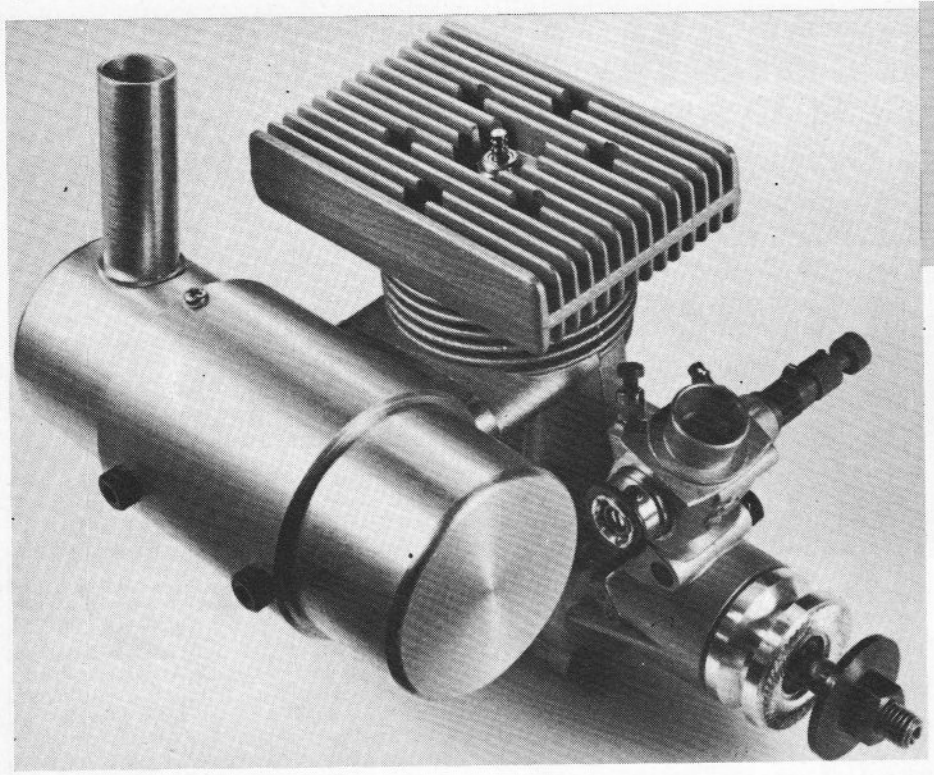
Peter Chinn's

ENGINE TE

OS MAX 61 FSR-H HELICOPTER ENGINE



This optional G.222 helicopter type silencer was used in the tests. Alternatively, standard OS-744 silencer can be used.

O.S. '60' SIZE engines were first made as far back as 1940 and again, briefly, in 1946-48. However, with medium and small size motors very much the vogue, world-wide, for the first two post-war decades, it was not until 1964 that any more 10cc O.S. engines were produced. Since that time, there has been much progress in their design and construction, culminating in the present quite extensive range of .60 cu.in. O.S. Schnuerle-scavenged engines. This range currently includes the rear-exhaust Max 61VF front rotary-valve and Max-61VR rear rotary valve motors, and the side-exhaust Max-61FSR front rotary-valve models. These engines are primarily intended for FAI class r/c aerobatics and FAI r/c scale models and the 61VF and 61FSR models are now also obtainable with built-in reduction gears for the more efficient use of their high top-end power.

The Max-61FSR is also available in a special helicopter version, the 61FSR-H, which is the subject of this report. The 61FSR-H is marketed only in a ringed piston version (the standard 61FSR is available in a choice of ringed piston or ABC ringless types) but has most of the other features of the 61FSR. It also has some special characteristics of its own.

The manufacturer's primary objective, with the Max-61FSR-H, was to provide all-round reliability, with special emphasis on immediate and predictable response to the throttle control, qualities that are obviously of greater importance with helicopters than with fixed wing aircraft. That these aims have been met, would seem to be confirmed by user reports.

