

**Ken Willard and Bob Andris
present their spectacular
R/C version of
the full-scale
Rhomboid-winged
Phoenix-Warren S-31**



THE SKYCAR

Sometime in 1970, if present plans materialize, a "new" sport airplane will be test flown in England. Known now as the Phoenix-Warren S31, it is a development of a design first conceived by Norman Hall-Warren in 1926! The wing layout was patented by him in 1937, and tests have been made intermittently with free flight and wind tunnel models ever since.

The original concept was for a cabin type plane, with the engine in the rear, which was relatively easy to balance because of the shape of the wing and the location of the Center of Gravity.

You can take your pick of the ways to describe the Warren-Young wing configuration — call it a Rhomboid wing, or a tandem wing with sweptback forward wing and swept-forward rear wing — or a swept back wing with a stab that sweeps forward and meets the wing tip. No matter what you call it, you have to admit that it IS different.

My friend Bob Andris, while searching for an unusual design for RCM's design contest about a year or so ago, picked this design. However, he became embroiled in other projects and let it drop for a while. I became interested and began to rekindle Bob's interest about five months ago, and together we decided to build a radio controlled model of the Skycar.

Bob corresponded with Norman Hall-Warren, who replied and gave us all the specifications necessary to build the model, including permission to publish the design if we found it successful.

So we set about it. Bob built the wing, and I designed a fuselage which would accommodate the radio up front and the engine and fuel tank in the rear. Before getting it underway, though, I built a small glider and experimented with fin size, C.G. location, and developed what appeared to be the best combination.

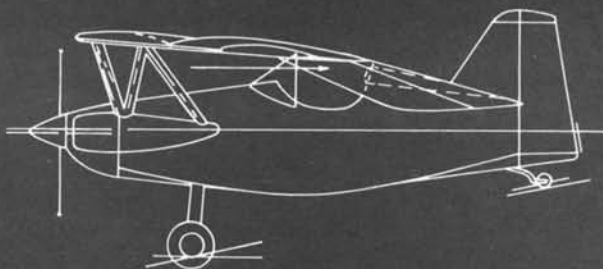
Some of the claims which the inventor of the design makes are that it won't stall, won't spin, and has great stability due to the 'scavenging' effect of the closed wingtip, where the spanwise flow outward on the forward wing is counteracted by the inward flow on the rear wing. It certainly promised to be a very interesting project.

Building the fuselage was a very straightforward job, requiring very little ingenuity, but the wing is **something else!** The twist in the rear wing requires that you make a sort of jig to block the tips so they sweep up to meet the forward wing, and the centersection has to be blocked up at the trailing edge so that you get the six degrees differential to the forward wing incidence. It takes some doing, and you have to be careful that both rear wings have the same twist from root to tip. The photos show how the setup looks.

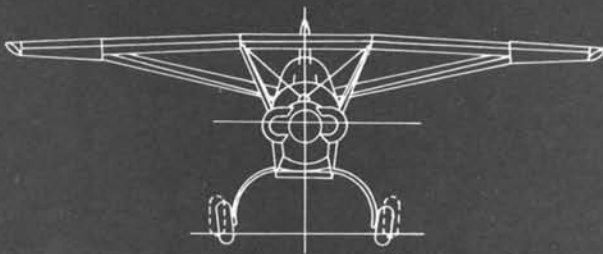
No detailed radio installation is shown on the plans, since it will depend on what type of equipment you have. In our case, we used the Kraft plastic mounting tray, which made a very simple and accessible installation. Note how the forward hatch is hinged so that it swings up for access to the switch which is mounted integrally with the servos on the tray.

The nose gear was a little tricky, until I found an old Babcock escapement rudder yoke which I soldered to the top of the nose gear wire to use as a steering arm. I found that it worked perfectly, but if you don't have one, you can make an arm, or use one of the commercially available ones. However, none of the commercially available nose gears were of the right size, so I bent my own, using Jim Sunday's handy dandy wire bender.

