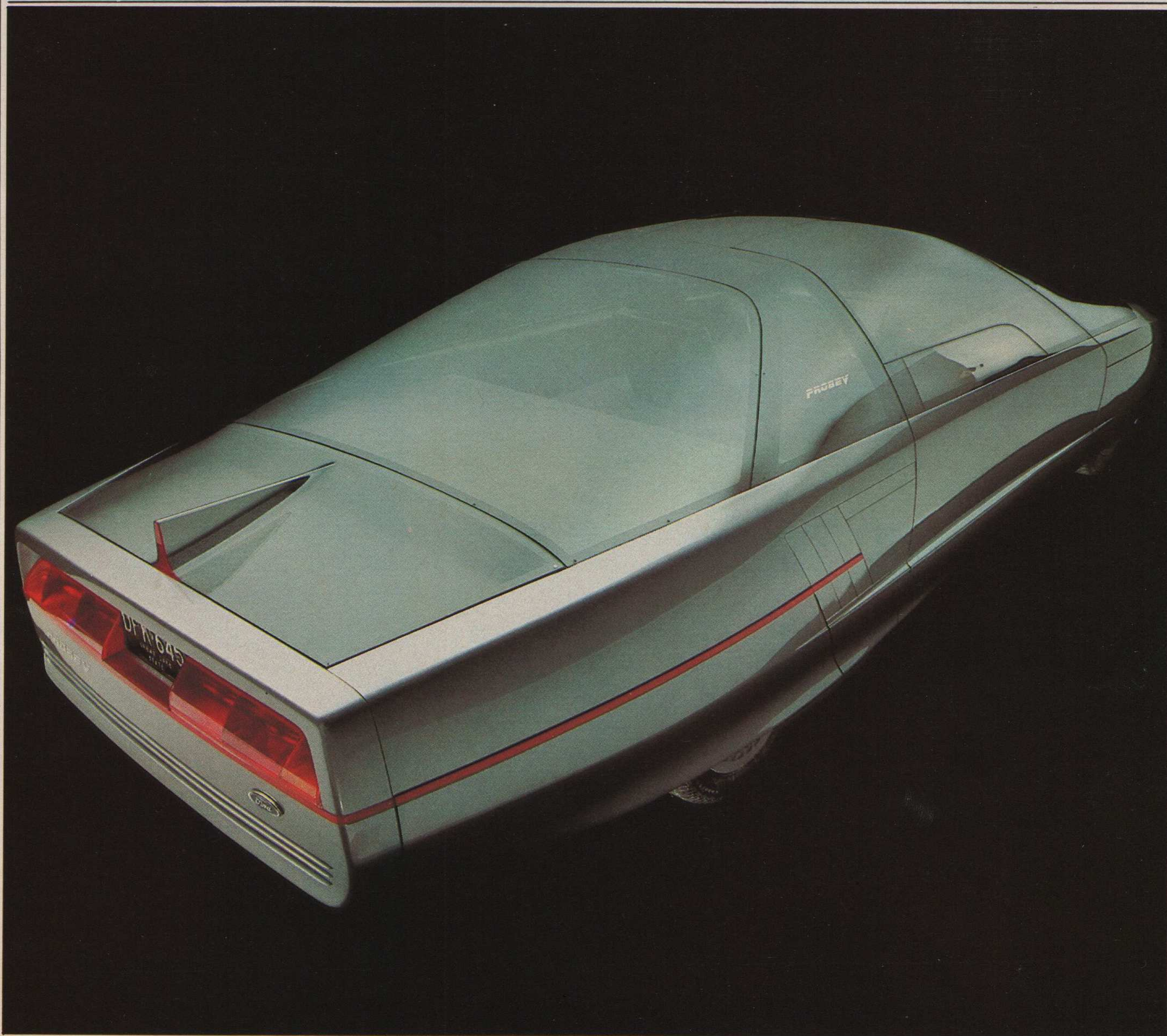
quattro

A leading motoring journalist wrote that driving one "was like being welded to the road."

Welded to the road it may be. Riveted to the spot it isn't.

We only wish we could take all the credit ■

BLAKELANDS, MILTON KEYNES MK14 5AN. TEL: (0908) 679121. EXPORT AND FLEET SALES, 95 BAKER STREET, LONDON W1M 1FB. TEL: 01-486 8411.



Design exercises, *such as Ford's Probe V, are important in determining the shape of tomorrow's cars: low drag coefficients are vital*

THE FUTURE STYLE

Fuel economy is now an important consideration in passenger car design, and aerodynamic efficiency is an important part of achieving that goal and ensuring stability at speed

You can be certain of one thing about cars of the future: aerodynamic efficiency will become run-of-the-mill. For normal saloon and hatchback cars, a drag coefficient of more than 0.30 will be regarded as unusual. It will take a minimum of five years for this to become true across the industry, but thereafter it will be inescapable, particularly when the next, inevitable, oil price rise crisis approaches.

Equally, something just as exciting technically has to happen, even if it is not so obvious to everyone at the moment. That is the application of knowledge from racing to ordinary cars of how to harness aerodynamic forces for greater stability at motorway speeds. Admittedly, if what we regard as authority's astonishingly Luddite persistence in applying overall speed limits gets any worse, then aerodynamic efficiency would seem to have little rèlevance. That may seem obvious until you consider how buyers, bless them, will have little or, if they are well-off enough, nothing to do with cars that are not capable of at least 50 per cent more speed than the present 70 mph limit. It is likely, therefore, that high speed aerodynamics will survive as long as legislators allow the illegally fast high speed car.

High speed aero-stability will involve a mixture of optimum aerodynamic trim — bálancing and reducing to a minimum lift at each end of the car — and, as *Autocar* showed in some specially commissioned MIRA wind tunnel work led by John Miles and Peter Stevens, harnessing the effects of better underbody design for a touch of negative lift. It is likely, certainly, that on more expensive cars, this may be most reliably obtained by adding a minimum ride height attitude control, and in the even more expensive optimum, by programming car attitude to change with speed.

While designers have been aware for many years of the importance of good aerodynamic

Vauxhall Astra: *practical wind-cheating*

Wind tunnels *are useful design aids*

performance, however, difficulties in reproducing the complex shapes of wind tunnel design studies on the mass production line at reasonable cost encouraged companies to stay with more easily fabricated shapes.

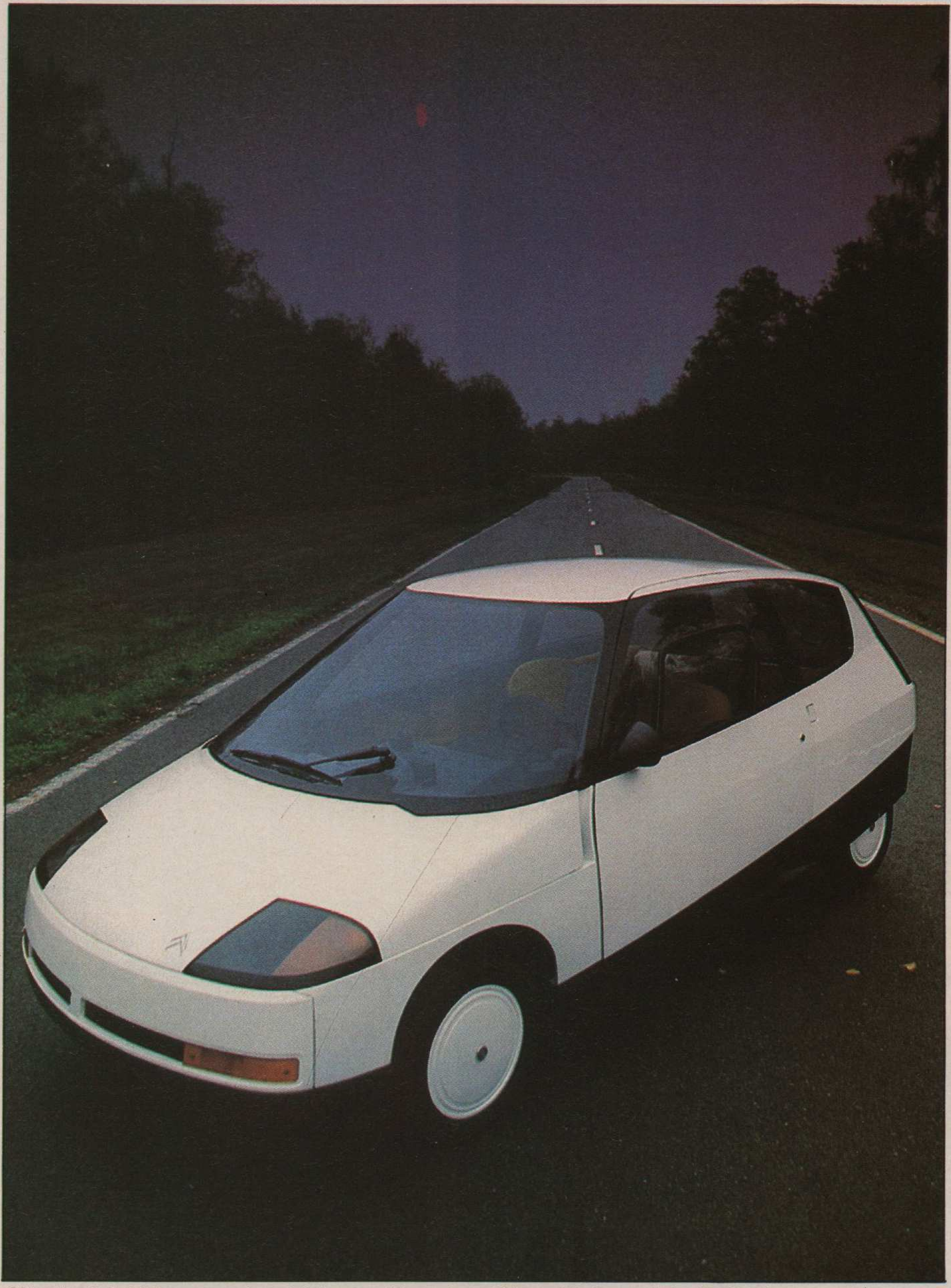
The fuel crisis changed this as well as many other attitudes. Good shapes are more efficient, requiring less power to drive them along and therefore the car's drag coefficient suddenly emerged as a fashionable and useful advertising tool. Audi was so proud of the performance of the new shape 100 that the figure was etched on the side window.

