Ben Collins **July 2003**

Research Project Proposal

Compact Linked Piston Engine

technology

CONTENTS

Supporting Documents Annex (separate document)

A1	www.clptech.com
A2	Document "An Introduction to the Compact Linked Piston" – the latest embodiment is always to be found on the website.
A3	Last two years project concept phase expenses (contained as worksheets on the Excel file : 2003-07-09 CLP Engine RD spreadsheets.xls).
A4	Last 2 years accounts.
A5	Last full contract year earnings for Ben Collins
A6	Public/private finance balance.
A7	Patent application certificate.
A8	WIPO patent search summary.
A9	CV's of both participants.
A10	Independent global fuel consumption and oil price predictions.
A11	VW - response to concept.
A12	AVL - response to concept.
A13	Reasons for the Swedish office.

Title Compact Linked Piston Engine. Research proposal : definition, numerification, physical and computer modelling of the engine.

Project Scope

Improved Combustion engine for use in; electricity generation, pumps, compressors, machinery, transport and marine.

Project Cost and Length

£105,000 – 1 year (60% / £62,000 grant funded). Funding mainly internal, except for STL models costing £7,000. Squarise balance of funding supplied as discounted labour (£43,000).

Project Location

Elvaston Derbyshire / Göteborg *The Göteborg location is explained in the supporting documents (f).

Project Goals.

Construction of 17 full and scale size engine models with detailed numeric information. World impact launch and presentation of the concept.

Need for the grant

I have spent 2 years developing this concept, which is a long time self funded. Yet the project still hasn't started in real terms. There is very little numerical data, there are still some big questions and the quality computer and physical models are lacking.

Realistically the present CLP technology is not commercially appealing to a generating set manufacturer, or any other engine manufacturer. However this does not mean the technology is without promise, merely that it has no detail refinement. Engineering is about numbers and costs, and choices derived from them.

Right now, any engine developer (the target customer) is faced with a host of available and near future technologies to implement (e.g.; multiple direct injection). The CLP Engine remains out there as an "alternative technolgy" with too many unanswered questions and therefore carrying too much risk.

The grant is needed to move the CLP Engine from "alternative technology concept" to a more commercially appealing "near technology".

Without the grant

If the grant isnt awarded, the project will most certainly continue, but at a very moderate rate. No numerical data will be deriven or quality physical models constructed. The CLP Engine would remain an interesting engine aside, but distant from commercial appeal and implementation. The most likely form of progress is a computer model, with a working (firing prototype) built in scale by one of the many scale engine modelling clubs.

Advantages

3 and 1 stroke mechanical action. Reduces numbers of parts. Reduces masses. Reduces friction. Improves piston cooling. Offers low resistance flexible capacity. Reduces packaging volume. Has same or competitive production cost. Is manufactured using contemporary materials and methods of assembly. *Overall fuel saving*. (see advantages www.clptech.com)

Altruistic Goal

Piston engines dominate worldwide power supply in modern life, from electricity generation to chain saws, trucks to mopeds, the world is largely powered by the piston engine. The piston engine is around 25%-42% efficient and certainly has room for improvement. Any percentage improvement results in a reduction of fuel consumption and emissions and that has got to be good for everybody.

The CLP can theoretically be employed in virtually all current piston engine disciplines, but is most likely to begin life in large scale industrial and marine diesel engines, themselves significant contributors to the pollution matrix.

Other Funding Activity / Applications

Nesta fund application was made 4th June 2003, no decision has been received. The Research Council was contacted on 7th July, and it is now being considered. Ány successful research council funding is likely to be involved with the metal frictional buck, and should not affect this application or contribute directly to it or Squarise.

Technical Work Plan (B)

The work plan is straight forward;
1 Establish CAD and physical models of all the possible engine CLP layouts, a "benchmark family" of 12 models (4 months).
2 Develop CAD and Physical models of 5 identified target market engines (5 months).
3 Develop marketing information and press launch at an international fair, thereafter chasing sales (3 months).

1 Establish CAD and physical models of all the possible engine CLP layouts (4 months).

The CLP layout has a number of possible layouts.

In order to practically compare like with like, and also to rapidly educate a technical audience, an array of physical models provides immediate understanding. The models enable the audience to quickly move from understanding to the more salient stage of "consideration for application".

The direct physical desktop comparison also provides strong sales ammunition in consideration of the overall smaller, fewer and lighter parts, and reduced packaging volume.

Short and long stroke piston models will also be useful to compare applications. Contemporary piston engines will be built to the same format. Each model can then be broken down into a spreadsheet of parts, weight, moments, costs and sizes, footprints and volumes as applicable. This produces a definitive benchmarked comparison. This forms the basis for the first technical paper: "Layout possibilities, comparisons and likely applications for the CLP Engine".

For further details see the website www.clptech.com and search using this icon: BENCH MARKS CLP BL SL XL

2 Develop CAD and Physical models of 5 identified target market engines (5 months).

The second stage is a continuation of the earlier work but getting into specific load, stroke, bore, cylinder numbers, fuel, speed, material and cost environments.

The models delivered will represent a desktop and portable comparable solution/argument for study by potential applicators, specific to their field. Each will provide a plethora of numerical data as before; mass, size, cost etc. This means real details are addressed and gives ammunition to the sales effort. This will make a sale more likely. The Second (daughter) technical paper will derive from this work "Modelled applications for the CLP Engine".

Also included is a parallel study into developing a revised conrod able to best handle the new tensile load applied.

For further details see the website www.clptech.com and search using this icon: CLP ENGINE CONCEPT FAMILY

3 Develop marketing information and press launch at an international fair, thereafter chasing sales (3 months).

The family of models will be shown at the expo, and both papers presented in the seminar forum, while also issuing the press release.

The engine expo is detailed at http://www.ukintpress.com/engineexpo/review.html

Project risks

The CLP engine has three principal doubts; robustness of the rotating bottom end under different types of loads, piston slap risk and lubrication changes.

The project risk is that answers to the last 2 questions may not be found with these models. But the models serve to widen the debate and hopefully opinion etc will be received during the project to at least "gain a handle" on these issues.

The challenge of completing the models within the timeframe is the other issue, but with logical cross pollination of base CAD data, multiple CAD and STL models should be possible, delivering a wealth of salient and precision data in a relatively short timespan.

clp technology

(B) Technical Work Plan

Aug 15th		Direct marketing to multi cylinder pump and compressor manufacturers
Aug 20th		PRESS RELEASE
Aug 25th		Conrod redesign evaluation
Aug 26th		Metal and benchmarking CLP : hunt for collaborator(s)
Aug 27th		Seek hobby modeller construction partnership (not essential)
Sept 1st	£	Decision on next step / commercialisation / freeze or PROJECT START
Sept 8th		Establish CAD office and engine benchmark data
Sept 15th	◆	PATENT APPLICATION PCT/GB2003/00671 Published
Oct 10th		Metal CLP collaboration at HEI begins (not essential)
Oct 10th		Begin construction of benchmarking family CAD models
Nov 25th		Conrod redesign conclusion
Nov 25th		Metal CLP CAD modification model submitted to HEI
Nov 28th		Complete construction of bench marking CAD models – Order STL models
Nov 30th		Begin data gathering for market specific engine family
Dec 1st		Compile comparitive data of bench marking CAD models
Dec 5th		Begin contruction of portable display unit for bench marking CAD models
Dec 10th	◆	Receive benchmarking STL models, check, finish, paint, motorize and assemble
Dec 20th		Compile benchmarking technical paper, report and account.
Jan 1st		DECISION ON PROCEEDING WITH PATENT APP GB0301996.5
Jan 2nd	£	Completion bench marking Exercise, present to SBS monitoring committee
Jan 10th		Conclude data gathering for market specific engine family
Jan 12th		Begin CAD models market specific engine family
Feb 1st	◆	Metal CLP buck manufactured – inspection visit
Mar 1st	◆	Metal CLP friction results completed
Mar 1st		Finished "first loop" CAD models for market specific family, consult with industry
Mar 4th		Complete contruction of portable display unit for bench marking CAD models
Mar 15th		Refined "second loop" CAD models for market specific family
Mar 20th		Stress Analysis "second loop" CAD models for market specific family and refine
Mar 25th		Final consultation with industrial contacts
April 15th		Third and final design loop and ordering STL models
April 30th		Modification of portable display unit for engine specific CAD models
April 30th	◆	Metal CLP friction results published
May 1st	◆	Receive engine specific STL models, check, finish, paint, motorize and assemble
May 5th		Compile engine specific technical paper, report and account.
May 10th	£	Completion engine specific exercise, present to SBS monitoring committee
May 12th		Likely construction of hobby modellers firing 3 stroke and or 1 stroke
May 15th		WORLDWIDE PRESS RELEASE
May 24th	◆	WORLDWIDE LAUNCH AT ENGINE EXPO STUTTGART
June/July		Marketing and next step evaluation/applications/investigations/sales leads
Aug 14th	◆	Manufacturing collaboration project TARGET DEADLINE
Aug 15th		Compile project report and account.
Aug 25th	£	Project completion, present to SBS monitoring committee and recover final costs
Sept 1st	◆	Decision on next step / commercialisation / project freeze

Commercialisation Research or Project Freeze..

Basic Marketing

Con rod design

Holiday

1st Model family

STL Model

Holiday

Technical Paper

SBS Review

2nd Model Family

2nd STL

Technical Paper

SBS Review

Launch and Marketing

Holiday

Commercialisation or Project Freeze..

August
September
October
November
December
January
February
March
April
May
June
July
August

HEI Frictional buck – hopefully a university will join the project and make some (independent) frictional analysis work.

Hobby modellers build interesting engines for joy alone! http://www.baemclub.com/

MILESTONES ◆

Sales Target

A sale is defined as one or a combination of the following;

- Sale of exploratory technology licence – where the purchaser can freely investigate the suitability of the engine.
- Exploration contract – where Squarise Designers are used to develop feasibility in a specific market sector or contribute to a programme.
- Sale of production licence (unlikely before 2006).

The first family of models move discussion immediately from education toward application. The second sequence of models is commercially targeted and presented at the engine expo with a simultaneous press release.

The Expo is hoped to produce; a worldwide CLP education/bulletin, a sale(s) or new sales lead(s), and is used to refresh old sales leads.

CLP Engine Market

The market is theoretically any piston engine maker, however the practical target market is;

1 Manufacturers of; generators sets, industrial, truck and marine engines.

2 Universities, government and grant providers.

3 Material supplier groups.

4 Compressors and pump manufacturers.

The audience is anyone involved in piston engine development, but especially the decision makers.

The marketing question is a battle against other technologies for development budget and application, these are the sales competitors.

Competitors - Other technologies available to engine builders form three groups; ***available*** technology, ***near*** technology and ***alternative*** technology. Secondly, classified as either ***top end*** (T), or ***base engine*** (B), according to their location.

Either location of technology still competes against one another for the same development budget. In the last 30 years most advances have come in top end design, through application of available and near technology. At present the CLP is a ***base engine alternative*** technology.

Available technology - a component or technique that is contemporary and proven, but yet to be incorporated into production. E.g. multi DI.

Near technologies are ones that legislation or long term testing and analysis have proven as realistic. Sellers of these technologies have detailed numerical and cost information. Components associated with this technology are under mass production evaluation or approaching mass production. E.g. 42 volt ancillaries.

These are also the technologies that market leaders seek out as a means to stay level with or ahead of the pack. Market leaders frequently monitor such technology through modestly budgeted exploratory projects.

Current Update - Never have so many proven, or near proven technologies been available to budget controllers. Budget controllers have to select new application technology methodically and logically, to pursue a successful engine development program which concludes with a reliable and progressional engine improvement, slotting into production ahead of their current model.

By simply applying the available and near technologies, most product planners can readily attain fuel savings and efficiency gains by evolution not revolution. This is why "alternative" technologies are, and have largely been, commercially poor performers.

A further consideration for the product planner is that legislation is steering or even driving engine development at the moment, particularly in respect to EC4, multiplexing and the 42 volt changeover.

Alternative Technology - This technology is the most interesting to the casual observer and is the one that drives inventors to; bankruptcy, bitterness or both. There are very few true success stories for alternative technology, and the time span for any success is typically protracted. Time, money and patience with technologies offering 20 year payback cycles is lacking, and the days of chasing altruistic technological breakthroughs for corporate or national prestige are mostly gone. There are countless "alternative engines" out there, see the links section at www.clptech.com

Some Alternative Engine Technologies under exploration and include;

1 - Variable compression-seems very complicated, and maybe there are other ways to achieve this exciting goal. (SAAB)
2 - The hydrogen fuel cell – this is the widest known and most promising radical technology currently in focus. But demands total change of fuel supply and industry mindset. Also questions of true efficiency are raised when the near technology is applied to the ICE. Is truly "green" if you generate the hydrogen at home using roof mounted solar panels, but more likely it will come from a fossil fuel burning power station.
3 - The 2 stroke cycle – another holy grail of IC design, chased by many manufacturers in the early 90's at huge cost ($100M+), to end in failure due to poor longevity and emissions. But still kept in mind by most. (Ford, GM).
4 The rotary valve, frequently explored, with the same conclusion of poor longevity due to worn sealing.
5 Scotch yoke engines – explored but always questions of the complex bearing longevity and practicality haunt these projects.
6 Quadratic engines – theoretically great, difficult to package.
7 Rotary engines – never achieved satisfactory efficiency, so far that is. Time may be kinder to the concept. (Mazda)
8 NEW! The Compact Linked Piston CLP –needing much more powerful numerical information and consideration of detail design.

The identified principal target market is;
Manufacturers of; generators sets, industrial, truck and marine engines. This market seems very attractive because;
A) The technology and market of this sector is "mature" and so a technological advantage must be maintained to retain profit margin.
B) These products are typically made by one company or group of companies.
C) Such companies are typically large operations; Man B&W, Cummins, Caterpillar, GE, Volvo, Wärtsila, with muscle and big R&D budgets.
D) This engine group tends to be fairly static in development, and while turbo charging and common rail delivery has been delivered as new technology, it is harder to find an efficiency saving technology in this market because of the predictable load cycle.
E) Production runs for the larger engines are small, usually NC machined, and are therefore more flexible.
F) Fuel usage is heavy, and represents the primary ownership cost, this means the reduced fuel consumption of the CLP is attractive.
G) Their customers typically operate a simple financial business model with a reasonably long term outlook. Considering that an engine may burn thousands of litres an hour, extra purchase cost to achieve a fuel saving is very acceptable. (NB - almost inevitably, initially the engine will cost more to build as a new technology, which will reduce with time).
H) The production and end customer relationship is close and reasonably flexible to incorporate / mutually welcome a technology advance.
I) Physical piston & is large, and due to structural compromises of the linked piston, this means sufficient robustness is easily achieved.
J) The dynamic environment of large industrial engine is clearly defined and predictable, typically run at ideal loading for the majority of their lifespan, reducing extremes of performance and reducing the risk of longevity failure during operating extremes.
K) The CLP arrangement works in collaboration with (not against) other available and near future technology.
L) The customer selection process is simple, 4 factors are sought; reliability, longevity, fuel efficiency and purchase cost.

The goal is to achieve that first research project, evaluation project and comparative build, which transforms the CLP from alternative to near technology.
Some of the work load of this project inevitably generates some public domain general interest information, especially the first sequence of models, which commercially doesn't provide a return, but then that is another justification for public share of the financing.
The end goal is of course increased efficiency of power generation, reduced CO^2, SOx and NOx, and also of course, fuel consumption cost.

Trump Cards - There are 2 trump cards for the project;
(1) is that it works in parallel (not competing with) other technology currently being implemented, (2) is that it is a mechanical simplification.

Intellectual Property (See supporting documents).
Protected in applications PCT/GB2003/00671 & GB0301996.5.
- The patent application has been searched and declared novel by the UK and European Authority.
- The first PCT patent application format has been accepted as correctly presented by WIPO, and will be published in September.

technology

Appendix F – Business Cashflow

Assuming the CLP Project delivers attractive numbers and models, enough to snare manufacturers interest.
The business is likely to grow in several ways in 2004-6:-

- Exploratory licences issued to interested manufacturers.
- Additional contract designers or permanent staff (depending on workload) brought in house to deliver design work.

In the event of rather low commercial interest, a fallback option is for further grant assistance to build metal and firing prototypes in subsequent years. The EU's principal import is oil, and further research funding is therefore also likely (if this project stage proves useful).
After 2006, Squarise might build a team of unrivalled experts within the field of CLP Engines, and full production licences and royalties may be possible.
The much vaunted "holy grail" of engine design, whereby everybody adopts the CLP layout is very unlikely within the lifespan of the patent, simply because of the implementation cost implications.
However, more likely is a "critical mass" of adoption within a particular market sector (e.g. power generation), driven by competition, within a decade. I suspect overall, more money is to be gained developing Squarise as CLP experts, rather than sitting back and expecting royalties.

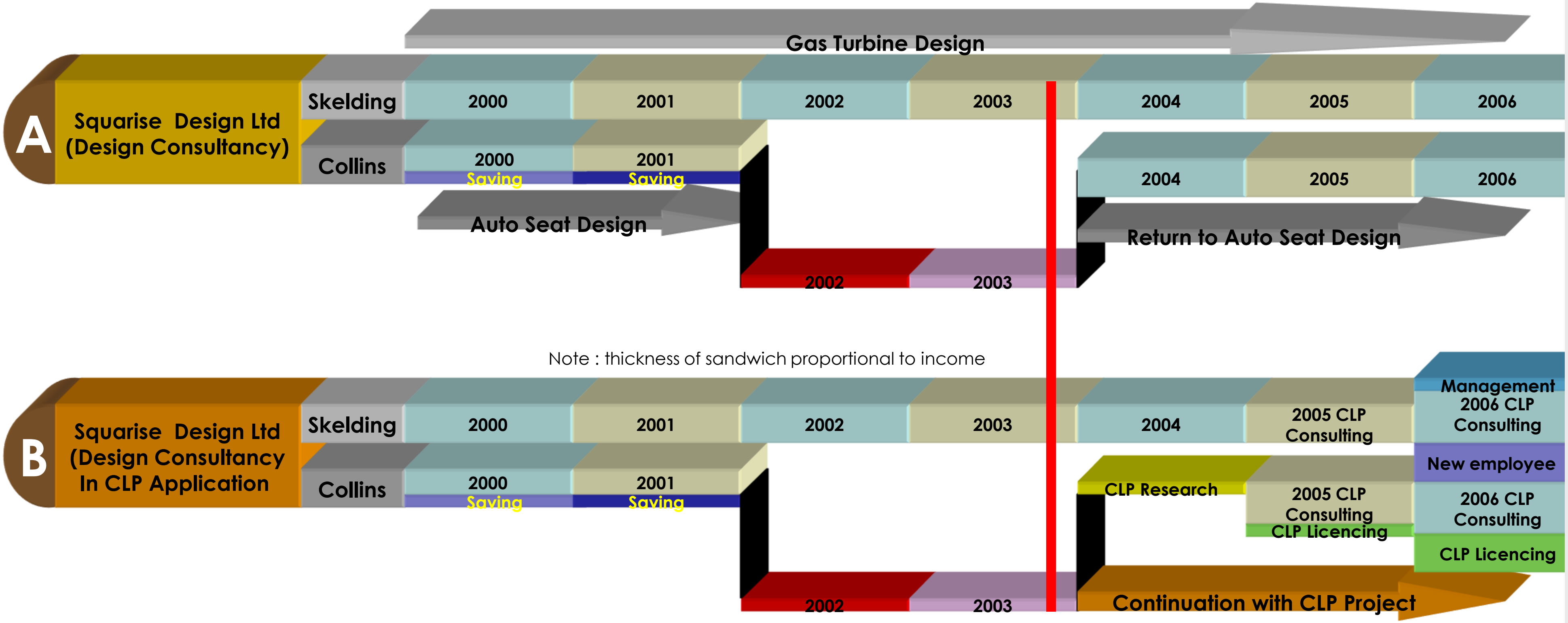
BUSINESS CASHFLOW	**Squarise Design Ltd**										**Appendix F**	
Year 1 of a 1 year project / Month	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**August**	**Total Yr 1**
Income (£)													
Sale of retained value items to BC	0	0	0	0	0	0	0	0	0	0	0	1,000	**1,000**
Working cash loan from B Collins	8,000	0	0	0	0	0	0	0	0	0	0	-8,000	**0**
R&D Grant	12,500	0	0	20,000	0	0	0	0	20,000	0	0	10,500	**63,000**
Other grants	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Sales	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Skelding Design Consultancy	2,000	5,000	5,000	6,500	5,000	5,000	5,000	5,000	5,000	6,500	5,000	2,000	**57,000**
Total	22,500	5,000	5,000	26,500	5,000	5,000	5,000	5,000	25,000	6,500	5,000	5,500	**121,000**
Expenditure (£)													
BC Salary (Inc NI and Tax)	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,800	1,700	1,700	**20,500**
CLP Engine Project Costs	4,450	2,350	880	1,230	4,360	230	230	6,050	9,230	230	1,430	230	**30,900**
CLP Engine Project OH's	770	770	770	780	780	780	810	810	810	840	840	840	**9,600**
Skelding CLP Engine Time	0	0	0	1,500	0	0	0	0	0	1,500	0	0	**3,000**
Skelding Costs and Overheads	500	500	500	500	500	500	500	500	500	500	500	500	**6,000**
Skelding Drawings (Inc NI+Tax)	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	**18,000**
Skelding dividend	0	0	0	0	0	0	0	0	0	0	0	33,000	**33,000**
Audit & Accountancy Fees	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Finance Charges: Bank	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**8,920**	**6,820**	**5,350**	**7,210**	**8,840**	**4,710**	**4,740**	**10,560**	**13,740**	**6,370**	**5,970**	**37,770**	**121,000**
Surplus (Deficit)	13,580	-1,820	-350	19,290	-3,840	290	260	-5,560	11,260	130	-970	-32,270	**0**
Retained value of new assets	350	400	250	0	0	0	0	0	0	0	0	-1,000	**0**
Balance (b/f from previous month)	0	13,580	11,760	11,410	30,700	26,860	27,150	27,410	21,850	33,110	33,240	32,270	**0**
Closing Balance (c/f to next month)	13,580	11,760	11,410	30,700	26,860	27,150	27,410	21,850	33,110	33,240	32,270	0	**0**

- BC NI paid in UK, but income tax paid in Sweden as a resident no. 690309-5096.
- Skelding; design consultancy, drawings, costs and dividend are all run completely partitioned from the CLP Engine project, except for his 120 hours contributed to the project.