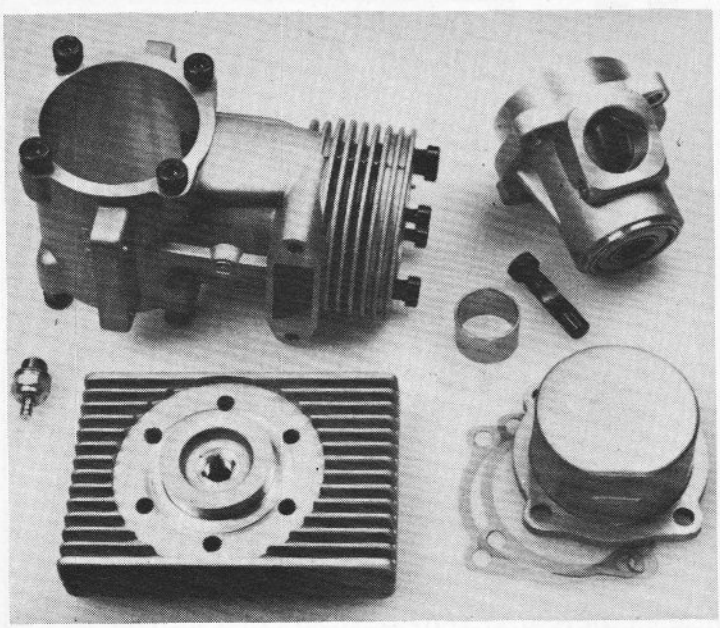
Design and construction summary

Main casting. This sturdy but nicely finished aluminium alloy pressure casting comprises the crankcase barrel and a full length finned cylinder jacket. The crankcase has an i.d. of 35mm and a substantial wall thickness of 3.5mm. The cylinder casing has three well shaped passages to supply the transfer ports.

Cylinder liner. The steel cylinder sleeve has a wall thickness of 2mm and, in common with other current O.S. high performance engines, has the company's exclusive extra-hard wearing, low-friction, non-electro-deposited composite plating. This is a process that seems to have proved superior to all others to date, both for ringed engines with steel liners, and for ringless pistons with plated brass liners.

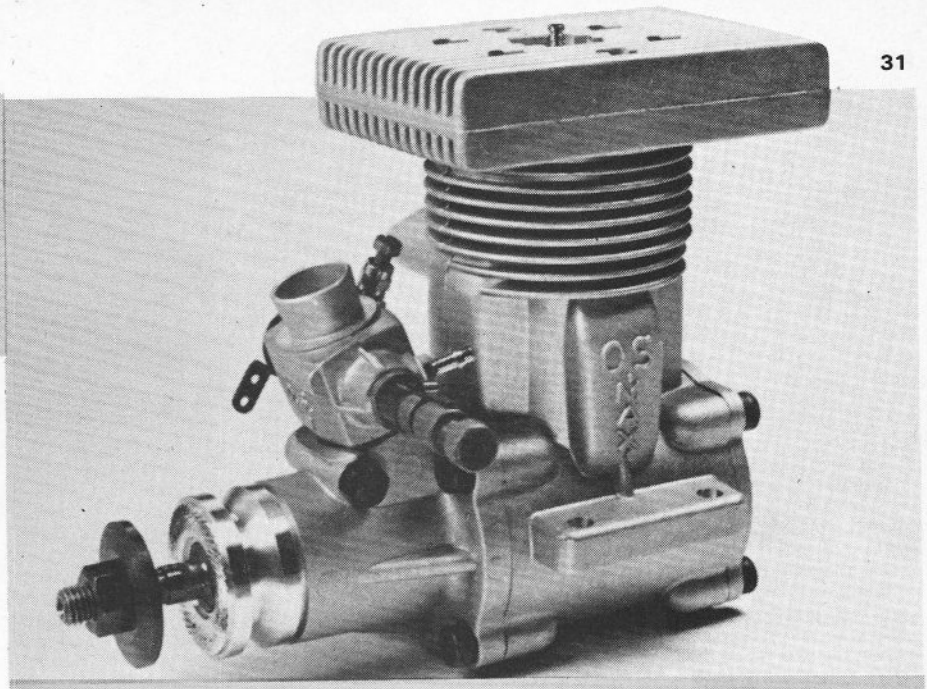
The cylinder has a conventional Schnuerle-plus-third-port scavenging system, consisting of a centrally bridged exhaust port on the right side that opens and closes at 73 deg. each side of BDC, flanked by suitably angled fore and aft transfer ports that open and close at 60 deg. each side of BDC and an upwardly inclined third port, diametrically opposite the exhaust, which opens and closes at 56 deg. each side of BDC.

