

ENGINEERING EUROPEAN STYLE

1966 Models from Abroad Reflect Evolutionary Change; But a Revolution is Coming!

BY JOSEPH LOWREY

OFFSTAGE, ENGINEERS in Europe's car factories are putting a lot of work and even more thought into really revolutionary car designs. Some highly respected men hold the belief that Wankel or other rotary engines will outnumber reciprocating engines in the mid-1970s. On stage, intensive evolutionary development work on familiar sorts of cars is going ahead at a pace which makes it progressively more difficult for rotary engines to show major advantages in weight, compactness or cost.

Always, in Europe, where many roads are narrow and all towns are congested, the emphasis is on cars far smaller than those preferred by U. S. buyers. Important factories spread around Britain, Czechoslovakia, France, East and West Germany, Holland, Italy, Russia and Sweden offer serious commercial models over a range of engine sizes from the 30.5-cu. in., 2-cyl. Fiat to the 386-cu. in., 8-cyl. Mercedes-Benz.

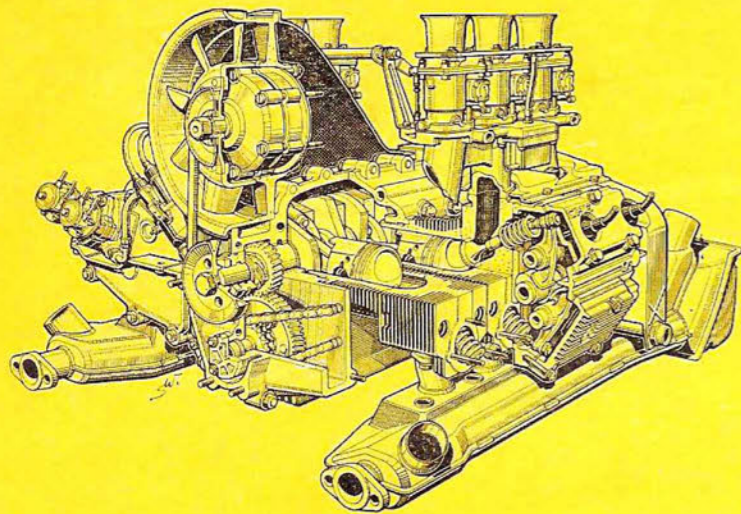
Car development in Europe habitually parallels the "compact car" phase through which Detroit passed a few years ago. There are times when new models of small size are introduced and then subsequent periods of growth in which these small cars gradually expand into roomier and more powerful

models. Quite emphatically, Europe has been in a growing phase recently, although a recent slump in car sales in various countries is likely to hustle along one or two new small cars for announcement as 1966½ models. At the moment, the most popularly sized car around Europe has a 4-cyl. engine of 70-90 cu. in., weighs 1750-2000 lb., has a wheelbase in the 90-100 in. range, a tread of 48-50 in. and an overall length of 140-170 in.

In-line, 4-cyl., liquid-cooled engines with rocker-arm valve gear remain the European norm, though the horizontally-opposed Volkswagen air-cooled engines go on and on in popularity. Lengthening of the Volkswagen's piston stroke from 2.52 in. to 2.72 in. typifies the 1966 trend to deliver extra torque in this way, rather than by bore enlargement. Another example is the Rootes Group's stretching of the 97-cu. in. Hillman-Humber-Sunbeam engines to 105 cu. in. by lengthening piston stroke from 3 in. to 3.25 in. This latter change was accompanied by installation of a 5-bearing in place of a 3-bearing crankshaft, a change provided for when the basic engine design was laid down more than 10 years ago!

Expensive automated tooling discourages frequent basic changes

in engine design, although a majority of factories seem to have taken the decision that one more generation of conventional engines will be needed, even if rotary units eventually will replace these. Future shapes of cars seem certain to demand very compact power units and there is a great deal of interest in out-of-line engines. Three years after Ford of Germany turned what was to have been the Cardinal into a moderately successful front-wheel-driven V-4 Taunus model, Ford of Britain applied that engine's lessons to a slightly larger pair of V-4 engines. Initially, this very modern Ford V-4 half fills the space under an existing Corsair sedan's hood, but it and the V-6, which will follow shortly, cannot show their true worth until new cars are designed around them. While the 60° V-4 can be a very short and reasonably narrow engine, it requires the complication of a counter-rotating balancer shaft, gear driven from the crankshaft, to eliminate its inherent rocking couple. A V-6 built on the same machinery escapes the need for this extra component and offers even greater length savings in comparison with in-line engines. Lancia continues to build narrow-angle V-4 and V-6 engines with cylinders in one block and a flat-Four engine. Porsche continues



PORSCHE's FLAT, opposed 6-cyl. (911) engine, upper left, features valve operation by overhead camshafts and rocker arms. One triple-throat carburetor feeds each bank. Dry-sump/oil-cooler lubrication is used.