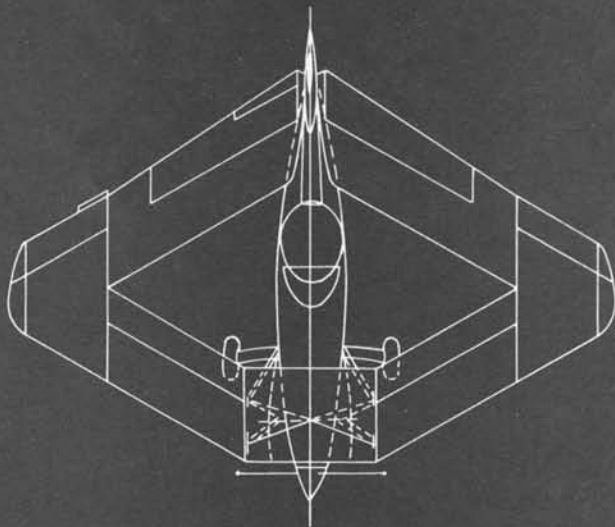
The plans show the rest of the construction in sufficient detail for the average builder, and frankly, the Skycar is not intended for building by a beginner - even though the flying qualities are amazingly gentle.



PHOENIX - WARREN S31



SPAN 17.5 FT.
LENGTH 14.0 FT.
HEIGHT 6.15 FT.
AUW 750 LBS.





Perhaps the best way to describe the flying qualities is to repeat here the flight report which I forwarded to Norman Hall-Warren at the conclusion of the flight tests. Here's the letter:

*Mr. Norman Hall-Warren, Esq.
Sea Cottage
Torcross
Kingsbridge
S. Devon, England*

Dear Mr. Hall-Warren:

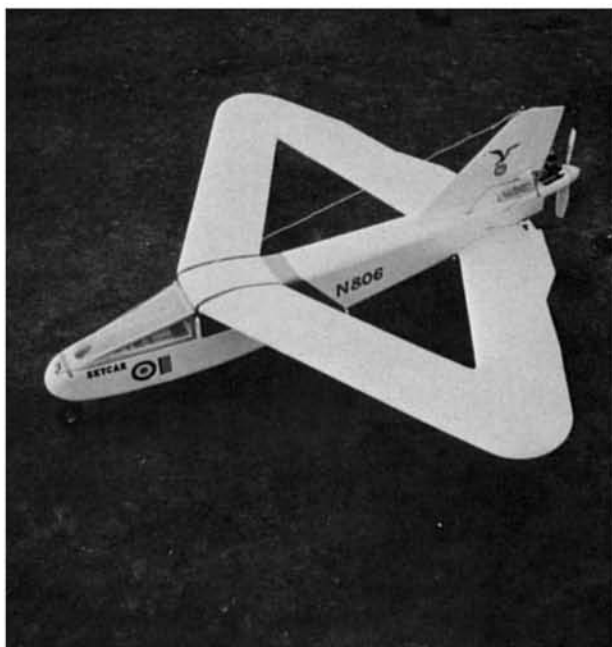
Some little time ago, in 1968, my friend Bob Andris corresponded with you concerning the Warren-Young

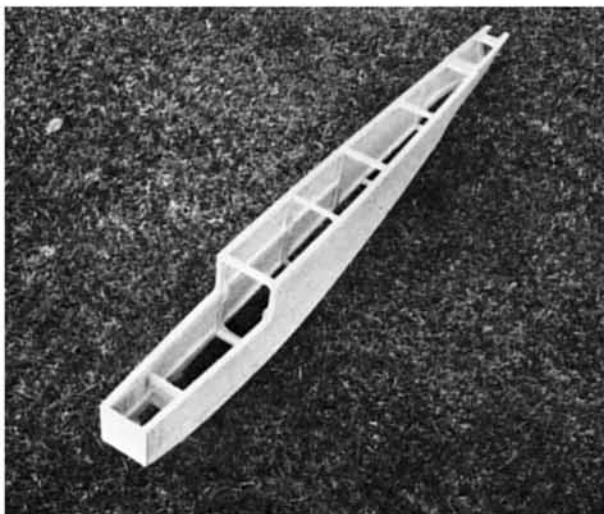
Skycar. He had planned to build it as a radio controlled model and enter it in R/C Modeler Magazine's design contest. You were kind enough to grant him permission to publish the design, and requested that the results of the flight tests be made known to you when they were completed.

As it so happened, Bob became involved in some other projects, and the design contest went on without his entry. However, he had told me about it, and also gave me copies of the articles in the various British publications, and the typewritten specifications which you had sent to him.

