

OS Max 21 FSRc

by Mike Billinton

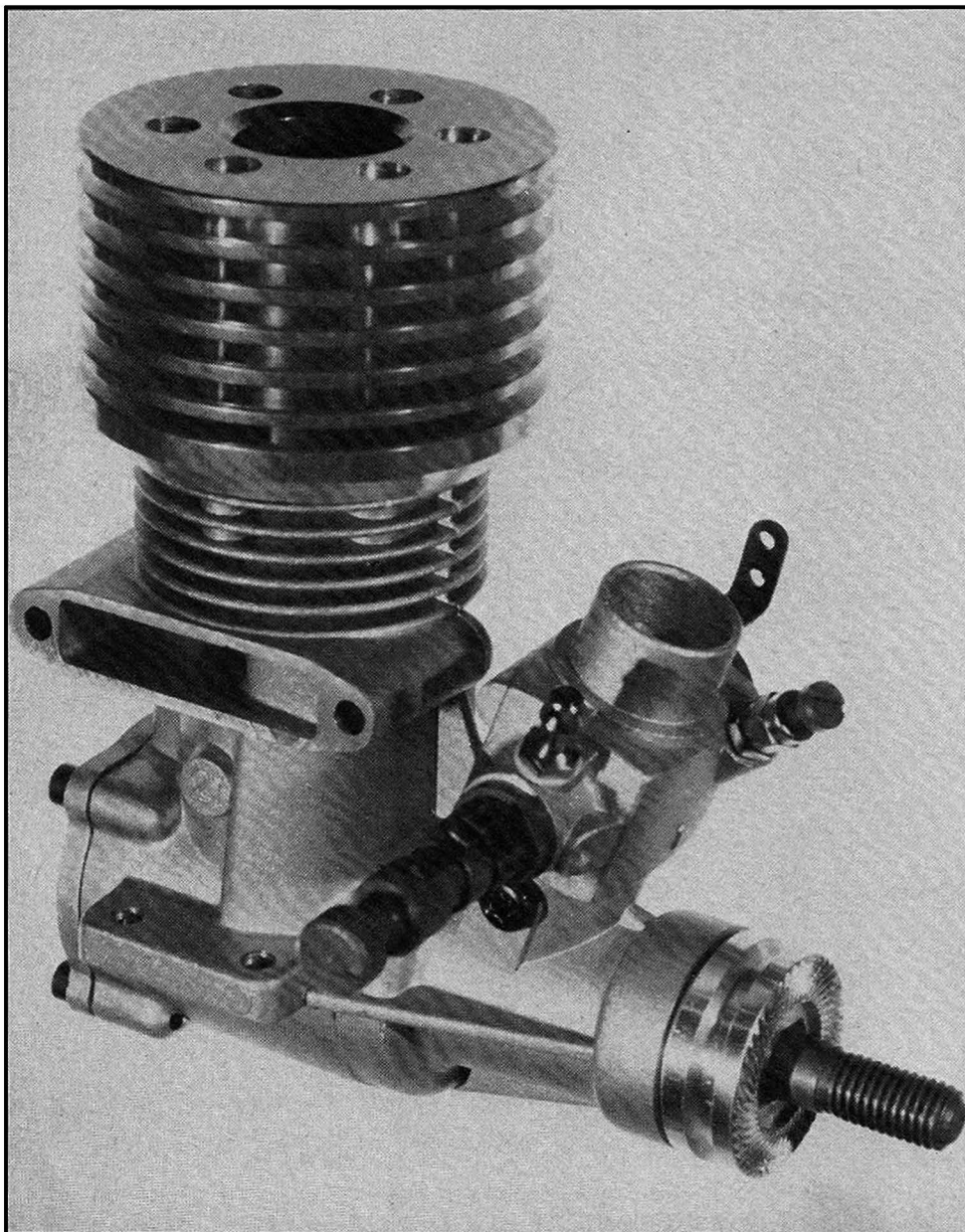
OS Max enters the R/C car scene with a high r.p.m., Schnuerle ported gem. It's a hot one.