Ford's Probe series provided valuable research input as well as preparing the way for public acceptance of more radical shapes for cars. Even so, the more conservative markets—such as the UK—still needed to be won over and taught to live with cars like Ford's Sierra and Vauxhall's slippery Astra. The latest in the Probe series, Probe V, has been shown already in the US and a fully trimmed version in steel is being built at the Ford owned Ghia concern in Turin for a possible appearance at the Tokyo Show next month.

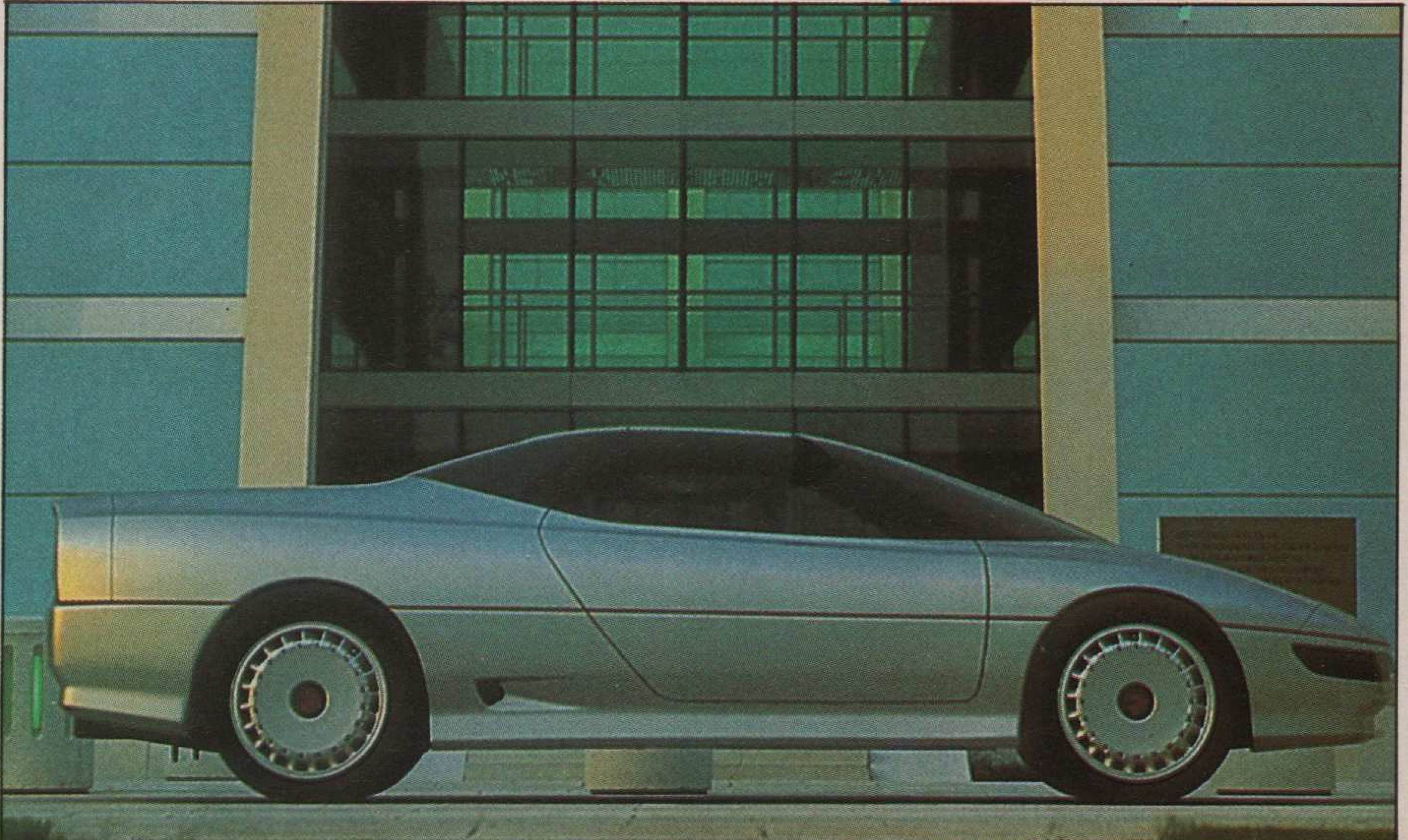
Probe V follows its immediate predecessor with a fully enveloping bodyshell, including flexible covers for the wheel arches. The 0.137 Cd is reckoned to be better than that of an F15 'Eagle' fighter plane and allows the car to achieve a steady 50mph on a power output of only 2bhp.

Other sophistications include the adoption of special narrow section wheels and tyres, full length undertray, an automatic vehicle attitude control system and a speed sensitive front air dam. The close-fitting doors extend up into the roofline and open on a lift-and-slide arrangement.

A major problem with ultra smooth shapes can be getting a sufficient volume of air to feed the engine induction process and more important for cooling. The Probe V study includes special louvres that are adjusted thermostatically to admit air to the engine bay.



Citroën SA 119 *research vehicle combines low Cd and light weight for fuel economy*



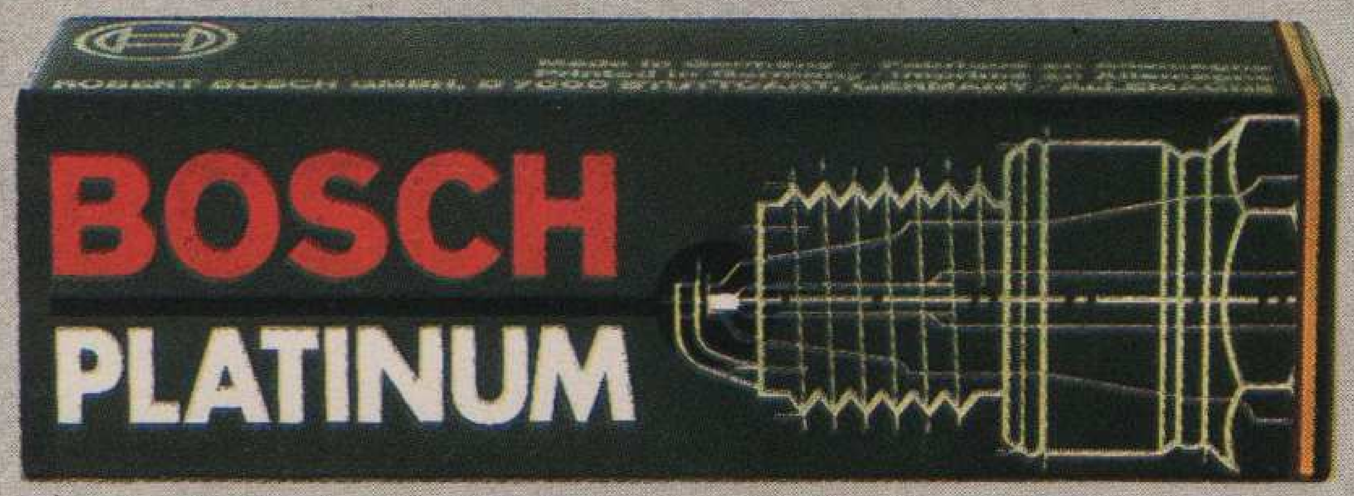
Sports car style: *dramatic looks for MG EX-E, as well as the remarkably low Cd of 0.24*

Here's a great tip for better engine performance

The New Bosch Platinum Spark Plug

The problem with conventional spark plugs is the time it takes them to reach their ideal operating temperature, approx 400°C. Before that temperature is reached the plug fouls up. Which means wasted fuel, poor starting and ultimately lower performance and increased engine wear.

New Bosch Platinum Spark Plugs reach that temperature faster, and better still are self cleaning seconds after starting.



All because of their unique design. The platinum centre electrode, which is sintered tight into the insulator, allow the plugs to work at the heart of things, deep in the combustion chamber.

