"A LONG ROAD TO A LYNX"

In this underside view of the head the detail of the pitch linkage, lead-lag dampers and adjustable stops may all be seen. If you are trying to figure out why there isn't a swashplate you haven't read the text yet!

KEITH HARLOW gives the story so far on his totally scratch built Westland Lynx.

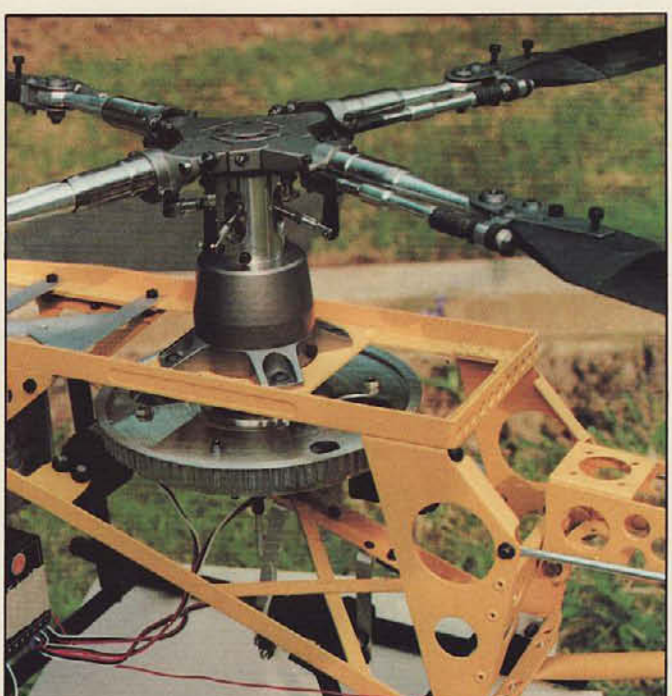
You may be interested in my attempt at making a scale model helicopter. After years of messing about with mechanical bits and bobs I thought it was about time I made myself something decent to play with.

A small helicopter seemed like the ideal thing to make. Plenty of nice, shiney, moving bits to fiddle with. I had plenty of hand tools so I just bought a small, old lathe and a few cutting tools.

First Attempts

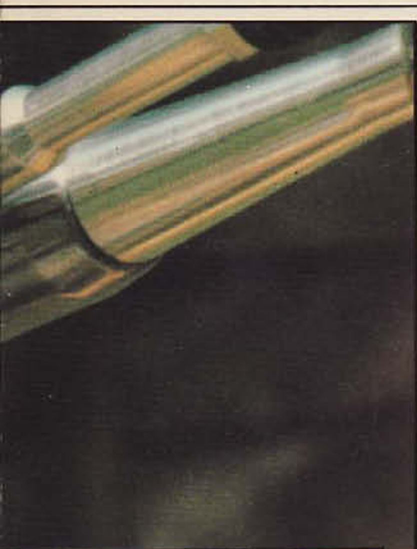
I knew nothing about models and decided that an electric powered helicopter would be best as I could use it indoors too, I read a few books bought a small electric buggy motor and some blades and started experimenting on a small test rig. I found one of these motors, gears 20:1 down, turning a 2 bladed 46 inch rotor would lift 2 ¼ lbs with the batteries I'd got.

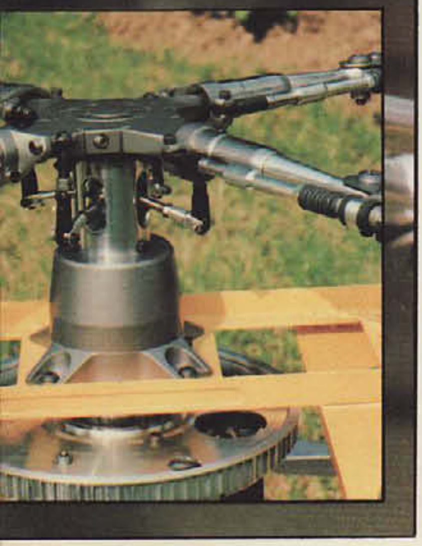
So I designed a small model around 2 of these motors and set about making it. It had sliding swashplate collective pitch and mechanical mixing for the tailrotor. Six months later came flight testing time. It weighed 3 lbs without batteries, I kept



This shot of the main body of the model shows the large combined main and autorotation clutch. Drive will be by belt to the outer rim.