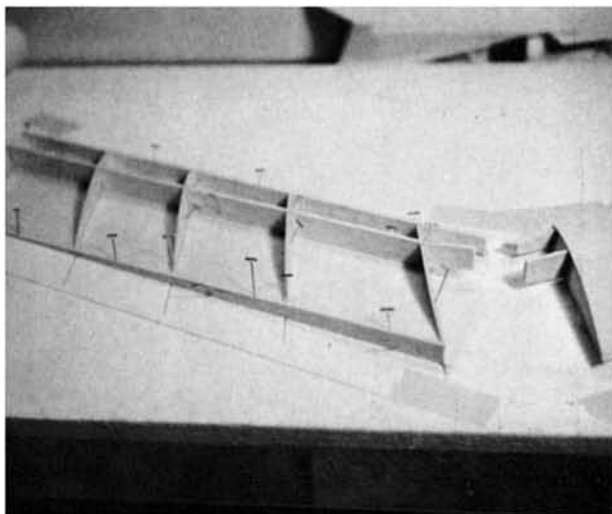
After reading them over, I was greatly intrigued, and asked Bob if he would mind if I undertook the construction of the model. Well, the more I talked with him about it, the more I rekindled his interest. The upshot of it all was that we decided to build it together; he'd build the wing, and I would design and build the fuselage. It would have to be somewhat different from your projected full scale design — with a longer nose in order to get the radio weight well forward and balance the weight of the engine and tank which would be located in the tail.

However, in the design of the

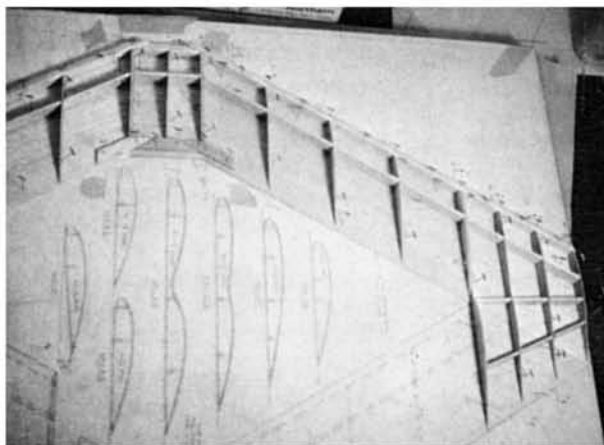




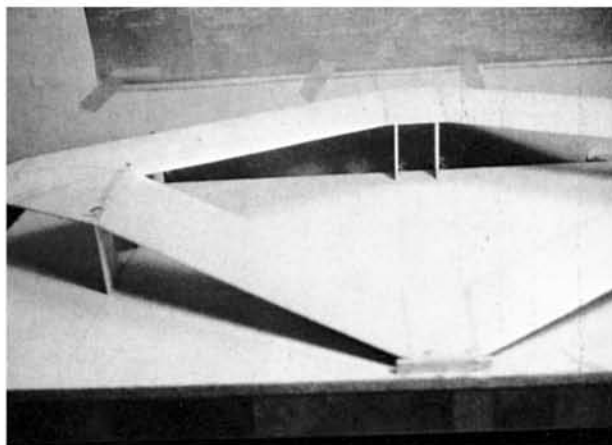
The basic fuselage construction is quite straightforward . . .



. . . but not so for the "wing"! Photo shows the first sections being constructed.



Overall "plan view" of the Rhomboid type wing that characterizes the Skycar.



The sheeted wing, jugged to hold the unusual shape.



Aft section of Skycar showing Max .10, fuel tank and rudder, elevator, and throttle linkages.



Radio installation in forward section of model. Note "V" bend in nosegear linkage to protect servo.



isosceles wing, we followed your layout specification very closely. The wing section is an NACA 4415, which is practically flat bottomed, and the sweepback of the forward wing together with the forward sweep of the rear wing is exactly in accordance with your drawings. Also, the forward wing has no dihedral, while the rear wing has the dihedral required to bring the tip up to meet the tip of the forward wing, since the root of the aft wing is below the root of the forward wing per your specifications.

We also maintained the angular settings wherein the root section of the aft wing is at an angle of 6 degrees less than the root of the forward wing — with the aft wing washing in toward the tip until it has the same angle as the forward wing.

