

# X-cell

# News

The Official Newsletter For Miniature Aircraft

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## Introducing: The New Fury Tempest FAI Rotor Head!



At last, Miniature Aircraft is pleased to present our latest development, a new rotor head designed specifically for FAI style flying.

Designed by 1995 FAI World Champion pilot Cliff Hiatt, this rotor head will help bring your precision flying to a new level! Cliff has relied on his many years of competition at the international level to develop a head that improves both hovering stability and high speed maneuverability. How did we do this? See Cliff Hiatt's article



### INSIDE THIS ISSUE

- 3 New Team Pilot/Latest Products
- 4 Designing The Tempest Rotor Head

"Designing The Tempest Rotor Head" (found elsewhere in this newsletter) for his detail insights.

There are a number of key features, that will make this the most successful competition rotor head we've ever produced. Here are some of those features:

*(Continued on page 12)*

## EDITORIAL

### Greetings

In this issue, you're going to see a lot of information about the new Tempest rotor head. This is just the first product release of several, which will comprise the new Fury Tempest FAI model. Expected to be shipping in April of this year, the Tempest will be the most adjustable helicopter on the market today. Almost every aspect of the model can be changed to fit your particular flying style.

Also this month, welcome to Henry Caldwell who's joined the Pilot team. Miniature Aircraft, the Fury, and our team of expert pilots continue to dominate the US market.

For those of you interested in AMA/FAI competition, the season is about to begin. Based on the current calendar, the number of events has gone down this year. Your participation is critical to the success of those that will be held. Most clubs aren't trying to make a fortune by running a contest, but they can't afford to lose money year after year either. Support your local helicopter event or it may not be around next year.

To give you some technical insight into the design behind the new Tempest FAI rotor head, Cliff Hiatt, the primary designer, has put together his thoughts as to why it works the way it does. It also shows some comparison with the existing XCell rotor heads.

As usual, a collection of the latest products that have been released are listed in this newsletter, as well as on the new products page of our website.

In the next issue, look for the release of the Fury Tempest FAI model. It will have many new features.

Fly as often as possible and stay safe!  
Carey

## X-CELL NEWS

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3743 Silver Star Road  
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(407) 292-4267

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***Florence Schoonard – President /Owner***

***Tim Schoonard – Vice President***

***Carey Shurley – Newsletter Editor***

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## Team Pilot Intro: Henry Caldwell



Miniature Aircraft USA would like to welcome its newest Team Member, Henry Caldwell. Actually Henry joined the team late last year.

Henry has been flying some pretty radical 3D routines for some time, so many of you are familiar with his shows at various fun-flys. We caught up with Henry at Mulberry FL back in November 2002 for this picture.

He's been flying the Fury Extreme models now for several months, and has been giving them a pretty good workout. If you've watched him fly before, you'll be amazed at what he can do with these.

Hopefully in the future, Henry can sit down for a few minutes and tell us more about himself.

## Latest Products

### Pro-3 Flybar Paddles



- For FAI, Sport or Smooth 3D flying styles
- Adjustable weight paddle - using included weights
- New thicker airfoil for more smooth maneuvering
- 10% more paddle area than Pro 2 paddle
- Can be built at any weight between 38 and 55 gms. Weights are easily removable and reusable
- Threads onto flybar and is locked into place with set screws
- Can be installed on any XCell model or any helicopter with a 4mm flybar

*(Continued on page 5)*

## Designing the Tempest FAI Rotor Head

By Cliff Hiatt



One of the signatures of any model helicopter is how the rotor head performs, because that will define how the helicopter flies and ultimately its reputation. Having the opportunity to work on something like this just doesn't come along very often.

After the world championships in 2001, I was eager and determined to design a competition oriented rotor head, that would be more stable for FAI flying, and that would be more competitive with designs from other manufacturers. And its true, I also just wanted to fly something totally new so this opportunity was going to be fun! I've had a working relationship with Miniature Aircraft for many years, and some of my ideas have been incorporated into various XCell models, so I approached them about building this rotor head.

### My Background

Just to give you some idea of my background, I'm 45 years old, married with two children.

