NEW CARS FROM GERMANY, JAPAN, FRANCE & ENGLAND

ROAD & TRACK

ICD

DECEMBER 1966

3/6 IN ENGLAND SIXTY CENTS

TRIUMPH TR-4A ON ROAD, TRACK & DRAGSTRIP

Jack Brabham - World Champion Driver & Constructor
Exclusive Story of the Man, his Car and his Company

BIZZARRINI GT AMERICA ROAD TEST
CHEVY-POWERED FOR GRAND TOURING

In Memoriam

RENZO RIVOLTA

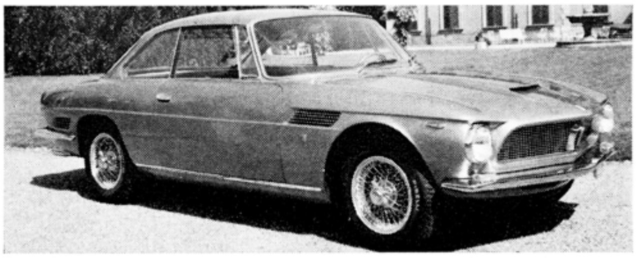
RENZO RIVOLTA, founder and president of ISO Autoveicoli SpA, succumbed to a heart attack on Aug. 19, 1966. He was born in Desio, Italy, on Sept. 5, 1908, and grew up in the family's lumber business. In 1940 he began manufacturing refrigerators under the name Iso Thermo, from which the present firm name derives. He had a passion for cars, motorcycles and inboard boats and raced them all in his youth; he won 1st overall and three 2nds in the Pavia-Venezia boat races. He used to say, "At the wheel of a car I enjoy myself only above 120 mph."

Italy's postwar economic recovery made possible the motorization of the country for the first time and in 1948 Rivolta began manufacturing scooters, light motorcycles and light 3-wheeled trucks under the name of Iso. In 1953 the industrialist conceived and began producing a vehicle which he described as "half motorcycle and half car." This was the Isetta, a thorough failure in Italy. But BMW acquired the manufacturing rights to the design and some 250,000 of these motorized eggs were sold, chiefly in Germany and France.

In 1961 Rivolta conceived the idea of a fine, 4-passenger GT car which would combine the best of Italian coachwork and roadability with an American mass-produced power train. He reached an accord with Chevrolet and with former Ferrari engineer Giotto Bizzarrini as the designer and with Bertone providing the bodies, the first of the Iso-Rivolta GT cars appeared in 1962.

Renzo Rivolta was a hard-driving businessman who combined hobby and career in the creation and production of a very wide range of highly original motor vehicles. He was well-educated, urbane and multi-lingual. His estate at Bresso, a Milan suburb, is a Bugattiesque melange of palatial villa, parklike formal gardens and sprawling factory buildings. One of these is the modern, efficient plant in which Iso-Rivolta cars are assembled. He was generous and engaged in many philanthropies, devoting much of his time and energy to the Bressa Children's Asylum of which he was president.

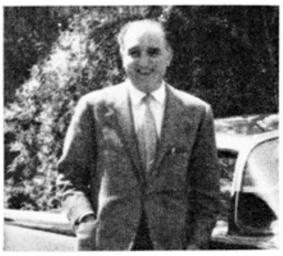
In building his empire Renzo Rivolta planned carefully for its future. His son, Dr. Ing. Piero Rivolta Barberi, was educated as a mechanical engineer and for the past several years has participated in the management of the family's manifold interests. The work of the dynamic and gifted father will be carried on with unbroken continuity by his son.



ENRICO NARDI

ENRICO NARDI passed away in Turin, Italy on Aug. 23, 1966. He was 60 years old, and one of the best loved figures in the long history of Italian automotive sport.

Nardi's fame in recent years derives from his line of fine light-alloy-and-wood steering wheels and other well-designed and well-made custom equipment for cars. What is not generally known is that, almost to the last, Nardi remained active as one of the most gifted preparers of engines for racing that Italy has ever produced.

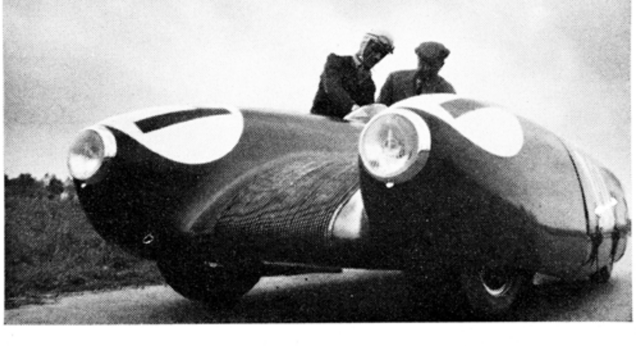


He was born with *benzina nella sangue*—gasoline in his blood—and cars and racing were his very life. In 1930 his talents as an engine tuner were recognized by Vincenzo Lancia, who became his personal patron. In 1937 Nardi left Lancia to become one of the top engine specialists in Alfa Romeo's racing department, working directly under Enzo Ferrari. When war came, it was Nardi who was directly responsible for putting Ferrari in the machine-tool manufacturing business.

Nardi remained with Ferrari for the duration and then, in 1945, returned to Turin, where he set up his own shop close to the Lancia factory. Here he began building ultra-light monoposto and sports cars, first around the BMW opposed-twin engine and then around the American Crosley, modifying the engines extensively. What was most remarkable about these prophetic machines was Nardi's pioneering use of tubular frame construction, which had a tremendous impact on race-car design. In 1949 he created the extremely advanced Nardi-Danese (R&T Jan. 1950). In 1952 he built a Lancia-engined Formula 2 machine which was reported on in R&T for November of that year. These machines brought him international fame but in Italy he remained most noted as a great racing-engine talent. He specialized in Lancias, from the Aurelia GT epoch up to the recent Fulvia and Flavia. He was a friend and profound admirer of Vittorio Jano.

Enrico Nardi was as generous as he was kind and friendly to all. The competition section of the *Museo dell'Automobile* in Turin is indebted to him for the donation of a Type 35 Bugatti and the Nardi-Monaco race car which he built in 1932. He was a little man, physically speaking, but in every positive sense he was a big broad person who enriched the world with his life.