Engine castings are robust, very accurately machined and finely finished.



Crankshaft has ¼in. dia. shaft end to suit helicopter clutch assemblies. Cylinder liner has special low-friction, hard wearing surface treatment exclusive to O.S.

ST BENCH



Externally, the Max 61FSR-H helicopter engine can be distinguished from the standard 61FSR by its heatsink head, smaller carburettor and smaller propshaft thread.

Piston and connecting-rod assembly. The piston is produced from a gravity casting in high grade piston alloy. It has a flat crown, wide bosses to ensure a good bearing area for the gudgeon-pin and rectangular skirt cutaways to avoid masking the entry to the transfer channels when the piston is at the bottom of its stroke. The piston is fitted with a single pegged compression-ring.

The connecting-rod is machined from high duty alloy and is bronze bushed at both ends. It has an oil slot in the 7.8mm wide small end bearing and two oil holes in the big end which is 6.8mm wide. The rod is 40mm (1.82 × stroke) between centres and the shank has a maximum width of 9.8mm and a thickness of 3.5mm. The 6mm o.d. hardened, tubular, fully-floating gudgeon-pin is highly finished and closely fitted to the piston to minimise wear. It is retained in the piston by wire circlips.

The weight of the piston, complete with ring, was checked at 10 grammes, or 13 grammes with gudgeon-pin added. The connecting-rod weighed 6.8 grammes.

Cylinder-head. In order to dissipate heat more readily in a typical helicopter installation, the head is of the 'heatsink' type, rectangular in shape and extended, fore and aft, with fins top and bottom, to increase

General Information

Manufacturer: O.S. Engine Mfg. Co. Ltd., Osaka 546, Japan.

U.K. Distribution and Service: O.S. Products Ltd., Brunswick Industrial Park, New Southgate, London N11 1JL.

Type: Single-cylinder, Schnuerle-scavenged, side-exhaust, glowplug ignition, two-stroke, with crankshaft rotary-valve and twin ball-bearings.

Bore and stroke: 24 × 22mm (0.9449 × 0.8661in.)

Stroke/bore ratio: 0.917:1

Measured compression ratio (full stroke): 11.6:1

Effective compression ratio (exhaust closed); 8.5:1

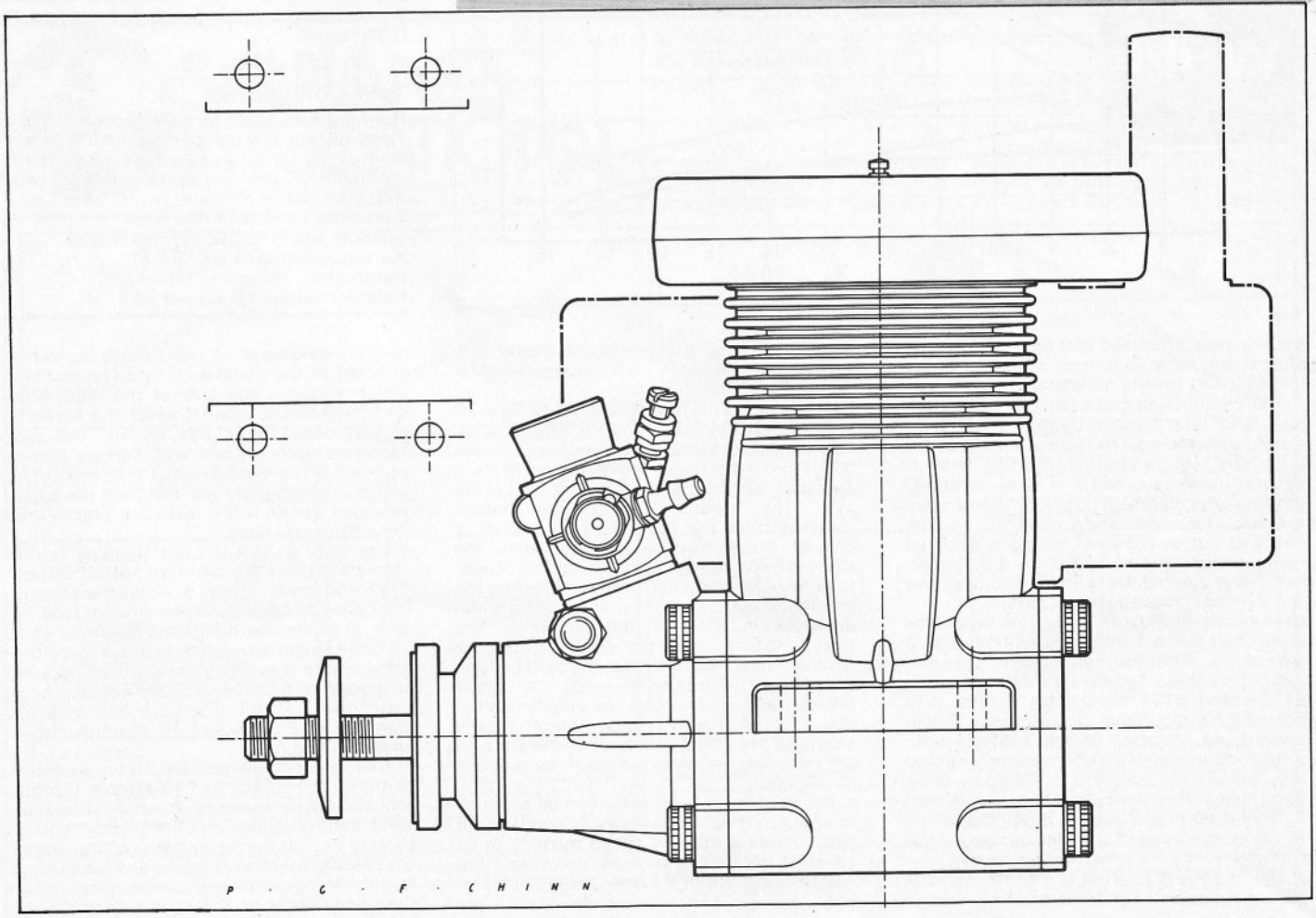
Swept volume: 9.953cc (0.6073cu.in.)