I've been a staff engineer for Lockheed Martin for many years, working on the production of various high tech military programs, so I'm familiar with the requirements of precision design and manufacturing.

From a modeling perspective, I've been flying models since 1970.

- I began flying pattern airplanes competitively in 1974 and I earned national pattern championships in 1978 and 1979 and placed 6<sup>th</sup> at F3A Team Trials in 1981, as well as placing in numerous local competitions.
- I began flying helicopters competitively in 1982 and earned national helicopter champi-

onships in 1983, 1984, 1988, and 1990.

- I've been involved in international helicopter competition since 1985, when I finished 7<sup>th</sup> at the World Championships in London Ontario Canada. In 1995, I won the F3C Helicopter World Champion in Kasaoka Japan, and later finished 5th in the World Championships in Ankara Turkey in 1997 and 6th at the F3C World Championships at Muncie IN in 2001
- I was team manager for the US Helicopter team in 1989 and I've continued to place in numerous local competitions.

### How Did I get Here?

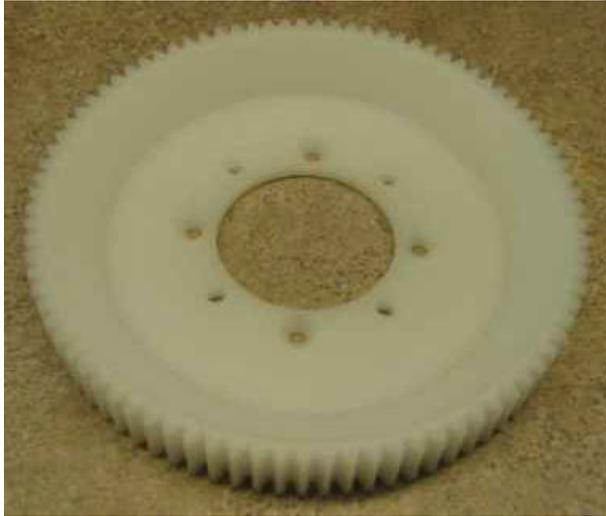
For over 6 years (including when I won the World Championships) I've used MA's original competition rotor head the Pro-2 (sometimes known as the 0840 head). It uses an under slung fly bar, and is a teeter damped head with coning angle built in separate blade axles (similar to dihedral in an airplane wing). It also uses a secondary set of mixers for increased hiller authority (the amount of influence that the fly bar has over changes in cyclic rotor blade pitch).

As much as I liked the Pro-2 head, I knew that it has some tendencies that most pilots could not come to grips with. It was difficult to get damped correctly and exhibited marked trim changes in hover depending on wind variation. I was successful with it because I flew it exclusively for uncountable gallons of fuel. But I knew that at the 2001 world championship, in Muncie, I could have been more competitive (although I'm very happy with my placing) with a more current design than the Pro-2 head, because the other manufacturers had used improved rotor head designs.

The standard XCell/Fury rotor head is great for general purpose flying. Depending on the bell mixer (bell input is the direct input from the swashplate to the rotor head) and hiller authority configurations that are chosen, it can be set up for decent precision characteristics and obviously works terrific for 3D style flying. It's a floating solid axle design that uses no coning angle on the blades. It is a very smooth flying head that holds setup well but it is at a competitive disad-

*(Continued on page 6)*

## **XCell 87 tooth Main Gear Part # 865-87**



- Fits 0865/0866 Autorotation/Constant Drive hubs
- For use with 10, 11, or 12 tooth pinion gears
- Resulting Gear Ratios -
  - 10 tooth pinion - 8.7 : 1
  - 11 tooth pinion - 7.9 : 1
  - 12 tooth pinion - 7.25 : 1
- Installation kits for various XCell models will be available soon

## **FAI Rotor Head**

*Designed by 1995 F3C World Champion - Cliff Hiatt*

### **Part #123-01 Complete Rotor Head**

Completely new style machined FAI style rotor head which features:

- Precision two piece head block
- Increased rotor head diameter - 195mm

- 5mm blade bolts
- Simple, yet very precise construction
- Full floating axle with variable damping
- Variable delta options (positive and negative)
- Variable bell mixing options (mixers now mounted on flybar cross tube)
- Increased fly bar authority without binding or use of secondary mixers
- Adjustable flybar control input - 3 positions
- Easily built and repaired
- Accepts rotor blades up to 700mm
- Can be used with any XCell model (33" tail boom required)



## **New Optional Density Damper Rings**

### **Part #'s**

**0844-7 50 durometer (1-dot)**

**0844-8 60 durometer (2-dot)**

- Available in two densities, soft (50d) and medium (60d)
- Can be used separately or in combi-

*(Continued on page 8)*

## **Rotor Head**

(Continued from page 4)

vantage for FAI flying as compared to some of the other heads on the market today in part because it offers less hiller authority than they do.

MA had started some work on a new FAI rotor head design in '01, but the introduction of the Fury consumed most of the design/manufacturing bandwidth until last year. While at the 2001 World Championships, I spent quite a bit of time looking at other competitive designs and watching their flying characteristics (you see a lot when you watch a pilot warm up in the practice box). So, armed with that enthusiasm and knowledge, I was ready to embark on designing something new.

## **What Were The Major Design Goals**

You might ask, where does one start when taking on something like this? For me, I started out by looking at the components of the existing rotor heads available from Miniature. Tim Schoonard provided me with the engineering drawings and material lists for the existing Xcell SE rotor head, which is well proven with thousands of units in use today. Some of the basic components of this, such as the lower part of the head block, didn't need to change so I was able to use them to speed up the design.

I had specific goals that needed to be met to be successful. These goals were to:

- Improve hover stability in all conditions, and to help minimize the trim change that we've seen especially in cross wind conditions
- Improve tracking of the model in forward flight, so that less inputs are needed to maintain a given flight path
- Improve the accuracy in control inputs so that the model locks into maneuvers better and requires fewer corrections

To meet these goals, two major areas needed to be addressed:

### **Overall head Damping**

I've done a lot of work to understand how damp-

ening affects the way a model helicopter flies. With the stock head, and with the Pro-2 head, where the pivot of the head is in the center of the head block, the distance between that pivot and the dampers is fairly small. This puts the blade axle at a mechanical advantage over the dampers, and you have to either use dampers that are made of a harder material or compress them significantly to try and overcome that advantage.

In either case, the damper isn't really able to work, because it only allows the axle to move a small amount before the damper itself is no longer flexible and effectively becomes hard. When the rotor blades (and as a result the blade axle) try to move around in response to inputs (wanted or unwanted), the amount of damping they incur isn't linear at all (meaning that there is only a little bit of dampened movement and then the dampers compress and get hard). This re-

*"it makes the helicopter fly more like a pattern airplane"*

duces the rotor heads ability to stabilize itself.

So I wanted to create a design that would improve the damping be as linear as possible.

### **Hiller Ratio**

The fly bar is just a big mechanical gyroscope. Just like any gyroscope, when its spinning, it resists moving. By connecting this to the rotor blades, it resists unwanted blade movements and tries to keep them stable. If the fly bar didn't have movable paddles attached, it would stabilize the rotor head to the point that it would be barely maneuverable. However, the fly bar paddles cause the fly bar to deflect with pilot inputs, which is fed directly to the rotor blades via the linkages. This helps make it maneuverable and stable at the same time.

As a gyroscope, the fly bar can be changed in several ways. The fly bar length can be changed, the size, shape, and weight of the paddles can be changed, the amount of deflection that is possible with the fly bar paddles can be changed, and finally, the amount of affect it can have on

(Continued on page 7)

## **Rotor Head**

*(Continued from page 6)*

the rotor blades can be changed by varying the hiller ratio. On almost any helicopter available today, it is very easy to change the fly bar length and the type/weight of paddles used, however the range that the amount of paddle deflection can be varied and available hiller ratios are usually inherent to a design.

## **More About the Physical Design**

To start with, this is an all-metal rotor head. To me plastic components should be used to provide a cost advantage for mass production of a basic design. They can be designed to be as strong / straight as metal, but require more work to make small changes to the design as development progresses. Of course, most people have a mental thing that says machined metal equals precision too. There was never any consideration in my mind to make / use any plastic parts in this design except for the control links and paddles.