Introduction :
The normal business model for Squarise design couldn't be simpler (***diagram A*** from 2004-2006).
Two employees both aim to put in as much as possible through design consultancy, then after business costs from each employees activities are subtracted, (including a salary), the remainder of the earnings are issued as a dividend or final drawing (both employees are directors), thereby each director takes out whatever he puts in.

The complication comes about when in the last 4 years, I have attempted to diversify the income, so that we become broader based inventing / design management company also. I have isolated my contribution from 2000 and 2001, saved then spent this on developing several ideas in my 2 year sabbatical period.
There are advantages of generating inhouse work over gas turbines/automotive which include; working from home/private office, controlling own destiny and stability of income source, and design "inpiration" of pollution reducing technology.

These sabbatical generated ideas are now completed, and it will be decided over the summer whether to take the ideas forward by out sourced funding ***(diagram B)*** (hence this application) or to return to consultancy, for a sustained period (A).



Note : thickness of sandwich proportional to income

Project Cost Breakdown	**Appendix C**
Squarise Design Ltd	
Expenditure (£)	**Year 1**
Pay of staff R Skelding	3,000
Pay of staff B Collins	62,500
Overheads (see 2004 Oh's)	9,600
Materials used during the project	960
Consultancy fees	1,200
Display Stand	1,000
Model Group 1	5,000
Model Group 2	2,000
Intellectual property costs	2,390
Computing	2,550
Engine Expo trip - Market assessment	6,000
Training	1,200
Contingency fund	600
Project costs (excluding Ohs and staff)	22,900
Gross Total Project Costs	**106,000**
Less estimated residual value of capital equipment, tooling and scrap material	**1,000**
Net Total Project Costs	**105,000**

Cost Summary

The project is a straight forward cost model. The end products are 2 families of engine models. This requires; one contract designer and associated overheads, and the actual cost of the externally produced STL models (but in house finished).

This ***Research Phase*** will develop a defined concept into a commercially realistic and attractive technology.

Staff

Ben Collins will provide 100% project commitment.
Robert Skelding will provide financial control and second opinion, also assisting at Engine Expo.
CV for both parties are contained in supporting documents.
Staff costs are based against current earning rates for Collins and Skelding (see invoices examples in the supporting documents)

Project Staff Costs					
Name	**Salary**	**Hourly Rate (£)**	**Daily Rate (£)**	**Daily Units**	**Total cost**
Ben Collins	0	28	250	250	62,500
Robert Skelding	0	25	250	12	3,000
					65,500

				Overheads for CLP Engine Research Project of Squarise Design Ltd.							
	A	B	C	D	E	F	G	H	I	L	
	Travel	Telecoms including isdn	Courier	Comp-uter inc printing	Tools / Materls	Bank & Money Transfers	General	Website Maint	Power	Office Space	
Sept-Nov 2003	250.00	200.00	40.00	50.00	60.00	40.00	200.00	70.00	50.00	1350.00	2310.00
Dec-Feb 2004	250.00	200.00	40.00	80.00	60.00	40.00	200.00	70.00	50.00	1350.00	2340.00
Mar-May 2004	250.00	200.00	40.00	150.00	60.00	80.00	200.00	70.00	30.00	1350.00	2430.00
June-Aug 2004	250.00	200.00	200.00	120.00	60.00	40.00	200.00	70.00	30.00	1350.00	2520.00
Totals for 2004	**1000.00**	**800.00**	**320.00**	**400.00**	**240.00**	**200.00**	**800.00**	**280.00**	**160.00**	**5400.00**	**9600.00**
Mileage	1200.00										**1200.00**
2004 TOTALS	**2200.00**	**800.00**	**320.00**	**400.00**	**240.00**	**200.00**	**800.00**	**280.00**	**160.00**	**5400.00**	**10800.00**

Research Project Cash Flow	**Squarise Design Ltd**											**Appendix E**		
Year 1 of CLP Engine Project														**Funding Ratio**
Month	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Total Yr 1**	
Expenditure (£)														
Robert Skelding	0	0	0	1,500	0	0	0	0	0	1,500	0	0	3,000	
Ben Collins	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,300	5,200	5,200	62,500	
Overheads (see 2004 Projected Ohs)	770	770	770	780	780	780	810	810	810	840	840	840	9,600	
Materials used during the project	80	80	80	80	80	80	80	80	80	80	80	80	960	
Mileage	100	100	100	100	100	100	100	100	100	100	100	100	1,200	
Display Stand	0	0	0	0	0	0	0	0	1,000	0	0	0	1,000	
Model Group 1	0	0	0	1,000	4,000	0	0	0	0	0	0	0	5,000	
Model Group 2	0	0	0	0	0	0	0	3,500	5,000	0	0	0	8,500	
Benchmark Engines Purchase	0	1,000	0	0	0	0	0	1,000	0	0	0	0	2,000	
Intellectual property costs	1,000	0	0	0	130	0	0	0	0	0	1,200	0	2,330	
Comp Upgrade / Projector / Plotter	900	920	650	0	0	0	0	0	0	0	0	0	2,470	
Engine Expo trip - Market assessment	1,320	0	0	0	0	0	0	1,320	3,000	0	0	0	5,640	
Solidworks Software/Training	1,000	200	0	0	0	0	0	0	0	0	0	0	1,200	
Continguency fund	50	50	50	50	50	50	50	50	50	50	50	50	600	
Project Costs exc Oh's + Labour	4,450	2,350	880	1,230	4,360	230	230	6,050	9,230	230	1,430	230	**30,900**	
Total	**10,420**	**8,320**	**6,850**	**8,710**	**10,340**	**6,210**	**6,240**	**12,060**	**15,240**	**7,870**	**7,470**	**6,270**	**106,000**	
Less Residual Value	350	400	250	0	0	0	0	0	0	0	0	0	1,000	
Net Project Expenditure	10,070	7,920	6,600	8,710	10,340	6,210	6,240	12,060	15,240	7,870	7,470	6,270	**105,000**	100%
Squarise Contribution	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	42,000	40.0%
R&D Grant	12,500	0	0	0	20,000	0	0	0	20,000	0	0	10,500	63,000	60.0%
Total Input	16,000	3,500	3,500	3,500	23,500	3,500	3,500	3,500	23,500	3,500	3,500	14,000	105,000	
Balance c/f	5,930	-4,420	-3,100	14,790	-6,840	-2,710	-2,740	-8,560	8,260	-4,370	-3,970	7,730	0	
Ben Collins Provided Float	8,000	0	0	0	0	0	0	0	0	0	0	0	-8,000	
Bank Account	13,930	9,510	6,410	21,200	14,360	11,650	8,910	350	8,610	4,240	270	8,000	0	

Spreadsheet Notes

- Engine expo, requires, payment of small booth, travel and accommodation, Booth 6081 is reserved, 12m^2, and opposite Bosch (everyone will visit them). Cost £2640 + travel, delivery and accommodation. http://www.ukintpress.com/engineexpo/
- Squarise contribution comprises labour contribution worth £3,400 per month *see annex E.
- The STL model costs are estimates, but should be accurate +/-25% - quotes are not available as the models dont exist yet.
- Display stand covers lighting, motors, wiring, construction etc necessary to mount 15 small engine models and images.
- A projector is necessary for the engine expo, but more especially as I have a slipped disc vulnerability and cannot sit down for more than 20 minutes. I have stood working for 8 months, but this is tiring!, hence I would like to try the dentist's chair + ceiling projection route next year.

CLP technology

squarise
design
ltd

www.clptech.com
info@clptech.com
Signalgatan 4b, Göteborg 413 18, Sverige. +46 31 422107
The CLP Technology project is managed through Squarise Design Ltd.
Squarise Design Ltd. 9 B, Silver Lane, Elvaston, Derbyshire UK DE72 3TQ.

Research Project Proposal

CLP Engine

technology

Ben Collins **July 2003**

SUPPORTING DOCUMENTS

A1 www.clptech.com

A2 Document "An Introduction to the Compact Linked Piston" – the latest embodiment is always to be found on the website.

A3 Last two years project concept phase expenses (contained as worksheets on the Excel file : 2003-07-09 CLP Engine RD spreadsheets.xls).

A4 Last two years accounts attached as word documents.

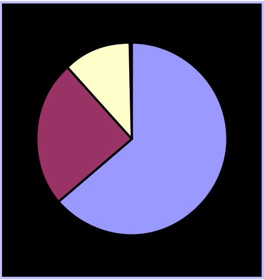
Last full contract year for Ben Collins

bens bottom line 5 Apr 01					
income	58177.98		deductions		
- VAT	-7297.45		tax /NI	6147.43	
+ interest	263.57		corp tax	2260.13	
income total	51144.10		squarise	1000.00	
			total	9407.56	
in yer bank	14186.80		in squarise	24866	
	1520.00				
	3250.00				
	2100.00				
	226.94		note: VAT to be paid on last 2 inv.		
total	21283.74		note: next dividend in late apr 01		
gross personal income					
salary	18600				
dividend	2310				
=	20910				

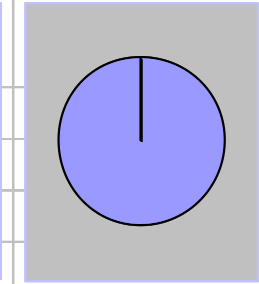
cyp
technology

Public / Private Finance Balance

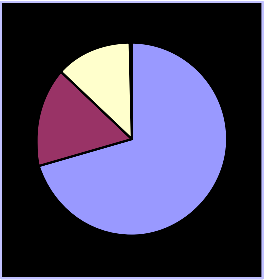
Concept Phase 2002	*Totals*	*Squarise Funded*	*% Squarise*	*Grant Award*	*% Public*
Staff	62,500	62,500	90.7	0	0.0
Models	512	512	0.7	0	0.0
Overheads	5886	5886	8.5	0	0.0
2001/2	**68898**	**68898**	**100.0**	**0**	**0.0**
Concept Phase 2003					
Staff	62,500	62,500	85.6	0	0.0
Models	1500	1,500	2.1	0	0.0
Overheads	9000	9,000	12.3	0	0.0
2002/3	**73000**	**73000**	**100.0**	**0**	**0.0**
Research Phase 2004					
Staff	65,500	42,000	43.5	23500	24.4
Costs	21,400	0	0.0	21400	22.2
Overheads	9,600	0	0.0	9600	9.9
2003/4	**96500**	**42000**	**43.5**	**54500**	**56.5**
Totals up to Commercial Phase					
Staff	190500	167000	70.1	23500	9.9
Models	23412	2012	0.8	21400	9.0
Overheads	24486	14886	6.2	9600	4.0
2002-04	**238398**	**183898**	**77.1**	**54500**	**22.9**



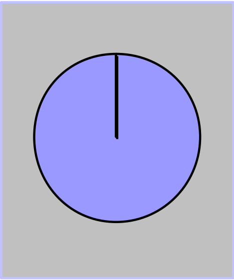
Staff / Models / OH



Public / Private



Staff / Models / OH



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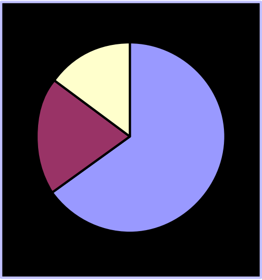
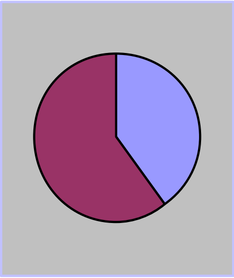
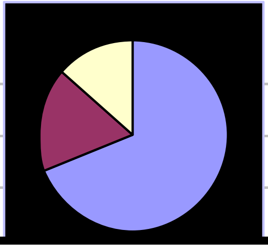
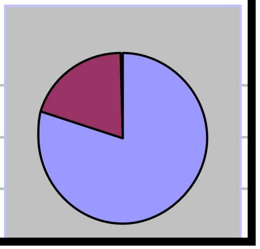


Staff / Models / OH

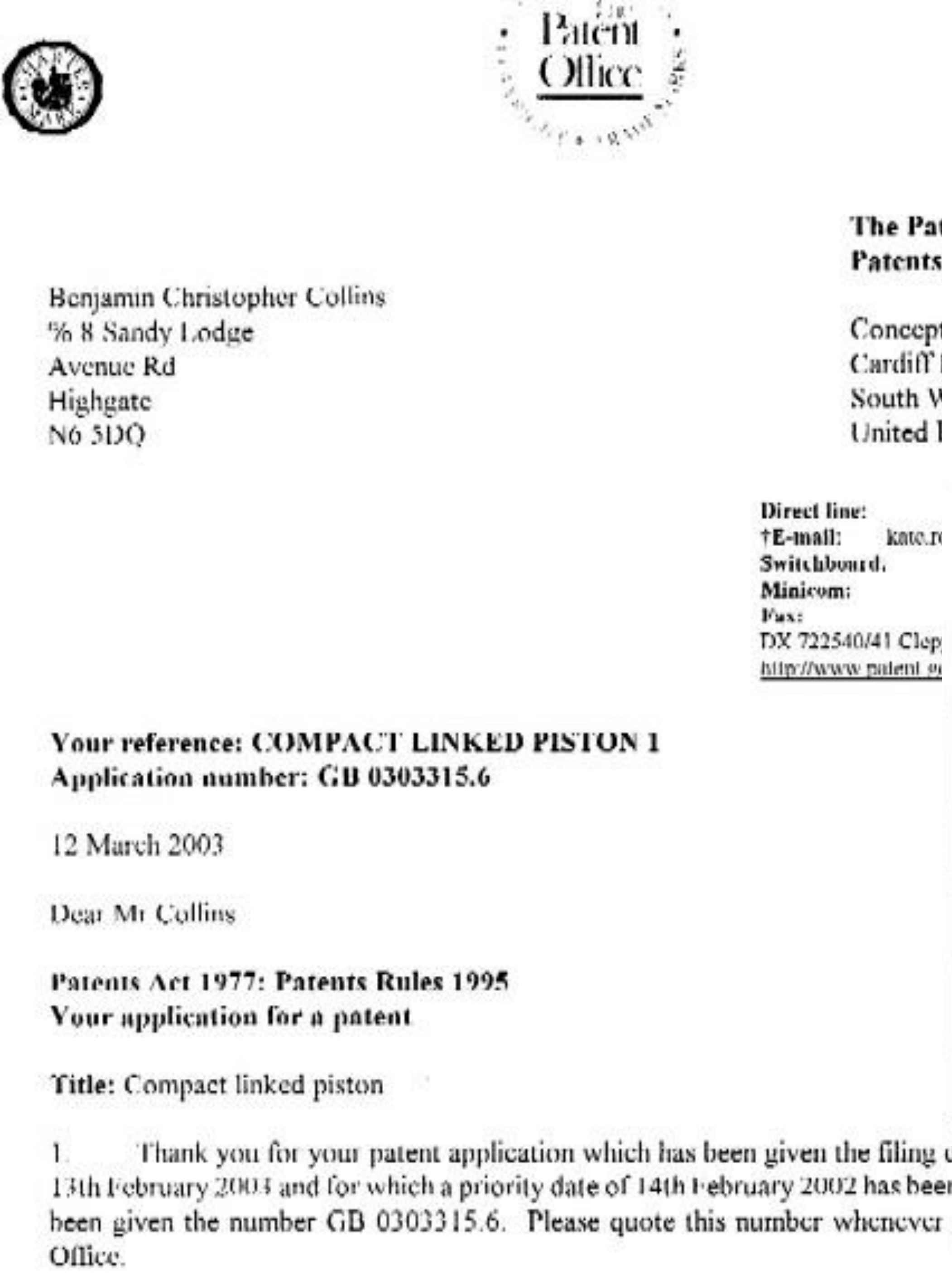


Public / Private





Patent application certificate



The Patent Office

The Pat
Patents

Concept
Cardiff
South W
United I

Benjamin Christopher Collins
℅ 8 Sandy Lodge
Avenue Rd
Highgate
N6 5DQ

Direct line:
†E-mail: kate.r
Switchboard:
Minicom:
Fax:
DX 722540/41 Clep
http://www.patent.g

Your reference: COMPACT LINKED PISTON 1
Application number: GB 0303315.6

12 March 2003

Dear Mr Collins

Patents Act 1977: Patents Rules 1995
Your application for a patent

Title: Compact linked piston

1. Thank you for your patent application which has been given the filing date of 13th February 2003 and for which a priority date of 14th February 2002 has been declared. It has been given the number GB 0303315.6. Please quote this number whenever you contact this Office.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

ONLY 'A'S "HURRAH!"

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 03/00671	International filing date (day/month/year) 13/02/2003	(Earliest) Priority Date (day/month/year) 14/02/2002
Applicant COLLINS, Benjamin Christopher		

NO ACTION REQUIRED

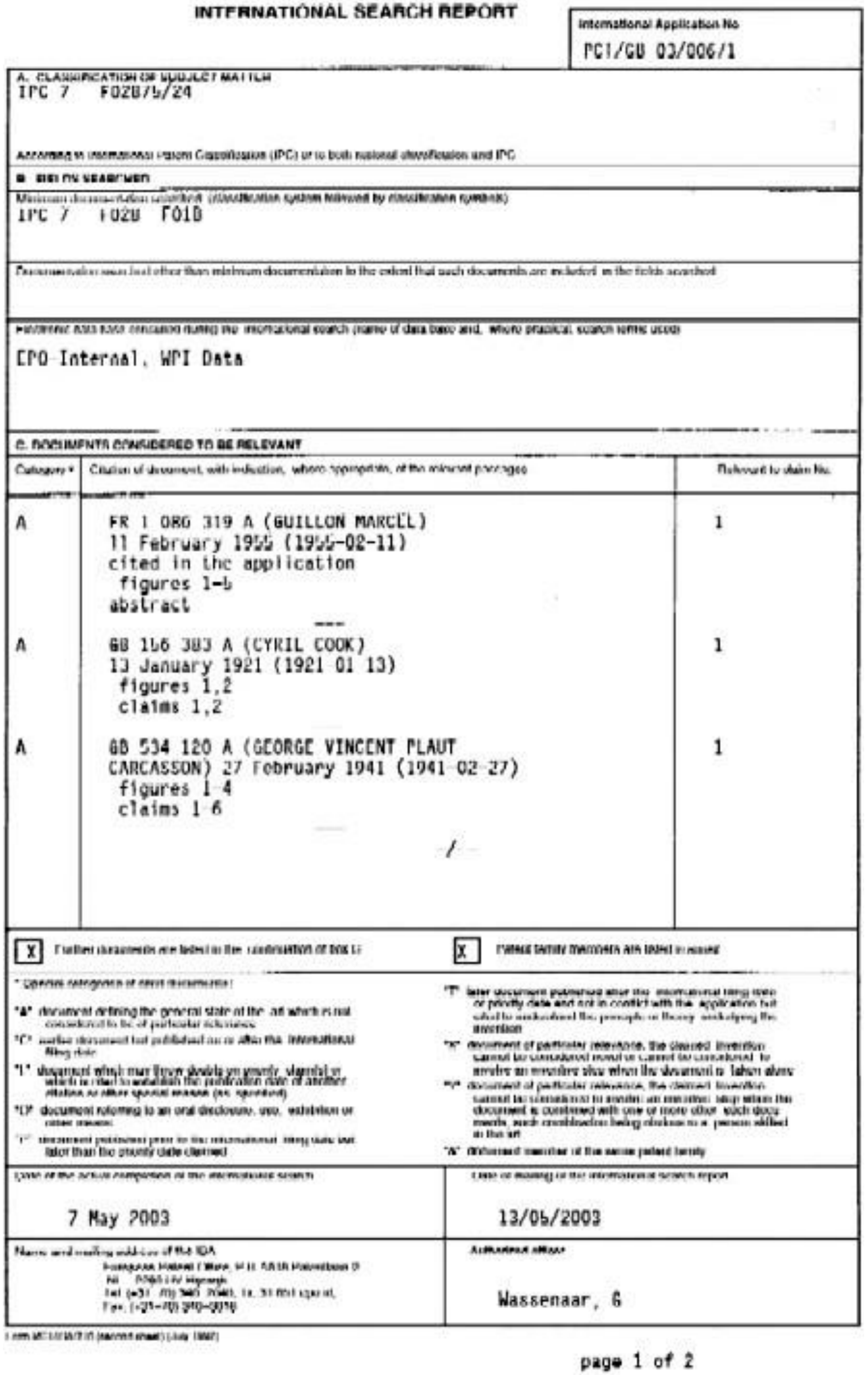
This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.
☒ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.
      ☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).
   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :
      ☐ contained in the international application in written form.
      ☐ filed together with the international application in computer readable form.
      ☐ furnished subsequently to this Authority in written form.
      ☐ furnished subsequently to this Authority in computer readable form.
      ☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
      ☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished
2. ☐ **Certain claims were found unsearchable** (See Box I).
3. ☐ **Unity of invention is lacking** (see Box II).
4. With regard to the **title**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract**,
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. The figure of the **drawings** to be published with the abstract is Figure No. 7
   ☒ as suggested by the applicant.
   ☐ because the applicant failed to suggest a figure.
   ☐ because this figure better characterizes the invention.
   ☐ None of the figures.

