SHINDEN

No matter which way you look at it, the *Shinden* is an awkward looking son-of-a-gun! First flights of the full-size aircraft must have been awkward for the pilot too! See text.

By COL. BOB THACKER . . .
The "Shinden" never made it as a production line fighter in WW-II; the end of the war came before the "bugs" could be worked out of the design. Leave it to the colonel to do that 40 years later!

• In WW-II, the Japanese were well aware that their continued success and high superiority with their *Zero* fighter would not continue, particularly when the P-38s and the US Navy's *Hellcats* and *Wildcats* started to achieve high kill rates in the middle of 1942 and 1943. They immediately started to design and develop the *Shinden*, which means "magic lightening." This aircraft was to be a state-of-the-art fighter to handle all of the allied and enemy interceptors, plus take on the B-29 long range, high altitude bomber they knew would be encountered over their homeland.

The initial development of the aircraft was started in 1942; a two-place, man carrying model was built to test the theories and concepts of the canard. It was to be a navy fighter, and research indicates there was a German engineer as co-designer of this extraordinary airplane. The engineer's name was Franz Pohl.

A few of the state-of-the-art features, at least for the Japanese fighters were: self-sealing fuel tanks, armor plating, four 30 mm cannon, and oxygen augmentation to the engine above 40,000 feet. The oxygen augmentation to the engine was something that US aircraft did not have until well into the American spy plane era. It was a very new and very unique feature.

The airplane had experienced only three initial test flights as of the last week of the war in August 1945. In each test flight, the duration was only ten minutes. Your author, having been in the test pilot business, assures you that a ten-minute test flight is a, "My God, let's get this thing on the ground!" The *Shinden's* problems were: excessive torque reaction because of the six-bladed propeller, the oil temperatures were running above the red line on each flight, and the pilot could not trim the aircraft to fly to the left (it could only fly to the right because of the excessive torque). Initially, the *Shinden's* canard incidence was one degree, and it took full back stick to keep the aircraft straight and level. These were just some of the problems. They never did get the gear up on any of the three test flights. Corrections were underway, but the end of hostilities stopped all work. We liberated the only *Shinden* built, and it is now in the Smithsonian Institute in Washington, D.C.

What I really achieved with this project was the satisfaction, the excitement, the thrills, and some of the tragedies of successfully completing the flight test program of the *Shinden* by radio control drone forty years after the end of the war. The excitement and some of the problems will be fully covered in the flight test program of the model itself.

I like to start my projects with the construction of the wing because it's the easiest component of the aircraft to build and it gets me going. Besides, we must have it to make the fuselage wing saddle. We decided to use foam core construction (have your foam wings cut commercially). You will see the center and tip rib patterns to be used on the plans. When you have them cut, make sure there are three degrees of washout in each wing panel to assist against tip stall. The only recommendation I can make is if you are not familiar with foam core wings and balsa covering, *RCM* magazine has a pamphlet on techniques to be used. I used an epoxy to put the skins on, and I'm not too satisfied with the results. I think a good magic tape (sticky on both sides) would work out, or you can use the conventional contact cement method. Either one would do. Make sure that your torque rods are at least 1/4-inch diameter aluminum tubing. If you use a thin wire for a torque rod, you're going to have aileron flutter. I used B&D pneumatic retracts. (B&D Company makes a very fine box that the gear sits into, and I highly recommend its use.) Make sure that you put 1/8-inch plywood reinforcements on each end of the box so that you will have a good, solid bearing for the box between the foam core and the sheeting itself.

While we're at it, let's talk wheel well door covers. In order for those wheel well doors to fit perfectly, laminate them from two sheets of 1/32 ply. Form them right over your wheel well door area before you make the cutouts. Epoxy both sheets together and tape them to the wings. When they're cured, you will have a perfect door. For the nose gear covers, use six layers of six-ounce cloth.

As long as we're talking about wings, we might as well discuss the canard, which is also a wing. (That's where you get some of your increased performance: both flying surfaces of a canard design are lifting surfaces.) The canard wing is made out of balsa. I would strongly suggest that you take your Dremel tool and make a slit all the way around the 1/2-inch balsa wood. You just tap thin plywood in the slit that you have made. (You can do it by hand . . . you don't have to make up any particular jig . . . just draw a line midway around the canard's edge with a felt pen, take your Dremel tool, free hand in the middle, and go all the way around.) Once you get the slit cut, tap your ply in, hit it with a little Hot Stuff or Zap, sand it, and you've got beautiful, hard, ding proof edges. It works like a charm! Do the same for the main wing.

