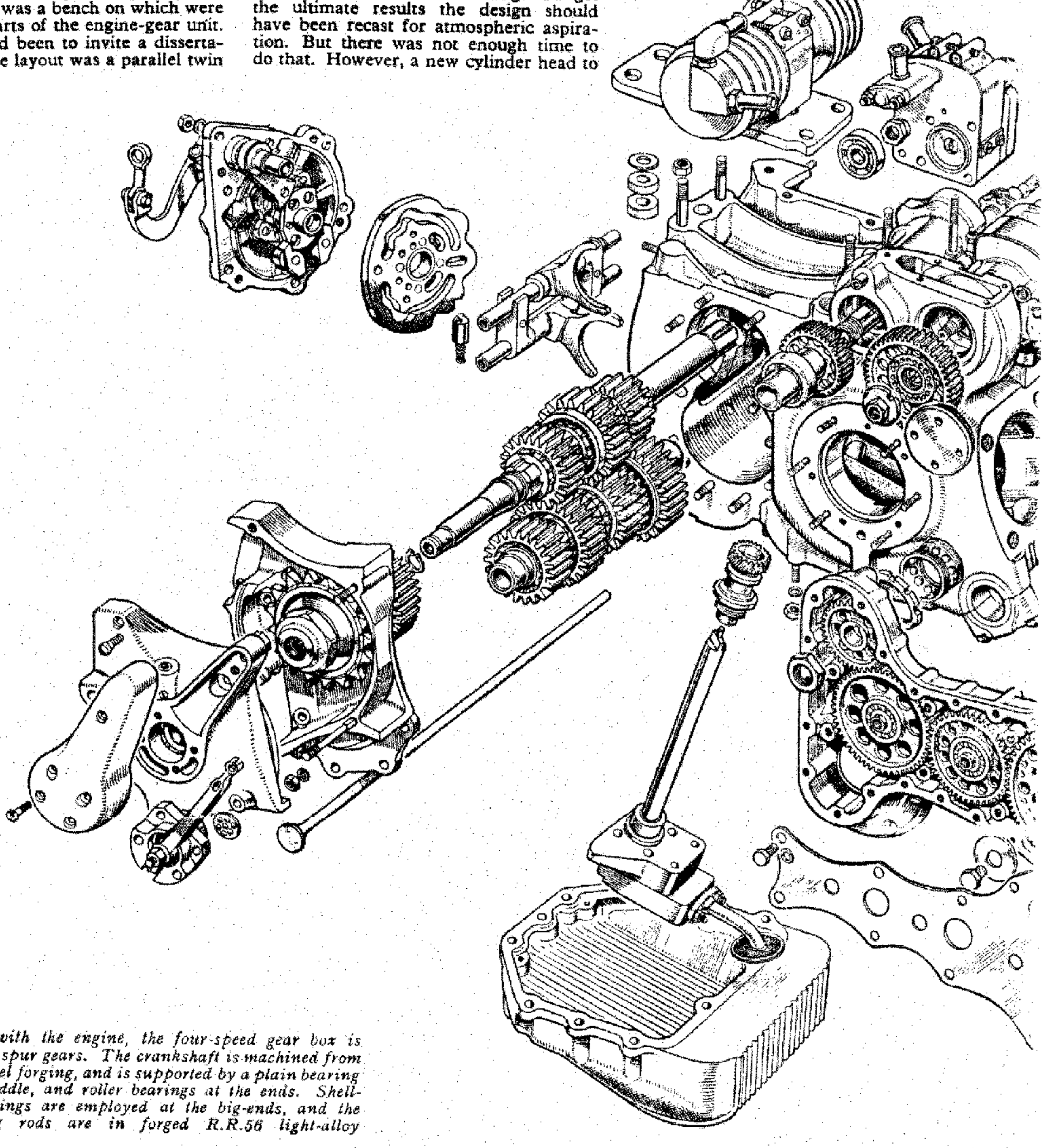
498 c.c. Racing Twin A.J.S.