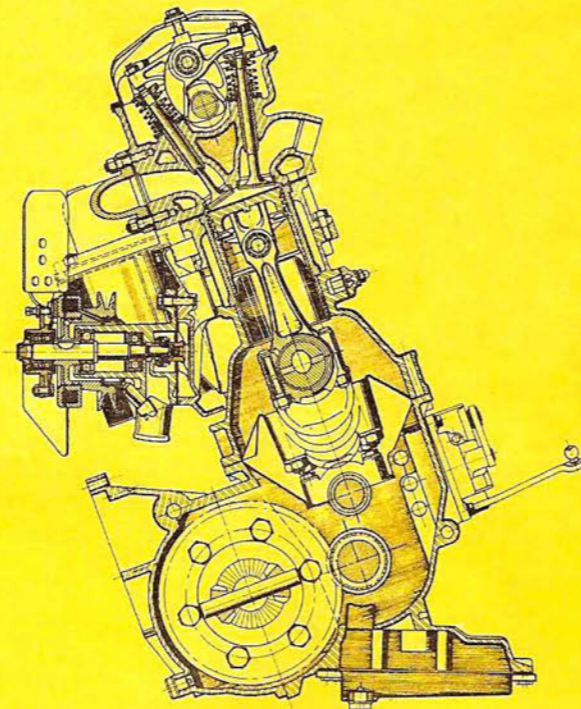
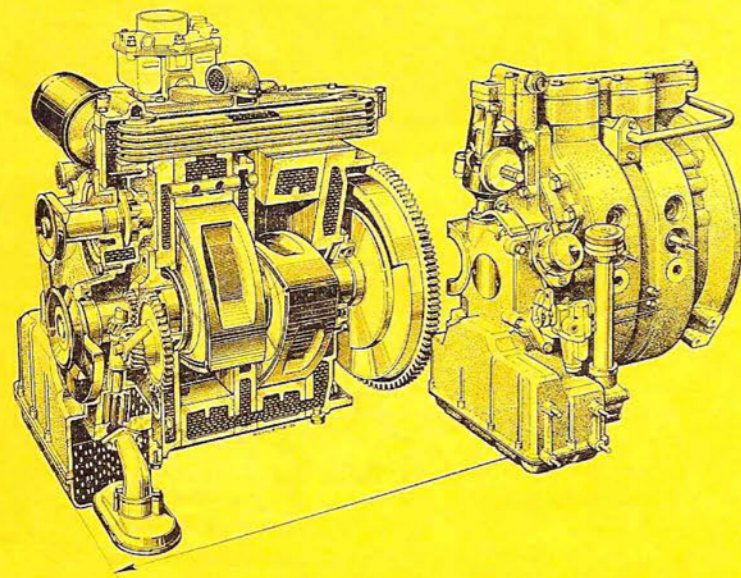
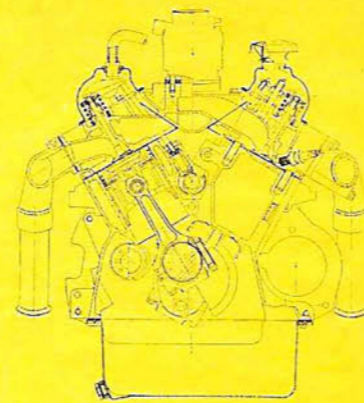
FORD OF Britain's 60° V-4, upper right, carries a gear-driven shaft counterweighted to eliminate rocking couple. Bowl-in-piston design improves gas swirl and eliminates shrouding of valves as they open.

MODERN DESIGN features in the Peugeot 204 fwd engine, middle right, are wet liners in a die-cast block, five main bearings and an overhead camshaft driven by duplex chain. The transmission is in the oil sump.

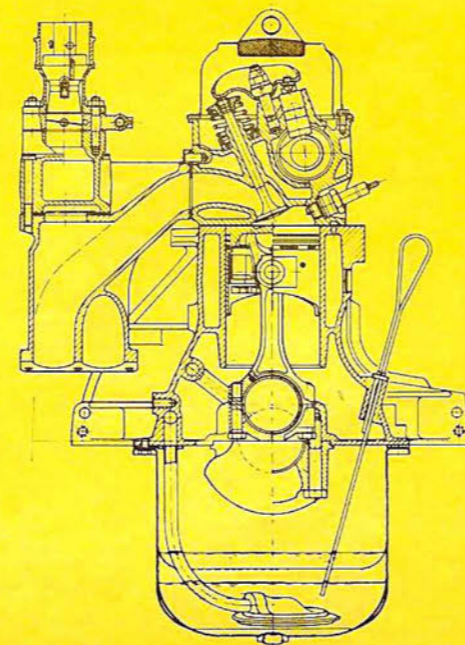
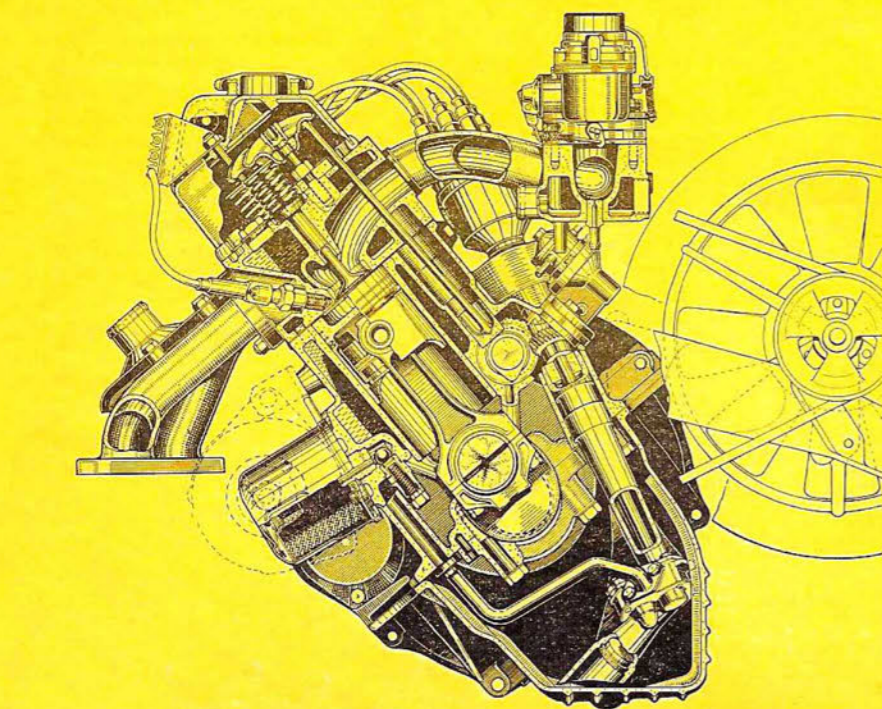
VALVE TRAIN inertia is greater in Opel's "camshaft-in-head" engine, lower right, than is the case in other ohc designs. With tappets and pressed rockers the unit should show good wear characteristics.