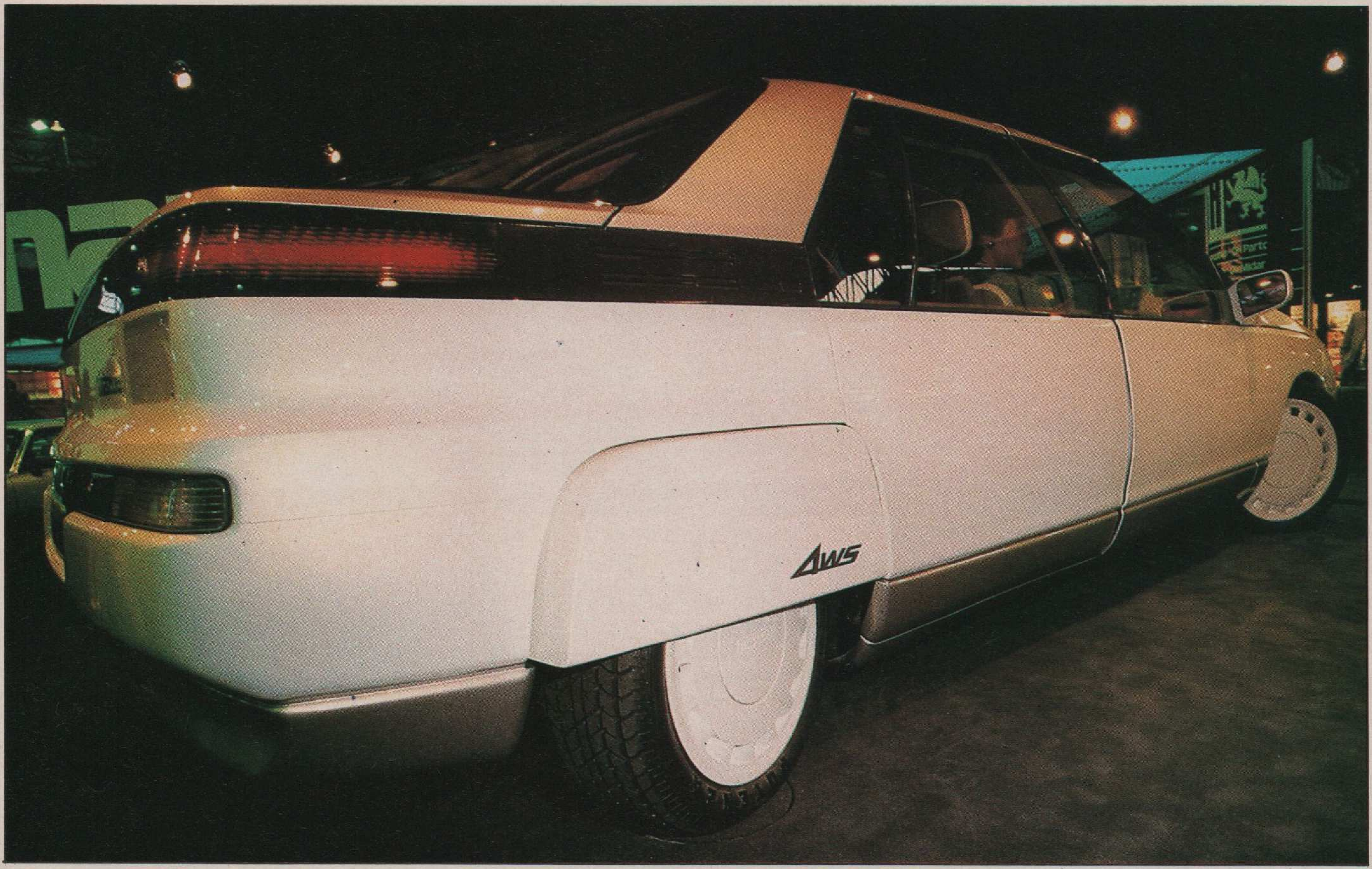
You'll notice the difference from the moment you switch on, and appreciate it in town driving or at speed on the motorway. Better still Bosch Platinum maintain this performance between service intervals.

And what price peace of mind when you turn that key on cold mornings?

Driving's getting tougher, so get tough on driving efficiency now.

Insist on Bosch Platinum Spark Plugs for your car.

BOSCH



Mazda MX-02 *experimental car is fitted with four-wheel steering. The Japanese claim that the effect is to enhance a car's stability*

SUSPENDING BELIEF

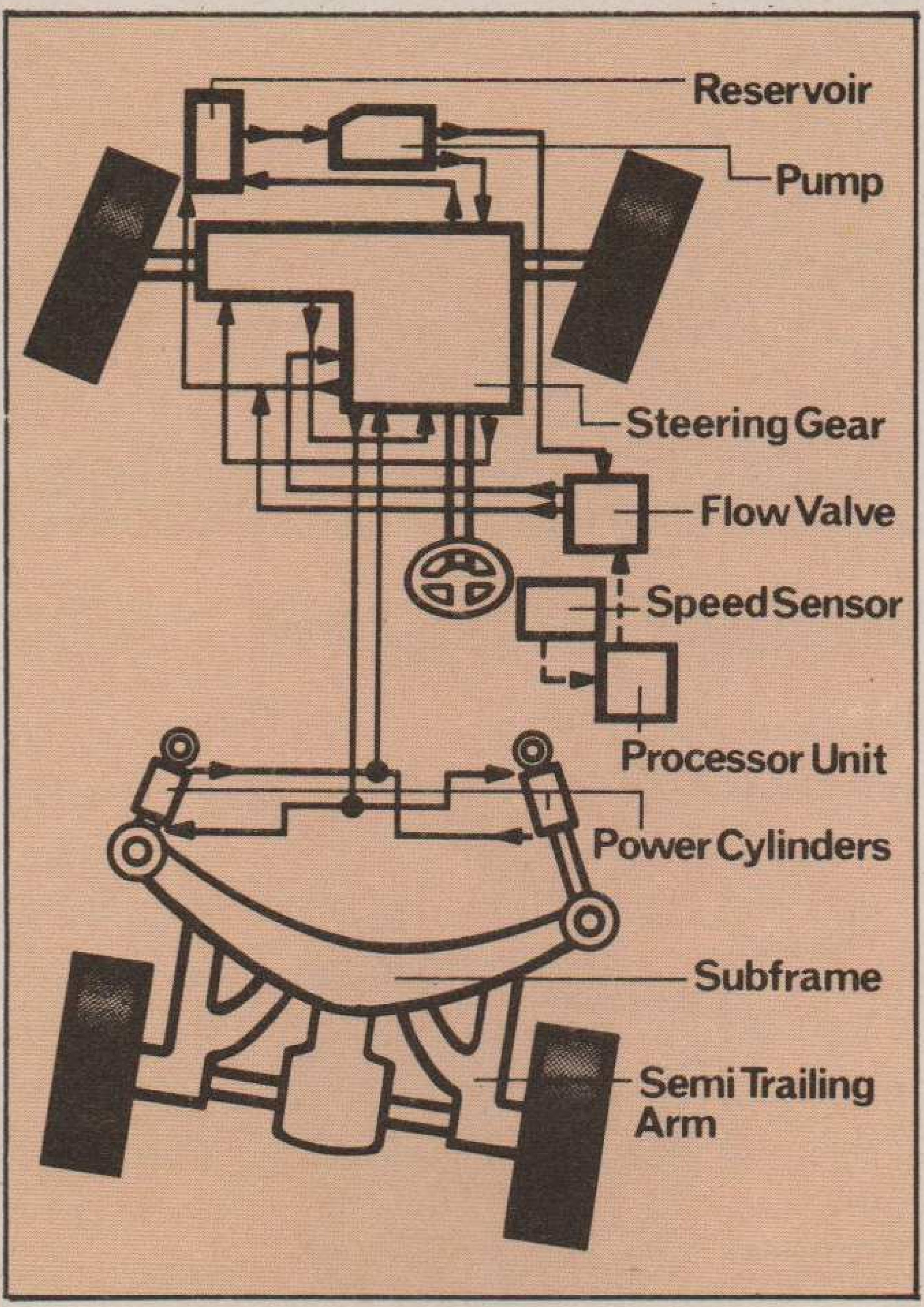
Recent chassis developments have proved that there is life after the MacPherson strut: active suspension and four-wheel steering are due soon, ABS is now here to stay

Of the future advances possible in suspension, steering and brakes, the most obvious one we will see adopted more widely is anti-lock brakes, or ABS.

It doesn't take any sort of prophetic ability to see that ABS will spread lower and wider in the price scale: due to the German company Alfred Teves (ATe), and Ford, it has become standard equipment on the already competitively priced new Granada/Scorpio, even on the cheapest model, therefore putting the cat among the manufacturing pigeons.

The ATe system is, like the Bosch original, electronically based in its sensing and determination of when and how much to back off otherwise locked brakes. Its main advance over the Bosch arrangement is its neatness by combining the brake application, release and pressure maintaining systems in one relatively compact unit. This makes life easier for the car designer who has to cope with increasingly cramped bonnet areas.

The crucial thing which fixes how far down the car class you will find ABS systems of the future is, once again, cost. Everyone concerned is working hard on lowering the cost; one cannot help but suspect that in the existing ATe system case it was the size of the Ford order for the Granada that made it possible for the brake manufacturer to make his OE price low enough.

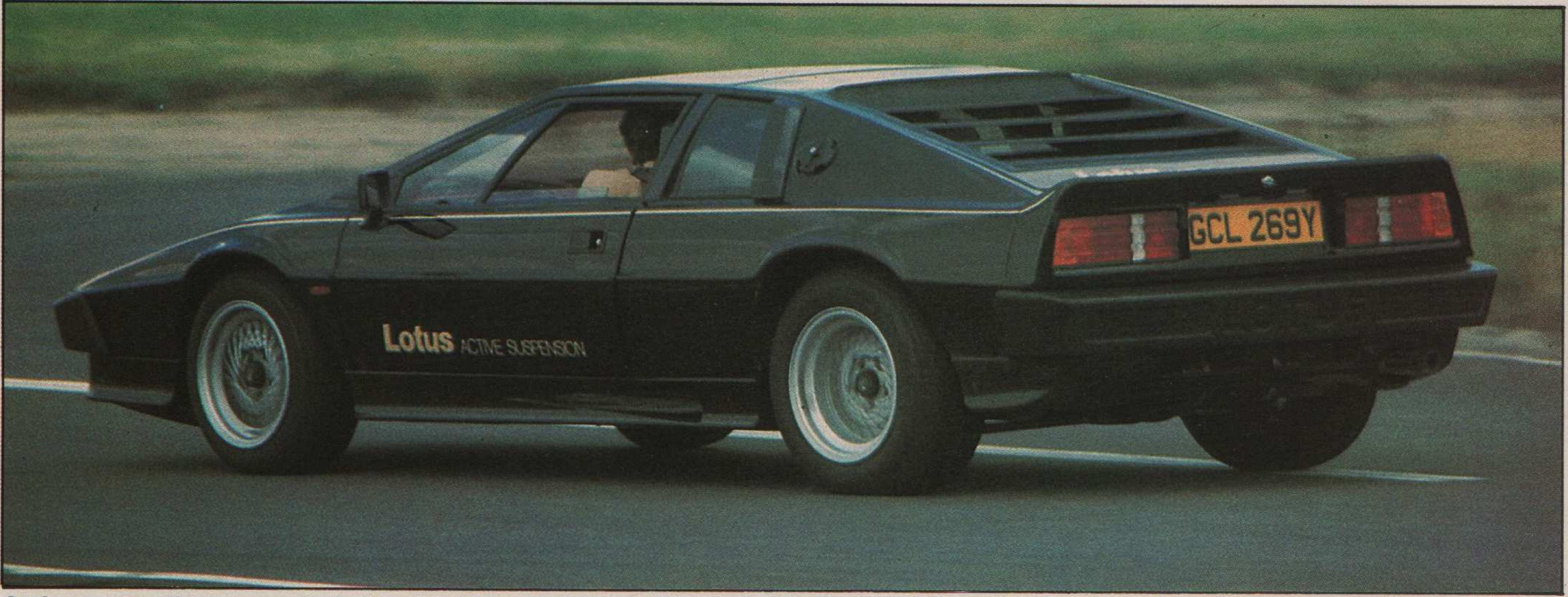


Nissan ingenuity: *four-wheel steering has rear wheels 'steered' by power cylinders attached to subframe: they are controlled through electronic power steering*