BY GRIFF BORGESON

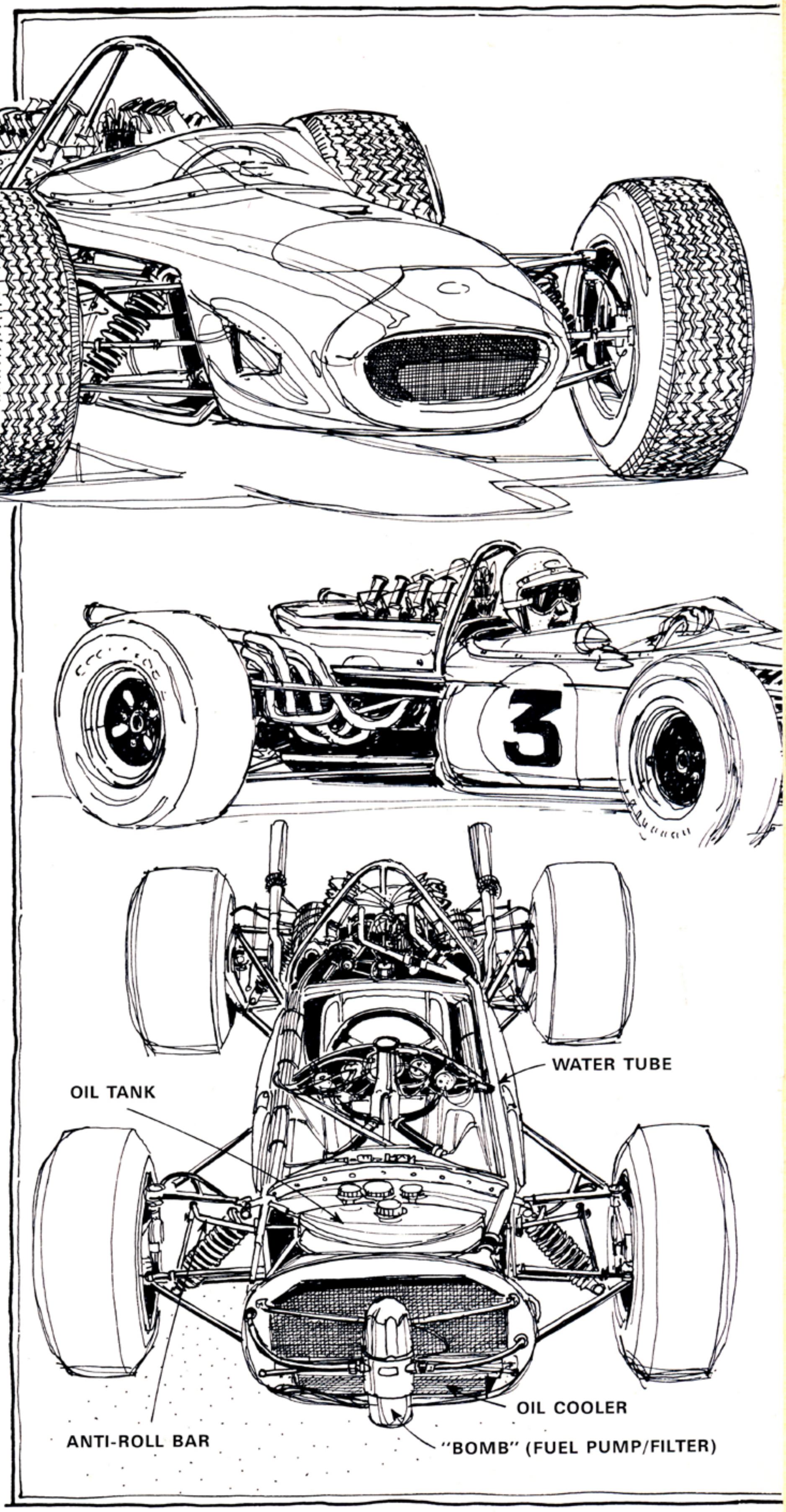


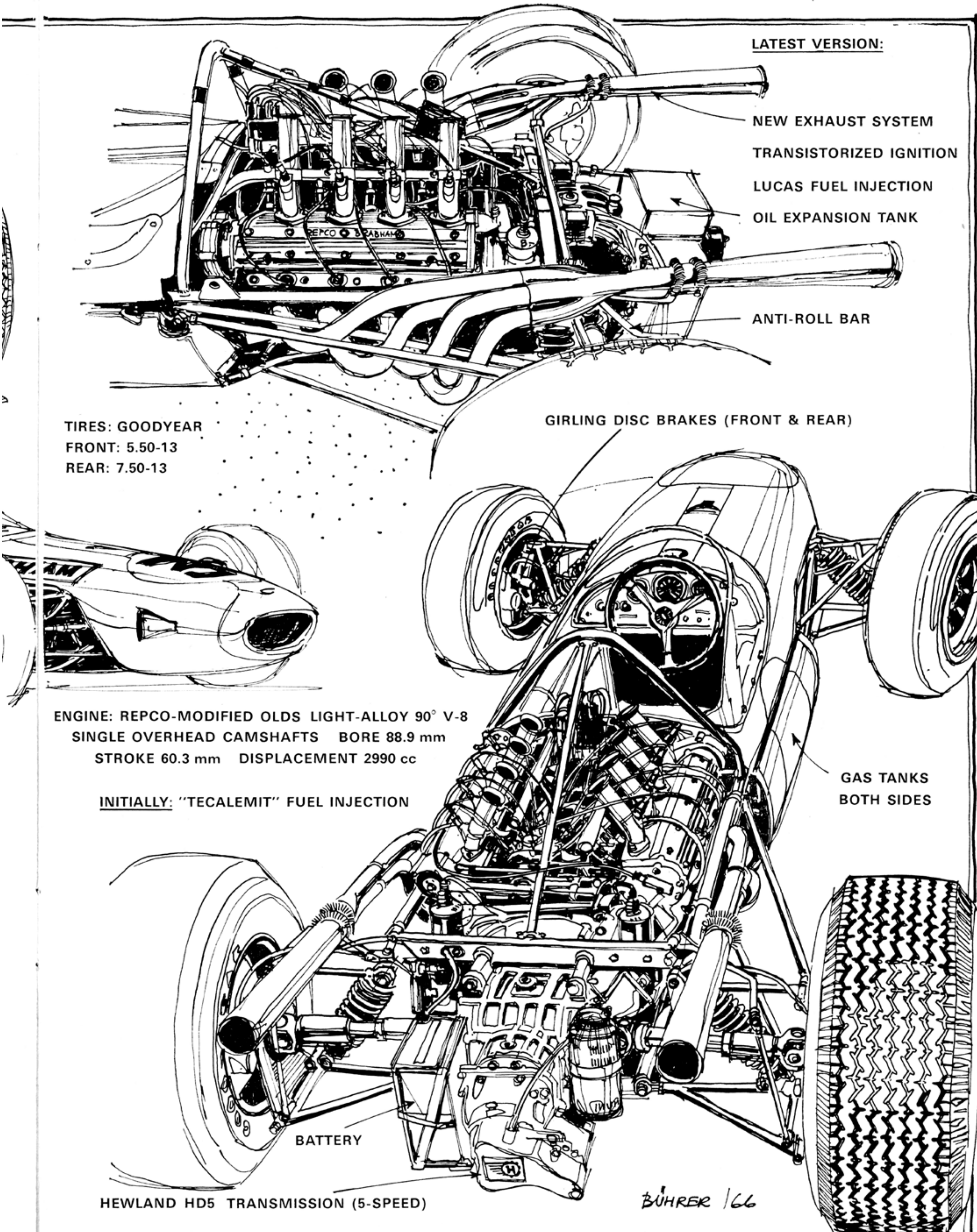

16

BRABHAM
a special section on The Machines and the Men Behind Them

1966: A former World Champion returns to the top, dominating two formulas with equal parts of straight thinking and hard driving.

CENTER SPREAD: Winner and again champion, Jack Brabham and his Brabham-Repco Formula 1 car at Zandvoort. Color photo by Dennis Cipnic. RIGHT: The top Grand Prix car of 1966 illustrated in detail by artist Werner Bührer.




LATEST VERSION:
NEW EXHAUST SYSTEM
TRANSISTORIZED IGNITION
LUCAS FUEL INJECTION
OIL EXPANSION TANK
ANTI-ROLL BAR
REPCO BRABHAM
TIRES: GOODYEAR
FRONT: 5.50-13
REAR: 7.50-13
GIRLING DISC BRAKES (FRONT & REAR)
ENGINE: REPCO-MODIFIED OLDS LIGHT-ALLOY 90° V-8
SINGLE OVERHEAD CAMSHAFTS BORE 88.9 mm
STROKE 60.3 mm DISPLACEMENT 2990 cc
INITIALLY: "TECALEMIT" FUEL INJECTION
GAS TANKS
BOTH SIDES
BATTERY
HEWLAND HD5 TRANSMISSION (5-SPEED)
BÜHRER /66

BRABHAM

The Organization

A champion's team is made of many parts

BY CLELLAND MILLER

ONLY ONE THING about the Brabham car is funny, and that's how it came by its name. When Jack Brabham and Ron Tauranac went into business as constructors in 1961 they said the hell with the cult of personality, let's leave ourselves out of it and call the car the MRD, short for Motor Racing Developments Ltd., their newly formed firm. Alas, this was irreverently rendered in France as MeRDe. So they rethought and made it Brabham instead.

As it developed, of course, Jack didn't win a single Championship race in the 5-year stretch 1961 through '65, the period bracketed by his second and third tenures of the world title; so the French, for whom the indelicate 5-letter word symbolizes good luck, may think he was rash in not letting it stick.

Apart from the fact that he's driving better and more stylishly, and the laugh wrinkles outboard of his eyes are etched a mite deeper, the 1966-vintage Brabham is almost indistinguishable from the World Champion we knew six and seven years ago, back in his Cooper days. It's still his habit, only more so, to scorn delights and live laborious days in pursuance of the profession that absorbs his whole being. He combines engineering and driving skills to a degree unique in living memory. Social wassail, particularly if it involves bow taking and speech making by J. Brabham, tops his list of long felt unwants. He is almost quaintly unself-opinionated on subjects of which he is a master. Slow to updander, he nevertheless doesn't suffer fools gladly, least of all the authors of the fiction that he owes his championship and other successes to his own almost unaided efforts.