TO REPLACE the Audi's 2-cycle engine, a 4-cycle unit, lower left, with bowl-in-piston combustion chambers and intake restriction, was produced for fuel economy rather than for extreme power output.

NSU WANKEL twin-rotor engine, middle left, is in evolutionary stages now, but such units could replace reciprocating engines by the 1970s. Lubrication and gas seal problems must be solved, however.



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its Volkswagen-inspired flat-Four alongside a more recent flat-Six. Only Ford, however, has introduced a new out-of-line engine for 1966.

For quite divergent reasons, manufacturers are changing to bowl-in-piston combustion chambers beneath flat-faced cylinder heads. Precise control of combustion chamber dimensions and finish are easier to secure in a piston crown than in a cylinder head casting. Cosworth Formula II racing engines and the Rover 2000 sedan have been using the principle for some time. New adherents for 1966 are the British Ford V-4 engine (built with 2.38 in. or 2.85 in. piston stroke to provide 101.5 or 122 cu. in. displacement), the in-line 4-cyl. Audi and de Tomaso's drastic racing rebuild of the Ford Cobra V-8 engine.

On the racing engines and the Ford V-4s, good breathing is the prime reason for adopting bowl-in-piston combustion chambers. With conventional high-compression engines, the sides of the combustion chambers mask almost half of the valve periphery, whereas with a flat-face cylinder head the valves open directly into the cylinder and provide much better gas flow during most of the piston stroke. Rather oddly-shaped piston crowns are needed if a high-compression engine is to have safe clearance at top dead center for valves which are bouncing or have long opening periods. But with the modern short-stroke, large-bore engine, good power seems to be obtainable. Ford is reported to have had problems with unexpectedly high octane requirements on some of its experimental V-4 engines, but seems to

have the smaller-displacement unit going well. Initially, Ford had been getting disappointing road performance with the longer-stroke engine which carries an inapt GT designation.

In Germany, the Audi model from Auto Union (a company now jointly controlled by Volkswagen and Mercedes-Benz) has a quite contrasting application of the bowl-in-piston combustion chamber aimed at fuel economy, rather than at power. A relatively long-stroke engine (3.15 in. bore x 3.33 in. stroke) has been built with limited valve sizes, its inlet ports shaped to generate high velocity gas swirl rather than for free breathing. Compression of mixture into a circular bowl in the piston crown accentuates induction swirl and a compression ratio of 11.2:1 is compatible with a moderate octane requirement, despite ignition timing and fuel mixture strength being set for best torque rather than to suppress knocking. Torque on the extremely conservative German DIN rating is 0.91 lb.-ft/cu. in. with peak power (on the same basis) of 0.69 bhp/cu. in. The notable figure is a best specific fuel consumption of about 0.43 lb./bhp hr., which puts the engine within sight of Diesel engine economy!

Compression ratios are generally lower in Europe than in the U. S., despite smaller cylinder sizes and despite availability of 99 octane rating (Research Method) or better fuels in most countries. This seems to be because lower-powered cars are quite customarily required to run at full throttle uphill for long periods and moderating the full-throttle octane requirement

appreciably by over-retarded ignition timing or over-rich carburetor settings is unacceptable. Popular cars currently have compression ratios in the range from 8:1 to 9:1, with the few air-cooled engines in a range about one ratio lower.

AS ENGINES require complete redesign, there is a decided trend toward the adoption of single overhead camshafts, for precisely the reasons which influenced Pontiac to adopt this layout for its new in-line Six. Glas cars from West Germany have been using toothed-belt overhead camshaft drive for some years with apparent success. Other makers have watched the results with interest, but only Pontiac has as yet copied this feature. There is some puzzlement about the new engines introduced by Opel, the German subsidiary of GM, which retain tappets and rocker arms above a camshaft in the cylinder head. One probable explanation is that this design, which retains considerable inertia in the reciprocating parts, results in an engine of minimum height for possible future use in a Toronado-like front-wheel drive layout.

Aluminum always has been widely used by European car builders and die-castings of this material are the basis of several recently-introduced engines, notably the Renault 16 and the Peugeot 204. Ease of machining is an attraction of aluminum, in addition to its low weight. Corrosion problems have been solved and the extra noise of an aluminum engine has become tolerable. The Peugeot has a strange cylinder block with the upper few inches bolted to a main casting which forms the crankcase. This elaboration apparently is to reduce the size of die-casting required, rather than to permit easier installation of wet cylinder liners. So far as weight is concerned, American techniques of making thin-section iron castings have been brought to some European foundries and have greatly narrowed the advantage which aluminum can offer.

Almost exclusively in Britain (and also in Japan, although that is hardly part of Europe!) there is a boom in the popularity of constant-depression carburetors. At first used mainly for dual carburetor installations, the Zenith-Stromberg CD now is being used as a single carburetor on Vauxhall and Triumph engines. In Japan, the Mikuni-Solex and Keihin carburetors go even farther in modernizing the variable-choke principle which S.U. carburetors have been using since before World War I. On the mainland of Europe, 2-barrel compound carburetors remain more popular.