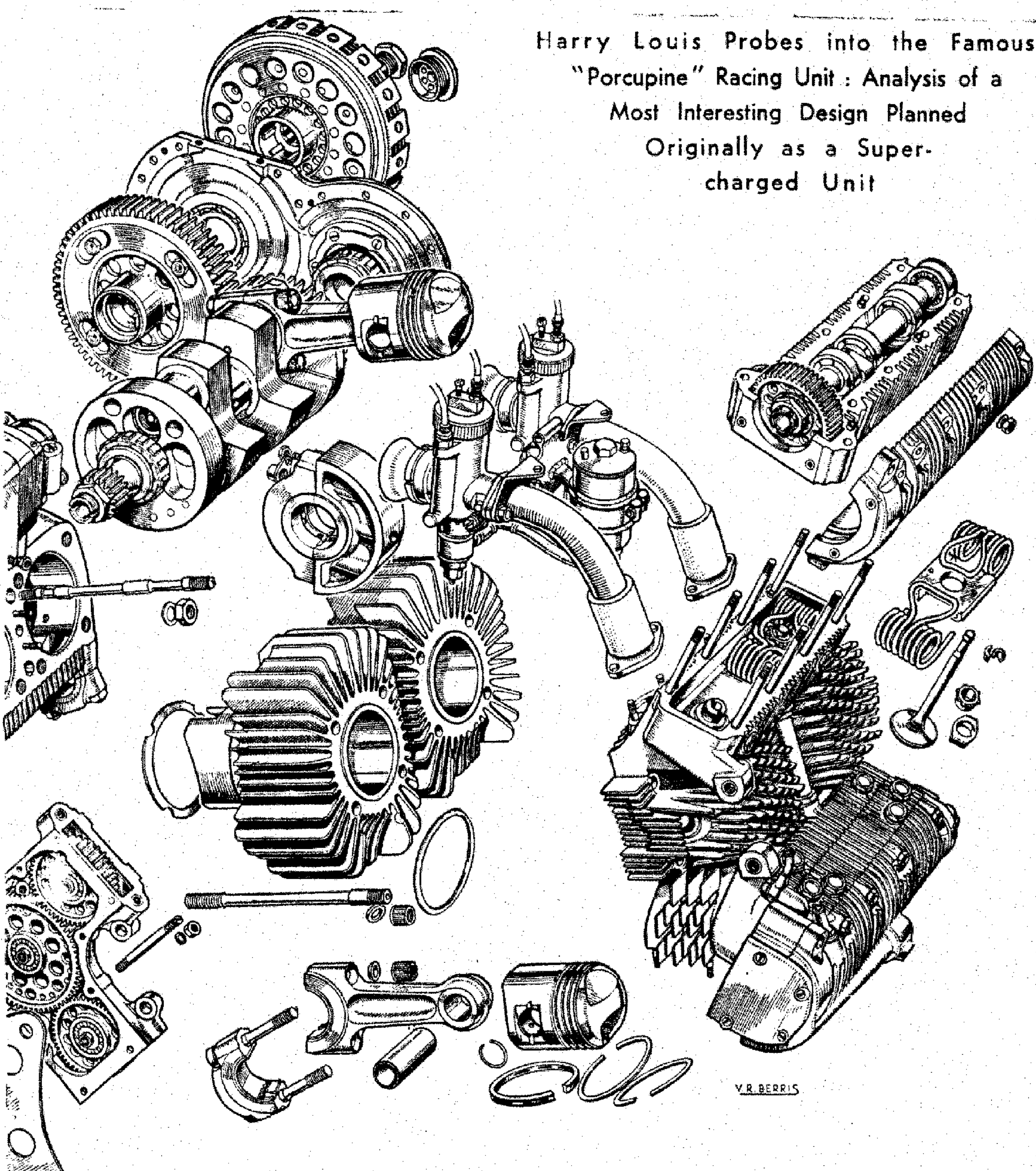
"IT must be remembered that this power unit was envisaged as a blown job," mused Jock West. We—that is Jock, the racing man and Associated Motor Cycles' sales manager, Matt Wright, chief of the racing department, and I—were standing beside the London Show model of the famous 498 c.c. double-camshaft A.J.S. "porcupine" twin. Nearby was a bench on which were lying all the parts of the engine-gear unit. My gambit had been to invite a dissertation on why the layout was a parallel twin with the cylinders set almost horizontal.

