# POWER CURVE

## by Mike Billinton

Still actively consolidating their current position as the major UK manufacturer of 2 stroke model engines, Irvine Engine's .21 cu. in. Rear exhaust engine specifically adds weight to the well-known adage that 'competition improves the breed' because the main design influence of this engine has been provided by that successful competitor Pete Halman, whose dominance of C/L speed (aircraft) in UK's FAI 2½ cc and 3½ cc Formula .21 classes has been quite marked over several years now.

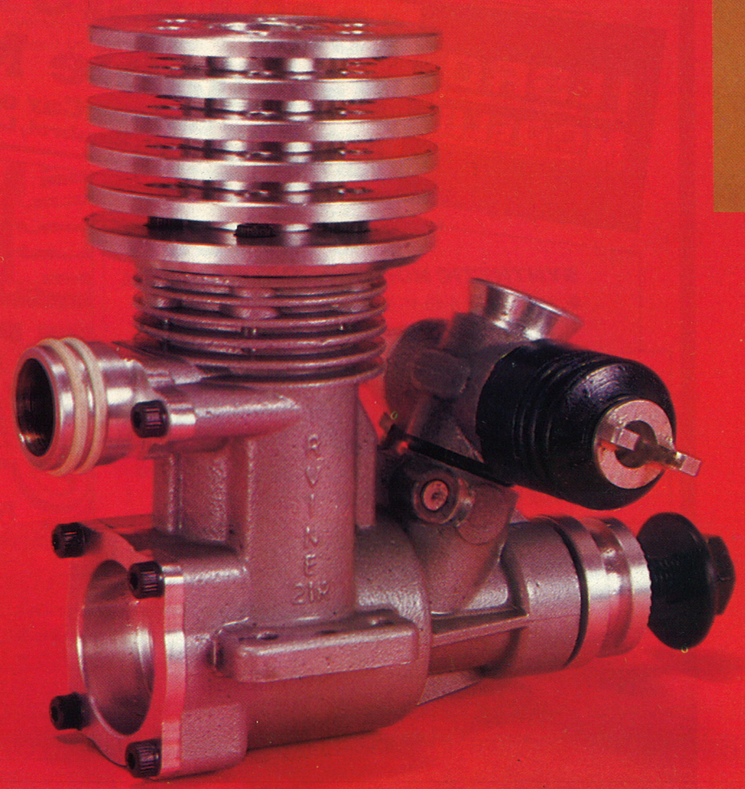
The earlier side exhaust Irvine .20 owed much to his influence, but transition to the Rear exhaust layout (to meet the dictates of the typical C/L speed model and its Tuned exhaust system) has allowed a full expression of the engine's capabilities to the point where Pete Halman's 3½ cc engine proved capable of securing for this country the 5 cc C/L speed World record at velocity of 194 mph late in 1986 — a feat which still stands. In addition his engine also holds the UK Formula .21 3½ cc C/L speed record at 174 mph — a speed reduction due to in the main to mandatory .4 mm flying wires of higher drag than those used for the World record.

Not content with that, a prototype of the Halman designed Irvine 15 R/E (hoped for production in mid 1988) also holds the UK FAI 2½ cc record at 176 mph. This fearsome engine utilizes 198° Exhaust timing, and releases a nice and easy 1.7 HP at 39,000 RPM on Methanol. As can be seen there is a definite connection between these record speeds and unusually high power levels, and in the case of Pete's 3½ cc engine, the chosen way was also the 'raised Exhaust/higher RPM' route to achieve more HP. In the standard production form the Irvine 21 R/E uses 164° exhaust timing for the Car engine and around 172° for the Marine version, but for maximum effect, this was raised for the record runs to a high 190° (that's over half the piston stroke given over to the open exhaust port!). With appropriate changes to pipe length this then allows good effective reasonance to occur at the much higher RPM of 36,000 which together with virtually the same level of Torque at 52 oz. ins. means an automatic HP increase on RPM grounds alone (HP equals Torque times RPM). Pete's figures on his Dyno. were 1.9 HP using 20% Nitro and a 7 mm carb. Of interest is the surprisingly low effective compression ratio used both on the record engines and in standard production. This amounts to around 4½/1 for the 190° timed engine and 5/1 for standard production and is the ratio from the point where exhaust port is closed upward travel of piston. The actual figures are deceptive though, because, as was surely the case in the record flights, the tuned pipe is working so well and effective cylinder pressures raised to an extent that a relative 'backing off' of the head compression is called for — and is equally a feature of the full-sized super-charged 4 stroke dragster engine of 8 litres and 3000 HP also being reduced down to lower compression ratios around 6/1 on high Nitromethane fuels.