He is in fact a natural delegator, and the Hosanna-to-Brabhamites would do him a better service if they acknowledged his knack for picking good people to delegate *to* and letting them get on with it. Considering he has four separate businesses, Brabham Racing Organisation Ltd. (the title explains itself), Motor Racing Developments Ltd. (the car construction company), Jack Brabham Conversions Ltd. (go-faster kits and treatments) and Jack Brabham Motors Ltd. (a neighborhood garage and car dealership), even Jack, with his habitual 15-hour working day, would find one-man-bandsmanship a bit beyond him. And for another thing he's in England only about three months a year on the average.

Jack has never made any secret of his preference for Australasians in the capacities that concern him, so it isn't surprising to find the key Brabham posts filled by Australians or New Zealanders. Phil Kerr, his overall second in command, who has been with him eight years, is a Kiwi. So is Roy Billington, chief racing mechanic, likewise the strong majority of the "enlisted" mechanics. Ron Tauranac, chief car designer and both manager and a director of Motor Racing Developments Ltd., is from Sydney (albeit from England at the age of three).

If Tauranac is *chief* designer, who, you may ask, are the others? There aren't any, in the sense of accredited assistants. But the adjective acknowledges the grain of truth (no more) in the journalistic parrot-cry that Jack won the World Championship "driving a car he had designed and built himself." By precise definition, Tauranac is a designer and Brabham isn't. But Jack does contribute ideas and suggestions which, according to their merit, are or aren't incorporated in Tauranac's drawings. From the MeRDes of yesteryear right on down to the current 3-liter Repco-Brabham, the structures and running gear of all the racing cars built under Brabham/Tauranac auspices have taken shape in the mind and on the drawing board of Ron Tauranac. It remains true, of course, that Jack is a tester and development engineer of the highest order, and that without his work in these departments the marque could never have achieved the success it has, either as a race campaigner or a purveyor of cars for independents.

As for Brabham's car "building" activities, it's an odd fact that even today he quite often carries out complex machining operations on parts for his own racing cars with his own hands. Making a guess at the sterling value of one Brabham man-hour, this sounds crazy but isn't. Detailed drawings would be indispensable if you were giving the same parts to a normally skilled operator to machine, but this is a plane on which Jack and Ron Tauranac read each other's minds so well, communicate so subtly, that they can often make out without drawings and thereby save priceless time. "Anyway, it's his trade," says Ron in disrespectful allusion to the one-horse machine shop that Jack owned and manned back in Sydney before fame and fortune claimed him.

Motor Racing Developments is easily the world's biggest producer of pure racing cars for the open-wheel formulas, and in his position of total responsibility for its day to day operation, Tauranac doesn't exactly find time hanging heav-

Ron Tauranac, the man who designs the Brabhams.

ily on his hands. But back in 1962, when the first F1 Brabham was on the easel, it hung even less heavily and he ruefully recalls coming home for dinner each evening and eating it standing up because he knew if he sat down he'd fall asleep into his soup and maybe never wake up again.

He attributes the commercial success of Brabham cars to several factors. Customers, including unknowns operating on shaky overdrafts, know they can walk right up to him or Jack in any race paddock and unbosom their problems, ask advice—and get it. ("Making private owners happy is the best bit of tuning you ever could do.") Second, the basic designs are not only simple but they change seldom and little, so the cars' secondhand value holds up uniquely well. Third, Brabhams are easy and therefore cheap to service and adjust (e.g., the make originated the adjustable anti-roll torsion bar, subsequently adopted by all the competition). Again, tubular frame construction makes it easy to vary suspension geometry by darning in alternative pivot points.

Making theory and practice walk in step is a matter of personal pride for Tauranac, and out of all the Brabhams he has designed, only one, the BT8 sports car, failed to handle right when it came off the drawing board. A spoiler was added and this immediately cured the natal understeer. Incidentally, the low-pivot swing axle, which Daimler-Benz engineers are popularly supposed to have originated, was a feature of a 500-cc racing car that Ron designed, built and hillclimbed a clear two years before it appeared on Mercs. This machine, the RALT, had developed back-end tantrums on turns, and indeed once ejected its driver painfully. It was then that Ron, who had studied every authoritative word ever published on suspension theory, was struck with the idea of nether articulation for his shafts.

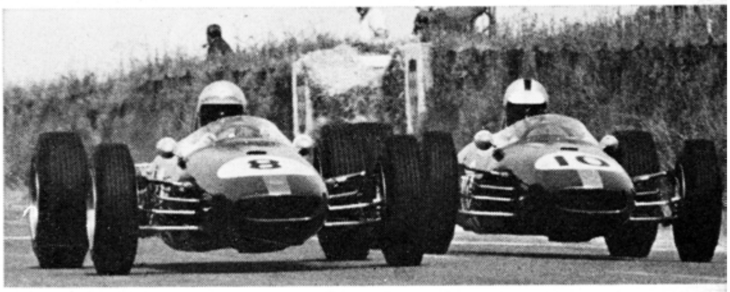
The leave-well-enough-alone policy applies to Brabham bodies as well as structures. The current F2/F3 shell was established nearly five years ago. Subsequently, wind tunnel tests on alternative shapes have twice failed to show better drag factors than the original, so no change.

Another MeRDe claim is that Brabham cars leave the factory in a fit condition to race without a wrench being laid on them. At least two instances are on record of a brand new F3 Brabham being delivered to a private owner on a Saturday and winning races the following day. Neither of the customers concerned had ever driven Brabhams before.

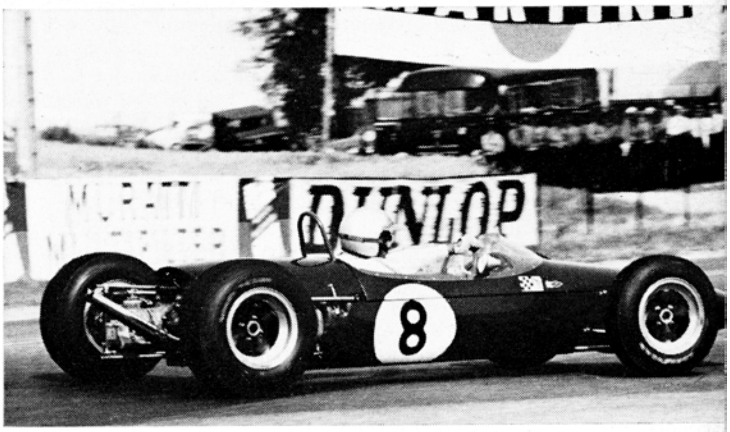
By the time this is published, somewhere around 250 Brabhams will have been minted, predominantly formula types, of course—FJ, F3, F2—plus an insignificant number of sports cars. This year's output will be between 80 and 90. One of the oddities of the interrelation between Brabham companies is that MeRDe sells Brabham Racing Organisation the cars that BRO campaigns. Also, although MeRDe's recognized *raison d'être* is car construction, it is the official entrant of the Brabham-Hondas with which Jack and Denny Hulme have flattened all F2 opposition this year. This effectively disassociates Honda from the Repco-sponsored side of Brabham enterprises.

Not the least of many unique features of the 1966 Brabham success story is the way that Jack and Hulme have dominated a secondary formula, F2, in time left over from Jack's and Repco-Brabham's resounding triumphs in the drivers' and constructors' World Championships. Brabham's F2 conquests, with Hulme almost invariably second up, have been nearly as habitual as breathing, resulting in walkovers in both the British and French championships for this class. I asked Jack what part coincidence played, if any, in the fact that he'd done nearly all the winning and Denny the runner-upping in F2, and he frankly said none: this was a clearcut pre-arrangement between them.

No. 1 and No. 2. Jack Brabham and Denis Hulme.