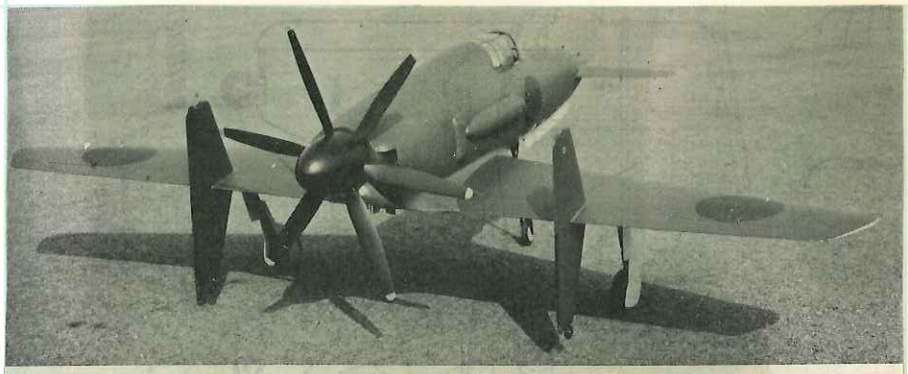
Now that wasn't too difficult, was it? You're sitting here now, with both wing surfaces ready for finishing. Next, make the rudders the same way that you made the canard.

Now we come to making the fuselage, which is really no problem to a semi-experienced model builder. There are, however, a few things I would like to discuss. This model uses normal bulkhead and planked fuselage construction. There are stringers of spruce running down the top, the bottom, and on each side. Now, when you start putting your formers in, initially lay balsa wood along the outside of the fuselage to make sure that your formers are going to allow the external contours you want. We're not saying that the bulkheads are absolutely perfect, but they are very, very close. If they are not perfect, move them up and back a little on the longerons to make them fit. If they're not going to fit exactly true after repositioning them, then bush them on the inside with a little bit of balsa. No one

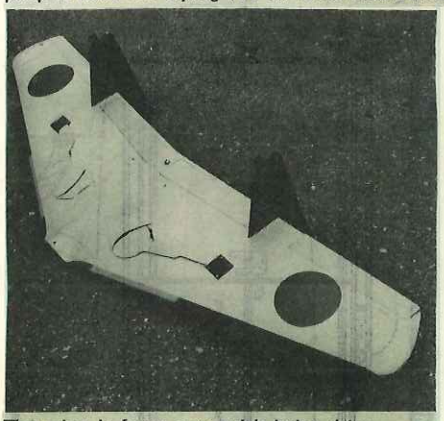
MISC. SHINDEN SPECIFICATIONS

Scale	14%
Wingspan	62 in.
Wing Area	712 sq. in.
Weight	12-1/2 lb.
Wing Loading	36 oz./sq. ft.
Wing Construction	foam & balsa
Canard Span	24 in.
Canard Area	96 sq. in.
Canard Construction	all balsa
Airfoils	9-1/2% fully sym.
Canard Incidence	+7-1/2°
Wing Incidence	+1° at root
Wing Washout	MAC 0°, TIP -3°
Balance Point	4% of wing center chord (5-1/2% with gear down)
Fuselage Length	51 in.
Fuselage Construction	built-up & planked
Engine	K&B .61 pumper
Propeller	11-7 pusher
Performance	12,800 rpm on 18%
Vertical Thrust	-4.5° (tail down force)
Horizontal Thrust	3° right (left turn force)
Guidance System	Airtronics Championship

Takeoff requires 200 paces and full up elevator.
Landing requires good air speed, power on.



The scale, six-bladed propeller is used for static display only, a normal, two-bladed pusher prop is used for flying (11-7). Note small wheels at the tips of the fins.



The wing is foam core with balsa skins. Plywood gear doors are laminated from two layers of 1/32 ply. Flaps haven't been used.

will know the difference, anyway.