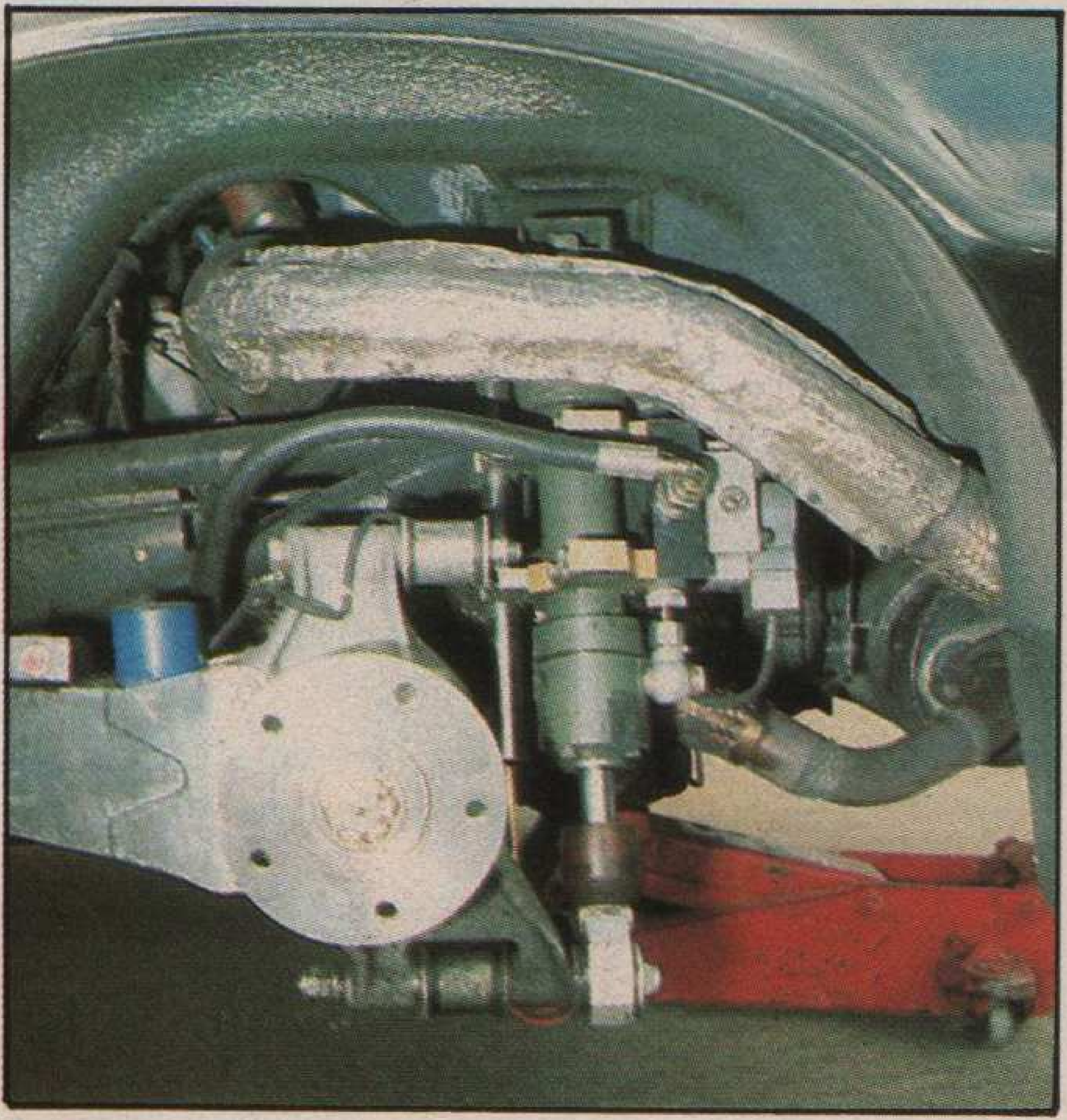
However, there is some argument about exactly how cheaper systems will arrive.

Lucas Girling's very interesting SCS (Stop Control System) was demonstrated to the press last winter by its developers in conjuction with Ford. Fitted to Escorts, it is obviously less expensive than anything shown before, and suggests that, for a change, there is a future in mechanical ABS devices. Mind you, stopping distance performance in small depths of loose snow on an ice base was the best confirmation we have seen of the frequently admitted problem of ABS systems, which is that the one time they don't stop you as well as locked brakes is in fresh snow. Volkswagen is not convinced about mechanical ABS yet, and believes that electronic control is still the best way. That is partly because it also believes that anti-wheelspin systems are a future necessity: as both BMW with Bosch and VW have demonstrated, anti-wheelspin is tied-up with anti-wheel-lock, so that to some extent both functions could use the same electronics.

Talk to Lotus in general, and Tony Rudd in particular, and you are assured that true active suspension — spring-less automatic control, usually hydraulic, of each wheel's vertical deflection according to very rapidly processed information by accelerometers about how the suspension is beginning to be deflected — is ▶



Active suspension, *currently being developed by Lotus, offers real gains for the high performance car. Note Esprit's flat cornering attitude*



Automatic control *of active suspension operates through hydraulics, with information processed by accelerometers*

one certain advance to come in the next decade. Incidentally, active suspension is *not* electronically variable springing.

The fact that few other manufacturers have spoken up about active suspension is more a measure of how many are working on it than a sign of disagreement with Rudd's predictions. We find it hard to believe we shall see active ride on anything below relatively expensive cars, because it is difficult to see how its cost can be brought down far enough. But for the ultimate car, active ride offers a real leap forward in chassis behaviour.

We do not understand why the two Japanese manufacturers who have shown four-wheel-steering systems are so sanguine about it. We are not alone in this: Dr Ulrich Seiffert, VW's head of research, and infinitely more clever and imaginative than us, says he feels likewise, believing that the potential gains in high speed handling and stability can be achieved less expensively and more safely in other ways, such as four-wheel drive. We can see some point in it for a small city car, because of ease of parking, although it would be an interesting exercise to make such a car competitively space efficient with what is obviously greater wheel arch intrusion.

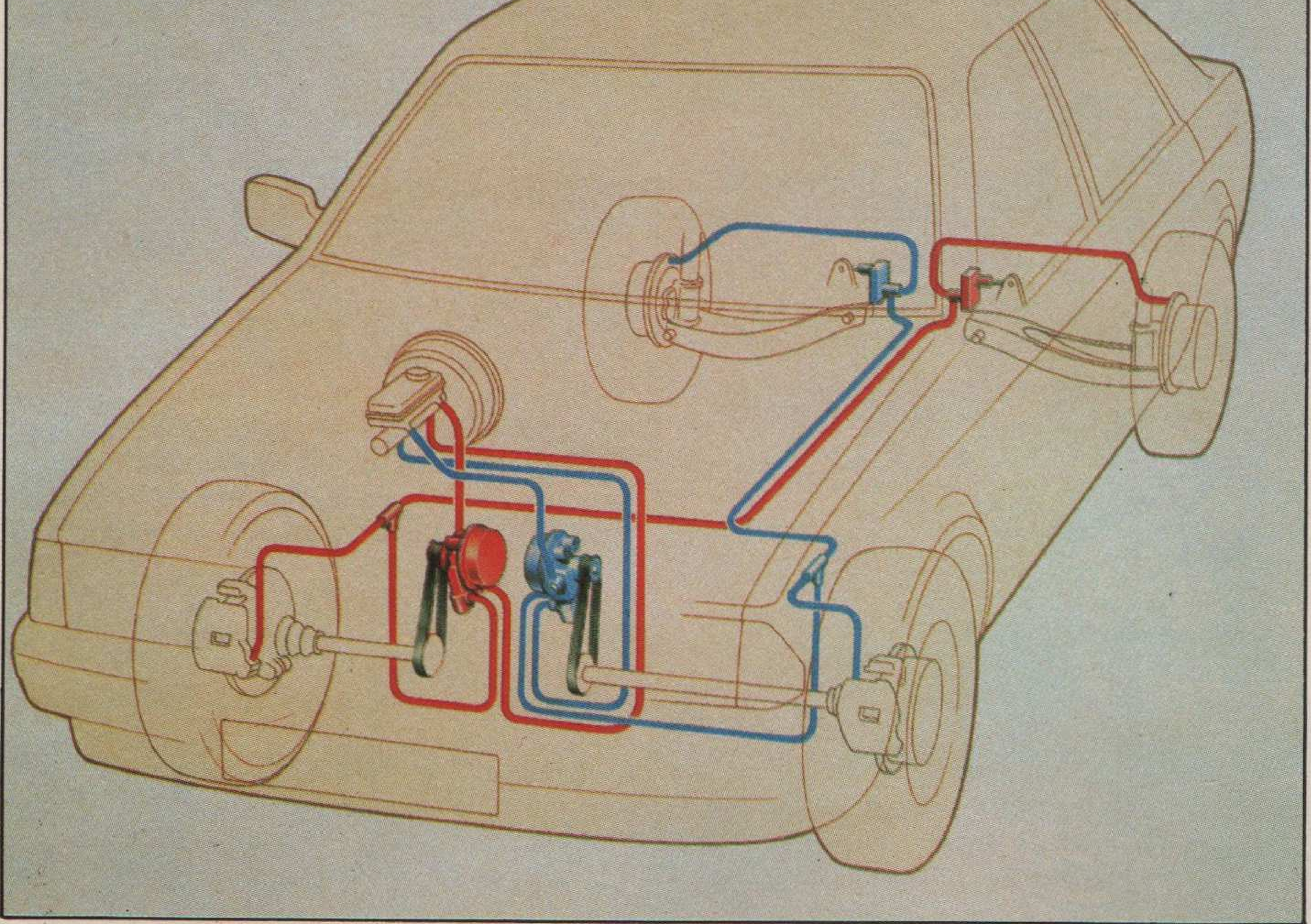
Some manufacturers, Mazda in general, and their brilliant technical chief, rotary-engine disciple Kenichi Yamamoto in particular, are so certain of its virtues that they promise a four-wheel-steered saloon in three years' time. Mazda, of course, is the company which re-started the four-wheel-steering hare with the MX-02 project car. Why is it so keen on it?

