The

Bolly

BOOK

6^{th} EDITION 1998

The discerning Aeromodellers handbook for Props, Pipes, Engines, Model + more.

Enjoy the reading, and the best of flying.

Also see our new Web Site at: http://www.bolly.com.au/ **This book is to be 'online' early 1998**

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INTRODUCTION

THE BOOK

The aim of this book is to keep our customers better informed on the products we manufacture, and to provide the theory behind the product. As with any publication of this type, not everyone will agree with everything we do or say, but then that's life.

Much of the content of this book will not be found elsewhere in aeromodelling press, or if it can be found, you will need to search years of back issues. Enjoy the read, and if it inspires you to try some of our products, then we will be honoured to receive your patronage.

COMPANY AIMS

It is the aim of Bolly Props / Bolly Products / Precision Propellers Pty Ltd is to manufacture the best propellers (+ pipes, mufflers and kits) available. Bolly products are made from top quality materials, with precision and care. All Bolly products are of Bolly's own design, or designed in collaboration with top aero-modellers. We also have the best range available to suit almost every competition or sports flying need. We also market a large range of specialist raw materials and accessories to complement the products we manufacture.

DEVELOPMENTS

We are proud that many new techniques and ideas have come from the Bolly work shop. For example we were the first to produce the plug-on nose cone now so popular in the F3B glider world, we were the first in Australia to produce fuselages using the overlap seam method (credit for originating this goes to Germany), and the first company to successfully commercialise carbon fibre tuned exhausts that can actually survive the harsh environment the work in.

METHOD

To maintain our excellent quality and high standards, most Bolly products are hand made. The exception to this is of course our **clubman** Series propellers.

With the introduction of the **clubman** Series, we have now developed the capacity to computer model and machine many of our products. As the next century approaches, this CAD / CAM capability will become vital to maintaining our company aims.

Still much of the work is by hand, and we make all our own master patterns (with several exceptions) and moulds. This vital ingredient to quality takes time and care. The result of this is that:

A) the products must be more expensive than machine made products.

B) we can make products machines can't.

C) our product range is extremely versatile, with something for every modeller or type of model.

For the **clubman** series of propellers, we researched the design and production methods to ensure we could produce the best possible product. They are made using all of the latest advances in design, production and materials.

For the Bolly brand GRP Products, Glues and Hardware range, we will only package and sell the products we ourselves use in production or personal modelling. It has taken us many years to develop these products, we will not and are not packing simply the cheapest 'stuff' on the market.

WHO

The owner/founder of Bolly Props is Les Bollenhagen, often referred to as 'Bolly', hence the name 'Bolly Props', or as it is now known 'Bolly Products'. Having flown a large number and variety of events at competition level for over 25 years has provided an excellent foundation for the understanding and development of propellers, pipes and engines.

A list of Les's involvement in the hobby would be .... starting as many do, with free flight (rubber glider and power), moving to control line (racing and aerobatics) and then radio. At several stages there has been a move back and forwards between these events.

Les currently flies R/C Pattern (Aussie expert class F3A) and whilst not actively flying pylon, he continues to maintain his fleet of pylon models and writes the r/c pylon column in Australian Radio Control News which is one of Australia's 2 premier modelling magazines.

STAFF

Employed at Bolly are many fine aeromodellers (we currently have a staff of 11). Amongst the staff are many skills in the areas of R/C pattern, pylon and scale, as well as expertise with many of the materials we use. At last count it was about 135 years of modelling experience.

SUCCESS

A guide to Bolly Products is the success of the product in competitions throughout the world.

The TOC (Tournament of Champions) event has been won by Chip Hyde and Quique Somenzini (twice), using a Bolly props, as have many of the other competitors in this event. The 1997 event was a highlight as Bolly Props were the most used and most successful props at the TOC event.

Quique Somenzini, one of the world's best, uses Bolly Products extensively for his fine performances. We now produce (exclusively), Quique's latest F3A models, the Desafio S / 2000, and will soon be producing a Laser cut, all wood kit of his Hovering Cobra.

The Australian Nationals have had many Bolly triumphs. There have been many times where over 50% of competitors of various events have been using Bolly Props and / or Pipes, with great success.

The same applies to many of the special interest championships, i.e. the pylon AMPRA Champs or pattern APA Masters or old timer events. Mr Bolly has himself won several of the APMPRA titles.

WORLD CHAMPS SUCCESS,

To our knowledge at least 3 World Championships have been won using our propellers. Several times complete teams have used our products. We look forward to this trend continuing.

PRODUCTS

Bolly Props are best known for top performance GRE or CRE propellers

However as Bolly interests have expanded, so has our range of products. Initially Bolly was producing propellers, foam core wings and GRE fuselages for retail outlets. These three products are still made, but now only under the Bolly name - where we have full control of type, quality and price.

New to the range of Bolly Products, is the **clubman** series injection moulded propellers. This has been a very exciting project for us, and the product is fulfilling (often exceeding) all of our expectations. To manufacture such a product is very expensive, and it has taken several years to build a capital reserve to be able to do it. The waiting for those years before we could apply our knowledge acquired manufacturing our normal line of composite propellers, has been well worth it.

To fully utilise an engines potential, not only does it need the best propeller, but also a good exhaust system. A good pipe can improve power output by 50%. We now manufacture an increasing range of Carbon Fibre Pipes. Our speciality being the advanced square and rectangular shape pipes.

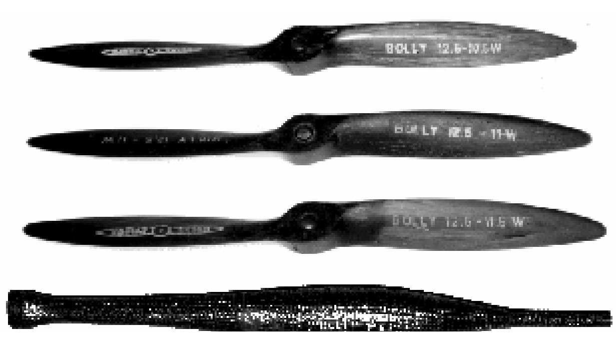
Recently introduced is our 'GRP Products, Glues & Hardware' range. This range features ... Epoxy resins, glass cloth, C/F , glassfibre, Aramid fibre (kevlar) rovings, silicon exhaust fittings, etc, just to name a few of the products.

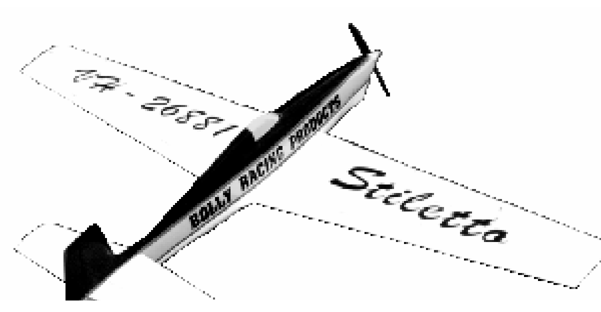
WORLD-WIDE BOLLY AGENTS

Bolly Products are now distributed to over 44 countries.

We have agents in many of these countries, a few of whom are sole agents.

We can provide details of our agents etc on request.





PROPELLERS

PROPELLER THEORY - TECHNICAL DATA

BASICS

The following is a basic outline of prop theory and conclusions on prop design. A comprehensive outline would require more mathematics and technical references than is practical to include here.

For most model aircraft, the propeller is the only means of converting the power of the engine into flight performance. This makes the choice of propeller vital for the performance of a model.

Treat a propeller as a wing, and the theory will be easier to understand. Blade shape, pitch and airfoil selection all become understandable. The major difference is that a propeller is a rotating wing, with the 'Reynolds' number (via different blade width and air velocity) changing along the blade.

One of the biggest problems with propeller design (for all props including ‘full’ size), is that it is impossible to know what a prop is doing in a ‘dynamic’ state. Often static testing does not relate to dynamic performance. It is very easy to develop a prop which gives excellent ‘pull’ on a static test, however a prop designed to these criteria often don’t work that well in the air.

The choice of prop construction material will have a marked effect on prop design and performance.

BLADE SHAPE

As the average model propeller operates at a Reynolds number (scale effect) similar to a R/C Glider. A high aspect ratio, elliptical based shape generally works best, whether it be for glider wings or a propeller. If you take the average Bolly Prop and give it a well rounded or swept back tip, this overall shape will be as practically close to an ellipse as possible. This is especially so with the 3 and 4 blade Bolly Props. Practical considerations sometimes prevent the 2 bladed propeller from being the ideal shape, ie, undercarriage lengths and ground clearance.

The choice of blade shape is also determined by the propeller’s end use. For slow flying high drag models or models which need small diameters, a lower aspect ratio, wider chord prop is more suitable.

1, 3 AND 4 BLADE PROPELLERS

The rules vary when dealing with single blade and racing propellers. A small 2 blade 5.8 x 5.8 with 12mm chord is equivalent to a single blade of 6.2 x 5.7 with 17mm chord. The single blader is more efficient due to the extra diameter and chord (much higher Reynolds number). Large diameter single blade propellers are not practical due to the high weight of the counterbalance required.

For some racing applications a high aspect ratio blade is not possible due to the extreme loads imposed at high RPM, especially if the tip is expected to exceed mach 0.7.

Contrary to popular belief, multiple-blade propellers do not operate in severely disturbed air from the previous blade (when in forward flight). The reason multi blade propellers often appear inefficient is the need to use considerable lower diameter propellers (in comparison to 2 blades), for the same horsepower available. Diameter for diameter, a well designed 4 blade prop will in some circumstances perform better than the equivalent 2 blade propeller.

It is rare (if not impossible), to find an efficient 3 or 4 blade propeller manufactured from nylon based materials. The reason for this is the most efficient shape (thin, narrow blades) for these propellers is difficult to produce in anything but a carbon or glass composite construction. For this reason Bolly have one of the best and most efficient ranges of 3 and 4 bladed propellers in the world.

AIRFOILS

As with a glider wing we want the maximum lift over drag performances. Practical strength and aerodynamics means an optimum airfoil thickness of around 15 to 18% near the root, progressively thinning to 10% at the tip. About 12% at the 3/4 span in optimum.

The blade airfoil will vary slightly with use, with the Clark Y style airfoil as a standard. The root of the blade which does less of the work and the tip which has ‘tip speed’ problems should have less camber (semi-symmetrical). For some applications the centre portion of the blade may need a lower or higher cambered airfoil. One advantage of CAD/CAM propellers such as our **clubman** Series is that a very accurate airfoil can be maintained from design to end product.

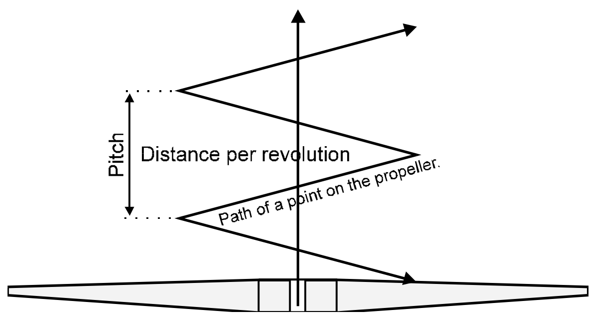
REYNOLDS' NUMBER

The Reynolds' number (Re) is a theoretical number used to describe the 'Scale Effect', ie - an exact 1/8 scale replica of a Boeing 747 wing will not behave identically to the full size version. The higher the Re, the greater the efficiency. The equation is - Re = 68500 x Velocity x Length (chord or wing or prop). This is the most important of all considerations when comparing full sizes theory to models.

PITCH

Without doubt this is the least understood factor of propeller design. Pitch is the theoretical distance the propeller will advance along the axis of rotation in one complete revolution.

The fact that a propeller of constant pitch will have a twisted blade is also not often comprehended, ie - at 5 inch radius the propeller will travel a circle of 31.4 inches, at 10 inch radius it will travel 62.8 inches (double the distance). Hence it will need half the pitch angle to travel the same distance.



BLADE ANGLE (degrees) AT GIVEN PITCH & DIAMETER DATA CHART

Pitch (inches)

Radius (mm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15
20	22.0	31.2	38.9	45.3	50.4	54.7	58.2	61.2	63.6	65.7	67.5	69.1	70.5	71.7
30	15.0	22.0	28.3	33.9	38.9	43.3	47.1	50.4	53.4	55.9	58.2	60.2	62.0	63.6
40	11.4	16.8	22.0	26.8	31.2	35.2	38.9	42.2	45.3	48.0	50.4	52.7	54.7	56.5
50	9.18	13.6	17.9	22.0	25.8	29.5	32.8	36.0	38.9	41.6	44.1	46.4	48.5	50.4
60	7.67	11.4	15.0	18.6	22.0	25.2	28.3	31.2	33.9	36.5	38.9	41.2	43.3	45.3
70	6.58	9.82	13.0	16.1	19.1	22.0	24.7	27.4	30.0	32.4	34.7	36.9	38.9	40.9
80	5.77	8.62	11.4	14.1	16.8	19.4	22.0	24.4	26.8	29.0	31.2	33.3	35.2	37.1
90	5.13	7.67	10.1	12.6	15.0	17.4	19.7	22.0	24.1	26.2	28.3	30.2	32.1	33.9
100	4.62	6.91	9.18	11.4	13.6	15.8	17.9	19.9	22.0	23.9	25.8	27.7	29.5	31.2
110	4.20	6.29	8.36	10.4	12.4	14.4	16.3	18.3	20.1	22.0	23.7	25.5	27.2	28.8
120	3.85	5.77	7.67	9.56	11.4	13.2	15.0	16.8	18.6	20.3	22.0	23.6	25.2	26.8
130	3.55	5.33	7.09	8.83	10.5	12.2	13.9	15.6	17.2	18.8	20.4	22.0	23.5	25.0
140	3.3	4.95	6.58	8.21	9.82	11.4	13.0	14.5	16.1	17.6	19.1	20.5	22.0	23.4
150	3.08	4.62	6.15	7.67	9.18	10.6	12.1	13.6	15.0	16.5	17.9	19.3	20.6	22.0
160	2.89	4.33	5.77	7.20	8.62	10.0	11.4	12.8	14.1	15.5	16.8	18.1	19.4	20.7
170	2.72	4.08	5.43	6.78	8.12	9.45	10.7	12.0	13.3	14.6	15.9	17.1	18.4	19.6
180	2.57	3.85	5.13	6.40	7.67	8.93	10.1	11.4	12.6	13.8	15.0	16.2	17.4	18.6
190	2.43	3.65	4.86	6.07	7.27	8.47	9.66	10.8	12.0	13.1	14.3	15.4	16.5	17.7
200	2.31	3.47	4.62	5.77	6.91	8.05	9.18	10.3	11.4	12.5	13.6	14.7	15.8	16.8
210	2.20	3.30	4.40	5.49	6.58	7.67	8.75	9.82	10.8	11.9	13.0	14.0	15.0	16.1
220	2.10	3.15	4.20	5.24	6.29	7.33	8.36	9.39	10.4	11.4	12.4	13.4	14.4	15.4
230	2.01	3.01	4.02	5.02	6.02	7.01	8.00	8.98	9.96	10.9	11.9	12.8	13.8	14.7
240	1.92	2.89	3.85	4.81	5.77	6.72	7.67	8.62	9.56	10.4	11.4	12.3	13.2	14.1
250	1.85	2.77	3.70	4.62	5.54	6.45	7.37	8.28	9.18	10.0	10.9	11.8	12.7	13.6
260	1.78	2.67	3.55	4.44	5.33	6.21	7.09	7.96	8.83	9.70	10.5	11.4	12.2	13.1
270	1.71	2.57	3.42	4.28	5.13	5.98	6.83	7.67	8.51	9.35	10.1	11.0	11.8	12.6
280	1.65	2.48	3.30	4.12	4.95	5.77	6.58	7.40	8.21	9.02	9.82	10.6	11.4	12.2
290	1.59	2.39	3.19	3.98	4.78	5.57	6.36	7.15	7.93	8.71	9.49	10.2	11.0	11.8
300	1.54	2.31	3.08	3.85	4.62	5.38	6.15	6.91	7.67	8.43	9.18	9.93	10.6	11.4
310	1.49	2.24	2.98	3.73	4.47	5.21	5.95	6.69	7.43	8.16	8.89	9.62	10.3	11.0

320	1.44	2.17	2.89	3.61	4.33	5.05	5.77	6.48	7.20	7.91	8.62	9.32	10.0	10.7

PITCH DISTRIBUTION

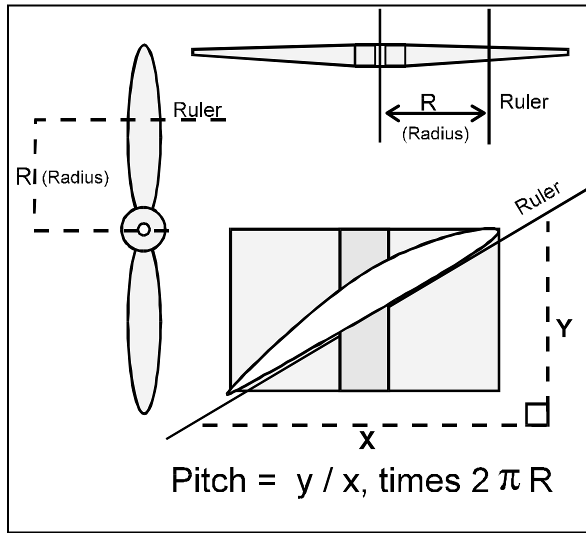
Pitch should always climb from the root to the tip, with the rate of increase being less at the tip - even constant over the last 20% of the diameter. The quoted pitch should always be the 'peak' measurement, although to be more reliable and consistent quoting the pitch at 80% of diameter is the usual practice.

The pitch distribution described above is often described as 'progressive pitch', ie - the pitch progressively increases along the blade from root to tip. Some prop manufacturers quote pitch as say 6 - 10. This refers to a 6” pitch at the root, and 10” of pitch at the tip. This should simply be regarded as a 10” pitch propeller.

The often quoted alternative to progressive pitch is 'constant or helical' pitch, ie - the identical pitch measurement from root to tip. This type of prop tends to be extremely efficient .... but at only one rpm range.

The mathematical explanations to why progressive is best are very involved and will not be discussed here. Basically it involves the angle of attack that the airfoil is operating at, coupled with the need to slightly washout the root and tip to reduce drag.

The diagram below shows how most Bolly Props are pitched...... The diagram has 4 lines.

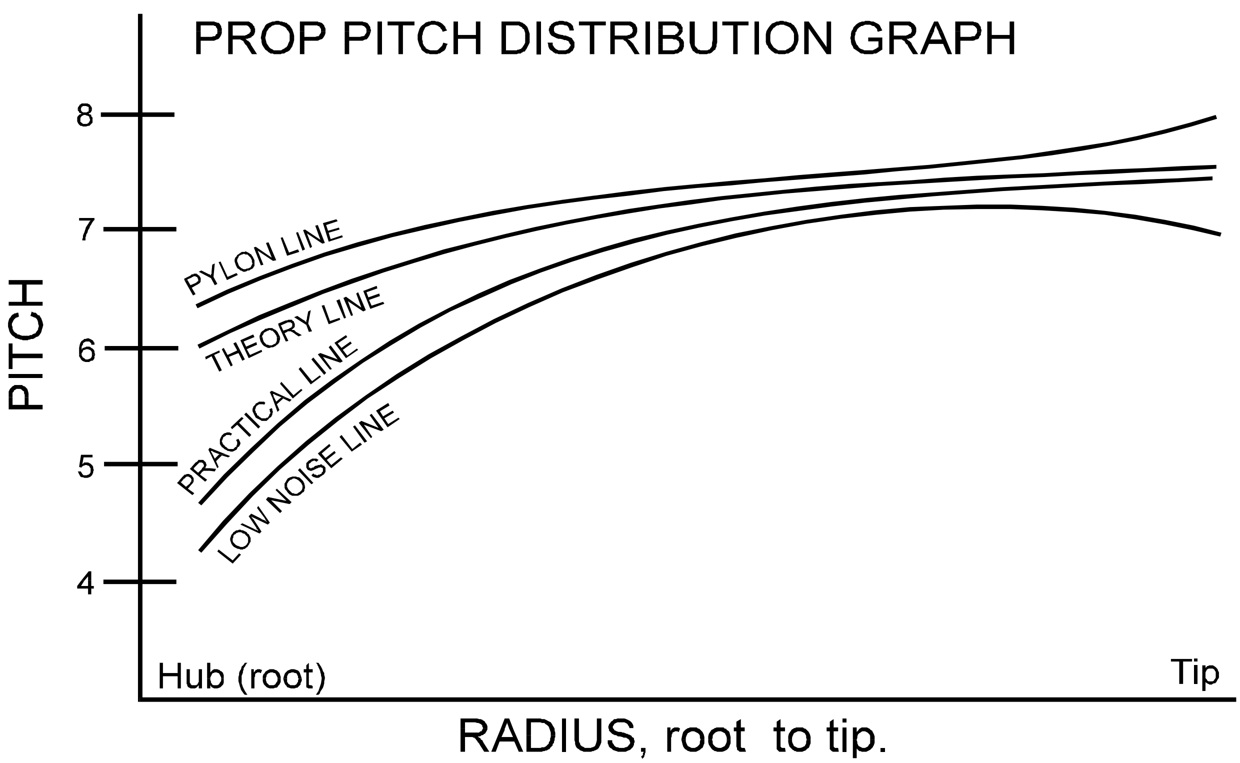


Theoretical pitch distribution line

Practical pitch distribution line ... this is what works better in practice (usually)

Low noise pitch distribution line ... for props to generate less noise, the tips need to be ‘washed out’.

Pylon line, for the best high speed performance a ‘pitched up’ tip is often best.



The lines are drawn separated for added clarity. They should all be identical at about 70% of radius.

SLIP

Is a word often used to describe the propellers lack of efficiency. To say a propeller has 15% slip is in fact saying a propeller is only 85% efficient at converting the pitch to forward motion.

It is also often described as the difference between the angle of the blade and the angle of the relative airflow (which is less than the angle of the blade). It is a word we NEVER use.

EFFICIENCY

Most Bolly Props are in the 90 to 95% efficiency at converting pitch to airspeed, ie - very efficient. Some props we have tested struggled to have 60% efficiency at converting pitch to airspeed.

NOTE... this assumes a correctly matched prop to airframe.

NOTE... the above is different to overall efficiency, which is the measurement of converting the engine energy into kinetic energy via the propeller. This measurement is considerable less than above.

PROPELLER NOISE

Over the last few years noise has become an important issue to many model clubs. The exhaust noises are fairly easy to reduce, leaving the propeller as the main source of noise. The fact remains, to convert engine power into propulsion must by its very nature be noisy, FACT = the more powerful the engine, the more noise it will produce for any given propeller / muffler / airframe.

There is a big difference between true and accurate noise levels as measured and the perceived noise of the average person. An outstanding example of this is the noise level produced by a model with a high rpm small engine, (.049) compared to a ‘large scale’ model (say 60cc). To the ear both may sound equally noisy, but a noise meter will tell a different story .... the large model will be far more noisy, and if the noise is measured from a long distance away, the small model will hardly register at all.

The overall design and even the materials from which the propeller is constructed, also have a significant effect on noise. The softer materials such as the **clubman** Series nylon produce a ‘softer’ noise to the ear, but as they are more flexible (compared to carbon / epoxy), this flexing will create noise. To make such a prop rigid will require a thicker blade (heavier and more expensive to produce), which in turn operate at lower rpm (due to absorbing more power), and reduce the propellers overall efficiency. As can be seen, designing for low noise as opposed to high efficiency is a compromise.

The most obvious factor in prop noise is tip speed and shape. Reducing tip speed and using a good tip shape is the most productive method of reducing noise. This will generally mean using a lower diameter higher pitch prop than before.

TIP SHAPE

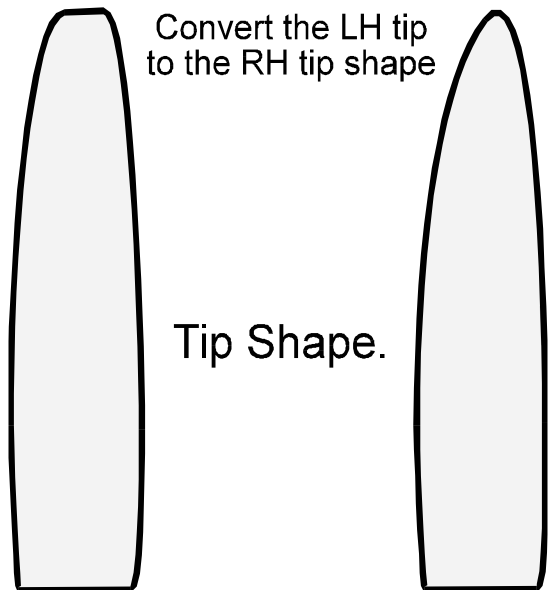
Propeller noise is predominantly a product of tip noise. The propeller tip is travelling much faster than any other part of the blade, speed = noise... A high drag tip shape will always create more noise than a low drag shape, the tip shape will have an effect on the props overall efficiency

A well rounded or raked tip should always be used, **never leave the tip square**. The very end of the propeller should be rounded on all sides, not only the leading and trailing corners, as would a model wing tip - never leave it cut off square.

Although not necessarily the best shape a well rounded tip is easily reproducible and less prone to damage than some more exotic shapes.

By all means, use other shapes. A raked tip of between 20 and 35 degrees is often used successfully.

Important .... not only should a tip be rounded etc in plan view (as shown), it should also be rounded in side view, as if it were a well rounded wing tip i.e. the tip circumference should be a fairly sharp edge as per the leading or trailing edge.



TIP SPEED VS RPM & DIAMETER DATA CHART

The speed of sound is approximately 760mph (at sea level). It varies with atmospheric pressures etc.

A propeller should NEVER be used over 550mph without paying attention to tip shape, due to compressibility and shock waves as mach 1 is approached.

An optimum maximum tip speed for achieving a low noise is about 400mph. There appears to be a marked increase in noise above this speed. The best example of this is R/C Aerobatics where low noise is an advantage. These models have developed a basic set of rpm vs. diameter equations, which are reasonably accurate to the below chart, F3A models avoid going above 375mph tip speed.

19” diameter	=	6,500 rpm	18” diameter	=	7,000 rpm
17” diameter	=	7,500 rpm	16” diameter	=	8,000 rpm
15” diameter	=	8,500 rpm	14” diameter	=	9,000 rpm
13” diameter	=	9,500 rpm	12” diameter	=	10,000 rpm

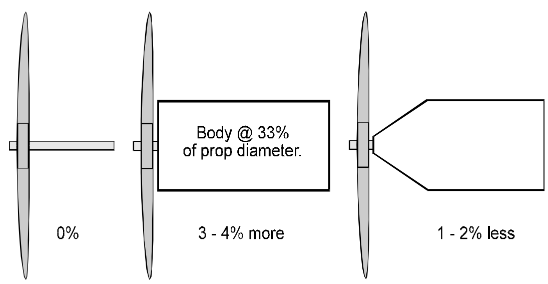
RPM x 1000

Dia	5	6	7	8	9	10	11	12	13	14	15	16	17
6	89	107	125	143	161	178	196	214	232	250	268	286	303
7	104	125	146	167	187	208	229	250	271	292	312	333	354
8	119	143	167	190	214	238	262	286	309	333	357	381	405
9	134	161	187	214	241	268	295	321	348	375	402	428	455
10	149	178	208	238	268	297	327	357	387	416	446	476	506
11	164	196	229	262	295	327	360	393	425	458	491	524	556
12	178	214	250	286	321	357	393	428	464	500	535	571	607
13	193	232	271	309	348	387	425	464	503	541	580	619	657
14	208	250	292	333	375	416	458	500	541	583	625	666	708
15	223	268	312	357	402	446	491	535	580	625	669	714	759
16	238	286	333	381	428	476	524	571	619	666	714	762	809
17	253	303	354	405	455	506	556	607	657	708	759	809	860
18	268	321	375	428	482	535	589	643	696	750	803	857	910
19	283	339	396	452	509	565	622	678	735	791	848	904	961
20	297	357	416	476	535	595	654	714	773	833	892	952	1011
21	312	375	437	500	562	625	687	750	812	875	937	1000	1062
22	327	393	458	524	589	654	720	785	851	916	982	1047	1113
23	342	411	479	547	616	684	752	821	890	958	1026	1095	1163
24	357	428	500	571	643	714	785	857	928	1000	1071	1142	1214
25	372	446	521	595	669	744	818	892	967	1041	1116	1190	1264
26	387	464	541	619	696	773	851	928	1006	1083	1160	1238	1315

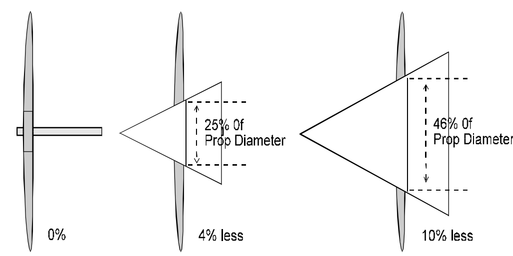
	18	19	20	21	R 22	P 23	M 24	25	26	27	28	29	30
6	321	339	357	375	393	411	428	446	464	482	500	518	535
7	375	396	416	437	458	479	5000	521	541	562	583	604	625
8	428	452	476	500	524	547	571	595	619	643	666	690	714
9	482	509	535	562	589	616	643	669	696	723	750	776	803
10	535	565	595	625	654	684	714	744	773	803	833	863	892
11	589	622	654	687	720	753	785	818	851	884	916	949	982
12	643	378	714	750	785	821	857	892	928	964	1000	1035	1071
13	696	735	773	812	851	890	928	967	1006	1044	1083	1122	1160
14	750	791	833	875	916	958	1000	1041	1083	1125	1166	1208	1249
15	803	848	892	937	982	1026	1071	1116	1160	1205	1249	1294	1339
16	857	904	952	1000	1047	1095	1142	1190	1238	1285	1333	1380	1428
17	910	961	1011	1062	1113	1163	1214	1264	1315	1366	1416	1467	1517
18	964	1017	1071	1125	1178	132	1285	1339	1392	1446	1499	1553	1606
19	1017	1074	1130	1187	1244	1300	1357	1413	1470	1526	1583	1639	1696
20	1071	1130	1190	1249	1309	1368	1428	1487	1547	1606	1666	1725	1785
21	1125	1187	1249	1312	1374	1437	1499	1562	1624	1687	1749	1812	1874
22	1178	1244	1309	1374	1440	1505	1571	1636	1702	1767	1833	1898	1963
23	1232	1300	1368	1437	1505	1574	1642	1711	1779	1847	1916	1984	2053
24	1285	1357	1428	1499	1571	1642	1714	1785	1856	1928	1999	2071	2142
25	1339	1413	1487	1562	1636	1711	1785	1859	1934	2008	2082	2157	2231
26	1392	1470	1547	1624	1702	1779	1856	1934	2011	2088	2166	2243	2320

SPINNERS

As can be seen from the diagrams, a large diameter spinner or fuselage doesn't have as large an effect on propeller efficiency as expected. Using an exposed propeller nut will reduce propeller performance, instead a short blunt spinner flaring into the fuselage should be used.



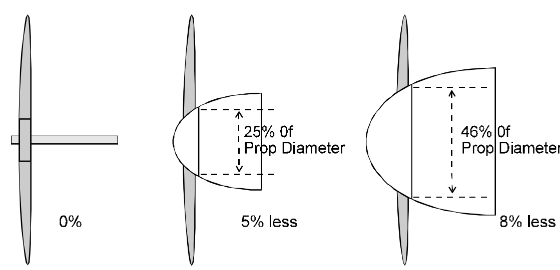
Propeller Efficiency Difference Vs Body Iterference



Propeller Efficiency Difference Vs Body Iterference

Many large scale models have a problem with large radial cowls. It is important to pay attention to the shape. Where possible, allowing air to flow through the cowl will help.

When designing a model pay close attention to the shape of the 'front end'. The shape and drag of this area is very important for performance.



Propeller Efficiency Difference Vs Body Iterference

PROPELLERS ... MATERIAL TYPES

GENERAL INFO

Over the years there have been many materials used for model propellers. Some good and some bad, some cheap and some expensive, some are dangerous and some are safe. As with most things in life, you generally get what you pay for.

The best materials for propellers are glass or carbon reinforced epoxy, where the strands run from tip to tip for maximum strength. The extra strength of these materials allows for a more efficient propeller.

METAL

Whilst it may seem that metal would be the perfect material, they are prone to metal fatigue and if bent will stay bent and not return to their original shape. These factors produce a high risk situation. Metal is just too dangerous and for this reason they are quite rightly banned from use.

CARBON FIBRE (CRE)

Carbon Fibre is a wondrous material, it is light and strong (when used in conjunction with a good resin system). **It is very important that any carbon (or glass) prop by made using the correct resin** ... usually a high quality epoxy resin.... hence the description of CRE.

Carbon Fibre propellers will flex less under load, maintaining their efficiency, producing an increase in RPM and / or decrease in noise. Some modellers believe a glass prop is quieter than carbon due to it's 'softer' sound .... this may be true to the ear, but generally the carbon is quieter on the noise meter.

The greater strength of Carbon Fibre also allows the user to thin down (file or sand) the propeller. A thinner propeller will almost always perform better. Carbon is the easiest of all materials to work with.

The disadvantages of carbon are it's expense and sometimes brittle nature (this is usually only a problem with very thin racing propellers). Many carbon props (including Bolly) are made with a core of glass fibre in the middle with the carbon on the outside faces (much in the same way of a balsa covered foam wing), this offers advantages in cost and reduction of the brittle nature of carbon.

When moulding carbon (or glass) propellers, the aim is to pack in the highest concentration of carbon to resin as possible. For this reason the mould is overfilled resulting in the excess escaping the mould in the form of what is known as 'flashing'. The down side to this method is that it becomes impossible to produce a perfectly balanced or finished propeller. All carbon props are black.

As a matter of interest, Aramid fibres (kevlar) is far too flexible to make good rigid propellers.

GLASS FIBRE (GRE)

Glass reinforced epoxy props are similar to carbon, they differ in being heavier and not quite as strong but less brittle. They are also cheaper in material cost. It must be said however that most of the expense of a GRE or CRE prop is in the labour, **it can take from 15 to 100 minutes to make a prop**, depending on the size. Glass props can be any colour (pigment in the resin).

Generally a Glass Fibre prop will be able to deliver the performance required except at high RPM where Carbon Fibre props should be used. Glass props can be slightly quieter than carbon, if sufficiently rigid in the glass form .... carbon props often have a slightly metallic 'ring' to them.

Fibre contents for CRE or GRE props is usually between 55% and 65%, the more the better.

WOOD

The most common of props until the advent of good plastics and fibres. Generally made of good strong maples etc, the wood prop has the advantage of light weight and suitability for any size of prop.

The disadvantages of wood are it's ease of breakage (not a safe way of flying) and are sometimes prone to warping. The light weight of most woods can be a problem when operating 4 stroke engines, which prefer a heavier propeller for smooth running.

LAMINATED WOOD

Modern laminated woods are almost as good as fibre filled epoxy props, being almost as strong and possibly quieter, but with the disadvantage of being machined to shape which prevents the optimisation of the design. They are also very expensive. They do look nice however.

NYLON

Along with the advent of plastics came the nylon prop. These props are made by pressure injecting molten nylon into a mould, which when cooled, is opened to reveal a finished prop. The advantages of these props are that they can take less than a minute to make and are all much the same.

The disadvantages of nylon are it's lack of strength , weight and flexibility. For these reasons the performance of a nylon prop is less than satisfactory. When used for larger props the weight of the prop combined with the low strength will actually stretch the prop to the point of breakage. It is possible for a 15" prop to stretch a 1/4" or more in operation.

