Villiers Singles

Improvements

Handbook

3

John Wood

First published in 1995 as Villiers Singles Improvement Handbook in cooperation with Rob Carrick.
Printed copy only, spiral bound

Second edition in 2005 as electronic publication only, containing much additional material and research.

Third edition in 2012 as electronic download PDF,
and 2013 print-on-demand paperback via the Amazon self-publishing service.

Subsequent PDF-only additions to VSIH3 are:
305 Revised chapter on silencer design with spreadsheet
310 Ring flutter, belt drive, fluid diode, resonant air box
320 Forced change of desktop publishing software after computer failure
New chapter on simple computer simulations to aid design changes

Preface for first edition

John Wood

John Wood is a professional engineer, and started racing in 1977 on an air cooled Suzuki T20 and later an air cooled Yamaha, then a Yamaha 250 LC in the Marlboro championships of the early 1980's to top 5 positions. After a break from "modern racing" and a year on a 250cc Royal Enfield, today his allegiance definitely lies with the Villiers product. Racing a 9E powered Greeves Hawkstone with the VMCC, he won the 1993 Historic 250 cc championship using a Summerscales tuned 197cc motor. During the winter of 1993/94 a 250cc motor was developed in conjunction with Arthur Summerscales, and this broke the Cadwell Park long circuit lap record, Lydden lap record, won six consecutive races, and won the 1994 Historic championship. John also races an Invader engine Greeves Silverstone in the CRMC 200 cc class, and has had several CRMC class wins.

Major historical contributions from Rob Carrick

Having served his apprenticeship on a James K7 Captain, Rob Carrick formed a bond with the Villiers Engineering Co. that he has not been broken to this day. Despite a break when he went over to big four strokes, the Villiers product still found favour, which was rekindled with the purchase of a Greeves Scottish. Today racing an Invader engine 197 Greeves and an Alpha/Greeves/Villiers Special in classic events.

Acknowledgements

Over the past few decades many famous names have added to the immortality of the 9E, but in latter years these experts have become fewer, due to the decrease in popularity of the marque. It is to John Collard of the Greeves Riders Association, Barry Hickmott, Tom Thacker of Invader Engines, Simon Bateman of Nametab Engineering, Brian Woolley of Classic Motorcycle and Australian journalist Derek Pickard, that we give thanks.

Disclaimer

While the authors have personally tested and used the vast majority of modifications described in this manual under racing conditions, the authors accept no responsibility or liability whatsoever for modifications made to engines or motorcycles as a result of recommendations or advice given in this manual.

John Wood 1995

Preface for second edition

The original manuscript for VSIH was written in 1995. The corrected and slightly amended version (VSIH2) is available in electronic form. If “on-demand” publishing ever gets its act together, I will again have some printed. Since 2002 both John Wood and Rob Carrick have retired from championship club racing, and both are active in the workshop.

In this revised edition of the Villiers Singles Improvements Handbook we have tried to heed the advice and requests of VSIH/1 readers. I have captured diagrams and illustrations, updated chapters where the procedure was not totally clear, corrected mistakes, and formulated the most comprehensive list of Villiers engine IDs anywhere. The paucity of frame and engine data had irked Rob Carrick for many years, and he has spent half a life-time gathering information.

The aim of VSIH/1 was to supplement the existing Villiers handbooks. These are now getting harder and harder to find, although many dealers and autojumblers are providing photocopies for sale, we have tried to gather all the information available for these Villiers singles engines in one volume before it is too difficult to locate. John Wood has continued to research the scientific output for 2-stroke related publications. Where suitable and relevant, this information has been used to enhance the chapters on tuning theory and practise.

The days of plentiful Villiers spares at autojumbles in 1995 have long gone, and the ever increasing popularity of karting and pre-1965 scrambles have made good items quite rare. The beneficial side effect of this is that more parts of competition quality are being manufactured to supply a new generation of competitors.