Mazda's system, electronically controlled from a pre-programmed set of rear-wheel steer angles, makes the outside (in a corner) back wheel steer outwards slightly at up to around 30 mph! This makes the car oversteer a little, giving increased agility at low speed. Above the transition speed, it increasingly changes to inward-steer at the outside rear, which reduces the overall turning effect of the front steering angle. This reduces rear slip angle effects, making the car effectively understeer, which is a kind of stability.

Mazda sees a danger in the very stability of four-wheel drive. It is normally very good, assuming that the wheels have been located properly. But Mazda fears that when a four-wheel-drive car oversteps its limit, and loses grip, the effect is so unexpected that the driver used to two-wheel drive is frequently surprised by it, and by what Mazda claims is its abruptness. Add four-wheel steering, and Mr Yamamoto says the combination is "perfect — 100 per cent perfect".

Maybe the point here is how well a four-wheel-drive car can be made to handle predictably in the first place. Our experience suggests that this is not impossible to achieve — several current European all-wheel-drive sporting cars, if not all, are perfectly predictable and easy to handle on or over their limit — so that the danger worrying Mazda engineers does not seem to warrant an amazing piece of extra complication. It clearly interests the Japanese, however, with Nissan investigating something similar on its mid-engined Mid-4 project. And Mazda says that the main thing concerning it before the planned four-wheel-steer car appears in three years is how to make the system fail-safe — when it breaks down, the back wheels should always lock automatically in the normal, slightly toed-in, 'straight-ahead' position.

Alfred Teves ABS *uses electronic control which receives signals from wheels via electro-magnetic sensors*



IT'S BEAUTIFUL BECAUSE AN ENGINEER DESIGNED IT. NOT A DESIGNER.

Everything on the Honda Prelude is designed to make it a better car to drive, not simply an object of aesthetic pleasure.

The power assisted steering, for instance, gives you all the help you need at low speeds, but diminishes as you accelerate above 28 mph.

You've the option of automatic transmission but, in the opinion of Motor Sport Magazine 'there can be few five-speed gearboxes nicer to use than the Honda's.' Motor Sport also found the 12-valve four cylinder engine 'notably smooth' and said driver vision 'cannot be faulted.'

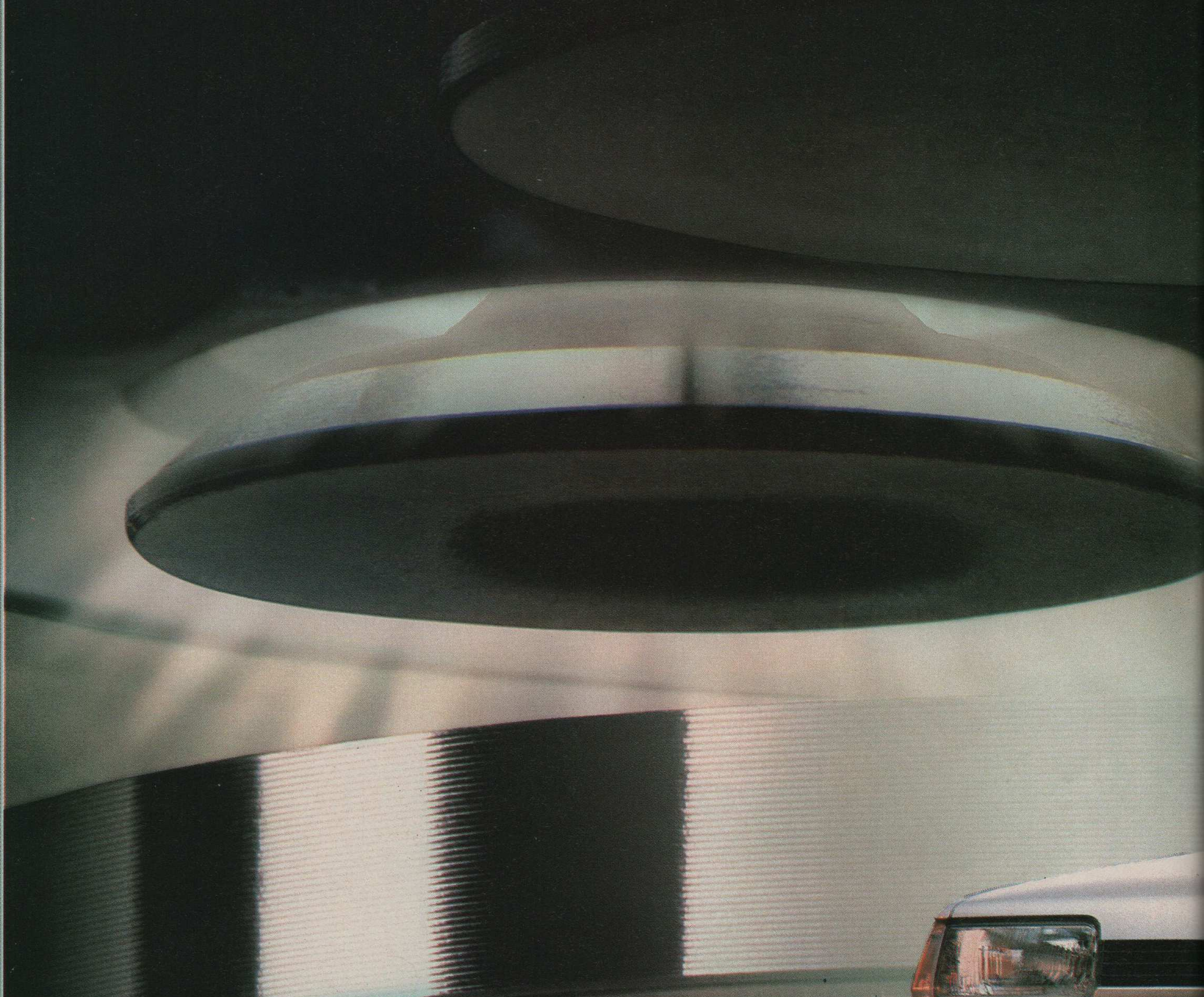
While striving for driving perfection, however, we haven't felt the need to neglect the creature comforts.

So, electric windows, an electric sunroof and a digital stereo cassette-radio are standard equipment. If, after all this, you are still seduced by the look of the car, that's fair enough.

But always remember one thing. At Honda, beautiful is as beautiful does.

Honda. Our standards are higher.

HONDA (UK) LTD., POWER ROAD, CHISWICK, LONDON W4 5YT



FACT: ONE MORE VALVE PER CYLIND
MORE POWER AND MORE ECONOM

To get the speed and acceleration you expect of a car you need one thing: power. And to get the economy you need for daily driving you need another: efficient fuel consumption. Toyota's multi valve engine technology has resulted in 12-valve engines for Corolla and Starlet. Their dual-intake ports and twin-squish combustion chambers provide a fast efficient burn that equals more power and more economy. Facts come alive at Toyota.

Corolla

12VA

Official fuel consumption figures: Starlet 1.0GL: Urban Cycle: 46.3 mpg/6.1 lit/100 km Constant 56 mph: 62.8 mpg/4.5 lit/100 km Constant 75 mph: 44.1 mpg/6.4 lit/100 km Corolla 1.3GL: Urban Cycle: 38.2 mpg/7.4 lit/100 km Constant 56 mph: 55.4 mpg/5.1 lit/100 km Constant 75 mph: 39.2 mpg/7.2 lit/100 km

ER EQUALS
Y PER CAR.