The object of this exercise — in this case a Dutch Navel Lynx.





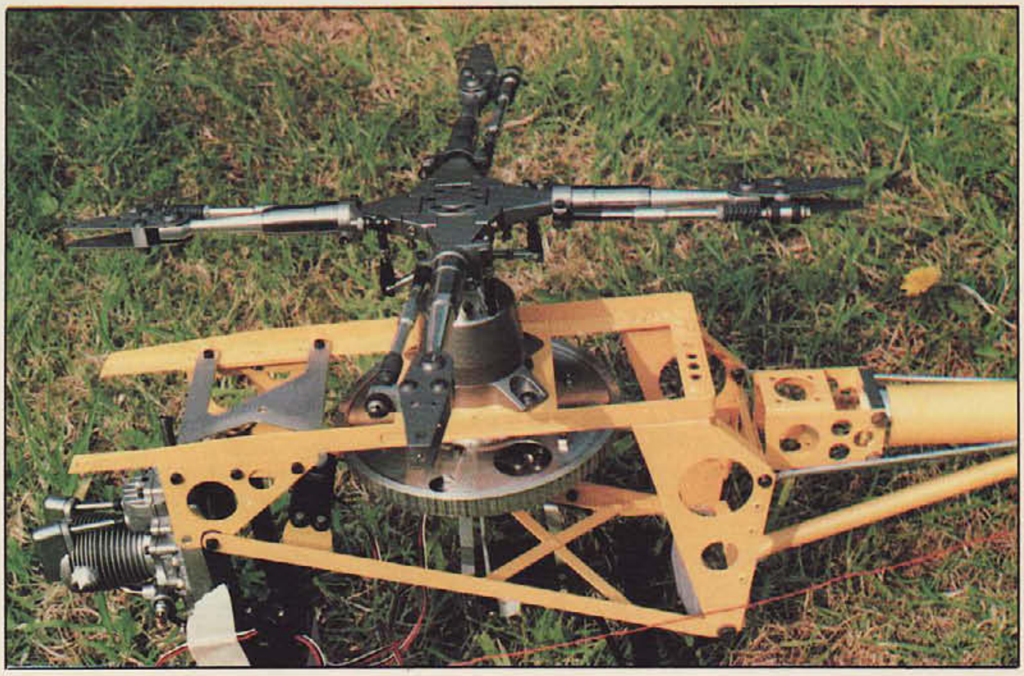
these on the floor for the moment connected by thick flexible wire. A large three foot square undercarriage made of wooden dowelling was strapped to the skids to stop it tipping over. The model was put on the garage floor and I started to build the rev's up. At about 600 rpm I slowly pushed the collective slick up and all of a sudden the model lifted, tipped sideways and smashed into the garage wall.

I thought to myself "well bless my cotton socks, its smashed to pieces", or something similar. Two weeks later the repaired version had another go, this time loosely tied to the floor. It hopped and skipped all over the place and seemed completely uncontrollable, then the motors burnt out. Subsequent trials over the following weeks ended in its maiden free flight when I threw it over as many garden fences as I could manage.

It was disapointing to say the least, but over the months I had noticed that since starting to make bits on my lathe my learning curve and consequently, the quality of my work, had risen very fast. So much so that, for example, the rotor head of this helicopter, which I thought was an excellent piece of workmanship whilst making it, seemed very amateurish 3 months later.

More detail of Keith Harlow's amazing project.

Tail rotor head is a work of art in its own right — none of your bendy plastic bits here!