### **Head Block/Blade Grips**

In my original design for the head block, it was similar to the Pro2 rotor head. It used a one piece head block, with two separate plates that bolted on to capture separate damper blocks. Tim and the rest of the MA design team decided that this could be made with fewer parts, and with better esthetics, so this part of the design was changed so that the entire head block consists of only two pieces, with the upper block being one precision machined piece which includes the damper blocks. The head also includes a separate head button, which is the same as was the one on the original 840 head. I did this mostly for sentimental reasons, plus it works great.

Also in my original design, I used blade grips that were similar to the grips on the Pro2 head. Tim wanted to use the metal blade grips from the 0848 XCell head because they're a proven, great design, and they look better with the streamlined head block. The only change to the grip is that the standard blade bolts are going to be 5mm. With the higher head speeds and heavy blades, the 4mm blades have sometimes bent. These won't bend!

I chose to go with a fully floating straight axle design because of its natural tendency to counteract un-intended inputs. The axle is supported on each side of the head by two "O-ring dampers. These are compressed with shims that are captured between the blade grip bearings and the dampers (This head does not use the c-clip axle design).

In the early prototypes, I tried some different schemes for limiting axle movement but no configuration actually flew better than a floating axle so in the final product, the axle normal range of motion is limited by only the damper rings and the head block itself.

### **Fly bar**

As far as the fly bar design, If you look at what designs have been tried, you will see things such as over slung fly bars, fly bars in the same plane as the blades and even moving fly bars.

- The over slung fly bar requires a more complicated control system, and more complicated parts to manufacture.
- Having the fly bar on the same plane of the blade axle limits flexibility for adjustments and makes some parts very complicated.
- I never once considered a moving fly bar.

I chose to make this an under slung fly bar design because it yields parts that are simpler to precisely manufacture, particularly the see-saw itself, and less parts count overall.

### **General Features**

An important aspect I wanted to incorporate was to make this a precision assembly that could still be repaired by the modeler.

You may recall that the Pro-2 rotor head was manufactured with very tight tolerances, but had to be returned to the manufacturer to be repaired.

The Tempest head incorporates the best of both as it is also built to very close tolerances and can easily be repaired without any unusual tools.

*(Continued on page 9)*

**Latest Products** (Continued from page 5)

nation



- Allows more fine tuning of rotor head response to fit your flying style

**New Extreme Heavy Duty Tail Rotor Hub Kit**  
**Part #120-56**



- New Stepped Axle design is much stronger

- Larger 5mm ID Lower bearings
- Retaining bolt now 3.5 mm
- Stronger design is 17% lighter than original
- Currently can ONLY be used with plastic blade grips

**New Fury Clutch Driver Assembly** Part #120-28



- New CNC machined bearing block now contains threaded 3mm frame mounts - prevents overtightened bolts from applying unwanted bearing preload
- New 7 x 10 x 19 high quality sealed bearing - retains grease and better prevents contamination - mounted with loctite and captured with 3 x 8 flat head tapered screws - torque load rating is 2 x that of original bearing
- New threaded center driver hub is made from stainless steel
- New clutch driver made from 7000 series aluminum and permanently locked onto driver hub with hollow point set screws.
- New tapered spacer washer

(Continued on page 11)

## How Were the Design Goals Met?

Damping has been improved by increasing the distance between the blade axle pivot and the damper. Overall, this head is 35mm wider. Because of this, the dampers have more leverage over the axle in all directions. This allows the dampers to be made of a softer material, and they don't need to be compressed tightly to work properly. This results in a more linear damper rate (as the blade axle moves, it incurs a similar amount of damping all the way to the mechanical stop). The result is that the rotor head is better able to stabilize itself.



Hiller input to the rotor blades has been improved in two ways.