We did make one change. You show the wing (forward) as having 7 degrees of incidence, with the aft wing at 1 degree at the root and washing in to 7 degrees at the tip to come into alignment with the tip of the forward wing. The net result, of course, is 6 degrees of decalage at the root, zero decalage at the tips, yielding, for all practical purposes, an average of 3 degrees of decalage — disregarding the spanwise flow components of which you speak in your discussions of the arrangement.

So, although we kept the angular setting of the fore and aft wings exactly as you specified, we decided that we would set the forward wing with the flat bottom right in line with the anticipated line of flight, which would

give the wing an effective angle of incidence of about 2½ degrees, and thus the root section of the aft wing would then have an angle of attack of —3½ degrees. These angles are in relation to the thrust line of the engine which was considered to be zero degrees. Our reason for doing this was that you had indicated that your free flight models, under power, tended to climb rapidly, and the more power that was applied, the steeper the climb, with the model going up in a series of gentle, oscillating swoops that, in a normal configuration, would have resulted in a series of stalls. In effect, then, we wound up with a thrust angle 4½ degrees lower than you had, with respect to the wing; in other words, comparatively speaking, we had some “downthrust” compared to your setting.

The design of the fuselage required a longer nose than your design, in order to get the weight distribution without the necessity of ballasting the nose. This longer nose put quite a bit of side area forward of the center of gravity, so the fin was enlarged to offset it. In order to determine how large the fin should be, I made a small glider model and experimented with various sizes, along with various locations of the center of gravity, until the right combination showed up. It is interesting to note that with too small a fin, the model would oscillate to one side, then to the other, but then would seem to glide almost broadside, without returning from the yawed condition, until it fell to the ground.

For simplicity, we had only rudder, elevator, and motor control. Also, as you can see from the photographs, the elevators are at the trailing edge of the aft wing, and are added surfaces rather than cutouts in the wing contour itself. Although it would be interesting to have a model with all the controls which you envision — rudder, elevators, flaps, and ailerons — we were really more interested in the basic aerodynamic characteristics of the layout.

The model has a wingspan of 38½ inches and is 37½ inches long. Chord of the wings is 5.4 inches. All up weight is 2½ pounds. Control is fully proportional, and the power is an O.S. Max .10 glow engine.

Center of gravity of the model is very slightly forward of the position shown on the drawings which you sent. I felt that this would be best from the standpoint of conservatism, and the glide test had already shown that the configuration is quite stable through a considerable range of C.G. movement. Also, at the outset of a flight, the gas tank is full and moves the C.G. back a bit anyway.

So much for the model design and its variations from your layout, which you will agree are very small. Now let's get on to the more interesting and exciting part — the flight tests.

To say I was nervous on the first flight is putting it mildly. Yet, as events turned out, my nervousness was completely unwarranted. Take-off, climbout, and leveling off were absolutely no different than with a conventional design. For the first flights, I had the controls set at minimum travel, but as I gained confidence I moved the control rod linkages to the inner holes on the control horns so that maximum control surface throw could be achieved.

In normal flight, the Skycar controls just like any other model, with one exception. As you noted in one of your articles, down elevator is “destabilizing” — it seems to be much more effective than up elevator for the same amount of travel. But, once you are aware of it, it is not dangerous. In fact, it lead to something which you may find hard to believe — but it's true. I'll get to it in a minute.

After I became thoroughly familiar with the Skycar's response to the controls, I decided to try some of the usual maneuvers before I began testing it for some of the characteristics which you had claimed it should have — no spin, no stall, full control at high

angles of attack, and steep descent at high angles of attack under full control.

First I tried a loop: Nothing to it; it looped like every other plane. Next, a roll; the first roll was pretty hairy, because I fed in too much down elevator as the model rolled past the vertical bank, but after a couple of practice rolls I became quite proficient. In fact, to most observers it appeared as though the model had ailerons, the rolls were so true. It rolled in either direction without any problem other than the necessity to be careful about feeding in the down elevator.

Next, inverted flight. This was rather difficult, since every force factor was against any stability in the inverted position, yet so long as care was taken not to let the nose come up too high in the inverted position, it could be flown around inverted. If the nose got up too high, the model would suddenly flip into upright position, and if you didn't correct immediately, the down elevator – which, in the inverted position made the nose go up – would make the model go into a steep dive. But control was positive, and recovery immediate.