Rleased in 1978 in steel liner form and last year provided with an ABN piston/liner, this engine lies in the top competition bracket for open class circuit use. As such it is a fairly specialized piece of machinery designed to give out more power and rpm's than is usual for standard sports motors in this capacity range. It should be judged accordingly be-

cause this class inhabits a rather separate area of the model I/C engine world. There are several reasons for this, none fortunately affecting the normal power testing procedures.

1. Unlike the marine and aero sectors, most development work and competition activity in cars is currently concentrated on only one engine size, the 3½ cc.
2. Single cars, so far being the norm, have

PHOTOGRAPHY: MIKE BILLINTON



placed a stringent requirement on an unusually wide band-width of useable power.

3. The pursuit of this wide flexibility, together with more hp has led to provision of alternative carburetors by specialist producers. And, these, plus, the virtually essential air filters for the unique ground-level operation, the specialist clutch assemblies and silencers (tuned or otherwise), are thus areas of accessory provision which are sometimes not catered for by the engine manufacturers.

The unique problems of the car class have attracted most of the world's top engine producers with units from OPS, S. Tigre, K&B, Webra, Pico, and this test subject, the O.S. The internationally competitive nature of this area is therefore clear, and surprisingly intensive considering the narrow area of interest that one major capacity class would suggest. From a tester's point of view, the actual variety that does exist makes the final choices of which Carb/silencer/fuel combinations to use somewhat more difficult than normal. It's as well other possible car areas such as drag racing, hill climbing or scrambling are not receiving such interest at present. Otherwise, the number of different types of engine and accessory combinations would well exceed the known profusion of such in the aero or marine fields.

However, one at a time—here is the latest OS 21 in the car format.

Mechanicals

The basic layout largely retains the current norm for racing engines: Single schnuerle 4-port cylinder, over-square, 2-stroke, ABN, with a ringless piston. The main exception is the use of front induction. This provides more convenient installation in the car chassis apart from which it is more likely to provide the longer-term reliability at very high r.p.m.

Crankcase

The crankcase is made of rigid one-piece aluminum alloy accommodating an unusual pinned liner which is axially rotated by 30° (clockwise viewed from the cylinder head, and as compared with the usual side exhaust position). The exhaust port consequently fires out diagonally backwards. The main purpose of this exercise is however centered on the gudgeon pin. The fact that this part normally requires retaining rings to prevent port intrusion and firm plugging to prevent gas leakage from boost to exhaust port, all lead to the idea that the pin shall only be allowed to traverse portless sections of the cylinder liner. Leakage can occur in any case with the onset of wear in the gudgeon pin bearing holes in the piston. One simple geometric act leading to both improved volume efficiency and less production work, is that the bottom of all three transfer passages are in a less constricted area of the crankcase by comparison with the 90° side exhaust

An interesting feature is the small groove in the crankshaft bore, connecting the front

The OS 21FSR-C is seen here with the one-piece head and small bore OS carburetor. Note the diagonal exhaust port opening. It's a brute!

bearing with base of the induction hose. The effect of this to allow sub-atmospheric pressure to suck excess fuel/oil back into the induction system and away from the front bearing where, even though shielded, this mixture would escape at high r.p.m. and thus ruin fuel economy.

Liner

The new OS method of brass core with subsequent nickel coating is in use here. This surface, being too soft for the purpose is allowed to absorb a micro-fine suspension of silicon carbide particles during the coating. This Nickasil process thus provides the required hardness. All final dimensioning (such as the two thousandths taper on the bore and final honing) is done before the coating. Because this is a non-distorting process with none of the build-up at the ports common with electro-plating methods, it makes no meaningful change in the dimensional accuracy. It is impractical to undertake any subsequent honing because of the coating's three micron thickness. Exhaust timing is an unusually high 170°—for a motor which has no specific tuned-pipe use in view. This looks, therefore, to have a definite connection with the ultra-high r.p.m. expected.