Never use a nylon prop on high performance engines. Nowdays generally only available in small sizes.

NYLON, GLASS FILLED

The modern 'plastic' prop uses a nylon filled with very short lengths of glass fibres. The length of fibres varies from manufacturer to manufacturer, ranging from very short, to claims of being reasonably long (we have analysed several props claiming to be long strand, but have only found short strands), but nowhere near being the full length continuous strands of a 'glass' or 'carbon' prop.

These props are a big improvement on straight nylon, but still suffer from the same problems, but to a much lesser degree. The downside to the manufacture of these props, is that the more glass fibres in the nylon the more brittle and breakable the product becomes. Common glass fibre contents vary from an industry 'normal' of 30% up to about 58% for high glass content props.

For the average modeller, glass filled nylon props are the 'normal' prop. They are cheap, and the better brands perform very well. It must be said however some brands (generally the older designs) are not very good in design or quality.

All nylon based props should be accurate and close to perfect balance, which is no excuse for not checking, as some we have checked are badly out of balance.

Use extreme care when using these props on high performance engines, they are simply unable to cope at extreme performance levels. This is especially so with large 4 strokes, or a bad engine mounting. A glass filled nylon prop may survive above 50,000 rpm on an electric engine, but fail at 18,000 in a high vibration environment such as a 2 or 4 stoke model engine.

PLEASE NOTE:

There are many different carbons, glass's, resins, woods and nylon type products available. The above can only be regarded as a summary of the different 'styles' of materials.

There are some GRE props which are badly made and dangerous etc.... just as there are some outstanding glass filled nylon props available. Buyer beware, and don't believe some advertising.

HOW PROPELLERS ARE MADE

When our factory site is visited, people are amazed to see what is involved in the manufacture of a propeller. Now that we think of it, such information is rarely seen in modelling magazines (they fail us again). There is far too much mystery involved. If modeller knew what it takes to make that prop on the front of their engine, perhaps they will appreciate it more than they do.

WOOD PROPS

Wood props are in use from indoor free flight rubber models through to giant scale radio models. For smaller models the average modeller can make their own. If you search hard enough, there will be magazine articles on how to do it. It generally involves obtaining a good wood, marking the blade shape, shaft hole and hub, followed by a leading edge and trailing edge line. Start carving. The bottom is flat and the top (of the airfoil) is curved. The actual airfoil and thickness is usually a function of what 'looks and feels' right. The finished prop is sanded to balance, painted with a clear lacquer and balanced again. The lacquer is vital to stop fuel soakage and warpage through moisture absorption.

It is good fun, but unless you have access to the proper timber don't make your own for anything but small / lower powered engines. Commercial wood propeller are made in a similar, except they use a process of guides (for pitch angles etc) and cutters to machine the wood blank to shape via a special router type machine called a spindle moulder.

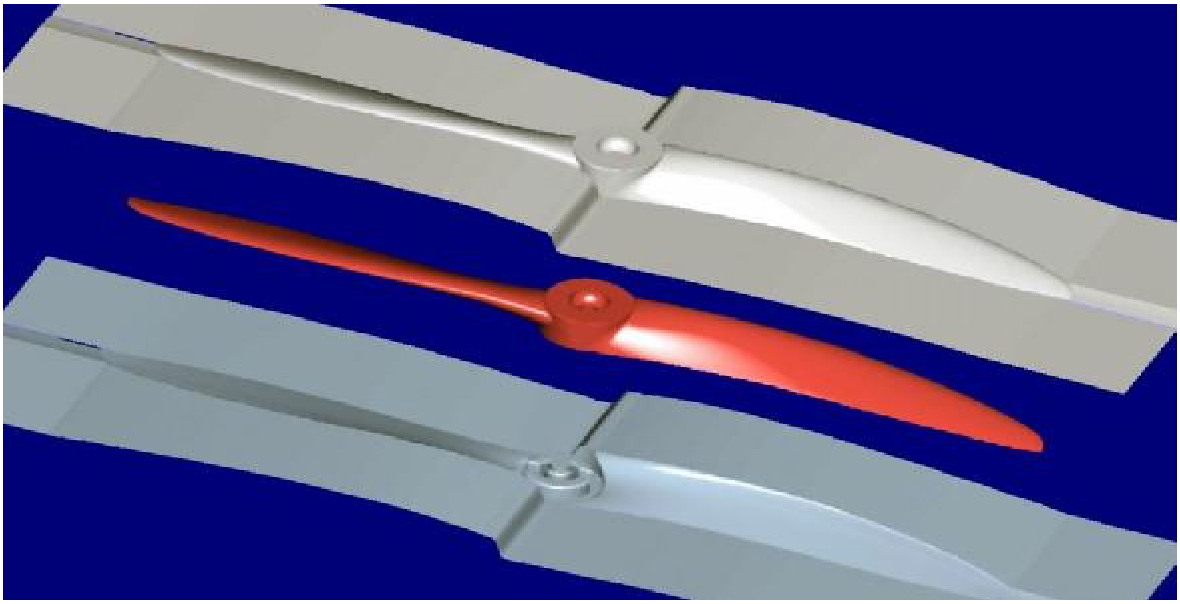
By all accounts good wood (such as special maples) is difficult (and expensive) to find.

Some wood props have been / are made through steam and resin compression moulding process.

MOULDED PROPELLERS

All other props are made through a process of moulding in top and bottom cavity dies. This enables propellers to be reproduced with some greater degree of control and finesse compared to hand or machine carved propellers. In some cases the moulds (or dies as they are often called) are made by machining (or EDM burning) the cavity from computer (CAD / CAM) designs, or by using a Pantograph where the mould cavity is machined from an existing master pattern. The alternative is to metal or resin cast a mould from an existing pattern.

Below is a computer picture we created to show this. It is not an actual production version (that we don't



show). Note the top portion of the die is shown in positive, not the negative (cavity).

The process for moulded nylon props is briefly described in the (material types) page above, whereby molten plastic is injected into the close cavity under extreme heat and pressures. Most people are familiar with this process as so many household products are made this way.

There are many technical hurdles to good moulding to maintain fibre integrity and shrinkage / accuracy. Needless to say we don't have room to discuss them here (if we wanted to).

HAND MADE, MOULDED PROPELLERS

Not so well understood is the far more complicated process of making a hand made composite propeller in carbon and / or glass fibre. Magazine articles on this subject are rare and questionable.

Take one cavity mould similar to that used for injection moulding (minus all the injection business).

Take one good resin system, generally an epoxy, because it is stronger and shrinks less than other types of resins. The higher the shrinkage the less accurate the end product, which is vitally important. As a matter of interest, injection moulded propellers can have a high shrinkage rate.

Take good quality, epoxy compatible carbon or glass fibres. There are many commonly used descriptions for these fibres such as rovings, tows, yarn and filaments. For those who haven't seen the type of fibres referred to here, they are best described as being similar in size to the flat fancy string to tie us your Christmas presents. Yes, a thin flat (sometimes round) length of fibre.

There are also many different descriptions for the fibres. In the case of carbon it is usually referred to as say a 12K tow, and in the case of glass a 2,400 tex. A 12K tow means there are 12,000 separate filaments of fibre in each length, and 2,400 tex refers to the weight (in grams) per 1,000 metres.

The fibres are impregnated with resin. Everyone has their own favourite method of doing this. It is an important step as the fibre must be fully 'wetted' with the correct amount of resin. Too little and there will be dry patches, too much and the high fibre to resin ratio which is so important for optimum strength will be lost. At the same time there is a chemical binder holding the fibres together (just think of the mess if it wasn't), which must be broken down.

The impregnated fibres are then laid into the mould, piece by piece, lengthways all of which must all be individually placed into the correct position until the cavity is filled. The difficult part is obtaining the correct volume of fibres at each given point of the blade. There may be 14 rovings filling the tip, and 140 rovings to fill the blade near the hub. That number will vary from prop to prop. Maybe 20 or less, maybe 200 or more.

Quite often a carbon or glass cloth is used in the 'lay-up'. This helps improve the torsional rigidity and lessens the chance of the prop splitting down the grain of the fibres.

Then there is the hub. Naturally this takes even more material to fill. There are several different approaches to this, at Bolly we used a combination of resin and short fibres mixed to form a strong filler. If we tried to fill it with individual roving pieces, it would take a very expensive amount of time.

As can be imagined, it is impossible to perfectly judge the volume and distribution of fibres. For this reason the cavity is overfilled, and any excess is squeezed out when the 2 mould halves are clamped together. The prop is cured at an elevated temperature (epoxies are stronger when cured at higher temperatures), and after curing, demoulded the next day. The moulds are cleaned and release agent is applied. Yes, one prop, per mould, per day. It can be done faster, but at the expense of curing time.

The excess fibre and resin, which has been squeezed out, is called 'flashing'. This is trimmed off and the prop receives more heat curing at a higher temperature again (called 'post curing'). As one can expect, a perfectly balanced, cheap prop is not made this way.

HOLLOW C/F PROPS

Becoming more available these days are the hollow carbon fibre props. These are generally identified by having a glossy carbon cloth pattern showing. The techniques for these is somewhat different, being more like making a glassfibre fuselage.

There are several techniques, but the easiest to describe is that each half of the die has the appropriate layers of cloth (and rovings if applicable) applied, and cured to an appropriate stage. When it can be handled, the two halves are joined, whilst at the same time installing the appropriate reinforcement to the edges and hub. After curing the manufacturer checks and adjusts the balance. If you look closely at most of these, you will see a hole where resin is injected into the blade (of the light side) to match the other side. One manufacturer we know of, inserts lead weights, which is a very dangerous practice.

Such a technique makes for a very attractive and light weight propeller. It does not have the structural integrity of a solid propeller, and due to it's hollow nature, must be made thicker (in the airfoil) to cope with the dynamic forces of a propeller, hence will absorb more horsepower to spin at the same rpm as a well designed solid propeller.

At Bolly we have made hollow C/F props. It is a more expensive process, and they didn't perform as well as our solid propellers. We have discontinued this process for now.

PROPELLER SELECTION GUIDELINES

There are many factors which govern propeller selection. The most difficult propeller to select, is the first one - especially when trying an all new set up. Once you have a 'working' propeller it is much easier to predict the outcome of changing propellers.

The recommended method for prop selection is :

find the correct prop size, experimenting with cheaper props / instruction manual etc.

then try a carbon fibre propeller of the same size,

to improve this, thin down the carbon fibre propeller. The extra strength of carbon fibre makes this acceptable.

Models will influence propeller selection. A large, high drag, slow flying model will need a larger diameter (or area) propeller with lower pitch than would a smaller, lighter faster flying model. For example a 120FS powered Piper Club would be best using 16 x 6 where as a 120FS Pattern model is best using between a 14 x 13.5 to a 15 x 11 or even a 16.5 x 12 for the latest engines.

A good analogy is to compare motor vehicle gearbox ratios, high gearing for racing vehicles, low gearing for load carrying vehicles.

Please consider these causes and effects.

HIGHER PITCH	More load on the motor - lower RPM.
HIGHER PITCH (same RPM)	Higher air speed - slower acceleration, more noise

LOWER PITCH	Less motor load - higher RPM, etc.
LOWER PITCH (same RPM)	Lower air speed - better acceleration.
HIGHER DIAMETER	Greater motor load - lower RPM.
HIGHER DIAMETER (same RPM)	More torque (pull) - vertical pull, more noise.
LOWER DIAMETER	Less motor load, higher RPM.
LOWER DIAMETER (same RPM)	Less torque - more power.

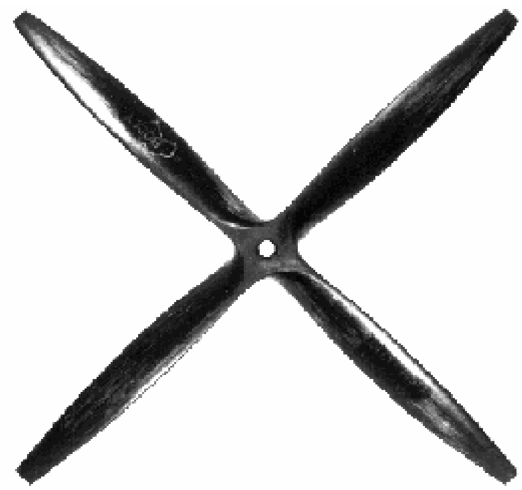
BLADE AREA: Changes in blade area will have a similar effect to variations in diameter. However an increase in propeller diameter is far more effective than simply increasing blade area. Most wide blade propellers are inefficient compared to higher aspect ratio blades.

MULTI BLADE PROPS

There is no exact formula for selecting a 3 or 4 blade prop in comparison to a 2 blade prop, pitch remains much the same but the diameter must decrease. A 4 blade 11 x 7 is not double the load of a 2 blade 11 x 7. Selecting the correct 3 or 4 blade prop is very dependent on the brand and type of prop.

Most nylon type 3 blade props are very inefficient to the point where (for a given engine size), the diameter reduction makes for a drastic reduction of performance. For example, a .60 size engine using a 2 blade 12 x 6 will need to go to a 3 blade 10 x 6 for similar engine rpm.... clearly not acceptable, especially where vertical performance (= diameter) is a criteria.

A well designed (narrow bladed) CRE or GRE prop can be used at a diameter between 90 to 95% of the equivalent 2 blade prop. For example, in the Bolly range the 11.25 x 6.5, 3 blader would be the equivalent of a 12 x 6, 2 blade prop.



AIRSPEED VS RPM AND PITCH DATA CHART

This chart is a good guide to the airspeed of the model. As a general guide, a good propeller will be about 90% efficient and the engine will unload by at least 10% in the air, therefore ground rpm x pitch should closely represent in air performance.... assuming a clean airframe and correct propeller choice.

PITCH	RPM x 1000												
Inch	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
2.5	12	14	17	19	21	24	26	28	31	33	36	38	40
3	14	17	20	23	26	28	31	34	37	40	43	45	48
3.5	17	20	23	27	30	33	36	40	43	46	50	53	56
4	19	23	27	30	34	38	42	45	49	53	57	61	64
4.5	21	26	30	34	38	43	47	51	55	60	64	68	72
5	24	28	33	38	43	47	52	57	62	66	71	76	80
5.5	26	31	36	42	47	52	57	63	68	73	78	83	89
6	28	34	40	45	51	57	63	68	74	80	85	91	97
6.5	31	37	43	49	55	62	68	74	80	86	92	98	105
7	33	40	46	53	60	66	73	80	86	93	99	106	113
7.5	36	43	50	57	64	71	78	85	92	99	107	114	121
8	38	45	53	61	68	76	83	91	98	106	114	121	129
8.5	40	48	56	64	72	80	89	97	105	113	121	129	137
9	43	51	60	68	77	85	94	102	111	119	128	136	145
9.5	45	54	63	72	81	90	99	108	117	126	135	144	153
10	47	57	66	76	85	95	104	114	123	133	142	152	161
10.5	50	60	70	80	89	99	109	119	129	139	149	159	169

11	52	63	73	83	94	104	115	125	135	146	156	167	177
11.5	54	65	76	87	98	109	120	131	142	152	163	174	185
12	57	68	80	91	102	114	125	136	148	159	170	182	193
12.5	59	71	83	95	107	118	130	142	154	166	178	189	201
13	62	74	86	98	111	123	135	148	160	172	185	197	209
13.5	64	77	89	102	115	128	141	153	166	179	192	205	217
14	66	80	93	106	119	133	146	159	172	186	199	212	225
14.5	69	82	96	110	124	137	151	165	179	192	206	220	233
15	71	85	99	114	128	142	156	170	185	199	213	227	241

	18	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
2.5	43	45	47	50	52	54	57	59	62	64	66	69	71
3	51	54	57	60	63	65	68	71	74	77	80	82	85
3.5	60	63	66	70	73	76	80	83	86	89	93	96	99
4	68	72	76	80	83	87	91	95	98	102	106	110	114
4.5	77	81	85	89	94	98	102	107	111	115	119	124	128
5	85	90	95	99	104	109	114	118	123	128	133	137	142
5.5	94	99	104	109	115	120	125	130	135	141	146	151	156
6	102	108	114	119	125	131	136	142	148	153	159	165	170
6.5	111	117	123	129	135	142	148	154	160	166	172	179	185
7	119	126	133	139	146	152	159	166	172	179	186	192	199
7.5	128	135	142	149	156	163	170	178	185	192	199	206	213
8	136	144	152	159	167	174	182	189	197	205	212	220	227
8.5	145	153	161	169	177	185	193	201	209	217	225	233	241
9	153	162	170	179	188	196	205	213	222	230	239	247	256
9.5	162	171	180	189	198	207	216	225	234	243	252	261	270
10	170	180	189	199	208	218	227	237	246	256	265	275	284
10.5	179	189	199	209	219	229	239	249	259	268	278	288	298
11	188	198	208	219	229	240	250	260	271	281	292	302	313
11.5	196	207	218	229	240	250	261	272	283	294	305	316	327
12	205	216	227	239	250	261	273	284	295	307	318	330	341
12.5	213	225	237	249	260	272	284	296	308	320	331	343	355
13	222	234	246	259	271	283	295	308	320	332	345	357	369
13.5	230	243	256	268	281	294	307	320	332	345	358	371	384
14	239	252	265	278	292	305	318	331	345	358	371	384	398
14.5	247	261	275	288	302	316	330	343	357	371	384	398	412
15	256	270	284	298	313	327	341	355	369	384	398	412	426

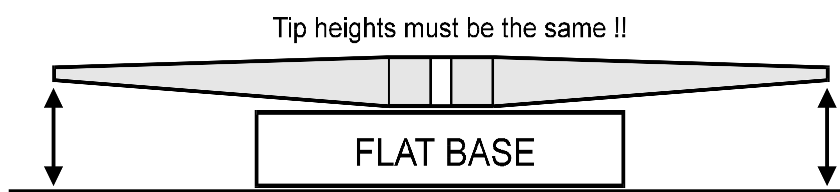
Remember: Static thrust has never flown an aircraft. Think about it !!

PROPELLERS … BALANCING, CARE / SAFETY & MODS

PROPELLER BALANCING

It is important that propellers be well balanced. The propeller should also sit square to the engine prop driver. Check for an equal height under each tip with the prop sitting on a flat surface.

Many props (especially moulded nylon types) will have an uneven bottom (and / or top) surface due to uneven material shrinkage. Check this before checking for equal heights below each tip.



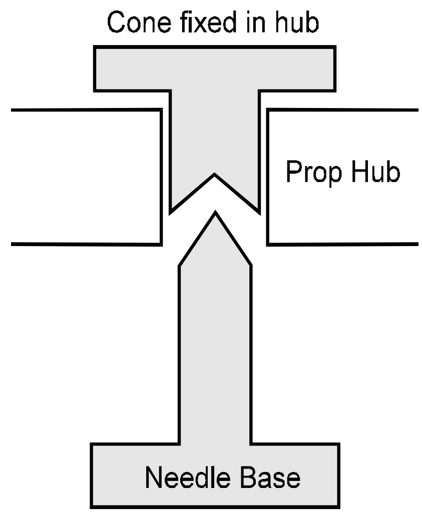
It can happen that the shaft hole isn't square to the rear face of the hub, for this it is a good idea to step or taper ream the prop, leaving only a small amount of the hole at the required diameter.

Please note, unlike machine made products which should be perfectly balanced (but often aren't), hand made props will require some balancing and finishing. Just to be safe, all props should be checked.

We use 4 types of prop balancers

1) **Basic double cone type**. This is the common easy to use type. Take care to hold this balancer square between the fingers. It is easy to create a false reading. Used properly, they can be quite good.

2) **The Pin and Cone type**. This type is good for checking balance in 2 directions, a) along the length, b) across the hub. The position of the cone adjusts the sensitivity. High = insensitive, Low = sensitive or 'overbalance'. Make a series of spit sleeves to fit larger shaft diameters. This type of balance is very good for multi blade propellers.



Pin and Cone stye balancer

3) **Rotating Wheel type**. The rotating wheel style of balancer has 2 sets of rotating wheels onto which the prop is placed via a shaft which is fitted through the hub of the propeller.

These are the most expensive, but are very accurate and hardest to use. Caution, we have found the alloy wheel types to be far better than the plastic types.

These balancers are also very good for balancing spinners. Note - many spinners are out of balance.

At Bolly, we used the DuBro True Spin type balancer (#499) for most of our balancing work.

4) **Magnetic type**. To a large degree these work on a similar principle to the basic double cone type, but without the friction of the fingers. The good versions are as accurate as the rotating wheel type. They are at a disadvantage when balancing large, heavy propellers.

Note: We have found one of the most common magnetic balancers to be hopelessly inaccurate … we have now check 10 of them, all are unacceptable.

Always balance by evenly removing material (sanding) from the top (curved) side of the blade. To remove material from the bottom may change the pitch and to remove material from the blade length or chord will create a dynamic imbalance.

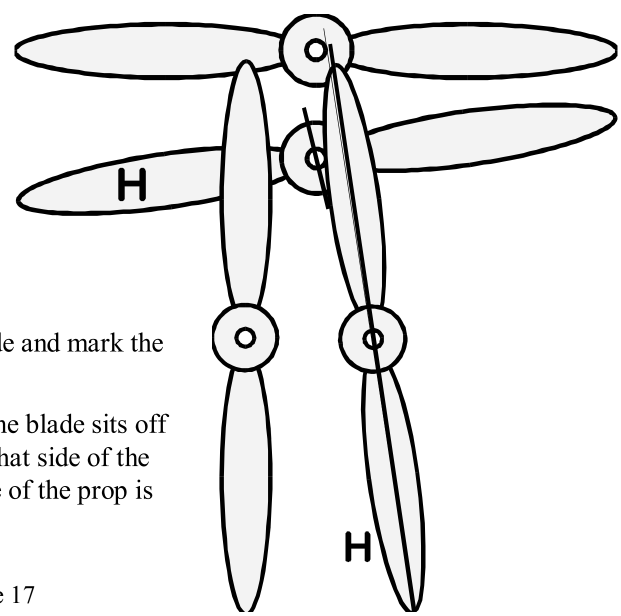
When removing the material, the choice of abrasive paper will depend upon the type of prop material. When modifying nylon base props, use a very fine abrasive paper as leaving any scratches on the surface is very dangerous, 1 deep scratch is potentially fatal. Wood props are easy to work with any appropriate abrasive paper. GRE / CRE props are very tough and will often require a very course paper for initial work, finishing with finer grades.

It is common for the prop to be heavy one side (across the blade). It is necessary to evenly remove material from the LE side of one blade and the TE side from the other, i.e. it is best to use a pin and cone or Tru-spin type balancer.... See the next page...

USING PROP BALANCERS

It is surprising how many modellers have never used a prop balancer, and even more surprising as to how few know how to 'read' what the balancer is telling them.

With any balancer, and any propeller, the prop should stay stationary at any point throughout it's 360 degrees of rotation. Sounds simple, but it isn't. If you have ever had a prop which refuses to stay put, or one that is different when rotated through 180 degrees, it is almost certain that the prop has a heavy side ... across the blade (chord) as opposed to along the blade (diameter).



The technique we recommend is this ...

Check the blade horizontally to find the heavy blade and mark the blade H.

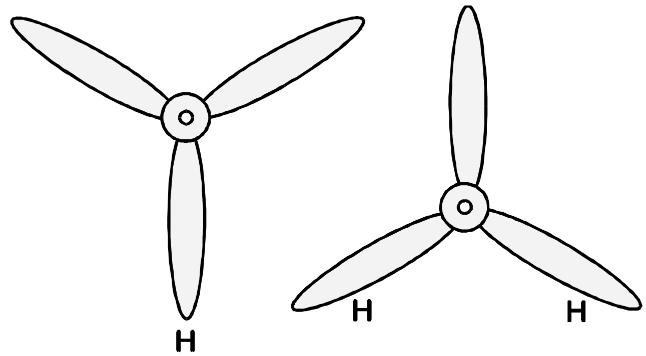
Put the prop vertically, heavy blade down, and if the blade sits off centre as per the diagram below, mark a H on that side of the heavy blade. The diagram shows the heavy side of the prop is the left hand side. Many modellers mistakenly think it is the right hand side.

Tip - to help determine the heavy side of a prop, use a piece of plasticine stuck to a hub or blade.

Now bias the material removal from that half of the heavy blade. In extreme cases material may be removed from the side of the hub, or even the opposing blade ... but on the same side of the hub.

Three and 4 blade props use the same principle, except it is often a combination of blades that need to be checked.

SUMMARY .... Any of the prop balancers can be used, just remember to check the prop in horizontal and then vertical. If in doubt, check the direction of the imbalance with a small weight on the side opposite what you believe is the heavy side. This will also allow you to gauge the amount of material to remove.



PROPELLER OPTIMISATION & MODIFICATION

If the propeller produces slightly too much load for you engine, don't be afraid to trim the diameter slightly. If you would rather not reduce the diameter, your other options are,

a) reduce blade thickness, b) reduce pitch or c) reduce blade chord.

Glass or Carbon propellers have the advantage of being easy to cut, file and sand. Don't be afraid to 'play', it is a good learning process. Carbon is easier to work than glass.

If you thin down your propellers, be sensible about it. Care must be taken on the back face, as this angle determines the pitch.

Do not modify nylon types of propellers.

Epoxy resin propellers can also be modified by twisting the blade under extreme heat, ie - boiling water or a heat gun. It is important that an accurate pitch gauge is used when attempting this form of modification. Take care to not over-do it, and avoid damaging the structural integrity of the prop.

PROPELLER CARE

After spending time balancing the propeller, take care to keep it in balance on the field. Frequently clean off residue, ie - grass, insects, earth, etc from the blade.

If you insist on mowing terra-firma, chances are you may split or feather the tip. These splits can often be repaired with a drop or two of thin cyno glue. If the split is too long of the cyno fails to repair the split, the propeller should not be used. A badly feathered propeller is often best trimmed to a lower diameter.

If using a wood or nylon type propeller, these should not be used if any damage or stressing is evident. Avoid storing propellers in a stressed position or hot environment, ie - model nose down, resting on the prop. The propeller may warp under these conditions. Nylon needs to maintain a moisture content for optimum properties. Most manufacturers (we hope) moisture condition the props before sale.

PROPELLER SAFETY

Propellers are potentially dangerous. Please treat with care, respect and common sense. Modellers have died from injuries caused by propellers. Remember a static propeller is safe, it is how they are used that causes the problems. Your safety (and those around you) is your responsibility.

At Bolly we have a test bench where we frequently test our products, when testing a 20cc engine we had a prop kick loose (the prop nut wasn’t tightened sufficiently), the prop flew forward 3 metres and hit the roof which was 4 metres above. It then bounced back to the test stand. It was a very good example of the potential dangers, luckily no one was nearby when it happened.

Correctly secure the propeller.

Do not stand to the side of, or lean over a rotating propeller. Always adjust an engine from behind.

Have a helper hold the model (or secure the model in some way), and keep spectators well clear.

Discard any propeller, which is scratched, nicked, stressed or damaged in any way.

Almost all props sold will have an instruction leaflet, please read them and take heed of them.

FULL SIZE Vs MODELS, PROPELLER SELECTION

At Bolly, we continually receive requests from modellers who want to use a scale diameter propeller on their model. So often do we receive these requests, we are adding the answers to the 'Book'.

Let's get one thing straight, right now. It is almost **impossible to use a scale diameter propeller** on a scale model.

Why: lets take the example of a 1/5 scale (about 80" span) Focke Wolf-190.

Naturally the first comment to make is re the 'scale factor' or Reynolds number effects.

If true scale is wanted, then why don't modellers expect the model to weigh 1,800 pounds.

The front end (forwards of the LE) of a FW-90 is filled almost exclusively with 12 or 14 cylinder, 1,700 hp engine. To be scale, where is that scale 340 horsepower engine.

The FW-190 used a 3 blade propeller, and a long undercarriage. Some Spitfires and Mustangs used 4 blade propellers, and shorter undercarriages. They needed multiple blade propellers to absorb the horsepower. If they used 2 blade propellers, the undercarriage legs would have been impossibly long.

Need we so any more!

Despite the above dose of cynicism, it is possible to get close to scale diameter, if using a 2 bladed propeller, coupled with a gear driven, powerful engine. To keep the diameter high, pitch would need to be low. Scale models often tend to be heavy, and as such must have a high flight speed to remain airborne … that requires some extra pitch.

As can be seen, it might be possible to 'scale' prop a Piper Cub, but not a FW-190.

PROPELLERS ... DYNAMIC FORCES AND EFFECTS

TORQUE

Almost every modeller is aware of the torque reactions caused by rotating propellers. It is fairly easily understood by all, that with the rotation of a propeller, there is a twisting (roll) force in the opposite direction to that of the propeller. For most models it is a rolling force to the left.

THE 'P' FACTOR

Not so well understood is the so called 'P' factor. Under normal flight conditions the propeller meets the airflow 'head on'. Under some conditions, especially take off and landing, the model (and hence the propeller) is flying at a higher angle of attack, compared to the airflow.....

This angle of the blade to the airflow creates uneven forces on one side of the prop to the other, and so the 'P' force will be seen as an effect in yaw. This 'P' effect on the normal model engine rotation is to the left in a nose up attitude, and to the right in a nose down attitude.

GYROSCOPIC FORCES

Gyroscopic forces, in particular gyroscopic precession are best demonstrated by a spinning top or a bicycle wheel. If you hold a spinning object in a plane simulating a propeller, and move the object up, down or sideways (whilst spinning), there will be a pitching or yaw effect on the spinning object.

To summarize the forces, assuming the normal model engine rotation of anti clockwise (from the front)

The model pitching up, causes right yaw.

The model pitching down, causes left yaw.

The model yawing right, causes pitch up.

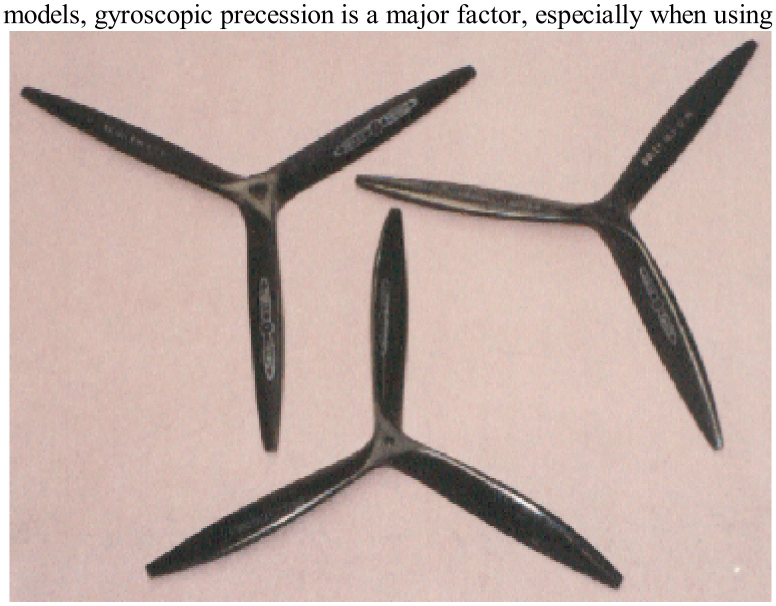
The model yawing left, causes pitch down.

THESE EFFECTS ON THE MODEL

Under normal flight conditions the above forces caused by the rotation of the propeller are usually not noticed, but are always in effect, and can be a problem for models that are inherently unstable. These forces are most noticeable at take off, especially taildragger models such as a scale Focke Wolf 190, which has a long undercarriage, a short tail moment and small tailplane. Under these circumstances all 3 forces will combine to create a potential crash on take off. If left unchecked (mainly with right rudder) the model will take off with a violent yaw and roll to the left.

Full size propeller driven fighter aircraft have similar problems, (some legendary) to models.

For F2B (aerobatics), control line models, gyroscopic precession is a major factor, especially when using large diameter propellers. Upon the application of up elevator, the model will yaw into the circle, loosing line tension. The opposite is true for down elevator where the line tension usually increases.



F3A (aerobatics) models all use a degree of side thrust, and very long tail moment arms. These 2 factors reduce the effect of these forces, and make for rock steady flying. the effects generally only show up in rolls and snaps, where the model will roll quicker one way than the other.

BOLLY PROPELLER DETAILS

COMPOSITE PROP DETAILS

1) SIZE

Due to the superior strength and construction of Bolly Props, many of the (prop) sizes we produce are a little different from the norm'. For example, our 10.5 x 6.5 is equivalent to (in terms of RPM) a nylon 10 x 6, but performs much better due to the extra diameter and pitch. For practical reasons some of our quoted sizes differ slightly to the end result, ie the Bolly 12 x 12N is actually a 12.2 x 12.2 and our 10 x 6 is a 10.2 x 6.2. Most Bolly props are quoted to within 1/4" of true size and are subject to a similar variation of size in manufacture (especially in pitch).

2) CHORD

As a guide to the load a propeller will place on an engine, the maximum chord is noted in the prop listing. For example, the chord of our 10.5 x 6.5 is by design, about 2mm less than most nylon propellers. The narrower high aspect ratio propeller is however more efficient.

There are applications which require a larger chord. For example the 12.5 x 11W (chord 29mm) has far more load than our 12 x 12 (12.2 x 12.2 with 23mm chord). This prop was developed to absorb the power of Long Stroke Pattern engines without increasing diameter (higher tip noise).

3) COLOUR

Carbon Fibre propellers are black. Bolly Glass Fibre propellers are also usually black in colour, and occasionally may be grey/silver, orange or copper/brown. Different colours may be ordered. To tell black carbon and glass props apart from each other, hold the prop to the light. Glass props are semi transparent (with a blue hue), carbon props are a solid black.

4) USE

Many of the Bolly propeller range were developed for a specific purpose, ie, the 12.2 x 4.2 was developed for .60 C/L stunt but has a big following for Old Timer contest work. The range of models, motors and ways of using propellers is so vast it is impossible to publish all the variables of prop use.

5) SPECIALS

Specials and modifications of existing props. We can often increase the diameter or repitch an existing prop to suit your needs. Please enquire by mail or phone before ordering specials.

6) NYA LISTINGS

Props which are noted NYA are new sizes planned for production, but are ‘not yet available’. As this edition of the book is being printed for a 6+ month supply, all sizes planned for the next 6 months are listed. There may or may not be an update sheet with this book.