1.3GL

ALVE

- Max Power
  73 Bhp at 6200 rpm
- Max Torque
  76 lb/ft at 4200 rpm
- Fuel Consumption
  Urban Cycle 38.2 mpg/7.4 lit/100 km

TOYOTA

CHIPS DOWN

Electronics have already caused numerous advances in modern motoring, and are likely to have an even more important role in the future

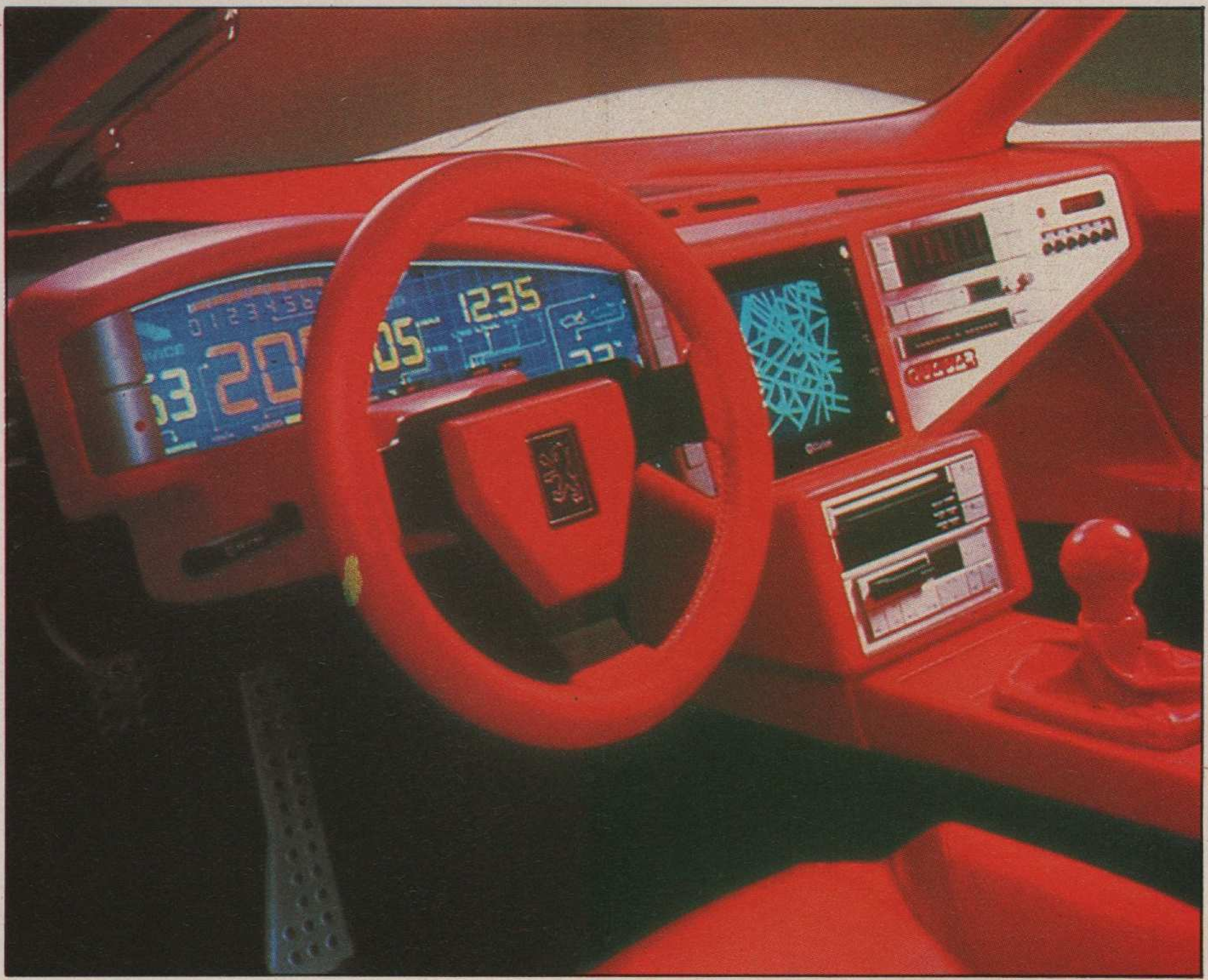
Electronics have already made a tremendous impact in motoring, as much in how cars are made as in the cars themselves. At the start of a car's existence, computer-aided design makes life infinitely easier and more efficient for the design engineer. Nowadays, he can try out ideas, shapes, forms and methods entirely electronically, predict and visualise how well or otherwise they will work, all without committing anything or anybody to manufacture. Having designed and refined, he can afterwards go direct to programming the manufacturing process electronically. As Austin Rover proves as well as the much-vaunted continental manufacturers, electronics can provide a totally integrated overall system of manufacture.

Electronic control of fuelling, even with carburettor cars, is already here, and will certainly become widespread. The days of the contact breaker are already numbered, and few will shed any tears over that. Electronically 'mapped' ignition, in some cases combined with the fuelling control, is coming down the price and car class scale. Electronics have an undeniably important role to play in more and more of the automatic transmission cars of the future; there are already several automatics so equipped. Such control will probably be essential for the success of the continuously variable transmission, in order to make optimum use of engine characteristics.

Inside the car, multiplex wiring at least has a future in simplifying the presently complex wiring systems of some expensive cars: one would have thought that multiplex would be worthwhile only if applied fully. Whether we shall see a return of synthetic voice warnings and digital speedometers after the initial market resistance is a matter of 'wait and see'. I see no objection to synthesised speech for warnings, provided that they occur only for serious cautions or situations in which the driver should stop immediately; voice warnings are counter-productive when heard too often or too soon, such as for seat-belt off or handbrake on.

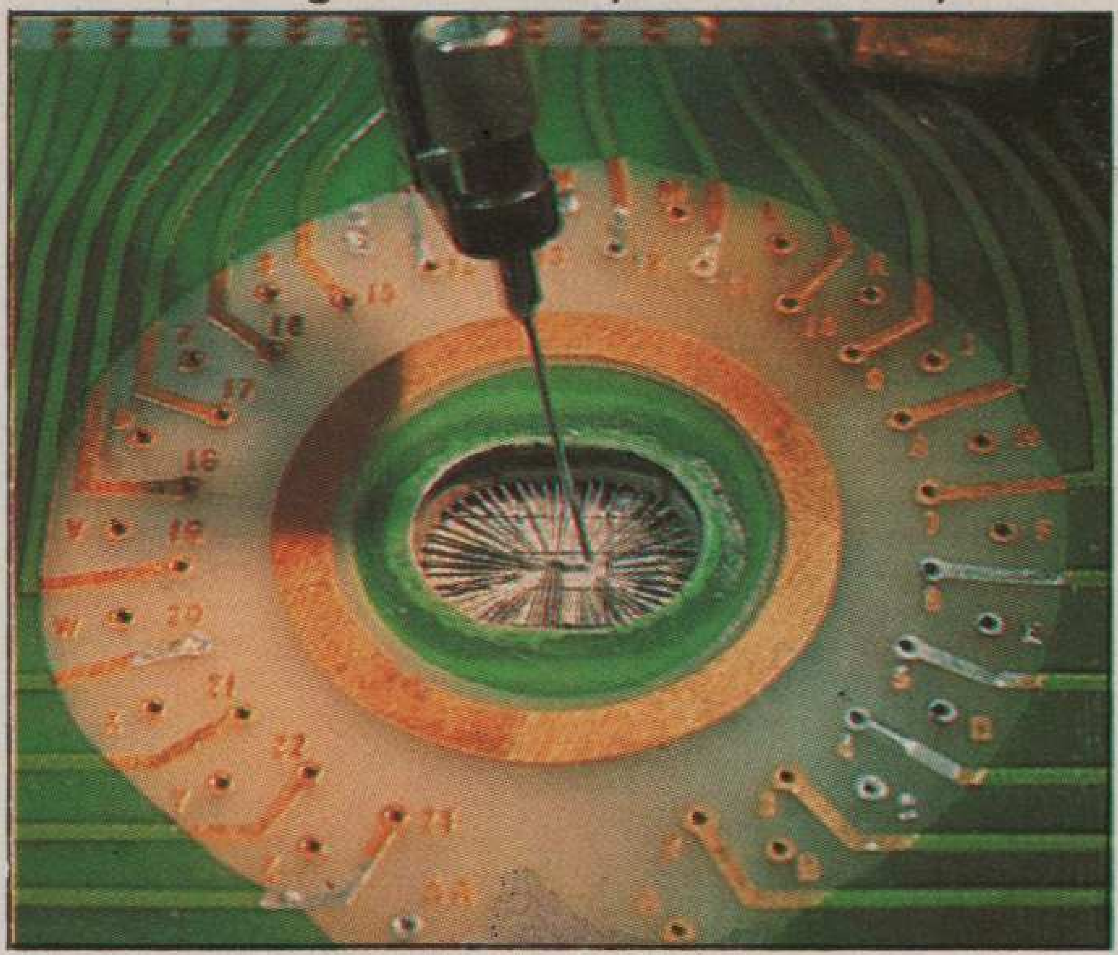
The most important thing about electronics and the car is to keep things simple, reliable and inexpensive. It is already relatively easy to make electronic parts reliable, immensely so by mechanical standards. The point is that the future car should be cheaper to run, and to repair, so too much electronic integration is undesirable if it means costly throw-away parts.

Another area where electronics may help is in navigation. It is hard to pin down just how much time and money is wasted by drivers having to ask for directions, or travelling extra miles because their map reading or someone else's signposting is not good enough. The Department of Transport reckons that in Britain alone the financial costs could be close to £900 million each year.