Form PCT/ISA/210 (first sheet) (July 1998)

WIPO patent search summary



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/006/1

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F02B75/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F02B F01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 1 086 319 A (GUILLON MARCEL) 11 February 1955 (1955-02-11) cited in the application figures 1-5 abstract ---	1
A	GB 156 383 A (CYRIL COOK) 13 January 1921 (1921-01-13) figures 1,2 claims 1,2	1
A	GB 534 120 A (GEORGE VINCENT PLAUT CARCASSON) 27 February 1941 (1941-02-27) figures 1-4 claims 1-6 ---	1

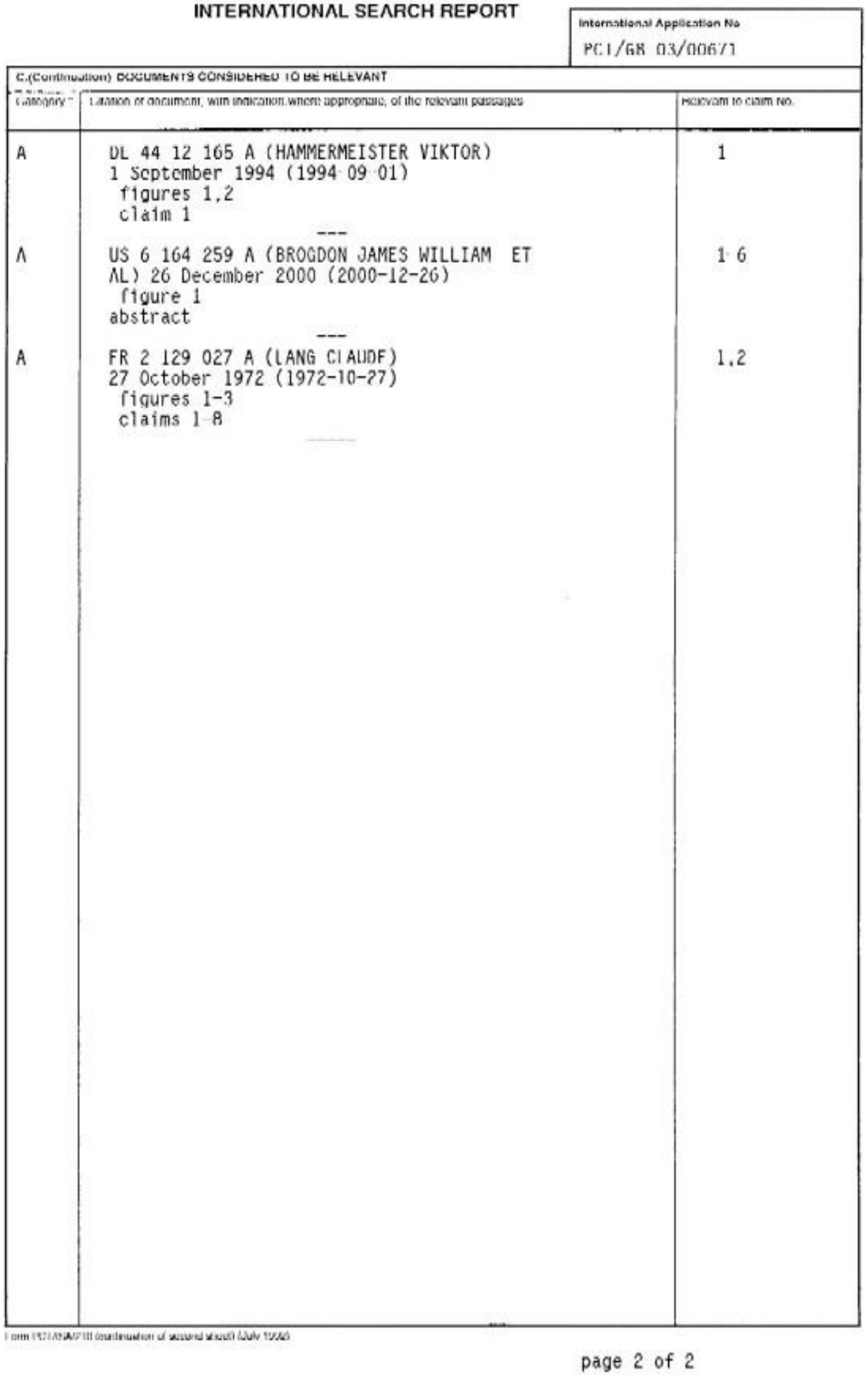
☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

Date of the actual completion of the international search	Date of mailing of the international search report
7 May 2003	13/06/2003

Name and mailing address of the ISA	Authorized officer
[illegible]	Wassenaar, G

page 1 of 2



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/00671

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 44 12 165 A (HAMMERMEISTER VIKTOR) 1 September 1994 (1994-09-01) figures 1,2 claim 1 ---	1
A	US 6 164 259 A (BROGDON JAMES WILLIAM ET AL) 26 December 2000 (2000-12-26) figure 1 abstract ---	1-6
A	FR 2 129 027 A (LANG CLAUDE) 27 October 1972 (1972-10-27) figures 1-3 claims 1-8 ---	1,2

page 2 of 2

technology

Curriculum Vitæ : Ben Collins : JULY 2003

Personal :

Benjamin Christopher Collins. Aged 34 years. British. Single. Male. Born Kendal, Cumbria, 9th March, 1969.
Signalgatan 4b, 413 18 Göteborg. Svensk Personal Number 690309-5096
Home +46 31 422107 Handy +46 708 453589 ben@clptech.com

Professional History :

2001-2003 *D*evelopment of CLP Engine, Airgonomic Truck and LaminR Vehicle Concepts.

1997-2001 Trimtec Autotechnic - Contract automotive design engineer - vehicle interiors including on site support at Eldra (Audi) and Johnson Controls (Fiat and Volvo). Especially safety elements of seat design, plastics and innovation.

1996-97 - Principal Product Development Engineer - Mainetti Technology Ltd. Developing new products, ancillaries, telecommunications systems, moulds, tooling, process improvement at Scotland's largest plastic processing company.
1995-96 - *Microfuge* bicycle transmission and two braking systems at the Centre for Sustainable Technology.
1994-95 Innovation research and product development at Sunderland University's Innovation centre. Focused on walking crutches, hand grips, bicycle suspension, (a front wheel suspension design won an Alcan design prize).
1989-94 Vehicle Design Engineer / Graduate Trainee - Hawtal Whiting, including six months at UMM in Portugal. Broad range including; crash testing, full scale vehicle interior and exterior modelling, styling, packaging, BIW.

Professional Skills :

Catia - IBM Germany Catia trained in Solids, Surfacing and Drawings (4 weeks) + 10,000 hours.

SolidWorks 97 and FEA - CosmosWorks (1 year).
2D draughting - AutoCad (6 years).
Broadly computer literate, Office, Lotus, Digital Cameras, DTP of brochures and technical Literature.
Ergonomic research, including collaboration with Loughborough Uni, Coopers Ltd and the Inst. of Naval Medicine.
Prototype builds, including; vehicles, mechanisms, bicycle components and general products.
Milling, turning, grinding, welding, moulding. Extensive practical experience. Engineering Certificate (Hackney).
Vehicle modelling and digitising - including foam, fibre glass and clay build up and body in white fabrication.
Patent and technical writing. Holder of current US patent no. 5,570,896, granted 5/11/96. Also 9 Patent Apps.
Graphic design - including packaging and carton design, design registration, trademarks and commissioning.

Design Summary :

Automotive design and prototype build.
Plastic moulding and extrusion.
Mechanisms, Bicycle frames, brakes, minor components and transmission.
Walking crutches.

Education :

BSc Honours (Sand) 8 "O" levels, 3 "A" Levels. Graduate Trainee with Hawtal Whiting (Leamington).
Degree 2:2 in **Engineering Product Design - multidisciplinary product engineering.**
94-95Sunderland University, Green Crescent, Sunderland SR1 - Innovation research.
87-91 South Bank University, Borough Rd, London SE1.
84-86 Ulverston Victoria High School, Ulverston, Cumbria LA12. 80-84 South Wolds Com, Keyworth, Notts NG12.

Personal Profile :

I am positive, methodical and versatile.
To relax I play; golf, football, snowboard, outdoor swimming and enjoy general socialising.
I have a clean European driving licence and speak basic German and Swedish.

Employment and Personal Referees :

Arnold Beunis, JCI Sweden, Arendal, Göteborg, Sweden. arnold.beunis@jci.com

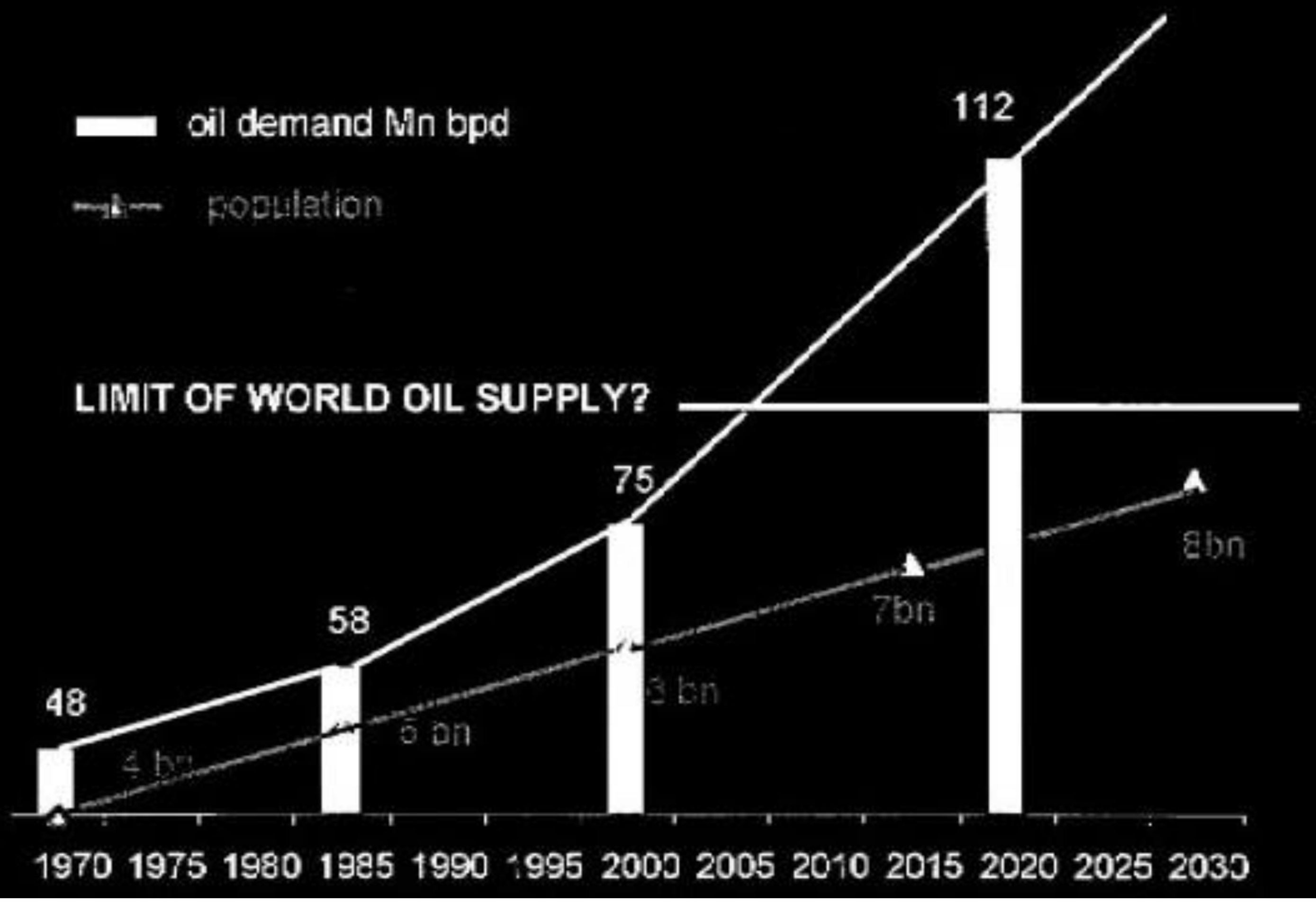
Peter Gillett, Director of Weapons Engineering, VSEL, High Medart, Ireleth, Askam, Barrow, Cumbria. LA16.

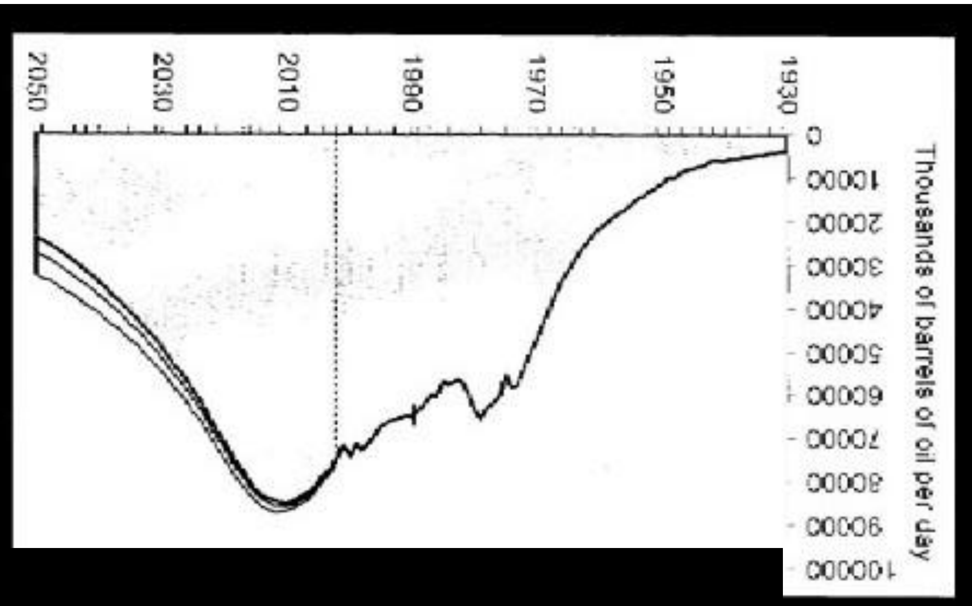
Robert Skelding
Born 1968.
Lives Elvaston Derbyshire.
Gas Turbine Designer.

Work Experience:
Rolls Royce Turbines Derby 1992-97
Boeing 1998
Inbis External Design Consultant 1999-2003

Global Oil Consumption Versus Population

Future oil demand is forecast to greatly exceed population growth rate





sources: oil demand - EIA, population - UN

World oil production set to peak

VW - response to concept.

- VW already make in line engines for all their cars. The cost a of a switch to boxer engines is too much. This illustrates why the car engine product is not an ideal first market for the CLP.
- Cars are chosen for the alloy wheels as much as the engine technology. The most suitable market therefore is an engine wholly concerened with effiiciency, pollution reduction and lower fuel consumption. That points to industrial engines, which is the also the conclusion in the marketing section.

Volkswagen AG · 38436 Wolfsburg · Deutschland

CLP Technology Sweden
Mr. Ben Collins
Signalgatan 4b

Göteborg 413 18
SWEDEN

Ihre Zeichen
Ihre Nachricht
dj Unsere Zeichen
05361-9-26578 Durchwahl
Telefax
E-Mail

10. März 2003 Datum

Compact Linked Piston Engine – Your letter from Febr. 03, 3th

Dear Mr. Collins,

thank you for having sent us over your detailed information regarding your compact linked piston design.

We checked all given datas at our Engineering Predevelopment Department with the result, that we are not interested in a further Cooperation with your product.

This is not due to any technical restriction or functional doubts but more caused by the general implementation possibilities. Your piston is designed for a Boxer-Engine application which is not in our aggregate portfolio.

Nevertheless we wish you much success and good luck for further acquisitions.

Best regards

Dirk Jaeckel
Assistant
Executive Director
Powertrain Development

Volkswagen AG
38436 Wolfsburg
Deutschland
Telefon (0 53 61) 9 0
Telefax (0 53 61) 9 2 82 82
E-Mail vw@volkswagen.d

Vorsitzender des Aufsichts
Ferdinand Piëch

Vorstand:
Bernd Pischetsrieder · Vors

Bruno Adelt
Robert Büchelhofer
Francisco J. Garcia Sanz
Peter Hartz
Jens Neumann
Folker Weißgerber
Martin Winterkorn

Markenvorstand Volkswag
Bernd Pischetsrieder · Vors

Wilfried Bockelmann
Francisco J. Garcia Sanz
Peter Hartz
Jens Neumann
Lothar Sander
Folker Weißgerber
Detlef Wittig

Volkswagen Aktiengesells
Sitz: Wolfsburg
Amtsgericht Wolfsburg
HRB 1200

More Positive Responses

From : stephen.dexter@avl.com
To : collinsben@hotmail.com
CC : wolfgang.kling@avl.com, theodor.sams@avl.com, karl.wojik@avl.com
Subject : Compact Linked Piston Engine
Date : Fri, 2 May 2003 16:44:58 +0100

[redacted]

Dear Mr. Collins,
Thank you for sending me details of this engine. We note your requirement to find an organisation to help you exploit it. I have asked colleagues to look at it with respect to application for large engines as well as automotive engines, though this may take a while since we receive many requests.
I should warn you that, while AVL invests some 10% of our turnover into research, we usually only take on projects from other companies on a fee paying basis. It is unlikely that AVL would put money into the engine since we do not see a way that we might get a return. Apart from instrumentation and software sales and sales of single cylinder engines for research, our only activity is design, research and development of engines.
While we would be very interested to work on this engine to make it a commercial success we would need a backer to fund it.
I am sorry that my reply has taken a little time. If you would like more information on ASV please let me know.
With kind regards and best wishes for success,

Stephen G. Dexter
Deputy Vice President & Product Manager
Large Engines

e mail: stephen.dexter@avl.com
Phone: +43 316 787 1416
Mobile phone +44 780 14 39 244
Fax: +43 316 787 1022

AVL LIST GMBH
A-8020 Graz, Hans List-Plat
http://www.avl.com

AVL – leaders in diesel design in Europe

This is a typical response from a non producing company but expert in the field.
Its pretty tough going to find a company that has money lying around, not already allocated to a research programme to investigate the CLP concept.
This illustrates the need for the grant and a model and a "numerification" bridge to the next stage.

cyp technology

Swedish Design Studio – Why?

Swedish Studio

Despite presently wishing a return to England, this isnt practical because of sever

- I am currently working from home at a reasonable rent (approx £10000 pa inc s a superb work location, with view, floorspace and balconies for fabrication work.
- Best contract situation – there is lots of contract design work in Goteborg right n I will be starting in October if this application is unsuccessful), while there is very lit automotive contract work in the UK presently.
- Goteborg is a major centre of engine engineering, including Wärtsila and Volvo both genset manufacturers.
- The cost of a move home is around £5,000 which cant be justified in the project

technology

squarise
design
ltd

www.clptech.com
info@clptech.com
Signalgatan 4b, Göteborg 413 18, Sverige. +46 31 422107
The CLP Technology project is managed through Squarise Design Ltd.