BOLLY Mfg COMPOSITE PROPELLER DATA CHART

NOMINAL SIZE			EXACT SIZE			BLADE CHORD	AVE WEIGHT (GRAMS)		DESIGNED USE OTHER COMMENTS
DIAMETER	x	PITCH Inches	DIAMETER	x	PITCH Inches	MM	GLASS FIBRE	CARBON FIBRE	
4 BLADE PROPELLERS									
26	X	15							NYA
22	X	10 Pusher	22.1	X	10	43.5	380	-	100 - 120 cc
21	X	12							NYA
20	X	10							NYA
18.5	X	12							NYA
15.5	X	12.5W	15.4	X	12.4	32	175	160	140 / 180
14.5	X	11							NYA
14	X	8							NYA
12	X	6	12.1	X	6.2	22	-	55	.60 C/L Stunt
11	X	10.25	11	X	10.25	18	56	50	Narrow blade
11	X	7	10.9	X	7.1	21	52	45	.60 sports
9.5	X	6.5	9.5	X	6.6	17.5	43	-	.45 sports
3 BLADE PROPELLERS									
24	X	12							NYA
22	X	12	22	X	12.2	42	290	265	65 – 80 cc
21	X	13	21.2	X	12.7	36.5	220	190	70cc
20	X	12	19.9	X	11.9	34	195	170	60cc
19	X	11	19	X	10.9	33	180	160	50cc
18	X	10	18	X	10	32.5	165	145	40 - 45cc
16.5	X	12	16.4	X	12.1	32	145	125	F3A to 35cc
16.5	X	10	16.9	X	9.6	29.5	145	125	30 - 35cc
16	X	13W	16	X	12.7	33	145	-	140 / 180
15.5	X	13							NYA
14	X	13N	13.9	X	13	24	70	60+	.108 / .120
14	X	10							NYA
14.5	X	8							NYA
13	X	4.5							F2B / low speed
12.5	X	11.5	12.6	X	11.5	24	60	45	.90 / .120
12.5	X	8	12.5	X	8	25	55	50	.90
12.5	X	6.5	12.6	X	6.7	24	50	40	.65
12	X	10	12	X	10	23.5	-	45	.90
12	X	6.5N	11.8	X	6.7	22	-	40	.60 C/L Stunt
12	X	4.25	12.1	X	4.1	22	45	40	.40 C/L stunt
11.5	X	11	11.5	X	11.2	20	45	-	Narrow blade
11.25	X	6.5	11.2	X	6.7	22	45	37	.45 C/L stunt
11	X	7.5	11	X	7.4	22.5	50	40	Old .60 pattern
10.5	X	6.25	10.5	X	6.2	20.5	40	37	.45+
2 BLADE PROPELLERS									
54	X	22							NYA
36	X	14.5							200+ cc
32	X	12							NYA
30	X	15	30.1	X	15	55	485	435	120 + cc
30	X	12	30.1	X	12.25	57	500	455	TOC winner
29	X	12	29.2	X	12.2	53	-	450	NYA
28	X	14	28.3	X	14.2	52	-	430	NYA
28	X	12	27.9	X	11.8	50	-	395	NYA

NOMINAL SIZE			EXACT SIZE			BLADE CHORD	AVE WEIGHT (GRAMS)		DESIGNED USE COMMENTS
DIAMETER	x	PITCH Inches	DIAMETER	x	PITCH Inches	MM	GLASS FIBRE	CARBON FIBRE	
2 BLADE PROPELLERS Cont…									
28	X	10							NYA
26	X	14							NYA
26	X	12	26.3	X	11.8	49		330	75 – 90cc
26	X	10	26	X	10.2	52		340	75 – 85cc
24	X	24	24.1	X	23.5	45		225	Reno racing
24	X	14							NYA
24	X	12	24	X	12	47	275	245	70+ cc
24	X	10	23.9	X	9.9	47	280	265	60 – 70cc
24	X	8	24	X	7.9	49		280	60 – 70cc
23	X	12	23.1	X	11.8	45	235	200	70cc
23	X	8							NYA
22	X	20	22	X	19.5	41	210	195	Reno racing
22	X	12	22	X	12	45	200	185	70cc
22	X	10	22.1	X	10	45	200	185	60cc
22	X	8	22.1	X	7.8	45		185	45 – 60cc
21	X	14							NYA
21	X	12	21	X	12	43	175	155	60cc
21	X	10 v2	21.1	X	10.2	43	160	140	40 - 50cc
21	X	8							NYA
20	X	10	20	X	9.8	43	155	135	35 - 45cc
20	X	8	20.2	X	8.2	43	160	140	30 - 40cc
19	X	10	19.1	X	10	38	125	110	30 - 35cc
19	X	8	19	X	7.8	39	130	115	30cc
19	X	6	19.1	X	6	39	125	110	20 - 25cc
18	X	12	18	X	12	35	130	115	30 - 35cc
18	X	10	18.1	X	9.7	38	130	115	30cc
18	X	8	18	X	7.8	39	125	110	25 - 30cc
17.5	X	12	17.5	X	12.6	34	105	95	.120 / .180
17	X	10	17.2	X	9.9	35	105	90	20 - 25cc
16.5	X	12	16.4	X	12	32	100	90	F3A
16.5	X	8	16.6	X	8	33	95	85	.120
16	X	14	16.1	X	13.7	32	95	80	F3A
16	X	13W	16	X	12.8	34		90	.120 / .145
16	X	10	16.2	X	9.9	35	105	90	20 - 25cc
16	X	6	16.3	X	5.7	35	95	80	20cc
15.5	X	13							NYA
15.5	X	10N							NYA
15.5	X	8	15.7	X	7.8	31.5	95	80	.108 - .120
15.3	X	12.3	15.3	X	12.2	32	90	80	.120 / .145
15	X	25	15.2	X	25	33	125	110	Man power boat
15	X	11	15	X	10.8	29.5	85	75	.120 pattern
15	X	7	15	X	7.2	29.5	75	65	.90 - .108
14.5	X	14.5	14.6	X	14.3	29	75	65	.120 pattern
14.5	X	13.5	14.3	X	13.3	29.5	75	65	.120 pattern
14.5	X	12.5	14.7	X	12.1	28	75	65	.120 pattern
14.5	X	12W	14	X	12	30.5	75	65	.108 / pattern
14	X	16	13.7	X	16.3	27	70	60	fast .120
14	X	10							NYA
14	X	8							NYA

14	X	6	14.2	X	6.2	28	55	45	low rpm use
NOMINAL SIZE			EXACT SIZE			BLADE CHORD	AVE WEIGHT (GRAMS)		DESIGNED USE COMMENTS
DIAMETER x PITCH Inches			DIAMETER x PITCH Inches			MM	GLASS FIBRE	CARBON FIBRE	
2 BLADE PROPELLERS Cont...									
13.75	X	10	13.8	X	9.7	29	65	55	.90 / .60 pattern
13.5	X	12	13.5	X	12	29	65	55	.90 / .108
13.5	X	11	13.6	X	11	28	75	55	.90 / .60 pattern
13.25	X	10	13.15	X	10	28	60	50	.90 / .60 pattern
13	X	7	13.1	X	6.8	28	55	45	.75 - .90
13	X	6	13	X	6	26	48	38	.60
13	X	4.25	13.1	X	4.2	21		35	F2B / hovering
12.6	X	3.8	12.55	X	3.8	26	40	32	new F2B style
12.5	X	11.5W	12.5	X	11.7	28	57	47	LS 60 pattern
12.5	X	11W	12.6	X	10.8	28	55	45	LS 60 pattern
12.5	X	11	12.5	X	11.1	27	53	43	60 pattern
12.5	X	10.5W	12.7	X	10.6	28	56	46	Best LS 60 Pattern
12.5	X	5.5	12.5	X	5.4	26.5	43	35	.60 C/L
12.25	X	4.25	12.25	X	4.3	25	34	29	F2B / hovering
12.2	X	4.2	12.4	X	4.2	24	35	30	F2B / hovering
12	X	12N	12.2	X	12.2	23	45	38	sport pattern
12	X	11N	11.9	X	11.1	23	45	38	sport pattern
12	X	10N	11.9	X	10.1	23	44	37	sport pattern
12	X	11QT	11.9	X	11	24	53	43	quiet tip
12	X	8	12.1	X	7.9	26	45	38	.75
12	X	6	12.1	X	6.1	29	37	31	NYA
12	X	6	12.1	X	6	25	40	33	.60
12	X	4.5W	11.9	X	4.6	29	39	35	F2B / hovering
12	X	4	12	X	4	23.5	33	25	narrow / OT
12.25	X	4.25	12.25	X	4.2	25	36	29	C/L stunt
12.2	X	4.2	12.15	X	4.2	24	35	28	update of above
11.8	X	3.8	11.85	X	3.8	24	34	27	Latest F2B piped
11.75	X	4.25	11.7	X	4.2	25	34	27	piped C/L
11.5	X	6.5	11.5	X	6.3	24.5	37	29	sports / C/L
11.25	X	8	11.25	X	8.1	23	35	28	piped .45/ .60FS
11.25	X	4	11.2	X	4	22.5	32	24	new F2B / OT
11	X	6	11.1	X	5.9	23	32	24	C/L / OT
10.5	X	8	10.4	X	7.8	20	26	22	.46
10.5	X	6.5	10.4	X	6.6	20	26	22	.40 - .46
10	X	6	10.25	X	6.2	21.5	26	22	.34 - .45
10	X	6SP	9.85	X	6.4	20	22	-	Aust S-pylon
9.5	X	4.5	9.5	X	4.5	19.5	22	17	40 FF / OT
9.25	X	7	9.15	X	6.85	20.5	21	16	Very thin blades
8.5	X	6.5	8.6	X	6.3	17		16	Clubman style
8.25	X	6.25	8.45	X	6.3	20	19	15	.25 - ..32
8	X	7.5N	8.1	X	7.6	17.5	18	15	.40 pylon
8	X	7N	7.9	X	6.8	17	17	14	FAI pylon
8	X	6.5	7.9	X	6.6	18.5	18	15	FAI pylon
8	X	6.5N	8	X	6.7	17	17	14	FAI pylon
8	X	6	8	X	6	19	18	15	.19 - .25
8	X	5.75	8.1	X	5.7	19	18	15	.19 - .25
P11								NYA	Westland N.Z

P10B					7.1+			NYA	Smaller P10
P10			7.6	X	7.3+	16	17	14	FAI pylon
P9		1.5” hub	7.8	X	7.2	16.5	24	18	FAI pylon
NOMINAL SIZE			**EXACT SIZE**			**BLADE CHORD**	**AVE WEIGHT (GRAMS)**		**DESIGNED USE OTHER COMMENTS**
DIAMETER x PITCH Inches			**DIAMETER x PITCH Inches**			**MM**	**GLASS FIBRE**	**CARBON FIBRE**	
2 BLADE PROPELLERS Cont…									
P8			7.6	X	7.0	16.5	17	14	FAI pylon
TR10		oversize	7.1	X	7.1	17	11	8.5	C/L racing
7	X	5.5	7.0	X	5.3	15	13	11	QM / electric / CL
7	X	4	7.0	X	3.7	16	11	8.5	.15
7	X	3	7.1	X	3	16	10	8	FF
G3			6.8	X	4.7	15	8.5	7	thin blades
6.75	X	4.25	6.7	X	4.15	16.5	12	10	.15
TR43			6.6	X	7.1	16	9	7.5	cuffed root blade
G2			6.6	X	5.6	14.5	9	7.5	cuffed root blade
G22			6.7	X	5.25	14.5	10	8	.21 QM
G23			6.5	X	5.6	14.5	10	8	.21 QM
QM4			6.4	X	5.6+	14.5	8.5	7	.21 QM
TR84			6.4	X	6.6	14	8.5	7	C/L Team Race
TR82			6.3	X	6.8	15	9	7.5	C/L Team Race
TR92			6.3	X	6.4	16.5	9	7.5	Cuffed root, TR
TR83			6.2	X	6.6	14.5	8.5	7	C/L Team Race
TR85			6.15	X	6.5	14.5	8.5	7	C/L Team Race
6	X	6	5.8	X	5.8	13	6.5	5.5	C/L speed
6	X	5	5.85	X	4.9	13.5	6.5	5	.11, 1/2 A pylon
6	X	4.5	6	X	4.5	14	6.5	5	.11, 1/2 A pylon
6	X	4	6.1	X	4	14.5	6.4	5	.11, 1/2 A pylon
A4			5.6	X	5.2	13	6.5	5	.11, 1/2 A pylon
A42			5.5	X	4.8	12	6	5	.11, 1/2 A pylon
5.5	X	4	5.5	X	3.7	15	5	4	.051 1/2 A pylon
5	X	5	5	X	5.1	14	4	3.5	.051 C/L racing
SINGLE BLADE RACING PROPELLERS									
QM5									nya
A5									nya
6.4	X	6.2	6.4	X	6.1	15	5.5	4.2	C/L FAI speed
6.2+	X	5.7	7	X	5.65	17	5.5	4.2	C/L FAI speed
6.2+	X	4.2	7	X	4.2	17	5.5	4.2	.15 QM
6.2	X	5.4	6.15	X	5.4	18.5	5.7	4.5	C/L FAI speed
ELECTRIC FOLDING PROPELLERS									
13	X	7				29.5	15	13	
10.2	X	4.5				23	7		
9	X	4.5				23	6		

NOTES ON COMPOSITE PROPELLER USES

PROPS FOR LARGE R/C SCALE MODELS

The Bolly GRE propellers are especially suited to the large engine use. The extra strength make them much more economical than wood (at any price), and much safer than nylon types which are prone to stretching to destruction at these sizes. The extra weight of a composite prop (compared to wood) often helps the idle characteristics of an engine.

Our first large prop was a 20 x 10 in 1979 when even wooden 20 x 10 were rare.

For large models, props size is often determined by noise, ie, on some flying fields a 18 x 10 may be regarded as too large on a ST 3000, in other areas a 19 x 10 may be regarded as too small. The choice is yours. As a rule the 3 and 4 bladed props make a good choice for noise reduction.

Avoid using tip speeds in excess of 400 MPH if noise is of concern, although 450 MPH tip speed is common in areas of low noise sensitivity.

400MPH tip speed @ 22" = 6 100 max. RPM

20" = 6 800 max. RPM

18" = 7 500 max. RPM

The range is expanding. It is easiest to list the propellers and the engines commonly used. It is our aim to manufacture prop sizes 18" to 30"in diameter, at a pitch of 8, 10, 12 and 14" before mid1998. At the time of printing this book, we have listed many of these newer sizes as NYA.

Please remember, large slow flying models (i.e. Piper Cub, etc) will need more diameter and less pitch.

Selecting the correct propeller is a little like selecting the correct gear ratio for motor vehicles. For slow flying ,high drag models (i.e. a Piper Cub)select a higher diameter / lower pitch prop for it's 'pulling' ability. The reverse is true for faster type models (ie, Laser, etc), use a smaller diameter / higher pitch propeller.

Engine Size / Type	*'Cub' Style model*	*'Laser' Style model*	*3 blade choice*
108's	15 x 7 to 16 x 6	15.5 x 8	14.5 x 8 3B
Std 120 4-strokes	15 x 7 to 16 x 6	15.5 x 8 to 16.5 x 8	14 x 10 3B to 14.5 x 8 3B
Super 120 4-strokes	16 x 6 to 18 x 6	16.5 x 8 to 17 x 10	14 x 10 3B +
2 stroke 120 / .145	19 x 6 +	15.3 x 12.3 to 17.5 x 12	15.5 x 13 3B
25 to 32cc	19 x 6 to 20 x 8	17.5 x 12 to 19 x 10	16.5 x 10 3B to 16 x 13W 3B
32 to 38cc	20 x 8	19 x10 to 21 x 10	16.5 x 12 3B +
35 to 45cc	20 x 8 to 22 x 8	20 x 10 to 21 x 10	18 x 10 3B
45 to 55cc	22 x 8	21 x 10 to 22 x 10	19 x 11 3B
55 to 65cc	22 x 8 to 24 x 8	21 x 12 to 23 x 12	20 x 12 3B to 22 x 12 3B
65 to 75cc	24 x 8	22 x 12 to 24 x 12	22 x 12 3B
75 to 85cc	26 x 10	24 x 12 to 26 x 12	24 x 12 3B +
85 to 100cc	28 x 10	26 x 12 to 28 x 10	NYA
3W-120 etc	28 x 12	28 x 14 to 30 x 12	NYA
3W-160 etc	32 x 12	30 x 15	NYA
3W-240 etc	36 x 14.5	36 x 14.5	NYA
Don't forget the 4 blade propellers in our range.			

PROPS FOR SCALE MODELS (BELOW .108 ENGINES)

Many scale models could be described as overweight, bulky (high drag) and under powered (for good flying speed). It is quite simply the nature of the beast, especially when engine size is compromised in order to fit within the cowling.

For this reason, it is imperative to keep diameter up, and to find the correct pitch. Not so high as to load the engine, nor so low as to have insufficient flying speed.

For all of the above reasons, using a good and efficient composite propeller is a must. The use of Nitro fuel is also highly advised to enable the use of bigger propellers.

PROPS FOR COMPETITION R/C PATTERN (F3A)

We have done intensive testing to develop a range of propellers which will outperform any other popular pattern prop that we know of. Without doubt our GRE or CRE propellers are much safer and longer lasting than products made of wood or injection moulded plastics.

To avoid confusion we have deleted, or re designated many of the older sizes from our list.

Also see our pipes section of the book.

120 / .145 2 Strokes

The new .120 / .145 engines are coming into use. We have done extensive testing of propellers, pipes and models for this new wave of engines. It is difficult to give definitive figures as there are many ways of setting up for pattern re choices of model, rpm and nitro.

To keep noise levels down due to tip speed, we will soon have a range of 3 & 4 blade props in (or about to enter) production. As a rule a 14.5" prop (2B) is adequate for performance, but many of these engines can easily turn a 17 or 18" prop, but the noise is too high.

4B Props =	15.5 x 12.5W 4B	14.5 x 11 4B			
3B Props =	16.5 x 12 3B	15.5 x 13 3B			
2B Props =	17.5 x 12	16.5 x 12	16 x 13W	16 x 14	15.3 x 12.3

.60 / .80 / 1.08 2 Strokes

3B Props =	12.5 x 11.5 3B	11.5 x 11 3B		
2B Props =	14.5 x 12.5	13.5 x 12	13.5 x 11	
	12.5 x 11.5W	**12.5 x 10.5W**	**12.5 x 11W**	12.5 x 11

.120 / .145 4 Strokes

We have had many new developments for the 4 strokes. Some of the smaller props being developed for the new .120 2 stokes also suit the later more powerful 4 strokes.

4B Props =	14.5 x 11 4B			
3B Props =	14 x 10 3B			
2B Props =	16.5 x 12	15.5 x 12.5	15 x 11	14.5 x 13.5

The older design props for earlier 4 stokes, such as 14 x 13 3B, 14.5 x 14.5, 14.5 x 13.5, 14.5 x 12.5 and 14.5 x 12W are no longer suited to modern pattern, but make excellent choices for 'sports' pattern.

For information updates, ask for the Bolly 'Pattern Products' Newsletter.

PROPS FOR SPORTS R/C PATTERN

Over the years pattern has changed from a high revving, conventionally muffled engines using small props to the currently used quiet pipe, bigger low revving engines, and .120 / .140 4 strokes.

We also cater for the novice pattern flyer using the .45 / .60 sized engine, piped or conventional style.

For the older .60 engines using a pipe we recommend:

The '**narrow**' and the popular **"QT"** style props are best suited to the short stroke engines. Popular with the 'sports' pattern flyer.

12.5 x 11 (better engines), 12 x 11 QT 12 x 12 N 12 x 11 N 12 x 10 N

For conventional .60 engines recommendations are (with standard muffler)

12 x 8 11.25 x 8 11 x 7.5 3B 11 x 7 4B **clubman** *12.5 x 8 to 11.5 x 7*

For the .45 engine using a conventional muffler we recommend:

10.5 x 6.5 10.5 x 8

10.5 x 6.25 3B

clubman 11.5 x 7 or 10.5 x 8

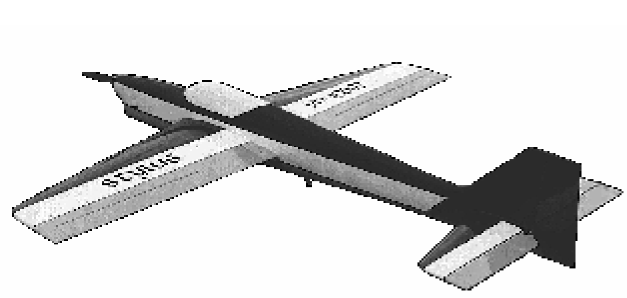
For piped .45's etc we recommend:

10.5 x 8 10.5 x 6.25 3B

11.25 x 8 11 x 7 4B

clubman *10.5 x 7 or 10.5 x 8* (nya)

STYLUS, the ideal first .60 pattern model



For conventional (sports) .120 4 cycle engines we recommend:

13.5 x 12	14 x 10	**clubman** *14.5 x 8*	Early 120
15 x 10N	14.5 x 12.5	**clubman** *15.5 x 8*	Surpass, 120R, YS

PROPS FOR SPORTS 4-CYCLE ENGINE

The most common mistake with 4-stroke (cycle) engines is to under-prop them, especially under pitched. It must be noted that 4-stroke engines rev slower than 2-strokes, hence when used in a similar model the 4-strokes must use a high pitch prop to fly at the same speed.

Higher pitch props. Although lacking in initial acceleration usually deliver a much smoother style of flying for reduced noise levels.

Below is a suggested prop size for the OS range of engines. Other brands will be similar.

FS 120 Supercharged	16.5 x 8, 15.3 x 12.3, 15 x 11, 14.5 x 13, 14 x 10 3B, 14 x 8 4B
FS 120 Surpass	15.5 x 8, 14.5 x 12.5, 14 x 8 3B,
Old FS 120	15.5 x 8, 15 x 7, 14 x 10, 12 x 10 3B, 12.5 x 11.5 3B, **clubman** *15.5 x 8*
FS 91 Surpass	14 x 8, 13.75 x 10, 13.5 x 11, 12 x 10 3B, **clubman** *14.5 x 8, 13.5 x 8*
FS 90	13.75 x 10, 13.25 x 10, 13 x 7, 12.5 x 8 3B, **clubman** *13.5 x 8*
FS 70 Surpass	14 x 6, 13 x 7, 12 x 8, 12.5 x 8 3B, **clubman** *13.5 x 6, 12.5 x 8*
FS 61	13 x 6, 12 x 6, 11.25 x 8, 11 x 7.5 3B, **clubman** *12.5 x 6*
FS 48 Surpass	11.25 x 8, 11.5 x 6.5, **clubman** *12.5 x 6 or 11.5 x 7*
FS 40 Surpass	10.5 x 8, 11 x 6, 12 x 4, **clubman** *10.5 x 7*
FS 40	11 x 6, 10.5 x 8, 11.5 x 6.5, **clubman** *10.5 x 6*
FS 26 Surpass	9.5 x 4.5, 9.5 x 7, 10 x 6, **clubman** *9.5 x 6, 9.5 x 5*

PROPS FOR .45 SIZE MODELS

The world's most common size of model is the .45, being used in trainers and general sports models.

Whilst a specific prop is not produced for trainers, the use of a Bolly prop will help that marginal model perform much better. The original Bolly .45 prop was the 10 x 6. This prop will out perform any wood or nylon equivalent of that size.

Further developments have led to the production of a 10.5 x 6.5 and 10.5 x 8. Both of these narrow blade props will offer an improvement over a 10 x 6. The 10 x 6 and 9.25 x 7 are best when wanting straight line speed. Also available, the 9.5 x 6.6 4B and 10.5 x 6.25 3B.

For modellers wanting a less expensive product, the Bolly **clubman** Series propellers are perfect for the sports 40 / 46 market. These include the 10.5 x 5. 10.5 x 6, 10.5 x 7 and the11.5 x 5 which is especially suitable for .45 powered trainers. The 12.5 x 6 is excellent for .51 etc engines.

PROPS FOR R/C PYLON

The Bolly Racing propellers have been developed over many years of flying and testing. An extensive range is available for almost all classes possible.

Please note: We are changing all our newer props to a number code

For **FAI** we have our base 8" range and the variations moulded from the base types. For models using a 2" spinner, we have found it best to use the 8" props at 7.75" diameter. And for models using a 1.5" spinner, we use the 8" props at 7.5" diameter. Smaller diameters are frequently used.

8 x 6	Now out dated unless used with an older engine.
8 x 6.5N	As above.
8 x 6.5	Too much load on most engines, fast if it can be made to work.
8 x 7N	A very successful prop especially on OPS, best time of 1.11
8 x 7.5N	Gaining favour as power levels increase, the best time of 1.13
P8 (7.7 x 6.8)	A variation of the 8 x 7N.... infact a copy of the 1.11 version.
P9 (7.8 x 7.0)	DeChastel designed large 1.5" hub prop. No spinner required.
P10 (7.7 x 7.5 +)	Our latest prop, for Rossi, Jett etc. Best time 1.08.
P10B (7.7 x 7.2 +)	*NYA*... Lower pitch version of P10, when less load is required.
P11	Based on the successful Harvey Westland (N.Z.) designed propeller.

<u>Props for Australian Quarter Midget, using piped .21 engines.</u>

7 x 5.5	Must be trimmed down in diameter to perform. Best time 1.09.
G22 (6.6 x 5.3)	The 'standard' prop. Best time 1.07
G23 (6.6 x 5.6)	A higher pitch G22. Best time 1.07
QM4 (6.4 x 6.6)	An all new shape....best time 1.07. Best in c/f only.
QM5 *NYA*	New single blader, with integral counter weight..

<u>Props for Australian 1/2A, using .11 engines.</u>

6 x 4	For lower power engines.
6 x 4.5	Alternative to the 6 x 4.
6 x 5	Popular and successful prop. Best used under 5.5” diameter.
A4 (5.6 x 5.5)	An all new shape. Works well if you have the power to pull it.
A42 (5.5 x 5.0)	A smaller variation of the A4, proving to be very popular.
A5 *NYA*	New single blader with an integral counterweight.

<u>Props for Australian Sports 45 pylon, the rules vary around the country.</u>

10 x 6SP	(sport pylon) enjoys a very good reputation for performance. This prop is supplied ready to 'bolt on' in order to meet the rules.

9.25 x 7	often cut down to smaller diameters. Best in c/f only.
8.5 x 6.5	Our new prop for 40 size 'sports / QM' pylon. **clubman** Series shape.

GENERAL: It cannot be stressed enough, that a successful pylon model is one where the complete power-plant and model are correctly matched with themselves and the weather. The dominant factor in engine performance is heat (see 2 stroke theory).

For prop selection it is a compromise between high acceleration (high diameter or area) Vs straight line speed (high pitch). Often a low pitch prop will give faster race times (than high pitch) due to its faster turning / cornering ability. For sports models, wind is a dominant factor. The 8.5 x 7 may be best in calm and 10 x 6SP the best in wind, but less successful when roles are reversed.

PROPS FOR R/C OLD TIMER

Bolly Props are especially suited to competition 'Old Timer' events. Where the rules limit the power plant (as in OT) the biggest advantage is in the propeller.

Despite selling large quantities of props to old timer enthusiasts, very little information is at hand within our offices to specific applications. The 13 x 6 has proven very successful as have the 14 x 6, 12 x 6, 11 x 6 and 9.5 x 4.5 in other engine sizes. These 5 sizes are efficient thin, narrow bladed propellers suited to 'climbing' type events.

For most O.T events, a fine pitch prop is generally best, especially for duration. As it so happens the props used by the modern F2B (c/l stunt) model also suit.

To meet these 2 demands the 12 x 4 (narrow), and the broader blade props, the 13 x 4.25, 12.6 x 3.8, 12.25 x 4.25, 12.2 x 4.2, 11.75 x 4.25 and 11.25 x 4 have been introduced to the Bolly range.

PROPS FOR R/C FUN / HOVERING

The 1990's have seen the proliferation of what are commonly called 'Fun' models for combat, hovering or extreme manoeuvres. Many of these are profile fuselages, flying wings etc. Many of these models are not suitable for high speed as the lightweight structure is prone to flutter.

Bolly Props originally designed for C/L aerobatics or Old Timer are perfect for this type of flying. See the list in the above OT section.

To give an example of this, the Bolly factory prototype of the Quique Somenzini designed 'Hovering Cobra', uses a Super Tigre S-45K and a Bolly 12.6 x 3.8. The performance is awesome. If we used a 'normal' nylon prop, say a 11 x 4 (to achieve the same rpm), performance would be much less.

For larger size 'Fun' models, using a high diameter, narrow blade composite prop such as our 16.5 x 8 or 16 x 6 (for a .120 2 stroke) will help performance.

PROPS FOR C/L RACING

Bolly Props were originally produced for C/L only, and therefore we cater for most sizes and events.

For .051(mouse racing), the 5 x 5 or 5.5 x 4 have held many records.

Goodyear (Scale Racing) is a variable world wide (.15 or .21).

For .15 glow use, the G series, ie, G3, G2, G22, G23 (New) are all good as are some of the QM props, the 7 x 5.5 and QM4 (New). For .21, some of the large QM or smaller TR props should work.

TR 85, 84, 83 & 82 (top to bottom)

Team race (FAI) has seen many of our old 1970's designs deleted to the X-List, and many new choices. The TR82 / 5 series are all developments of a similar style prop, all are good, it's a matter of selecting the correct version for your set-up.

The 'odd-ball' TR events, ie, 1/2A and B will often find a suitable prop amongst the TR or FAI pylon props. For 1/2A or Mini Goodyear the new TR84 should be suitable due to its low blade area. Some 1/2A pylon props may be of use in smaller classes.

PROPS FOR CONTROL LINE SPEED

Four (4) props are made for FAI speed, all are proven performers and have held national records at one time or another.

Newest is the 6.4 x 6.2 SB. This prop has recently been used to rewrite all Australian records.

A fool proof starting set-up is an Irvine or Rossi, etc, and a 6 x 6 prop.

The 6.2 x 5.7 SB, 6.4 x 6.2 SB and 6.2 x 5.4 SB are square hub single blades suited to competition work. These props can use a specially machined counterweight spinner to suit the square prop hub

PROPS FOR CONTROL LINE AEROBATICS

By far the biggest success story of Bolly Props is the impact they have had on C/L Stunt. In many parts of the world, Bolly's dominate the top results , top 7 or 8 in 10 is not unusual. Bolly Props have been used to win at least two C/L World Champs and countless Walker Cups (USA Nats).

There appears to be three distinct 'set-ups', dependent on how the pattern is flown. In areas where an 'open' schedule is allowed, big prop loads dominate, as opposed to the 45 degree rule being observed on manoeuvre heights. The third set-up is the tuned pipe.

As with all models, the higher the diameter the more ‘pull’ , especially in vertical climbs etc. With C/L aerobatic models considerable attention must be made to forces of ‘gyroscopic precession’. See the ‘Propellers - Theory’ section of the book.

Whilst 2B props may give better vertical performance, the 3 blade prop will deliver a much smoother, more consistent performance - due to wind up suppression and lessened gyroscopic forces. For higher wind use, the 4 blade props are especially good at limiting 'wind-up'. High pitch props suffer more than low pitch props with the windy ‘wind up’ factor. The downside of low pitch props (unless being used at higher rpm ... =... pipe) is that they can lack ‘bite’ and authority. As with all things it is a compromise.

There has been much said of late about using undercambered airfoil sections on Stunt props. In our experience this is of limited advantage, and only then on large chord props. As Bolly props are of a high aspect ratio blade shape (because it is more efficient), we do not use an undercambered airfoil.

In 1997/8 we added several new props, the 13 x 4.5 3B, 12 x 4.25 3B, 13 x 4.25, 12.6 x 3.8, 12.2 x 4.2, 12 x 4.5W 11.8 x 3.8 and 11.25 x 4. Add these to the existing range and it is a big list to choose from.

STD .60	13 x 4.25, 13 x 6, 12 x 6, 12.5 x 6.5 3B, **12 x 6.5N 3B,** 12 x 6 4B, 11 x 7 4B
STD .46	12.25 x 4.25, **11.25 x 6.5 3B**, 12 x 6, 10.5 x 6.25 3B, 11.5 x 6.5
STD .40	12.25 x 4.25, 12 x 6, 12 x 4.5W, **10.5 x 6.25 3B**, 11.5 x 6.5, **clubman** 11.5 x 5
STD .35	**11 x 6**, 11.25 x 4, 10.5 x 6.5, 10 x 6, **clubman** 10.5 x 5
Piped 50/60	13 x 4.5 3B, 13 x 4.25, **12.6 x 3.8**, 12.25 x 4.25, 12 x 4.25 3B

Piped 40/45 12.2 x 4.2, **11.8 x 3.8**, 11.75 x 4.25, 11.25 x 4, 11 x 4

PROPS FOR R/C ELECTRIC GLIDERS

For electric's use, 3 prop sizes are made in the folding range. For pylon type racing several fixed blade props are often used. It is very difficult to suggest prop sizes for electric's due to the vast array of variations possible in the setup of motor, batteries and prop load etc.

As a rule, the below props are showing their age for latest 'fashions' of electric flying.

For F3E the 13 x 7 EFP has been often used, and is suitable for considerable thinning.

The 13 x 7 EFP is also used in 'sports' applications - especially gear driven '540' motors.

For direct driven sports gliders (540 + 6 cell) without any doubt the best props is the Bolly 7 x 5.5.

The 9 x 4.5 and 10.25 x 4.5 are used with medium size 7 cell set-ups.

PROPS FOR FREE FLIGHT

Whilst we do not make 'state of the art' free flight props, two Bolly sizes are very popular and often perform better than the 'fancy' props of the day.

7 x 3 (7.1 x 3.1) for FAI or similar at the 'base' level model.

9.5 x 4.5 this prop has won numerous National Championships in Open Power.

For the high rpm uses of free flight, it is best to use carbon fibre propellers.

BOLLY PROPS

Bolly Clubman Series Propellers

"... 1/2 an inch ahead of the rest ..."

The Bolly Products range of Glass Fibre Reinforced, Injection Moulded Propellers

PRODUCT INFORMATION

PRELUDE

After 20 months and 1,800 hours of research and prototype trials, we released the first of our new clubman Series propeller range in early 1996. We have drawn extensively on our 20+ years of knowledge gained from manufacturing our range of carbon and glass fibre reinforced epoxy propellers.

We have continued to maintain our research and development to continually improve the product.

Club modellers can now have a piece of that world famous experience, at an economical price.

CAD / CAM

The design and tooling is fully computer generated for optimum accuracy and performance. The 40% glass reinforced nylon material used is stiffer and stronger than most, but less prone to breakage than props made with a higher glass content nylon. We believe it is the perfect compromise. The props are being produced in an attractive Fawn colour. Not only is it a different, 'wood' like colour, it also makes the clubman Series props stand out from the pack. It certainly won't be confused for any other brand.

UNIQUE SIZES

Clubman props are available in a whole new range of 1/2" sizes to suit the modern engines of today, not the 'old bangers' of yesterday. The extra diameter gives a discernible difference to thrust, and the efficient blades will still give good rpm at very low noise levels.

We have 36 sizes planned for production over the next 36 months, + many more including a range to suit electric's, to follow. The 9.5, 10.5 and 11.5 inch diameter ranges are to be the first sizes produced.

GOOD NEWS

Our testing of the prototype and production versions of the **clubman** Series Propellers has exceeded our very high expectations. They are VERY GOOD.

Further to this, almost all feedback we have received from customers is very positive. Many of our customers have described the propellers as the best they have ever used (of any brand).

We believe we have achieved a technology breakthrough in propeller design, and now we can confirm it. Our design philosophy sure works. The test results prove it ...

Balance.... Very consistent and accurate balance from all production propellers.

Quieter.... At no stage did an opposition prop produce quieter readings.

Smoothness of operation.... Better than all other props tested.

Good RPM.... Excellent results compared to other same sized props.

Excellent in air Performance.... Out performing all other props.

See you local hobby dealer to try out the new 'Standard' in glass reinforced nylon propellers ... **clubman** Series props work !!!

Clubman SERIES, PROPELLER RANGE & USAGE

At the time of printing this book, we have just 13 (18 by April) of the intended 36 sizes planned, in production. This covers the most popular sizes of props. As this edition of the Book is intended to be in print until late 1998, we have listed the props planned for production to that stage.

"... 1/2 an inch ahead of the rest ..."

Bolly **Clubman** Series props are available individually, or by the bag. See the number of props per bag below. The suggested use column below, is a guide only, the number of possible uses is so vast, we could never list them all.