The electronic VSIH/2 continues to grow, and the emphasis moves from being a book to read in addition to the various workshop manuals, more towards being a complete workshop manual and tuning guide, in short it aspires to be a “must-have” book for the Villiers rebuilder.

John Wood 2005.

Preface for third edition

The original manuscript for VSIH was written in 1995, and updated for electronic distribution in 2005. Now in 2013 the age of “print on demand” may have finally arrived, and hopefully VSIH3 will be in print as well as electronic distribution. There are not many good spares at autojumbles, and the problems of adequate documentation for the older models of Villiers is acute. VSIH3 now covers some earlier models and pays more attention to trials and road-riding than before, though power with engine harmony is still the focus. The original adverts in the printed book are no longer relevant, and companies mentioned (such as Invader and Motoplat) do not exist any more. I have tried to add as many photos as I can.

The problem of documentation is significant, especially if you do not live in the UK. Therefore I have incorporated some additional wiring and ignition diagrams as well as some exploded diagrams. The best way to see the full exploded diagrams is on my web site http://www.villiers.info .

In the intervening years I have had the opportunity to work on Greeves, StarMaker, Excelsior, British Anzani two-stroke engines in addition to Villiers, as well as the DMW Typhoon, a sprint Brooklands TT machine, and an Alpha Centuri. I tried to remember to take some pictures too.

I have also had some help with acoustic analysis for tuning exhausts, and electronics for monitoring crankcase performance. The silencer section has been rewritten, I recorded a 210cc Villiers kart race and analysed the sound, and I designed a silencer for the 210 kart class. The maths, spreadsheets, and procedures that I used are fully documented.

For the 32A/9E style engines, there are now new crankcases, additional gear ratios, new slim-line primary drive castings, square alloy barrels and heads available in decent alloy with consistent CNC quality, from Nametab Engineering in Redditch.

John Wood 2013

Preface for VSIH3 – 2025 update

Now thirty years since I sat down to write an article for the Greeves Riders Association, that overran and became five articles, and that attracted the attention of the late Rob Carrick, and together we wrote the VSIH first edition.

The intent then as now is to provide some understanding and workflow for those who want to improve their 2T competition motors, now in the age of personal computers we should be able to have computer assist rather than calculator assist. The books by Dixon, Blair, Heywood, and Sher have fuelled a desire to create simple computer simulations with graphics, simple enough to understand and run, and informative enough to refine the “by-calculator” design. The whole text is now under a newer word processor after a computer failure and my old software will no longer reinstall, so glitches there might be.

Most businesses mentioned in prior editions are no longer with us, but Nametab in Redditch is still going strong.

John Wood 2025

Conventions and Terminology

We need to be sure that the terminology we use is understood in the way that we intend, so first we have defined some of the terms and the way we use them, where their use is known to differ throughout the industry. There are several conventions used in describing ports and compression ratios in two stroke engines, the conventions used in this book are as follows:

Units

Unless specifically stated at each instance, the units used are

Weight	Kilograms(Kg) Grams ('gm') Pounds ('lb')
Distance	Centimetres (cm) Inches ('in')
Volume	Cubic centimetres ('cc')
Atmospheric pressure	Bar ('bar') lb/sq in ('psi'): 1 Bar=14.5 psi
Geometric "pi"	**Pi** = 3.14159

Ports

A four port barrel has 1 inlet, 1 exhaust and 2 transfer ports.
A six port barrel has 1 inlet, 1 exhaust and 4 transfer ports.
One primary pair as per 4 port design, and an additional smaller pair between the main pair and the inlet port. A split inlet or exhaust port still counts as one. A little ‘finger’ port at the rear, two liner ports joined by a short passage counts as one even though there are two holes (ports) in the liner.