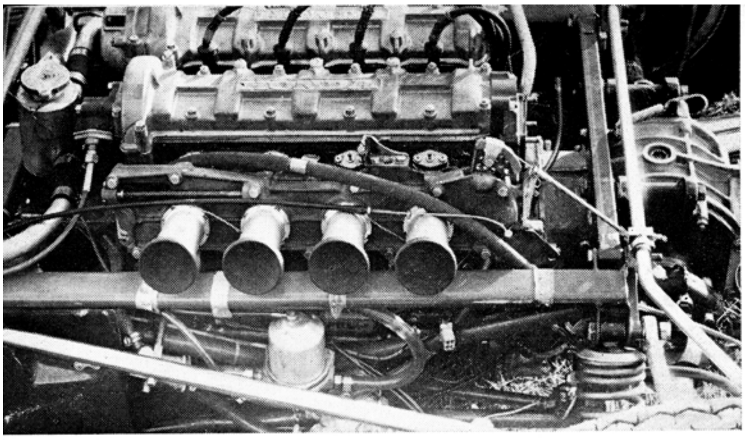
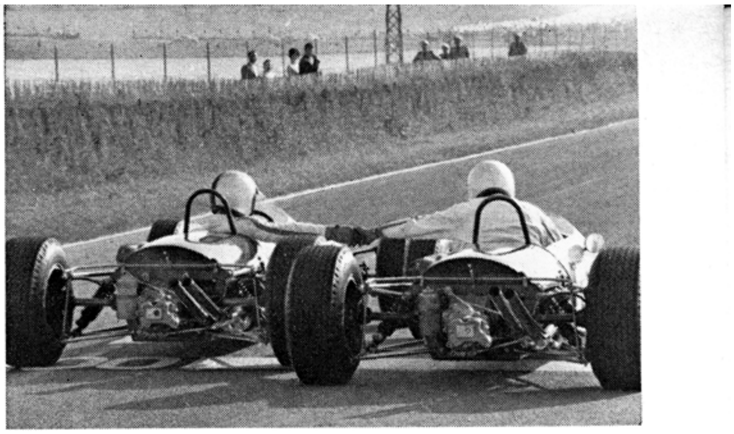
In Formula 2, Brabham-Hondas entered 12 races and won 12. Jack Brabham scored 10 wins and Hulme took the other 2.



Honda doesn't have an engine to fit the new 1600-cc stock-block version of F2 due into force in '67, and Brabham is to revert to Ford engines (in lesser capacities, these already power the cars sold to the private clientele).

Jack hadn't disclosed his source of F1 engines for 1967 when this was written, leading to wild flights of speculation in Britain and elsewhere. I pumped him for clues but got nowhere, like everybody else. It's as official as anything is, though, that no dohc V-8 Repco is planned. One guess from a good source is that Honda may supply Brabham with duplicates of the 3-liter V-12 as raced by its parent factory.

It isn't only in design matters that the *status quo* is beloved by Jack Brabham and his entourage. It's also an article of Jack's personal philosophy that while you've got good *old* friends there isn't any point in making new ones. This explains his longtime association with Repco (which began back in his Cooper days), Esso for fuel, Goodyear for tires. This year, as you may have noticed from the race reports, →

Success of Honda-engined F2 Brabhams led to speculation that Honda may furnish V-12 engines for Brabham F1 cars next year.

BRABHAM: THE ORGANIZATION

while other teams have been switching frenziedly back and forth between Dunlop and Firestone (and even sometimes running one brand on the front wheels, the other on the rears), he has calmly and contentedly stuck to Goodyear.

Unlike the competition, too, he has had no need to be constantly changing from dry to wet weather casings and *vice versa,* for the simple reason that Goodyear, at his specific urging, developed an all-purpose tire that he uses regardless of weather and portents. This one may be a mite inferior to rival rubber in extreme dry and extreme wet, but on balance he has undoubtedly had the laugh. The only time Jack actually raced this year—experimentally—on tires using an uncompromising dry-weather compound was at Spa in the Belgian GP, which turned out to be the wettest race of the season. He spun wildly, giving himself the fright of his life, in trying to avoid the gyrating Cooper of Jochen Rindt.

It seems unlikely that Jack, who first demonstrated the fateful notion that small, light, mid-engined GP cars might stand a chance at Indianapolis, and of course placed ninth there in a Cooper in 1961, will be having a bash at the 500 next year. There are two reasons: it would take up time that can't be spared from the pursuit of his central ambition to win three more World Championships and thus beat Fangio's record of five; second, in important leagues (excluding, for instance, the sedan racing he does more or less for diversion), he has a prejudice against driving cars that don't bear the Brabham label.

How near is GP car design to finality, in terms of basic layouts? "There's still a very long way to go in chassis and suspension design," says Jack, and Tauranac agrees. "We know where we want to go," says Ron, "but we don't know how to get there. Vertical wheel travel, to take fuller advantage of the wide tire treads currently in use, is a high priority objective. Constant ride height, without the almost inevitable complication, would be an asset too."

When Jack and his team were crystal-balling their 1966 chances in the Grands Prix, late last year, they figured that there were two World Championship races they didn't stand much hope of winning: the French and Italian GPs, both run over fast circuits offering the least scope for their good-handling, torquey but not overly powerful car. Well, just for once events proved them 50% wrong (at Reims, you remember, Jack won at the highest-ever Championship race speed), and they weren't too far from nonsensing the whole forecast. At Monza Brabham retired after leading for a 4-lap spell and then spilling his engine oil. But the joke was this, if jokes in a spilt-oil context are permissible: until his retirement, thanks to his own skill and the Repco-Brabham's brilliant track holding, the Brabham-lubricated Monza surface gave Jack less cause for worry than almost anybody else in the act. Teammate Denis Hulme, who eventually finished third, afterwards said that for his part it "helped" him. But oil is like cake—you can't eat it and have it too.

BRABHAM TEAM RECORD—1966

Formula 1 (3-liter Brabham-Repco V-8)

SOUTH AFRICAN GRAND PRIX East London, Jan. 1
Brabham retired (inj. pump), Hulme* retired (differential)
SYRACUSE GRAND PRIX Syracuse, Italy, May 1
Brabham retired (engine), Hulme* retired (oil leak)
INTERNATIONAL TROPHY Silverstone, England, May 14
Brabham 1st, Hulme* 4th
MONACO GRAND PRIX Monte Carlo, May 22
Brabham retired (gearbox), Hulme* retired (drive-shaft)
BELGIAN GRAND PRIX Spa-Francorchamps, June 5
Brabham 4th, Hulme* retired (accident)
FRENCH GRAND PRIX Reims, July 3
Brabham 1st, Hulme retired (engine)
BRITISH GRAND PRIX Brands Hatch, July 16
Brabham 1st, Hulme 2nd, Irwin* 7th
DUTCH GRAND PRIX Zandvoort, July 24
Brabham 1st, Hulme retired (ignition)
GERMAN GRAND PRIX Nurburgring, Aug. 7
Brabham 1st, Hulme retired (distributor)
ITALIAN GRAND PRIX Monza, Sept. 4
Hulme 3rd, Brabham retired (oil leak)
GOLD CUP Oulton Park, England, Sept. 17
Brabham 1st, Hulme 2nd
UNITED STATES GRAND PRIX Watkins Glen, Oct. 2
Brabham retired (engine), Hulme retired (engine)
*indicates 2.7 Climax 4-cyl engine was used

Formula 2 (1-liter Brabham-Honda 4)

INTERNATIONAL TROPHY Goodwood, England, April 11
Brabham 1st, Hulme 2nd
PAU GRAND PRIX Pau, France, April 17
Brabham 1st, Hulme 2nd
JUAN JOVER TROPHY Barcelona, Spain, April 24
Brabham 1st, Hulme 3rd
LIMBOURG GRAND PRIX Zolder, Belgium, May 8
Brabham 1st, Hulme 2nd
LONDON TROPHY Crystal Palace, England, May 28
Brabham 1st, Hulme 2nd
REIMS GRAND PRIX Reims, France, July 2
Brabham 1st, Hulme retired (engine)
NORMAND CUP Rouen, France, July 10
Hulme 1st, Brabham retired (gear lever)
KANON LOPPET Karlskoga, Sweden, Aug. 21
Brabham 1st, Hulme 2nd
KEIMOLANAJO MEETING Helsinki, Finland, Aug. 28
Brabham 1st, Hulme 2nd
COUPE DE VITESSE Montlhery, France, Sept. 11
Brabham 1st, Hulme 3rd
LE MANS GRAND PRIX Sarthe, France, Sept. 18
Hulme 1st, Brabham retired (engine)
ALBI GRAND PRIX Albi, France, Sept. 25
Brabham 1st, Irwin 3rd

Tasman Championship (2.5-liter Brabham-Repco V-8)

SANDOWN PARK INTERNATIONAL Melbourne, Australia, Feb. 27
Brabham retired (oil pressure)
SOUTH PACIFIC CHAMPIONSHIP Longford, Tasmania, March 7
Brabham 3rd

BRABHAM

The Repco V-8

An engine for a champion

BY FRED PITT & JOE LOWREY

REPCO LTD., Melbourne, Victoria, Australia, owns a large group of companies which manufacture (among other things such as garage equipment and machine tools used in the repair industry) a vast variety of pistons, wrist pins, rings, bearings, gaskets, ring gears, clutches and universal joints which are used both as original equipment and as replacement parts. Despite this experience, they had never made a complete engine until 1964.