Squarise Design Ltd. 9 B, Silver Lane, Elvaston, Derbyshire UK DE72 3TQ.

An Introduction to the

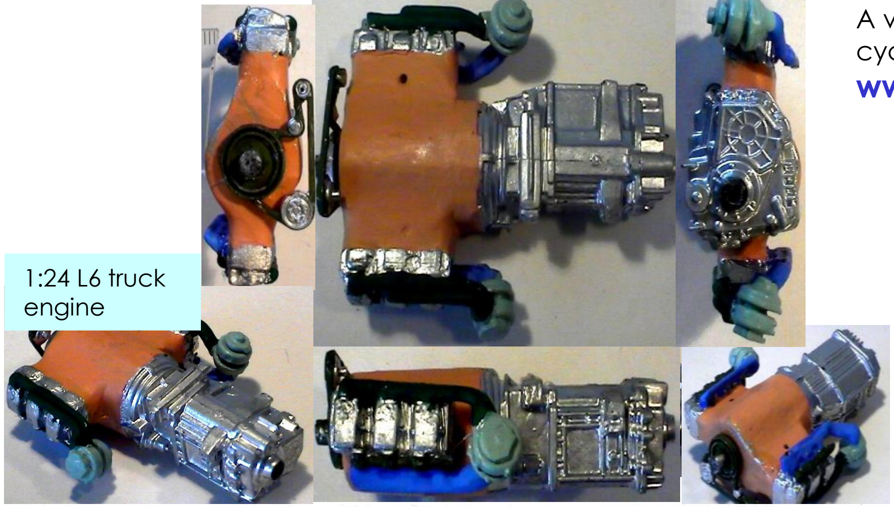
Compact Linked Piston Engine

clp
technology

clp technology

Contents & Introduction

A video of the engine cycle is available at **www.clptech.com**



1:24 L6 truck engine

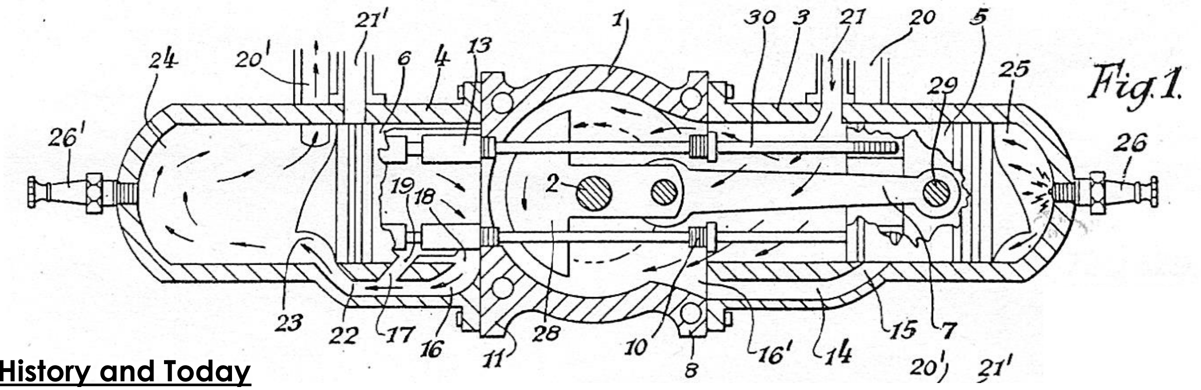


Fig. 1

Introduction : Compact Linked Piston Engines : History and Today

The linked piston was first conceived by Cyril Cook in 1920, developed by Marcel Guillion in the '50's, but still proved impractical to manufacture (shown above).

The "***compact*** linked piston" (CLP) employs a new "outboard" balanced crankshaft concept sympathetic to an also new wishbone structure for the linked piston, enabling sufficiently robust contruction of the rotating assembly in an *extremely compact* package.

Recent (economically realistic) material selection opportunities are also essential to achieve robustness and allow such construction.

Benefits

The CLP engine concept has been developed primarily to reduce friction, half effective stroking and reduce parts. The engine also; increases variability, reduces reciprocating and overall weight, improves piston cooling, pumping efficiency and packaging.

Applications

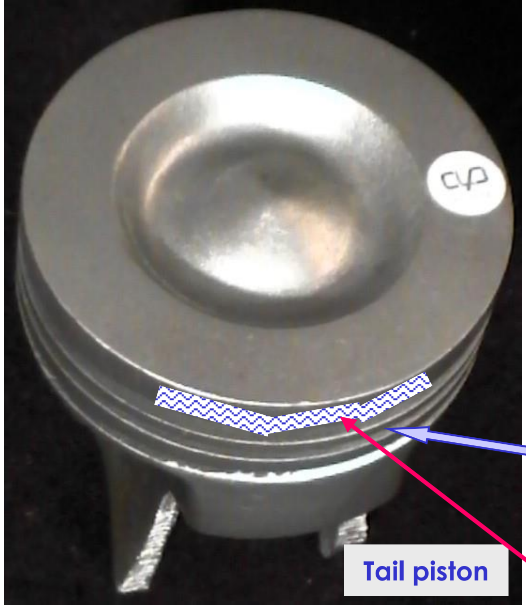
Several engine groups are particular suitable to the arrangement, especially large industrial powerplants. The larger diameter of high capacity piston means the crankshaft and piston legs retains a reasonable size, clearance and stiffness, because as sectional modulus increases disproportionately to size, load bearing capability and stiffness greatly improves.

2 Cycle Combustion and ***Compressor*** applications also have great potential, these are dealt with in separate documents.

The crankshaft and cylinder combination shown is based on a D129mm piston x 175mm stroke, 2.3litre Cylinder.

Wishbone Piston Features

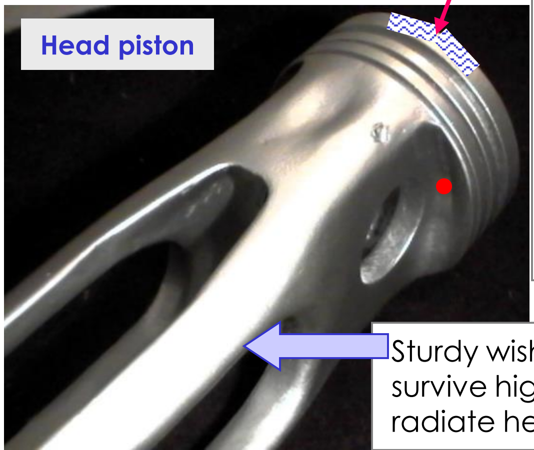
The compact linked piston (CLP) comprises a head and tail piston sharing one conrod connected at the head end.



Tail piston has no gudgeon pin and large radiator fins in the cool sump zone to improve cooling and cold tolerance compromises.

Because of improved alignment, the second piston scraping ring may be reduced in height or eliminated.

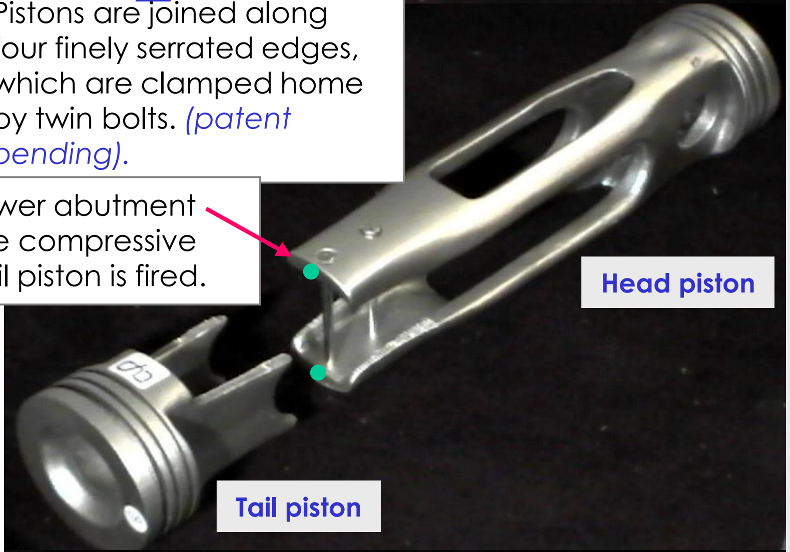
The main bore contact zone is above the upper piston ring. (▨)



The linked piston narrows and scallops (●)under each piston crown to improve cooling, and to provide room for a larger countermass (c/m). This lengthens the effective distance of the c/w to the fulcrum and crucially allows full width main bearings as the c/m now circumnavigates above the bearing. This keeps the overall package stiff yet very compact. *(patent pending)*

Sturdy wishbone pattern legs *(pat. pend)* survive high compressive loading, and radiate heat within the cooler sump zone.

Pistons are joined along four finely serrated edges, which are clamped home by twin bolts. *(patent pending).*



The upper and lower abutment faces (●) carry the compressive load when the tail piston is fired.

technology

Crankshaft Features

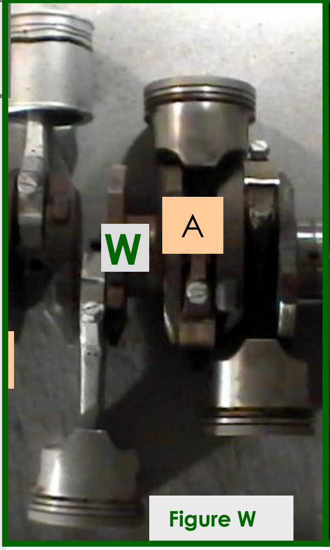


Figure W

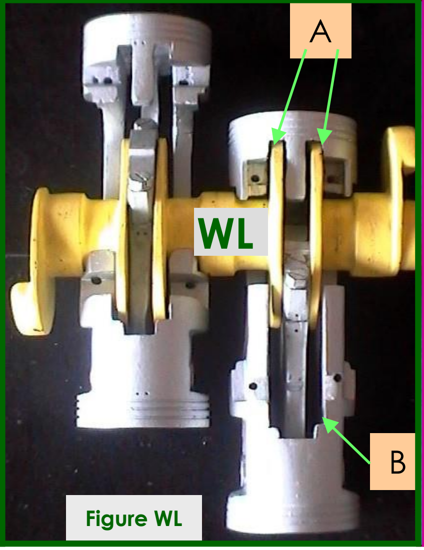


Figure WL

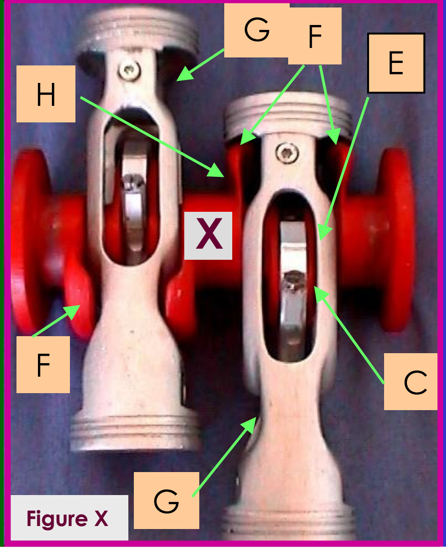


Figure X

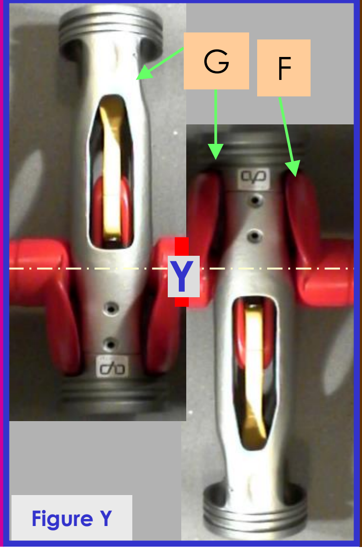


Figure Y

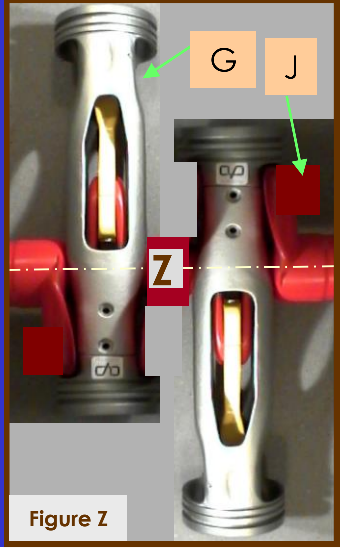


Figure Z

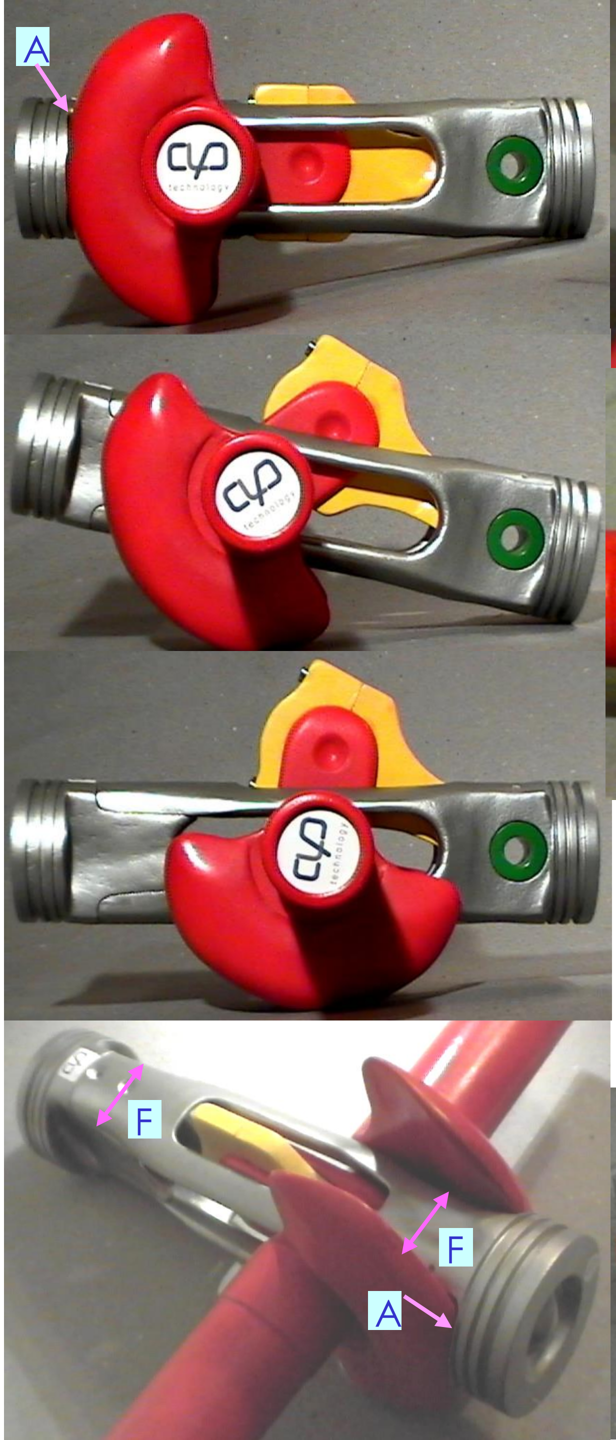
(W) Conventional Crankshaft shown in both figure W (normal piston) and WL (linked piston).
The disadvantage of this construction, also seen on Cook and Guillion’s first invention, is that the balance webs (A) cut a huge swathe (B) through the centre portion, reducing integrity and practicality for a CLP.

(X) Outboard Crankshaft *(patent pending)* – The principle advance of this concept is external balancing. Wherte the counterbalances are moved outboard, shown centre right, specifically suited to linked pistons, whereby the counter balance webs (H) are separated from the connector webs (C) required for the crank pins.
Because the central connector webs are much reduced in sized, only a modest sized hole (E) in the top and bottom of the linked piston centre is required to clear the rotation. The swollen tips (F) of the c.b. webs pass though grooves (G) on the linked piston at a point where there is plenty of metal for removal, so there is no width package penalty. The extra web carries a modest cost penalty but this is more than offset by the reduction in width and number bearings (7 to 4 on a straight 6) achieved by a CLP6.

(Y) Compact Outboard Crankshaft *(patent pending)* – by oven brazing SG 18.5 powder sintered countermasses too prepared crankshaft flanges, narrower countermasses are possible. This allows more room within the crankcase, so that a narrowed but realistic gudgeon pin can be brought between the countermasses, allowing the conrod, piston and overall block to be shortened.
This allows the important step where head and tail pistons can be alternated in banks so that better balance is achieved.
In addition this eliminates undercutting the base steel crankshaft, so that a more dramatic forging force can be delivered.

(Z) Single Outboard Crankshaft *(patent pending)* – Single outboard counter balancing moves all the countermass to one flange (J) hence is only suitable at the end cylinders, this may or may not prove advantageous in combination with (c) used in the centre position, but for instance with 4 cylinder as shown, both ends might feature the single countermass, thereby keeping the bores close together and the block size modest, whilst also simplifying and reducing crankshaft cost.

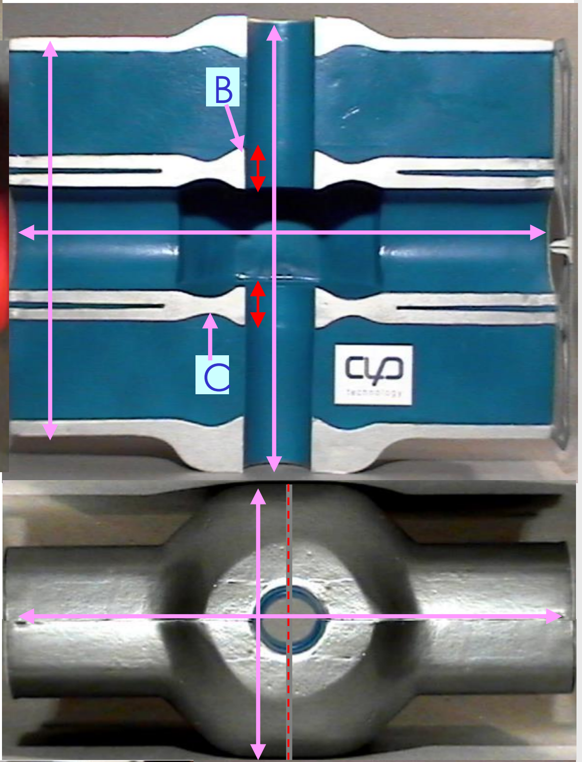
Block Features



An single cylinder countermassed crankshaft is shown, to illustrate just how much room is available.

The C/M's circumnavigate the main bearings, providing close on bearing support.

Main bearing width is kept broad (B), but space for the C/M's is provided immediately behind (C) *(pat pend)*.



Large components are packed into a very modest space. C/M's avoid the main piston wishbone width by swinging past the necked portion (F) and under scallops (A) under the piston crowns and beside the gudgeon pin. Block width, footprint and volume is reduced, employing a; narrow, light and stiff crankshaft. (countermass shown oversize).

technology

Assembly and Rotation


0°


90°


180°


270°


1a

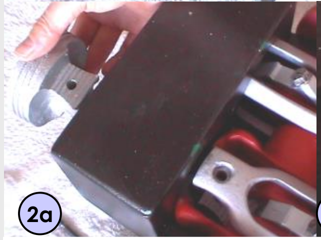

1b

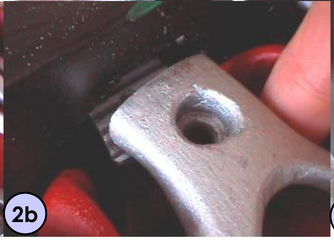

1c


1d


1e

Assy is identical to standard engine except where the tail piston is screwed to the head piston (2).