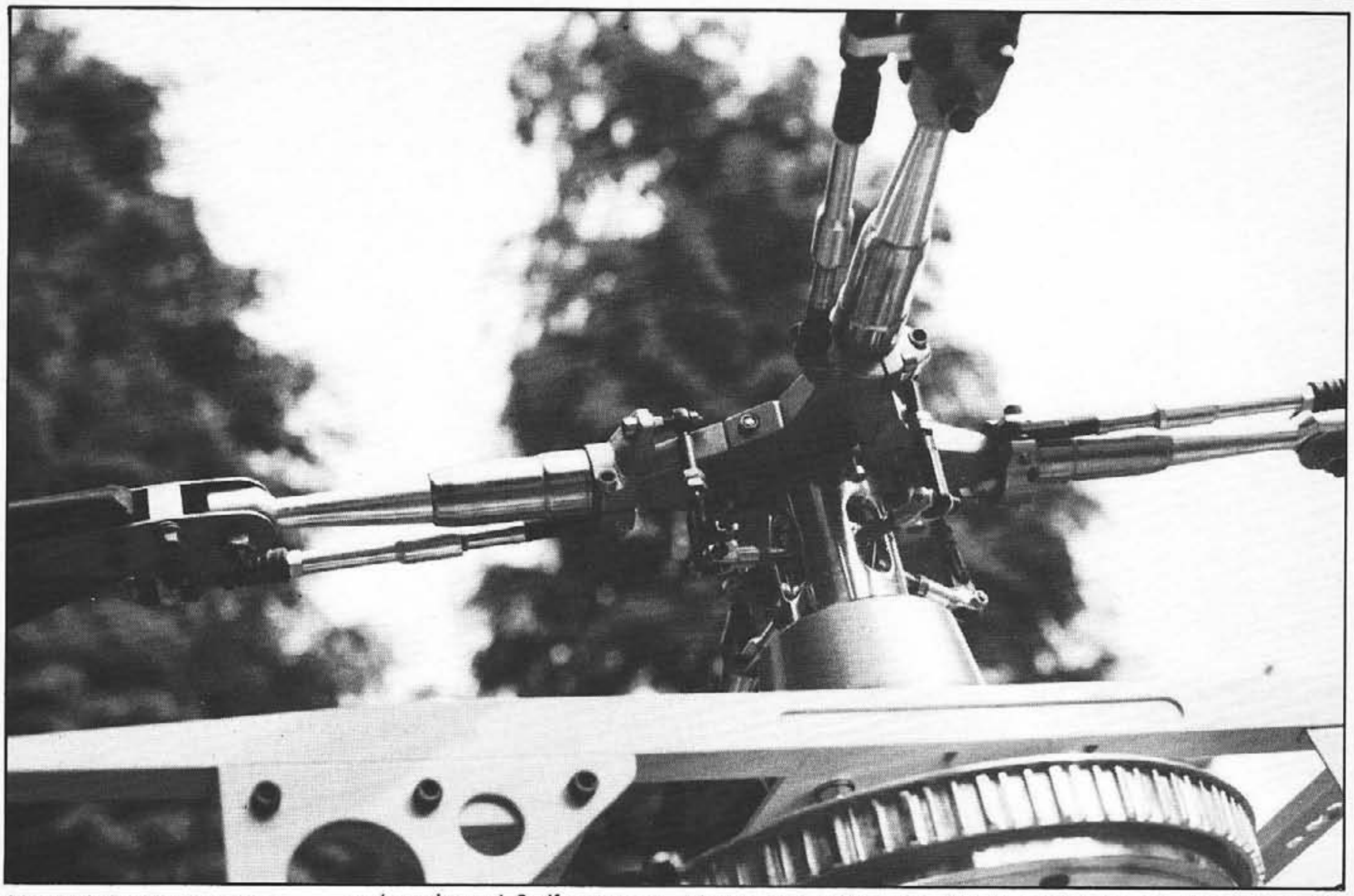


Back To The Drawing Board

I put this episode down to experience and decided on a new project. A 1/10 scale Westland Lynx with scale 4 bladed rotor head and tail rotor.

Reading helicopter books it seemed most models had 2 rotor blades and this funny pair of paddles called a flybar. To my mind this looked very peculiar, especially on top of a Sea King or similar body. My first model had no flybar, it was direct control, this is perhaps why it never

Most of the basic machine awaiting its final clothes.



Now this is what we call a rotor head. Everything works and what a finish.

flew. Getting a bit cleverer now I decided to read up a bit on helicopter aerodynamics and I put all the relevant information on my computer. For pure lift, with a 52 inch 4 blade rotor, 1.7 inch blade chord at 4° pitch I got an answer of 0.4 HP to lift 8 lbs. This power included the tail rotor but neglected bearing friction and drive belt losses, say another 25%.