Propeller size		Availability	Props	Suggested Uses
Imperial	Metric		Per bag	
8.5 x 4	21.5 x 10.0	**new**	7	.10 to .15 general flying
8.5 x 6	21.5 x 15.5	Yes	7	.15 to .25 general flying
9.5 x 5	24.0 x 12.5	**new**	6	.25 to .32 Club flying & .20 FS
9.5 x 6	24.0 x 15.5	Yes	6	Fast .40 to .46 models, .32 to .34 Club flying
9.5 x 7	24.0 x 17.5	Yes	6	Fast .40 to .46 models
10.5 x 5	26.5 x 12.5	Yes	5	.32 to .45 slow models / trainers / fun models
10.5 x 6	26.5 x 15.5	Yes	5	The new standard for .40 to .46 models.
10.5 x 7	26.5 x 17.5	Yes	5	.46 models requiring extra 'go' & .40 FS.
11.5 x 5	29.0 x 12.5	**new**	5	.46 slow models & trainers, Old Timer & C/L
11.5 x 6	29.0 x 15.5	Yes	5	.45 to .60 Club flying & .48 to .52 FS.
11.5 x 7	29.0 x 17.5	Yes	5	Excellent .51 to .60 prop & .60 FS.
12.5 x 6	31.5 x 15.5	Yes	5	The standard .51 to .60 size prop & .60 FS.

13.5 x 6	34.5 x 15.5	**new**	4	.60 to .80 Club flying, & .60 to .90 FS.

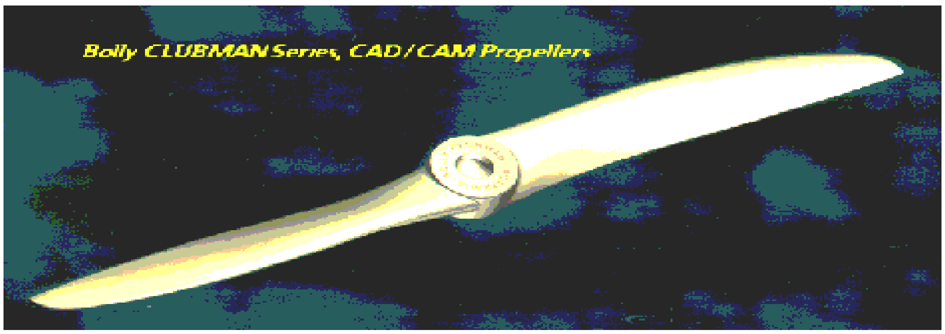
To be followed by ...				
10.5 x 8		Feb. 98	5	.46 to .51 Aerobatics models & .40 - .48 FS.
12.5 x 8		Feb. 98	5	.60 Aerobatics (no pipe), & .60 to .80 FS
13.5 x 8		Feb. 98	4	.75 to .90 Club flying, & .90 FS.
14.5 x 8		April 98	4	.90 to .108 & .90 FS
15.5 x 8		April 98	n/a	The new standard for .120 4 stroke engines

More sizes to come	7.5 x 5, 12.5 x 4, 14.5 x 6, 15.5 x 10, 16.5 x 8, 16.5 x 10

WHERE TO BUY YOUR CLUBMAN PROPS

The **clubman** prop range is being sold via our dealer network throughout the world, (they are also available direct from the Bolly Shop). If your shopkeeper doesn't stock them, please ask him to do so.

All shops stocking them are reporting very good sales ... and many satisfied customers.

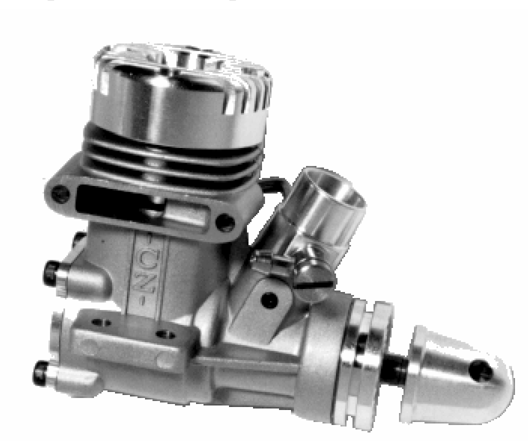


ENGINES

THE BASIC THEORY

The engines we use in our hobby are known by a number of names, some of these are, 2 stroke, 4 stroke, Otto Cycle, Internal Combustion Engine, Compression Ignition engine, Diesel Engine, Heat Engine, etc.

All Internal Combustion engines rely on heat as their source of energy. When the piston is near the tip of its stroke (usually just before) the fuel and air mixture is ignited within the combustion chamber releasing a large quantity of heat. This heat expands the gas within the combustion chamber to a very high pressure which forces the piston down towards the bottom of the cylinder. The actual force generated is dependent on the amount of air introduced into the cylinder during the induction process, the compression ratio, the type of fuel used, and the timing of the actual combustion.



Ignition can occur a number of ways. In our cars, spark plugs are generally used. In our models, timing of the ignition is not so easily controlled. In diesel, ignition occurs as a result of the heat generated by the actual compression of the air fuel mixture as the piston rises. As compression temperatures increase, the fuel eventually gets to self ignition temperatures and the whole mixture explodes. Glow plug engines on the other hand, do not rely entirely on the compression process but also take advantage of the heat retained by the glow plug to induce combustion. What we also have to consider is the temperature of the engine itself. If the head and cylinders are too hot, then in both the diesel and the glow plug engines the air/fuel charge will heat up too quickly and not only will ignition occur too early it will also occur too rapidly. Hence the fuel will be burnt before the piston has reached the top of its stroke. The effects of this on engine operation are known as pre-ignition (the ignition of the fuel before the desired moment) and detonation (instantaneous combustion of the fuel or part there of).

Pre-ignition in model engines can be difficult to detect, as in our petrol engines, it may result in 'running on' (engine doesn't stop when turned off), reduced power, poor fuel economy and overheating. In model engines, most of these effects are difficult to detect. No amount of pre-ignition will result in 'running on' if there is no fuel to run on with. Lack of power will be more easily noticed as so too will overheating.

Fortunately pre-ignition is more commonly caused by another ignition source such as leaking headers, glowing carbon, red hot metal burrs or metal gaskets, etc, so de carbonising of the combustion chamber, etc, will more than likely promote the cure. When pre-ignition occurs, detonation will also occur in most cases. The effect of detonation can be far more serious than pre-ignition. The most obvious signs (especially in cars), is the 'pinking or pinging' noise associated with it. The most damaging, is its ability to gouge or pit the surfaces of the combustion chamber, and burn holes completely through the pistons. Other effects are as for pre-ignition.

TWO STROKE THEORY

HOW THE ENGINE WORKS

The term '2-stroke' is used to describe this type of engine because the piston passes through two strokes (from the top of the cylinder to the bottom, then back to the top) to complete all the phases of operation. The 4-stroke engine's piston has to pass through four strokes or two complete revolutions of the crankshaft, before it begins to repeat itself.

The 2-stroke engine doesn't need valves (although some use them), but instead use ports, the inlet, the exhaust and the transfer ports. The rest of the engine should be familiar to us all. There is a cylinder, in which the piston reciprocates. The piston is connected to the crankshaft. The top of the cylinder is sealed by the cylinder head which also houses the combustion chamber and the glow plug (except for diesels). The bottom of the cylinder is sealed by the piston. The bottom half of the engine, the crankcase, is sealed and connected to the cylinder via a transfer port.

The Inlet Port, to which the carburettor is connected feeds into the crankcase. There are two common methods by which this is done. The inlet port either begins in the front housing and travels down the centre of the crankshaft, or is mounted on the back plate (rear induction). The rear induction types use a disc or drum valve assembly to seal this port closed at the appropriate times.. The front induction use the rotation of the specially designed (timed) crankshaft to serve as a valve.

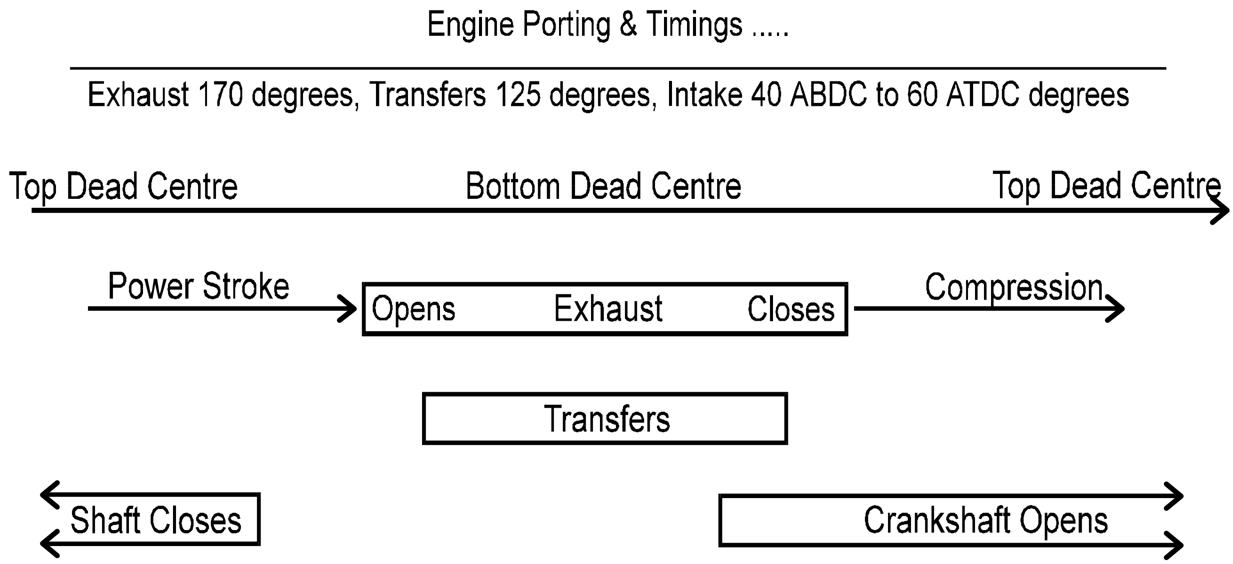
The Exhaust Port connects the cylinder to the type of muffler/pipe fitted (if any). It is open and closed by the movement of the piston.

The Transfer Ports are passages through which the crankcase gasses flow to the cylinder. They feed into the cylinder opposite to the exhaust port and are positioned so that their top edge is approximately the same height as the centre of the exhaust port. These ports are opened and closed by the movement of the piston.

All model 2-stroke engines are lubricated by oil mixed with the fuel. Some common variations in designs are, Ball bearings, shaped piston crowns (top), rings on the piston, etc. In most cases the cylinder consists of a sleeve mounted within the engine block, and are air cooled.

Now to its operation. The engine has two chambers in which different events occur at the same time ...

The piston moves up the cylinder, it closes the transfer port and increases the volume of the crankcase. This produces a low pressure in the crankcase which allows atmospheric pressure outside of the engine to force air through the carburettor (picking up fuel and oil) into the crankcase. When the piston moves down, the crankcase volume decreases, so the air/fuel/oil mix is pressurised, being trapped within by which-ever inlet valve system is used. ... See diagram below



The above diagram is a ‘normal’ set of timings figures for a high performance / racing engine.

A ‘sports’ engine is likely to have timings such as Exhaust = 150^{o}, Transfers 115^{o} and intake 40 - 55^{o}.

As the piston approaches the bottom of its stroke it passes and exposes the transfer port allowing the pressurised air/fuel/oil charge to flow into the cylinder. When the piston next moves up, it closes the transfer port, followed by the exhaust port. Further movement of the piston compresses the charge in the combustion chamber. Due to the compression and the glow plug, the temperature of the charge rapidly rises to ignition temperature, especially in the vicinity of the glow plug where combustion begins.

As combustion occurs, sufficient heat is released to cause rapid expansion of the gases which provide the force required to push the piston down. Most of this energy is spent by the time the piston has moved down far enough to expose the exhaust port. When it does so the still very hot gases rush out through this port leaving a low pressure area within its wake. This low pressure area in the cylinder then aids the flow of the fresh charge from the transfer port(s) when opened.

Ignoring the kinetic energy in the crank shaft etc, all the force experienced by the piston on each down stroke originates from the expanding gases, created by the combustion process.

The amount of expansion force exerted is dependent on the following factors;

The amount of air entering the cylinder during induction.

The type of fuel.

The amount of fuel.

The ratio of fuel and air.

The amount of swirl in the combustion chamber.

The temperature of the air entering the cylinder.

The degree of vaporisation of the fuel.

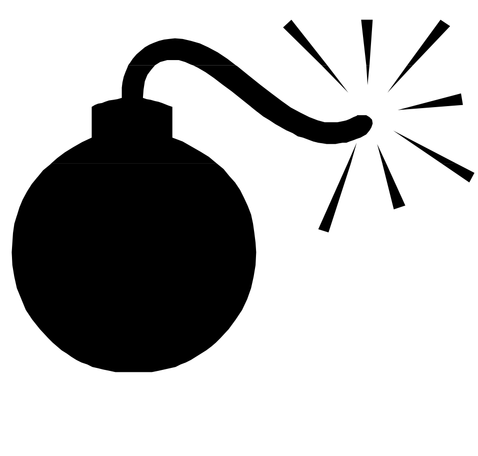
The amount of compression of the charge before ignition.

The rate of heat loss to cylinder and combustion chamber walls.

The temperature of the combustion chamber during compression.

The rate of combustion.

The time of ignition relative to piston position and movement.



Please note; the effectiveness of transferring this energy to power is then determined by the amount of drag imposed on the system, i.e. good bearings, fits and clearances etc.

COMPRESSION RATIO

We have all heard that the greater the compression ratio an engine has the greater the power produced, and this is true. There are limiting factors, and the most important of these is the fuel. The compression ratio of an engine is calculated by adding the volume of the cylinder (that volume through which the top of the piston passes when travelling from one end of its stroke to the other) (swept volume), to the volume of the combustion chamber (above the piston when at the top of its stroke), then dividing the answer by the combustion chamber volume. It could also be described as... all the volume above a piston at the bottom of the stroke, divided by all the volume above a piston at the top of it's travel / stroke..

Compression Ratio = Swept Vol. + Clearance Vol. / Divided by Clearance Vol.

The greater the compression ratio, the more the air/fuel mixture is compressed before the desired ignition time. The more the air/fuel is compressed the greater the amount of heat generated by compression. The real danger here is that the fuel will reach self ignition temperature and explode (known as detonation) rather than burn. On automobile engines it is common practise to lower compression ratios when fitting turbo charges and the like, to prevent the resultant pressure increase (and therefore temperature increase) from raising fuel temperature to self ignition temperature.

Compression ratios can be increased by fitting a head with a smaller combustion chamber, or shaving some material from the bottom of the head. They can be decreased by fitting two head gaskets (the easiest) , fitting another head with a larger combustion chamber, physically increasing the size of the existing combustion chamber or using a shorter reach glow plug.

Detonation may be eliminated by reducing compression ratio, decreasing the temperature of the cylinder head and walls, using a cooler glow plug, using a fuel with higher octane rating, etc. Detonation can have serious effects on an engine. These are;

Overheating

Pitting to burning of the head and/or aluminium piston

Rapid wear to big end, gudgeon and crankshaft bearings

Excessive strain on gudgeon pin, big end journal and con rod.

Blown glow plugs.

SPARK IGNITION / PETROL ENGINES

Many of the larger engines now finding favour with large scale models etc use a timed spark ignition process rather than the conventional glo plug system. Most of these engines are 2 strokes and operate on a petrol based fuel, although they can (often with modification to the carburation) operate on a methanol based fuel .... for more power but are far more expensive to run.

DIESEL ENGINES

Diesels are similar in all respects except for the fuel ignition and fuel. The ignition is based on using a low flashpoint temperature fuel and high compression to ignite the fuel. Generally the engine features a 'contra-piston for the adjustment of the compression ratio. No glo plug etc is used.

OPERATION OF THE FOUR STROKE ENGINE

HOW THE ENGINE WORKS

The term Four Stroke stems from the fact that the piston must pass through four complete strokes before events within the combustion chamber are repeated. Some use the term 4 cycle. During this time the crankshaft rotates through 720 degrees or 2 revolutions. Each of the four strokes are given a name which best describes the event occurring within the combustion chamber. These are, the Inlet (Intake), the Compression, the Power and the Exhaust strokes and they occur in that order.

Our brief description starts at the beginning of the Inlet Stroke where the piston is at the tip of the cylinder, the Inlet valve is opening and the exhaust valve is closed. As the piston moves down (carried by stored energy within the flywheel) the combustion chamber volume increases producing a low pressure within. Atmospheric pressure now begins to force its way through the inlet passages into the cylinder.

As the piston passes through the bottom of its first stroke the inlet valve closes, and the Compression stroke begins. The piston rises, decreasing the volume of the cylinder and compressing the air fuel mixture. At a predetermined point when the piston is near top dead centre (the top of its stroke) ignition starts. Depending on the amount of fuel (throttle position) combustion continues as the piston passes top dead centre, generating sufficient heat to expand the gasses which in turn forces the piston down on the Power stroke.

Towards the bottom of the stroke all of the useful expansion force of the gas has been converted to mechanical energy, so the exhaust valve opens. The piston, entering the Exhaust stroke, passes bottom dead centre and moves up the cylinder driving out the exhaust gas.

The forces of Detonation, Pre-ignition and Compression Ratio apply to four stroke engines in the same way as described for two stroke engines.

The main differences between two and four stroke engines are that a two stroke engine has a Power stroke for every crankshaft revolution where as the four stroke engine has one for every two crankshaft revolutions. Therefore two stroke engines are more powerful than four strokes. However more air enters the cylinder during the four stroke Inlet stroke than is the case with the two stroke, hence more pressure is generated after combustion. More air means more oxygen and this means more fuel can be burnt. The result of this is that the piston is forced down the cylinder a greater distance than is the case with two strokes. Hence four stroke engines produce more torque than two stroke. In practise this means a four stroke would be most suited to spinning a large prop at slow speed and a two stroke a small prop at high speed.

As a rule, 4 cycle engines run hotter than 2 cycle. Although a 4 cycle engine only needs 10 to 15% oil for lubrication, it is often best to use 20 to 25% oil to aid heat diapason, especially for pattern flying when using big props and low RPM.

ENGINE DESIGN

There are far more details to engine design than can be discussed here, however here are the basics for 2 stroke engines, many of the principles apply to 4 strokes etc.

MODERN INDUCTION SYSTEMS

Almost all ‘sports’ engines feature ‘front’ induction, where the fuel / air mixture enters through the hollow crankshaft. Most racing engines feature ‘rear’ induction, of several types. The more common is the disk induction where an extended crankpin drives a ported disk which opens and closes the inlet.

The less common rear induction is the ‘drum’ system, which in turn has 2 types, the ‘normal’ and ‘reverse drum’. Instead of the crankpin driving a disk it drives a smaller version of the hollow crankshaft.

The conventional drum has the fuel / air mixture enter via the drum centre and exit vertically in a manner similar to a front induction set-up.

The reverse drum has the fuel inlet from above (or below) in a manner similar to a front induction set-up and exits through the centre of the drum. This system has the advantage of providing fresh fuel (oil) to the crankshaft / conrod which is why it is very popular for C/L team race engines.

LINER PORTING TYPES

Almost universal nowadays is the Schnuerle port liner as opposed to the old loop scavenged , cross flow or piston port systems.

The loop scavenged system used one large transfer port and one exhaust port on the opposite side. Some times these ports were split into several sections. The intake charge was prevented from exiting straight out the exhaust by using a piston baffle.

The cross flow system which was employed on many diesel engines where a transfer port was used front and rear combined with an exhaust used on either side of the liner.

Piston port induction as per the famous Mills engines is where the fuel induction is directly into the liner.

Several manufacturers have recently introduced a reed valve induction system, via the engine back-plate. Not totally new as it was done by Frog many years ago (although in a different fashion).

Schnuerle porting uses a group of transfer passages arranged in the liner as to direct the incoming mixture away from the exhaust port (infact often crashing into each other). Over the years the system has seen many configurations of transfer port numbers etc, but the same principles apply. The classic Schnuerle port liner has 1 @ exhaust, 1 @ boost (opposite to the exhaust) and 2 @ transfer ports on either side.

PISTON & LINER MATERIALS

Most early engines and a decreasing percentage of modern engines featured a cast iron piston in a steel bore. Many of these engines feature a range of different ring types to provide the seal.

A more recent and now more common engine is the ABC, ABN and AAC piston and liner. Some of these engines are ringed.

The ABC engine has an aluminium piston operating in a hard chrome bore, brass liner.

The ABN engine has an aluminium piston operating in a special nickel plated bore, brass liner.

The AAC engine has an aluminium piston operating in a hard chrome plated bore, aluminium liner.

METALLURGY

The reason for all of the above liner configurations, apart from using materials compatible for wear and long use, is to provide for the different expansion rates of the components due to heat (combustion).

If an engine used the same material for the piston and liner it would seize almost instantly as the piston is subject to higher heat, hence expands at a greater rate than the liner.

In the case of the AAC engines, the piston is made of an aluminium featuring a high percentage of hard wearing silicon in the alloy. This alloy expands at a lower rate than the lower silicon alloyed liner.

In theory the ABC, ABN, and AAC engines should never seize as the liner will expand away from the piston as heat rises.

The major difference between good and bad engines is the metallurgy and quality of the component fits.

TOLERANCES & FITS

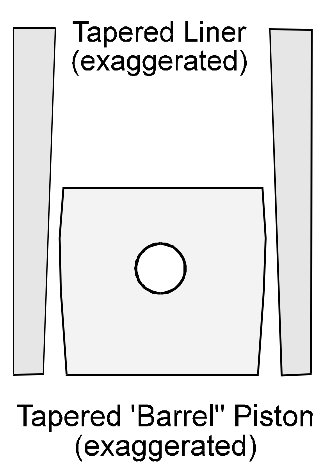
Whilst it is not easy to see without a trained eye, the quality of component tolerances, shape and fits is the most important area of all engines.

It goes without saying, but often not the case, all the major components of an engine should be round, i.e. the liner fit in the case, the bore, the piston, the head and the bearing housings. A close examination of a liner will often show an uneven wear pattern, i.e. the piston and / or liner are not perfectly round or operating in a very uneven cooling system.

The crankshaft often rubs on the case between the bearings due to the flexing loads imposed on the crankshaft. All engines should have the case diameter of this area enlarged (most manufacturers do this).

The liner of an engine should not be a perfect cylinder. The cylinder should taper to a larger diameter at the bottom (only the top of the liner is critical to the compression seal and power stroke). The average taper is between .002 to .003 of an inch per inch of liner height.

The piston should also be tapered, although only the ‘better’ engines are tapered, or barrelled as it is often referred to, because the piston should in a lesser way be shaped like a wine barrel, i.e. a lesser diameter at the very top and bottom of the piston.



The reason for the piston to be barrelled is 4 fold.

To reduce contact friction with the liner.

It is best to have a small gap at the top of the piston to form a sealing oil wedge.

The top of the piston is the hottest, causing the piston crown to expand.

To help prevent a piston edge catching in a liner port. As the piston travels up and down there are many side loads etc which can force the piston sideways slightly. This can be a problem for racing engines which generally use very large exhaust ports.

CRANKCASE VS. CRANKSHAFT

One of the biggest problems for engine designers is the expansion coefficient difference between the aluminium crankcase and steel crankshaft. As engines are 'fitted' cold, under operating temperatures the case will expand (lengthways) more than the crankshaft. This puts an uneven load on the bearings.

Many competition C/L team race engines have gone to great lengths to improve this problem, including the use of all steel front section of the crankcase. Some of the better brand engines use a special low expansion aluminium crankcase, and it shows in excellent performance.

It is important that the 'front end' of an engine receive cooling air.

TIMINGS

The duration of the opening of the intake, transfer and exhaust ports (timings) is dependent on the end use of the engine. Racing engines often have very high timings (generally quoted as the degrees of rotation for which the port is open). The shape of the ports can also be very important.

As a general rule, the manufacturers do a good job of providing well designed ports, normally the only time the end user can justify modifying a port's duration is to match an engine to a tuned pipe. A good example of this is some of the larger 2 strokes above .90 size, where the manufacturer has used low timings to increase torque. For an engine to respond well to a pipe, the exhaust timing must be no lower than 145 degrees. Below 140 degrees, the pipe can actually deteriorate the engine's performance.

CLONE ENGINES

I would like to think modellers support the genuine manufacturers where they can. There a lot of 'clone' engines on the market. In engine tests, they normal come up pretty well … but don't be deceived by peak horsepower figures. Look closely at the rpm figures for bigger 'normal' prop sizes.

It is our experience that a lot of the 'clone' engines have high compression ratio's and high timings. This makes em suitable to rev (if you can trust em), but hopeless with a decent prop load. If your clone engine is giving trouble, first try another (few) head shims. We see this problem so often ….

FUELS

One of the most important factors in a good healthy engine and a trouble free run, is fuel.

OIL

The most important ingredient of any model fuel is oil. This is the only means of providing lubrication and is important for engine operating temperature. **The golden rule of fuel is** ... if in doubt run more oil. Never run an engine with an unproved oil.

Without doubt castor oil is still the best for lubrication. Occasionally castor is not the chosen oil because,

It is very messy.

It wont mix well with high nitro content fuels (say above 40%), or petrol.

The higher viscosity sometimes doesn't agree with pump / carby settings. If allowed to stand a while castor will 'clag' some pumps

It does not 'burn' clean. In time the engine will need cleaning to remove the gum on the outsides and the glaze on the insides. The inside 'glaze' is a constant problem for applications such as C/L Stunt where engine are run on high oil (say 25%), low rpm and big props.

Synthetic oils usually don't have any of the above problems, but don't handle extreme heat as well as castor. Beware: there are a lot of 'snake' oils on the market.

Our chosen synthetic oils are the Morgan's Cool Power, or GBG's Powermaster. These oils have good results and reputation whilst having a very good rust inhibitor. (Needed when running nitro).

METHANOL

Methanol is the major component of most fuels. It is important to use a good clean grade. Take care as some methanol's include other ingredients such as acetone.

Note: Methanol is very hydroscopic. In other words, it will absorb moisture from the atmosphere like you wouldn't believe. Manufacturers of good quality fuels go to great lengths to keep the air / moisture out of their bulk vats and mixed fuel.

To give several examples

Have you ever seen the dreaded whit bits (a bit like coconut flakes), in the fuel. That's the moisture combining with the methanol. Throw such fuel out … or invest in a fuel filter factory.

Have you ever noticed how some fuel split into the top of a fuel can will quite quickly change appearance. Again, that's the moisture combining with the methanol. Keep containers well closed.

NITRO METHANE

Nitro is a power enhancer as it increases the amount of oxygen available in the fuel for combustion. The down side is that it generates more heat (often needs a lower combustion ratio) and can contribute to rusting of the engine (caused by the acidic by-products of the combustion). The use of small amounts of nitro will help most engine run smoother.

Nitro methane will not increase rpm, but as it's combustion produces more energy, the engine will develop more torque, allowing the use of bigger propellers, or better operation under high loads. A classic example of this is R/C aerobatics where adding nitro to the fuel will give a big performance increase in vertical climbs.

With the exception of just a few countries, nitro is a very expensive commodity. Modellers being modellers, generally try to use low or zero nitro fuel. After having spent many years having done that ourselves, we have come to the inevitable conclusion that you just can't beat nitro. Engines run much smoother, more reliably and performance under load is vastly better.

Beware. There are good and bad grades of nitro out in the market (or for that matter used in commercial fuel). The ONLY way to check is via a hydrometer. Your fuel supplier should be able to provide details.

PETROL

For large spark ignition engines (although sometimes added in small percentages to glo plug fuels), use the leaded versions of petrol as this aids the lubrication process.

FUEL MIXES

For 2 stroke engines above .108, we use 10% Synthetic, 5% Caster, 10% Nitro and 75% Methanol.

Engines above .180 can often go as low as 8 - 10% oil content. Big prop loads need more nitro.

Our favourite mix for larger pattern engines such as Bully 120 / 145 or OS 140 is to use 14% nitro, 13% synthetic, 3% castor and 80% methanol.

For .60 Pattern and large 4-strokes, 16% Synthetic, 4% Castor, 15% Nitro and 65% Methanol.

For C/L Aerobatics and other very low RPM uses we use 12% Synthetic, 12% Castor, 6% Nitro and 70% Methanol.

For General Sports Flying we use 10% Synthetic, 10% Castor, 5% Nitro and 70% Methanol.

For large scale flying we use 5% Synthetic, 5% Castor, 5% Nitro and 85% Methanol.

For large petrol engines we use 6% Synthetic, 6% Nitro and 88% 'Super' (leaded) Petrol.

For those who mix fuels themselves, be very sure of thoroughly mixing the fuel, castor in particular requires thorough mixing.

DIESELS

Diesels generally use a mixture of oil, kerosene and ether. A diesel ignition improver is also often used.

A 'normal' mix would be 20%, 38%, 40% and 2%. Racing engines often use less oil and more kero' whilst sports engines often use an equal 1/3 mix of oil, ether and kero.

PLEASE NOTE

Where possible, run one or more fuel filters. We recommend the Sullivan Crap Trap. Many of the cheap old style filters will leak or cavitate the fuel.

Using restrictive exhaust systems or tuned pipes place excessive strain on your engine and lubricant. Make certain your fuel contains the suitable type and quantity of oil. It will not only reduce friction but it will also help to cool your engine, this is especially so with pattern 4 strokes.

Nitro methane is used to provide the torque to drive larger propellers. The Nitro will allow bigger props to run at the same RPM. For .120 Pattern flying it's the difference between 15 x 12 and 16 x 12 at 8, 000.

When in doubt, use more oil and nitro.

ENGINE OPERATION & CARE

As with all things mechanical, an engine needs to be operated correctly and have regular maintenance to be at it's best. Many an engine has been ruined by not observing basic rules.

It is a good practice to disassemble an engine to check for remnants of production 'swarf', dirt , flaky chrome plating etc before ever turning an engine over. It is very rare that an engine can be checked (no need to remove the ball races) and found to be perfectly clean.

Use very fine abrasive paper tightly rolled to imitate a needle file, to carefully remove any sharp edges in ports etc.

DISASSEMBLY ETC

Much of the following page or so assumes the user has the skills to dismantle an engine and reassemble it correctly. To do this is not hard provided several golden rules are followed.

Work on a clear and clean bench top, and use the correct tools to fit the bolts etc.

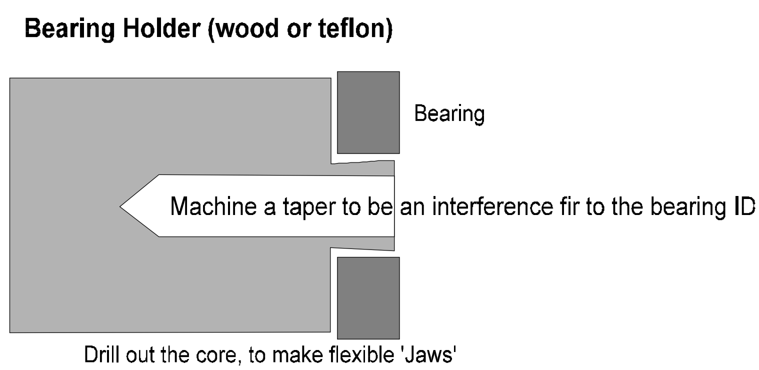
Always keep a record of how the engine comes apart, some components may need a fine scratch mark for identification, for example put a very fine X on the rear of the conrod before removing it.

Never force a component with a metal tool, for example never use a screwdriver in the exhaust port to lever out the liner.

To remove the crankshaft which uses a tapered collet to lock the prop driver (generally very difficult to disassemble). A) use a bearing puller to pull off the driver if it can be fitted (usually not), or B) place the prop nut on the end of the shaft thread and with the backplate off and conrod removed, use a wood block to cover the nut, and knock the assembly loose with a hammer.

Beearings should not come loose without the aid of heat. NEVER force the bearings out .... let them drop out with heat. Heat the crankcase (with all other parts removed) by placing it in an oven (try at 120 degrees C, and increase as necessary), or heat the area evenly with a portable gas torch. Often the rear bearing will drop out with a sharp knock on the bench. The front bearing will need to be pushed from behind with a suitably sized wooden dowel.

To install bearings, use the process in reverse. It is vital the bearings go back into the housings all the way, and square. It is often necessary to make special wooden or Teflon holders to aid the process. Take care to not force the inner race of the bearing when installing (or removing if the bearings are still in good condition).



The bearing holders etc, should be made to only push against the outer rim of the bearing, and to be an interference fit inside the bearing shaft hole, to hold the bearing onto the mandrel.

The process of removing and installing bearings with heat works on the principle of expansion rates, the aluminium crankcase expends at a greater rate than the steel bearings. On some occasions the liner may also need removing via this method.

RUNNING IN

The modern ABC or ABN engine generally does not require much running in, and can often be done in the aircraft in flight.

The first 5 minutes should be done with a small prop running very rich with intermittent faster periods. If it appears obvious there are no problems, go flying ... assuming the model will fly OK under powered.

It is vital that the next 30 or more minutes of operation be done without stress. The best procedure is to use a smaller than intended prop running richer than usual at about the same as the intended end use rpm. If after a time it is obvious the engine can maintain a correct tune without leaning out (a sign of excess heat due to being too tight), then bolt on the intended prop and go fly, still keeping it rich for a while. It can be that just one lean run / flight can severely damage or destroy an engine's performance.

Ring engines will require much more running in time than ABC types. It is vital that the is properly 'bedded' and not overheated. It is possible to change the temper of a ring with excessive heat. This will result in very poor compression and performance. As a ring is running in, it will generate more heat than normal, so it is vital to keep the prop load small and the needle rich during the run in process.

OPERATION

The same rules for running in also apply to general operation. There are no prizes for running an engine too lean, except the hobby shop, who will sell you another engine sooner.

Always use fuel filters and maintain the fuel system in good order. It is a good idea to provide the tank with some sponge rubber insulation to prevent 'frothing'.

Mount the engine securely, and only use balanced spinners and props.

GLO-PLUGS

Glow plugs are a vital and commonly disregarded part of engine performance. More than half of the cost of a glo plug is the element. The fine wire elements are made from alloys combining platinum, iridium and rhodium in different proportions. Variations of the alloy, thickness of the wire, length of the wire and the volume of the plug cavity are adjusted to produce different plugs for different applications.

Use the correct plug, and change it if it looks a bit worse for wear. Use the warmest plug practical.

Plugs come in many different shapes and sixes. All common plugs use a 1/4 x 32 thread. It is handy to own a tap for this uncommon thread size. If you have any doubt about the quality of the thread in the head, a quick use of the tap can save a lot of trouble.

The common variables in plugs are..

Heat range 'Hot' plugs for small / slow running, engines that do not develop much internal heat of their own, through to 'cold' plugs in hot running engines (i.e. racing engines). Using a 'hot' plug in a racing engine will cause pre ignition and quick destruction of the plug. Using a 'cold' plug in small engine will cause very unreliable running.

Element The majority of plugs have a platinum based 'wire' coil. Variations of the alloy (iridium, rhodium and other metals are often used), the thickness of the wire and length of the coil control the plug performance, reliability and heat range. The volume of the coil cavity also have a bearing on the plug's performance.

There are many specialist plugs on the market which use a different coil type. The most common of these is the flat coil type, most commonly found in the 'Globee' brand / style.

Reach Plugs come in short, long and medium reach. This refers to the depth of thread. The ideal depth of plug is one where the bottom of the plug is level or marginally short of reaching the combustion chamber (at the end of the threads in the head). It is often necessary to use extra plug gaskets to achieve this.

VoltagePlugs are sold in different voltage ranges, from 1.2v to 2v. Using a 2v battery on a 1.2v plug may 'blow' it, and using a 1.2v battery on a 2v plug may not heat the element sufficiently. Many 'hard to start' situations are caused by a weak starting battery.

Important Tips When starting an engine, leave the plug leads on until after the engine has been run up to full throttle for a few seconds. Take note of what happens to the engine RPM when the leads are removed (it is safest to do this at idle). If the engine picks up RPM (rare), the plug is too hot or the combustion ratio is too high. The reverse applies, if the engine drops a lot of RPM, the plug may be too cold or the compression ratio is too low. Please note that a small RPM drop is normal, especially at idle.