The musing continued. "The war was still cracking when the engine was roughed out mentally so to speak. With the war over, the design was laid down and a prototype made. Then in the autumn of 1946, came the F.I.C.M. decision that superchargers would be banned for international racing. To get the ultimate results the design should have been recast for atmospheric aspiration. But there was not enough time to do that. However, a new cylinder head to



In unit with the engine, the four-speed gear box is driven by spur gears. The crankshaft is machined from a solid steel forging, and is supported by a plain bearing at the middle, and roller bearings at the ends. Shell-type bearings are employed at the big-ends, and the connecting rods are in forged R.R.56 light-alloy

Harry Louis Probes into the Famous "Porcupine" Racing Unit : Analysis of a Most Interesting Design Planned Originally as a Supercharged Unit



Twin camshafts are driven by a train of spur gears. Each hollow camshaft is supported by five roller bearings and there is a pressure oil feed through jets on to the flanks of the cams. The light-alloy cylinder head casting has formed with it the valve-spring wells. Spike finning is used for the forward-facing cylinder heads give higher compression ratios was essential.

"Two main problems arise when supercharging is envisaged—accommodating the power unit in the frame and cooling the cylinder heads. A.M.C. had had considerable experience with supercharged fours—remember the pre-war 'octopus' vee-four?—and knew that, for air-cooling, the cylinder heads must have first call on all the air that's going.

"A supercharged parallel four with the crankshaft across the frame on the lines of the Gilera might be successful if air-cooled. But if the width of the engine is to be kept within reasonable dimensions, the valve-gear, cylinder head hemispheres and cylinder bores might be too crowded for adequate cooling. Remember that the pre-war blown Gilera parallel four was liquid-cooled. Now that the Gilera four is normally aspirated it is air-cooled.

Best Compromise

"So, the best compromise seemed to be a twin. And almost the best way of air-cooling the cylinder heads is to face them forward; another good point is that the weight is kept well down in the frame and the centre of gravity of the machine is thus very low, which is half the battle of good handling."

"Wouldn't a horizontally opposed twin layout with crankshaft in line with the frame give better cylinder head and cylinder cooling for supercharging?" I suggested.

"Possibly yes," replied Matt Wright, "but it is doubtful whether the weight could be got so low down as with the parallel twin, and in any case the weight would be less concentrated. It would not be 'in' the frame."

"Unit construction of engine and gear box is employed. Got any talking points on that?" I inquired.

"Oh, yes," said Jock. "With the engine lying down there's ample space for a sturdy gear box, but not for the usual gap between separate units for engine and gear box. Hence our crankcase casting embraces the gear-box shell. But the gear box is self-contained and independently lubricated."

"Gear drive between crankshaft and gear-box mainshaft, I note. The engine runs backward presumably?" was my next query. "Yes, it does," answered Matt Wright, "and gear drive is the obvious choice. The crankcase cum gear-box casting gives fixed centres apart from the expansion under heat of the Elektron, which is of no consequence from the point of view of efficiency. A chain drive would not theoretically be less efficient, but there would have to be some form of slipper adjustment which might well put the chain drive at a disadvantage. The $\frac{3}{8}$in width spur gears are, of course, fully enclosed and run under ideal, fully lubricated, conditions."

"The difference in diameters between crankshaft and gear-box mainshaft gears is not very great," I observed. "Obviously the clutch runs at fairly rapid r.p.m. Does the high inertia ever give any bother, are there any worries with overheating due to heat transference from the crankcase, and is it not difficult to obtain the necessary overall gearing reductions by means of the gear box and rear sprockets?"