As an alternative to using one carburetor barrel per cylinder on high-

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performance engines, fuel injection shows signs of gaining favor. Bosch pumps derived from a Diesel engine design are used on several Mercedes-Benz models. Kugelfischer pumps have become optional on the Lancia Flavia as well as on the Peugeot 404, and Maserati offers the Lucas system which has been helping BRM and Coventry Climax cars to win Grand Prix races. Marvel Schebler fuel injection pumps of American design are to be made in Britain soon. Tecalemit, which is a maker of service station equipment, has its own fuel injection system at a pilot production stage and another well-known British company has under development a neat little injection pump with electronically-controlled fuel metering. Until recently, fuel injection (usually at a fairly low pressure into the induction pipes) has seemed commercially unattractive. Cylinder bore enlargement is a cheaper technique for getting 10% more power out of an engine. Now, mechanically perfect sharing of fuel between cylinders, by a system which needs no accelerating pump, appears to be an aid to meeting anti-smog laws concerning exhaust gas purity which will improve rather than impair an engine's performance.

Two-cycle engines have been fighting hard for survival, nobly aided by Eric Carlsson's demonstrations of what a fine motorized-sled the Saab (with no oil pan to get punctured) is for high-speed rallying along very rough forest roads. Fuel thirst (admittedly for low-octane gasoline), bad idling with trapped exhaust gas maintaining full compression pressure in the cylinders and an unduly limited range of really useful speeds have been among the snags of 2-cycle engines, offsetting the astonishing smoothness at high rpm which can come from eliminating poppet valves. Meeting California's exhaust gas purity requirements with an engine which pre-compresses its mixture in an inevitably oily crankcase has proved just about impossible. As other areas are likely to follow California in establishing anti-smog laws, Saab has a 4-cycle engine on order for a few years hence. Auto Union already has added the 4-cycle Audi to its range of 2-cycle cars.

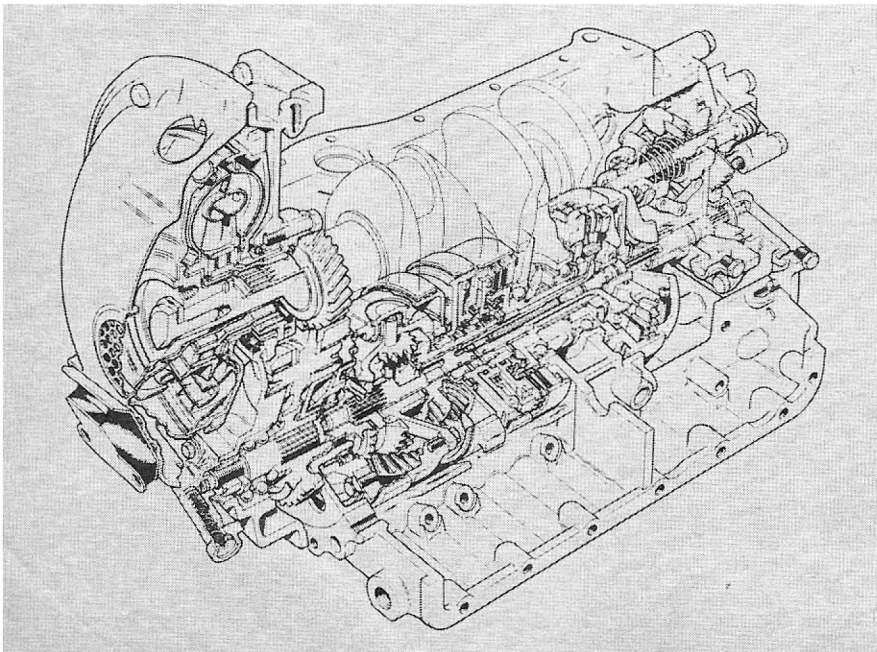
Mostly behind the scenes, development of the Wankel rotary 4-cycle engine goes ahead quickly. Only NSU of Germany has a car actually on the market. A few, which are being sold at high prices, seem to give good service, though on the day after each example

is delivered (usually, it appears, to a company with good reasons for wanting to know more about rotary engines) the single-rotor engine tends to be outdated by the latest design improvement! NSU also has shown a twin-rotor engine in advance of the car which is to use it. The tandem unit doubles power to 110 bhp, though not greatly enlarging the total bulk of the engine and its auxiliaries.

Exhaust gas purity laws could inhibit Wankel engine development, too. Any lubricant applied to rotor tip and flank seals is almost inevitably lost. Carbon sealing strips represent one possibility of operating these gas seals without oil, hence a great deal of the development going on is aimed at finding the best combinations of materials for this kind of engine. There is some division of opinion as to whether inlet ports to the Wankel engine's working chamber should be on the periphery or the flanks. The former location (used by NSU) gives good port areas and permits compact coupling up of multiple units, whereas the latter (used by Fichtel & Sachs) gets away from radical port timing which has spoiled low-speed torque of some earlier Wankel engines.