If the engine is 'crunching plugs' or sounding harsh or hot and bothered when it shouldn't, add an extra head shim to decrease the compression ratio. This is most likely to happen when using large props, high nitro or a cowled engine.

If an engine which is normally very reliable, suddenly starts to 'crunch' plugs, it is often a sign of internal wear. Usually it is a bearing or conrod beginning to fail.

COOLING SYSTEMS

For cowled engines it is vital that cooling air be provided to the engine and exhaust system. It may even pay to up the oil content of the fuel.

The hot part of an engine is the exhaust. Rear exhaust engines require air to be ducted to the back of the cylinder. The hot spot for side exhaust engines is to the rear of the exhaust.

Remember the air outlet should be double the inlet area.

CARE

If flying on a dusty field, use a venturi / carby filter.

Regular cleaning (externally and internally) is necessary for continued good performance. A build-up of carbon deposits will impair performance by making the engine run hotter. If the deposits on the head (internally) build up enough, the effects can be severe.

The outside of the engine should be kept clean. Eventually baked on fuel deposits will need to be removed, especially if not regularly cleaned. One product to use for this is an **aluminium** frypan cleaner, but take care to follow the instructions.

The head and exhaust port etc should be periodically cleaned. If done regularly they can be wiped clean. If the deposits have baked on hard the only alternative is to carefully scrape the areas clean.

ENGINE MODIFICATION (HOT UPS etc)

It would be fair to say that most attempts at engine reworking infact does not improve the engine. Using the correct tools carefully and be conservative in what you do and all should be well. Take care that no sharp edges are left behind. A piece of fine wet and dry sandpaper rolled up to resemble a small round file is a very useful tool for de-burring port edges.

To check engine timings, mount the engine on a bench etc, and bolt a circular protractor to the crankshaft. Use a pointed needle attached to the engine or bench and arrange the pointer and protractor to read 0 degrees at bottom dead centre (BDC). It may be necessary to take an average reading of the BDC, for left and right hand rotation. It is notoriously difficult to find an exact BDC or TDC (top dead centre).

The following are the areas of modification that will improve most engines.

CRANKSHAFT

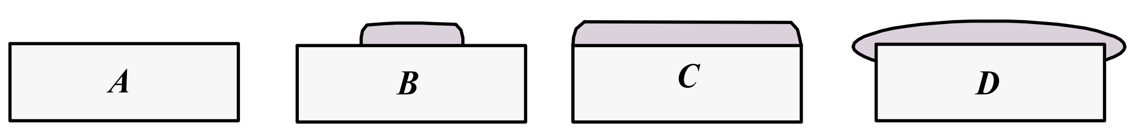
Improve the flow of the mixture by blending and flowing the inlet and outlet to the shaft. Check for wear marks between the ballraces, if present relieve the crankcase. For racing the shaft timing may be changed to close at 60 - 65 degrees ABDC (after bottom dead centre).

LINER

The bottom of the transfer ports can be rounded to improve gas flow into the ports. It is rarely worth adjusting transfer timings or shape.

Most liners become glazed and smooth with use. For the best oil retention etc a fine cross hatch pattern is best. Good manufacturers do this from new. To duplicate this wrap a finger with 240 grit wet and dry and score the bore in a cross hatched pattern. Take care to not work vertically.

A major modification that can improve an engine is the size and shape of the exhaust port. See below



A) is the standard shape port, say at 170 degrees timing, which is a high ‘normale’ type timing.

B) is often used to give an extra boost for pipes, at say 180 degrees timing.

C) to increase the overall timings, the port is simply raised, at say 180 degrees.

D) is going to the max. Not only is the port raised but increased in width to extend almost over the transfer ports. This can be done in a curve as shown, or square cut similar to #C. Be careful that the piston crown doesn’t try to drop into the port on the upstroke.

PISTON

Almost all pistons can be improved slightly by lightening the lower skirt, checking for a good barrel shape and / or providing a small cut away to improve gas flow to the boost port.

Most non racing pistons have little or no barrelling, and can be improved by very carefully modifying the top of the piston crown edge by turning the piston several times against (oiled). # 240 wet and dry sandpaper Hold the sandpaper in a V shape between the thumb and fore finger. The effect of this is to take the very sharp edge of the piston crown and provide for an oil wedge.

CONROD

Almost all conrods can be improved by lightening. Take off the square edges of the traditional rectangular conrod to create an oval shape. Be very careful to not introduce scratches etc.

VENTURI / CARBY

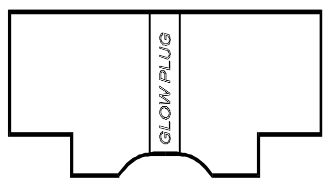
Most engines are supplied with a carby / venturi set-up for easy use. It is rare that more power can’t be gained by using a bigger one. The down side is that fuel draw etc may suffer. For racing models with large venturi, crankcase or pipe pressure will be needed. If using crankcase pressure it will often be necessary to use a restrictor in the pressure line of .008” to .015” (.2 to .4mm) to prevent excess pressure and the resultant tuning problems.

HEAD

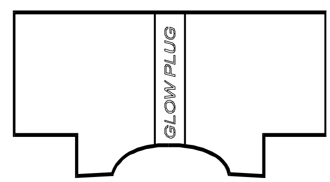
The head is vital to performance. It should always be a snug fit into the liner. The shape is dependent on the fuel and end use.

Just about every shape imaginable has been used at some time, however they tend to fall into 2 distinct categories or variations.

High rpm, small props and standard fuel set-ups tend to use the smaller, wide flat squish head.



Conventional wide squish band, shallow bowl head shape.



Small tapered squish, large bowl head shape.

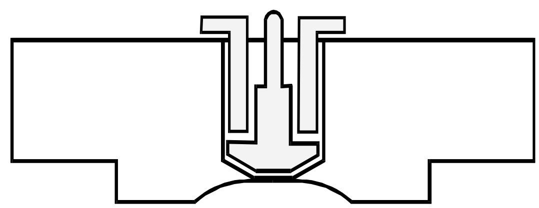
High nitro / bigger prop set-ups will tend to use a bigger head volume.

Check that the plug is flush with the bottom of the threaded section. There are big variations in plug thread lengths and head thread lengths.

The modern racing engines are often using the flat coil element ‘Glo Bee’ set-up, which has a specially designed tapered seat plug (no threads), which fits to a corresponding tapered seat head, held in place by a special clamp ring.

There are also versions of the tapered seat plug which use a ‘normal’ fully threaded plug. Some of these use the flat coil element, but most have a conventional element. These plugs are often referred to as the ‘Nelson’ plug.

Taper Plug + Clamp Ring



Cylinder head using the "Glo Bee" style plug.

In racing, the use of the flat coil style is the most common. Of interest is that the coil is generally ‘pulled’ out, away from the plug, into the combustion chamber. When operated like this, the compression can generally be increased, and more power is the result.

Please note, these descriptions and names etc may vary from county to country. It must also be noted that the thread (common between the full plug and insert types) is much larger than the common plug.

CRANKCASE

Crankcase’s should be checked for clearance between the ball races. It is rare that this area needs to be relieved in a modern engine, as almost all manufacturers now relieve material between the bearings. The tell tale sign of insufficient clearance is wear marks on the crankshaft. It is surprising how far a crankshaft can move and bend in operation. An oil hole or slot from the venturi / shaft junction to front bearing is also necessary to keep the front bearing cooler and oiled.

Transfer passages should be in reasonable alignment to the transfer ports. If the case blankets a portion of the transfer passages etc, it needs to be corrected.

Use a ‘Dremel’ and carbide cutters (do not use grindstones on aluminium) for this work ... carefully.

BEARINGS

Good bearings are vital. If you are not sure of the bearings (a shaft should spin very easily, and the bearings feel smooth), remove the bearings and thoroughly wash in methanol or similar. Oil with a light oil and check. For racing engines, phenolic cage C3 bearings are a must.

CLEANING & RE ASSEMBLY

It is vital that components be thoroughly cleaned (methanol is good), before assembly. A box of facial tissues is very handy. When assembling the engine remember to properly oil every component.

Take care to properly tighten all bolts, that is by first a finger tightening, and then firmly, in a pattern that evenly distributes the forces. In a 4 bolt pattern, tighten in a sequence of 1,3,2,4. And for a 6 bolt head tighten in a sequence of 1, 4, 2, 5, 3, 6 or similar.

Flick the engine over by hand for a few dozen times, remove the head and clean out the oily residue, chances are the tissue will be black from the initial wear process. Time to now run the engine.

Shown above is the BULLY 120LS, smooth running long stroke pattern engine.

EXHAUST SYSTEMS

Aero-modellers are demanding greater performance and power from their two stroke engines. Without doubt, the future use of the 2 stroke engine in aero-modelling will be more closely coupled with tuned exhaust systems, especially the ‘quiet pipe’ versions which reduce noise levels and add power.

Most conventional mufflers (as supplied with most engines) cases suppress a lot of power, whereas the tuned exhaust / muffler system improves a combination of power, handling or noise.

Some different exhaust system types are .....

MINI-PIPES

Basically a straight tube attached to the exhaust of the correct length and diameter to extract burnt gasses from the cylinder. Power gains are small at the expense of a lot of noise. Such pipes are often called 1/4 wave pipes, as it is about 1/4 the length of a ‘normal’ full pressure wave pipe.

MEGAPHONES

Similar to the mini pipe, but tapered to an expanding diameter (as the name would suggest). They are more powerful than mini pipes and very noisy.

‘MAGIC’ MUFFLERS

Magic mufflers are half way between full tuned pipes and mini pipes. Basically a mini pipe within a larger mini-pipe, which allows for the exhaust wave to travel the same distance as a full power pipe.

A lot of new ‘conventional’ power enhancing mufflers are employing the principles of mini pipes / magic mufflers in their design.

THE POWER PIPE

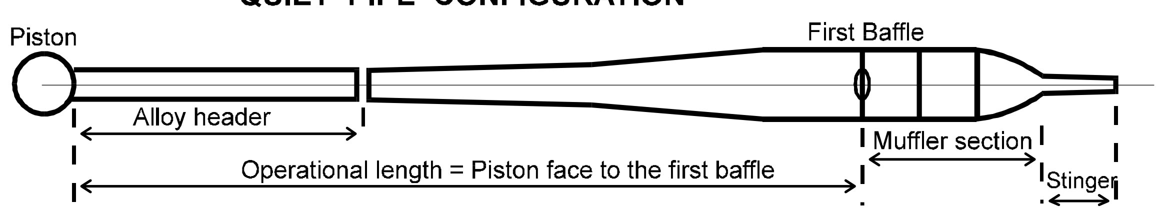
Power pipes are of the conventional double cone, tuned exhaust design. These pipes are designed for a specific purpose, are of a set length and attach directly to the motors exhaust stack / adapter via a silicon sleeve / o’ring. This technique makes for quick efficient sealing and installation.

Generally these pipes (often called ‘Nitro’ pipes) are used for racing only. They are very powerful, but noisy and generally only work best at one (high) rpm range.

THE QUIET PIPE

Quiet pipes such as those used for R/C Aerobatics, are of the expansion type chamber (similar to the first section of a power pipe), combined with a rear section a multiple baffle / muffler. Almost all of these have a flat ‘washer’ style first baffle as a reflective disk. To some degree these pipes are infact a combination of a muffled megaphone and a muffled power pipe. Used in conjunction with an alloy header, these pipes develop good power at low rpm (high torque) and are very quiet.

QUIET PIPE CONFIGURATION



Not only is the engine more powerful, the handling characteristics are vastly superior to a non-piped motor. The broad operating range of the pipe produces power anywhere above one third to half throttle, giving good vertical climb power. When in a dive, the pipe will 'hold back' the engine (assuming the pipe is long enough). The pipe becomes a constant speed governor. The 'hold back' symptom comes from the rpm exceeding the speed at which the pipe can pump or reflect the gases back into the cylinder, causing a power loss exactly when it is wanted - in a dive. The vertical climb power is obtained by setting the pipe at a longer length that used for optimum power on a given prop load. Under high load condition (i.e. vertical climb), the rpm drop, creating a situation where the length is at an optimum for those rpm.

THE QUIET POWER PIPE

The quiet power pipe is a combination of both the Power and Quiet pipes. It is basically a muffled power pipe, or quiet pipe designed for high rpm use. These pipes are usually attached directly to the engine similar to a power pipe. Often used in ducted fan models. Power, noise and handling are also between the power and quiet pipes in use. Bolly also use the DF designation for this style of pipe. Shown above is the Bolly QP-90.

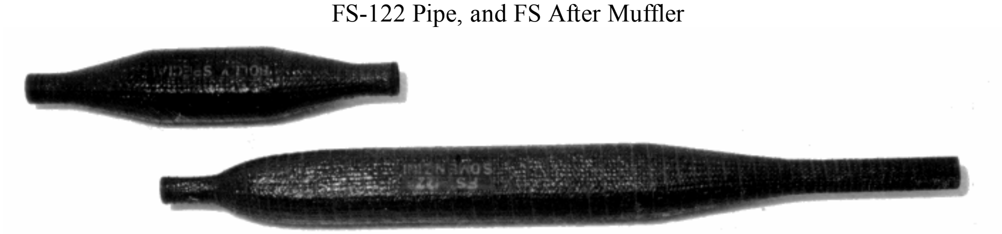
MUFFLER 'PIPES'

With the increase in popularity of large (.120 and bigger) 2 strokes for pattern use, has come the development of suitable muffler only exhaust systems. As the engines have more than enough power, a power enhancing pipe isn't required, but low noise is still vital. Such a muffler needs to be relatively large in volume and built in such a way as to inhibit pipe action. Note, a small volume can not be used as it suppresses engine power and builds up heat.

THE 4 STROKE PIPE

With the increase in popularity of 4 strokes for pattern use, has come the development of suitable exhaust systems. They are of the Quiet pipe type of design. These pipes work on the exhaust extraction system similar to car exhaust systems. They are nowhere as effective as 2 stroke exhaust systems (for power increase), and are sometimes combined with a large volume muffler. The ideal muffler should have an outlet diameter similar to the exhaust valve diameter. This type of muffler offers a very slight increase in power for a large noise reduction. Their effectiveness is very noticeable when compared to a conventional 4 stroke muffler which work by inhibiting the exhaust outlet.

FS-122 Pipe, and FS After Muffler



4 STROKE HEADERS

There is a major design fault with almost all 4 stroke engines. The exhaust valve size is usually much larger than the outlet of the head, and the commonly used exhaust 'headers' are even smaller. Combine the above problem with the fact that 4 strokes run very much hotter than 2 stokes, and you have a major problem.

For many years, throughout the world, manufacturers and modellers have been searching for the perfect 4 stroke exhaust system. The heat makes for many problems, if the header pipes from the engine to the pipe were aluminium, the alloy would break down or even melt. For this reason almost all headers are of stainless steel or high temperature Teflon variants.

A problem of the stainless steel is finding the correct types of semi flexible tubing (rigid tubing will break with vibration), the correct diameters and to then be able to weld or braze fittings without damaging the metal. Very few header system could be described as optimum.

2 STROKE HEADERS

As the 2 stroke engine using tuned quiet pipes have been around for some time, an industry has been established to provide suitable exhaust headers. Usually it is the form of an alloy header plate that bolts to the exhaust flange of the model, with an aluminium tube of the correct diameter and shape welded to the plate.

With such a wide variety of models, pipes and engines, it is often a problem to supply the correct header.

As with 4 stroke headers, metal fatigue is still a problem (but much less so) with 2 stoke headers. Several golden rules apply ..... never use a long header, this only increases the vibration strain on the weld, and never thread a pressure nipple into the metal on a curve (where the metal has been stressed).

HOW THEY WORK (2 stroke pipes)

Starting with the moment the engine fires, forcing the piston down and the exhaust port begins to open. At this point the cycle starts. The exhaust gases are forced out of the engine and start to travel down the 'header' section of the pipe. Before long the gas reaches the expanding / divergent / front (the names vary) cone. The effect is a pressure drop, creating a vacuum which helps 'pull' the remaining exhaust gases out of the engine.

Not only are the exhaust gases being 'sucked' out of the engine, the fresh intake mixture is being 'drawn' into the combustion chamber from the crankcase via the transfer port. Some of this new charge will follow the exhaust gas straight through the still open exhaust port.

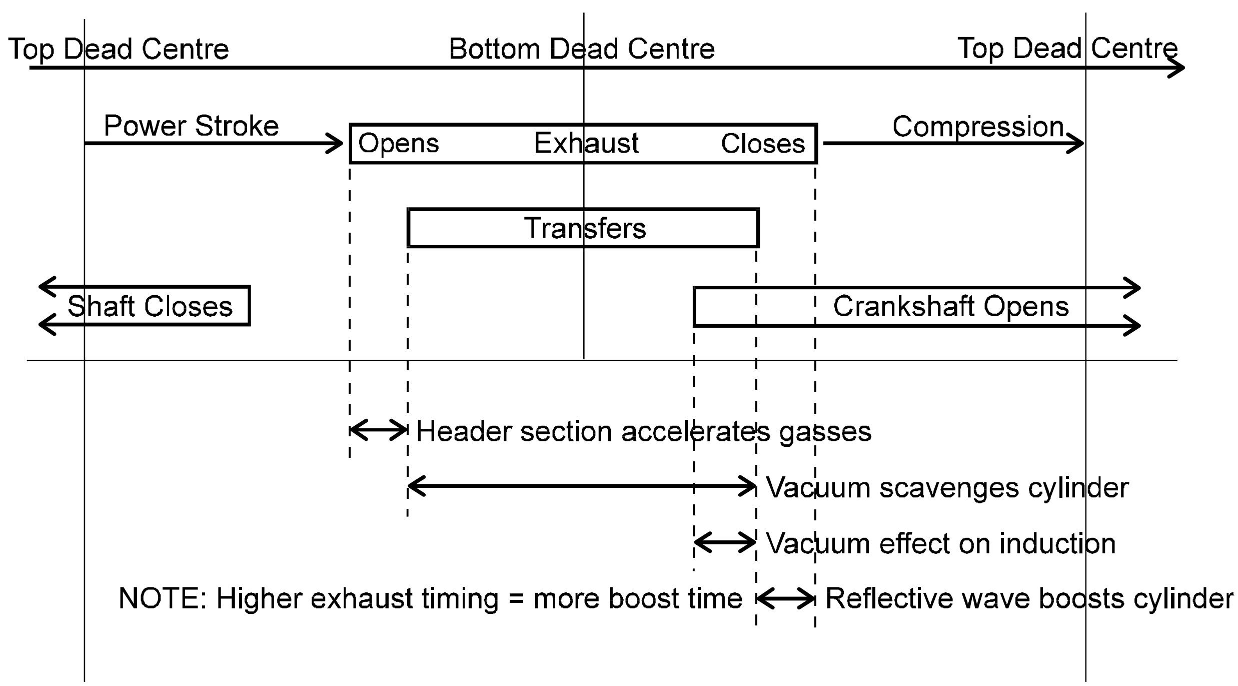
The exhaust gas travels down the pipe, through the expanding cone till it meets the rear reflecting / converging cone. The converging cone forces the pressure to rise, generating a pressure wave which reflects back towards the exhaust port.

As the reflected wave approaches the exhaust port, it forces the fresh mixture (which flowed through the combustion chamber), back into the combustion chamber. As the transfer port closes before the exhaust port this results in a pressurised charge in the combustion chamber as the exhaust port closes, - the result - more power. See diagram below.

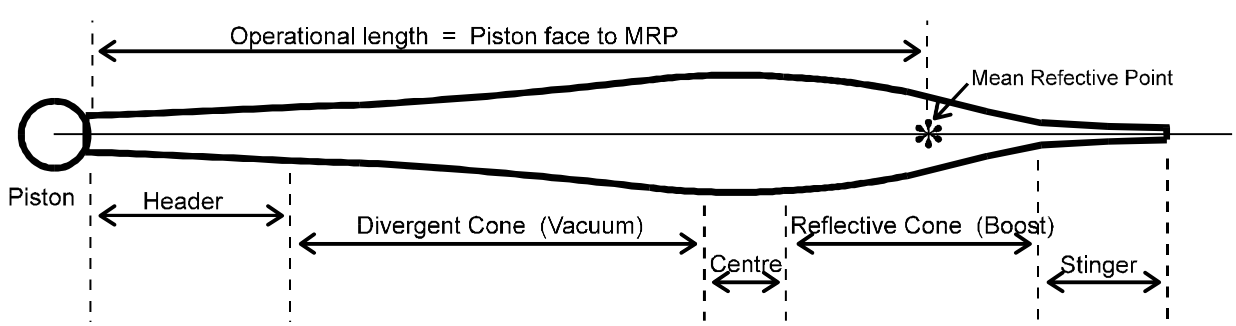
Engine Porting Sequence Vs Pipe Pulse Sequences

Engine Timings .....

Exhaust 170 degrees, Transfers 125 degrees, Intake 40 ABDC to 60 ATDC degrees



POWER PIPE CONFIGURATION



POWER PIPE DESIGN

Pipe design is complicated by the many variables. The art of pipe design is to combine the lengths, angles and diameters of the pipe to suit the characteristics of the engine, especially the exhaust timing and end use.

Some example are;

Small volume - high heat - narrow operating range (peaky)

High volume - lower power (if too big) - broad range

Steep angles - 'peaky' - high power

Shallow angles - broad range - moderate power

Shorter or larger diameter stinger - lower or higher pressures and heat.

There is a multitude of ways of quoting pipe length. The most accurate method (and most rarely used) is to quote the distance from the piston face to the Mean Reflection Point (MRP). The MRP is the average of the reflected wave forces. (see diagram). Many people quote a length of plug to the high point, which is easy when pipes have a clearly defined high point ... most modern pipes have a flat or mildly curved centre section which makes for a smoother, broader power band..

The 'pipe length' is only a guide to optimum performance. Only in pure speed events, ie, FAI and C/L Speed are pipes and engines used near optimum. In the case of R/C Pylon the engines must be 'on pipe' on the ground and in the air, ie.. 25,000 ground rpm, 29,000 air rpm on a pipe designed for 27,500 rpm.

The basic equation for pipe length is:- $L = \frac{E \times V}{rpm}$

where L = Length of pipe (to MRP), E = Exhaust timing and V = Exhaust wavespeed = 1675 feet / sec

In this equation the exhaust wave velocity can be regarded as a constant. From the equation we can tell that as engine speed increases the pipe length will decrease. High RPM, high exhaust timing and high power often go hand in hand as increasing the exhaust timing will enable the engine to rev faster, producing more power.

However, as can be seen from our formula, if we increase the exhaust timing, we need to lengthen our pipe, yet the usual result of increasing the exhaust timing is higher RPM, and the formula states that higher RPM requires a shorter pipe. If we consider the size of the numbers involved, it usual that a shorter pipe (rather than a longer pipe) will be required. Also see the pipe length chart.

Several other handy pipe design criteria, (all the equations on this page are in inches).

Max pipe dia = 2.6 to 2.8 x header diameter (ID)

Mini Pipe length = (755 x exhaust timing in degrees) divided by rpm.

Mini Pipe diameter = the square root of ((4.52 x capacity in cu. in. x 4), divided by (pi x length)).

The above are just a few of the basic equations, there are many rules of thumb for all sorts of diameters, lengths and angles, which are far to involved for a book of this type. For modellers wanting to learn more about pipes, pipe design and general 2 stroke principles, there are several very good books available, written primarily for 2 stroke motor bikes.

Shown below is the Bolly P42 pipe, designed for FAI pylon racing. An excellent performer.

POWER PIPE LENGTH CHART, EXHAUST TIMING Vs RPM

Please Note: The following chart applies to Power Pipes only, and will vary slightly from design to design. Many design variables apply, and the following should be used as a guide only.

Please Note: The operating lengths of **Quiet Pipes are different**, the operating lengths often vary from the below table, however the effects of changes in pipe length and exhaust timing are the same.,

Racing engines commonly have exhaust timings of say 175 to 195 degrees.

Other high performance engines (ducted fans / free flight etc), have timings of say 160 to 175 degrees.

'Normal' engines have timings of 145 to 160 degrees.

NOTE: Engines below 145 / 148 degrees are often difficult to operate correctly on a pipe.

Exhaust Length (mm) , equals Piston Face to Mean Reflection Point (MRP)

Exhaust timing in degrees

RPM	140	145	150	155	160	165	170	175	180	185	190	195
7,000	851	771	912	942	972	1003	1033	1064	1094	1124	1155	1185
8,000	745	771	798	824	851	877	904	931	957	984	1010	1037
9000	663	687	710	734	758	781	805	829	850	876	900	923
10000	597	618	639	661	682	703	725	746	765	788	810	831
11000	542	562	581	601	620	639	659	678	696	717	736	756
12000	497	515	533	551	568	586	604	622	638	657	675	693
13000	459	475	492	508	525	541	557	574	589	607	623	639
14000	426	441	457	472	477	502	518	533	547	563	578	594
15000	398	412	426	440	455	469	483	497	510	526	540	554
16000	373	386	400	413	426	440	453	466	478	493	506	519
17000	351	364	376	389	401	414	426	439	450	464	476	489
18000	331	343	355	367	379	391	403	414	425	438	450	462
19000	314	325	336	348	359	370	381	393	403	415	426	437
20000	298	309	320	330	341	352	362	373	383	394	405	416
21000	284	294	304	315	325	335	345	355	364	375	386	396
22000	271	281	291	300	310	320	329	339	348	358	368	378
23000	259	269	278	287	296	306	315	324	333	343	352	361
24000	249	258	266	275	284	293	302	311	319	329	337	346
25000	239	247	256	264	273	281	290	298	306	315	324	332
26000	229	238	246	254	262	270	279	287	294	303	311	320
27000	221	229	237	245	253	260	268	276	283	292	300	308
28000	213	221	228	236	244	251	259	266	273	282	289	297
29000	206	213	220	228	235	242	250	257	264	272	279	287
30000	199	206	213	220	227	234	242	249	255	263	270	277
31000	192	199	206	213	220	227	234	241	247	254	261	268
32000	186	193	200	206	213	220	226	233	239	246	253	260
33000	181	187	194	200	207	213	220	226	232	239	245	252
34000	175	182	188	194	201	207	213	219	225	232	238	244
35000	170	177	183	189	195	201	207	213	219	225	231	237
36000	166	172	178	184	189	195	201	207	213	219	225	231

USING TUNED PIPES

The greatest advantage gained from using a pipe is the increase in combustion chamber pressures that are generated during the combustion process (by virtue of the denser air / fuel charge). As a general rule, a piped engine will require a higher volume combustion chamber (lower compression ratio) to reduce the initial compression. As stated earlier, heat is the greatest undesirable result of most engine modifications, the higher the compression and the higher the rpm, the more power and the MORE heat produced. Hence when engines are modified to produce more power, then modifications are also necessary to dump the accompanying increase in heat.

The most common signs of over heating are blown plugs and a 'sand-blasted' looking head. A sand blasted / pitted head is actually caused by detonation ... which can be caused by under compression, and running lean to compensate, or by over compression at any needle setting.

TUNING

For optimum performance, the following guide may prove useful (for with or without a pipe).

OVERHEATING / HOT WEATHER

Increase combustion chamber volume or head (squish band) clearance

Increase stinger diameter or decrease stinger length (to reduce pipe pressure)

Decrease prop load.

Improve cooling

Decrease nitromethane content of the fuel (if using nitro)

COOL RUNNING / COLD WEATHER

Decrease combustion chamber volume or head (squish band) clearance

Decrease stinger diameter or increase stinger length

Increase prop load or

Decrease cooling

Increase nitro content of the fuel (if the competition rules allow nitro)

HIGH HUMIDITY

Decrease prop load

PIPE LENGTH

PIPE TOO SHORT

frequent blowing of glow plugs

Sand blasted head

over heating engine

difficult to get 'on the pipe', sensitive needle

excessive carbonising of the head

engine sags under load, ie, long climbs

'Harsh' running

PIPE TOO LONG

very easy on needle

smooth, quiet running

prone to burbling, rich running

no power

none of (a) to (g) above, try shorter and see what happens.

ENGINE REFUSES TO RUN

The above cause and effects list is fine, but what if the engine simply fails to respond correctly. Quite simply some engines are not built or designed for pipe use.

The normal symptom of poor ‘pipe’ running is the engine’s refusal to throttle properly. Generally from the engine going rich as the throttle is opened, and staying rich. Quite often fuel can be seen pulsing out of the carburettor. This condition is caused by insufficient exhaust timing / duration.

The other common problem is for the engine’s compression ration to be too high. The pipe pulse has the effect of increasing compression. Such engines display extreme overheating type symptoms.

ADJUSTING QUIET PIPE LENGTHS

It is rare that a pipe will not need adjusting in length, in fact the only way a pipe can be optimised is to vary the length to observe the changes to determine the best length. (This can also be done by varying the prop load and observing the pipe characteristics).

To shorten a pipe, remove material from the alloy header pipe. This will lessen weight and help prevent fatigue of the alloy. Save the off-cut and use for extending the pipe.

To extend a pipe, use the header off-cut, pushed inside a 75mm length of silicon coupler. Many pilots will have several silicon extensions in their flight boxes, at say 10 and 20mm lengths.

In some circumstances there will be a diameter difference between header and pipe, where possible, use the larger diameter.

IMPROVING HEADERS

There can be a fair degree of performance improvement gained by an hour of work on the header.

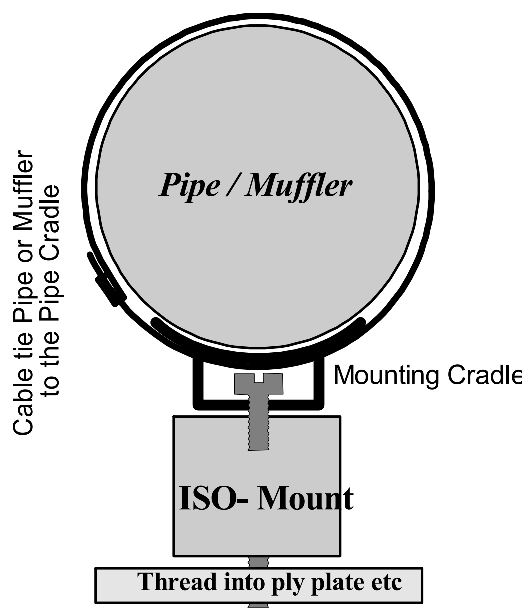
The flow of exhaust gas from the cylinder through to the pipe should be flowed as smoothly as possible. Most headers are far from smooth. The port should match the engine, and the junction of header tube to header mounting plate should also be smooth. As headers are generally an aluminium alloy, the easiest way of doing this is via a cutter + motor tool (Dremel etc). Do not use grinding tools as the aluminium will clog the tool in seconds.

Improving the header flow can often improve rpm by 200 to 300 in 10,000.

MOUNTING PIPES

It is important that pipes be correctly mounted.

The header end should not be contacting the alloy header. Quite a degree of damage can occur when the header and pipe are allowed to rub and vibrate together. We have seen a header's outlet area reduced by half from constant pipe to header contact, which in time peened the tube's end over.



Pipes need to be insulated from vibration. This is especially so for any pipe that has internal baffles and plumbing. Vibration is the biggest single 'killer' of pipes. Alloy pipes are also prone to failure through metal fatigue of which vibration is the chief cause.

If the engine is soft mounted, the pipe MUST also be soft mounted.

The drawing shows a cradle, which is screwed to a rubber 'iso-mount'. This cradle can be a plastic moulding (available in several different brands, including Bolly), or manufactured from plywood or similar. A cable tie wraps through the cradle and over the pipe. The iso mount is screwed to the model.

GENERAL / CARE

Make sure the silicon joiner, is a good fit and in good condition. Use nylon cable ties for attachment.

Header springs (which wrap around the engine cylinder head) should be used for Power pipes which attach directly to the engine's exhaust stub. A suitable attachment can be made by twisting together a wire fitting (with a hook each side of the pipe).

If you wish to use a pressure fuel system, where possible use a large bore nipple. We have found the **best** fitting to be a MACS brand thin wall 90 degree pressure fitting. This fitting uses a nut for both sides of the pipe wall, using a threaded nipple body.

Where possible use a pump system to supply fuel to the motor. On Quiet pipes it is best to place the pressure fitting in the alloy header (but not on a bend). This is equally effective and more convenient that positioning it on the pipe.

For the ducted fan QP / DF pipes the Pitot style of fuel pressure fitting can also be used.

For racing engines, pipe pressure is the suggested fuel system. The fitting is best placed at the front of the maximum diameter section (not critical). Crankcase pressure can be used (in conjunction with a .012 to .018" restrictor) for engines with less than 175 degrees exhaust timing.

When cowled, cooling air Must be provided, especially for the first third of the pipe length (hottest area) ... for cowled racing models, it is essential that cooling air be forced directly into this area. Don't forget the exit to any cowl needs to be much larger than the inlet.

At the completion of flying the pipe should be removed from the model and be allowed to drain ... front end down. If the pipe is to be unused for any time, wash out with lacquer thinners or methanol. Periodic cleaning will help maintain the good heat conducting properties.

Most 'P' pipes are provided with the silicon attachment tube. It may be necessary to shave this to improve fit. The use of a petroleum jelly will ease fitting a tight assembly. Some 'P' pipes attach direct to the engines exhaust stack.

The 'P' pipes should be anchored at the stinger and the 'Quiet' types at the stinger or near the first baffle position. Where possible use some silicon or rubber between the mounting points and the pipe. On pattern ships, 'soft mounting' is highly recommended, as per the previous page.

USING QUIET PIPES / LENGTHS

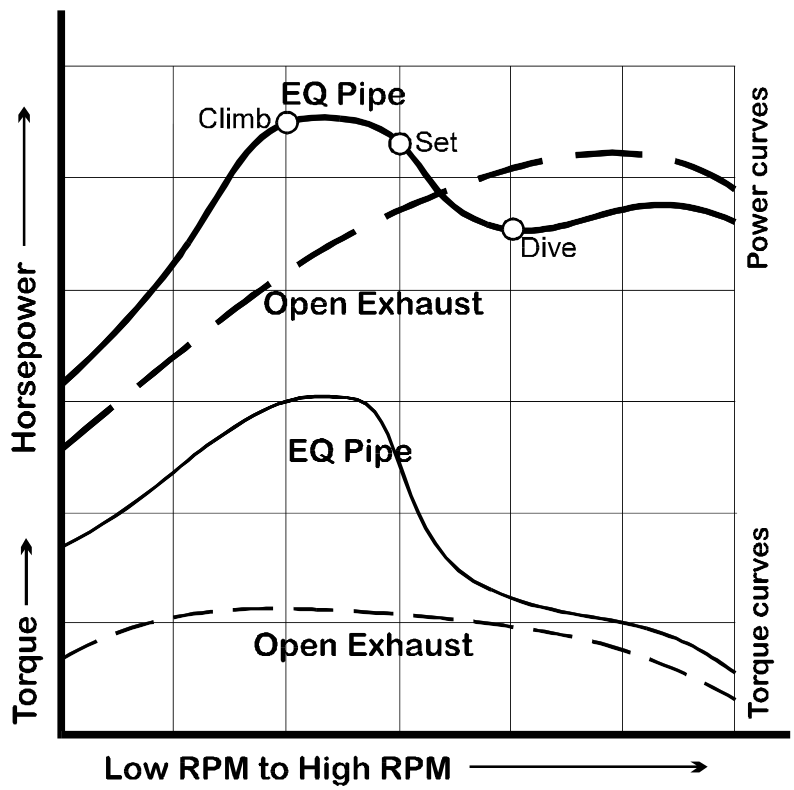
As outlined previously, and later in this section, the operational length of the Quiet / Pattern style pipes is not directly related to the Power pipe length chart of several pages prior to this.