2a


2b

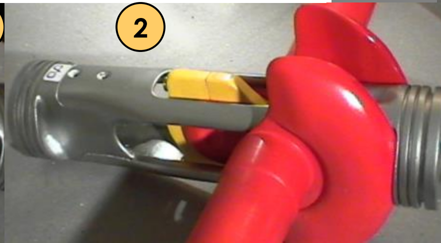

2c


2d


1a

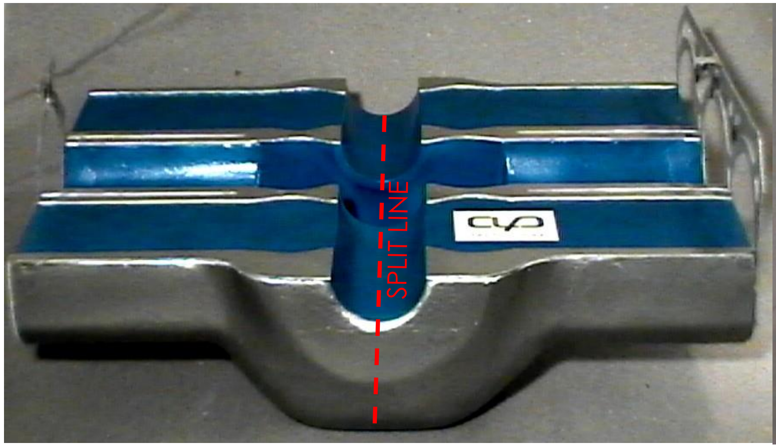

1b

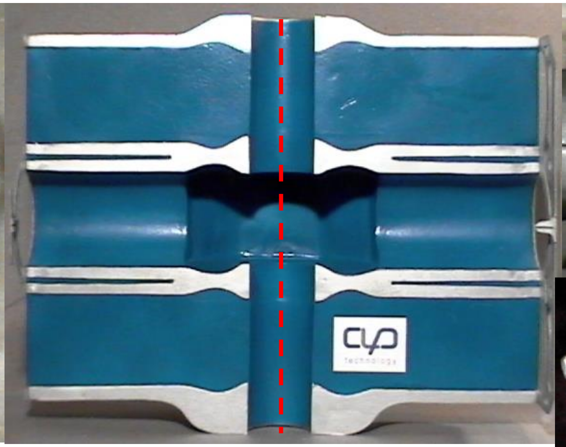

1c

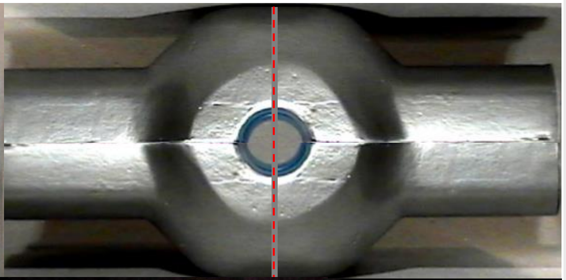

2

Block Production

- The two identical diecast halves are positively engaged and bolted together, machining the entire unit as one, wholly referenced unit.
- Huge ribbing surrounds the block to stiffen and strengthen, radiate heat, reduce noise and assist mounting.
- Block weight is reduced by @ 30% (using "short linked pistons" in a B6 truck)



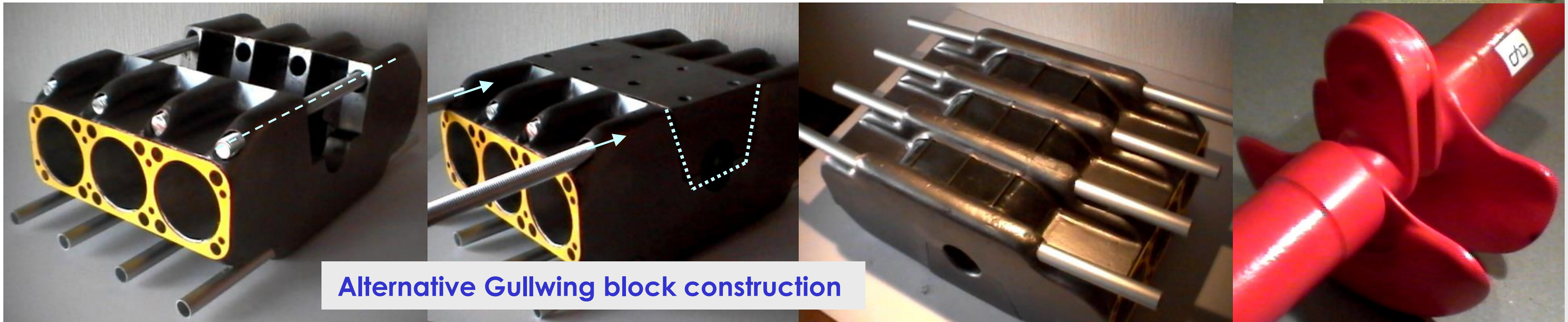




Likely Materials (truck engine):

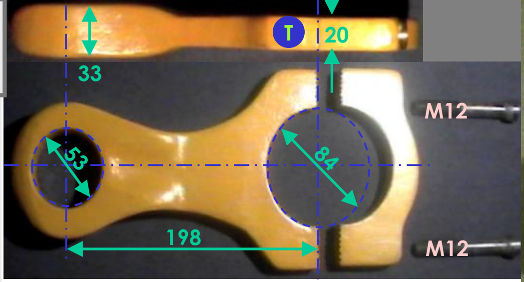
Shared rods and pins and a shorter crankshaft means "exotic" materials can be economically considered. The materials proposed match those projected for a typical production engine in 6 years.

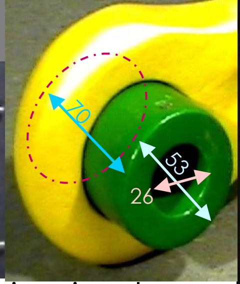
block -2 identical MMC diecast cylinder block and crankcase halves.
crankshaft -drop forged steel.
conrod -fracture-split conrods from forged-steel with M12 high tensile heavy duty bolts.
gudgeon pin-D50x30 nitrided steel.
head piston -squeeze cast metal matrix with cooled top ring carrier, 3 core box.
tail piston -squeeze cast metal matrix with cooled top ring carrier.

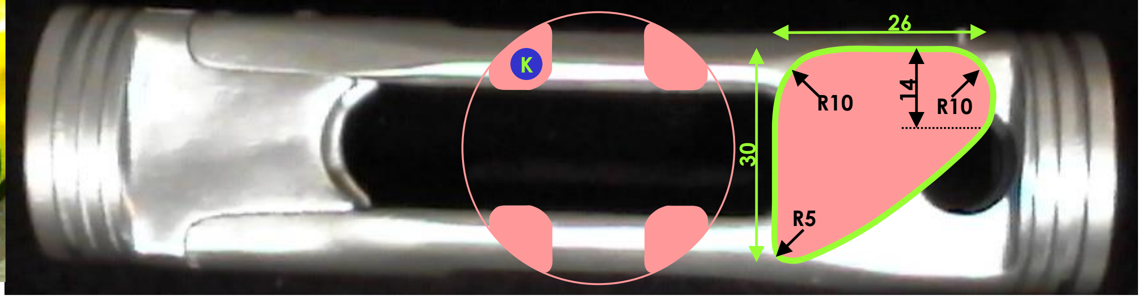


Alternative Gullwing block construction

2 x 2.3L Sizes and Masses



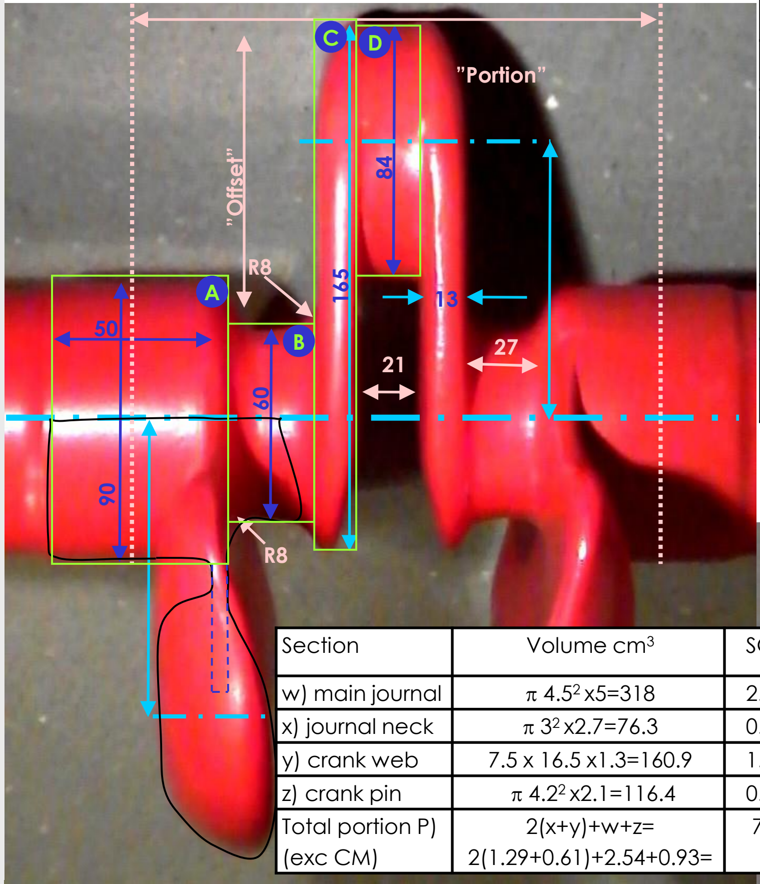




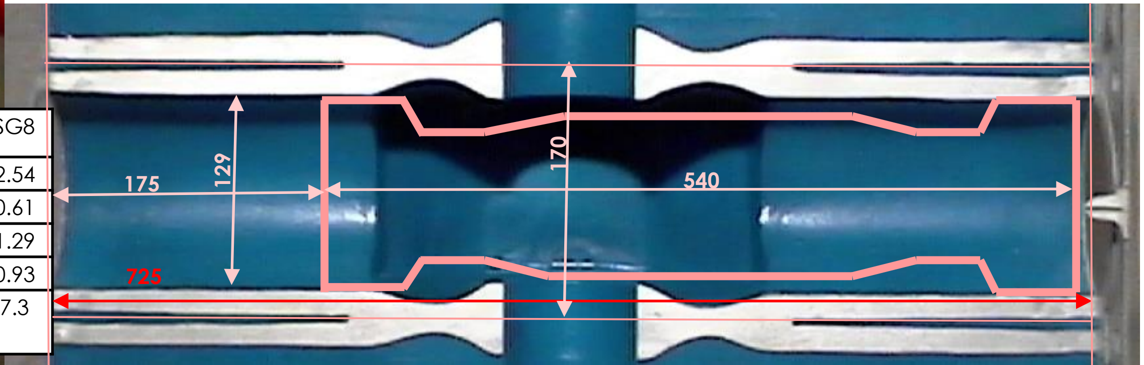
Dimensionally the CLP arrangement is uniquely compromised between four principal elements; crank neck diameter (B), crank web thickness (C), conrod width (T) and volume of the wishbone piston legs (K). All represent a fatigue strength and bearing challenge, but with appropriate materials, appear feasible and robust.

(see elementary calculations document by Robert Skelding)

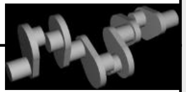
Component	Density sg	Volume Calculation	Vol (cm³)	Mass (Kg)
A) Head Piston	2.9	Displaced +/- 5%	1380	4.0
B) Tail Piston	2.9	Displaced +/- 5%	680	2.0
C) Clamp Bolt x2	7.8	$2(\pi\ 0.4^2x13)$	13	0.1
D) Conrod (inc bolts)	8.2	Displaced +/- 5%	500	4.1
E) Gudgeon Pin	7.8	$(\pi\ 2.6^2) - (\pi\ 1.3^2) \times 7$	111	0.9
F) Reciprocating	mixed	A+B+C+D/2+E =4.0+2.0+.1+2+0.9	-	9.0
G) Crankshaft "Offset"	8.0	$z+2(y-8\ \pi\ 4^2)=0.93+2(1.29-(\pi\ 16x8))=$	-	1.65
J) Counter mass	8.0	Displaced +/-10% (volume was maxed)	2x695	1.65
L) Crankshaft "Portion" (P)	8.0	7.3+1.65	-	8.95
M) CLP6 crankshaft	-	3P+w+key=3x9+2.5+1.8	-	31.3
N) 14L CLP6 bottom end (estimate!)	-	M+3F+Balancer shaft (8)= 31.3+(3x9)+8=	-	66.3



Section	Volume cm³	SG8
w) main journal	$\pi\ 4.5^2 x5=318$	2.54
x) journal neck	$\pi\ 3^2 x2.7=76.3$	0.61
y) crank web	7.5 x 16.5 x1.3=160.9	1.29
z) crank pin	$\pi\ 4.2^2 x2.1=116.4$	0.93
Total portion P) (exc CM)	2(x+y)+w+z= 2(1.29+0.61)+2.54+0.93=	7.3



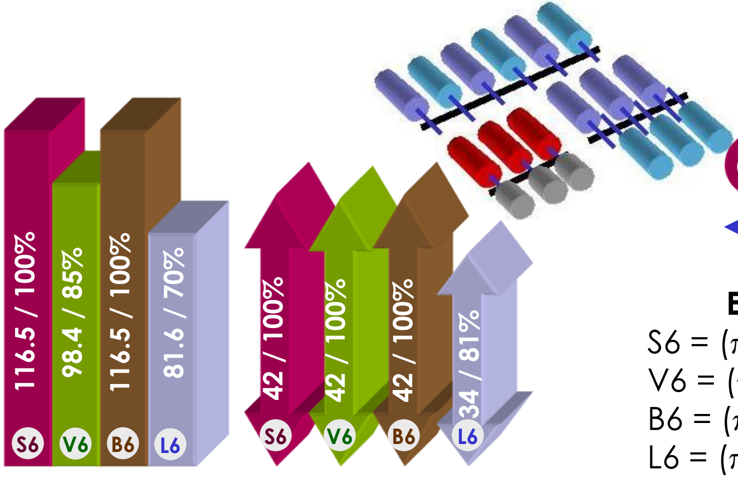
Comparitive Masses & Costs

Configuration	**Straight S6***			**Vee V6**			**Boxer B6**			**Linked L6**			**Notes**
Component	**#**	**Part**	**Total**	**#**	**Part**	**Total**	**#**	**Part**	**Total**	**#**	**Part**	**Total**	
Head Piston	6	2.6	15.6	6	2.6	15.6	6	2.6	15.6	3	4	12	As measured from the model
Tail Piston inc cl. bolts	0	0	0	0	0	0	0	0	0	3	2.1	6.3	As measured from the model
Conrod (inc bolts)	6	3.5	21	6	3.5	21	6	3.5	21	3	4.4	13	L6 conrod also tensile, 0.9kg heavier.
Gudgeon Pin	6	0.9	5.4	6	0.9	5.4	6	0.9	5.4	3	0.9	2.7	
Reciprocatinging	6	7	42	6	7	42	6	7	42	3	11	34	V6=2part webs,½ flyweb+2 pins
Crankshaft "Offset"	6	1.6	9.6	3	3.1	9.3	6	1.6	9.6	3	1.6	4.8	0.72+0.5(est)+2x0.93=3.1 
Countermass	6	1.6	9.6	6	3.1	18.6	6	1.6	9.6	3	1.6	4.8	V6 c/s shown left
Crankshaft centre shaft	6	4.3	25.8	3	4.3	12.9	6	4.3	25.8	3	4.3	13	Centre=w +2(8x4x π 3^2)=2.54+1.8=4.3
Crankshaft Portion/Total	6	12	74.5	3	15	48.4	6	12	74.5	3	12	39	CM+offset+Cen+1MJ(2.5)+Key(1.8)
End-end Balancer Shaft	0	(-)	0	1	(-)	8	0	(-)	0	1	(-)	8	Guestimate
Bottom end (kg)	**6**	**18.7**	**116.5**	**3**	**21.7**	**98.4**	**6**	**18.7**	**116.5**	**3**	**23.1**	**81.6**	

For comparitive purposes the crankshaft offset and webs etc have been kept identical where appropriate even though the S6, V6 and B6 would employ heavier (but tougher) crank webs etc because they dont face such space compromises.

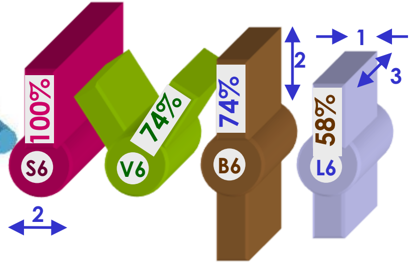
*The S6 also saves some; weight, cost and friction over the others by using only 1 (but double length) valvetrain.

The main question is of course whether the CLP crankshaft is sufficiently robust under such space compromise, but this is helped by its short and stubby length and reduced whipping.



Bottom End Mass (Kg)

Reciprocating Mass (Kg)



Estimated Block Mass

$S6 = (\pi*6)+(2*6) = 31x^3$

$V6 = (\pi*3.5)+2(2*3) = 23x^3$

$B6 = (\pi*3.5)+2(2*3) = 23x^3$

$L6 = (\pi*3)+(2*3)+(1*3) = 18x^3$

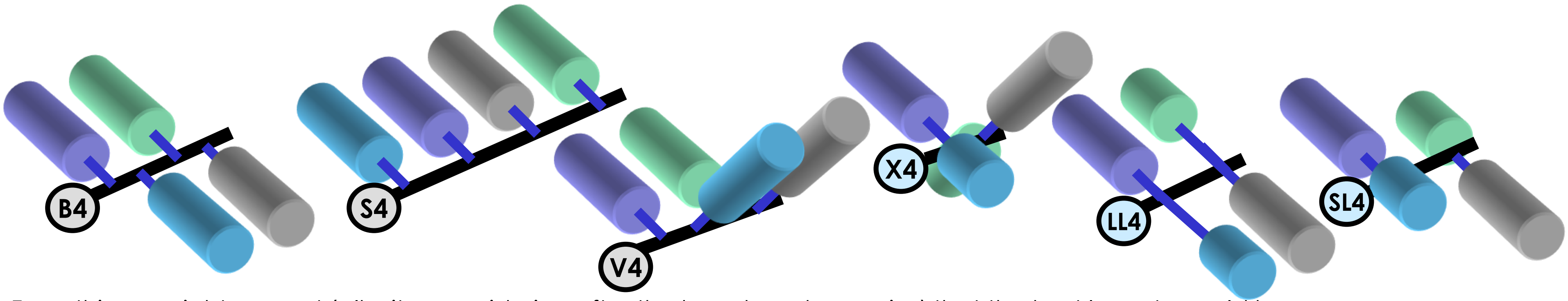
<u>$€+ Costs increase due to;</u>
2 valvetrains (as with Vee and boxer), bearing surfaces are narrowed and require special finishing.
The head piston, requires a 3 core mould.

New technology cost will be substantial, but in consideration of high volume and also assuming that current technology will move to squeeze cast pistons, in many applications the CLP reduces costs overall.

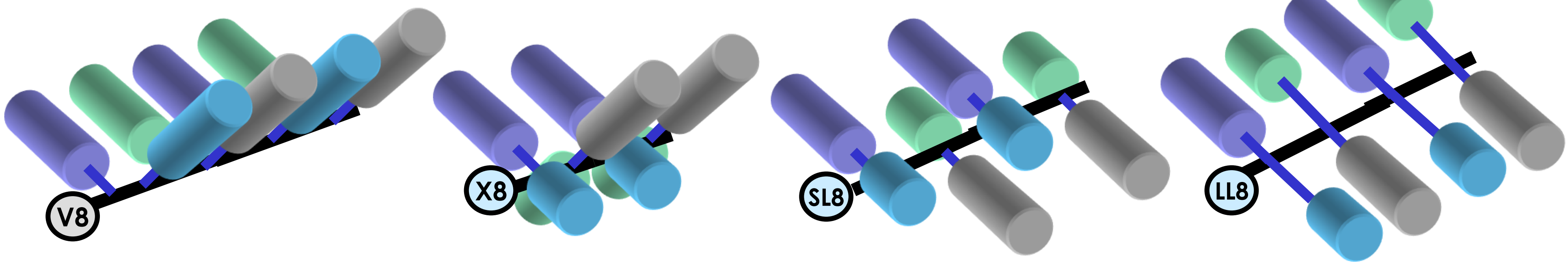
<u>$€- Costs reduce due to (eg truck);</u>
Fewer parts, smaller block, stubby crankshaft, 3 fewer main bearings, less materials.

Layouts and Notes

- **Unique CLP Layout** has major advantages and disadvantages that make most layouts self defining.
- **Single Balancer Shafts** (1:1 crankshaft speed) are required for 4 and 6 cylinder layouts.
- **Natural Balance** is available with 8 or 12 cylinders.
- **180dg Crankshaft Rotation** seperates head and tail piston firing in all cases. So firing order must take account of this and is equally important in choosing numbers of cylinders.
- **Smooth Torque** output is acheived with multiples of 4 cylinders, where firing is evenly spaced.
- **BDC Dwell** seen at the tail piston TDC demands sympathetic valve and injection timing.
- **"X" (Vee) or "Sheaf"** pattern engines are theoretically possible, but pretty much demand a new method of valve actuation over the ubiquitous camshafts in order to become economically viable, i.e. A return to pushrods or more likely electric valves.
- The X arrangement has 3 possible layouts; "Ex", "Cross" or "Swords" formation which correspond to head piston layout equivalents of; narrow Vee, 90dg Vee, and wide Vee, respectively. X "Swords" is shown as X4 and X8 below.
- A sheaf pattern would be a combination of two or more x patterns, rather like the VW "W" formation.
- Linked pistons can either be short (**S**) (lightest), or long (**L**) (which match up opposing valve trains- shown below inside right).