For several years the company had assisted Jack Brabham when he was competing in Australia. The 2.5-liter Coventry Climax engines he was then using for the Tasman race series were prepared in the laboratory of the Engine Parts Group under the knowledgeable hand and eye of Frank Hallam, using Repco products as much as possible. These engines were very successful but were beginning to be tuned a bit on the ragged edge by 1963. As a result, blow-ups of a fairly catastrophic nature were being experienced by quite a few drivers, the trouble being that there was not much safety margin between peak power rpm and safe maximum rpm. The Tasman Formula capacity limit of 2.5 liters still had some years to run, so the Repco directors, with Brabham and Hallam, agreed that it would be a good idea to design a complete engine for the remainder of the series.

This was early in 1964; the engine was required by the end of the year or, if possible, sooner. In view of this short lead time Repco decided to use an existing 8-cyl block, of which two or three appeared suitable. The final choice was the Oldsmobile F-85 of 3.5 liters capacity, which had the advantage of being cast in aluminum as well as being readily available commercially. [Also, the Olds block used a 6-bolt/cyl pattern for the heads whereas the Buick had only 5.—Ed.] By varying the bore and stroke dimensions the capacity could be reduced to 2.5 liters or increased to 4.3 liters with little trouble. In other respects the block was not all that could be desired; the crankshaft seals at both ends were of the simple "rope" type which doesn't like high rpm, the bores for the hydraulic tappets and the cored holes in the floor of the central valley would have to be rendered oil-tight, and there was some doubt about the general stiffness of the crankcase section and whether it could cope with the 400 bhp expected from the largest displacement versions.

In addition to all these considerations, the overall dimensions had to be small enough to fit into the existing Brabham chassis; this ruled out the use of double overhead camshafts. In view of the success of the short-stroke overhead valve engines in Formula 2 and 3, it was felt that a single camshaft per bank would suffice, furnishing something like 250 bhp for the 2.5-liter version, measured on the dynamometer in Melbourne. This may seem like a low figure, but it was considerably above the output of any Climax engine on the same dynamometer and these were the only figures Repco could use for comparison.

Phil Irving, at the time on the staff of Repco Research, was entrusted with the design work, to be done as unobtrusively as possible for obvious reasons. The whole exercise had to be carried out on a limited budget. Irving flew to London in March 1964, set up a small drawing office and began the first sheet of paper on the 15th of that month, after initial conferences with Brabham and Ron Tauranac, the chassis designer. Because of the haste required, there was no time to make extensive and accurately detailed general arrangement drawings, so the design of the components began after the basic locations were established. After correspondence with Hallam 12,000 miles away, the dimensions of the 2.5-liter engine were settled at 85 x 55 mm, distinctly oversquare. As the original bore was 3.5 in. (88.9 mm), this necessitated boring out the cast-in liners and fitting new ones, but for the 3- and 4.3-liter versions it was intended to retain the original bores, which were formed by very thin (0.093-in.) gray-iron liners with a corrugated outer surface. Irving was a bit distrustful of these liners as a result of experience with cast-in liners on motorcycle engines; subsequent events showed that this distrust was well founded.

In order to keep the overall engine width within the permitted maximum, and to dodge the existing head studs, it was necessary to incline the valves inward 10°, locating their heads in a shallow wedge-shaped combustion chamber into which the plug seated at the deepest point. In this position the plug wrench just clears the chassis rail, a desirable feature!

The valves are arranged with the exhausts and intakes spaced alternately; to reduce pattern costs and ease the spares situation, both heads are basically identical, although the left and right camshafts and covers have to be different. The intake valve head diameter is 1.625 in., the exhaust 1.375 in., and the stem diameter 0.312 in.; the lift was initially 0.400 in. In order to clear the valves at top dead center, the piston crowns have recesses at 10° angles. Although the valves are partially masked by the combustion chamber, the gas flow is reasonably good, especially as the bend in the intake ports is only 35°. The valves seat on Austenitic cast-iron inserts shrunk in position and the guides are a copper alloy known as Hidural 5, a very tough material with good head conductivity. To assist in cooling the exhaust valves the center third of the guide is finned and directly exposed to a flow of cooling water.

The bucket-type cam followers of chilled cast iron run directly in holes fine-bored in the heads, which are cast by Sterling Metals, Nuneaton, in fully heat-treated LM23WP aluminum alloy. Each camshaft is carried in five cast-aluminum bearings retained by four 0.250-in. studs, while replaceable bearing shells are fitted in the bearing caps only, as the lower side is virtually unloaded. The general camshaft diameter is 1 in., the cam base circle 1.062 in., and the cam width 0.75 in. The shaft is drilled all the way through for lubrication, oil being supplied by way of the front location bearing and leaving through holes at the remaining bearings. No holes are provided through the cam flanks, side leakage from the bearings being relied on for cam lubrication. The oil leaves partly through four drain holes and partly by leakage into a cast gallery running the length of the head and connecting at the front with the timing case. At the rear of the galleries, quickly detachable elbows sealed with O-rings conduct oil through two external pipes to the crankcase; thus there is little likelihood of oil piling up at one end or the other under acceleration or braking and possibly causing plug-oiling.

As installed, the intake passages are vertical and emerge into channels milled to accommodate duralumin throttle slides which are supported on transverse rollers and chromium-plated to resist the scoring which is likely to occur between two unlubricated light-metal surfaces. Each slide is surrounded by a magnesium cover, to which are bolted the intake elbows carrying the Lucas fuel injection nozzles and the tubular air horns, which can be varied in length to suit the power curve required. As the throttle slides are both horizontal and in the same plane, the throttle linkage is simple and looks rather heavy compared to some designs, but it doesn't fall off!

The camshafts are chain-driven, a rather unusual scheme being employed to avoid disturbance of the drive when removing the head. Irving places great importance on simplicity of overhaul for racing engines, since mechanics are so often working against time and lack of sleep. Accordingly, each shaft has at its front end a flange on which is milled a tongue that engages a 2-in. diameter Oldham coupling disc, machined from 80-ton steel, which in turn engages the appropriate camshaft drive sprocket. The shaft tongues are machined in relation to the cams so that when No. 1 cylinder (the front one on the left side) is at TDC on the compression stroke, the tongues are square to the faces to which the cam bearings are bolted, and the shafts slide up freely when the nuts are removed. It is necessary to remove the shafts when detaching the heads; because of the existing stud disposition, five of the head nuts are hidden beneath the cam bearings.

This feature was unfortunate but unavoidable. There are four instead of the more usual two rows of studs, which makes for very good gasket clamping by six studs around each bore, as well as a reduction in head distortion, but the center rows are too close together to provide room for the camshaft between them. With the 10° valve location, the offset of the camshaft is enough to place one row outside the cambox and the other row beneath the cam bearings, inside the cambox. In practice, there is little disadvantage. Usually if a head has to be detached it will also be necessary to remove the camshaft to gain access to the valves and it doesn't matter whether the camshaft comes off with the head or not.