Start At The Top

The first bit to make was the rotor head and shaft assembly. There is no swashplate on this model, the rotor shaft is hollow and the pitch changing is by four arms coming out of slots in the top of the shaft. These four arms are fixed to a conical head on top of an inner shaft. This inner shaft has a sliding constant velocity joint below the conical head and the outer half of this joint is fixed to the inside of the outer shaft. The constant velocity joint is similar to front wheel drive car driveshafts, pins and balls and a slotted housing. The bottom of the inner shaft sticks out below the end of the outer shaft and has a ballraced fitting, with 3 fork ends on its end. So if you were to grab hold of this fitting and spin the rotor outer shaft, then the inner shaft and hence the four arms would spin in a different plane, depending where you held the fitting. The four arms are effectively acting as the swashplate, as they can spin in a plane up to 20° from the rotor shaft in any direction and also rise and lower on the constant velocity joint, thus giving cyclic and collective pitch control.

So, assuming you're still reading. I turned, bored and milled the outer shaft from light alloy, the inner shaft is titanium alloy, as are the four arms. The bearing housing for the outer shaft is light alloy in 2 parts, turned and milled on the lathe. In fact most bits are light alloy and all the milling was done on the lathe, using a dividing head bolted to the cross slide. Fiddley little fork ends were made for the ends of the four arms.

The rotor head itself was turned and slots milled in for the four rotor arms. The arms were rough machined and pinned into the head and the whole head was then wired onto a backplate, at a coning angle of 3° and machined to a smooth upper and lower profile. The pins are the flapping hinges and adjustable droop stops are below the rotor arms.

On the ends of the rotor arms are 2 ball races in a stainless steel housing. The pitch change arm is clamped onto this housing and connected to the inner rotor shaft arms via left and right hand threaded ball links. The flapping hinges are inboard of the pitch change arm so if the blades flap up due to anything other than a control input, then the pitch of the blade is reduced and so will hopefully form a sort of aerodynamic damper, in gusts of wind.

Thinner alloy arms screw into the ends of the bearing housing and have plain bearings in their ends. These are the lag-plane bearings and offer no resistance to the lagging of the blade, as there are separate lag dampers alongside the rotor arm. There are adjustable for initial lead/lag attitude, as well as damping rate.

I have a stroboscope to do the blade tracking, firstly to set the tracking height and then from above to set the dampers so the blade axes are in line with the rotor arms. This may seem unnecessary, but the blade axes do not pass through the spinning axis, they are slightly in front in the interests of scale. I think this offset just shows up on the photos, it's only 3 mm. On most models, if not all, the rotor ams are in line, their axes therefore pass through the spinning axis. Presumably the manufacturers have positioned the root fixings and spanwise centre of gravity of the blade such that in flight the blades take up a lagwise attitude which is in line with the pitch axis. If the blades did lead or lag too much then as the blades changed pitch, cyclicly, the tips of the blades would be travelling through an arc, rather than pitching on their pitch axis. I don't know what aerodynamic effect this would have, but it must at least put an undesireable load back through the control system. Obviously (or not) the blades do alter their positions in the lag plane as they go round, unless in pure hover, due to the Coreolis effect caused by the radius of gyration of the blades changing as the blades flap up and down if a cyclic control is applied. I just thought that I would like the average position of the blade to be in line with the rotor arm.

Knitted Brows

As I say, I don't know whether anybody bothers about this as in a model the loads are relatively small. But this is the interesting bit (yawn!), with my rotor arm pitch axis being ahead of the spinning axis, this effect could be much worse. This is because, all else being equal, the apparent centre of gravity of my blade would still pull away from the spinning axis due to centrifugal force in a straight line, therefore pulling the blades forward.

I calculated the theoretical position of the blade in hover and adjusted the centre of gravity of the blade and the root fixing so that the leading effect of the C.F. and the lagging effect of the blade drag cancel each other out to give a correctly positioned blade.