From this we might suggest (albeit reconsidering after the benchmark exercise) that the best layouts would be:
Boxer arrangement; 1 SL (S1), 2 SL (S1), 4 LL (B2), 6 SL (S3), 8 LL (B4) or 8 SL (S4), 12 SL (S6).
X arrangement; 4 SL (V2), 8 SL (V4), 12SL (V6).
There is a myriad of possible layouts. This choice is of course dependent on application environment, length of stroke etc , but likely to be most common is the LL4. These layouts and others will be built as models for the "benchmarking" exercise.
Even from this basic comparison, the smaller block and shorter crankshaft are evident.

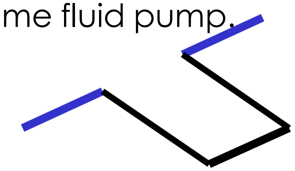


CLP1, CLP2 and CLP4

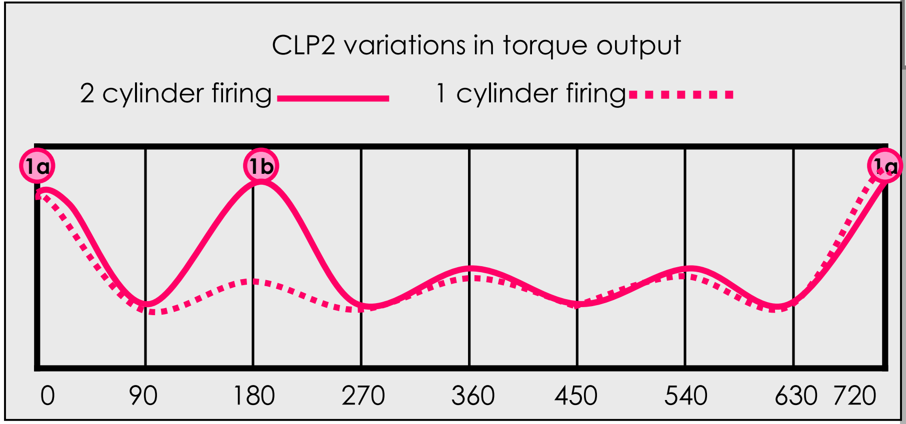
Firing Order CLP2: 1a,1b

	Cyl 1ha	Cyl 2ta
0	***TDC Fire***	BDC Intake
90	Power	Compr Stroke
180	BDC power	***TDC Fire***
270	Exhst stroke	Power stroke
360	TDC Exhst	BDC power
450	Intake stroke	Exhst stroke
540	BDC Intake	TDC Exhst
630	Compr	Intake stroke
720	***TDC Fire***	BDC Intake
rev	2	2

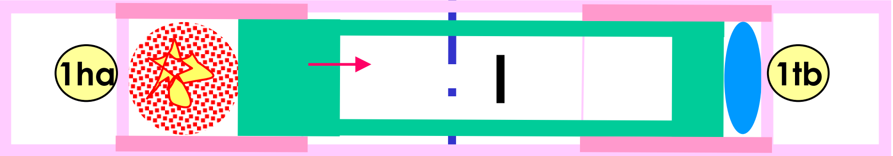
CLP1 is effective as a gearless high volume fluid pump.



CLP2 can work as a low friction generator, particularly in variable load conditions, where low load fires one side. Both L1 and L2 are unbalanced and have uneven torque spread, limiting refinement for other applications

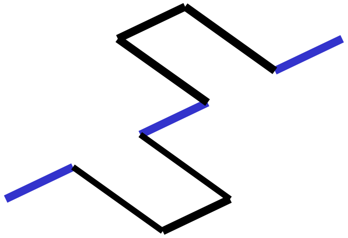

CLP2 variations in torque output

2 cylinder firing ▬ 1 cylinder firing ▪▪▪▪▪



Firing CLP4: 1a,1b,2b,2a

	Cyl 1ha	Cyl 2ta	Cyl 1tb	Cyl 2hb
0	***TDC Fire***	BDC power	BDC Intake	TDC Exhst
90	Power stroke	Exhst stroke	Compr Stroke	Intake stroke
180	BDC power	TDC Exhst	***TDC Fire***	BDC Intake
270	Exhst stroke	Intake stroke	Power stroke	Compr Stroke
360	TDC Exhst	BDC Intake	BDC power	***TDC Fire***
450	Intake stroke	Compr Stroke	Exhst stroke	Power stroke
540	BDC Intake	***TDC Fire***	TDC Exhst	BDC power
630	Compr Stroke	Power stroke	Intake stroke	Exhst stroke
720	***TDC Fire***	BDC power	BDC Intake	TDC Exhst
rev	2	2	2	2

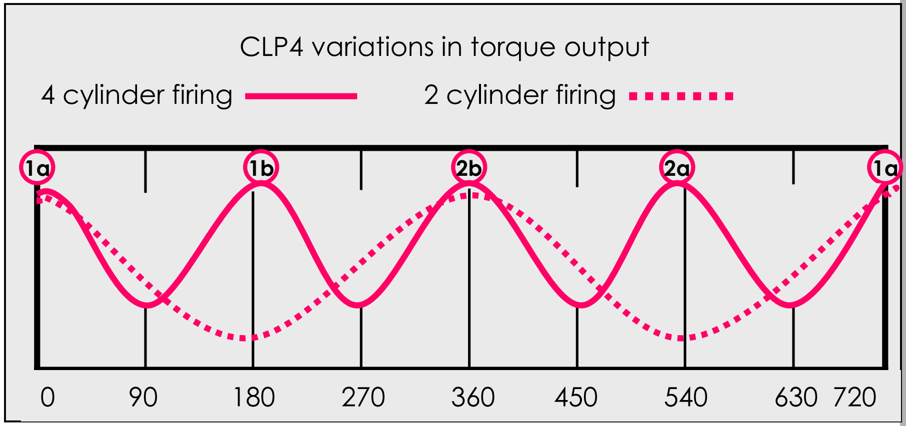


CLP4 makes a convincing argument for many applications.

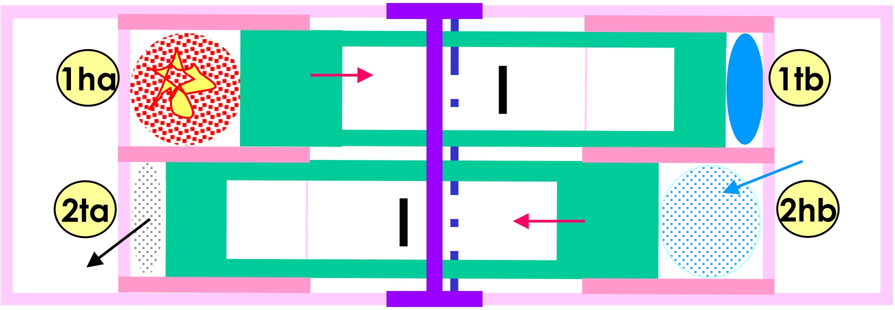
With just 1 "end to end" balancer shaft required (an S4 requires 2 balancers).

In addition CLP4 retains balance and even torque spread when fired on two cylinders only.

Broad range of applications and the most robust multi cylinder crankshaft.


CLP4 variations in torque output

4 cylinder firing ▬ 2 cylinder firing ▪▪▪▪▪

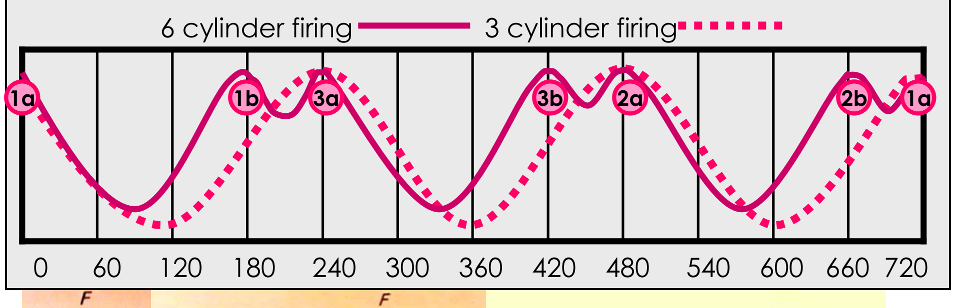


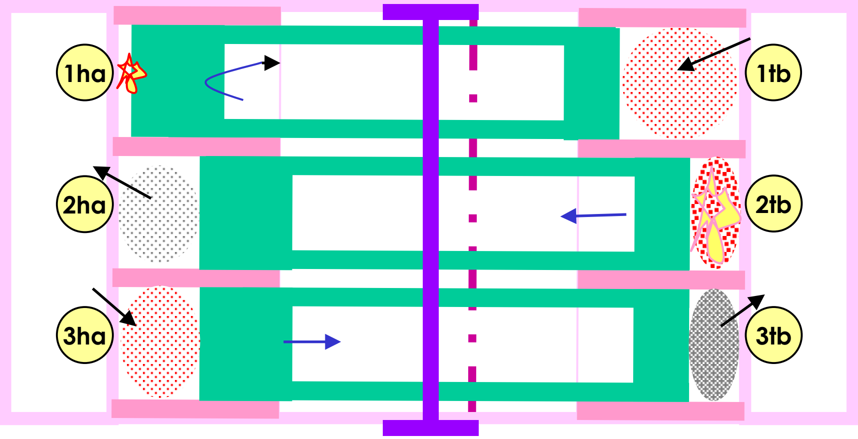
CLP6 (SL6)

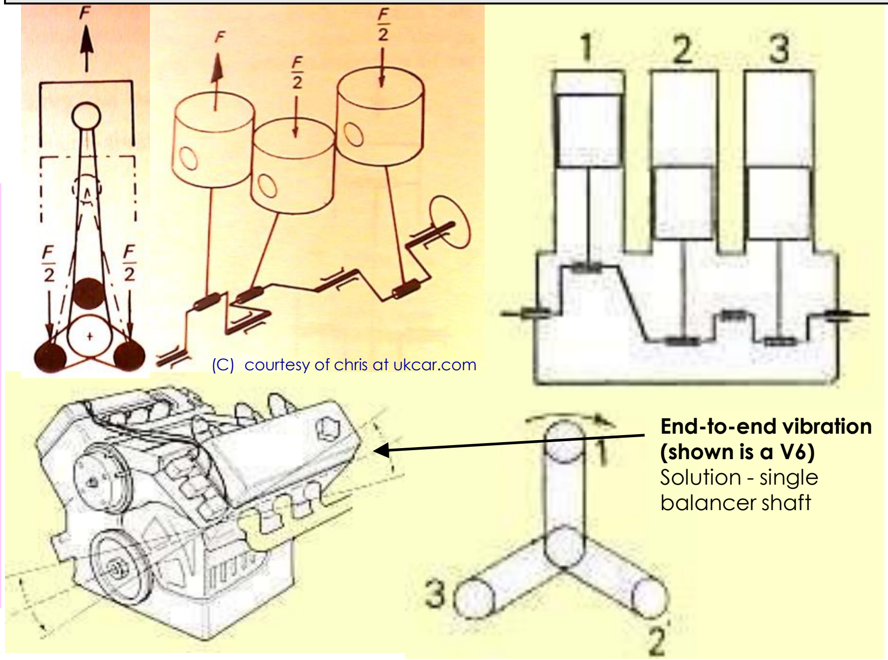
Firing Order % Cycle CLP : 1a,1b,3a,3b,2a,2b

Angle	Cyl 1a	Cyl 2a	Cyl 3a	Cyl 1b	Cyl 2b	Cyl 3b
0	TDC Fire	1/3 Exhst	2/3Intake	BDC Intake	1/3 power	2/3 Exhst
60	1/3 power	2/3 Exhst	BDC Intake	1/3Comprs	2/3 Power	TDC Exhst
120	2/3 Power	TDC Exhst	1/3Comprs	2/3 Compr	BDC power	1/3 Intake
180	BDC power	1/3 Intake	2/3 Compr	TDC Fire	1/3 Exhst	2/3Intake
240	1/3 Exhst	2/3Intake	TDC Fire	1/3 power	2/3 Exhst	BDC Intake
300	2/3 Exhst	BDC Intake	1/3 power	2/3 Power	TDC Exhst	1/3Comprs
360	TDC Exhst	1/3Comprs	2/3 Power	BDC power	1/3 Intake	2/3 Compr
420	1/3 Intake	2/3 Compr	BDC P	1/3 Exhst	2/3Intake	TDC Fire
480	2/3Intake	TDC Fire	1/3 Exhst	2/3 Exhst	BDC Intake	1/3 power
540	BDC Intake	1/3 power	2/3 Exhst	TDC Exhst	1/3Comprs	2/3 Power
600	1/3Comprs	2/3 Power	TDC Exhst	1/3 Intake	2/3 Compr	BDC power
660	2/3 Compr	BDC power	1/3 Intake	2/3Intake	TDC Fire	1/3 Exhst
720	TDC Fire	1/3 Exhst	2/3Intake	BDC Intake	1/3 power	2/3 Exhst
revs	2	2	2	2	2	2

Uneven torque output occur when using 240° crank spacing







(C) courtesy of chris at ukcar.com

End-to-end vibration (shown is a V6)
Solution - single balancer shaft

CLP 6 Cylinder Balance

The engine behaves roughly as a straight 3, albeit, firing twice as often as a straight 3 in the 720° cycle.

"In a straight three, primary and secondary forces balance out while end to end moments can be cancelled by a Simple balancer shaft driven 1:1 by the crankshaft" *[1]Fundamentals of automotive technology. VAW Hillier

In addition, the short stubby crankshaft does not suffer from the torsional oscillation found on a Straight 6 crankshaft.

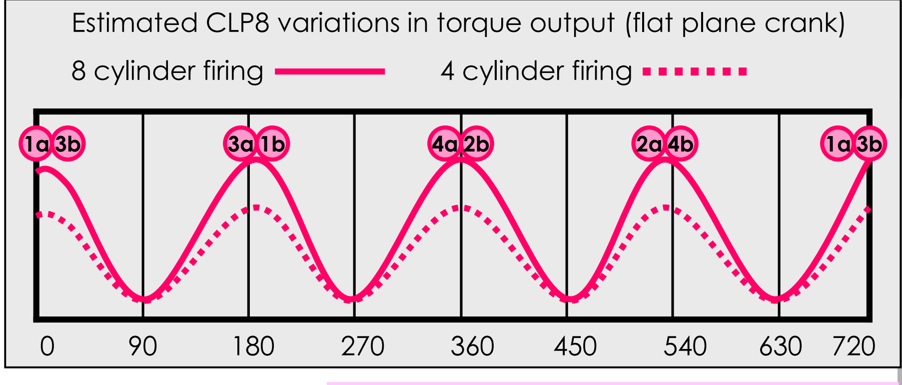
However, the engine produces a double pulse in a 60° crank phase, which gives a higher torque pulse, reducing smoothness, which may be unacceptable in some applications.

When fired as a 3 cylinder, perfect balance and smoothness is achieved, flexible capacity is also simplifes as 1 bank of cylinders can be closed off. Furthermore the block size may be even smaller than previously claimed (page 8), dependent on conrod length and because "short pistons can be used". (To be further investigated in benchmarking).

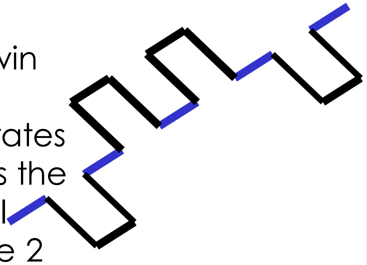
This engine is perfectly suited to work as a multi cylinder compressor. The tail piston might also have a different capacity to suit the pumping medium.

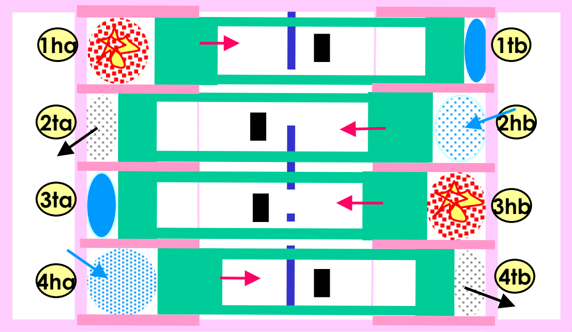
Flat Plane Firing CLP8 : 1a&3b,3a&1b,4a&2b,2a&4b

	Cyl 1a	Cyl 2a	Cyl 3a	Cyl 4a	Cyl 1b	Cyl 2b	Cyl 3b	Cyl 4b
0	***TDC R***	BDC P	BDC I	TDC E	BDC I	TDC E	***TDC R***	BDC P
90	Power	Exhst	Compr	Intake	Compr	Intake	Power	Exhst
180	BDC P	TDC E	***TDC R***	BDC I	***TDC R***	BDC I	BDC P	TDC E
270	Exhst	Intake	Power	Compr	Power	Compr	Exhst	Intake
360	TDC E	BDC I	BDC P	***TDC R***	BDC P	***TDC R***	TDC E	BDC I
450	Intake	Compr	Exhst	Power	Exhst	Power	Intake	Compr
540	BDC I	***TDC R***	TDC E	BDC P	TDC E	BDC P	BDC I	***TDC R***
630	Compr	Power	Intake	Exhst	Intake	Exhst	Compr	Power
720	***TDC R***	BDC P	BDC I	TDC E	BDC I	TDC E	***TDC R***	BDC P
rev	2	2	2	2	2	2	2	2


Estimated CLP8 variations in torque output (flat plane crank)

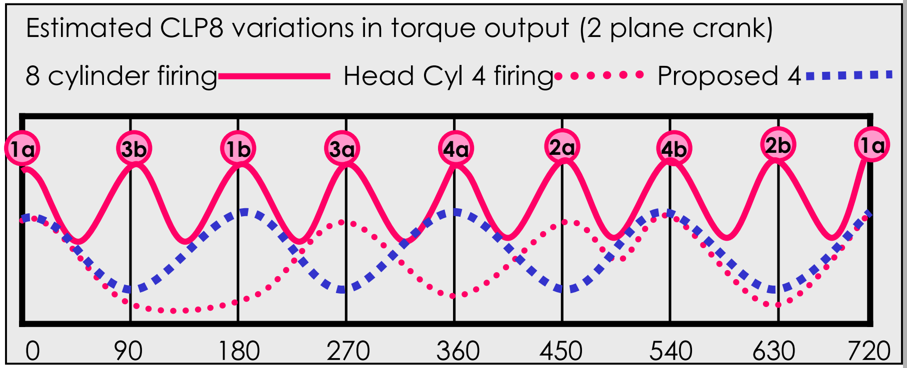
The crankshaft pattern and balance characteristic matches those of a boxer 4, i.e. naturally balanced. Likely to employ twin turbos, even when fired on the head pistons only (as a 4 cylinder), so both turbos stay warm and the engine now operates exactly as a B4. The most unfortunate unavoidable resultant is the double fire pulse which demands a beefier powertrain overall and places further demand on the crankshaft, hence only the 2 plane type crankshaft can be considered (below) which does not suffer this drawback.