The general rules of thumb apply, for example:

Lower exhaust timings = shorter pipe, and lower rpm = longer pipe and visa versa.

The ideal set-up for the Quiet / Pattern style pipe is to set the operational length much longer (by 300 - 500 rpm) than where peak power is produced.

The effect of this is most pronounced when in a vertical climb situation. As the increased load reduces rpm, the pipe is working at it's best, and when the model is in a vertical dive situation, and rpm increase, the pipe goes further off tune ('over the top'), which reduces power and 'holds back' the engine.



The graph is an approximation of the power and torque curve differences between open exhaust and an EQ pipe. The engine should be 'propped & piped' on the down side of the power curve as shown on the drawing.

The very broad (excessive) power range of the modern .120 / .145 engines used in pattern flying also make the use of a 'pure' muffler a viable alternative. If you compare the above diagram to a power curve for a small 2 stroke engine, you will see the small engine is much more 'peaky'. A muffler (such as the Bolly MF-xxx range) is a good alternative for those engines that just don't respond well to a pipe. (see previous section "engine refuses to run").

BOLLY: CARBON PIPES

CARBON FIBRE PIPES .... GENERAL INFORMATION

GENERAL FEATURES

The Bolly Carbon Fibre pipes / mufflers are the result of many years of development, featuring ;

Low weight - between 20 and 60% lighter than metal.

Exceptional strength for weight. Stronger than alloy.

Dent proof, and less prone to fatigue.

Generally quieter, by design and the materials. Carbon pipes have a better sound to the ear.

Better performance - using the latest designs, plus the production process allows the optimum shape to be produced. (Alloy pipes are often compromised to production methods).

Built in temperature gauge, via the colour change of the pipe.

Cooler running - leads to greater potential power. Our c/f pipe cools very quickly.

Note: Some of the larger pipes now feature a Carbon / Aramid (Kevlar) composite weave material and the new FS-124 now features a 75mm alloy header section build in.

SPECIAL FEATURES

Due to the different materials used in Bolly pipes, several unusual features need to be noted.

The unique resin used to manufacture Bolly Pipes has a ‘built in’ temperature gauge. The colour will change with the operating temperature. As the pipe temperature rises, the resins colour will first change from a yellowish colour to orange, then reddish/brown and finally to black. The optimum operating temperature of the pipe is an ‘brown / orange’ colour.

The pipes may make some 'crackle and pop' noises during the first few runs. This is due to small movements in the weave and evaporation of any moisture trapped in the laminate.

The pipes have an unusual smell which will soon dissipate with use.

NOTE: the above 3 conditions are largely alleviated by a 5 hour factory curing cycle up to 150 ^{o}C

The Resin and Carbon Fibre will withstand all exhaust temperatures...PROVIDING the pipe is cooled. **DO NOT** insulate the pipe. For boat use, a water cooled header is advised.

In some circumstances, the pipe may 'weep' exhaust gases. This is caused by the boiling out of any moisture present in the laminate, or from the expansion of the weave when hot. There is no detectable power loss from the weeping. Weeping is more likely to occur if the pipe has been 'run hot' at some stage, especially in it's first few flights.

USING BOLLY PIPES, GENERAL

The pipes are given a basic cleaning before packing. Before use; wash out with thinners or methanol.

Make sure the silicon joiner, is a good fit and in good condition. Use nylon cable ties for attachment.

If you wish to use a pressure fuel system, we recommend to use a MACS brand thin wall 90 degree pressure fitting. This fitting uses a nut for both sides of the pipe wall, using a threaded nipple body. Bolly pipes may be drilled and tapped to take a normal pressure nipple, but it is best to avoid doing so. Note that some Bolly Power pipes are fitted with a (round) reinforced section for this purpose. Care must be taken to provide a square seat for the nipple (use some cyno and filler, epoxy or silicon). On EQ pipes it is best to place the pressure fitting in the alloy header (but not on a bend). This is equally effective and more convenient that positioning it on the pipe. For the ducted fan QP / DF pipes the Pitot style of fuel pressure fitting can also be used.

The first ground run and test flight should be done with any pipe cowling removed for extra cooling.

When cowled, cooling air Must be provided, especially for the first third of the pipe length.

At the completion of flying the pipe should be removed from the model and be allowed to drain ... front end down..

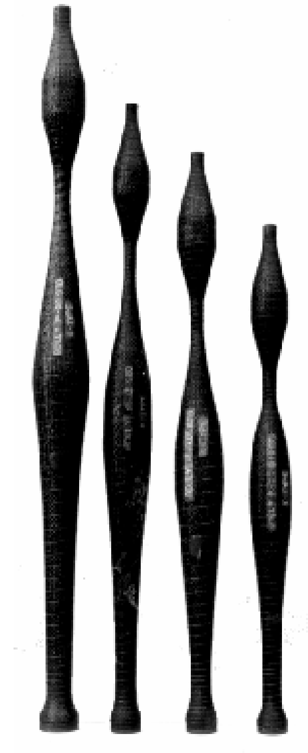
Pipes that we have deliberately 'cooked' during testing have continued to work fine..... but it is not recommended, we will not offer any warranty on an over heated pipe. A well cooled pipe results in greater power and reliability. This applies to alloy or C/F pipes.

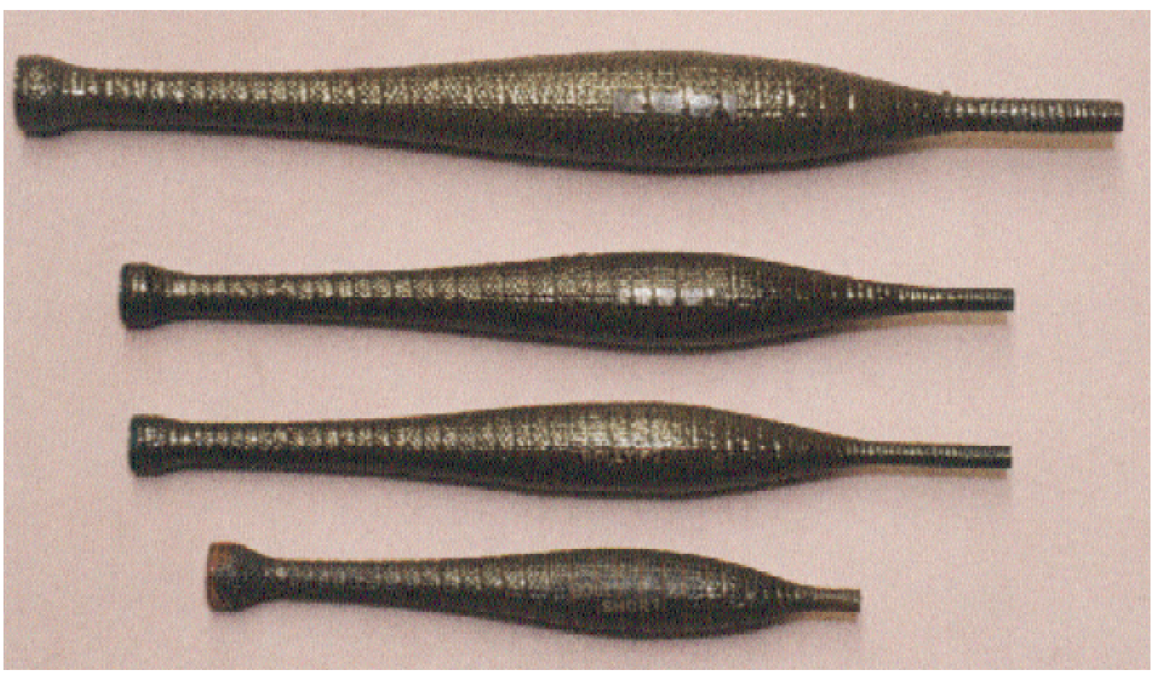
The Bolly C/F pipes are less prone to damage than alloy, but if you are unlucky enough to puncture one, it can sometimes be repaired. Please arrange by mail or phone call before returning pipe.

Carbon pipes can be made to the customers' own design, at similar cost, if the mandrel is provided. Inquiries by mail or phone call welcome. The photo to the right is a range of pipes we produced for customers (primarily in boat use), where they wanted an integral power pipe / after muffler combination. They work well.

For using pipes and tuning, see the previous section re pipes, in this book.

‘XP’ Pipes
made to special order only.





BOLLY

BOLLY Mfg TUNED EXHAUST SYSTEMS

BOLLY PIPES ..... 1998 SPECIFICATION CHART

EQ = Quiet Pipe (pattern), FS = Four stroke (EQ type), MF = Muffler versions of the EQ Series pipes

P = Power Pipe, QP or DF = Quiet Power pipe i.e. for Ducted Fan.

Pipe type	Shape	Diameter mm OD	Length mm of pipe	Weight gm	Pipe front to baffle	Piston face to baffle	Header length needed	Total system length	Usual ground rpm	Engine size used
EQ 7000	round	68	755	325	530	750	220	975	7200	65 - 75 cc
EQ 6000	Square	61	640	345	440	720	280	920	7500	50 - 65cc
EQ 5000	round	58	660	260	470	690	220	880	7500	35 - 50 cc
EQ 3002	round	53	655	210	465	640	175	810	8000	25 - 35 cc
EQ 180N	Rectangular	54 x 45	735	205	540	715	175	910	7700	.180 F3A
EQ 140R	round	48	685	175	525	700	175	860	7800	.140 F3A
EQ 120R	round	48	645	165	480	680	200	845	8000	.120 F3A
EQ 2000	round	47	590	130	425	600	175	765	8800	15 - 20 cc
EQ 80N	Rectangular	46 x 37	590	125	410	550	140	730	9600	.80 F3A
EQ 63	Square	43 x 43	535	120	380	520	150	685	10000	.60 pattern
EQ 62N	Rectangular	46 x 37	525	115	360	510	150	675	10200	.60 pattern
EQ 62	round	44	520	115	365	510	150	675	10200	.60 pattern
EQ 60	round	41	510	100	360	505	150	660	10600	.50 - 60 Pat
EQ 45	round	36.5	495	80	340	480	140	635	11400	.38 - 46 Pat
EQ 30	round	33	470	70	325	465	140	610	12000	.19 - 36 Pat
MF-605N	Rectangular	52 x 39	605	185	n/a	n/a	175	780	8,000	.120 - .150
MF-565N	Rectangular	52 x 39	565	165	n/a	n/a	175	740	8,000	.108 - .145
FS 124	Rectangular	38 x 33	445	95	285					FS.120 /.140
FS 122	Rectangular	38 x 33	375	80	236					.120 FS
FS 90	Rectangular	33 x 28	375	75	220					.90 FS
DF 91B	round	46	470	115	310	335	n/a	n/a	20,000	ducted fan
QP 45 DF	round	40	460	95	305	328	n/a	n/a	21,000	pattern.
P 92	round	52	470	85	n/a				22000	.90 - .120
P 90	round	50	445	60	n/a				22000	.65 - .90
P 45	round	41	390	45	n/a				22000	.45 / DF
P 42	round	39	340	45	n/a				24000	FAI pylon
P 40	round	41	340	40	n/a				23000	.40+ racing
P 21	round	35	280	35	n/a				27000	.21 pylon

New pipes & changes for 1997/8 are:

EQ-180N , New rectangular design philosophy, for optimum throttle response, .180 engines.

EQ-140R, Based on our round 2000 series pipes, high power & smooth throttle transition.

EQ-120R, As per 120R, optomised to suit the .140 or larger engines.

MF-605N, Low noise, minimal power loss ‘narrow’ muffler for F3A use, .108 to .145 engines.

MF-565N, Low noise, minimal power loss ’narrow muffler for F3A use, .120 to .150 engines.

EQ-80N, As per EQ-180N, for .60 to .90 engines at low rpm.

FS-124 , a 4 stroke pipe incorporating an alloy header section for improved heat dissipation.

Please Note: Specifications will vary slightly. Where applicable, all Bolly pipes come supplied with the appropriate silicon joiner and cable ties or clamp and cable ties etc.

BOLLY ... CARBON FIBRE MUFFLER SYSTEMS

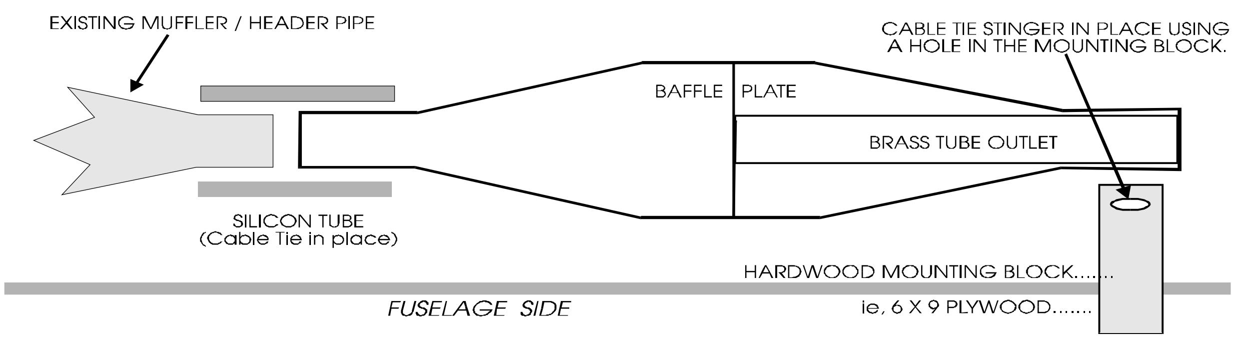
CARBON FIBRE 'AFTER' MUFFLER, 'SUPER' MUFFLER SPECIFICATIONS

The below sizes are based on the outlet diameter (id) of the muffler, match this to the outlet diameter of the engines exhaust system (pipe or muffler). When using in a high heat / low cooling environment i.e., cowled, high nitro, helicopter etc. It is best to use one size larger If in doubt go 1 size bigger.

Size	Type	Weight gm	Max. dia mm	X	Length mm	2 cycle	4 cycle
7.0 mm	After	19	31	x	139	.25	.50
7.0 mm	Super	23	31	x	139	.25	.50
8.5 mm	After	21	33	x	147	.40	.80
8.5 mm	Super	28	33	x	185	.40	.80
10 mm	After	26	35	x	185	.45	.80
10 mm	Super	34	35	x	198	.45	.120
12 mm	After	29	37	x	165	.60	.120 - .160
12 mm	Super	39	37	x	209	.60	.120 - .160
14 mm	After	44	42	x	205	.90 - .108	.160+
14 mm	Super	53	42	x	245	.90 - .108	.160+
16 mm	After	68	49	x	235	20 - 35cc	
16 mm	Super	80	49	x	290	20 - 35cc	
4 Stroke	Rectangular	33	38 x 33	x	177	.60 - .90	.120 - .160
See the previous page specifications for MF-565N and MF-605N, pattern mufflers.							

BOLLY PRODUCTS AFTER - MUFFLER

(The Super Muffler has an extra muffler chamber)



AFTER MUFFLERS

The Bolly After Mufflers have been designed to suppress exhaust noise levels of conventional mufflers and tuned pipes (P-Types), whilst remaining a practical size and low weight.

Amazingly, in many cases the noise levels are reduced markedly AND power levels increased, when using a Bolly After Muffler. As a result of their use, is the extra heat that can be generated, especially if the muffler is too small or the prop load too big. See the Book section on 'thermal efficiency'.

The average noise drop of 5dB for a 200 rpm increase. In some instances, we have measured a noise decrease of over 20dB (in a marine set-up).

Do not attach an After Muffler directly to a 4 cycle engines exhaust pipe (the heat will melt the silicon). For 4 cycle engines, use a flexible steel exhaust (as available for most 4 cycle) to position the After Muffler (and silicon joiner/s) further away from the exhaust outlet.

Optimum performance is obtained by using an After Muffler of **similar or <u>larger</u>** size than the exhaust outlet ie, an 8.5mm or 10mm After Muffler on a 8mm muffler outlet of a .40 engine muffler.

THE SUPER MUFFLER

The Bolly 'Super' Muffler has an extra muffler chamber in comparison to the After Muffler, hence the longer length. The Super Muffler is more effective at noise reduction than the 'After' muffler. The Super Muffler can be used as 'the' muffler, when used in conjunction with an alloy exhaust header.

NOTES ON BOLLY EXHAUST SYSTEM USES

Without doubt Bolly have one of the best ranges of up to date 'Quiet Pipes' and mufflers available for aerobatics use, for both 2 and 4 strokes. The major difference between our different pipes is volume. The earlier designs have been made to suit existing model designs. The later types have been designed for better performance and lower noise.... generally this has lead to larger volume pipes.

Most of our new pipes are square or rectangular in shape. Bolly are the worlds first to use this shape. The N designation is for Narrow (rectangular), S = Square., R= Round

PIPES FOR F3A AEROBATICS, .108 / .120 / .145 2 STROKES.

We have done extensive testing on pipes for .108 - .145 size engines. In fact we have had these pipes in production and testing a full year before the new rules came into operation. In our testing we have found several engines that do not respond as they should to a pipe, mainly due to an exhaust timing that is too low. For these engine we have introduced the Bolly MF-xxx series.

The normal pipe system should improve rpm by 600 - 800 rpm over open exhaust, but for engines with insufficient exhaust timing (less than 142 - 145 degrees), the rpm increase is insignificant, and the engine will not respond correctly to the throttle, often going very rich in mid range.

The below range is made of a Carbon / Kevlar mix. We know of no better pipes for strength to weight, performance, low noise or broad operating range. Please note, there has been a rationalisation of sizes.

EQ-180N For larger engines.

EQ 2000 This is our well established basic pipe for .108 to .120.

EQ 120R Our standard .120 / .140 pipe. (EQ-120N available on special request).

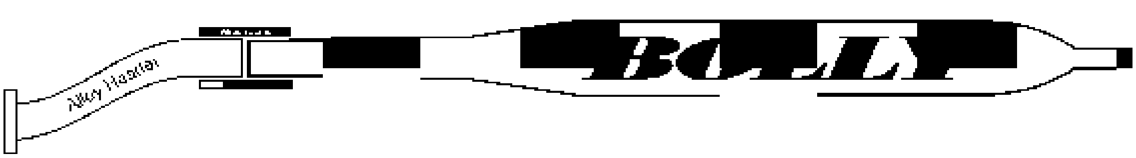
EQ 140R Longer / lower rpm version of the EQ-120R. (EQ-140N available on special request).

MF-565N The standard muffler for .108 to .120. Also fine on bigger engines.

MF-605N The muffler for .120 to .145.

For pattern use, we prefer to use a length of around 660mm for around 8,500 rpm through to a length of 720mm for 7,500 rpm. These pipes are not critical to length, and almost any length will work fine.

Our mufflers are a fixed length, (added to the header), but can be varied to suit without changing performance. The front 50mm of the pipe is specifically designed to be shortened if required.



Bolly Pattern Muffler (MF-xxx) System.

PIPES FOR F3A AEROBATICS, .60 / .80 2 STROKES.

We believe Bolly has the worlds best .60 size F3A pipe, in the EQ 63. The great pity for us is that is was developed too late to become appreciated by the modellers, as the world was turning to the 4 strokes. The brothers of this pipe are very good and easier to fit into a model. The EQ-80 has been developed for use with .75 to .90 size engines.

EQ 60 This is our standard pipe. A very smooth performer.

EQ 62 A larger diameter and slightly longer version of the EQ 60. Smooth and quiet with better power. This is our most popular pipe.

EQ 62N This is our latest pipe. Basically a rectangular version of the EQ 62 / 63.

EQ 63 A very unique pipe, square in shape, with awesome power. This pipe is usually 300 - 500 rpm better than the EQ60, with the other sizes between these.

These pipes are usually used at a length between 490mm (10,500 rpm) to 540mm (9,500 rpm).

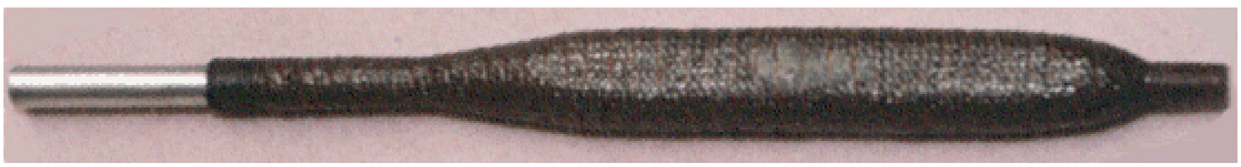
PIPES & MUFFLERS FOR F3A AEROBATICS ... 4 STROKES.

Used extensively by Quique Somenzini, with whom we do a lot of development work. These are tuned length, slight power gain pipes. They can be used shorter if required for a minimal power loss. The biggest advantage of these pipes is the excellent low noise sound.

As 4 strokes run much hotter it must be stressed that these pipes MUST be well cooled. Pipe attachment needs to be given careful consideration as the exhaust gas can melt silicon connectors. The longer the header the better. Where possible use a metal fitting to sleeve over (and inside) the pipe and header.

FS 122 Somenzini Our 3rd generation of 4 stroke pipe. This is a much more compact but larger volume version of the FS120 versions. Rectangular in shape.

FS 124 (Somenzini) As per the FS 122, but featuring an aviation grade alloy header tube, as an integral part of the pipe. Combined with our improved pipe resin, and carbon / kevlar makes for a pipe far more capable of withstanding 4 stoke exhaust temperatures than previous versions. The volume of this pipe makes it very suitable for the larger .140 size 4 strokes that have become available under the new 1996 F3A rules.



FS 90 Designed for the new YS 90AC or similar engine.

FS After Muffler Designed to plug onto the end of the FS122 / 124, or to be used separately as a 'sports' 4 stroke muffler.

PIPES & MUFFLERS FOR LARGE SCALE MODELS

Most large scale models (over 30cc), use petrol engines. This introduces a problem for exhaust systems (metal or carbon) due to the extra heat these engines develop. It is vital that careful consideration be given to cooling on these models, which generally use a fully enclosed exhaust system.

The best method we have found is to use a long alloy header to dissipate the heat before it gets to the pipe or muffler (metal or composite). The heat of these engines also makes it difficult to build headers that survive this operating environment.

Note: Vibration levels of these engines (especially the larger single cylinder versions), can be very high, and posed as many problems as the heat. We advise the modeller think very carefully about using pipes (metal or composite) on larger (above 50cc) engines, as the problems are many.

Bearing the above in mind we have a good range of products for the large model. The EQ range all operate similar to pattern quiet pipes.

EQ7000 Has been designed for the 60 to 80 cc engines.

EQ-Zehoah62 Will suit any engine 45 to 65cc. Uses our latest square pipe technology. This pipe has a large (id) header section to sleeve over the allow header. This reduces the need for a silicon joiner, which are prone to burning out on engines of this size.

EQ5000 For engines 35 to 55cc. The test engine was a Sachs 3.2.

EQ3002 A very popular pipe on 25 to 35cc engines e.g. Moki 180.

TOC Somenzini Developed for use on 3W60 twins, (2 pipes @ 30cc each side), for use in the Las Vegas TOC event. More powerful and more noise than the equivalent EQ pipe. Suitable for 30 to 40cc use.

EQ-180N Excellent pipes, see previous pattern section.

EQ2000, EQ-120R, EQ-140R For engines 15 to 25cc.

Don’t forget the range of After or Super mufflers. The Super Mufflers are especially handy where space or cost prevents the use of a full length pipe.

PIPES FOR PYLON RACING

The Bolly P21 has proven to be very popular for Australian Quarter Midget rules (using .21 engines). For some years it has been the most popular and successful pipe in Australian QM racing, especially the short version, when combined with the Rossi 21.

For FAI use we have the P42, designed in collaboration with the Bruce DeChastel who had a hand in the world’s most popular alloy pipe for pylon, the ‘MACS’ pipe. The most recent P42 have a larger 7.2mm diameter stinger which performs much better than the older 6.4mm stinger. Some customers are reporting a 8mm stinger is better again.

As a matter of interest, it seems that almost everyone has claimed credit for this style of FAI pipe. Just what the real story is, will probably never be known. All we know, is that ours works well.

The FAI pipes are available with different headers and bent stinger as an option.

PIPES FOR DUCTED FAN USE

We have done extensive development of our ducted fan pipes, in particular the QP90. This pipe is light, powerful and quiet. It is slightly larger in volume than most and benefits from being used in an ‘area rule’ tail pipe which allows for the pipe volume..... this makes for an unbeatable combination.

Note: The QP90 has now been replaced by the **DF-91B**. The DF-91B has been designed to withstand higher levels of vibration then the old QP90, otherwise the performance is very similar.

Our old P90 is a very noisy pipe now outperformed by the QP90, however we have developed the new **P92** which is more powerful and easier to use, but noisy. Great for where power is more important than noise, i.e. setting speed records etc.

Please note the ‘P’ pipes are not as easy to use as the QP / DF style, but will develop more power.

The P90 is well suited to old .65 to .77 engines.

The .45 size ducted fan models are well served by the P45 and QP45 pipes.

PIPES & MUFFLERS FOR SPORTS MODELS

More often the sports flyer is turning to pipes for quietness and discovering the power benefits. The ‘sports’ modeller is not as restrained by rules or scale appearance making the fitting of a pipe very easy. Pattern type performance is within any modellers reach.

Many a ‘Hots’ style model is flying with a pipe. The Bolly EQ-45, 60, 80 and 2000 pipes are very suitable for this type of application.

Don’t forget the range of After or Super mufflers. The Super Mufflers are especially handy where space or cost prevents the use of a full length pipe.

PIPES & MUFFLERS FOR HELICOPTERS

Finding the correct pipe for helicopter use is difficult, as few pipes have the ability to produce good power and be broad range enough to be ‘on the pipe’ properly at hover and top speed. Often a compromise must be found that suits top end performance at the expense of a rich hover, or a great hover at the expense of absolute top end power.

The EQ30 has proven to be an absolutely wonderful pipe on the .30 size helicopters (.28 to .34), when used at an operating length of 430mm. Ask for the EQ30H version.

Use the larger EQ pipes at 450mm length for ‘hover’, or 430mm for ‘top end’ performance.

Also troublesome is a good header to arrange for a pipe to be positioned parallel with the boom.

Full length pipes (c/f or alloy) should not be used with full body choppers due to inadequate cooling arrangements usually found in this environment.

PIPES FOR CONTROL LINE USE

The main area of pipe use for control line is aerobatics where our range of EQ30 , 45 and 60 are quite suitable. These pipes are a larger volume than some of the more popular pipes, and as such are less critical to set-up and use. They are also quieter than many other types.

The C/L Speed classes also use pipes, for which our Power pipe range is suitable. The P15 was developed in conjunction with the late Ivars Dislers, where it showed great promise, cooling being a problem in the airframes set-up for smaller alloy pipes.

KITS, BUILDING, TRIMMING etc

This section primarily relates to glass fuselage / foam core wing kits.

This type of kit has become more popular with the average aeromodeller over the years.

A glass fuselage has many advantages over wood.

Complex shapes which are possible in 'glass' which would otherwise be near impossible / impractical in wood. Glass fuselages are generally much more aerodynamically 'clean'.

Good strength for weight.

Large amount of radio space (compared to a wood fuselage of the same external size).

Quicker, easier building.

Easier to finish and paint etc.

Foam core wings are great for building strong, light accurate wings suitable for applying a good finish. A fully sheeted foam wing can be very light if built properly.

'GLASS' FUSELAGES

There are many types of fuselages available, unfortunately there is a lot of very bad fuselages on the market, so take care when purchasing a fuselage or you could be buying a lot of extra work.

A fuselage should be strong, but not heavy (often the inclusion of firewalls etc will transform what seems a slightly flexible fuselage to a very rigid fuselage). The join line should be accurate and without gaps and lumps etc. The overall finish should be good enough to paint with the minimum of preparation and not be filled with 'pin holes'.

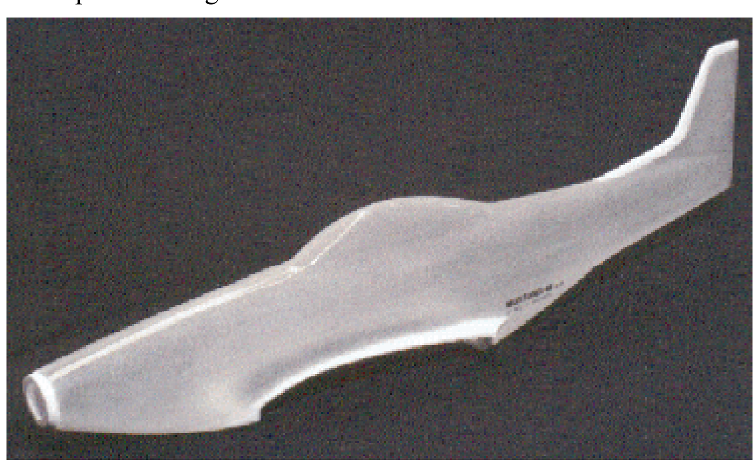
FUSELAGE TYPES

A fuselage should be made from a good high quality Epoxy resin, combined with good glass fibre cloths. Often made using a range of other products for filling in sharp corners and extra strength, i.e. localised carbon fibre. Be careful if the carbon runs full length of the fuselage as this can effect radio reception.

Other materials used for fuselage making are Polyester resin and glass mat. Polyester resin is not as strong as Epoxy, is more brittle, and prone to higher shrinkage rates. Glass random weave mat is heavy to use and not strong (unless thick as it usually is). The only advantage of polyester / mat is that it is cheap.

Most fuselages have what is known as a gell coat, and many epoxy fuselage will use a polyester gell coat (especially if white). The gell coat is an initial, thin (hopefully) layer of resin to improve the finish of the fuselage, preventing any cavities in the cloth pattern being on the outside.

Colour gell coats look good if the mould is perfect, however they can be heavy in order to achieve a good depth of colour. They also hide the mistake … especially the holes that need filling before you paint. Clear gell coats are much easier to work with, and allow the builder to look through the fuselage when installing gear etc.



Take care that you know which material your fuselage is made from as it effects the choice of glues to use.

Epoxy will adhere to polyester, but polyester will not adhere well to epoxy.

BUILDING 'GLASS' FUSELAGES

The following is a guide to preparing a GRE (Glass Reinforced Epoxy) fuselage.

Remove all traces of release agent.

Wash with water

Wipe with a solvent, ie - acetone

If painting, lightly sand the complete fuselage with a fine sandpaper or rub with steel wool.

Check the joins for any pinholes, mismatches, etc. Fill in any holes with a filler, either epoxy / Q-Cell mix or an automotive knifing putty.

Sand (any) filler smooth, then spray a primer to spot any extra problems.

When all is OK, wet rub to remove most of the primer etc.

Spray with your favourite paint. Paint after building.

Some epoxies go 'soft' when subjected to a pool of fuel, ie, leaking tank. Always place a small drain hole in the fuselage in case of such an accident.

SERVO TRAYS

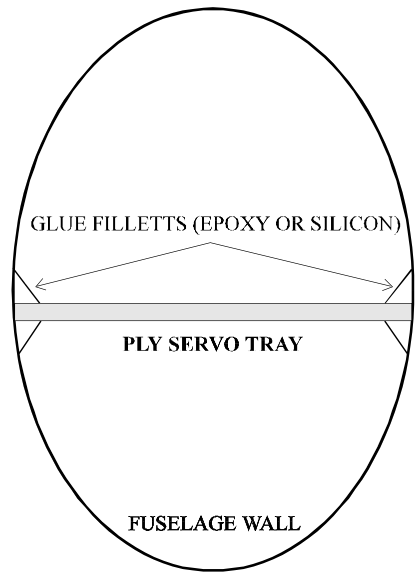
The flexibility of Epoxy fuselages can often lead to problems with servo mountings etc. **<u>Always use a servo tray</u>**. Use a 3mm light ply stiffened with 6 x 6 balsa cross pieces, or even better, lightly glassed 3mm balsa with spruce backing rails.

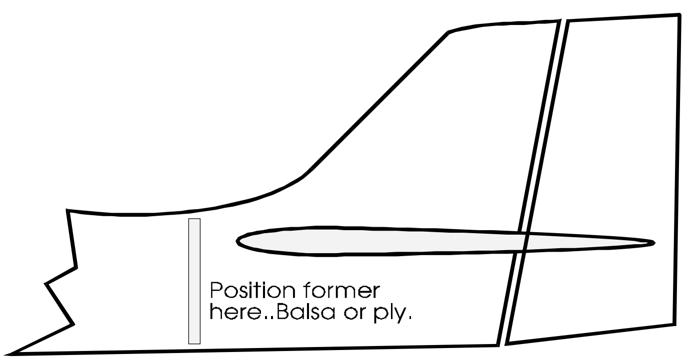
It is vital that any area to be glued, be thoroughly cleaned and sanded. Many cured resins have wax residue on the inside.

When attaching the servo tray, there are 2 options.

Tack in place with cyno, then use large fillets of Epoxy/Q-Cells filler, top and bottom of the tray to totally encapsulate the tray.

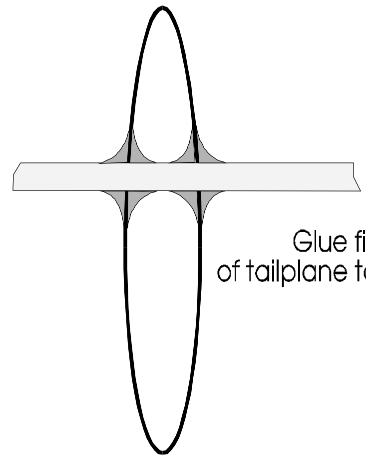
Tack in place with cyno, make large fillets top and bottom of the tray using a good silicon glue. Try to use a non acetic acid based silicon.





For models that have a long tail moment or a deep flat section at the rear of the fuselage it is **necessary** to install a vertical lightweight former at the base of the fin / tailplane area. This is to prevent unwanted flexing of this area.

INSTALLING TAILPLANES



Special attention must be given to the installation of tailplanes in GRE fuselage.

When a tailplane receives a knock, ie, cartwheel etc, it is easy to damage the tailplane mounting.

The problem is easily solved by either:

Make sure the tail has an inside and outside glue filleted.

Insert a horizontal former in lightweight balsa.

Do not store a GRE product in a hot stressed environment as it may distort, (ie, leaning against a tin shed wall in Summer, or with a weight resting against it).

INSTALLING FIREWALLS

The hardest task preparing a GRE fuselage is the placement of the plywood firewall (engine bulkhead, etc). Here is our favourite way: (having 3 hands helps...)

Mount the engine in its intended engine mount, usually an alloy radial mount.

Calculate the approximate position of the firewall, and shape the plywood until it is a reasonable fit.

Mark the approximate centre position of the engine mount on the firewall and drill a hole, say 3mm.

Use a 3mm bolt, nut and a scrap ply plate to hold the engine mount in position onto the firewall, ie, loosen the bolt to slide the mount around.

For models using a nose ring in glass, mount the spinner to the engine, and tack a spacer to the rear of the spinner. Hold the spinner (and spacer) firm against the fuselage, and whilst holding the fuselage vertical, find the mount position on the firewall.

After finding the mounting position, attach the engine to the firewall (usually bolts and blind nuts).

Reassemble the complete assembly, when happy with the firewall position, tack glue it to the fuselage with cyno.

Remove the engine, mount etc, then using Bolly epoxy, brush resin over both front and rear of the firewall. Mix up a paste of epoxy and glass powder. Use this paste to make a filleted glue line into the fuselage (similar to the way a tailplane has glue fillets).

COWLING / BELLY PAN ATTACHMENTS

Many kits have a removable cowling etc. For the larger cowls, pins need to be inserted to prevent excessive flexing. The best method is to use a pin (in the cowl) inserted into sleeve (in the fuselage). For small models the perfect components are a nyrod inner for the sleeve and an appropriate size piano wire pin. Also popular is the use of piano wire and an appropriately good fitting fuel tubing. The fuel tubing method is quieter in a high vibration environment.