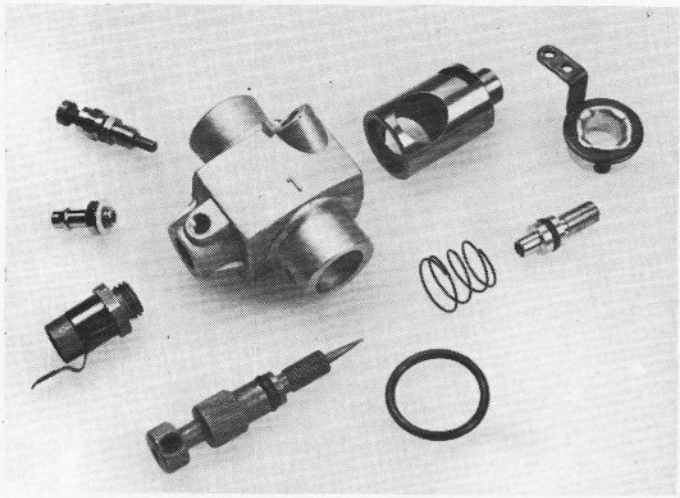
Measured port timing:
Exhaust period: 146°
Transfer period: 120°
Third port period: 112°
Rotary valve opens: 34° ABDC
Rotary valve closes: 48° ATDC

Carburettor: O.S. Type 7BH adjustable automatic mixture control type. Choke dia. 8.8mm. Effective choke area 38 sq.mm.

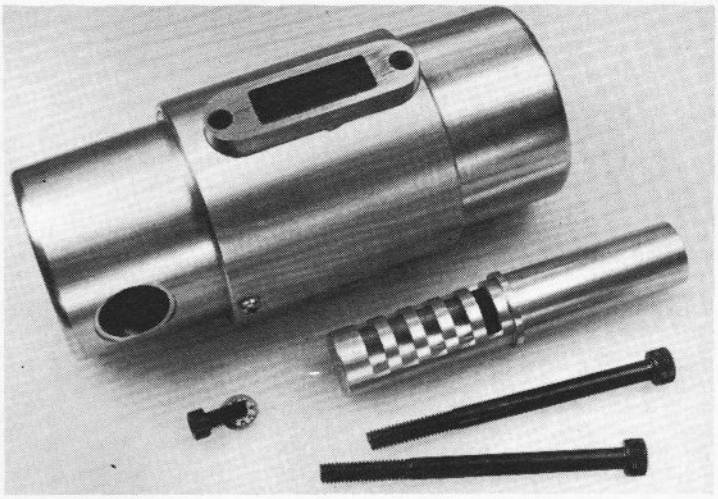
Silencer: Extra. Choice of standard OS-744 expansion chamber (volume 126 ml., outlet area 57sq.mm) or special G.222 helicopter type (volume 106 ml., outlet area 95 sq.mm).