Port timing

Port timings for Inlet are degrees of opening before top dead-centre (BTDC). An inlet port opening 80° BTDC would have 160° of crank opening. Exhaust and transfer port timings are degrees before bottom dead-centre (BBDC). A port is deemed closed when you cannot any longer get the tip of a 20 thou feeler gauge into the port while holding the gauge at 45° to the vertical. More practically, I use a 2mm welding rod in the top of the port at 45° and amend the measurement by 2mm.

Compression ratios

Compression ratios may be "real" or "geometric". Throughout this manual we deal with real compression ratios: primary compression starts when the inlet port closes, and the secondary compression starts when the exhaust port closes, in neither case may you assume that the pressure is atmospheric.

Assumptions

Specific ratio of heats (g)=1.40 but in reality it measures (exhaust at 350C).
as 1.17 under compression
and 1.35 under expansion
Gas constant R=287 (air) and 291 (exhaust)
Acoustic velocity V=sqrt(gRT) for T in degrees Kelvin

V(exhaust, 400C) = 514 m/sec V(air,20C)=343 m/sec

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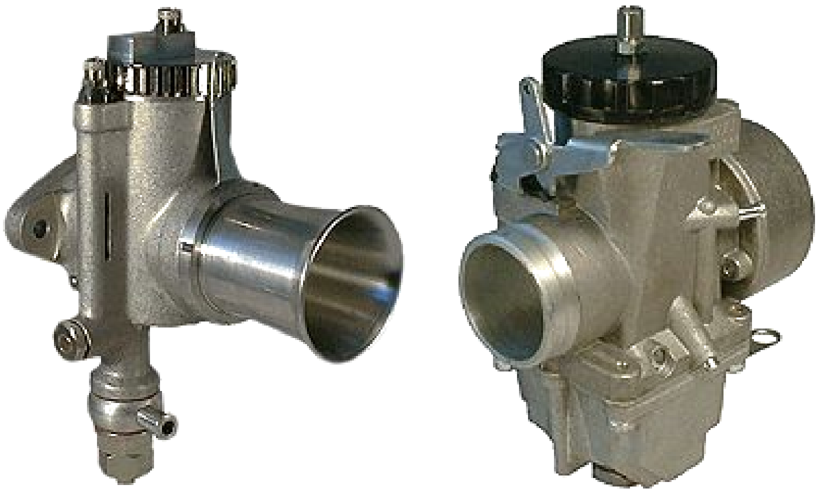

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Relative Air Density allowances

Atmospheric pressure is sometimes measured and stated as "inches of mercury (Hg)". The barometric pressure at sea level is about 15.5 lb/sq^2 or 30" Hg or 1.0 Bar or 1000 millibar. The pressure will drop about 1"Hg for every 10,000 feet in height. At 6000 feet, the air pressure will be down 20% and so will your engine power. At higher altitudes the air becomes less dense, and the carburettor gives a richer mixture for the same volume of air, and so rejetting may be necessary. Carburettors drag fuel by volume but mixture strength is by mass, and they are substantially effected by altitude.

At any altitude, the air density is effected by temperature as well as pressure. The air density changes with temperature in proportion to its absolute temperature, that is degrees Rankine or Kelvin. Zero degrees on this scale is where the molecules stop moving, and freezing point is 0^{o}C and 273^{o}K.

Adding water to dry air makes it lighter! The density of air is 18 g/mol as opposed to air at 29 g/mol. Each component of moist air will contribute its own partial pressure. Humidity has an indirect effect on engine power, however the effect is small unless the humidity and pressure are high. At 30^o C the saturation pressure of water is about 2"Hg (Mercury), so if the atmospheric pressure was 30"Hg then the actual air pressure is only 28"Hg, a drop of 6% due to water vapour being present. The density of that part of the atmosphere which is air will be less by 6%, and the engine power will be similarly reduced, and the fuel/air ratio will tend to be rich.

Usually the amount of water vapour in the atmosphere is less than saturation (100% humidity) and the actual amount is represented by the relative humidity. To take humidity into account you need to know your local humidity every time you test. In fact you need to know the pressure, temperature and humidity at your location while you do your testing.