Mark out the positions, glue (using a epoxy / glass powder mixture) the pins into the cowl (tack cyno first), making sure the wire is suitably bent to key in place. Drill the fuselage slightly oversize to accept the outer, and with the outer slipped onto the pins, tape the cowl in place and with a epoxy / glass powder paste glue the sleeves into the fuselage (from inside the fuselage). Easier said than done.

Where possible we prefer to nylon bolt a belly pan or cowling in place. The choice is yours.

BUILDING FOAM CORE WINGS

The following is a recommendation on how to build balsa sheeted foam core wings. We do not recommend using hardwood veneers as they are heavier and weaker (strength for weight ratio).

Use Epoxy resin, use a good thin resin which is a 2:1 mixing ratio (fool proof).

Epoxy is the best for strength, and can also be used very lightly. Latex based contact cements are also popular, and is lighter, but lower on strength and less versatile on high stress areas such as undercarriage mounts, nor is latex sufficiently rigid on thin areas such as trailing edges.

2) Prepare the foam cores.

a) Rub off all the foam 'spider' webs left on the core.

b) Prepare any servo cut-outs, undercarriage mountings etc at this time.

You may choose to glue the blocks at this stage or wait until the actual skinning process. To glue hardwood mounting plates, use a mixture of epoxy and Q-cells. This fills the foam bead holes for minimum weight, and you have maximum gluing area.

3) Prepare the wood skins. Balsa is superior to veneer or ply with the exception of dent resistance. Dent resistance is not a problem when the wings are 'glassed'.

a) Use only the lightest straight grain balsa. We suggest only the following weight.

1/16 x 4" x 48" / 1.5 x 100 x 1220	18 - 28 gm (2/3 - 1oz) per sheet
1/16 x 4" x 36" / 1.5 x 100 x 915	14 - 21 gm (1/2 - 3/4 oz) per sheet

Where possible use 4" (or more) wide sheets to reduce the number of glue lines.

b) Arrange the first sheets to have the grain parallel the leading edges. The diagrams (next page) shows two ways of arranging the wood sheets. The Mk 2 way is to join all sheets parallel to each other, then cut to shape with the leading edge having parallel grain (easier to curve) and the grain at an angle to the trailing edge (stiffer).

c) When matching the sheets, try to match the naturally curved edges to each other. If this is not possible, use a straight edge and a very sharp knife to trim all edges straight and square.

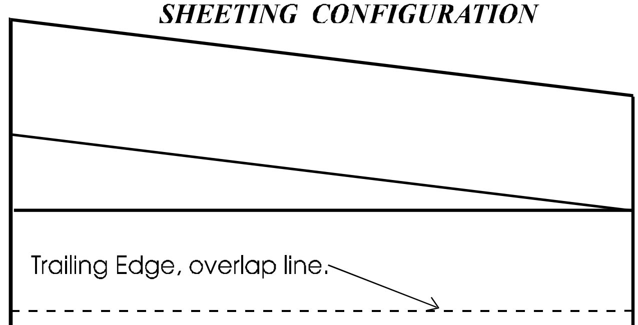
d) To join, use masking tape across the join to hold it together, then run another piece of masking tape along the join. It is not necessary to glue the sheets together.

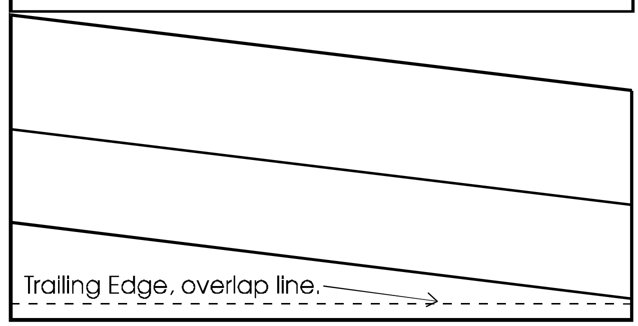
e) After taping together and trimming to size, apply a thinned coat of dope to the side of the wood which will be adhered to the foam. Make sure some dope enters the taped join to seal and 'glue' the joints.

Note: For the absolutely best job, glue the sheets together, remove any masking tape and sand both sides of the wood before doping.

f) If taking the trailing edge to a fine edge (ie, pylon models), draw an overlap line on the edge (ie, align 6 - 8mm from the wood edge). This is the line of the foam core.

SHEETING CONFIGURATION

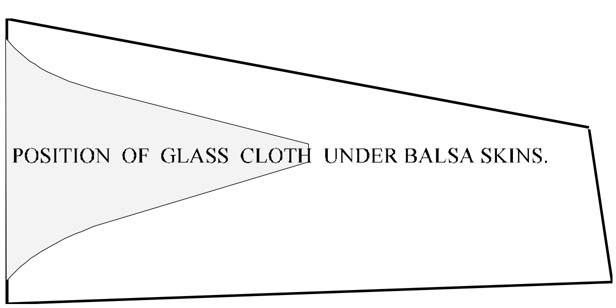


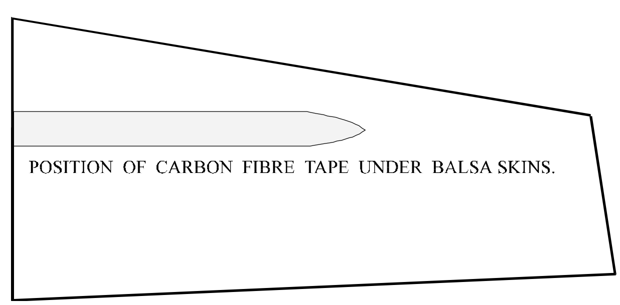


SHEETING CONFIGURATION Mk 2

4) Before mixing the epoxy, prepare all items needed for the job, and have a test run on the skins by putting them all together dry. It is very easy to tape or epoxy the skins on the wrong side.

If you need extra strength, the use of lightweight (no heavier than 2.5 oz / sq. metre) glass fibre cloth or carbon cloth / tape between foam and balsa skins is recommended. See the diagrams below. If installing undercarriage mounting plates, make sure to use a patch of glass over this area.





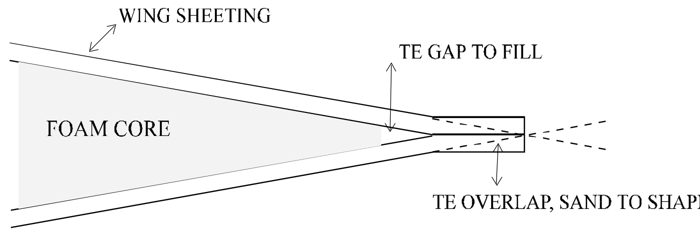
Mix enough resin to do the job. We suggest mixing 6 gm of Resin/Hardener per every 100 square inches of surface to be covered, ie, double the wing area. This should be the correct amount to do the job.

Brush resin onto the doped wing skins, bottom skin first. Wet out any glass reinforcement on the balsa.

With the balsa skin placed on the bottom foam shell, position the foam core, aligning the trailing edge of the core with line drawn on the balsa skin.

Mix a thin Q-Cell (micro balloons) and resin paste to travel along the trailing overlap. This will fill any slight gaps and strengthen the trailing edge.

Add the top skin, aligning it with the trailing edge of the bottom skin. Position the top shell to complete the assembly.



T.E. CONFIGURATION

Make sure the complete assembly is sitting on a flat surface. Place a sheet of glass/plywood or particle board over the top of the assembly. Add as much weight as practical to the board to compress the assembly, we use an 8" depth of bricks. Make sure your flat surface, remains flat under this weight.

Allow 24 hours before removing, trim all edges (except TE) with a very sharp knife. Add the LE and Tips as necessary. Sand to shape.

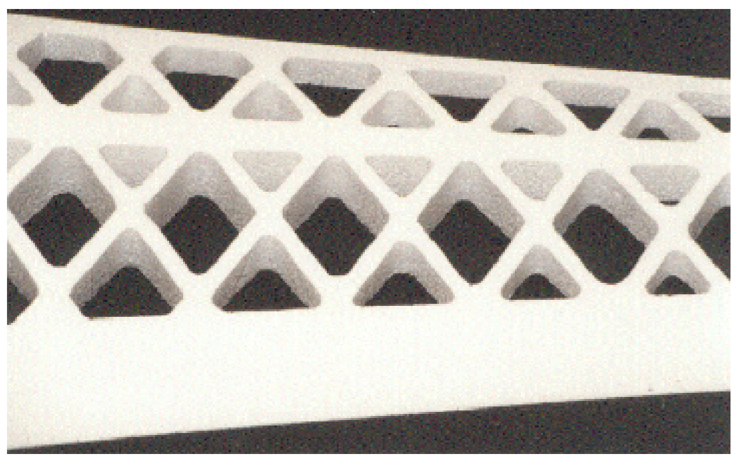
The result is a strong, rigid, accurate but light wing.

PLEASE NOTE: Some models use a different style of trailing edge to the above method, often by trimming the wood to match the foam, then adding another wooden trailing edge etc.

HONEYCOMB WING CONSTRUCTION

As used on some Bolly kits, Honeycomb wings, when properly built are very light and strong, with lighter tip weights for improved Aerobatics performance.

Highly recommended is the use of carbon fibre spars. With the introduction of snap roll manoeuvres to the Aerobatics schedule, wing breakage’s have been all too frequent. Generally the break occurs through the retract wheel well, and will occur with or without honeycomb.



CARBON FIBRE SPARS

The use of carbon fibre spars is highly recommended for all wings which will be subjected to high loads. The below system is without doubt the easiest and most satisfactory spar method for foam wings.

Procedure:

Prepare the wing skins and foam cores in the usual manner, preparing for the C/F spars is the last procedure.

Create a suitable groove to enable the use of 12 (6 top, 6 bottom) lengths of a 12K carbon fibre filament (tow). A triangular groove is best, use a triangular file or sanding block on edge. Position this groove in a straight line at the approximate high point of both the root and tip airfoil. Do not make the groove too big.

To prepare the carbon, lay out the rovings on a sheet of plastic and brush or stipple through the rovings to ensure a thorough 'wetting out'. Place the rovings as neat and straight as possible into the groove. Holding some tension will help. It is best to reduce the carbon content progressively from root to tip, i.e. 6 strands at the root, 4 at mid span and 2 at the tip.

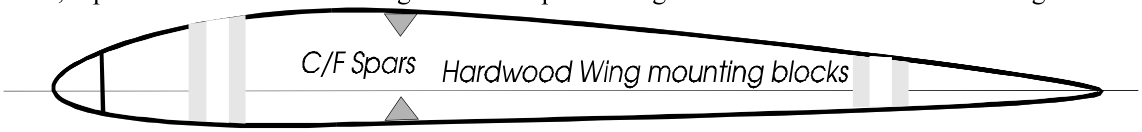
Once prepared, proceed with the wing sheeting as normal.

Please observe appropriate safety procedures when using epoxy resin and carbon fibres.

WING ATTACHMENT

The most popular way of attaching foam wings to glass fuselages is via two (2) or more nylon 1/4 x 28 bolts. These bolts go through the wing and thread into a suitable plywood plate mounted in the fuselage.

The wing must have a suitable hardwood support for the bolts, be it a plywood plate on the outside, or a hardwood dowel set through the wing, (drill or file a hole through the wing, glue in the dowel and sand flush, top and bottom. This is later 'glassed' into place along with the centre section of the wing.



With the ply or dowels in place, the wing is attached to the fuselage, then drill (13/64) through the wing and fuselage mounting plate. The wing is removed and drilled hole is drilled out to 1/4" diameter. The mounting plate is threaded using a 1/4 x 20 tap available from any hardware store (1/4 x 20 is standard 1/4" 'Whitworth' bolt thread). You may choose any other bolt size as is appropriate.

To mount the wing to the fuselage we use the following system.

Cover the centre section of the wing side adjacent to the fuselage with 'invisible' tape by Scotch.

When satisfied with the alignment of the wing (by measuring from each wing tip to a point on the fin or tailplane), carefully cyno the tape (and hence the wing) to the fuselage.

After drilling the holes, a sharp knock with your hand to the wing will release the cyno from the tape.

AILERONS & FOAM WINGS

After a foam core wing is sheeted and mounting blocks etc installed, the ailerons need to be made from the sheeted wing. (Some kits do this by adding a large trailing edge / aileron stock)

After sheeting and sanding to shape, mark out the position of the ailerons with a fine tip ink pen, top and bottom of the wing. Then mark the wing & aileron for the area to be removed and replaced by the balsa edging.

Carefully cut through the wing skins from top and bottom until all the way through. Carefully sand the edges to 'clean up' the area.

Glue the balsa facings to the edges of the aileron and wing. Sand to shape and hinge as per normal.

An alternative to the above system is to glue the balsa aileron edging into the foam core and sand flush before sheeting. After sheeting, simply mark out the ailerons (etc) and cut them out. The facings are already in place. This system has many advantages. It does need care at the initial stage.

Many kits require torque rods to actuate the ailerons. Make sure the rods are stiff enough and use a plastic sleeve as a bearing material.

Mark out the position of the tube onto the wing.

Cut through a wing skin (usually the bottom) and remove the wood and most of the foam to enable the rod to fit.

When happy with the operation of the aileron, tack glue the rod each end of the tube.

Fill the gap in with wood or a epoxy resin / Q Cells mixture and sand smooth.

Be careful not to glue the rod and sleeve together. Put a drop of oil between the rod & sleeve before bending the rod to size and when epoxying the gap, use a piece of plasticine at each end of the tube to prevent resin entry.

It must be noted that some builders find it acceptable to simply cut the ailerons from the wing and other than a light ply facing at the ends, use the wing / ailerons 'as is'. The hinging edges are not faced with wood. This system is very simple and light, but can only be used when the hinge is film or tape.

FINISHING A WING, 'GLASSING'

A fully sheeted wing can be finished in any way chosen, the most popular is the iron on plastic film, or tissue & dope followed by painting. The lightest finish is with coloured dope & tissue.

For the very best of finishes, a 'glassed' wing using a lightweight glass cloth and resin, primed and painted is the way to go, and the most work. As this method is not well known, the text below outlines the procedures for 'glassing', using .5 or .8oz glass cloth and epoxy or polyester resin.

Polyester resin has a slight advantage in speed and sanding (K&B Finishing Resin is highly recommend), but the disadvantages of higher shrinkage, attacks foam and is prone to being slightly brittle.

The Bolly General Purpose epoxy resin is the best epoxy resin for the job we have found: reliable cure, easy to apply and most importantly, easy to sand.

Note: If you choose the wrong resin, the result can be a total disaster zone. If in doubt, do a test piece.

Prepare the surface by sanding to final shape and applying thinned dope, allow 1 hour and lightly sand. The finished job can only be as good as the preparation.

Plan the method of covering, remembering it's usually not possible to cover a complete wing or tail at once, but the complete wing, etc must be completed as quickly as possible before resin shrinkage distorts the wing. This is especially important when using polyester resin. Never glass only the top or bottom of a surface without completing the other side immediately. As soon as the first side can be handled, complete the other side.

The usual procedure is to glass one panel, top and bottom, at a time, using the other side to hold the job.

Glass the top first, allowing approximately 15mm to be wrapped around the leading edge and tips. Wrapping a sharp TE is usually unsuccessful ... allow a small overhang at the trailing edge, which can be trimmed after both sides have cured. Next, the bottom is done without wrapping.

Once the first panel can be handled, cover the other side.

Allow <u>not less than 24 hours</u> before sanding, the longer the better. If the surface is mildly tacky, dust with talcum powder. Start sanding with 240 grit Aluminium Oxide sandpaper to knock off the high spots. Finish with 320 or 400 grit, unless re-coating to achieve a mirror finish, initial sanding can be 180 grit.

A satisfactory finish can be achieved by using a strong pigment for the finish, but more often the glassing is used for a base to paint. This method usually requires a second, thin ‘gloss’ coat after sanding.

<u>TIP</u>: Use an overlap method in the centre of the wing, ie, the left panel is covered with the glass overlapping to the right panel by several inches, and visa-versa. This gives a double layer in the centre for extra strength. On smaller or lightly loaded wings, this is enough ‘glassing’ to join the wing halves.

APPLYING THE RESIN / GLASS

There are many ways of applying the glass to the wing, the most common is to brush or roll on the resin. Also popular is applying the resin with a ‘credit card’ size scraper. This is not our preference as care must be used to prevent tearing of the glass grain.

A good procedure is to apply (brush) the resin reasonably heavy. We prefer to brush the resin through the cloth onto the wing. If you apply the resin first, you will tear the glass grain trying to place / pull the cloth into position.

Important: After applying the resin + cloth, the excess resin is soaking absorbed by ‘rolling on’ and patting down toilet paper (of the roll). This will soak up any excess resin. After carefully removing the toilet paper you will be left with a smooth, matt finish. Failure to soak the resin can lead to the cloth floating in an excess of resin, an uneven distribution of resin and doubles the sanding time required.

Follow this (after curing) by a good sanding and a second thin coat of resin. Alternatively finish by using a dope and talc mixture (sanding between coats). Where possible avoid second coats (just more work). This is only possible if the surface preparation and application of glass & resin has been properly done.

When done properly, glassing is not heavy. When done badly, it is as heavy as a rock. The following is an example of building a 300 square inch Flash Cat wing.

Complete doped wing before glassing	148 gm
Glassed - 1 heavy resin coating	200 gm
Wing after sanding (2 hrs)	182 gm
Wing after painting, (2 colour auto paint)	190gm

GLASSING WING CENTRE SECTIONS

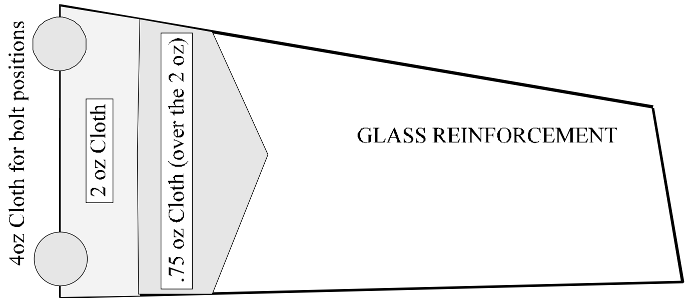
All 1 piece wings need to have the wing centre joint glassed.

Take care when joining the two (2) panels together as it is a vital operation (ie, don't set one wing at a different angle to the other). If in doubt use an incidence meter set at 50% span of both panels.

Use a slow epoxy to join the two wing panels. Sand the area smooth.

Use a light weight cloth to glass the centre, top and bottom. We suggest a layer 50 to 100mm wide, (depending on model), or cloth no heavier than 2.5oz.

We often use two staggered layers of .75 to 2oz cloth depending on the wing size. Additional cloth can be used in high stress areas such as mounting bolt locations.



Please note: The above diagram is an 'overkill' for most models, except for pylon racing models. Most models will only require less glassing than that shown.

USING EPOXY RESIN

For making foam core wings, and working with Glass fuselages, using a good epoxy resin is the key to success. Use only a thin, easy to mix resin with a good working time and a reliable cold weather cure.

The Bolly Epoxy Resin is an easy to use, reliable low viscosity (thin) resin, that is very easy to sand.

When using any epoxy resins, please do so in a well ventilated space, avoid contact with the skin and avoid breathing the vapours or the dust from sanding.

The secret to using epoxies, is to take care to apply a thin, even layer/s. Using a pigment in the resin is the best way of recognising the depth of resin being used. Almost any non oil based pigment or dye will be OK - but don't use any more than is needed to lightly tint the resin. If in doubt, do a test piece.

In cold weather it is best to pre-warm the resin by standing the bottles in a bowl of warm (not hot) water. The reverse applies in hot weather. Epoxy resin cures by chemical reaction. The speed of the reaction is dependent on heat. Too cold and it will stop, too hot and the resin will boil. A temperature of 25 degrees C is considered ideal. In hot weather mix the resin and transfer it to a shallow dish, the reverse applies in winter. Avoid using tall, narrow mixing containers as the heat buildup can cure epoxy in minutes.

Allow at least 24 hours (curing time) before using a product that has been epoxied. The longer the better. After 24 hours the epoxy is at about 96% of cure, the last 4% will take a week or more.

All resins will shrink with curing, (Polyester resin can shrink 10 times more than epoxy), for this reason never glass only one side of a flexible object, or it will be distorted by the shrinkage.

Most epoxies are hydroscopic, ie, they will absorb moisture. This generally, is only a problem in cold, wet weather. It does cause a surprising amount of curing problems. The cured surface will have a slightly tacky surface. A liberal sprinkle of talcum powder (and a lot of time in a warm environment) will usually solve the problem. It is a good idea to make a 'Hot Box' from a large cardboard carton or similar, with a low wattage globe to provide heat for use in winter.

Stored epoxy can often change to a whitish honey type consistency. Don't worry, the resin can be reverted back to normal by gentle warming; ie, place bottle in hot water, etc.

Bolly Epoxy Resin is a 2:1 mix; ie, 2 parts Resin to 1 part hardener, by volume or weight. It is highly recommended that a set of scales be purchased. Small electronic scales for about A$50 are a good investment for any modeller. Unless you have an accurate measuring system avoid mixing very small quantities. We suggest 20gms as a minimum mix.

Epoxy resin is compatible with most other resins including polyester resin. Always thoroughly sand the resin layer that you intent to epoxy over, as many resins will give rise to a wax layer to assist curing - this must be removed. Note: Polyester resin will not usually go over epoxy.

FINISHING A WING, 'TISSUE & DOPE'

Another very suitable wing finishing technique is the old fashioned tissue and dope method.

First dope the wing, followed by a light sanding to remove the 'fuzz'.

Apply the tissue with a thinned down dope, and rub the tissue into place with the thin dope. This ensures a smooth bubble and wrinkle free surface.

When dry, apply more coats of dope to seal the surface, sanding between coats. Allow to dry for several days or more before painting. The longer the surface is left to dry / cure before sanding and painting the better. Some dopes go on shrinking for a long time.

FINISHING A WING, 'PLASTIC FILMS'

For the average model, the plastic film would be the most common method of wing covering. There are many brands available, and 2 types of film.

The original 'Solarfilm' etc is a polypropylene film. This type of film has a very glossy surface and high shrinkage at a low temperature (which also means the hot Australian summer sun will affect it). It will go around curves relatively easily. It is lightweight but tears easily.

The 'other' film is polyester, i.e. 'Monokote', 'Profilm', 'Solarkote' etc. Polyester is a stronger and stiffer film compared to polypropylene, and requires more heat to apply. It also has less shrinkage and is generally regarded as easier to apply. It has an advantage of being resistant to diesel and petrol fuels. Some brands claim it can be painted.

To apply films to a fully sheeted foam wing is a different technique to open structures. Do not dope the wood, the wood must be allowed to 'breathe'.

Apply the film using the lowest heat possible, and apply by rubbing the film into place. In effect you are 'burnishing' the film into place. This technique is a disaster if the iron is hot enough to actually shrink the film. (For this reason, polyester is the preferred film). Always use a soft cloth over the iron to prevent scratching etc. Using this burnishing technique, allows for very accurate placement of different coloured panels. With care, it is possible to butt joint 2 colours for the full length of a wing.

Take care to not melt the foam, it is easily done if the iron is too hot, or if you work in 1 position for too long. A good film job is not quick or easy, and like 'glassing' takes practice to do well.

BASIC BUILDING PRINCIPLES

Building model aircraft is generally a common sense procedure. Attention to detail is important for a successful and long lived model. The first thing to do is to sit down with all of the components and plan the procedure for building. Most modellers start with the wing, as this is the core of the model, and is used to determine the correct fits and alignment of the fuselage and tail components etc.

ALIGNMENT

An incidence meter is a very handy item to check the alignment of wings, tails and thrust lines. A correctly aligned model has a good chance of success, a badly aligned model, whilst it may be flyable, is generally unpredictable and not much fun to fly. For all models except dedicated pattern type models, the wing should have at least 1 degree of positive incidence compared to the tailplane.

A common error when building models is the lack of down or right thrust. Almost all models will benefit from both. Pylon models need approximately 1 degree of both, pattern maybe as much as 3 degrees, usually 2 degrees and sports models at 1 - 2 degrees.

LIGHT & STRAIGHT

Nothing is more important to a model's performance than weight. A light weight model will fly so much better than a heavy model, and if built well, will actually be more survivable in minor accidents. Nothing survives a major crash, so don't try to build to survive one. A light model will require less engine power, will accelerate better and most importantly, will have a slower stall (snap) speed.

Building light is a state of mind. After having built several models where for every single component you think "how can this be built lighter or smarter". You will be amazed at how much weight can be saved, and you will start to build that way without thinking about it.

A straight model has at least an even chance of flying straight, the one variable being the design. A crooked model has no chance of flying straight, even if it is a perfect design. Maybe you could succeed with a crooked design and a matching crooked model …

As with building light, building straight is a state of mind. If it is warped, throw it away and start again. Not an easy state of mind for most modellers.

WING

The heart of all models. It is vital the wing be built straight. The leading edge should not be too sharp as this makes for a sensitive wing. Blunt thick trailing edges have the effect of de-sensitising the ailerons at the expense of precise feel, the opposite is so for sharp trailing edges. It is important the wing be set square to the fuselage. Measure from each tip to a point on the centre of the fuselage at the rear.

FUSELAGE

Like all components it should straight and square. Special attention should be given to the installation of the firewall and servo mountings. Make sure the engine bay is well fuel proofed and that there is a drain hole if the worst happens and the tank leaks or has a fuel tube come adrift or break etc.

If installing an engine with right thrust, take care of the alignment. If the fuselage is even in shape, from side to side, the engine will need to be offset to the left at the firewall. Some kits mount the engine square and offset the fuselage / spinner ring to the right.

TAILPLANE & ELEVATORS

The elevators must move freely and an equal amount each side (for split elevators using a Y shaped pushrod). It helps if the elevator servo is mounted to drive the pushrod down the middle of the fuselage. Y elevator pushrods are a universally disliked part of building. No one likes em, but you MUST get it done right. The elevators must be even in movement and free of slop under tension or compression.

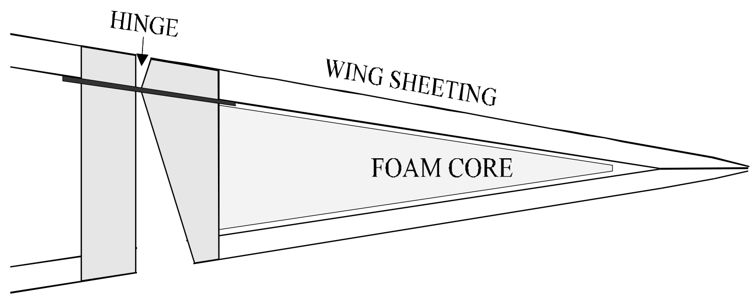
FIN & RUDDER

Where possible build a lightweight open structure. If using a tailwheel driven from the bottom of the rudder, a less easily damaged system can be fashioned by attaching the tailwheel driving arm to the rudder via a rubber band and hooks. If the wheel has a sideways knock it will not break the rudder.

HINGING THE CONTROL SURFACES

Bad hinges crash models. For models under about 10 pound weight the thin 1 piece mylar style hinge (i.e. Sig Easy Hinges) are good.

Bigger models should use a more solid style hinge. We find the Sig 'Poly Hinge' which is installed with epoxy impregnated pores to be excellent. Alternatively use conventional pin hinges or Robart's.



The above diagram is our preferred hinging method. It is very easy to determine the hinge line, as it is a constant depth from the top, just under the wing skin. Make a small template to mark the required depth. Please Note: The above hinging method can't be used on thin wings using the torque rod method of actuating the control surface.

The golden rule of hinges is to NEVER use less than 3 hinges on any surface, sometimes up to 5 will be needed. Make sure the hinges are square and are pinned. The easy way to pin, is to measure the depth of the surface, cut a pin to that length or slightly less and push in place. An advantage of the Sig Poly hinge (not to be confused with the Easy Hinge), is that the pores in the hinge trap epoxy and make for a certain bonding, and reduces or eliminates the need for pinning the hinge.

LANDING GEAR

If using mechanical retracts, it is vital that the linkages be setup correctly. Most modellers use a ball link connection on top of the servo output (wheel) arm. As the arms go through 180 degrees of rotation, the ball links can not be set exactly each side of the servo, or they will interfere with each other. For this reason the linkage should be offset by say 5 degrees. This is fine as most retracts units a fair percentage of 'locking' travel at each end.

Mounting plates in the wing for landing gear, (fixed or retract) should be supported by a chordwise sub ribs and vertical sub spar. These light / thin ply supports help spread the landing loads. When done properly it is light and very strong.

For fixed landing gear, the use of nylon bolts will help protect the mountings from tearing out in a heavy landing. The theory is the bolts will break first.

When flying from rough or lush grass flying fields, use as big a wheel size as is practical. Rearward position wheels are prone to nosing over, but if this problem can be avoided, makes for excellent landings. Forward position wheels are great for preventing nosing over, but are prone to bouncing if the landing isn't perfect. Make sure the wheels are free to rotate, and if possible have a touch of camber and toe in built into the undercarriage

ENGINE MOUNTING

Use a good alloy mount for high performance / high rpm engines, and a soft mount system for everything else, where practical.

The use of rubber type 'soft' mounts are good for noise reduction and more importantly help prevent the transmission of damaging vibrations through the airframe. Airframes and radio gear will last longer.

There are many types of 'soft' mounts available, few of which are cheap. The most common method is to mount the engine in a normal radial mount, or onto an alloy or composite plate that is mounted via the engine's backplate screws. This assembly is then to the firewall. The bigger the mounting plate the greater the spread of the load.

This type of backplate mounting system is available from Sullivan and Gator brands. We also like the 'MK' brand (and the numerous copies) beam mounts. The installation requires a horizontal ply plate into which the mount is screwed. Also popular in Pattern is the expensive 'Hyde' mount. For pattern use, it is now quite common to use a 'nose ring' soft mount in conjunction with the main soft mount system.

FUEL SYSTEM

Take care to wrap the tank with a vibration absorbing material to prevent fuel frothing (and wearing a hole in the tank). For high vibration models such as FAI pylon racers, the use of bladder tanks is almost mandatory for good fuel supply. Commercial bladder tanks are available but can be difficult to find.

Tanks should be well secured, a full 16oz tank is heavy, and combined with the G-forces a model can generate, the tank will moving unless restrained.

Fuel lines should be in good condition and not be able to kink. Use a good fuel filter, we highly recommend the Sullivan brand 'crap trap'. The fuel filling line should also use a filter.

RADIO INSTALLATION

Many a model has crashed due to bad radio installation. Attention to detail is paramount.

All linkages should be rigid and free to move, and all clevices made secure by sleeving with a short length of fuel tubing or similar. The servos should not be strained at the limit of travel.

All servo leads must be tucked away neatly so as to not foul on servo arms, pushrods etc.

The receiver MUST be well packed with sponge rubber or similar.

The battery pack should be in good condition and secured properly in sponge rubber or similar. Heavy battery packs can easily come loose and pull out the lead or snag other components. Almost all receivers and servos are made to use 6 volts (as in 4 @ 1.5 volt alkaline batteries), but most modellers use 4 @ 1.2 volt ni-cads. Using a 5 cell ni-cad pack (making 6 volts) is recommended for any model application using more than the standard 4 channels and 4 servos. Check with you r/c supplier re 6 volt suitability.

THE FIRST FLIGHT

Before the first test flight check the model for....

The C of G, Never test fly a rearward C of G model. The C of G will vary between model types. A Pattern model is usually 34-37% (of average chord). A racing model is usually 20-22% (of average chord). Most sports models are 25-30%.

No warps in the wing, tailplane or elevators. It is especially vital that elevators be warp free and that split elevators have equal movement. If split elevators have a different degree of movement or are not level in neutral, it will induce a rolling action.

Make sure all servo's are properly screwed in and the output arm screws are in place. Check that all controls operate properly, and that the hinges are secure.

Before flying make sure the engine will idle and throttle up properly. The last thing you want is a dead engine on take off or to land 'dead stick' on the maiden flight. Tune the engine for a click or so rich in case of a tank or fuel feed problem.

If possible fly with the help of another modeller, who may pick an obvious problem you have overlooked, (we have all done it). It is also safer flying with help to hold the model etc. Upon landing check that vibration has not loosed any screws, and that the tank hasn't leaked.

EXPONENTIAL

A very useful (and poorly understood) feature of modern radio transmitters is exponential. Expo (as it is commonly referred to) is the process where the servo's response to the transmitter stick is not linear. Normally 50% of stick movement equals 50% of servo rotation. Expo is the process where this can be modified to be a variable amount of servo movement. For example, it might be that the Tx stick moves 50% and the servo moves 30%. In this example, the last 50% of Tx stick throw will move the servo 70% .

The reason for expo is to desensitise the control responses. All models are more responsive to smaller throws either side of neutral, ie 5 degrees of movement from 0 to 5 degrees is more effective than moving the same 5 degrees from 20 to 25 degrees. Note: thick trailing edges help to reduce sensitivity at neutral. Further to this, pushrod movement is not linear to the degrees of servo travel, due to the circular movement of the output arm. If you don't believe or realise this, set up a servo (a long output arm is easier to test), attach a pushrod and try it.

The mathematics tell us that approximately 20% expo is needed just to make the servo output neutral. Set all transmitter expo values to 25% as standard (assuming your transmitter has this function). The improved smoothness of control response is very noticeable. Some modellers will use expo values at around 50% in the quest for smoothness. This can have it's problems, but is very smooth around centre.

BASIC MODEL TRIMMING

Once a model is built, it is vital that time be taken to correctly trim the model. All too often modellers forget the needs of the model once it is built. The difference between a good and bad model or fast and slow model is often the trim and attention to detail.

FLIGHT TESTING

Once the new model has been basically trimmed for hands off flying, the first surface to trim (and usually the one least checked by sports pilots) is the rudder.

We will assume you have control throws, rates and exponential set up as you prefer. It is best to have only enough movement to do what you require of the model, and no more. We suggest 20+ % of expo.

Fly away from yourself, wing level and into the wind. Pull too a vertical climb (reasonable sharp turn),if the model veers left or right adjust the **rudder trim** to suit. Re-trim for level flight (it may effect aileron trim) and repeat. When correct try again from inverted. It should also be vertical. If not you have an uneven wing tip weight or warped elevator. Keep adjusting until the model will go vertical from both upright and inverted.

To test for **wing tip weight**, obtain straight and level flight with correct aileron trim, then roll to inverted. If the model (when inverted) shows a need for the aileron trim to be changed, it is a good indication of a heavy wing tip. Push a large nail into the light tip and try again, and again.

One of the checks for engine **side thrust** is how the model behaves at the top of a vertical climb. After an initially straight climb the model's speed will diminish and the engine thrust will take effect. If at the top of the climb the model starts to go left or right, adjust the engine thrust line to suit.

If at the start of the climb, the model appears to roll slightly, it is often a sign of warp or uneven deflection of the **elevators**.

Pylon models are usually best with a slight right rudder bias (and right thrust). The test for this is to bank the model vertical and pull elevator to do a sharp turn, as per pylon turn. Adjust the rudder trim until the model will turn flat, (ie, no loss of height). Quite often a pylon model will turn flat to the left but dive slightly to the right. If the thrust line is correct, **turns both ways** should be flat.

Too much right rudder and the model will fly crooked ... the model may be **heading straight** but is pointing 5+ degrees off line. Such a trim is obviously wrong, and should be corrected with right thrust.

To test for **down thrust** trim, fly in straight line at 90 degrees to the wind and suddenly go to idle. The model should continue in a straight line, eventually it will loose height due to gravity. If the model dives when the power is cut, add down thrust. If the model climbs (rare), decrease down thrust.