By designing a new fly bar seesaw and new bell/hiller mixers that are installed on the fly bar seesaw. This allows increased hiller ratios without



requiring a secondary mixer, (and the associated increase in linkages, friction and etc) and it offers a more mechanically direct input path from the fly bar and the swashplate to the rotor blades. The initial design allows four different ratios of fly bar

tilt to blade movement. My design work and testing has shown that hiller ratios of less than 1:1 (degrees of movement in the fly bar seesaw as compared to degrees of movement on the blade arms) work well for FAI applications. So all of the ratios are less than that.

By increasing the space between the center of the blade axle and the pivot plane of the fly bar by 7mm, its possible to allow the fly bar paddles to be deflected further without any mechanical obstacles. As an added benefit, its no longer necessary to "droop" the fly bar control arms as is typically done now.



## Manufacturing

Once all the design was done, Tim Schoonard and the rest of Miniature Aircraft went to work on manufacturing it. Although a few small changes needed to be made for manufacturing efficiencies, the final result, is a precision rotor head, with a very low parts count.

## What Adjustments Can be Made?

The new head allows for mechanical adjustments in four ways. You can adjust:

- The axle damping ratio
- The bell / hiller mix ratio
- The amount and direction of delta correction
- Total fly bar throw

To better explain, I'll go into more detail about each of the adjustments:

### Axle damping

The damper adjustments are similar to other

*(Continued on page 10)*

## Rotor Head

(Continued from page 9)

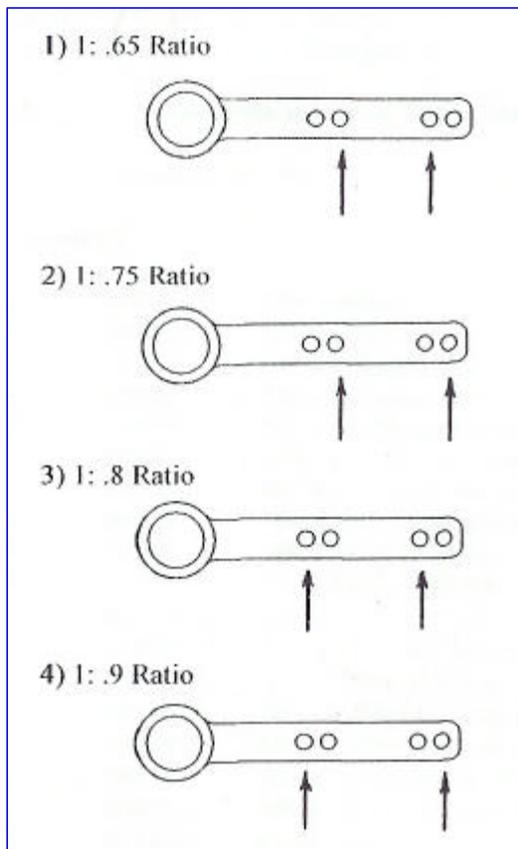
XCell rotor heads. The kits will be supplied with different durometer dampers and various shims of different thickness. By using combinations, the builder can adjust the feel of the head to their individual preferences.



One Possible damper/shim combination

## Bell/hiller mixing

Four different fly bar to blade mixing ratios are possible. 1 to .65, 1 to .75, 1 to .80 and 1 to .90.



Ball Link Location Combinations

Changing the ratios is very simple. Note that lower fly bar ratios result in increased direct con-

trol from the swashplate

## Delta Correction

The pitch arms are designed to allow for positive and negative "delta" corrections, using a combination of different length ball ends and a spacer stud. The head is designed to have a small amount of delta in the standard configuration simply due to linkage geometry.

The kit will include two settings for delta correction, +/- 3.3 mm and +/- 5.3mm. Either can be applied for positive or negative delta.

Changing from positive to negative delta can be easily be accomplished by removing one of the fly bar standoffs, flipping the seesaw over, remove the ball on the end of the blade arm, add a spacer and reinstall, and then reattaching the linkages. It's not necessary to change swashplate direction and as long as the fly bar ratio isn't also being changed at the same time, no other changes to pitch curves or servo throws are needed.



Positive Delta Correction

Negative Delta Correction

## Total Fly bar throw

There are now three different options on the fly bar control arms. Two of these are the same as previous XCell designs, plus there is an additional setting, that allows even more fly bar throw. Since the distance between the blade arms and the fly bar seesaw has been increased, there aren't any mechanical stops to deal with.