Now, when you get back past the pilot's windshield, you're going to have an inside and an outside fuselage for one or two bulkheads. The aft bulkheads are put on just like you would make a shish kebab. Drill a hole that's a nice, tight fit (you can have a round hole and a square peg, and it works very, very nicely), and just put those back bulkheads on, making sure that you put an air cooling hole in the firewall where the cylinder is, because you are going to need that for cooling the engine. Your little, vertical air scoops on each side of the fuselage were functional oil coolers on the prototype airplane. The long, half cigar shaped scoops on each side of the fuselage were supercharger air ducts, and they also should have a hole in them to give you some additional air circulation inside the fuselage. The big, slanting air scoops on each side are for engine cooling, but are not functional.

When you start laying your planking on, run your strips in pairs, one per side. I built the fuselage in my lap, and you can build a nice, straight fuselage if you get your four stringers and your bulkheads initially on straight. Then just flop the fuselage from side to side as you apply your planking, and you will end up with a nice, true fuselage.

Now, we're sitting here with our fuselage completely planked, but we don't have the wing saddle made or installed. So now, trim the bottom of the fuselage away until you get the wing saddle to fit very nicely on the opening. Take the wing saddle outline that you have in the plans, glue your wing saddle on, and make your fillets. Fillets are made out of foam and are covered with fiberglass and epoxy.

The two things that we haven't covered are the two supercharger air inlets (the long, cigar shaped things). Make them out of solid balsa, hollow them out for lightness, and finish them separately; they will be glued on after you completely paint the airplane.

You can't make a canopy? Yes, you can. You don't have to have a vacuum forming device at all. Make your canopy plug. Mount it on a piece of wood. Put the wood in a vise, take your plexiglass, nail two pieces of wood on each side of the plexiglass, march right into the wife's kitchen, put your form on the sink, take your plexiglass, hold it over the electric stove until it starts to smoke and goes wiggily a little, march right over to your plug, press the plexiglass down over your form, and PRESTO! You now have a beautiful canopy! I used to insist upon finishing the plug, and having it vacuum drawn . . . that is not necessary. *And*, if you first try, and don't succeed, try again. You will make a beautiful canopy.

Make your canopy in three pieces . . . the front, the center section, and the aft section. If you try to pull it all in one piece, it will get too thin on the edges. There is no problem. If you have a problem with this technique, and you want one made for you, notify the magazine, and we will draw some for you.

Okay, you say, but how are we going to finish this thing? Use any technique that you are accustomed to, and one that has worked for you in the past. If you don't have a system, however, here is one that I have been using:

- Sand everything nice and smooth and you'll be ready to apply your 3/4 oz. fiberglass cloth with epoxy resin.
- Do not use polyester resin. This resin will shrink, and it is nowhere near as strong and as flexible as epoxy.
- Use any good two or three-hour epoxy.
- Put your 3/4 oz. cloth on all your surfaces.
- Squeegee it off with a calling card to where you can see no bright spots, and let your epoxy set up for the night.
- Sand everything nice and smooth. Use K&B primer . . . you can either use a brush or you can spray it.
- Put about three coats on, sanding lightly between each coat.

Remember, the more primer you put on, the heavier your model is going to be, and that's what we want to avoid at all costs. I was not too successful with our initial *Shinden* in this area.

You say you don't know how to get a nice matte finish with any color you want? The best part of this article, and the one thing that you should take from it, is the final color. What did I use? Before I answer that, let me ask you a question. When was the last time you ran out of A-part, B-part? When was the last time you opened your can of polyurethane that you hadn't used for six or seven months, and it was congealed? When was the last time that you couldn't get the color you wanted to paint your model, so you mixed it yourself? Then you had to repair your model and you never could get the same color again because you had forgotten what you had mixed? When was the last time you opened a can of resin, and it wouldn't pour out? You finally got so mad, you took a fire axe to it and cut the can open, and it was a congealed solid mass in there. What's the solution? You need a matte color, it must be inexpensive, and it must be readily available to you. The solution is to use plain old matte household paint. It's called Latex. You can go to your local hardware store (they have 10,000,000 different colors to choose from), and you can select the one color that matches the closest to your color swatch. Not only will the paint salesman mix it for you, it will cost you 1/60 of what the specialty paints will cost you. We got all we could possibly use for about 20 airplanes for only $10.00.