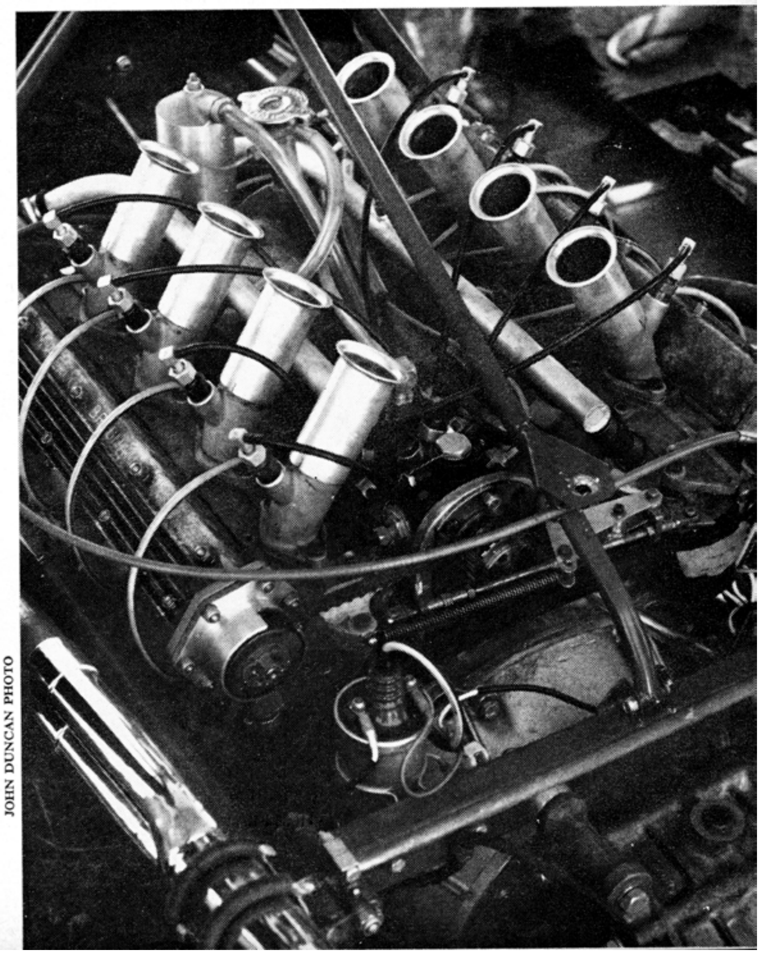
Split circular covers with rubber seal-rings enclose the Oldham couplings and join the heads to the timing case, while various bolt-on covers at the rear can carry anything required, such as a tachometer drive, oil pump, etc. These covers have hollow bosses which register directly with recesses bored in the rear camshaft bearings, thereby ensuring correct alignment of the driven component.

In the original design, 0.4375-in. UNC set bolts were used to retain the head, but these were replaced by double-diameter studs, reduced above the joint face to 0.375-in. diameter, this reduction enabling smaller nuts to be used and also assisting in clearing the ports without having undesirable bends or local bosses.

There is nothing unconventional about the head gaskets, made by Payne Byrne & Blackford (a Repco firm) from aluminum-reinforced steel with steel eyeletting around the combustion spaces and water holes. The compressed thickness is nominally 0.045 in., but slight variations do not matter mechanically, since the Oldham couplings can absorb a considerable amount of misalignment in the camshaft drive. Gasket trouble has been non-existent, partly because of the good original stud layout and partly because the head deck thickness is 0.437 in. minimum.

As far as the crankcase is concerned, the joint faces are 8.960 in. from the crankshaft centerline and thus unnecessarily far away for the 55-mm stroke. However, the connecting rod of the Daimler Majestic 4.5-liter engine is 6.3-in. long and just fills the bill, allowing a piston of good proportions. The connecting rod length/crank throw ratio of approximately 6:1 sounds somewhat unconventional but was thought to be an advantage, partly because it reduces the inertia forces at BDC and also the secondary out-of-balance forces, a very important point in view of the use of a "flat" crankshaft. A further advantage of the extra long rod, especially for the higher revving short stroke version, is that it raises the critical speed for piston ring flutter—by the generally accepted Hepworth and Grandage formula. The flat crank configuration was adopted because it simplifies manufacture as well as the design of the exhaust system; basically the engine layout is that of four 90° V-twins. If a 90° twin is counterbalanced by an amount equal to the whole weight of one piston and small end, the primary balance is perfect and the main bearings carry no inertia load from this source. However, the secondary inertia forces add up vectorially to give an out-of-balance force which operates transversely at twice engine speed; with a flat crankshaft all the forces from each pair also add up, resulting in transverse forces 1.4 times greater than the vertical secondary out-of-balance forces arising from an inline 4 of the same capacity as one bank of the V-8. It has been found in practice that operation at all engine speeds is extremely smooth, even on larger capacities in which the rod/crank ratio is less than in the 2.5-liter version. This is partly because of the low piston weight of 13.5 oz, and partly because of the stiffness of the shaft, with main journals of 2.3-in. diameter and crankpins of 2-in. diameter irrespective of the stroke, which is 2.165 in. on the 2.5-liter, 2.375 in. on the 3-liter and 3.375 in. on the 4.3-liter. The crank webs are basically circular, with two angular flats milled away to provide balance, and angular interconnecting holes drilled up from all five main bearings of the crankpins to provide lubrication for the big ends. The shafts are machined from solid billets of EN40B nitrided steel.

The main bearings and big-end shells are made by the Repco Bearing Co. with a copper-lead matrix overlaid with babbitt metal, and are slightly wider than the originals. End loca- »→



JOHN DUNCAN PHOTO

tion is provided by a pair of semicircular thrust bearings at the center web; these are restrained from turning by the bearing cap, this construction avoiding the use of a flanged center bearing.

Modifications to the crankcase are quite extensive. All the original tappet holes were blocked with aluminum plugs, through which pass bolts retaining four internal liners and two external aluminum plates which block off the large cored holes of the original crankcase. All these components are assembled with Araldite; though the process is long and costly, it makes the case oil-tight in this region and considerably stiffens the structure against transverse bending loads. At the rear the existing rope-seal groove is machined out to accept a spigotted aluminum seal housing which embraces the crankshaft flange. This flange carries two cast-iron sealing rings which bear on the bore of the housing and are free to take up their correct axial position. Other minor modifications include adding holes to locate the primary timing chain tensioner, replacing two water jacket freeze plugs with water inlets and machining a new starter mounting.

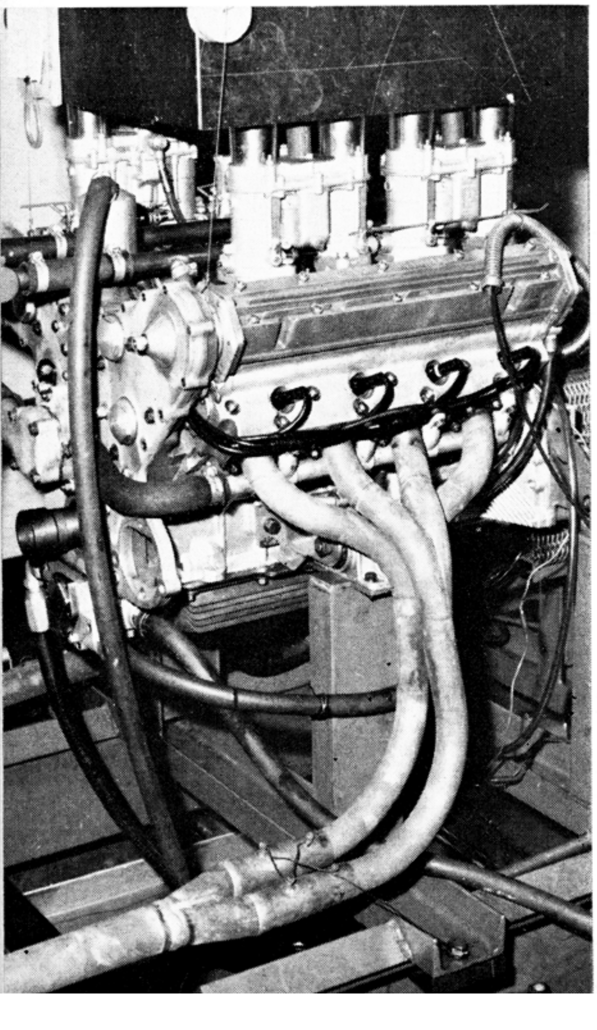
On all but the front main bearing, the original 0.5-in. set bolts are replaced by studs, long enough to project through a 0.187-in. high-tensile duralumin stiffener plate which is sandwiched between the crankcase and the cast magnesium sump. This stiffener plate is of ladder shape, the crossbars serving to restrain the crankcase walls from moving laterally, and extends forward of the front face of the case to close the bottom of the timing case and to form an attachment point for the duplex oil pump. Originally, the stiffener was steel but light alloy saves several pounds in weight and is sufficiently strong for the job.