That the same engine can be persuaded to release the same Torque, but at a point some 18,000 RPM higher up the RPM scale compared with the Open exhaust result indicates that the idea that increasing mechanical friction as RPM increased places some stop to automatic HP rises with RPM needs some qualifying — whereas the significance of gas flow restrictions as RPM rises (volumetric Efficiency loss) is the major factor which the pipe overcomes. This is however a more alarming possibility — that mechanical friction does indeed rise somewhat with RPM, but the massive pipe 'supercharge' is so marked that it overcomes (or masks) that increasing loss, and were this friction loss to be remedied in some way at source, then the true value of the pipe 'supercharge' would be more clearly revealed — and that maybe the 1 HP per 1 cc engine would become a reality! However, the likelihood is that Mechanical friction does not rise in such a manner and that Volumetric efficiency is the main determinant.

Readers may well wonder at the relevance of all this to the car engine? Well, the 'pedigree' aspect is always of interest in any area of I.C. engine developments — whilst the fact of operation at almost 2 HP whilst rotating at 36,000 RPM speaks loudly of the resulting reliability levels when the Irvine R/E is working at the lower power levels and lower RPM's of the standard production engine. The other point raised by the brief 'history' above is that operations at high Exhaust timings and high RPM's are usually a more critical, narrower RPM band affair, and thus less suited to the model ⅛ scale circuit car which demands a fair spread of Torque to provide good acceleration from low-speed corners. Lastly of specific interest to the car enthusiast is that the information concerning high HP being introduced by appreciable raising the exhaust timings almost certainly made for certain 3½ cc car engines during the last 3 years or so — the implication being that the figures were reached, but using the high timing method which was not necessarily taken accross to normal production runs — just as in this Irvine .21 case.

As can be seen from the power graph, the RPM spread provided by the 164° exhaust timed engine is reasonably wide in the Tuned pipe form, whilst in Open Exhaust form the HP spread is unusually flat.



### Mechanical Detail

In most respects the Irvine .21 R/E is mechanically laid out in conformity with established current practice for 3½ cc racing engines, ie:–

1. Crankshaft Induction through front housing for overall reliability at very high RPM (separate rear discs or drums have a hard life in the post 30,000 RPM area).
2. One-piece die-cast crankcase (joining together cylinder/piston and crankshaft in one rigid piece for maximum reliability and friction-free operation).
3. ABC piston/liner set-up (giving best combination of heat dissipation/freedom from friction/maximum compression seal).
4. Large heat sink head (to ensure adequate in-car cooling — but also the large area controls excessive variation of head and exhaust temperatures which then would vary accoustic velocity in the pipe and thus its effective length and RPM point for best reasonance).