Next, an outside loop. So long as ample speed was maintained, the model would do an outside loop without any trouble; if the speed dropped off, however, the model would suddenly fall off as it tried to come up the back side of the outside loop, and for a moment would be out of control. As soon as the nose got down and speed was regained, though, control would quickly return.

This gave me an idea, but I decided to put it off until I had completed making tests of the type you had expressed most interest in having performed. Again, though, it had to do with the unusual effectiveness of the down elevator.

Now it was time to perform the tests of performance at high angles of attack.

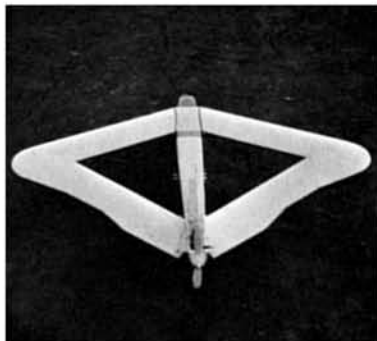
First, with the engine at full power, I gradually pulled the nose up, up, and up, until I had full up elevator applied. Holding full up elevator, the model would climb, mush, then climb some more and mush, but never did it fall off on a wing, even though I made turns in both directions. It remained under control at all times. This confirmed your claim.

Second, I tried to spin the model. No matter what I tried, I could not get it to spin, no matter how steeply I put the nose up and applied full rudder

just at the point when the model would start to mush.

Next, I tried the power descent at high angle of attack. With the power setting such that the model would descend even though full up elevator was applied, I let it sink to the ground. It was under full control at all times; however, I did note that on a couple of occasions, as it sank to the ground but in an unfavorable spot and I gave it power to go back up, momentarily, when full power was applied, the nose would drop, and then come back up. An interesting reaction, which I can't explain except that with the nose high attitude the engine thereby has an effective downthrust component, which momentarily overcomes the lift until the speed picks up.

Finally, I set the power at a speed which maintained the model at a constant altitude about thirty feet off the ground, with the elevators in the full up position, and did slow flight over the field. It "dragged the field" several



times, under complete control in each instance. To land, all that was required was to drop the power and the model would sink to the ground in the nose high attitude.

That just about concluded the flight tests. Everything that you had claimed for the design seemed to be borne out by the performance of this model. But – one thing remained. I had saved this for the last, because I had no idea what might happen.

As I previously mentioned, I confirmed the "destabilizing" effect of the down elevator control. I also noted the momentary period of uncontrollability if, when doing an outside loop, speed was not maintained coming up the back side. So – although I had also confirmed your claim that the model would not spin – at least in a normal, upright spin – I wondered if it would spin inverted.

Since all of the tests were completed, and the model had served the purpose for which it was built, I

decided to take a chance. After gaining plenty of altitude, I rolled the model over on its back, then gradually nosed it up inverted, and as it started to fall off, I applied full rudder in the same direction. The result was immediate – a tight, inverted spin. It was so fast that it startled me, and I neutralized the controls immediately. Just as immediately, the model stopped spinning, went into a dive from which recovery was normal.

So, interestingly enough, Mr. Hall-Warren, although the configuration will not spin right side up, it will spin inverted! But since the design was never intended for aerobatics in the first place, I do not consider this feature to be a drawback. It just proves what you said – down elevator, whether applied when the model is upright or inverted, is very 'destabilizing'. But recovery from this destabilizing force is fully as rapid as the displacement which results when the force is applied.

This series of tests of the Skycar was one of the most interesting projects in radio control that I have undertaken. As a by-product, the tremendous interest which the model evokes whenever I fly it is an added reward. I sincerely hope that you will be able to obtain financing for your projected full scale version, which I have every reason to believe will be very successful. Particularly, when you have the added features of flaps and ailerons, the slow speed characteristics should prove outstanding. Also, I doubt if you will have any need for some of the features which you mention, such as twin vertical surfaces, or separate horizontal stabilizer and elevators. The simpler the configuration, the easier and cheaper it will be to build, and in the configuration which I used, control is more than adequate. You'd have to see it to believe it.

We will be publishing the design in R/C Modeler Magazine in the near future, and as soon as the finished drawings are printed, I will send you a set for your files.

Considering the fact that you originated the concept in 1926, had it patented in 1937, and as late as last year were engaged in wind tunnel testing, I would say that the Skycar is a real modern 'oldtimer'. What is the saying? "The old is always new, and the new is always old."

And the Skycar is both.
Sincerely,
Ken Willard