Electronic revolution: *many manufacturers are changing the face of the car dashboard*

Mobile navigation: *Philips's CARIN system*



Engine management *uses silicon chips*

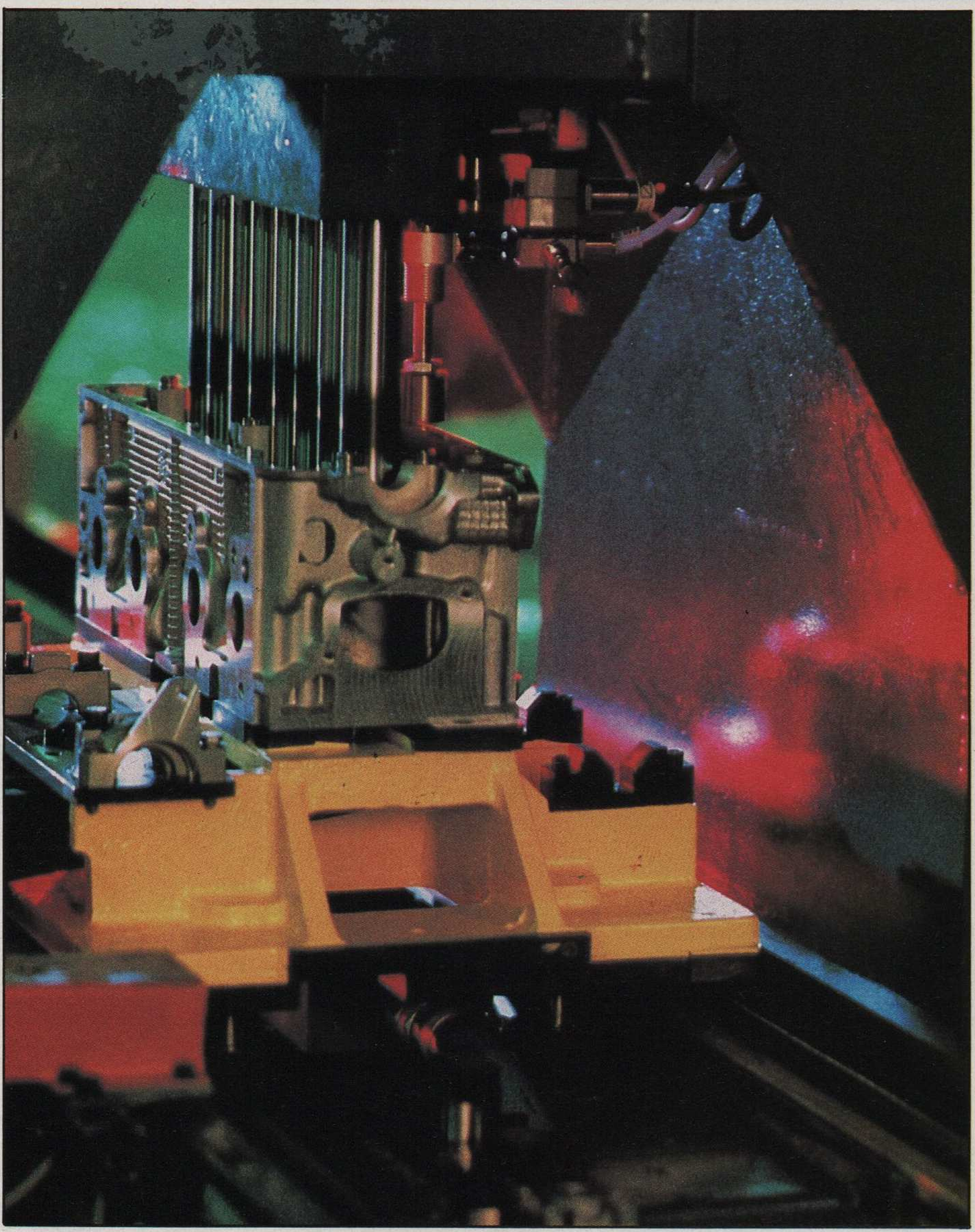
The simplest in-car navigation system is someone who can read a map and give instructions clearly. But this does depend on that person having the correct, up-to-date map.

One of the best navigations aids around is the US Defense Department's 18 satellite-strong NAVSTAR system. This can give a location virtually anywhere on Earth to around 20 metres for civilian purposes: armed forces get an even better service, down to a range of perhaps just a couple of metres. However, the cost of using almost any satellite navigation or location system as far as a car is concerned is prohibitively high.

The electronics and electrical giant, Philips, is very close to putting its CARIN (Car Information and Navigation System) into production, although it will probably be offered as part of a car manufacturer's option package first, rather than as an add-on accessory.

CARIN is centered around the amount of information which can be stored and very rapidly accessed from a compact disc. The information is contained digitally, and each disc can hold the equivalent of 150,000 A4 pages of information. On each disc can be entered the whole of a country's road system — from motorways to the smallest back-alley to which a car has access. Names can be added, of streets, garages, hotels, restaurants. The information on the disc, once entered into CARIN's own memory, is then compared with the input from the car. This consists of a distance-corrected mileage recorder and a compensated compass. CARIN's computer checks the car's actual position against its theoretical position three times every second.

Where CARIN does score over any immediate rivals is that the information is not displayed visually, but given verbally through a superb voice synthesiser. Philips does have a CRT display system on its demonstration vehicle, and might fit one on an up-market CARIN installation. But in Britain at least, it is illegal for a driver to be able to see a TV screen, so the CARIN would only operate when the vehicle was stationary. The route information given is also speed related. This means that when approaching a junction or turning, the instruction "Take next left" or "Take second right" are given in ample time for the driver to react, slow down and make the course change in safety. CARIN could cost around £1800 when it is ready for production in the autumn of 1987. So far £6 million has been invested, and the final cost may well top the £15 million mark.



EMPIRE BUILDING

Production methods have altered in the last decade. This is the age of the computer, the robot and advanced materials

In terms of serving up a whole new concept of how to make cars, the 1980s have been rather disappointing, at least so far. It was the 1970s, after all, that gave us Fiat's Robogate and the whole idea of group assembly. By comparison, the last few years have seen those earlier ideas refined rather than producing exciting new developments. In places, though, the pace is hotting up.

The current emphasis of production engineering lies in three areas, all of them more or less consumer-dictated. The first and perennial one is low production cost, or — to put it another way — high productivity. The second is high product quality and the third is corrosion resistance far beyond anything dreamed of in the 1970s when warranties ran for a year and responsibility for premature rusting was something to be haggled about even within that.

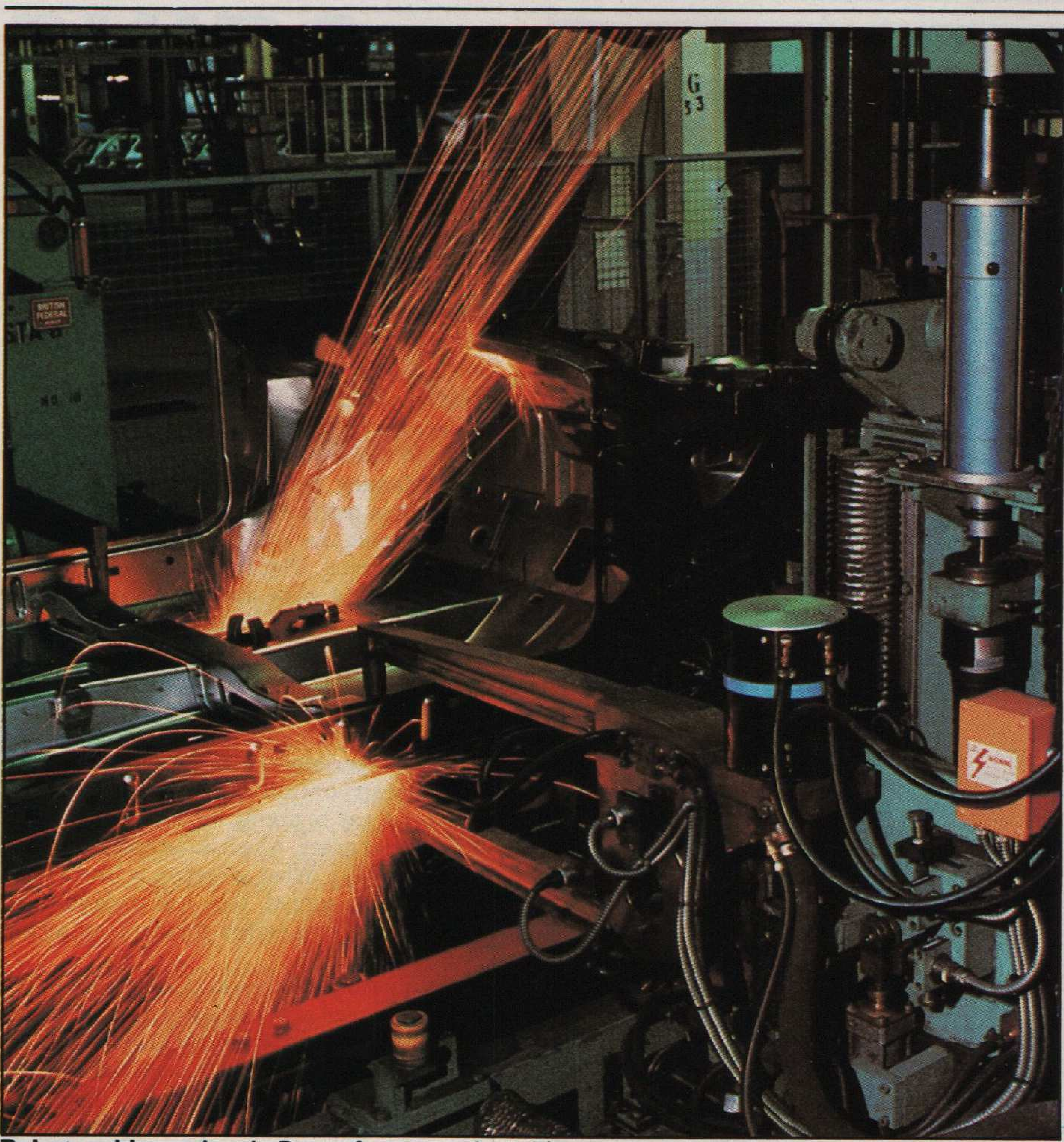
The key to productivity, it has long been assumed, lies in the robot. Sure enough, robots have been installed and human workforces shed, pruned, redeployed or whatever word suits your particular standpoint: and production costs have at least become infinitely more predictable even if they have not shrunk quite as dramatically as some industry managers had hoped. What *was* apparent very quickly was that robots were having a major impact on product quality. By definition, robot work is repeated exactly time after time; body designers have been able to exploit that to achieve better body stiffness with fewer spot-welds. Equally, since every modern robot is electronically controlled, its work can be electronically checked. Thus there has arisen a second generation of robots principally concerned with quality control, like Austin-Rover's leak 'sniffers'. The robot is, almost by definition, a superb inspector: its attention never wanders, its standards remain consistent and it has no conscience when it comes to failing anything as sub-standard.