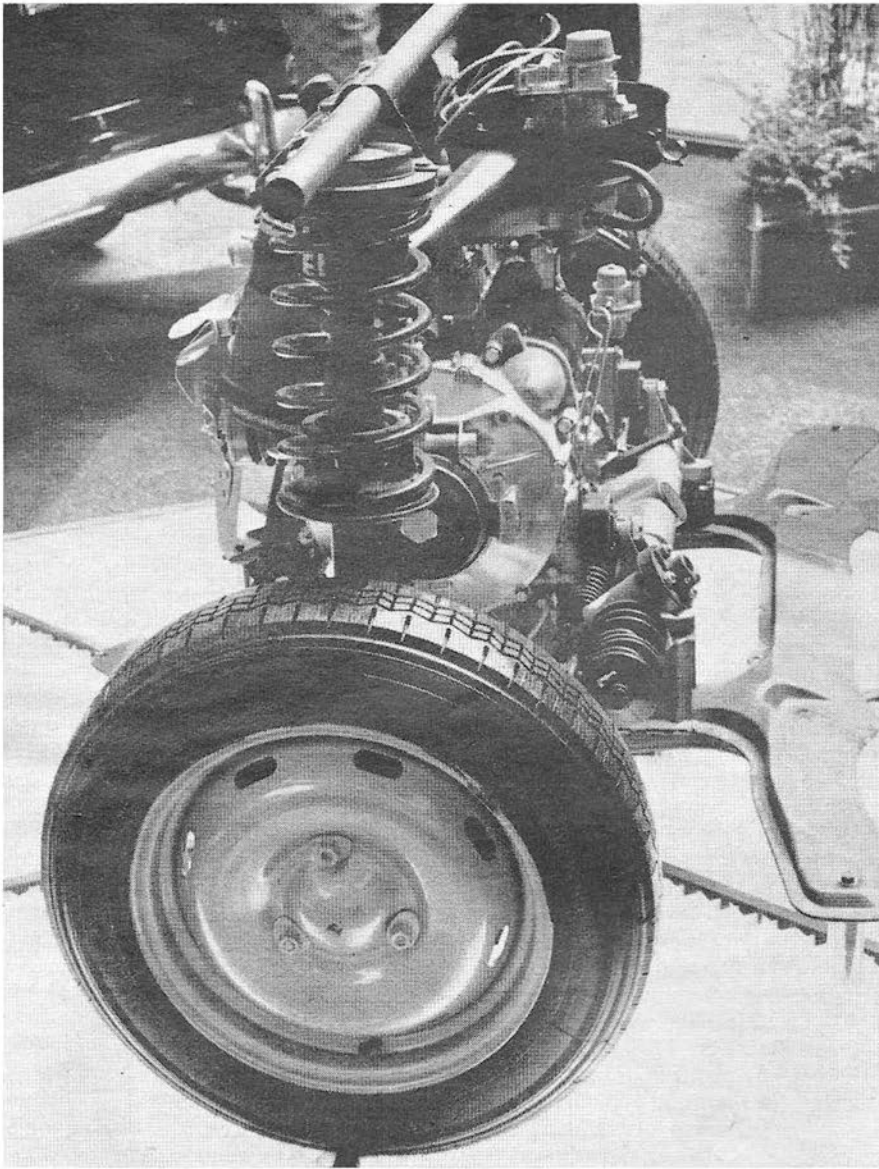
Despite continued development of Rover gas turbines, multi-cylinder piston engines power all of Europe's really fast cars. Modest numbers of V-8 engines for fast touring cars are being made or are planned by Maserati, Mercedes-Benz, Rolls-Royce and Glas, but V-12 engines power some of the most glamorous models. Ferrari V-12 cars have a new rival in the V-12 Lamborghini and, in due course, Jaguar is expected to produce a successor of this number and kind for its good old dohc Six.

MAJOR ADVANCE for the Mini-Minor is the new automatic gearbox with eight bevel gears for friction engagement of four forward speeds, reverse.



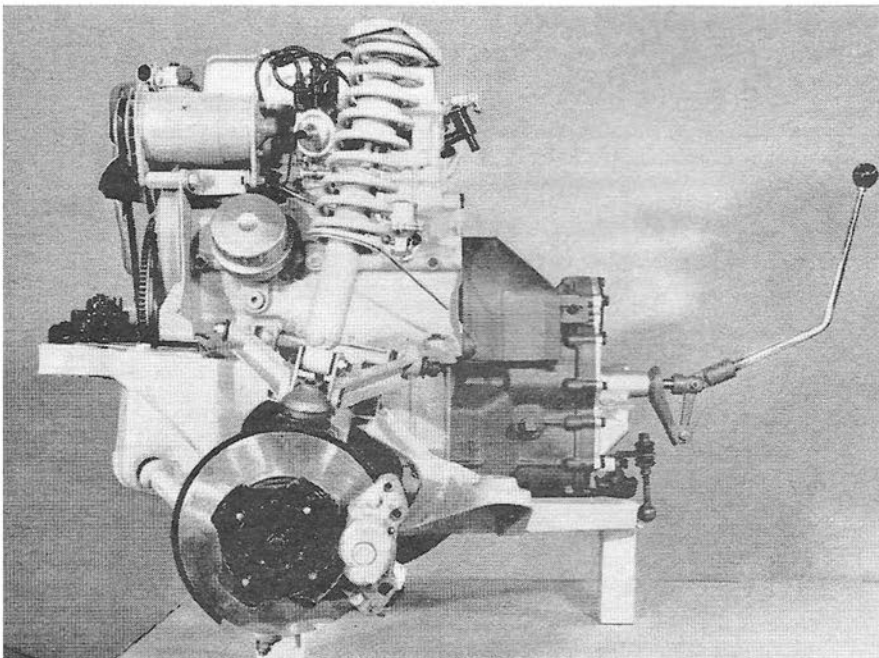
SINGLE DRY-PLATE clutches and synchromesh gears still dominate the transmission scene in Europe. Diaphragm springs are rapidly replacing multiple coils in the clutches and the absence of synchromesh on bottom gear has come to make a transmission appear very old-fashioned. With European car displacement-to-weight ratios, four speeds are more usual than three, with five by no means unknown. Overdrive is an option on a good many British models and on a few others. Two rival makers now offer an epicyclic unit with "hot shifts" either way between ratios controlled by an electrical switch. Solenoid-operated valves apply oil pressure to disengage a direct-drive clutch and apply a brake to the overdrive reaction member. Compound epicyclic gearing gives a ratio as close as 0.803:1 on the Hummer Sceptre and Triumph TR-4A.