Piston

The piston has a high silicon content (24 percent) casting with pin bosses extending to the crown. The top edge of the piston is very slightly rounded by a special "tumbling" process to prevent snagging at the port openings, at the exhaust side. An unusual commercial practice but very worthwhile.

Crankshaft

This part is of case-hardened chrome-molybdenum steel and is "borrowed" from the OS 25. Contrary to much racing engine practice, it has an unshrouded crankweb. Manufacturers economies can play a part in such decisions, particularly if the gain is marginal, as the OS feel is sometimes the case as here. A simple and effective method of torque transmission is used: Two ground flats on the shaft ahead of front bearing fit into a matching broached slot in the flywheel (or propeller) driver, and seems as efficient as many others. Strangely there seems no consensus exists as to the best method for power transmission. The user no sooner works out all the ramifications of end clearances, crank-float, and rotational accuracy for one type of driver, than one is confronted with an entirely different set-up requiring quite separate treatment.

Cylinder head

The cylinder head is a massive one piece "head sink" affair of aluminum alloy and this is increasingly finding favour. The earlier compromise solution (of Aero. head and heat-sink extension clamped thereto) cannot quite equal the conductive efficiency of the one-piece head because of likely inferior heat path X-sections. However this is a relative

matter and they both work.

In this test, the one-piece only was used and arrival of optimum heat balance was sometimes a lengthy process. It lasted a minute or more, but this was right for the sometimes lengthy circuit races. Strictly speaking it's misleading to use the words "heat-sink" as though they apply only to car engines.

Of course all thermally conducting materials in I/C engines are heat sinks. Even the most skimpy cylinder head is such. So what is really at issue is the total surface area (mainly of cylinder and head) exposed to the cars relatively limited airstream. Sensible thermal equilibrium demands that this area must vary according to total airflow. This OS head works very effectively on tests in which air flow is kept quite low at all times.

Connecting rod

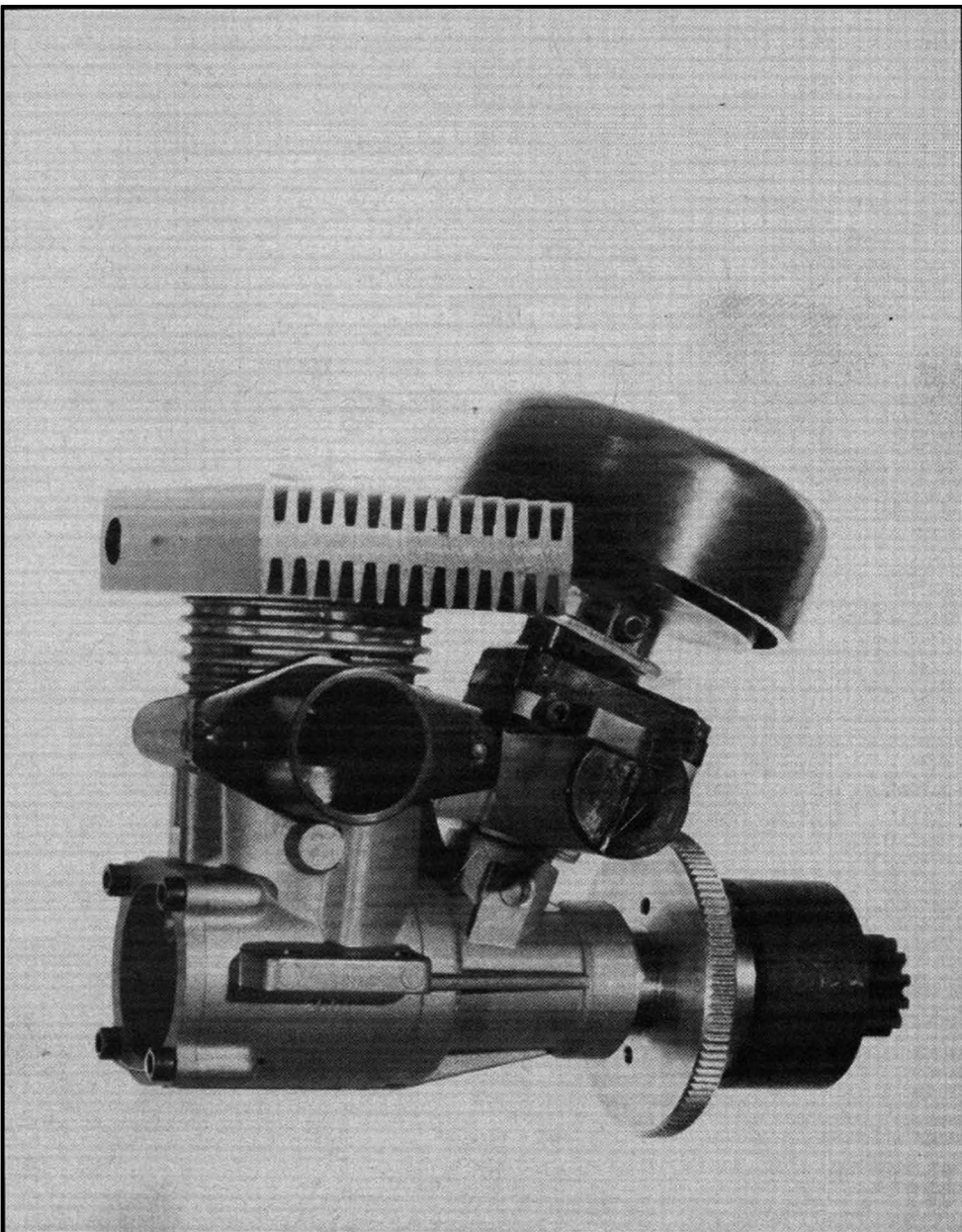
The connecting rod is made with 2024H aluminum alloy and is bronze bushed at either end. Two lubrication holes at the big-end are provided, and if the bush rotates