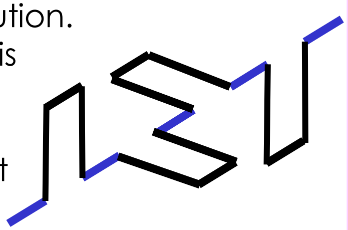


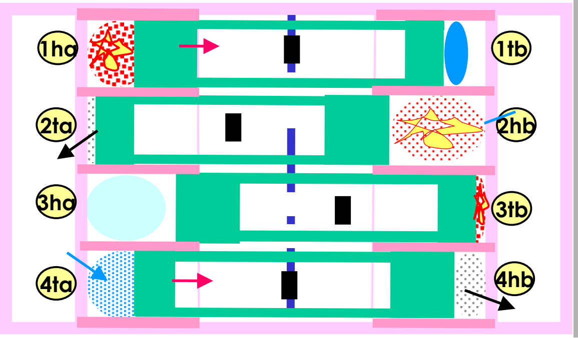
Cross Plane Firing CLP8 : 1a,3b,1b,3a,4a,2a,4b,2b

	Cyl 1a	Cyl 2a	Cyl 3a	Cyl 4a	Cyl 1b	Cyl 2b	Cyl 3b	Cyl 4b
0	***TDC R***	Exhst	Intake	TDC E	BDC I	TDC E	Compr	BDC P
90	Power	TDC E	BDC I	Intake	Compr	BDC P	***TDC R***	Exhst
180	BDC P	Intake	Compr	BDC I	***TDC R***	Exhst	Power	TDC E
270	Exhst	BDC I	***TDC R***	Compr	Power	TDC E	BDC P	Intake
360	TDC E	Compr	Power	***TDC R***	BDC P	Intake	Exhst	BDC I
450	Intake	***TDC R***	BDC P	Power	Exhst	BDC I	TDC E	Compr
540	BDC I	Power	Exhst	BDC P	TDC E	Compr	Intake	***TDC R***
630	Compr	BDC P	TDC E	Exhst	Intake	***TDC R***	BDC I	Power
720	***TDC R***	Exhst	Intake	TDC E	BDC I	Power	Compr	BDC P
rev	2	2	2	2	2	2	2	2


Estimated CLP8 variations in torque output (2 plane crank)

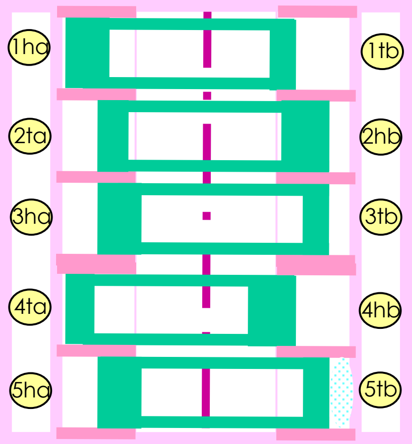
This crankshaft delivers perfect balance and even firing distribution. The only apparent disadvantage is with 4 cylinder firing which is uneven, however if only piston 1a&b and 4a&b are fired, the torque output is smoothed (shown blue). (or 2a&b and 3a&b). The 8 cylinder format is probably the limit of a sufficiently robust crankshaft for use as a variable load, heavy duty engine. The CLP8 provides a low friction balanced and smooth arrangement.



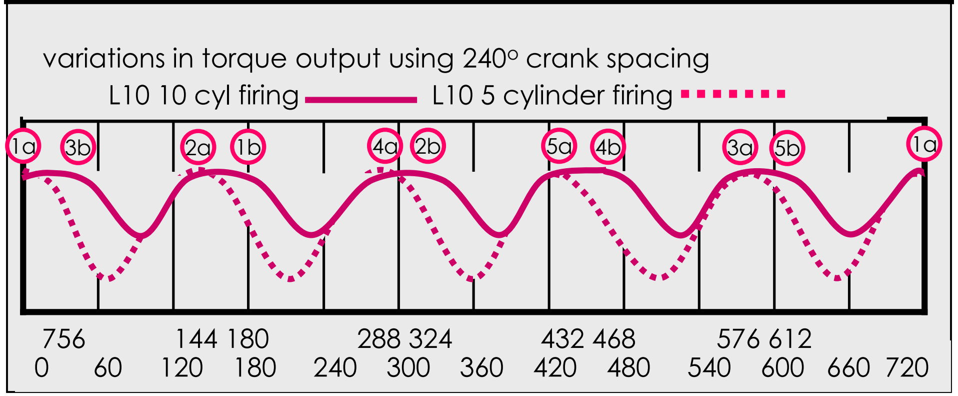


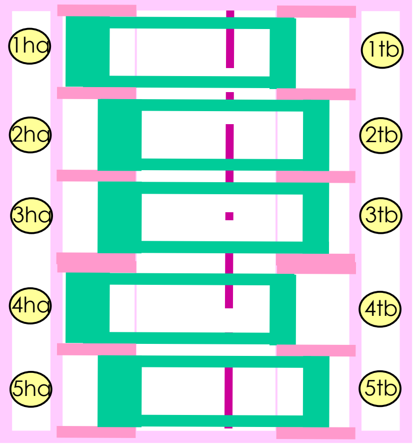
CLP8 (L8)

CLP10, CLP12+

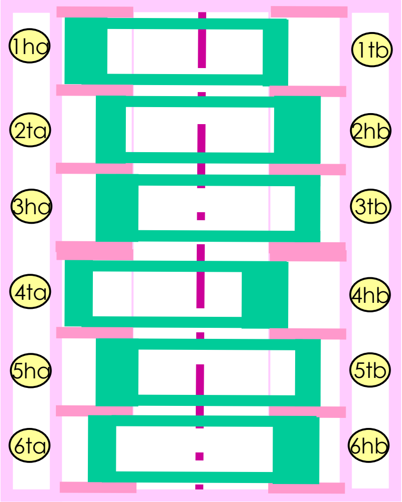


Firing CLP10 (debatable) 1a,,2a,1b,4a,2b,5a,4b,3a,5b

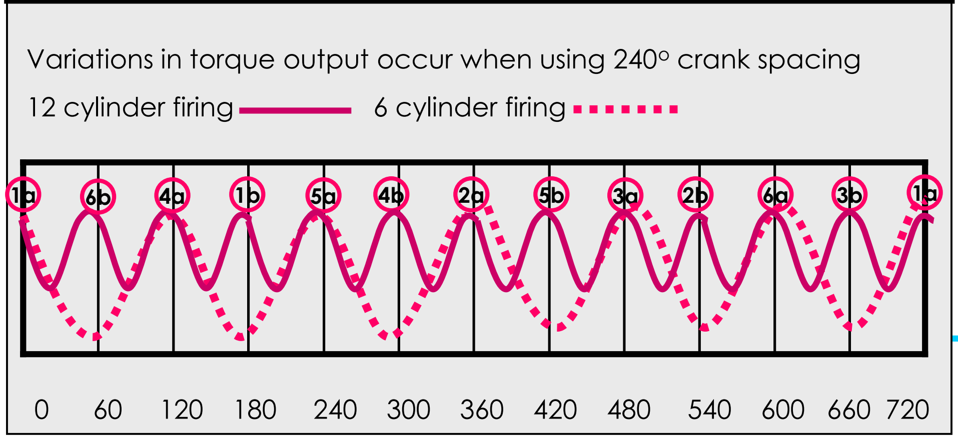




The CLP10 has 2 formats where the head pistons form one bank (LS5 pattern), or as in the "VW" LV5 configuration (above left). The author does not know the balance characteristic of the V5, so comment is limited. Torque input is adequately spread but *not even*. Therefore the CLP10 in either format is unfavourable to the smoother L8 and L12.

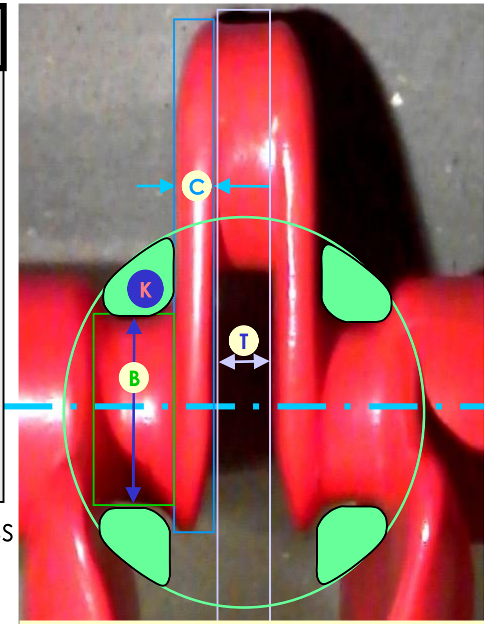


Firing CLP12 1a,6b,4a,1b,5a,4b,2a,5b,3a,2b,6a,3b



The crankshaft pattern match those of a boxer 6, perfectly balanced. Torque smoothness is V12. CLP12 cylinder formats allow a crankshaft only sufficently robust for marine or generator duties.

Over 12 Cylinders – It is unlikely a CLP16 or CLP24 be justified without compromising crankshaft integrity (see diagram right), therefore in all but exceptional cases, an L12 is the maximum recommended layout with an L8 preferable.

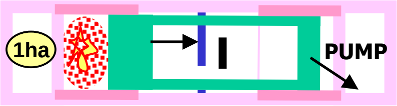


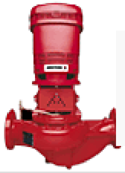
The CLP is compromised between four elements; crank neck & (B), crank web thickness (C), conrod width (T) and volume of the wishbone piston legs (K).

Applications

Applications are broad.
High economy and variability
Through flexible capacity make
the CLP attractive to most
industrial applications where
efficiency and low emissions are
foremost.

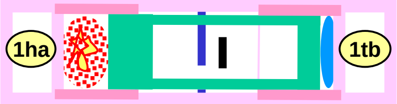
CLP1





Pumps : Simple efficient gearless pump.
Machinery : Tail piston drive linkage.
Vast application potential with time.

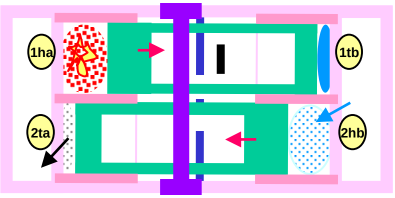
CLP2



Light generators and machinery

Flexible capacity means power is strictly demand orientated or acts as a dual power engine.

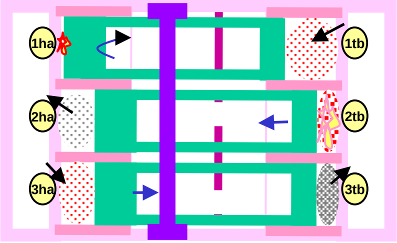
CLP4

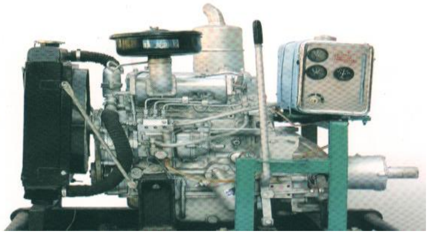


Light-heavy commercial diesel engines passenger vehicle engines (inc petrol).
Medium generators and marine.
Toughest crankshaft, compact unit with flexible output, smooth running and easily balanced.

The broadest application potential.

CLP6



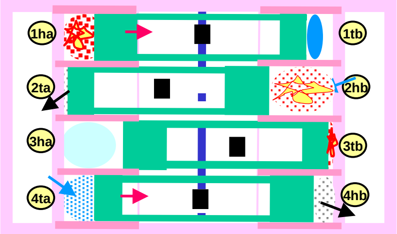


Medium and heavy duty compressors and pumps.

Tough crankshaft and multi piston format allows for high duty and capacity, but not as smooth as a L4 or L8.

Flexible capacity friendly as tail bank can be closed.

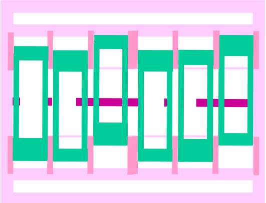
CLP8



Medium-Large Generators, Rail and Marine.

Naturally smooth and balanced, but sufficent bore diameter is required to achieve a robust crankshaft.

CLP12



Large Generators and Marine.
Where smoothness and large capacity permits,
the CLP12 delivers better economy than a B12 or V12.

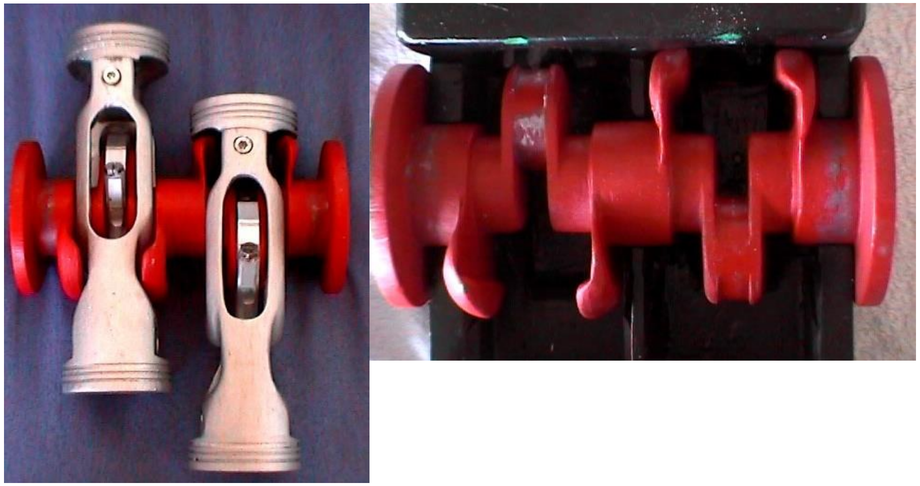
Horses for Courses: Just as a S2 or S8+ are poor engine arrangements, the CLP must be considered against other configurations for suitability, wholly dependent on application.

clp technology

2 Stroke Performance From 4 Cycle Combustion – A Dramatic Gain

In terms of the top end; burn, chambers and valves, this engine uses the same four (or two) cycle combustion as a contemporary engine, but in terms of the; pistons, crankshaft, g. pins and conrods and most importantly *output*, the bottom end base engine operates as a two stroke (or one stroke if 2 cycle combustion).
Crankshaft pumping losses reduce, as the compressive and exhaustive load of opposing cylinders is now driven directly between pistons in 50% of the firing sequence (100% in 2 strokes).

With fewer and lighter overall moving parts, reduced friction and better piston alignment, and 2 stroke performance, it is claimed that the base engine is significantly mechanically simplified and improved.



Balancing

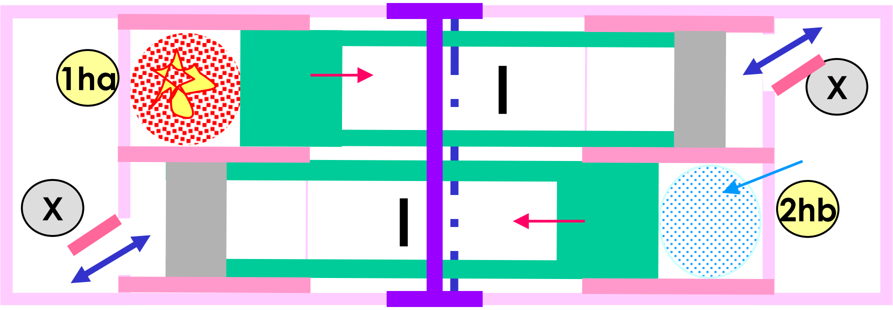
Below 8 cylinders, the CLP arrangement demands a single 1:1 geared contra rotating balancer shaft to achieve natural balance. The engine designer has to consider whether this reduction in natural balance is acceptable given the advantages of the arrangement.
In addition, piston weight doubles meaning increased local loading -even if overall reciprocating weight is reduced.

Countermassing is also suggested as tungsten alloy gloves, even though the unit could be entirely steel, and probably would be in most cases to reduce cost. Using tungsten would keep the countermasses at their absolute smallest allowing for the absolute shortest " short type piston", thereby keep the block size small and pistons light.
The crankshaft above left is shown with oversize countermasses as an investigation to see what was really possible, although the more likely sized countermasses are shown above right.

Flexible Capacity – *The Ideal Engine Flexibility*

Employing variable firing sequences under modest load leaves chambers operating on 6 or even 8 cycle combustion. Alternatively and more typically, entire banks or individual cylinders are shut down.
This allows a 12 litre engine to switch to a 6 litre capacity, depending on application. A truck engine is typically run at low load for 50-90% (e.g. 95kph on flat) of a journey.

Thus it becomes practical, logical and desirable to run an engine with effectively 6 litre capacity, in a 48 tonne vehicle.

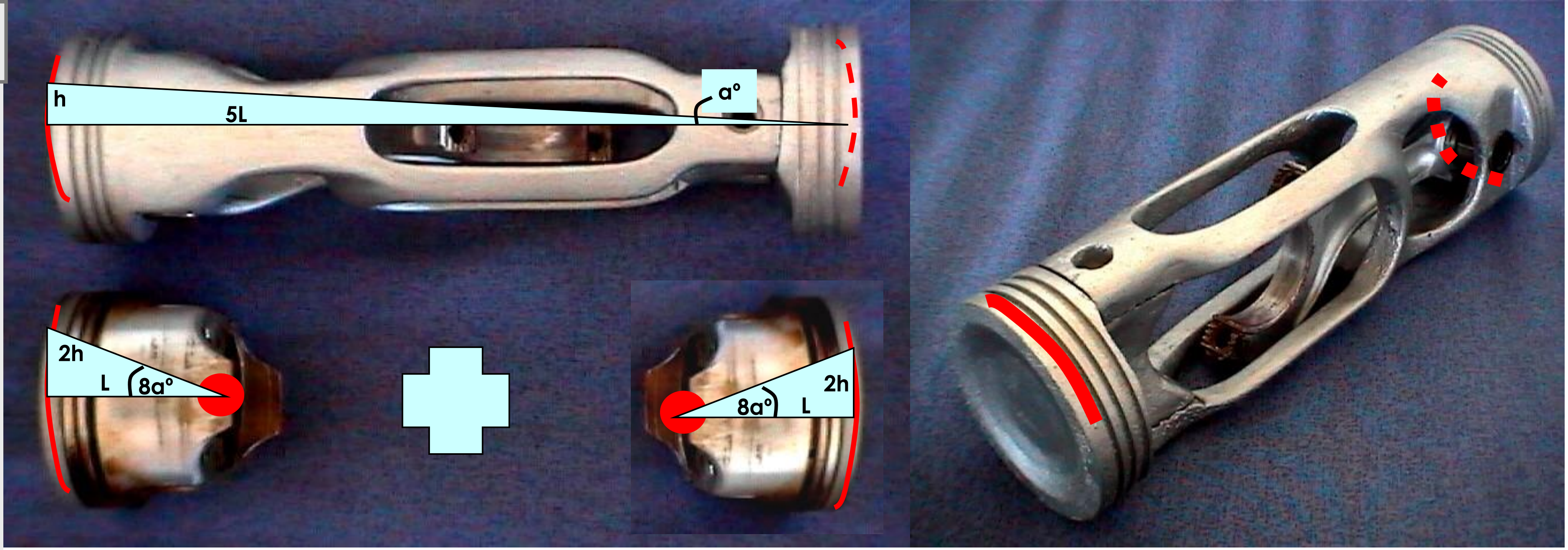


The 2 tail pistons (X) are shutdown, and only the head pistons fired, but low friction is maintained due to the nature of the linked piston. Preferably "blow valves" open to relieve pumping losses in the tail piston chambers. EVC would also help this problem.

While this shutdown feature already exists on many contemporary engines, what ***is new,*** is that whilst half the engine is "mothballed" the engine retains low friction and low reciprocating weight, compared to that of an contemporary engine with half the number of cylinders – hence the claim of real "**flexible capacity**".

While firing half the cylinders, the CLP engine remains balanced and smooth with; 4, 6, 8 or 12 cylinders.
This flexibility means the engine specifier may truly attain the "Jekyll and Hyde" performance typically sought, i.e.
power available on immediate demand but also with mean economy.
The arrangement also allows a reconsideration of, and likely more generous choice of engine capacity for greater power on demand, whilst not compromising fuel economy.

Friction

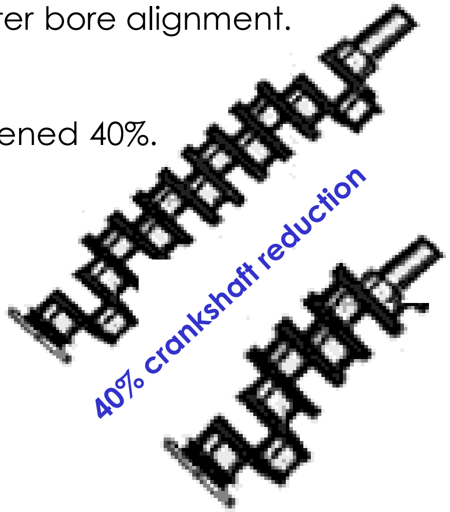


Reducing Piston Friction

- Improved cooling means expansion tolerance can be reduced substantially resulting in (h) not (2h+2h).
- The tilt resisting control length is increased 4-6 times resulting in (5L) not (L).
- Curved contact surfaces are used both ends, instead of the point area on a piston skirt.
- One contact point only is used for each piston, not two.
- **The resulting scraping angle is theoretically reduced 16 times : @2x8a°=16**
- Ring pressure is reduced or 1 ring removed due to reduced tilting, tolerance & better bore alignment.

Other reductions

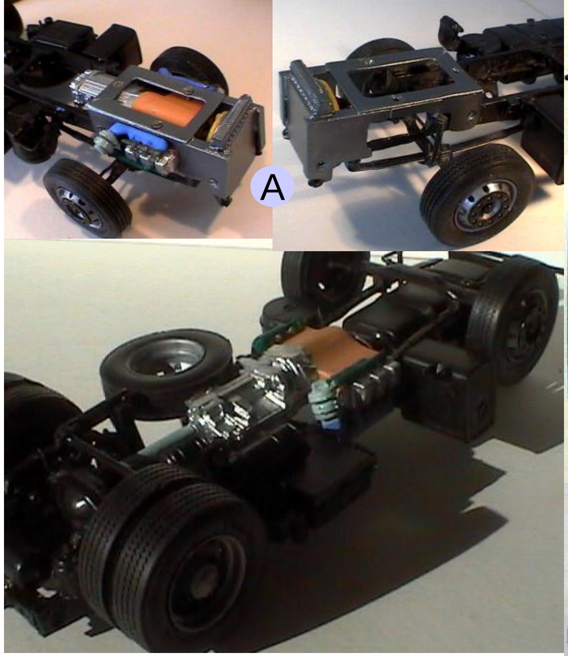
- Crankshaft bearings are reduced from 7 to 4 and the block and crankshaft is shortened 40%.
- Gudgeon pins and conrods both reduce from 6 to 3 (against a Straight 6).
- Overall bearing reduction, 31 to 16 i.e.=50%+1
- The direct loading of the opposing piston's chamber bypasses the crankshaft transmittal force, allowing the bearings to run lighter.