"Well," said Jock, "there was in the early stages a headache or two as a result of the clutch friction material being deformed by centrifugal force; new-type friction plates cured that. As you see, the clutch unit is remote from the gear-drive chest and well out in the air stream, so there are no overheating troubles. Answer to the final point is that we do get enough reduction by way of the gear box and rear sprockets. It is a fact, however, that the large rear sprocket approaches the maximum size permissible to avoid overstressing the chain due to 'fling.' We are within the safety limit and rear chains give good service and no trouble. But if we went up much on the diameter of the rear sprocket and used the top speeds of the bicycle, chains would be a problem."

"Now what other external features arouse queries?" I muttered. "Ah—perhaps you would run over the advantages of double overhead camshafts with spur-pinion drive."

"The best way to get the valves to follow the cam contours accurately at high revs is to keep the weight of the components operated by the cams as low as possible," said Matt. Then Jock West continued, "The weight of either an exhaust valve or an inlet valve and its tappet is approximately 100 grammes, which for an engine of this type is pretty low. On the point of the drive, the answer is that no form of gearing results in less friction than spur pinions. This method of drive is, incidentally, rather ruled out for production racing engines intended for private owners because of the difficulty of obtaining compression ratio changes.

"It might also be noted that double overhead camshafts are more or less impracticable on production engines because it is difficult to provide a means of reasonably rapid tappet clearance adjustment. On this 'porcupine' job every adjustment means removing a camshaft box, inserting or removing a shim behind the contact pad in the tappet, refitting the cambox, checking the clearance and, if necessary, starting all over again!"

"Spike finning," I observed, "is the obvious choice for the forward-facing cylinder head and the maximum cooling area for a given depth and pitch of fins is clearly achieved. Any snags involved?"

"No," replied Jock, "not if we have in mind only a 'few off' racing jobs. But, again, spike finning would be unattractive for production in any quantity. Casting is difficult and demands great care, and the spikes are very vulnerable; it is the easiest thing in the world to chip off a spike or two inadvertently when the head is being removed or is on the bench for attention."

We walked over to the bench where there was, in fact, a dismantled cylinder head and all the other major components that make up the racing power unit. "Elektron crankcase, gear case, and covers," I mentioned. "Yes," said Matt, "Greatest strength-to-weight ratio among the suitable materials available."

As I picked up the crankshaft, Jock gave a running commentary on its features. "Forged steel and machined from a solid billet. Nitrided journals for the plain indium-flash, shell bearings at the big-ends and at the middle. Caged roller bearings for the outer mai[illegible] crankcase. The middle bearin[illegible] diameter and 1¼in wide, is [illegible] locates the crankshaft laterally. [illegible] is immensely rigid, and experience [illegible] shown that the middle bearing is only lightly stressed."

West continued. "[illegible] carefully balanced, of [illegible] setting of the balance ratio is obtained by means of those three holes in the periphery of each bob-weight between the middle main bearing and the big-end bearings. Each hole behind its sealing Allen screw plug has detachable weights. In practice, the very best results are obtained by varying the balance ratio to suit the engine when it is bolted in the frame, notwithstanding apparently identical engines and frames. The balance alterations can be made quickly by removing the crankcase sump when the bob-weight Allen screws are exposed."

Plain bearings of similar type to that which supports the middle of the crankshaft are employed at its big-ends. Diameter is $\frac{1}{16}$in and width is $\frac{3}{4}$in. Connecting rods are in forged R.R.56 light-alloy and, at the small ends, operate direct on the gudgeon pins. The nuts for the big-end cap clamping bolts are splined on the outside to take a special key. "Why?" I inquired.

Smaller Cutaway

"The key is just as effective for tightening or loosening the nuts as a socket spanner on a hexagon," replied Matt Wright. "The advantage is that the outside diameter of the splined nut can be smaller for a given strength factor than a hexagon. Hence a smaller cutaway is necessary in the con-rod to accommodate the nut."

The Hepolite forged aluminium-alloy pistons have a full skirt, are domed, and provided with valve clearance flats. Each piston carries two $\frac{1}{16}$in wide compression rings with straight-side gaps and one slotted scraper ring. Gudgeon pins are in case-hardening steel, measure $\frac{7}{8}$in in diameter, and are taper ground internally. Round-wire circlips are employed.