Very slowly indeed, automatic transmissions have been securing ac-



PEUGEOT'S 204 for 1966 has a transverse engine with all transmission gearing in a narrow area between the car's steered driving wheels.

TORONADO-LIKE is the Triumph 1300 sedan engine, transmission and axle arrangement. The drive was used on a prototype military truck in 1944.



ceptance in Europe, where low-performance cars make considerable demands upon their efficiency. Keeping the extra cost of a complex transmission down to a reasonable percentage of a small car's price is difficult and the trade-in value of a 2-pedal car still tends to be lower than that of an originally cheaper car with stick-shift. Of the automatics which are sold, the largest proportion comes from Borg-Warner's factory in England, although the somewhat similar German-made ZF automatic transmission recently has been adopted for the BMW 1800 and the Peugeot 404. Both Mercedes-Benz and Rolls-Royce build their own transmissions to the old formula of 4-speed epicyclic gearing with a fluid coupling rather than a torque converter. R-R, however, works under GM Hydra-Matic patents. DAF in Holland still is happily using twin belts on expanding pulleys as its variable-ratio drive and has even been testing this transmission on a Formula Junior racing car.

SURPRISINGLY, a new semi-automatic has appeared for 1966 on the Simca 1000. This is a torque converter, plus an automatic clutch and a manually-shifted 3-speed synchromesh gearbox. More ambitious is the fully automatic transmission on the Morris Mini-Minor, which has a 4-speed automatic bevel-gear system and a converter packed into the oil pan of the transverse-engined, fwd baby car. One asset of this bevel-gear drive is the number of existing patents on epicyclic gears which it by-passes!

Front-wheel drive has been steadily gaining favor around Europe and one can discern three schools of design. There is the Renault 16 which, with its engine behind the differential, represents a modern production engineering interpretation of what Citroen did in the mid-1930s. Transverse-engined Autobianchi Primula and Peugeot 404 models represent variations on the theme of Alec Issigonis' Mini-Minor, avoiding either its patents or its mistakes. Third generation design, saving less space than does the transverse engine, but avoiding awkward noise and torque reaction problems, is represented by the Triumph 1300, which has similarities of power unit layout to the Oldsmobile Toronado, although the makers point out close similarity to their own military vehicle design of 1944.

For quantity-produced cars, integral steel bodywork still is very much in fashion, there being absolutely no European counterpart for the not-very-rigid perimeter frame separated by rubber mountings from a strong steel body. Instead, a good many cars have rubber-mounted front and/or rear sub-

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frames to keep power unit or road noise separate from the body shell. Interesting is the transfer from aerospace industry applications to cars of Vibrashock mountings, made from a mass of crimped stainless-steel wires, as alternatives to rubber. Backbone frames remain interesting for open 2-seat cars, though they offer no protection to passengers in side-on crashes. Fiberglass and plastic bodywork remains popular for cars built at the rate of 1-2 per working day, but use of this material for stressed bodywork, as pioneered on the Lotus Elite, has lapsed.

Front suspension design continues to swing toward the MacPherson strut system. Sturdiness and wide spacing of the mountings of this configuration offer advantages which can outweigh rather odd geometry. It is akin to s.l.a. linkage turned upside down. In addition to Ford of Britain and of Germany, Porsche, BMW, DAF, Triumph and Peugeot now are using this strut system on one or more models. Porsche uses it with a rear-mounted engine and Peugeot employs it with front-wheel drive.

Perhaps because concrete roads with tar strip joints are less common in Europe than in America, suspension compliance has taken longer to gain favor on the eastern side of the Atlantic Ocean. There may be long-term ad-

vantages in this, as new models now are being designed with the fore-and-aft suspension flexibility very carefully arranged so that it does not cause any loss of steering precision. Such models as the front-wheel-driven Peugeot 204 and Renault 16 have very carefully controlled fore-and-aft flexibility in the mountings of crossmembers on which independent rear wheel suspension systems pivot. In utter contrast, the Austin 1800 sets out to kill road noise by using heavy forged suspension links as an anvil without any rubber in the system, radial ply tires being fitted to all examples of this car.

Independent rear wheel suspension is slowly gaining ground, even on the front-engined, rear-wheel-driven cars which can get along fairly well on controlled rigid axles. Ferrari has applied a wishbone i.r.s. linkage to its front-engined 275-GT models as an aid to road holding. Rolls-Royce has sought overdue improvement of its rear seat ride by adopting one semi-trailing link per rear wheel. Triumph has borrowed a somewhat similar system from its 2000 sedan for the TR-4A sports car.

Diagonally-pivoted links have become by far the most popular form of i.r.s., the geometry often being akin to swing-axle halves lengthened so they have virtual pivots on or beyond the far side of the car. This arrangement escapes the alarming tendency of some divided-axle systems to go up on tiptoe when the side thrust of hard cornering tries to tuck the outside wheel under the car, yet retains enough wheel camber change as the springs deflect to offset the tendency of a heavily laden car to oversteer. Functionally, the Jaguar system of independent rear wheel suspension has not been bettered on touring cars, for combining good handling qualities with a quiet and smooth ride, but it does involve using taper-roller bearings in several highly stressed pivots.