To find the RAD , enter the chart from the bottom at the temperature of your location. Move vertically to the line which is the local uncorrected barometric pressure. Move horizontally over to the RAD scale and read the number. When you chart the power curves on a dynamometer, the uncorrected values should be adjusted pro-rata to a selected RAD number, say 100. Now you are comparing like with like when you examine the effect that tuning modifications have made. This chart is also useful to determine what changes in carburation would be required when racing in the cold and wet of Spring, or a hot dry summers day.

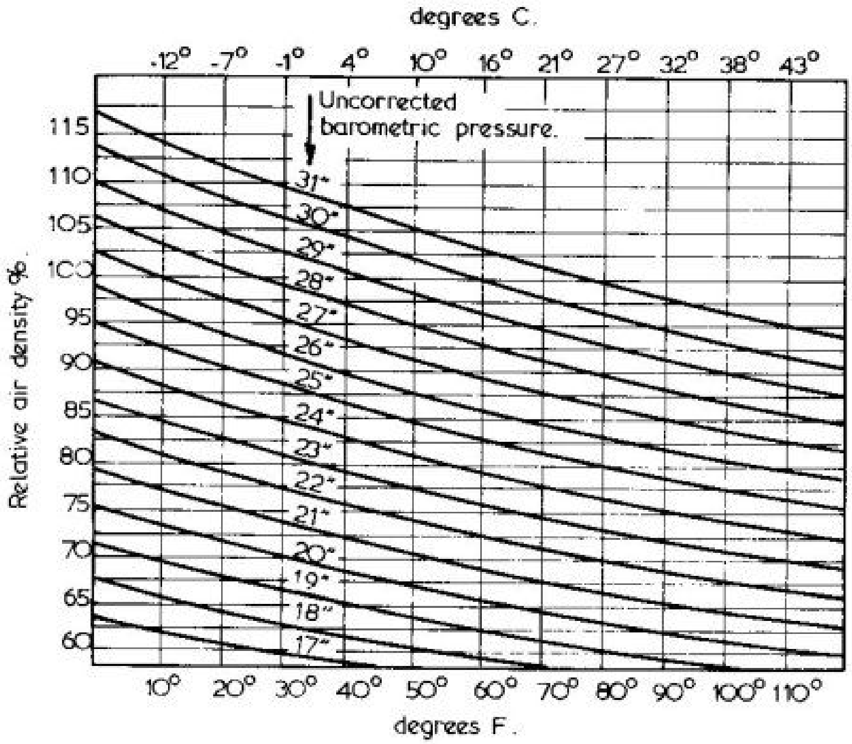


Fig 1: Relative Air Density chart

Fluid Diodes

An electrical diode is a device which permits electricity to flow one way and not in reverse, a fluid diode is not a valve as such but a shaped passage which offers considerably more flow resistance one way compared with the reverse.

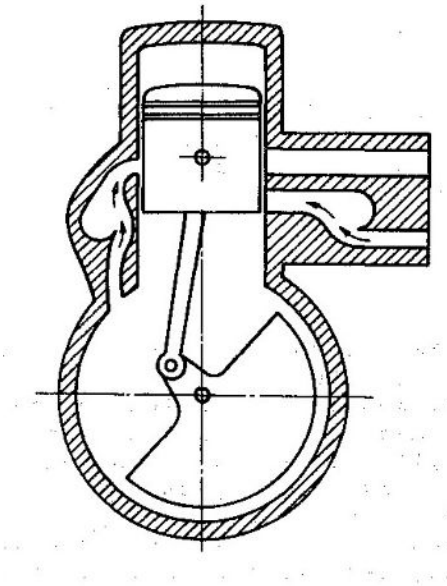


Fig 2: Fluid Diode on intake

In the case of a two-stroke engine consider an inlet tract which resists any inlet charge spit back, or even better, traps it and returns it to the engine on the next cycle. There is no static blockage of the inlet tract, just a shape which alters the inlet gas dynamic behaviour. This behaviour was known and studied in the 1970's and gave promising results, up to 30% improvement in power in the 3000-4000 rpm and 20% in 4000-5000 rpm range and less as the revs rise. This is useful power for the race engine as long as the power is not actually less than standard, but it seems exactly what you would like for enduro and trials