A rectangular sump is bolted to the base of the crankcase. This sump is ribbed externally *and* internally to assist cooling of the oil. Cylinders are separate. Each cylinder is an aluminium-alloy casting with a shrunk-in iron liner which protrudes at the base and is sunk in the mouth of the crankcase for 1¾in of its length. There are cutaways to clear the connecting rod. Finning is longitudinal and is 2in deep at front and back (or, rather, top and bottom with the horizontal cylinder layout), but is shallower at the sides.

The cylinder head is a one-piece light-alloy casting, which includes the two hemispheres for the combustion chambers, and includes the valve-spring wells —one for the inlets and one for the exhausts. Inlet-valve seatings are austenitic iron and the exhausts are bronze; they are all shrunk in.

"That cylinder head casting is a magnificent piece of work," said Jock West. "Spike finning at the top of the head gives the greatest possible surface area and is especially suitable for facing for- [illegible] the air stream. There is a ground joint between the tops of the spigots and the recesses in the head."

Exhaust valves are of the sodium-filled type, in K.E.965 steel, and have $\frac{7}{16}$in diameter stems. Inlet valves in the same material (but not sodium-cooled) are $\frac{1}{8}$in less in diameter at the stem, but are wider across the head. The bronze valve guides are a press fit in the head, and locate the valve-spring base plates. Valve springs are of the duplex, overlapping hairpin type and exert 100 lb pressure with the valve on its seat. Split collets retain a collar around each valve stem. This collar has a deeply serrated periphery, and the eight male serrations bear on another collar in which the overlapping ends of the valve springs seat; this arrangement allows the valve to turn. "This turning of the valve results in a lower mean operating temperature," explained Matt Wright.

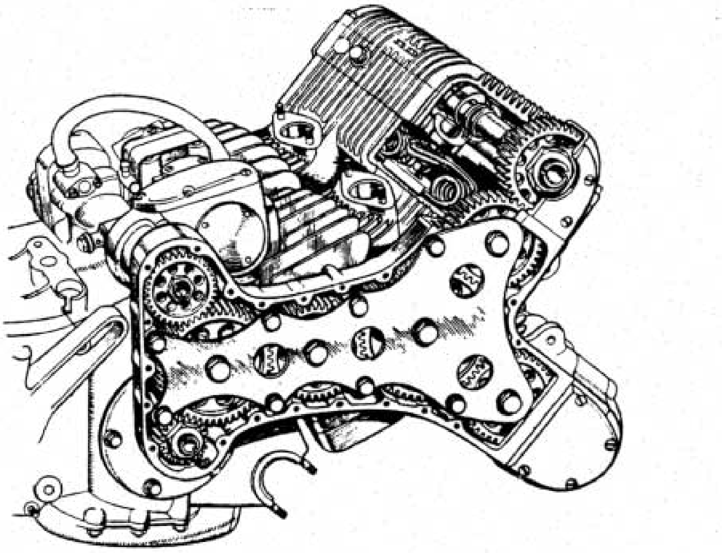
To each valve-spring well is bolted an Elektron cam box. Mounted in five 1in diameter roller bearings with split Duralumin cages, the camshaft is turned from a solid forging in case-hardening mild steel. The shaft is hollow, and its weight is only 12 oz. "To keep this shaft rigid it is necessary to support it with five bearings," explained Jock. "To reduce the number of bearings would make it necessary to have a heavier shaft, which means higher inertia and a greater load on the driving gears—a matter of some importance."

Operating in Duralumin guides, the tappets are hollow and are specially designed for light weight. The tappets carry pressed-in, hardened contact pads, and clearance between a pad and the valve-stem is adjusted by shims under the head of the pad. The head is threaded externally to take an extractor. Clearance is measured with a gauge inserted through a hole (fitted, of course, with a detachable cap) in the wall of the cam box. Adjustment of the mesh of the driving gears is obtained by shim gaskets between the face of a cam box and the appropriate face on the cylinder head.