within the rod end, (so cutting off oil supply) problems will then occur. Long hours of running hard lead to this condition in many makes and styles of engine and it is a peculiarly intractable problem. This becomes the subject of much attention amongst top competitors in this field.

Standards of workmanship of all parts is high, with linear/piston being perhaps the highlight.

Car engine considerations

The particular operating conditions of the typical open class, circuit car leads to engine tests having points of interest differing from the Aero engine norm. Prior to comment on the test findings, it may be useful to expand on these. Firstly, there is a frequently expressed view that these 3.5 cc motors realize their max BHP at 28K r.p.m. plus. (Existent track times set against gear ratios being quoted as an indication.) Assuming neither wheel-slip nor tire-growth are factors, then this figure is high when compared to the "going rate" for peak BHP points for silencer



A different look. The engine is shown fitted with UK's PB air-filter, slide carb and clutch assembly. Heat sink a must for enclosed engines.

equipped engines. It seems more likely that the top performers are effectively widening the available power band by deliberately under-gearing (which is a method of preceeding in both boat and aircraft top performance areas).

The extreme lengths to which this is carried in the car sector demands though, two specific points for success: Engines which can carry on revving well beyond their natural maximum BHP point; plus circuits which are possibly too short for the sort of power outputs the open class motors are reading. Operating just over the peak BHP point is based on the fact that if the motor slows slightly for any reason it then finds itself right at the tip of the BHP curve, from which there can be little excuse for non-recovery to original speed. Operation of the engine on, or just short of the peak has quite differing effects if the motor slows. Recovery is bound to be longer due to loss of power. To a large extent the car's exaggerated use of this concept is the consequence of the single-gear problem (which the slipping clutch only partially overcomes). The use of automatic clutches or multi-gear boxes would radically alter this mode of operation. In the meantime this is the way they're working and the reality is even harsher, with some reports of final

r.p.m.s (at end of straights) in the 35K area. If these figures are correct, then the question arises: how can operation at that r.p.m. (and say around 60 mph) be feasible when power usually falls off so alarmingly at high r.p.m.?