Checked weights: 547 grammes (19.3 oz) less silencer; 663 grammes (23.4 oz) with G.222 helicopter silencer, 673 grammes. (23.8 oz) with G.222 helicopter silencer plus 3in. tailpipe.

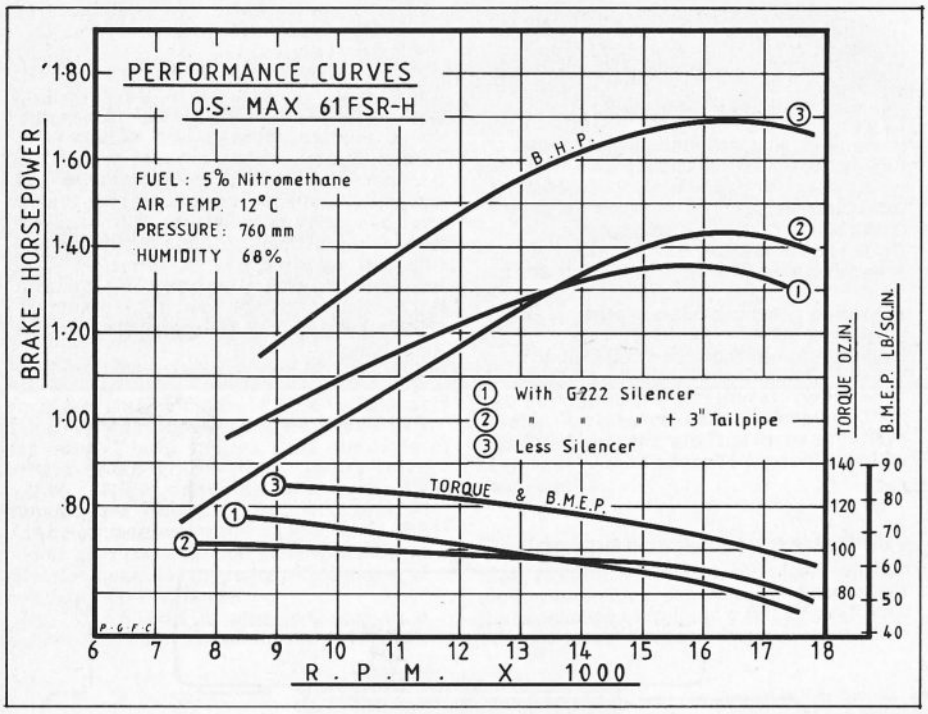




Type 7BH carburettor parts. From body, clockwise, they are: throttle barrel, throttle-arm, mixture control valve, throttle barrel spring, intake seal, needle-valve, n.v. holder, inlet nipple, throttle stop assembly.



Parts of G.222 silencer. It is a simple cylindrical expansion chamber, with slotted outlet tube acting as baffle.



Performance Tests

Power output, gross (less silencer): 1.69 bhp at 16.500 rpm.
Power output, net (with G.222 silencer): 1.36 bhp at 15,700 rpm.
Power output, net (with G.222 silencer plus tailpipe): 1.43 bhp at 16,250 rpm.
Torque, gross (less silencer): 130 oz.in. at 9,000 rpm.
Equivalent b.m.e.p.: 84 lb/sq.in.
Torque, net (with G.222 silencer): 115 oz.in. at 8,000 rpm.
Equivalent b.m.e.p.: 74 lb/sq.in.
Torque, net (with G.222 silencer, plus tailpipe): 102 oz.in. at 8,500 rpm.
Equivalent b.m.e.p.: 66 lb/sq.in.
Specific output, gross: 170 bhp/litre.
Specific output, net (G.222): 137 bhp/litre.
Specific output, net (G.222+tailpipe): 144 bhp/litre.
Power/weight ratio, gross: 1.40 bhp/lb.
Power/weight ratio, net (G.222): 0.93 bhp/lb.
Power/weight ratio, net (G.222+tailpipe): 0.96 bhp/lb.