A difficult aspect of model flying to trim is **knife edge** flight, especially as very few models except pattern aircraft do it well. Models tend to either continue to roll or roll out of knife edge and or pitch towards the top or bottom of the model. Most pilots can cope with correcting one but not both problems.

The easiest to fix is the **rolling tendency**. Roll to knife-edge and apply rudder as normal. Make sure you are not holding any extra elevator or aileron. If the model rolls back to the way it came - decrease dihedral. If the model continues to roll, increase dihedral.

To correct **pitching** towards the top of the model in knife edge, increase wing incidence, decrease tail incidence or move C of G rearward. Do the opposite if the model pitches towards the bottom of the model.

Snap rolls, many models have difficulty snap rolling. The best cure is to increase control throw or move the C of G rearward. If you have difficulty controlling a fast snap, decrease aileron and rudder throw.

The above is only a basic trim guide, quite often the correct fix is to alter the models design, ie, lower or raise tailplane or wing, angle or rudder tailpost, change fuselage areas etc.

Remember, do all tests at least twice before making a change, and for every change there will be a reduction that may also need re-trimming, ie, changing C of G will change many knife edge, thrustline and snap set-ups you have.

It is best to perform most tests in calm weather and flying the model away from the pilot.

Good models are well trimmed models, bad models are often good models badly trimmed.

BOLLY MODELS AVAILABLE

Bolly model kits are of the epoxy glass fuselage / foam core wing construction style. The fuselages are made from good quality epoxy resins, cloths, rovings and fillers. We are proud of the workmanship in our kits, and the good flying properties of the models. The **Hovering Cobra** is a Laser cut wood kit. (nya).

The kits also include some of the associated hardware such as aileron torque rods, elevator horns, wing mounting bolts, wing joiner tubes etc. (This list will vary from kit to kit depending on requirements). Basic hardware such as tanks, engine mounts, pushrods and wheels etc are not included. Some fuselages come with a moulded, integral ply front firewall, (those with a removable engine cowling)

All kits come with plans, (many of the larger models have full size plans), and instructions. The tailplanes and sometimes rudders are included in either foam or balsa as required by each model.

BOLLY KITS ..... MODEL SPECIFICATIONS

Model	Wing span inches	Wing area sq. inches	Length inches	Weight Pounds (average)	Engine	Airfoil % symmetrical / semi-sym ?	Wing loading oz / sq. ft.
SCALE & SEMI SCALE MODELS							
Laser 200	88	1280	68.75	17	45 - 65cc	15.5 % sym	30
To be announced							
To be announced							
Extra 300 S	66	848	58.25	9.5	.108 - 25cc	13% sym	25
Tucano	67	755	56	8.25	.80 - .120	14.5% sym	25
Super Chipmunk	62	670	51.5	6.5	.60 - .90	14.5% sym	22
Mustang	48	530	40.5	4.5	.40 - .46	14.5% semi	20
SPORTS MODELS							
Hovering Cobra	48.5	785	54.5	4	34 – 46	17% sym	11.8
Doo-Voo	50	530	44.5	5	.40 -.50	14.5% semi	21.5
Flash-Cat	45	320	32	2.25	electric	9.5% semi	16
AEROBATICS MODELS							
Desafio 2000-S	78	1080	78	10.6	.120 / .145	10.5% sym	22.5
Desafio S	74	935	75.5	9.2	.120	12% sym	22.3
Maestro	75	975	76	9.7	.120 / .145	12.8% sym	23
Lotus 120	73	930	74	9.4	.120	13.5% sym	23
Lotus 5	67	845	68.5	7.8	.60+ pattern	11% sym	21.25
Lotus 5 F	73	885	68.5	9	90 - .120FS	11% sym	23.5
Stylus	66	830	66	7.5	.60 pattern	13.5% sym	20.75
PYLON RACERS ..... ALL TYPES							
Stiletto	57	550	41.5	4.8	FAI .40	thin laminar	20
Mongoose	57	550	41.5	4.8	FAI .40	thin laminar	20
Python	54	550	41	4.8	FAI .40	laminar	20
Chambermaid	53	540	40	5	sport .45	laminar	21
Piel CP-80 Mk2	52	535	39.5	5	sport .45	laminar	21.5
Cobra	44	325	31.5	2.7	piped .21	laminar	19.5
QM Piel Mk2	42	320	31.5	2.8	sport .21	laminar	20
Viper Mk4	39	225	26	1.5	.10 / .11	10% semi	15.5
Tiger	37.5	210	27	1.5	.11	thin laminar	15.5
DUCTED FAN MODELS							
Scorpion	54	575	64	10.5	.90 Ramtec	11% laminar	41.5

Sports Scorpion	60	625	64	10.5	.90 Ramtec	11% laminar	38.5

AEROBATICS MODELS INFO

DESAFIO 2000-S

This model is built to the full 2 x2 model rule, and has a much larger fuselage than is normal having an attractive 'Sukhoi' look to it. This amazing model, is designed by Quique and Mario Somenzini, one of the world's best and most innovative F3A aerobatics teams.

The Desafio 2000-**S** is the latest version of a model that has been undergoing constant development. The S version has a new wing and belly pan, in conjunction with a new tail position, rudder C of G and wing incidence.

It is no secret that the early versions suffered from a bad trim problem of pitching down on rudder application. The good news is that in resolving these problems, we now have a model that flies better than the original prototype. It is a big model, and will require a powerful engine, in 2 or 4 stroke.

NOTE: There are 2 versions of this model. It can be used with both 4 and 2 stroke engines.

The standard 1 piece wing version, and

The 2 piece (plug on) wing version. Careful building is required to build below 5kg.

DESAFIO S

Without doubt one of the best F3A models ever produced, and our best selling kit for many years. Almost without exception, customers are reporting back to us as to how happy they are with the kit, and the model's performance. It is one of those classic easy to fly high scoring models.

It is a half step smaller than the 2 x 2 rule, but is very simple and easy to fly with any engine of .120 size. As new pattern rules feature more snaps, the size of the model is perfect for standard engines.

The model has been modified slightly from Quique's 4th place model at the 93 World Champs to have an enlarged and lengthened belly pan to allow for larger pipes up to 635mm operating length to the baffle, 2 stroke pipes. This can be easily extended to fit 690 mm pipes. The new Bolly MF-xxx muffler systems fit an unmodified belly pan.

MYSTERY MODEL

We are working on 2 new F3A models. Details will not be released until they are fully tested.

We will tell you they are 'conventional' 2 pce, plug on wing models.

MAESTRO

An attractive two piece (plug on) wing model designed by Chris White (Stylus designer), slightly bigger than a Desafio S.

The model was originally designed for 4 strokes. We have now made available a separate shell moulding which when installed provides room to be able to use the new Bolly MF-xxx mufflers.

LOTUS 120

A Peter Goldsmith designed 4 stroke model. Winner of the 1994 Australian Masters in an international field. This model is now outdated by those above, but still makes a very good model for everything but World Champs level of flying.

LOTUS 5

The best and last of the Goldsmith designs for .60 2 stroke Pattern , this model has become very popular, being used by many Masters class pilots in Australia.

Similar to the Lotus 120 in that it has plug on wings, optional honeycomb wing and tail and optional clear canopy. The model builds to an average weight of 8 pounds, and is best with a 'Hanno' or YS LS

LOTUS 5F

The Lotus 5 comes supplied as the F version for 4 stroke use. The wings and tailplane are a stretched (span wise) compared to the '5' version.. The fuselage is large for a 2 stroke model, large enough to fit any popular .90 or a .120 4 stroke engine (tight fit), for these engines use the extended wing and tail.

STYLUS

An attractive one piece wing model for .60 pattern designed by Chris. This model has proven to be the perfect introductory pattern model. It builds easily, to 7.5 pounds. With such clean lines it will fly well with any basic piped .60, awesome performance with a Hanno etc.

A very popular model for modellers ‘getting into’ pattern.

PYLON RACE MODELS INFO

STILETTO

A very fast FAI model based on the full size Stiletto Mustang (doesn’t have the P-51 oil cooler under the wing). Featuring a modified SD6060 airfoil, high aspect ratio wing, this model has been an outstanding success from it’s maiden flight. Best time a 1.08 with an OPS. Designed by Ian Horne.

MONGOOSE

At the time of printing the Book, this model is in pre production stages, due for release early 1998.

The Mongoose is based on the Stiletto wing and general layout (we know it works), but will feature different styling and more room for engine installation. The model will feature a fully removable belly pan for easier access to the engine and pipe. It will also enable a fully ducted cooling system to be built, which we feel will be an important development in the next few years.

PYTHON

A very practical and fast upright engine FAI model loosely based on the 1930’s Howard Pete racing aircraft. It has proven to be a delight to fly and fast. Designed by Tom Jacobsen. Best time 1.11, better to come.

It may be an ‘ugly duckling’, but it sure is a very user friendly / practical model and fast model.

CHAMBERMAID

For Sports pylon. Based on the 1930's racer. Rearward canopy, mid wing, inverted engine, fuselage mounted U/C (Bolly C/F). Best FAI race time 1.18. Designed by the Horne / Jones racing team.

The model was originally designed for FAI, but has insufficient space for a suitably large tank.

PIEL (CP80)

A Bernard McKay design of the French Homebuilt racer. It has become a popular sports pylon model and a successful 48 or 53 four stroke powered model. The model is attractive, simple and light to build. It is available in two versions, either piped or standard magic muffler exhaust. The piped version allows the pipe to be mounted close to the fuselage. Now supplied with latest airfoil wing.

COBRA

The latest QM design based on the successful Piel layout, but to minimum dimensions and has won almost every event that can be won.

This model has the well earned reputation for being exceptionally good to fly.

Side mount engine, but no cheek cowl, builds easily and light. First contest time 1.10, best time 1.04.

QM PIEL

This out dated quarter midget is of course a smaller version of the FAI model. Again it is supplied in two versions, piped and standard exhaust. Now supplied with latest airfoil wing. Best race time 1.11.

VIPER MK4

An .11 size 1/2A Pylon racer with an unsurpassed reputation and contest record, having won many major competitions .The Viper has remained competitive for nearly 10 years which is rare for a competition model. The Viper Mk4, has a larger wing using the Mk.3 airfoil and a new slimmer canopy to fit the wing correctly. This is the perfect introductory model to 1/2A pylon.

TIGER

At last, a model to outperform the Viper. This is an all new model but based on the Viper (no two components are the same). The model has been minimised to the rules and features a fully cowled engine. Despite being smaller, it is also a ‘smarter’ layout provides for much easier R/C gear and tank installation.

The model is cleaner and faster (by about 3 - 5 seconds a race faster) than a Viper, and much easier to fly. It is important to make sure the engine is well cooled within the cowling. It can be used without a cowl with minimal race time loss.

It is the fastest ‘legal’ airframe in the country. There are faster airframes around (by a small margin), but they are illegal, if one chooses to look at the rules book. Obviously contest directors can’t read.

SCALE MODELS INFO

LASER 88

An 88" Laser 200, TOC style scale aerobatics model for 35 to 65cc engines. Fuselage has a moulded in place front firewall and optional pipe / muffler tunnel. Plug on wings (optional honeycomb), glass undercarriage, wheel pants, glass or clear canopy and plan. Foam tail feathers. Weight 15 - 17 pounds.

This model has become very popular with the giant scale aerobatics contestants, using Zenoah G-62 or 3W-70 engines. The snap roll performance is regarded as the best there is.

EXTRA 300S

A very attractive model, of the single seat Extra 300S. Suitable for .120 or larger, this model can be used in the new 1996 F3A aerobatics rule as it can be built under 5Kg.

We are very proud of the design / smart engineering of this model. The model features a 2 piece wing, a moulded pipe tunnel (if required), and a large ‘top deck’ / canopy giving unsurpassed radio access + engine cowling. The flight performance is exceptional, the model has been successfully used to fly Masters class F3A at a very competitive level. Snap roll performance is impressive.

Bigger version to be available mid 1998 (but then we said that last year).

TUCANO

A semi scale model designed to have a very aerobatics performance. Similar to the PC9, but easier to build and more attractive. The model was designed for .120, 4 strokes and would be flyable on a .90 2 stroke with ease. The tricycle undercarriage can be easily converted to retracts. Flaps may also be used. The kit comes with a glass engine cowling and a clear cockpit.

SUPER CHIPMUNK

64" span semi scale for sports / scale. The fuselage has an integral glass canopy which makes for easy building and lots of radio gear space. As Super Chipmunks go, this kit is hard to beat. The model flies easily on a .60, 2 stroke or a .90, 4 stroke engine. Builds to 6.5 pounds.

MUSTANG

48" semi scale model for sports / scale or fun club racing. This model is simple as a Mustang could possibly be. Just plain good fun for a .40 /.45. Also available is a foam core ‘3rd wing’, to convert the model into a Twin Mustang.

MYSTERY FIGHTER

We have plans to produce a scale model WW2 fighter for the popular 30 to 38cc size range of engines. At this stage details will remain unavailable.

SPORTS MODELS INFO

HOVERING COBRA

The Hovering Cobra is unavailable at the time of printing this book. Quique Somenzini’s prototypes have flown, as have the 2 factory prototypes. As this is being typed, the CAD modelling of this model is being completed. Next step is to complete the Laser cut prototypes before full scale production commences.

The model is quite awesome. There is nothing of it’s type available in the world that matches it’s performance. It is called the Hovering Cobra because it is designed to do just that: hover (vertically)

FLASH CAT

45" span electric sports or pylon or slope soaring. Very attractive and easy to fly and with several innovative features. (now well copied). Easy to build and fly even with the most basic of electric motors.

DOO - VOO

A very unique jet styled model sure to turn heads at the flying field, with an exciting but stable performance to match. A well liked model by all who fly one. The name comes from the fact that it is very loosely based on the styling of a F-101 Voo Doo.

DUCTED FAN MODEL INFO

SCORPION

The Scorpion features attractive T-tail jet styling. Designed as a light, easy to build, easy to fly, fast flying sports style model based on the Ramtec fan, OS91 and Bolly DF91B pipe. Flight performance is sensational, with an easy take offs (even from grass), easy to fly and an incredibly good glide. Without doubt, this is one of the cleanest airframes in commercial production, (the glide must be seen to be believed) anywhere in the world. The very first flight through a radar trap (4th test flight) was 180 mph with an off tune engine. There have been several Scorpions using gas turbine power.

We have now introduced the **'Sport Scorpion'**, the only change being a bigger wing (and revised airfoils) for those who prefer a more sedated flying speed.

KIT COMPONENTS

Many of our kit components, especially the undercarriages have become popular accessories in their own right. Most popular are the F3A undercarriage and F3A wheel pants. With the advent of the bigger model, fixed undercarriages are more practical and less of an aerodynamic liability.

UNDERCARRIAGES ……

For use on Bolly **Laser** of similar. Has built in negative chamber to aid ground handling.

For use on the Bolly **Extra 300S** kit. As per 22.5% scale.

For use on **F3A Std** models, such as .60 through to .120 size models. (Stylus, Lotus, Desafio S etc)

For use on **F3A Large** models, such as .120 to .145 size models. (Maestro, Desafio S etc).

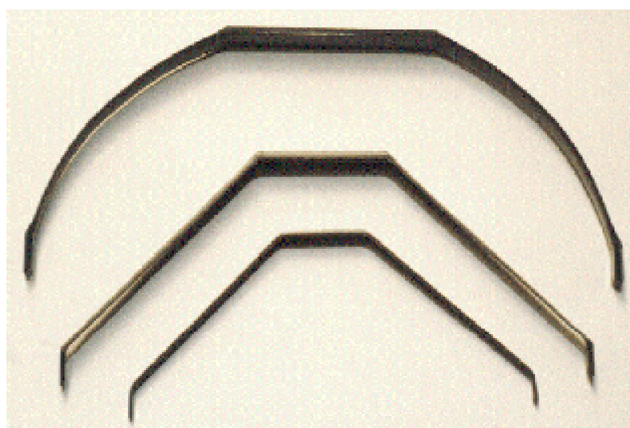
For use on the **Desafio 2000**, where a fixed gear 'Sukhoi' look is required. (part name FAI-2000).

For use on **FAI Pylon** models where the u/c mounts at the wing centre inc. (Piel, Python etc).

For use on Aussie **QM** pylon (Cobra etc), or the Bolly Chambermaid.

For FAI pylon, individually mounted u/c legs in **Titanium**. (Stiletto, Mongoose etc).

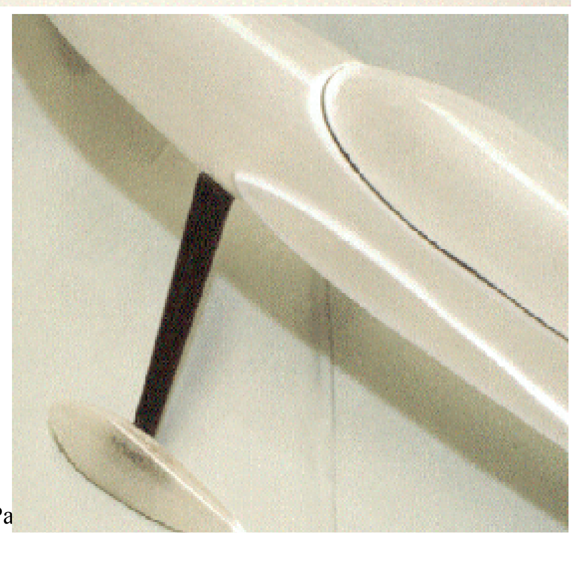
For use on **F2B** models (control line aerobatics)



Note: Most of the above undercarriages are manufactured in a combination of carbon, glass or kevlar fibres. Most are 80% carbon + 20% glass. The glass content is to 1) keep the price down and 2) improve the ability to take hard landings.

Several of the undercarriages are available in carbon only or glass only.

The Titanium undercarriages are subject to supply / availability. The are not cheap, but they are good.



GLASS FIBRE WHEEL PANT SETS ……

For Bolly **Laser** kit or similar. Designed to notch onto Bolly undercarriage to suit.

For Bolly **Extra 300S** kit. Designed to notch onto Bolly undercarriage to suit.

For fitting to Bolly **F3A – Std – Lge – 2000** undercarriages. Interchangeable with the Extra 300 u/c.

For Bolly **Super Chipmunk**. Suitable for many models this size.

PYLON RACING WHEELS …..

Low drag, integral hub style wheels for **FAI** pylon. Suitable for use on all but wire u/c legs.

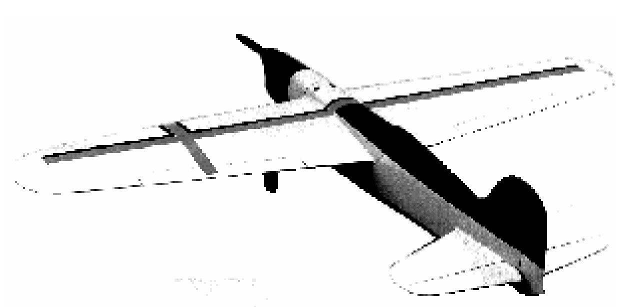
QM models, low drag design similar to the FAI wheels.

Please Note: All kit parts are available as separate spare parts. Also stocked are Gator wing tubes and other accessories such as pipe cradles, assorted soft mounts and retract units.

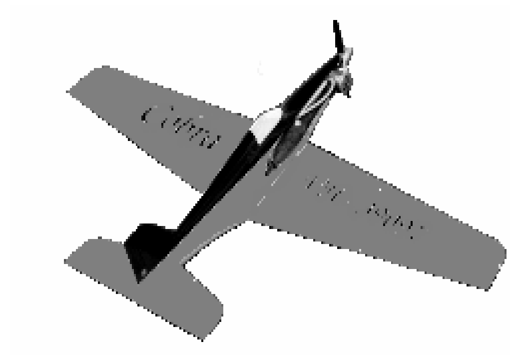
BOLLY MODEL KIT PHOTO'S

PYLON RACING MODELS

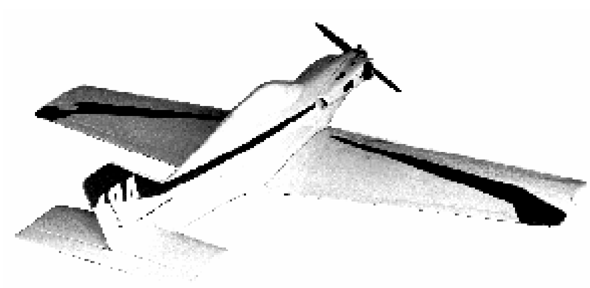
FAI Chambermaid



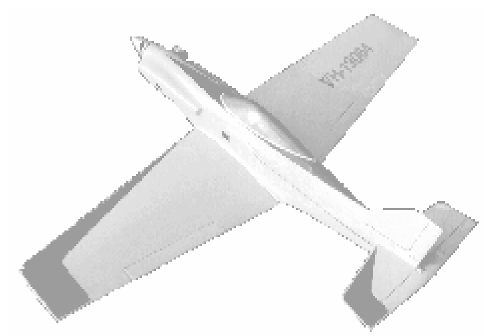
QM Cobra



Sports Piel CP-80

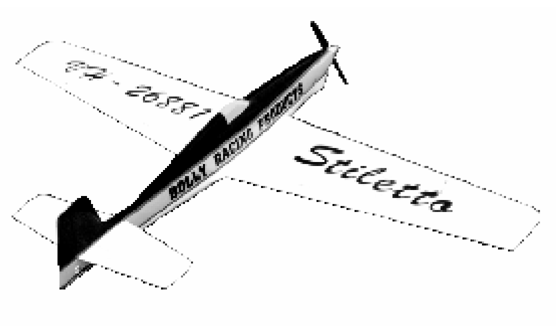


QM Piel

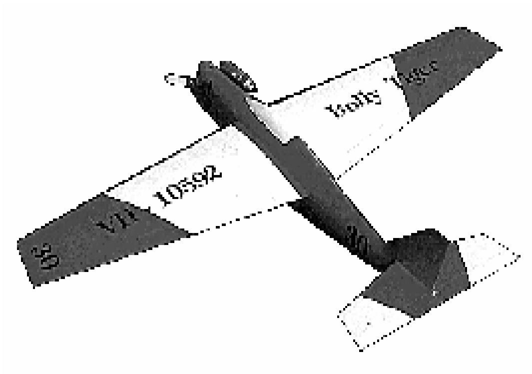


FAI Python

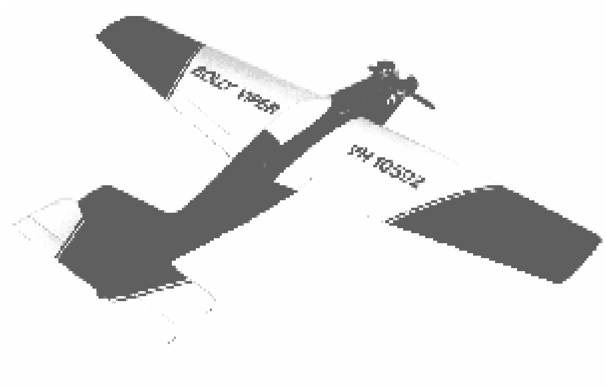
FAI Stiletto



1/2A Tiger



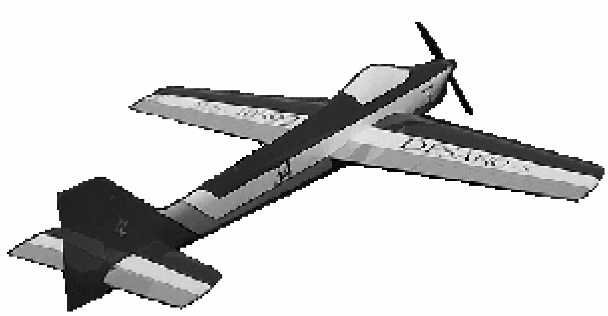
1/2A Viper (Mk 2 shown)



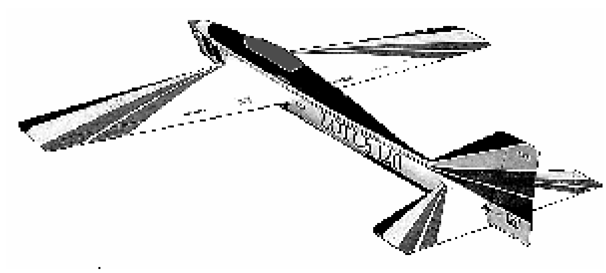
'<u>Mongoose</u>' photo unavailable at the time of printing.

F3A AEROBATICS MODELS

Desafio S



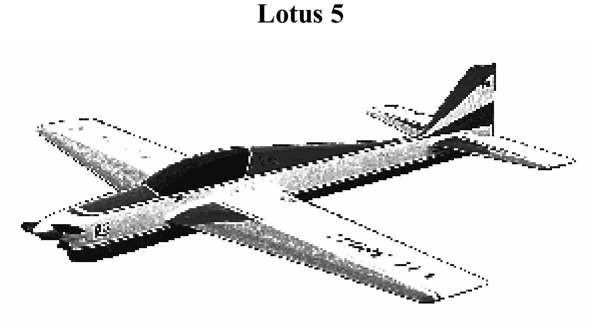
Lotus 120



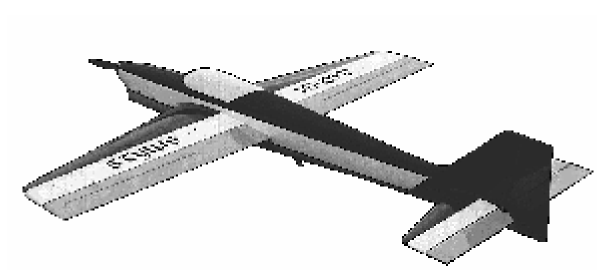
Desafio 2000-S

Maestro

Lotus 5

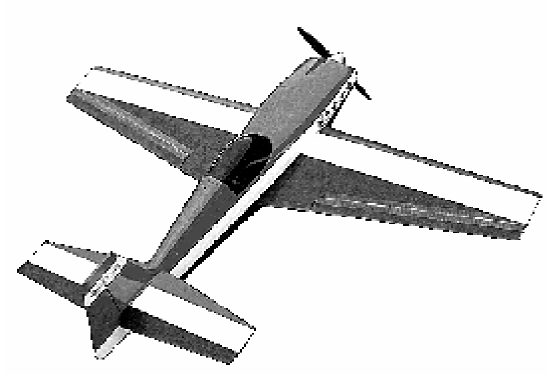


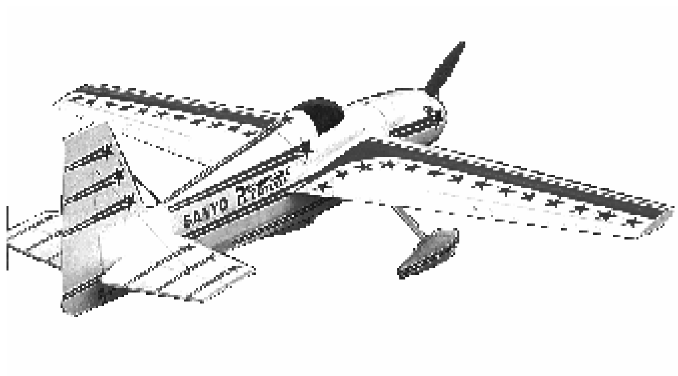
Stylus



SCALE AEROBATICS MODELS

Extra 300 S | **Laser 88**

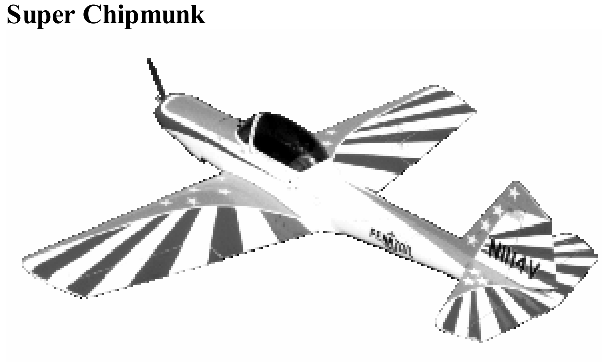




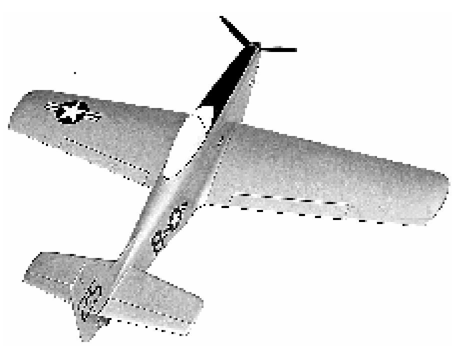
SPORTS SCALE MODELS

Tucano

Super Chipmunk



Mustang 48

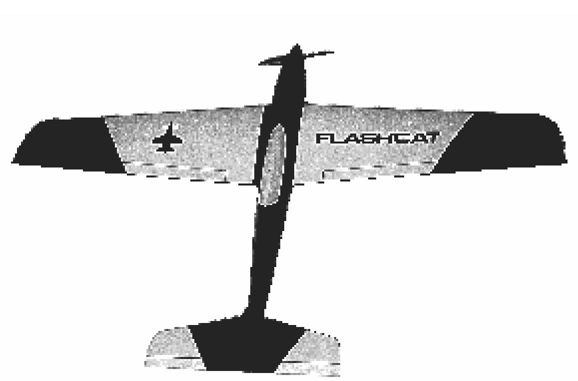


This space will eventually be filled by a WW2 model for 30cc – 38cc engines.

SPORTS MODELS

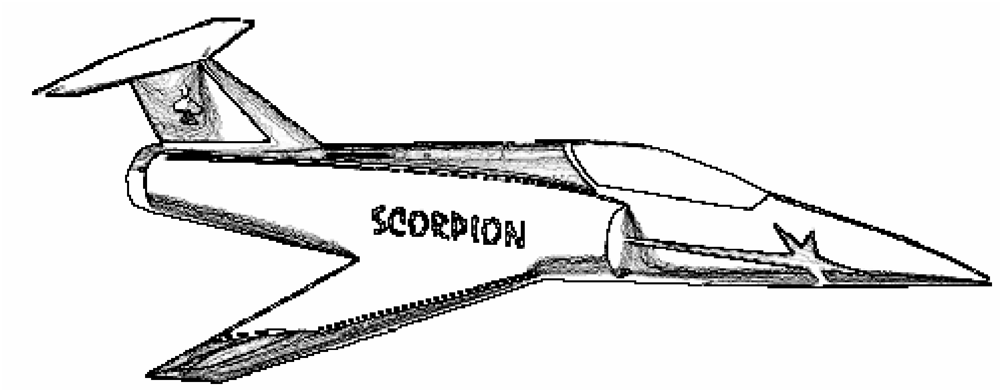
Doo-Voo

Electric Flash-Cat



DUCTED FAN AIRCRAFT

Scorpion



GRP Products, Glues & Hardware

Bolly Products are now making their top quality raw materials available to all modellers. Many of these products are a little 'different' to what is normally available. That's because many similar product ranges are sold on price alone, not the quality and usability which are our main criteria.

GENERAL PURPOSE EPOXY RESIN

An easy to use, 2 : 1 mix, low viscosity resin, with very reliable (overnight) curing and very easy to sand. Perfect for sheeting foam core wings with balsa or ply, 'glassing' wings and general building where a good quality resin is needed (i.e. firewall installation).

LAMINATING EPOXY RESIN

A very high quality resin system specifically blended to our own formula. Ideal for small castings and laminating. It is the same resin we use for our fuselage and propeller manufacture. A very tough, rigid resin system without being brittle, with good properties at elevated temperatures.

DISPOSABLE EPOXY BRUSHES

We use these by the 1,000's. With a metal handle (can be kept in thinners), and a 12mm brush stroke.

6 MINUTE, SUPER EPOXY

A very high quality version of the popular '5 minute' epoxy resins.

Combining the normal easy to use 2: 1 mixing ratio, but with a genuinely useful working time, and excellent properties when cured ... (not the normal rubber-like stuff of normal '5 minute' epoxies).

Note: At the time of printing, this product is in the development / testing stage (along with Cyno glues and Silicon Exhaust Deflectors). Expected market release, September 1996.

Q-CELLS

Similar to 'micro balloons' etc. Q-cells are very tiny hollow plastic spheres (miniature table tennis balls), which when combined with resin, makes for a perfect lightweight filler etc. The Q-Cells / GP resin combination is very easy to sand. Ideal for wing or tail fillets.

GLASS POWDER

We couldn't live without this product. It is glass fibres chopped into .8mm lengths. Combined with resin, it forms a paste, which cures to be incredibly strong. Perfect for firewall installation.

THIXOTROPIC POWDER

Used extensively in house paints (it stops the paint sliding down the wall). It is a perfect companion to Q-cells and Glass powder, to 'hold' a fillet or similar in place whilst curing..

CARBON FIBRE ROVINGS

Carbon fibre is incredibly strong for its weight, very rigid and easy to use. It can be used flat, or bundled to form a spar. Use extensively in high stress areas, ie wing spars. Using a few 'tows' top and bottom of a wing adds incredible strength for minimum weight.

GLASS FIBRE ROVINGS

Glass fibre is a much cheaper material than carbon. Use as per carbon fibres. Perfect for making your own glass fibre undercarriages, where carbon can sometimes be too rigid. This is a product normally difficult to buy in small quantities.

ARAMID (KEVLAR) ROVINGS

Aramid rovings are a very useful, but difficult to find product. 'Kevlar' is light, slightly flexible but incredibly tear resistant (and hard to cut). Perfect to use in areas where tear resistance is required, i.e. wheel pant mountings, cockpit openings & engine cowlings.

GLASS FIBRE CLOTHS

2 oz.___Perfect for making small components and 'glassing' wing centre sections. Actually 2.4oz.

.8oz___Ideal for 'glassing' wings, fuselages etc. Using the Bolly general purpose resin of course.

Note: Sold as a 2yd long x 1 yd wide packs, a much more useful size than normal.
(Cloth widths are subject to small variations)

NYLON BOLTS

All our bolts are made with a strong (but not brittle) nylon. Simply drill and tap into a ply plate, and you have the perfect attachment method for wings & undercarriages. Available in handy 2" (52mm) lengths and the best thread form of all for tapping plywood ...1/4 x 20 thread (Whitworth).

Countersunk___Perfect when a low drag attachment method is required , actually 1.75" long.

Round _______The standard bolt form used for most applications.

Hex drive______Where using an Allen key is preferred to a screwdriver.

M4 x 25mm___A small 4mm bolt perfect for cowling attachments etc.

HEADER SPRINGS

Handy, not only for ducted fan & pylon pipe attachments, but for a whole host of modelling uses.

SILICON EXHAUST TUBE

Our 'blue' cloth reinforced silicon exhaust tube has become a favourite with many modellers. Available in 5 (inside) diameters at different lengths. The longer size is usually used as an aid to extending a pipe's length, by using a spacer pushed into the middle of the tube.

10mm _______50 & 75mm lengths, for after mufflers and exhaust extensions.

13mm _______50 & 75mm lengths, for .30 to .45 size pipes etc.

16mm _______60 & 80mm lengths, for .45 to .60 size pipes etc.

19mm _______60 & 80mm lengths, for .90 to .140 size pipes etc.

22mm _______75mm only, Note: not available at the time of publishing the book.

25mm _______75mm only, for 30cc plus sized pipes.

BOLLY CLOTHING

Our stocks of cloth badges, 'polo shirts' and 'sloppy Joe's' have only got some of the smaller sizes left in stock. We have a new range of designs which are still some way from being available.

THE 'BOLLY' R/C AIRCRAFT HOBBY SHOP

As a separate section to our manufacturing section, is the Bolly R/C Aircraft Hobby Shop. The shop allows us to offer a better service to our customers, by stocking products associated to the Bolly range.

We stock a good range of products which are associated with our products, such as retracts and soft mounts. This is in addition to a 'normal' hobby shop stock.