Tire development has been rapid in recent years and is not yet stagnating. Braced-tread tires now usually incorporate textile cords rather than steel wire behind the tread and are being molded in low-resilience, clinging synthetic rubber for best wet road grip. Winter-tread tires with braced radial ply casings now are coming onto the market, encouraged by competitors in rallies. It has come to be appreciated

that the inside and outside wheels do different jobs on corners and Michelin, which pioneered braced-tread tires with the "X" now is supplying Citroen with tires which are asymmetric in both bracing and tread pattern. In the latter respect, Indianapolis crews are entitled to say, "We told you so."

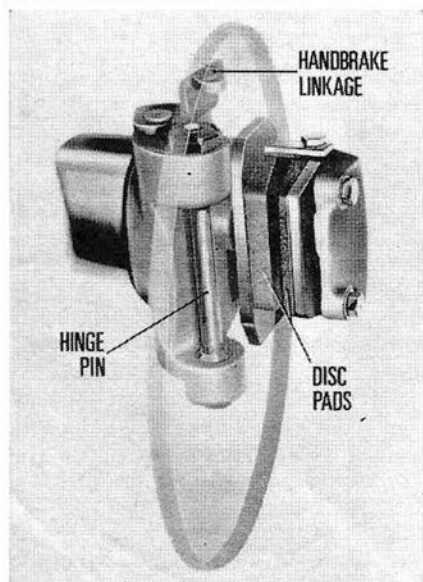
Disc brakes are taken for granted in Europe. They are fitted to at least the front wheels of cars as small as the British Motor Corporation's 61-cu. in. Mini-Cooper sedan. Pad wear often is rapid, but renewal is so quick a job that this shortcoming is tolerated as the price of smooth, fade-free retardation. There is interest in building some self-servo effect into disc brakes, but there is doubt whether this can be done without sacrificing fade resistance. More imminent is the adoption of disc brake calipers which require only one hydraulic cylinder per wheel instead of one at each side of the disc. Renault adopted this principle several years ago on the rear-engined R-8 model, letting the caliper slide laterally so the disc always is centered between the opposing friction pads. Now, Girling of Britain is tooling a swinging caliper mounted on hinge pins. This achieves the same result with less friction and risk of sticking, but requires wedge-shaped pads of tapered thickness.

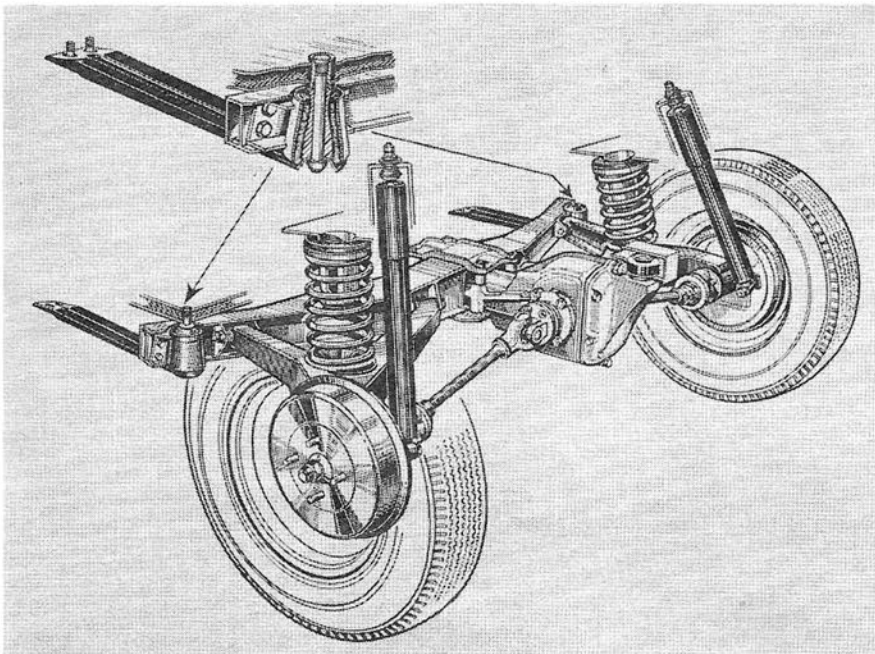
Anti-skid control of brake application hydraulic pressures is just coming onto production cars with the announcement of a Dunlop Maxaret system on the 4-wheel driven Jensen FF sedan. This car's Ferguson-Formula transmission allows one central unit to check locking of all wheels. A new form of Maxaret has been evolved which works on the vacuum servo system instead of directly on hydraulic pressure. More common are simple pressure or inertia-sensitive valves, which either stop or diminish the build-up of rear braking at high rates of retardation when balance is shifted forward.

LIGHTING REGULATIONS in Europe are varied, but generally less restrictive than in the U. S. A. Hence, now there is a boom in quartz-iodine lamps that almost double the efficiency of generating light from electrical energy. As this principle needs heat-resistant glass closely wrapped around the filament, sealed-beam ideas are in retreat. Making twin-filament bulbs of quartz-iodine pattern also seems an impossibility, so 4-lamp systems are essential, unless an electro-mechanical system of bulb screening is built into each headlamp to cut off upward light.