The ribbed cast magnesium sump, with sides sloped at 40°, is attached by studs in close-fitting holes; the whole assembly is very stiff indeed when bolted together and undoubtedly contributes to smooth running. A shuttle-type inertia valve is housed in a gallery cast in the floor of the sump and the single scavenge outlet is taken off the center of the gallery. The inertia valve slides forward or backward when the car is decelerating or accelerating, thereby opening the gallery at the end to which the oil is surging but closing the other end against the entry of air. This idea was thought simpler than using two scavenge pumps, also avoiding excessive in-feed of air to the oil tank. The sump can be removed for access to the big ends without disturbing the oil pump.

The pump is bolted to the underside of the stiffener plate and has a large central gear wheel engaging a pinion on the crankshaft. The gear-type pressure and scavenge pumps are of conventional design; the latter was originally only 50% wider than the former, but this was later increased to 100% to assist in clearing the engine when the oil is in a frothy condition. Pressure oil is conducted through holes in the stiffener plate and the timing case to an external oil filter and thence to the original oil gallery and main bearings. The relief valve is set at 75 psi when the oil is hot; it is accessible from the outside. The entire pump can be removed without touching anything but the three external pipe unions.

The layout of the timing gear is as follows: A short jackshaft is mounted in the original centrally located front camshaft bearing and a much smaller bearing mounted where the second camshaft bearing used to be. The original inverted-tooth chain was discarded as being unsuitable for 9000 rpm and a duplex 0.375-in. pitch Renold chain, running on a cast-iron 40-tooth sprocket, was substituted. In front of this sprocket and keyed to it is a vernier boss with 18 holes and a 23-tooth sprocket with 17 holes. For timing adjustment, a peg fitted to a washer is inserted into whichever pair of holes is appropriate and the entire assembly is locked up by a single

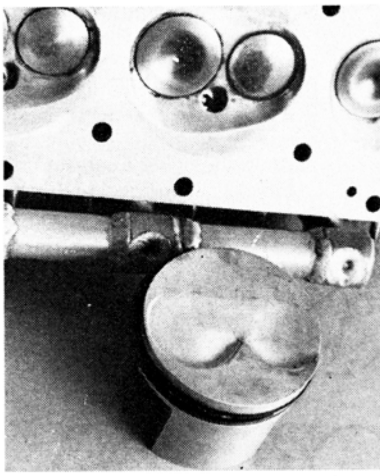
2.5-liter version of Repco V-8 (shown here on dyno with Weber carburetors) was built for Tasman series.



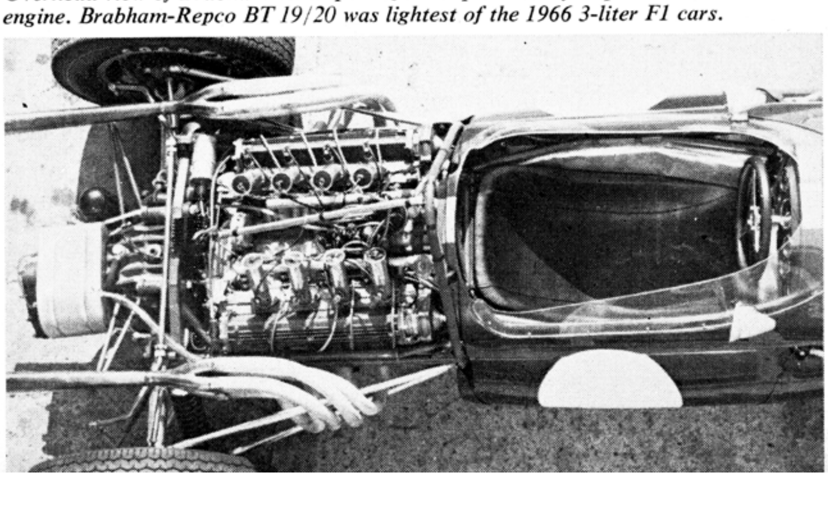
PHOTOS BY GEOFFREY GODDARD & PAT HAYES

Designer Phil Irving completed Repco V-8 engine design in just six months.

To clear valves, piston crowns have accommodating recesses.



Overhead view of Brabham F1 emphasizes compactness of Repco V-8 engine. Brabham-Repco BT 19/20 was lightest of the 1966 3-liter F1 cars.



large fine-thread nut. The jackshaft projects through the nut and carries the water-pump impeller on a parallel portion for easy removal.

The secondary timing chain is a single-strand 0.375-in. pitch component running from the jackshaft sprocket over the left camshaft sprocket, across the engine and under the distributor sprocket located on the centerline, over the right camshaft sprocket, around an adjusting sprocket which runs on a needle roller race on an eccentric shaft, and back to the starting point. Damper strips faced with synthetic rubber are fitted against all the unsupported runs of the chain, while the adjuster sprocket can be moved by means of an external sector plate to adjust its tension, which varies slightly between hot and cold conditions but not enough to matter. The primary chain is automatically tensioned by a Renold SCD hydraulic adjuster. The arc of contact of the chain with the distributor sprocket is about as small as practicable, which would not be so if the valves were not inclined inward 10°.

The camshaft drive sprockets run on caged needle roller bearings on pins fixed to the front half of the case only and steadied by external conical covers. Although there is only one bearing per sprocket, each is located directly in line with the chain and there is little tendency for the sprockets to wobble. In order to ensure accurate synchronization of the camshafts, each sprocket is spigotted on a vernier boss and held by four 0.25-in. Allen screws. These pass through one set of four holes in the sprockets into the appropriate tapped holes in the boss, the latter holes being unequally pitched to provide a vernier effect of limited range, but sufficient to obtain synchronization within 2°. Once set, these verniers never need to be disturbed unless a new pair of camshafts require synchronization, which can be carried out with no dismantling other than removing the external steadiers which also cover the four slots which give access to the Allen heads.

The timing case itself is cast in magnesium in two parts, held together with 14 Allen screws plus the usual studs attaching it to the front of the block. The distributor and Lucas fuel metering unit are attached to a bracket bolted to the rear of the case; the dual-outlet water pump is spigotted in the front section. The pump body carries a Romet-type water seal and a lip-type oil seal; leakage from either can escape through drain holes to the outside. If this occurs, either seal can be replaced in a matter of minutes simply by removal of the pump. As mentioned, the impeller is a slide fit on a parallel shaft, driven by a square-section key, so no special tools are required to withdraw the impeller.

If the timing case is to be removed (for instance, when changing a camshaft), the entire assembly, including water pump and distributor, can be withdrawn after removing the oil pump and the crankshaft nose setscrew, which clamps the oil-slinger ring, the pump drive pinion and the primary chain sprocket endwise. These three components are a slide fit on the shaft and are driven by one long key, so that the entire case can be replaced without disturbing the timing. For experimental purposes, timing variations can be made to both shafts simultaneously by removing the water pump and the inner jackshaft nut and then operating the master vernier, which changes the timing in steps of 2½° with respect to the crankshaft, so that it is always possible to get within plus or minus 1¼° of the desired valve timing.

So far no crankshaft damper has been employed, although there is provision for one on a boss which at present carries only a 22-tooth sprocket for the cog belt which drives the Lucas alternator. Mounted on an integral bracket on the left side of the timing case, the alternator has encapsulated stator windings to guard against failure from vibration.