Camshafts' Drive

There are, in all, eight $\frac{1}{4}$in-wide spur pinions in the drive to the two camshafts. First, there is the half-time pinion on the crankshaft, then two intermediate pinions, then a larger pinion where the drive branches to the two camshafts. Meshing with this large pinion is, for each camshaft, an intermediate pinion driving the pinion on the shaft. Pinions have roller bearings which operate on spindles held by the back half of the Elektron gear cover and an outrigger support plate. Each pinion is statically balanced.

The intermediate pinion meshing with the crankshaft half-time pinion also drives yet another pinion—the one on the pump shaft. This pump is of the duplex gear type and of high capacity; it passes 45 gallons an hour at 7,000 crankshaft r.p.m. The main supply is through a Tecalemit fabric filter, thence to the middle main bearing. At the bearing, the oil enters the crankshaft and emerges through the big-end journals.



An outrigger plate supports the spindles of the camshaft drive pinions. The gear meshing with the crankshaft half-time pinion also drives the duplex gear oil pump and magneto

Pistons and small-end bearings are lubricated by oil flung out from the big-ends. At the drive end of the crankshaft is a ported crankcase breather.

In the crankcase sump is a scavenge pump driven by a shaft and skew gear on the supply-pump shaft. This gear pump picks up the oil which drains down into the sump and returns it to the tank.

The secondary supply from the duplex-feed pump forces oil to the cam boxes. In each cam box housing is a gallery from which, through detachable jets, the oil impinges on the flanks of the cams. A vertical tube drains the oil from the upper (inlet) cam box to the lower (exhaust) cam box, from where a scavenge pump at the end of the camshaft forces the oil back to the tank. However, in the external return pipe is a banjo union above the gear box, and a by-pass with an adjuster from this union leads a supply of oil, by means of a nozzle, into an annular groove at the back of the teeth of the gear box sprocket. From this groove oil flows outward under centrifugal force through holes with outlets in the hollows between the teeth, and so lubricates the chain. "This semi-positive lubrication of the rear chain works so well," mentioned Matt Wright, "that chain adjustment is rarely necessary."

The magneto is mounted just in front of the oil-pump and is driven by a pinion on the pump shaft.

Transmission from crankshaft to gear box mainshaft is by means of $\frac{3}{4}$in wide spur gears giving a reduction of about 0.7. The gears are enclosed and lubricated; in fact, the gear cover carries the drive-side main bearing. Jock West then did some talking. "The gear box mainshaft gear has an integral shock-absorber which takes the form of curved coil springs interposed between a centre spider and the gear body. This device is a comparatively new addition, as originally the design did not include a transmission shock-absorber.

"The clutch case is machined from solid forged steel. There are 20 grooves to take the tongues of the driving plates, and 24 in the centre unit for the tongues of the driven plates. This high number of contact tongues spreads the heavy torque loading."

Six springs, by means of deep thimbles in the orthodox manner, bear on the light-alloy outer plate, which is freely drilled for further lightness. The operating thrust rod passes through the gear-box mainshaft and has a head bearing on a ball thrust race at the operating lever end.

"Yes, the gear box is more or less orthodox in design," continued West, "except for the fact that the rear-drive sprocket is on the right-hand side, and roller bearings are employed fairly freely. For example, the layshaft has caged roller bearings at both ends; $\frac{7}{16} \times \frac{1}{4}$in rollers support the mainshaft in the top-gear sleeve; needle rollers are employed for those pinions free to rotate on their shafts.

"To give rapid gear changes, alternate dogs are cut back at the ends. Gears are selected by a normal, double pawl, positive stop, foot-change mechanism."

My parting shot was definitely fishing, I know, but it had to come. "I see the top of the gear-box casing is cradle-shape. Obviously that cradle was intended to house a supercharger driven from the gear-box mainshaft gear. Wouldn't it be fun to clamp a blower on and have a crack at a few more track records—you know, those that are pretty well impossible with an 'atmospheric' engine?"

"Yep, it would be fun all right," agreed Matt. "But they tell me there's a T.T. in June . . . ."