Well, one is back to this problem of gearing: If the single gear ratio is such that low speed acceleration is acceptable, then the arrival at maximum BHP point (say 23,000 r.p.m. and 45 mph) finds a large excess of BHP over that required to propel the car at that point because of the combined loads of rolling resistance and air drag are still low even at that point. There is consequently continual acceleration beyond this speed, even though the power is now dropping. But it's still higher than that required for those opposing loads for some considerable way further up the r.p.m. scale. In fact, equality is only finally reached following such large overrevving that the resultant BHP finally drops to maybe only half of maximum value. So, now it is enough to just balance the loads.

This brings one to the other peculiarity of the car scene, the profoundly different drag patterns as between model cars and the other two sectors of boats and aircraft. As presently operated, the model car rarely meets the aerodynamic resistance implied by air speeds over 10 mph, nor does it suffer the large surface friction boats undergo even at very low speeds. Hence, until car tracks become longer the car is continually operating in relatively low drag situations and therefore it, uniquely, can operate in the manner described. This has led to the development of engines capable of revving as is required. At the time of this writing much of the foregoing is speculative and so the test results are awaited. It is hoped to prove (a) The OS 21 can rev to these bizarre r.p.m. and (b) That the resultant torque is minuscule with resultant BHP no more than 1/2 maximum value.

Power

Four differing modes of operation were undertaken to cover two commonly used silencer combinations (dashed lines on the

graph) and two "academic" open exhaust set-ups (solid lines). Synthetic oil (UK's ML70) at 15 percent concentration was used throughout. (The use of low percentage oils of this type is now common in the car operations considered here, with some drifting even to below 10 percent occasion.) A thorough oil test series by David Gierke (*Model Airplane News* May, 1974) concluded that around 14 percent oil was an optimum for best hp with minimum heat problems. But, that presupposed firm control over mixture settings. Any over-leaness brought trouble, hence the safety factor implicit in the higher percentage of 20 or more. Even when over-lean, there was hopefully enough oil at least still getting through the needle-valve. This area was worth an article on its own; there were dangers in going too low (with not much gain anyway). The OS advice with each engine was instructive on this point.

Taylor L/R two volt glow-plugs were used in all the 70 separate runs with only two blown during the whole test period. The main problem was the delicate task of getting plugs in and out of the very deep recess in the cylinder head. Modeller's cars can be turned upside down to assist—the 500 pound dyno cannot.

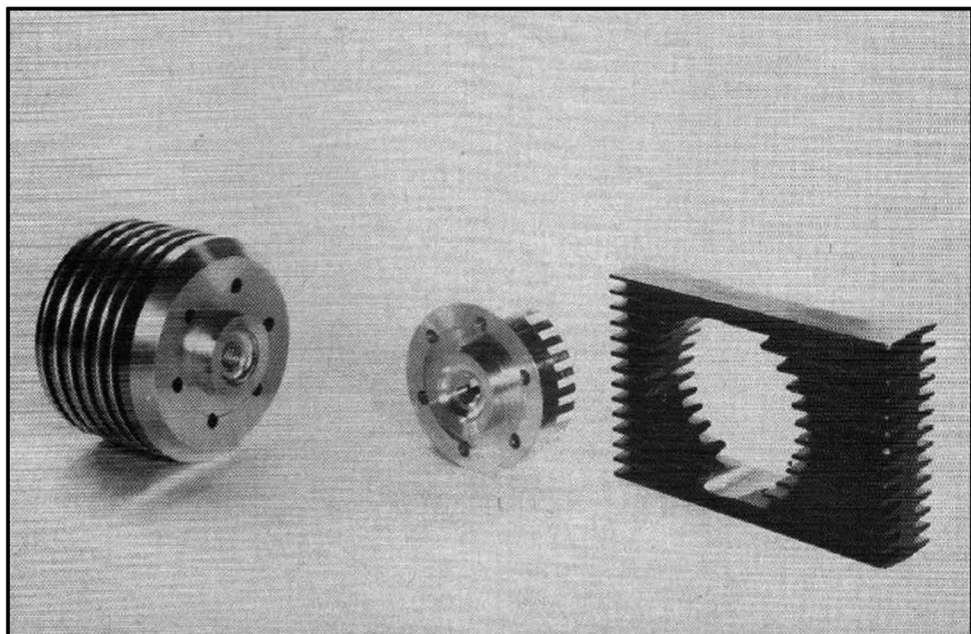
Atmospheric correction factors to BHP were very small throughout the test and so were ignored.