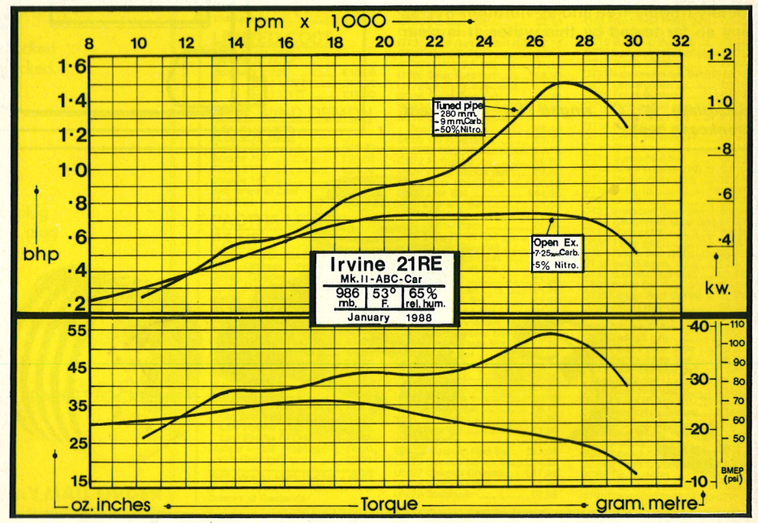
Within that overall standard package however, the Irvine .21 R/E has certain individual points of some significance:–

1. Piston is not through-bored for the gudgeon pin, and the resultant 'blind' hole at exhaust port side eliminates need for the often troublesome gudgeon pin retaining circlip which has been known to self eject at high RPM with interesting results. Additionally the method conveniently allows the use of a hollow tubular gudgeon pin.
2. Connecting-rod is a very solid machining from high-duty HE15 aluminium alloy.
3. The remarkably low compression ratio has been commented on earlier.
4. A neat practical point is that all Allen bolt fixings (4-40 ANC.) are the same size and length — this goes down well on competition days!
5. A last apparantly 'negative' though realistic point is that no carburettor is supplied as standard, it being a matter of observation that open car competitors are an individualist breed who usually throw the standard carb. away in order to achieve a unit of greater bore and/or greater installation convenience.

### Power Tests

In keeping with previous procedures, an open exhaust test was undertaken following a brief period of running on 2 standard propellers — all of which served to complete the quite limited running-in needed for todays ball-race ABC engines.

Additionally the Open exhaust findings give indication of the likely best place to operate the engine when fitted with a tuned pipe. In general it has been found (during this writer's test at least) that keeping open exhaust peak and tuned pipe peaks in a similar RPM (by use of a specific length of tuned pipe) usually gives best tuned pipe HP result. However, the large 15 cc marine racing engines have not yet fit-



ted this — whilst it would also be enlightening to know just where the Irvine .21 R/E peaks in its open exhaust form when fitted with 190° Exhaust timing!

Clearly there are questions which this writer has yet to find an answer for — though the possibility is that really effective tuned pipe operation (which has the capacity to overcome this provisional 'finding') is the factor.

### Test 1

In open exhaust form, and using 5% Nitromethane, and a small bore 7.25 mm carburettor (from ST S21 car engine), this rear exhaust engine gave results no more powerful than that of the earlier side exhaust engine tested mid 1983, though there was some significance in its ability to prolong the HP peak much further on from the similar 21,000 RPM peak onto 28,000 RPM.

### Test 2

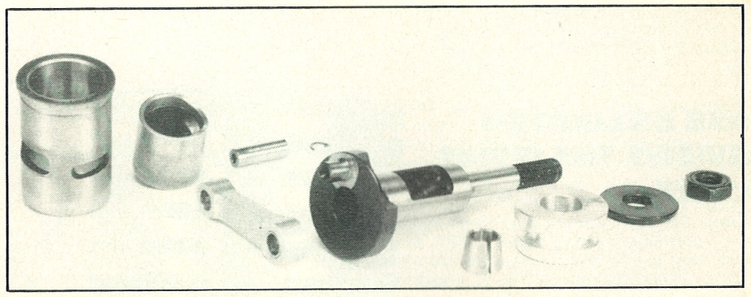
Based on the open exhaust findings then, the next test used a pipe length likely to generate maximum resonance and power at any RPM point near to the upper end of that wide band of open exhaust HP.