## So How Does It Fly?

It has a stable hover with less trim change from

(Continued on page 11)

## **Rotor Head**

*(Continued from page 10)*

the wind. In fact, inputs from wind gusts result more in collective reactions, which are easier to correct than cyclic wanderings.

Collective feel and response is very positive too. This hover stability holds true for both inverted and upright maneuvers, like the FAI pullover's.

For aerobatics, the best comparison I can make is that it makes the helicopter fly more like a "pattern airplane", with a very solid feel around center. Roll damping is good and loop tracking is straighter.

After coming back from the '01 World Championships, I tried many different types of rotor heads on one helicopter. From those tests, this head flies very similar to the best designs but with a slightly more "direct" feel.

My intent is that the head is designed to be a stable platform for primarily an "open" style of flying. It may be slower to respond to the pilot with the same control rates as compared to the standard Fury head though, depending on the mix ratio. Because of this, it may not allow enough direct bell input that the "extreme 3d" pilots are looking for in a rotor head for "open" 3D maneuvers.

I think that a higher hiller authority design like this can be used very effectively for smooth 3D maneuvers though.

Actually it flies even better than I had hoped. In fact it flies GREAT!

## **Conclusion**

The Tempest FAI rotor head, includes the culmination of my experiences in competing at the international level with model helicopters, and is the direct result of two years of design and hard testing.

It will make your helicopter very stable, and make precision hovering and aerobatics more fun because you can spend more time focusing on practicing maneuvers and less time on trying to counteract unwanted reactions from the helicopter.

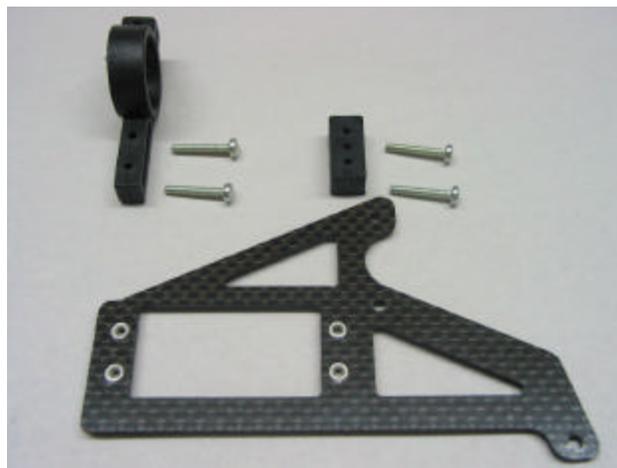
I'm sure there will be some slight improvements

over time, but I think everyone, especially the contest style pilots are going to be very pleased with how this rotor head will improve the way your helicopter flies.

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*(Latest Products Continued from page 8)*

## **Fury Rear T/R Servo Mount Part #120-65**



- Moves T/R servo to tail boom
- Eliminates intermediate pushrod and bellcrank
- Can be used for either left or right hand t/r mounting



**Tempest Rotor Head** (Continued from page 1)

- All-metal taller rotor head, with a two piece head block that includes a separate head button.
- The rotor head span is wider - 195mm
- The blade grips are a proven XCell metal design, with new 5mm blade bolts.
- Fully floating straight axle design supplied with two sets of different durometer dampers supplied and various shims of different thickness to fine tune the damping to your personal style
- Underslung flybar with new heavy duty seesaw design.
- New Bell / hiller mixers mounted directly to fly bar see-saw. Four hiller ratios are supported:
  - 1 to .65
  - 1 to .75
  - 1 to .80
  - 1 to .90.
- Stainless steel flybar control arms, now with 3 adjustments allowing increased throw.
- Adjustable delta correction – positive or negative depending on your preference

- Precision assembly. CNC machined to very tight tolerances.
- Fully Repairable by the modeler
- Fits all existing XCell models (with 33" tail boom)

And its available now! See your hobby dealer to get one for yourself!!

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Coming Soon - The New



**Miniature Aircraft USA**  
**3743 Silver Star Road**  
**Orlando, FL 32808**

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