Test 1. The basic parameters of five percent nitro with open exhaust and standard R/C carburetor (OS 2CA 7mm dia.) saw maximum torque being reached at a quite high 17K. The resulting BHP made the OS 21 one of the clear front-runners in its class. The effect of the smallish carburetor though was to put an end to effective operations past 24 thousand r.p.m.

Test 2. The second "academic" test (to obtain a maximum open exhaust power figure) used 50 percent nitro with a PB racing products slide carburetor (10mm dia.). Whilst a moderate uplift for the nitro was noted, the major difference was the much improved breathing beyond 24K.



The diagonal exhaust port is in view here, with the two main side transfer ports just visible (above). Boost passage is diagonally opposite the exhaust port. These are the two types of cylinder heads and the special heat sink (right).



Test 3. A standard non-demanding car set-up of five percent nitro with PB slide carburetor was used with a normal PB silencer (of 10.5 mm outlet dia.). These particular findings indicated the sense of car silencers being as large as they are. Their restrictive effect on power curves, as car users must have found out, was much less marked than with the typically smaller aeroplane type silencers. So much so was this, that the opposite derestricting effect of the large PB slide carburetor was still able to show through. So, some answers concerning these 35K reports began to appear. Torque dropped off as r.p.m. rose, but even at 31 thousand there was still enough of it to give just under

.4 BHP on five percent nitro.

In an enclosed space this seemed somewhat frantic, but the motor remained steadily and consistently running. However, at 31,500 r.p.m. after the many runs at maximum output over the extremely wide range from 6 to 31 thousandths, tightening of the big-end on the crankpin occurred. This was due to bush rotation. So no further move up the r.p.m. scale was possible. Replacement of the connecting rod at this point allowed the final move to potentially the most demanding test.

Test 4. This used 50 percent nitromethane with the PB slide carburetor together with a UK "AMPS" minipipe silencer; a top compe-

tion trio of power increasers. As can be seen, this combination finally enabled the engine to just exceed one BHP, with the minipipe part of the silencer causing this to occur (due to the resonance effects) at the higher speed of 26.5 K. The resonance (cycling) effects were clear also in the other parts of the torque curve. The major point of interest with this engine however, was the large r.p.m. increase possible (with each reduction of load) way past the maximum BHP point, with decline of torque being a considerably longer affair than common with many model engines. In fact, this long shallow decline provided the final evidence which had earlier been sought to account for the 4,000 r.p.m.

OS Max 21 FSR-C ABC Racing Car engine

Dimensions & Weights:
 Capacity—211 cu. in. (3.46 cc)
 Bore—.654" (16.6 mm)
 Stroke—.630" (16.0 mm)
 S/B ratio—.963/1
 Timing periods—Exhaust 170°
 Transfer 123°
 Boost 121°
 Induction: opens 38° ABDC; closes 60° ATDC; Total—202°