Test Conditions

Running time prior to test: Approx. 1 hour.
Fuels used: (i) 80 per cent methanol, 20 per cent castor-oil (running-in); (ii) 75 per cent methanol, 20 per cent castor-oil, 5 per cent nitromethane (tests).
Glowplug used: O.S. No. 8.
Silencer used: G.222 helicopter type.
Air temperature: 12°C (54°F)
Barometer: 760mm (29.92in.) Hg.
Relative Humidity: 68 per cent.

cooling area. The head is of pressure diecast aluminium alloy, but has a cast-in brass thread insert for the glowplug.

The combustion chamber has a 15.7mm dia. bowl surrounded by a 4.1mm wide sloped squishband. The head is installed with a 0.4mm soft aluminium gasket and is secured with six M3.5 × 0.6 hardened chrome-molybdenum socket head cap screws. The combustion chamber volume checked out at 0.94 ml, giving a nominal compression ratio of 11.6:1, or 8.5:1 when calculated against the cylinder volume above the top edge of the exhaust port.

Crankshaft and front-end. The one-piece crankshaft has a 17mm dia. main journal, a 9.5mm dia. front journal and a 6.5mm dia. tubular crankpin. It differs from the standard 61FSR and 61VF crankshaft in that it is ported for rotary-valve closure about 9 deg. earlier and, in place of the 5/16-24 UNF propshaft, has a ¼-28 UNF size to facilitate the fitting of standard helicopter drive assemblies. The shaft runs in a 17 × 30mm 11-ball steel-caged bearing at the rear and a ⅜ × ⅞in. steel-caged shielded bearing at the front.

The shaft and bearing are contained in a sturdy pressure cast front housing that is fitted closely to the crankcase barrel and secured with four M4 × 0.7 hardened Cr.Mo. socket-head cap screws.

Carburettor. This is a modified O.S. Type 7B adjustable automatic mixture control type. Fuel enters the pressure cast aluminium carb body from the left side and is fed into a fixed spraybar via the needle-valve on the same side. The ground steel throttle barrel, inserted from the opposite side, carries a coaxial brass mixture control valve, the sleeved end of which is a close sliding fit over the end of the spraybar, partially covering the longitudinal slit type jet that is cut into the downstream side of the spraybar. The throttle barrel, together with the mixture control valve, moves across the carb body as the throttle is rotated towards the closed position and, in so doing, the sleeved end of the mixture control valve automatically shortens the effective length of the slit type jet, reducing fuel flow to match the reduced air supply.

The mixture control valve can be screwed in or out by means of a recessed screwdriver slot, enabling the low-speed mixture to be adjusted. Both the mixture valve and the needle-valve are fitted with O-rings to maintain settings and prevent air leaks. The helical movement of the throttle barrel is effected, in the usual way, by an angled slot which engages the side of the adjustable throttle stop pin, against which the barrel is lightly loaded by a coil spring. The pin, hardened with a plain end, screws into a separate nickel-plated holder with locknut — which is much more positive than the usual set-up of a plain screw threaded directly into the aluminium body.

The Max 61FSR-H front housing is the same as that used by the standard 61FSR and 61VF and has a 15mm i.d. intake boss to suit the Type 7D carburettor. The smaller Type 7B carb used by the helicopter engine has a 13.5mm spigot diameter and this is therefore fitted with a thin brass sleeve, the complete assembly being held securely in place by a cotter pin and nut. The carb has a choke diameter of 8.8mm and an effective choke area of 38 sq.mm.

A couple of small but useful features of the carburettor include the adjustable throttle arm and the provision for an external needle-valve control extension. The throttle arm is fixed to a collar that is mounted on the end of the throttle barrel and can be easily adjusted by slackening an Allen grubscrew. The end of the needle-valve is drilled to take a 1.8mm

dia. wire extension, also secured by an Allen grubscrew.

Silencer. Unlike the standard 61FSR, the helicopter version is supplied without a silencer. It will, of course, accept the standard OS-744 silencer and a special 90 degree adaptor is available to enable the silencer to be placed parallel to the cylinder axis, rather than to the crankshaft, when this is more appropriate to a particular helicopter installation.