The lag dampers are therefore there for 3 reasons:-

1. To damp blade oscillations in the lag plane.
2. To correct any errors in my calculations, as I've probably calculated the actual drag and centre of drag of the blade, wrong. Anyway there is not much adjustment to be had out of the blade anyway as it is nice to have the chordwise centre of gravity and centre of lift, on the pitching axis, because......, well perhaps I'd better not, this article is too long already!
3. They look nice!

Round The Back

Let's move on. The tail rotor is toothed belt drive round pulleys, up the fabricated light alloy tail, to hollow driveshaft. The tailblade pitch change linkage is not really scale, just practical, but it's made fairly close tolerance, so there is zero slop, which does away with the need for a separate driver to turn the pitch change spider. Blades are just balsa covered with film.

The pitch change linkage is probably unconventional too. I tried the inner wire, outer guide tube, push pull idea but it wouldn't bend through the tight curve at the top of the tailfin to the end of the inner pushrod and also stay within the body outline.

There is a small wing on the Lynx tail, on the opposite side to the rotor, but its not thick enough to get any bellcranks, etc. inside it. The method I used is a nylon cable which goes from the pitch change push rod, round a series of pulleys, up the inside of the tailboom and on to the servo. Obviously this means that the pitch shaft has to be spring loaded, but not very much as there is very little feedback from the tailblades at all pitches.

Engine Room

The main rotor drive is via a toothed belt from the Saito 45 4-stroke engine to a large pulley on the main rotor shaft. I decided, for various reasons, to have the clutch on the main rotor shaft too. This means that the diameter of the clutch has to be very large as it is spinning relatively slowly. The pulley has ballraces to allow it to spin freely on the main rotor shaft. Fixed to this pulley are 2 pivot arms, with weights on the end and shoes halfway along. As the pulley speeds up, the weights fly out and the shoes rub on a drum, fixed to the main shaft. There is a 2:1 increase in force from the shoes as the weights are further along the pivot arms than the shoes, but there still wasn't room in the clutch to fit steel weights which were heavy enough. I therefore made these weights out of a tungsten alloy, 2½ times as dense as steel.

It all works beautifully smoothly and also provides the autorotation freewheel, because if the engine stops, the arms come in on springs and the rotor is free to spin.

The rest is just the airframe which is rivetted together light alloy. The undercarriage is alloy and designed to collapse in a very heavy landing and hopefully save the main structure. Since the photos were taken I have built the nose section, which adds about 10 inches to its length. The ni-cads, receiver and 2 more servos will go into the nose in an attempt to counterbalance that heavy tail.

There are one or two more mechanical bits to make and then I can start on the bodyshell. The shell provides no strength and will therefore be thin plastic sheet, vaccuum formed over moulds and just stuck on to the structure. I've made most of the moulds already on days when I was fed up with working on the lathe.

If anyone is contemplating a similar project then I can't say that it has been easy, but it has been fun and so far I have managed to make everything myself in my garage with just my lathe, Black & Decker drill and stand and hand tools.

If this article generates any interest I will write again after it has flown, or not flown, as the case may be!□

CLUB PROFILE

Bath Model Helicopter Club

The club started at the end of 1983 and now has about 20 members, approximately half of whom are novice standard. Membership of the club includes automatic membership of SMAE as an added benifit. They meet on Sunday afternoons and also on Wednesday evenings in he summer and fly an assortment of models, both sport an scale. Their aim is to enjoy the sport, exchange notes and encourage newcomers who are struggling to 'get it together'.

They have meetings with other clubs in the locality including some most enjoyable hovering weekends at the invitation of the South Coast Helicopter Club.

They periodically hold friendly competitions between members which involve simple skill manoeuvres, for which small trophies are awarded. In addition to this there is a "Challenge Shield", kindly donated by Stan Wilde of the Bath Model Centre. This award is presented at each AGM to the member who is assessed by the committee to have made the best progress during the preceeding year in aquiring his (or her) flying skills.

If there are any other helinuts around the West Country who would like to make contact with them, their Secrertary is Mary Leader, her telephone number is (0272) 834443.

A small group of Bath Club members, Mary tells us that most members are camera shy. We know most of the club and we know that they have a number of experienced fliers so if you live in their area and you need to know what it's all about, give Mary a call.