Using 50% Nitromethane and an OPS 9 mm slide carburettor, the OPS pipe's operating length was fixed at 280 mm from plug to end of rubber can. The result proved conveniently almost spot on, such that no more tests were felt necessary to further establish the point of 'the right length' to use. In any event, the OPS 300 glow-plug finally disintegrated at the last measured Torque point at 29,829 RPM, and its partial entrapment in piston surface terminated the test slightly prematurely. So there is some chance that further optimising of pipe length may just have increased power a little — maybe up to 1.6 HP say, though a large increase is unlikely without recourse to the higher exhaust timings mentioned earlier.

At 1.5 HP the Irvine R/E both exceeds the earlier side exhaust engine's figure of 1.17 HP at 29,000 HP (using similar equipment) by a significant margin, and also establishes itself amongst the current best figures being reached worldwide by normal production 3½ cc engines.

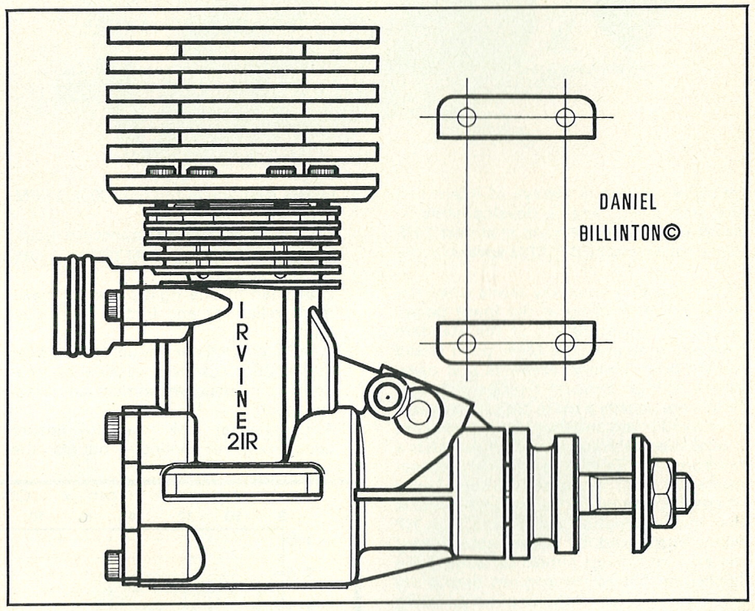
### Summary

During testing, the Irvine .21 R/E was completely trouble-free and as vibration-free as any so far tested by this writer. It is clear that the aircraft competition background has resulted in a much more powerful engine having considerable reserves of reliability, and its overall qualities seem likely to benefit the ⅛ car user in economic terms at the very least.