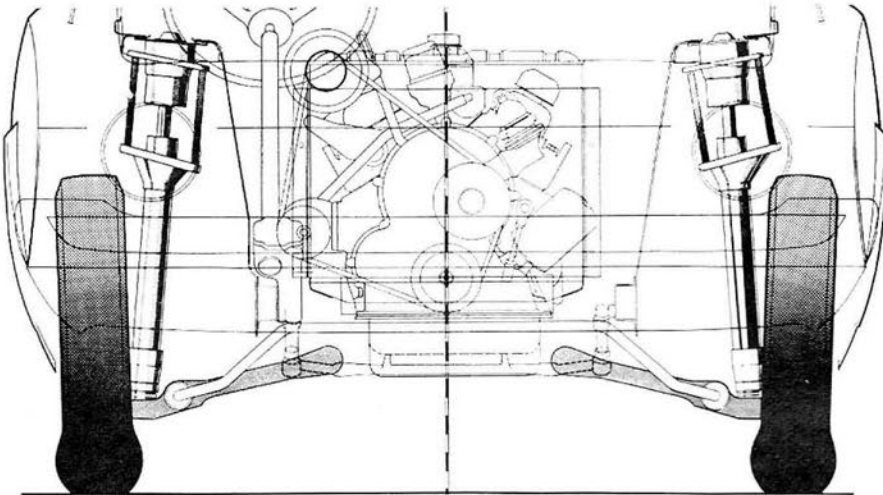
Small cars with soft springing now are being built with 2-position controls on their headlamps so that beam elevation can be corrected for full passenger loads. This is critical in coun-

GIRLING'S swinging caliper unit allows the caliper to move to compensate for wedge-pad wear.



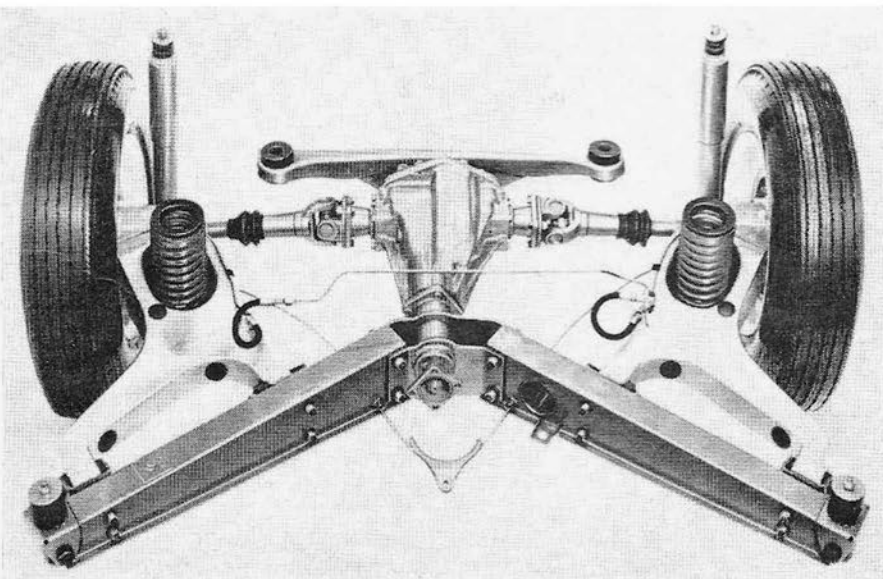


SOUND-INSULATING rubber mountings separate the BMW 1800 body from the crossmember carrying rear suspension links and the sprung differential.



COIL SPRINGS are angled to reduce static friction and counteract side forces in the British Ford Corsair's MacPherson front suspension system

TRIUMPH 2000 rear suspension, in which individual arms are pivoted to provide a swing axle effect, is typical of European i.r.s. layouts.



tries where regulations require a very sharply cut-off top for the passing beam. Citroen goes one better with a hookup from its hydro-pneumatic suspension (which has a slow-acting automatic height control, but permits rather large temporary changes of attitude during braking and acceleration) to the headlamp beam elevation adjusters! There is a steady increase in the popularity of low but wide rectangular headlamps, based on very large-diameter parabolic reflectors with their upper and lower sections replaced by two segments of a much smaller reflector. Such lamps provide large reflector areas, yet permit their centers to be raised close to the hood-line of a low-built car.

SMALL VARIATIONS of technique always are coming along. A new one is the adhesive glazing for bonding a windshield to the face of a rubber molding instead of seating it in a channel. In addition to greater immunity from water leaks, this scheme lends itself to welcome slimming down of windshield pillar blind spots. One user of the idea is the 1966 Vauxhall Cresta from the British plant of GM, which cures the adhesive by means of heat from an electrical resistance wire embedded in the rubber. Metal-to-metal bonding by adhesives also is gaining favor as an alternative to spot-welds, as yet only for non-vital parts, such as the steel stiffening channels which are bonded into place under the hood and trunk lids of the rear-engined Sunbeam Imp.

A very strange new pressure for orthodoxy is being applied to designers at some European car factories. It is being suggested that the growing business of supplying kits of car parts for assembly in developing countries around the world will in the future go only to those makers whose cars can accept near-standard transmissions, axles and the like built in local factories; and that components for unconventional cars soon will be refused import licenses by many countries, because laws governing incorporation of high percentages of locally made components cannot be observed!

Another adverse pressure on design is feared in England, where an American-style universal speed limit of 70 mph has just been applied. Nominally, this is a 4-month experiment to determine if traffic accidents are reduced, but there is widespread fear that the limit will become permanent and will have adverse effects upon the standards of handling and braking built into cars of the 1970s. Despite problems such as these and despite mergers that reduce the number of independent car factories, development still is going ahead, fast. ■