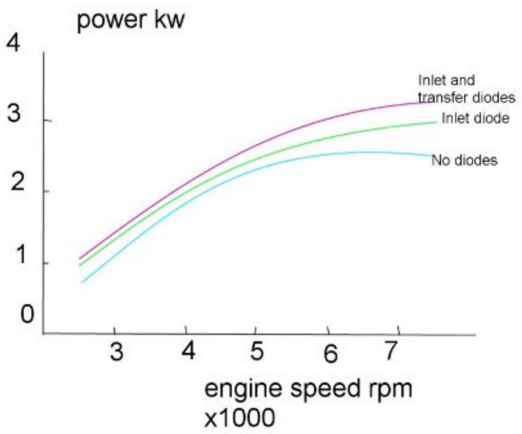
So why are these devices not commonplace on these types of engines?

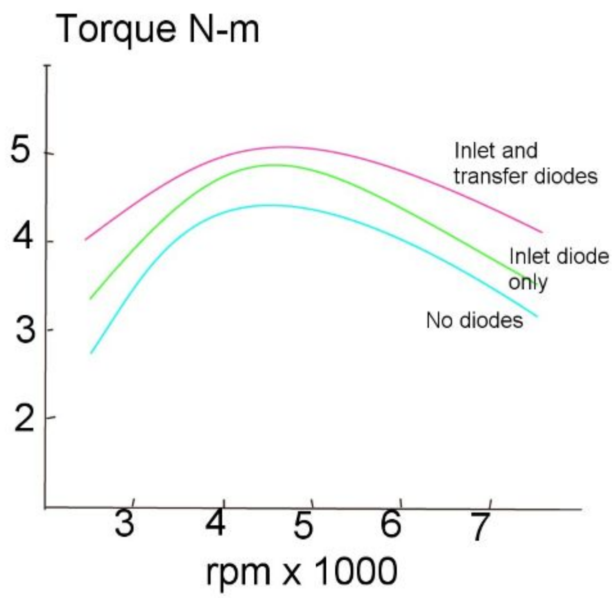
One reason is that they are bulky, but I don't see that as too much of a hindrance as long as they are light weight. They could easily be made of moulded plastic, and mounted behind engine and go where air filter and tools box as often sited. As with any resonant shape, it aids one frequency and detracts from another, and worked best in the lower frequencies

A second possibility is that the resonant plenum chamber would smooth out the engine induction pulses, and I have noticed that carburettors like a ‘signal’ to work properly. It is vague I know but that is what I think. With a significant plenum chamber between the engine and the carburettor there would be much less of a signal. My final reason is that it is much easier and cheaper just to fit a reed valve, they are simple and effective, and work at higher revs.

One who investigated the fluid diode was Eran Sher of Israel University, and some comment was included in the book he co-authored with John Heywood of MIT [SAE paper 830092, SAE book “The Two Stroke Cycle Engine”] . The essentially circular plenum chamber must have a radius of twice the inlet tract diameter, all the research papers agree on that, but I see no derivation or justification in these papers. This means that the plenum chamber needs to have a volume proportional to the carburettor choke size, in the case of my 32A this a 185cc as a minimum.

Verdict : If your club rules forbid reed valves on classic engines then this is interesting but a lot of work, and to get the 30% improvement achieved above, you need removable transfer port covers to reshape the transfers.