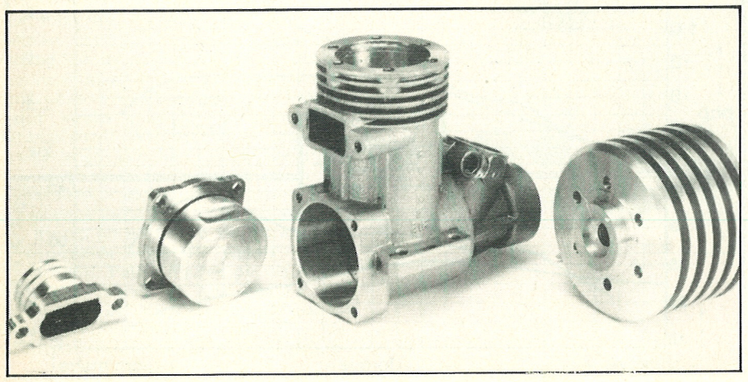


***Substantial connecting-rod is noteworthy. Note also piston not through-bored for gudgeon pin.***

***Drawn full size below, the new 21R.***




***Backplate is 'O' ringed for consistent crankcase seal.***



### Dimensions and Weights

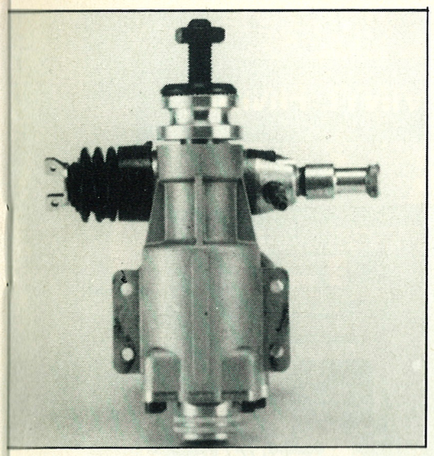
Capacity — .2123 cu in (3.48 cc).
Bore — .650 in (16.51 mm).
Stroke — .6395 in (16.24 mm).
Stroke/Bore ratio — .983/1.
Timing Periods:
- Exhaust — 164°.
- Transfer — 130°.
- Boost — 122°.
- Front Induction:
  - Opens — 41° ABDC.
  - Closes — 58° ATDC.
  - Total period — 197°.
- Blowdown — 17°.

Exhaust port height — .227 in (5.8 mm).
Combustion chamber volume — .5 cc.
Compression ratios:
- Effective — 5.486/1.
- Geometric — 7.96/1.

Cylinder head squish — .028 in (.70 mm).
Squish band angle — 5°.
Squish band width — .133 in (3.4 mm).
Crankshaft dia — .472 in (12 mm nominal).
Crankshaft induction bore — .332 in (8.4 mm).
Crankshaft nose thread — .248 in x 28 TPI (¼ UNF).
Crankpin dia. — .1868 in (4.74 mm).
Connecting rod centres — 28.7 mm.
Mounting holes — 16 mm x 36.7 mm x 3 mm holes.
Width between bearers — 30 mm.
Length — 2.92 in ( 74.2 mm) — front prop. driver to backplate.







Height — 3.59 in (91.1 mm).
Width — 1.70 in. (43.2 mm) — across lugs.
Frontal area — 5.01 sq. in.
Overall weight — 8.9 pz (252 gms) — without carb. (10 oz with carb).
Piston weight — .15 oz (4.25 g).
Crankshaft weight — 1.3 oz (36.8 g).

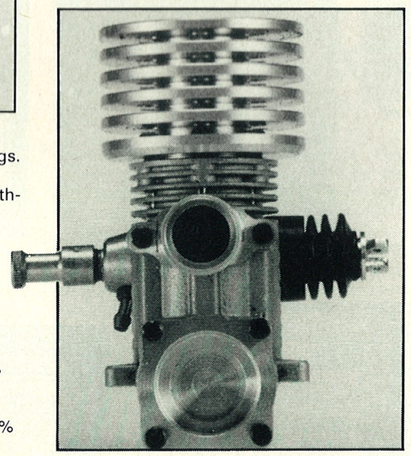
### Performance

*Max BHP:*
- 1.50 @ 27,300 RPM (OPS pipe/50% Nitro/9 mm carb.).
- .72 @ 26,800 RPM (Open exhaust/5% Nitro/7.25 mm carb.).

*Max Torque:*
- 54 oz in @ 26,800 RPM (OPS pipe/50% Nitro).
- 36 oz in @ 17,800 RPM (Open ex./5% Nitro).

*RPM Standard Propellers:*
- 7 x 6 Taipan — 16,603 (Open ex./5% Nitro).
- 7 x 6 Taipan — 18,701 (OPS pipe/50% Nitro).
- 7 x 4 Taipan — 20,869 (Open ex./5% Nitro).
- 7 x 4 Taipan — 25,187 (OPS pipe/50% Nitro).

***Left shows the underside whilst below the rear of the 21R is clearly shown.***



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|---|---|
| BHP/cu. in. | — 7.06 |
| BHP/cc | — .43 |
| Oz in/cu in | — 254 |
| Ox in/cc | — 15.5 |
| Gm. metre/cc | — 11.1 |
| BHP/lb | — 2.37 |
| BHP/kilo | — 5.24 |
| BHP/sq. in frontal area | — .299 |

### Manufacturer

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