The robots, then, entered the car factories as a means of raising productivity but rapidly assumed at least equal status — one way or another — as improvers of quality. Where they did improve productivity, it was often in a rather unexpected way. Instead of doing the same repetitive jobs more quickly and cheaply, they proved capable, through the easy manipulation of their electronic controls, of doing several jobs equally well. Thus arrived the concept of flexible manufacture — which is, of course, the key to Fiat's Robogate and many other exciting developments besides (though by no means all in the motor industry).

The manufacturing robots are still for the most part where you would expect them to be: in panel stamping, body welding and painting, the areas where manual operation is at its dirtiest, most arduous, uncomfortable and sometimes even dangerous. The human being continues mainly to hold sway along most of the final assembly line. Should the robot make an impact *here* then it may have a more notable impression on productivity. The signs of such a development are growing; witness the Cowley plant's robot assembling windscreen to body, and Fiat's energetic experiments with robots that can 'see' (and thus carry out assembly operations in which there is no way to pre-jig the various parts with sufficient accuracy, which is the case in much of final assembly). What is certain is that as such developments spread, they will contribute yet again to achieving higher standards of quality control.

The question of corrosion resistance is one which has vexed many industry minds. The last few years have seen largely unheralded but almost wholesale changes in paint systems with the adoption first of 'high-bake' melamine paints, and then of cataphoretic priming: the results have gone some way to solving the corrosion problem. To stand any hope of beating a six-year warranty you have to go further, though. Zinc-coated sheet steel oil/wax treatment of box-sections and plastic spraying of the whole underbody and lower panels have been ever more widely employed. Now, some manufacturers are beginning to look to polyurethane paint — more expensive, but far tougher and with better resistance to hydrocarbon attack — as the next stage in the process of improvement. Some iconoclasts even wonder how valid the price advantage of sheet steel for motor car mass-manufacture has become, when it costs so much to proof it against corrosion. Plastic and aluminium are both waiting in the wings for a favourable answer to that one; if either is adopted on a large scale, it will have implications far beyond anything we have seen since the displacement of the separate chassis by unitary body construction.

Even before that happens, one other change is creeping in. The validity of spot-welding itself, however convenient a method it may appear for joining together pressed sheets of mild steel, is being questioned by those who favour (sometimes, be it admitted, for vested interests) the greater use of chemical adhesives. Certainly a body stuck rather than spot-welded together would be better sealed, less vulnerable to corrosion, and would have used less electrical power in its making: and any robot capable of placing each 50 spot-welds to an accuracy of a millimetre should have little trouble (given a different 'hand') in placing a bead of adhesive with similar accuracy. Some of the most interesting developments along these lines ▶



Robot welder *at Austin Rover factory: robots increase productivity, improve quality*

Plastic panels *are used on BL's ECV3*

Computer aided design *is now widespread*

◀ are being conducted — yet again — by Austin-Rover.

Will the shape of car manufacture change radically by 1990? Almost certainly not. Will it alter by the year 2000? Almost equally certainly, yes: but exactly how it will change depends on the results of these apparently small and disparate exercises now being tried, mostly in Europe . . .

Materials changes will occur, too. For years, mass-produced cars have been made from mild-steel panels fitted with mechanical units machined from castings of iron or — where the weight benefit justified the extra expense — aluminium alloy. Today that whole establishment is under threat.

There are good reasons why it should be so — and equally good reasons why any change will be resisted. In the broadest terms, the challenge comes from 'composite materials': those at the forefront of industrial materials research no longer speak of pure metal, plastic, fibre or ceramic, but of combining the best features of each.

The best and most familiar example is the material most commonly known as GRP: glass reinforced plastic, as used in every production Lotus and Reliant for many years past. In effect, GRP combines the high tensile strength of glass-fibre with the easy shaping and (potentially) excellent surface finish of the plastic in which the fibres are laid. Composites have, however, come a long way from that simple beginning. It is in theory possible to create composites from a huge range of materials. Some of the most interesting recent results have been achieved, notably in Japan, with combinations of metal and ceramic, and with ceramic fibres embedded in metal parts to produce, for instance, pistons and connecting rods of remarkable strength in relation to their weight.

There has been no shortage of predictions in the last 10 years that plastics would take over the task of car body-building from sheet steel. It hasn't happened, and only partly because the motor industry managers are wondering what they would do with billions of pounds' worth of obsolete sheet-steel production machinery if it did. The plastics so far demonstrated have been far from ideal. Those in current use, such as GRP — even with the assistance of Lotus's sophisticated VARI moulding process — are ill-suited to production on a very large scale, mainly because of the time taken for mouldings to 'cure'.

One of the underlying problems, especially where any layman's understanding is concerned, is that we happily talk of 'plastic' as though it were a single material, when few of us would talk of 'metal' without bothering to distinguish between steel, copper, aluminium or lead. Yet these days, the differences between the various available plastics are at least as fundamental, and the arguments between the proponents of one kind of plastic and another can be bitter. Add in the apparently eternal ability of the plastics industry to offer the hope of 'something even better' in a few months' time and it seems less surprising that so many motor industry decision-makers have elected to wait until the picture is a lot clearer.

What does seem certain is that if and when the motor industry takes to plastic for body-building, it will go for a process which offers very high production rates and very good surface finish — considerations which favour high-pressure injection moulding even though the machinery needed is every bit as big and expensive as a modern sheet-metal stamping press.

There is, however, no immediate certainty that the plastics breakthrough will come in body manufacture. Before it ever does, one fundamental question which must be answered is whether the body should be entirely of plastic, gaining stiffness through added composites, plus (probably) box-sections filled with rigid foam, or composed of lightly loaded plastic panels over a highly stressed metal skeleton of some kind.

It may well be, though, that this question will be overtaken by the increased use of plastics in an area few would have predicted even a decade ago: in the main mechanical components. We have now reached the stage where almost everything on the 'cool' side of a cross-flow engine, up to and including the inlet manifold, *could* be made of one or another kind of plastic with demonstrable advantages. Meanwhile, as car bodies continue to become lighter in the continuing search for economy, the only way to maintain acceptable ride comfort will be to take weight out of the *unsprung* components. Some trucks are already produced with composite plastic leaf springs (a GKN development); the next generation of cars may well follow that lead.

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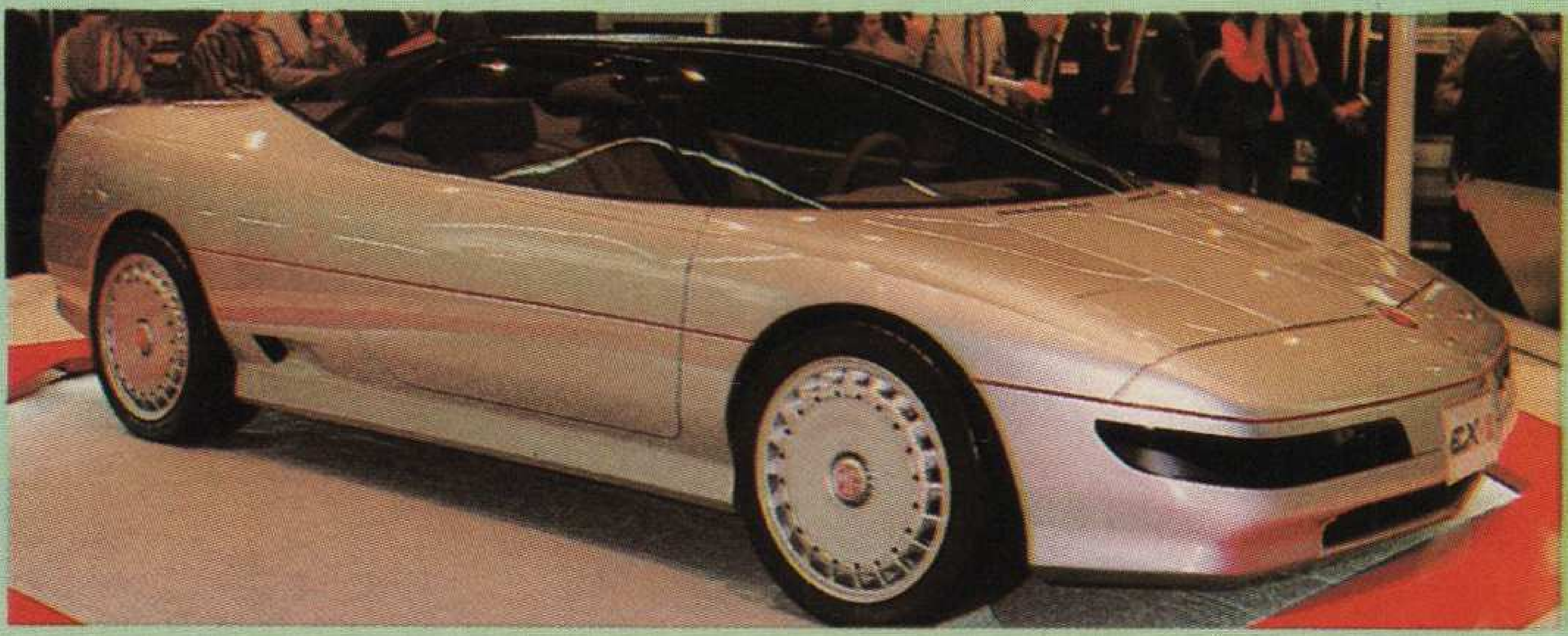

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