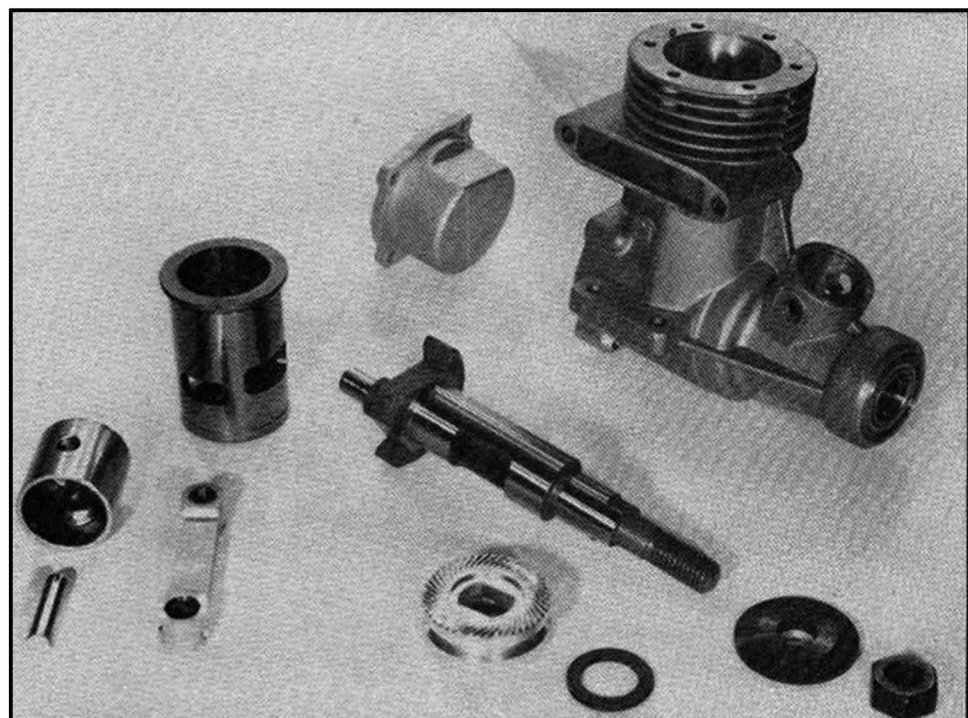
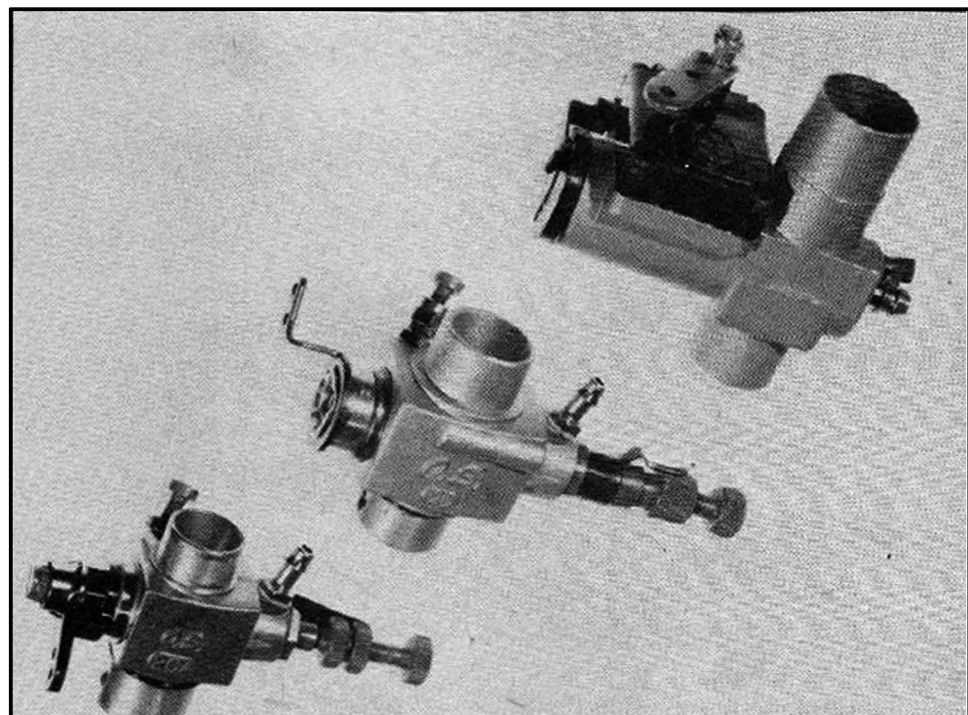
Combustion vol.—28 cc.
 Compression ratios—
 Theoretical 13.28/1
 Effective 8.63/1
 Ex. port height—.242"
 Cyl. head squish—.007"
 Squish band width—.10"
 Squish angle—10°
 Overall height—3.6" (with large head)
 Length—2.9"
 Width—1.75"
 Mounting hole spacing—1.5" x .6"
 Frontal area—4.76 sq. ins. (large head)
 Carb. bores—
 OS 2CA—.27" (7mm) (Standard equip.)
 PB Slide—.39" (10mm) (Specialist equip.)
 Crankpin dia.—.1968" (5mm)
 Mainshaft dia.—.472" (12mm)
 Induction bore—.341" (8.66mm)
 Rod thickness—.118" (3mm)
 Rod width—.258" (6.5mm)
 Gudgeon pin dia.—.157" (4mm)
 Weight—9.5 ozs. (incl. heat sink head @ 2.5 ozs.) (.27 kilos)