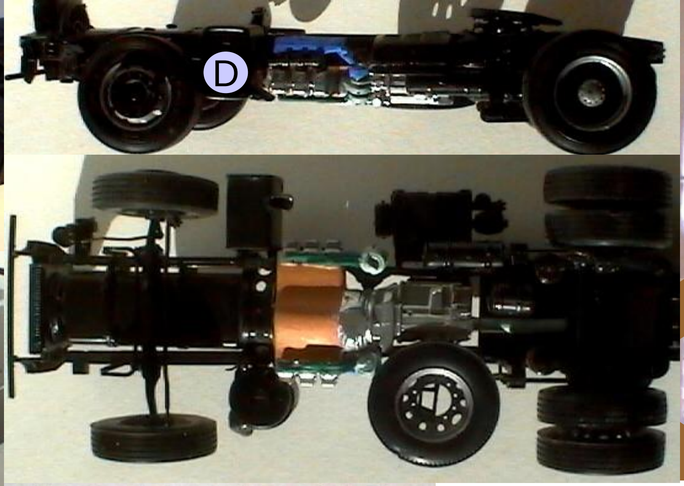


Metal buck Testing

Reduced Friction can be assessed quite early in a development programme, by static and dynamic comparison of a CLP2 and S2.
Some friction gain is lost against a straight engine (but not against a boxer or vee), due to two valvetrains, but with EVC not far away, this loss would be removed.

Packaging





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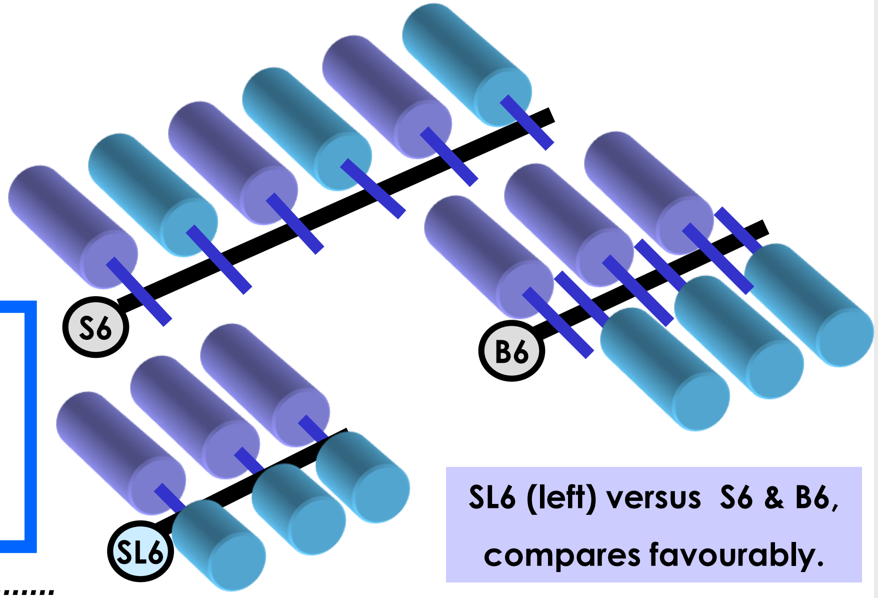
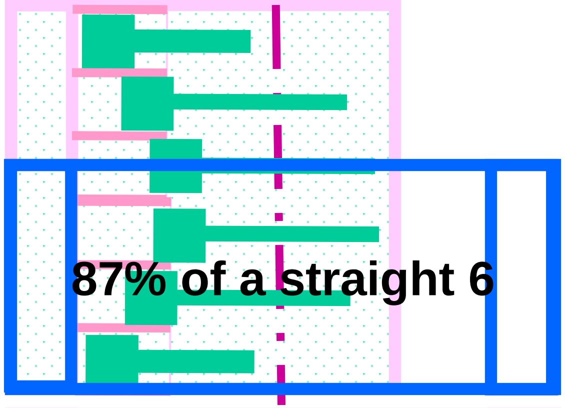


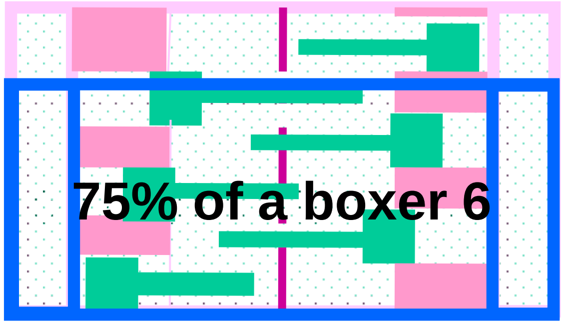
SL6 (left) versus S6 & B6,

compares favourably.

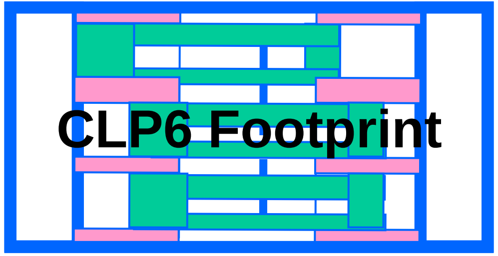
Engine Footprints............



87% of a straight 6



75% of a boxer 6



CLP6 Footprint

Truck Packaging Example............

Packaging the flat engine proves almost impossible in the current truck engine position (A), but even better, mid engined installation underneath the ladder chassis is possible (D). Not only does this permit better cab structures, the basic ladder architecture is unchanged. Substantial cost savings can be made due to this packaging, through using; fuel saving aero cab (B), fixing the cab without the need for tipping, and drastically shortening the propshaft (C), improving handling, service access, traction, payload volume.

Naturally this is dependent on application, e.g. in ships the CLP lowers C of G and increases cargo space, while in small FWD tranverse engined cars, the gearbox can be placed more centrally to avoid torque steer.

Advantages of the Compact Linked Piston Engine (e.g. Used: 12 litres and 6 Cylinders in a Truck)

1 Four Cycle Combustion but Two Stroke Output

- Using four cycle combustion, the bottom end functions as a 2 stroke mechanism, i.e. same firing but less movement.
- This results in the bottom end and associated components running at a lower stress and higher motive efficiency.

2 Flexible Capacity

- Friction of a 2 cylinder but with the volumetric efficiency of 4 cylinders.
- Flexibility of capacity while still in balance and at low friction, allows instant doubling/halving of capacity.

3 20% Reduced Reciprocating Mass (page 10)

- Narrower, lighter, stiffer crankshaft, @40% weight reduced.
- 4 conrods to 2 (but 20% heavier and narrower) conrods.
- Half (+1) the number of bearing.
- 4 gudgeon pins to 2 gudgeon pins.
- Improves acceleration and reduces capacity.
- Overall engine weight reduction, mainly through lighter crankshaft and smaller block.

4 Improved Piston Alignment and Lower Friction (page 7)

- Much reduces angular action of the piston and associated scraping / friction / lubrication demands / wear, producing a smoother and lighter pumping action.
- Lighter ring pressure may be feasible with the same scraping and sealing results achieved.
- Power sapping mixture compressive or exhaust clearance is driven directly by the power of the opposing chambers combustion, not via the crankshaft or bearings, without component forces, in 50% of the cycle. (100% in 2 cycles).

5 Improved Piston Cooling and Closer Tolerance Possibility.

- The pistons are directly cooled by oil spray in the sump zone which reduces the expansion tolerance required, thereby allowing improvement of cold start performance and reducing emissions (due to closer wall tolerance and reduced lubrication demand).

6 Packaging

- Reduction in block size and footprint.

7 Comparable Production Cost

- Although using separated banks of intake-exhaust components increases cost (as with a vee or boxer), the cost reductions of; 3 fewer bearings, smaller crankcase, smaller envelope, fewer parts, shorter crankshaft, all combine to reduce or match overall cost with reasonable production volume.

8 Realistic Alternative

- Uses a conventional top end.
- This is a "conventional alternative" where the engine is still recognisable as a known piston/crank mechanism, using known cylindrical bearings, similar crankshaft and general relationships.
- Slots into existing production, complementing not competing against current engine improvement technologies.
- Introduction to production can be made as a measured and quantified step.

Disads & Notes / Diagrams

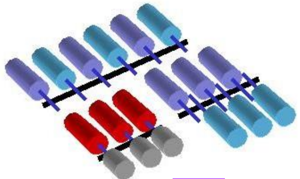
Disadvantages of the CLP

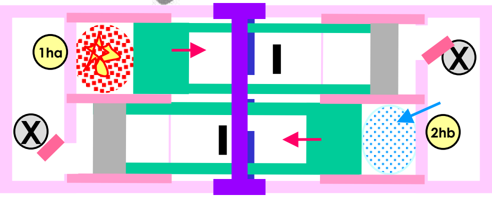
- Crankshaft robustness compromised (depending on environment – partly offset by the 40+% reduction in length).
- Two banks of valve trains necessary (as with a vee or boxer).
- Each piston weight is increased, raising the local load on the crankshaft and bearings.
- Needs a balancer shaft at 4 or 6 cylinders.
- Demands multi core squeeze cast pistons to achieve robustness.
- Risk of piston slap if bore tolerance reduction aims cannot be achieved.
- The narrower conrod has a smaller bearing footprint on the crankshaft.
- New technology risk and cost.

Notes

- Effectiveness of power delivery via conrod tension unproven, also requiring the conrod has a modified design.
- The conrod, crank shaft journal and gudgeon pin are loaded twice as often.
- The oil wedge lubrication normally occurring will be reduced or eliminated, offset hopefully by natural alignment of the siamese piston in the two aligned bores, reducing or eliminating the demand for wedge type lubrication.
- BDC dwell requires different timing for head and tail piston combustion.
- The tail end piston is much lighter than a std piston, but this gain is offset by the legs on the head piston.

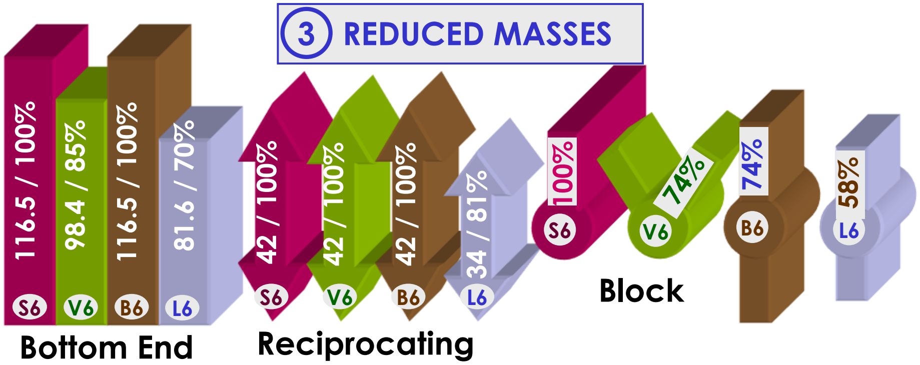
① TWO STROKE MECHANISM





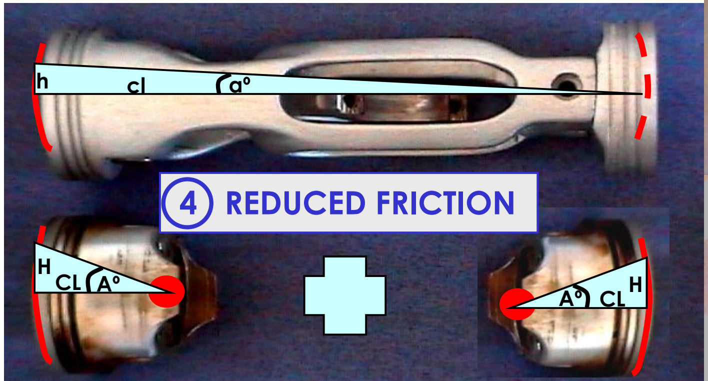
② LOW RESISTANCE FLEXIBLE CAPACITY

③ REDUCED MASSES

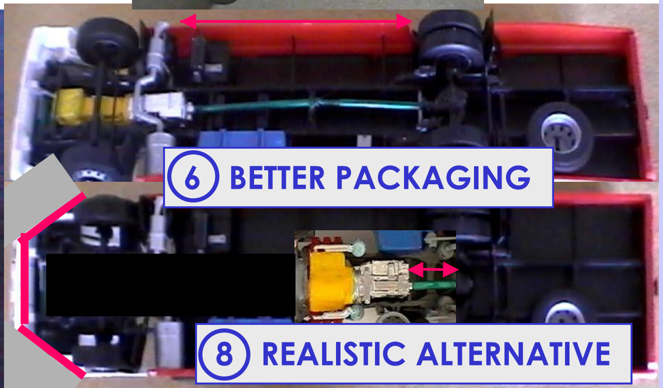


⑤ BETTER COOLING

⑦ COST



④ REDUCED FRICTION



⑥ BETTER PACKAGING

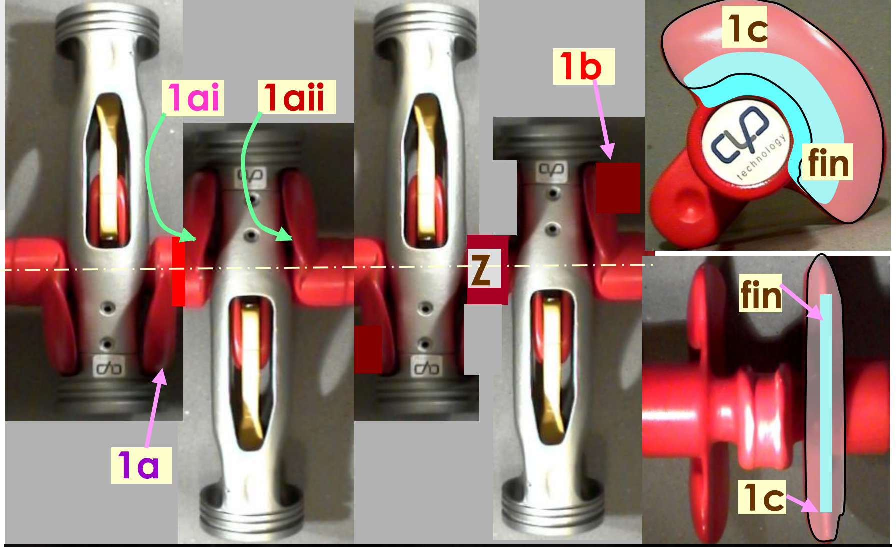
⑧ REALISTIC ALTERNATIVE

clp technolog

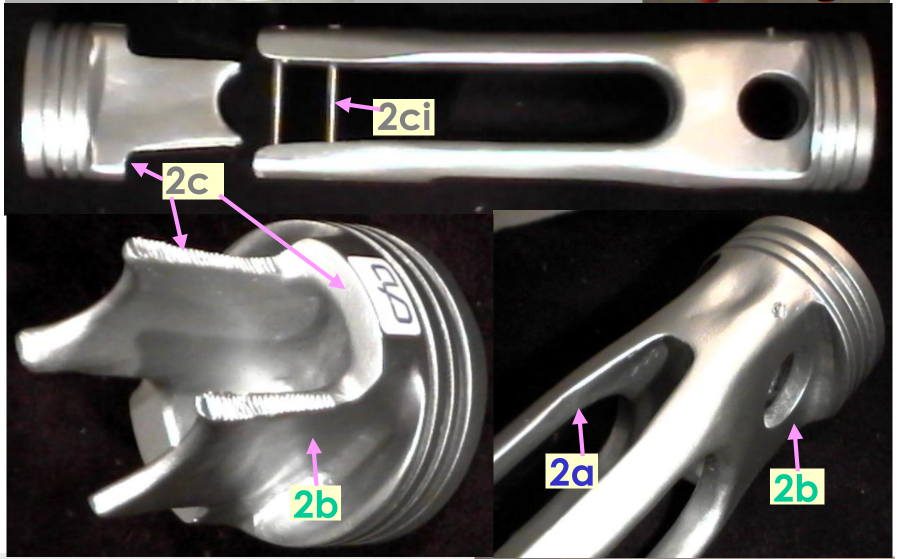
Patents and Licencing

There are two patents each now concentrating on the Outboard Crankshaft (1) and Wishboned Piston (2) respectively.

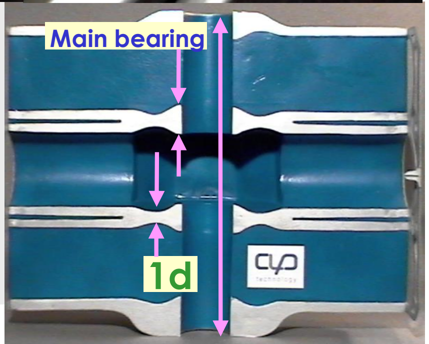
Essential Features Patent Applied For



1a Outboard crankshaft the counter masses are separated from the connector webs required for the crank pins.
1ai Compact outboard crankshaft external undercut The seperated CMs have an external undercut so that crankshaft is kept narrow, but the mass weight kept wide as it circumnavigates the wide main bearing.
1aii Compact outboard crankshaft The seperated CMs have an internal undercut so that crankshaft is kept narrow, but weight large and passes through necked areas on the piston.
1b Single outboard crankshaft as 1a (i+ii) except where all the countermass is located on one web
1c Attachable countermass tips made from a second (denser) material which attach over crankshaft fins to form the undercut CM.
1d Necked main bearing support ring to make space for the external undercut outboard CMs.



2a Double wishbone head or tail piston leg structure
2b Necking and scalloping of the piston between the wishbones and piston crown.
2c Serrated connection and plain abutment faces
2ci Bolting to support this connection



- Protected in application WO03069143 and GB0301996.5

Licencing

- The patent application has been searched as novel by the UK and European Authority.
- Licencing will be based on this patent and a second GB application pending.
- Numerous other areas for patent innovation are currently unfilled, so any team that takes on board this project has an opportunity to place their own solutions at the heart of CLP refinement.

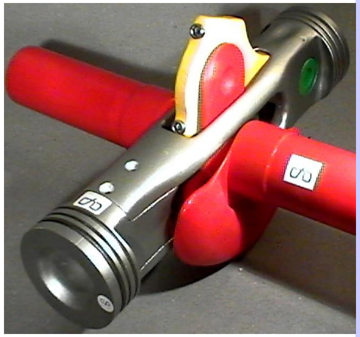
Summary

The COMPACT LINKED PISTON engine simplifies the base engine through;

- Reduction of masses
- Reduction of friction
- Reduction of numbers of parts
- Reduction of packaging volume
- Improved piston cooling
- Low friction flexible capacity
- 2 stroke output from 4 cycle combustion

The COMPACT LINKED PISTON engine is attractive in L1,L2,L4,L6,L8 or L12 cylinders.
In small, medium or large formats, the CLP improves the efficiency of;

- Commercial or economy vehicles
- Industrial engines
- Marine engines
- Pumps and Compressors



The COMPACT LINKED PISTON

- Has reasonable production cost.
- Is manufactured using contemporary materials and methods of assembly.
- Is an existing concept, improved and refined for realistic manufacture and toughness.
- Utilises new piston and crankshaft formats.
- Is patent protected through 16 independent and stacking features.
- Also has major 2 stroke implications for pumping efficiency and reduced oil demand.

CLP technology is seeking a first build project and development partners, comment is invited.

Major Questions Remaining:

By how much is piston and overall friction reduced?
What is the level of piston cooling improvement and by how much can piston / cylinder wall tol. can be tightened?
How well is piston slap contained by this tolerance change?
How well can the piston relubricate the walls without wedge action lubrication on the upstroke?
How robust is the crankshaft, pistons and narrowed conrods and big end bearings in various applications?
What is effect of BDC dwell timing issues?

Next Steps:

A refinement design loop in CAD and FEA with broad; dialogue, support and input from industry experts.
Then an STL models are made and compared to benchmarks, while a comparitive metal frictional buck is analysed.

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squarise
design
ltd

www.clptech.com
info@clptech.com
Signalgatan 4b, Göteborg 413 18, Sverige. +46 31 422107
Squarise Design Ltd. 9 B, Silver Lane, Elvaston, Derbyshire UK DE72 3TQ.