Also available (but at considerably greater cost) is a more compact helicopter muffler, of German origin and one of these was used in our tests. It is a machined cylindrical chamber incorporating an 11mm i.d. slotted outlet tube inserted at right angles to the chamber axis.

Performance

Each Max-61FSR-H leaves the O.S. factory with the carburettor throttle stop and idle mixture valve set approximately correct. However, in view of the fact that with a helicopter it is vitally important for the safety of the model that the engine functions reliably and responds instantly to the throttle at all times, the manufacturer's very comprehensive four-page instruction leaflet contains detailed advice for checking and, if necessary, re-setting the carburettor adjustments.

Various safety checks are included and, because the procedures for adjusting an engine for use in a helicopter are rather less straightforward than with the same type of engine in a fixed wing aircraft, suggestions are included as to how the less experienced helicopter pilot may carry out preliminary adjustments on the bench, using large and small airscrews to simulate load conditions.

For example, it is suggested that, to find the optimum *needle-valve* setting, the engine should be run at full throttle on a 14-16 inch diameter prop (to simulate maximum rotor load) and the needle-valve adjusted for maximum rpm, but keeping the mixture a little on the rich side to prevent any risk of overheating. As a helicopter engine is required to idle at virtually no-load conditions, however, the *idle mixture valve* is adjusted with a 10 × 6 prop fitted, the engine being set to idle at just below the speed necessary to operate the centrifugal clutch.

One has to admit that bench tests cannot be expected to reveal all the capabilities or shortcomings of a helicopter engine under actual flight conditions, but our tests did demonstrate that the O.S. 61FSR-H was able to maintain a commendably steady and linear response to its throttle. This was particularly so through the all-important mid-range where a helicopter may be required to hover steadily and respond smoothly to small throttle movements.

The all-round handling and running characteristics of the 61FSR-H were very good indeed. Starting was instantaneous, the needle-valve was easy to adjust, firing was smooth and steady and vibration levels were commendably low. The No. 8 glowplug supplied with the engine obviously suited it very well and survived the entire programme of tests. There was no loss of power when the plug lead was disconnected and virtually no loss of power on warming up from cold.

Airscrew rpm figures having no relevance to helicopter engine performance, our test data this month are confined to the torque and bhp curves determined from dynamometer tests. After a short but adequate period of running-in, three series of tests were undertaken, all using our standard 5 per cent nitromethane test fuel.

The first set of tests was run with the engine fitted with the G.222 silencer. The same silencer was also used for the second series but with the addition of a short tailpipe; the pipe, in this instance, being a 90 degree elbow, 3in. long, 9mm i.d. and connected to the silencer outlet with silicone exhaust tubing. Finally, the engine was checked in the open-exhaust condition, in order to determine its gross torque and bhp.

Examining the results of the latter first, in order to compare the performance of the 61FSR-H with other 10cc R/C engines running on similar fuel, it will be noted that this O.S. recorded an impressively high maximum torque of 130 oz.in. and an excellent power output of just on 1.7 bhp at 16,500 rpm. This compares with a figure of slightly under 1.6 bhp at 16,000 obtained in our last test (some seven years ago, now) of a 10cc O.S. R/C engine, the Max-60FSR, and with a maker's rating, for the 61FSR-H, of 1.7 bhp at 16,000 rpm. The current 61VF and 61FSR ABC engines, incidentally, are rated a little higher at 1.8 bhp at 17,000 rpm.

Adding the G.222 silencer reduced maximum torque to 118oz.in. at 8,000 rpm and peak power to 1.36 bhp at approximately 15,700 rpm but the manner in which quite small changes to exhaust systems can sometimes affect performance, was dramatically demonstrated when the three-inch tailpipe was added. This caused maximum torque to drop sharply to only 102 oz.in., but the curve was much flatter so that, as load was reduced, the two torque curves converged and cross over at between 13,000 and 14,000 rpm. As a result, the bhp curve was much steeper, peaking at 1.43 bhp at 16.250 rpm. From the operational standpoint, however, it is unlikely that this slightly improved top end power is worth exchanging for the much better torque under heavy loads otherwise available.

One final note. Although the 61FSR-H is designated as a helicopter engine, owners can also use it perfectly satisfactorily in conventional fixed-wing aircraft. A standard 61FSR cylinder head can be fitted, although some users have deliberately retained the heat-sink head for the improved cooling that it offers in closely cowled scale model installations.