This shows the increased torque for implementing an inlet diode, and inlet+transfer diode, and increased power. Both charts are redrawn from data in the SAE paper 830092

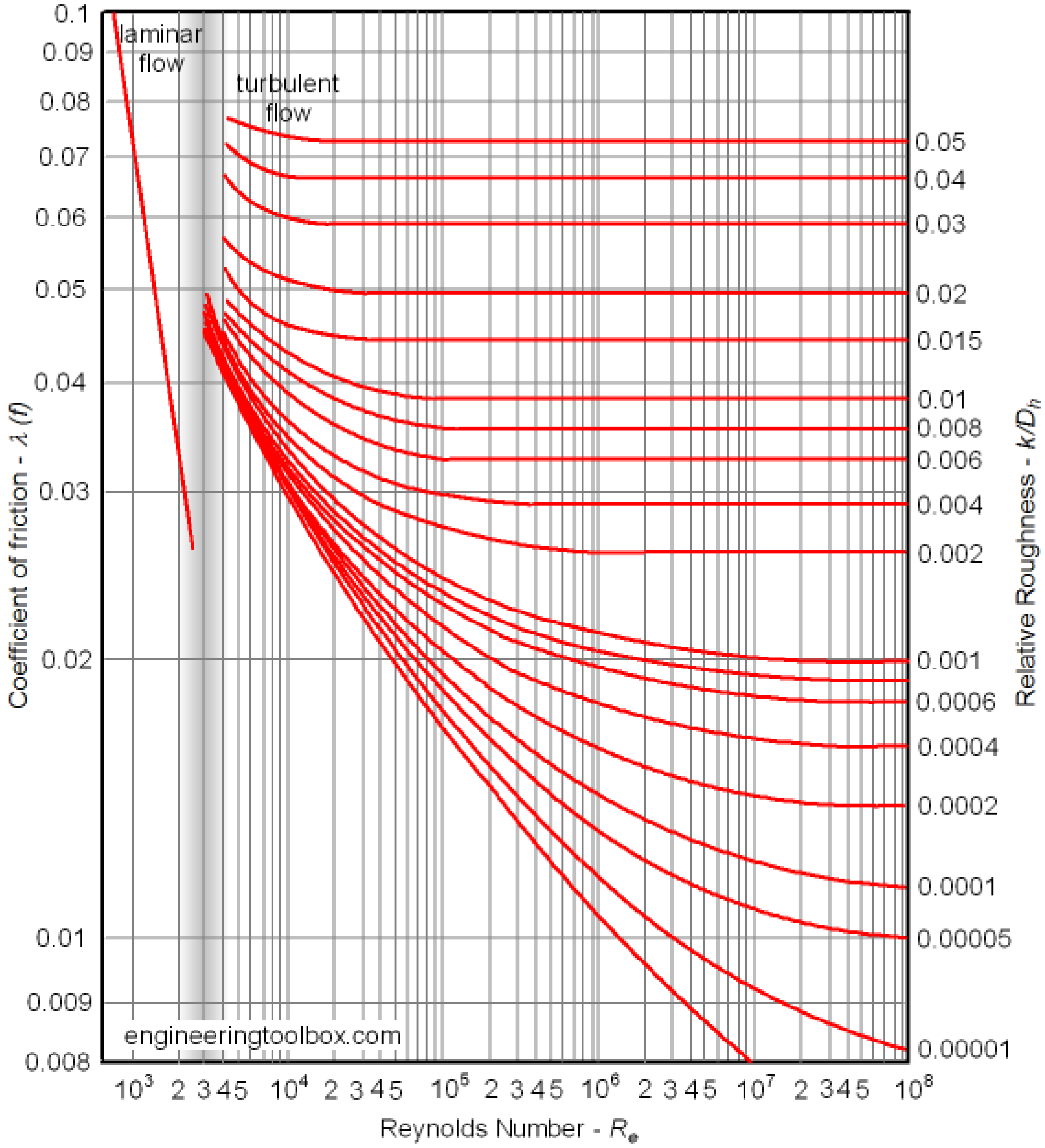


Fig 3: Moody diagram

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