Performance:
 Max BHP 1.06 @ 26,600 rpm. (AMPS Tuned silencer/50% nitro/PB slide carb.)
 .87 @ 23,000 rpm. (Open Ex./50% nitro/PB slide carb.)
 .74 @ 22,000 rpm. (Open Ex./5% nitro/PS 2CA carb.)
 .66 @ 21,300 rpm. (PB silencer/5% nitro/PB slide carb.)
 Max Torque 48 oz. in @ 18,620 rpm. (Equipment as above.)
 43 oz. in @ 17,800 rpm. (Equipment as above.)
 37 oz. in @ 17,200 rpm. (Equipment as above.)
 34 oz. in @ 19,000 rpm. (Equipment as above.)

R.P.M. Standard propellers:
 8 x 6 Zinger—13,700 (Open ex./5% nitro/OS carb.)
 8 x 6 Zinger—14,200 (Open ex./5% nitro/PB slide carb.)
 7 x 4 Zinger—21,600 (Open ex./5% nitro/OS carb.)
 7 x 4 Zinger—22,730 (Open ex./5% nitro/PB slide carb.)
 7 x 4 Zinger—23,900 (AMPS tuned minipipe silencer/5% nitro/PB slide carb.)

Performance Equivalents:
 BHP/cu.in.—5.02
 BHP/cc—306
 Oz.in/cu.in.—227.5
 Oz.in/cc—13.8
 Gm.metre/cc—9.53
 BHP/lb.—1.79
 BHP/Kilo—3.9
 BHP/sq.in. frontal area—22

Manufacturer:
 O.S. Engines Mfg. Co. Ltd.
 6-15 3-chrome Imagawa
 Higashiumiyoshi-ku
 Osaka 546, Japan.



OS carburetors both small and large are pictured here along with a PB slide carb (above right). The PB unit uses a remote needle valve. The idle adjustment on the PB carb is accessible by removing the plastic cap on the left side of the body. These are the parts of the OS 21FSR-C (right). Note the unique thrust washer attachment.

OS Max 21 FSRc

The last power figure arrived at was the 5 BHP to 36,400 r.p.m. It would require a wind-tunnel and rolling friction tests to logically confirm whether that amount of hp would power a typical competition car at maximum speed. Broadly speaking though, it is clear that the surplus of power in the mid-range of 20 to 30K was used almost entirely to provide abnormally high rates of acceleration. Finally it was noteworthy that the minipipe did in fact give a sufficiently

wide power band for the purpose of car racing.

Summary

The OS 21 proved surprisingly powerful and the general subjective effect of its testing seemed disproportionate compared with some of the larger racing motors recently handled. The most significant point of its actual performance was, however, the capacity to rotate at fearful r.p.m. for its ca-

capacity. After all, 2,400 piston accelerations and decelerations per second over a distance of $\frac{1}{8}$ inches was some going. It's no wonder that connecting-rod bearings were under some pressure therefore. The motor proved also a very consistent and steady performer at any point on the extremely wide r.p.m. capability range. The overall impression was of an impressively simple but subtle motor which could hold its own in the demanding area of open car circuit work.