In the original design, a Bosch double-breaker distributor was fitted and the fuel metering unit was driven by a cog belt from the rear of the left camshaft. Both of the components just fit in the space behind the heads. However, this was al-

Big valves (1.625-in. intake, 1.375 exhaust) are inclined at 10° in shallow wedge-shape combustion chamber.

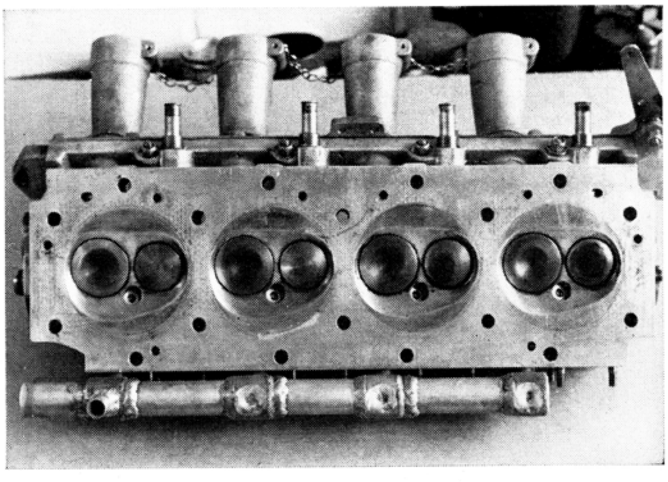
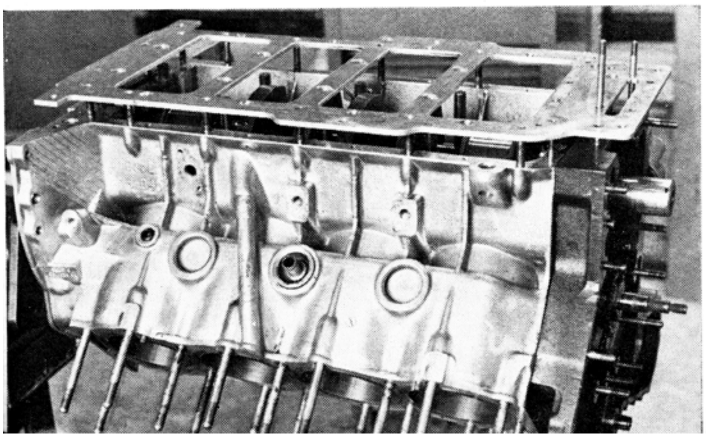
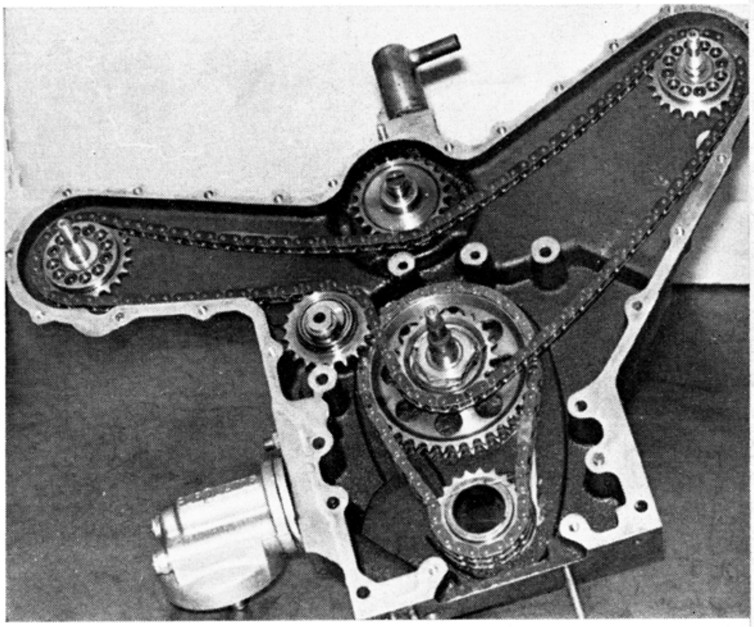


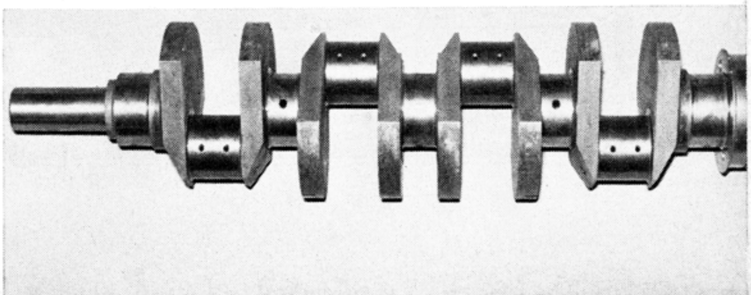
Plate is bolted to bottom of aluminum Olds block to add the stiffness required to handle greatly increased power.



Single overhead cam on each bank is driven by single secondary chain. Chain damping devices are not shown.



Single-plane billet crankshaft with 2.3-in. main and 2.0-in. rod bearings is simple to manufacture and extremely stiff.



BRABHAM: REPCO V-8 ENGINE

tered by using a Lucas OPUS distributor mounted almost vertically and driven by spiral gears from a shaft which also drives the metering unit by a vernier-type coupling. This simplifies the control rod system and leaves the left camshaft free to drive an auxiliary fuel pump (not yet used). The throttle slides described previously are connected by bell-cranks and a cross-rod; since they slide in opposite directions the inertia loads at varying speeds are balanced.

The design of the engine was completed in six months. During this period the major patterns were made in London and the castings placed on order. Meanwhile, in Melbourne, Hallam obtained the Oldsmobile blocks and organized the making of pistons, rings, liners and bearings in the Repco factories. Irving returned to Australia early in November; the first engine was running by March 1965, largely through the efforts of P. Holinger, another Repco man, who carried out most of the machining with help from the staff of the engine laboratory. The first 2.5-liter engine had four vertical 4C IDM Weber carburetors, which proved too large and too long, but after a bit of work Repco obtained 235 bhp at 8200 rpm, enough to beat any Climax 2.5-liter, on their dyno.

The opportunity to build a 3-liter for the South African Grand Prix on January 1, 1966 (and subsequent Championship events!) was met by using the same heads and valve sizes, the original 3.5-in. bores and the 2.375-in. throw crankshaft. Lucas fuel injection was also fitted. Because of the short time available and the long distances involved in getting the engine to England for installation in the car and then to South Africa, Repco only had time for six hours running before the race. Had the fuel metering unit not failed, the Brabham-Repco would have won the race easily. At that point the 3-liter engine gave about 280 bhp at 7500 rpm but would run to 8500.

The next step was to convert the 2.5-liter engine to fuel injection; this did not increase the maximum output but gave a more favorable power curve. In the Tasman race at Sandown in February, this engine in the Brabham broke the lap record previously held by Jack with a 2.7-liter Climax, and ran to 9000 rpm when required on certain parts of the circuit to avoid an extra gear change. The car retired from the race through failure of the proprietary sintered-iron gears in the pressure pump. Since then, all pump gears have been made from steel. In the next event at Longford in March the engine ran hot on one bank for some unexplained reason, but Brabham finished 3rd behind the BRMs, ahead of all the Climaxes.

Severe blow-by was one of the early troubles at high engine speeds; it appeared to be caused by lack of roundness of the thin cast-in liners. This was cured by boring them out and fitting dry gray-iron sleeves.

The bore/stroke ratio of the 3-liter version is more favorable than that of the 2.5-liter. In the smaller engine an 11:1 compression ratio was obtained only by squeezing everything to the limit; the engine gave the same power on almost any ratio between 9.5 and 11:1. In the 3-liter the intake valve size could be increased by 0.050 in. and the 11:1 compression ratio obtained without undue masking. Also, a small change in the intake port shape improved the torque, with 260 bhp available from 6000 to 8000 rpm and a peak of about 285 bhp at 7500 rpm. These figures have been exaggerated in the press, no doubt because of the excellent showing of the Brabham-Repco in Formula 1 races! Subsequent minor modifications have raised the power to just on 300 bhp, which is a good figure for a stock-block sohc 3-liter, and extremely competitive in a car weighing only 1219 lb, 150-300 lb lighter than its opposition.