Now, here are a few precautions when using Latex paint:

1. Do not over thin it. (Incidentally, what chemical compound do you use for thinning Latex? Water. What chemical compound do you use for clean-up? Water. What cleaning fluid do you use to get it off of your clothes? Water.) Latex is water-soluble, the greatest idea since sliced bread.

2. Latex paint remains rather soft for a day or two. You need to wait seven days before you can shoot the K&B matte clear over the Latex (Latex is not fuel proof). After seven days, however, it is hard as a rock.

Now you say, "Well, how do I handle panel lines with this paint?" That's all it is . . . *paint*. Shoot a very light first coat on. Let it set for two days, and then put your panel lines on by using Chart Pack 1/64 inch tape. Shoot right on over the tape and then wait one day and peel the tape off. You will have beautiful panel lines wherever you want them. Then wait seven days for the paint to completely harden. A final coat of K&B matte clear will fuel proof everything. This is a very good technique, and you will be extremely pleased with your final paint job.

We are now finished with the final paint job, and we are sitting there waiting for our first test flight. But,

before that, we have to make some decisions. They are: where to put the CG, how to set the thrust lines, in what directions, and how much throw is required on all the flight controls. I am going to give you a little lecture on how we set up the flight dynamics for (1) the unsuccessful flights, and (2) the successful flights.

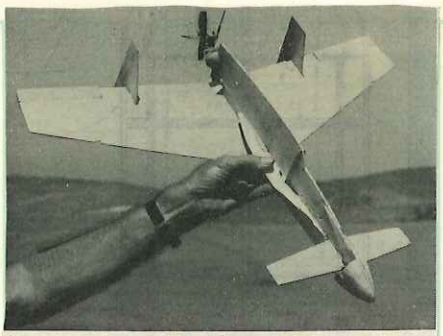
Firstly, we made a 12-inch, all balsa glider. We kept throwing this glider straight up until we got it to fall, recover, and glide. We kept moving the CG back until it became unstable. When this happened, the glider's flight became uncontrolled. We knew that we had discovered the further aft CG possible.

Next, we built an all balsa .020 free flight model. I did this, but I was fooled radically in my up and down thrust line. On the first flight of the .020, I almost got hit in the back of the head when it gave me a very tight loop. I started putting nose down thrust in it to take the loop out. That was a mistake, which I will explain later.

How do we initially get the CG set up? The following is what you should do with any canard. The front wing must carry so much of the load, and the aft wing must carry so much of the load. Because the aft wing is trailing in distrubed air from the forward canard, the aft wing is only 75% effective. Therefore, we take only 75% of the square inches of the aft wing in our formula. The canard surface has 96 square inches and the wing has 535 effective square inches. When we divide 535 into 96, we end up with 13%. Now, to use this 13% figure, we have to figure out the aerodynamic center of each wing. But how do we do that? We make a cardboard half wing and balance it in two planes 90° to each other. Where they intersect (it happens to be right where the fin is on the wing) is the mean aerodynamic chord of that wing. Twenty-five percent back from the leading edge is the aerodynamic center (AC) of that wing. Go straight over to the root chord and mark a little "X". Go up to the canard and do the same thing.

Now you have an aerodynamic center for the canard and for the main wing on the plans. Between the two ACs there will be approximately 28 inches; Take 13% of 28 inches (3.64 inches) and move this distance forward from the aerodynamic center of the main wing. This gives you the "neutral point" (NP) of the entire airplane. However, you have to have your CG further forward than your neutral point, or you will have longitudinal instability. So, take an additional 10% of your 28 inches (2.8 inches), and move this distance forward of the NP. This will be the starting point CG of your little glider and of your 020.

If you don't want to fool around with all that, use the CG shown on the plans for your *Shinden*, but *not one millimeter aft of that point.* This means that if you use the engine that I used, you will have to add approximately 2-1/2 pounds of lead shot in the nose to bring the CG to the proper location.



Balance point and incidence trials were first done with a F/F .049 powered mock-up. First flight almost took author's head off!

FIRST TEST "FLIGHT"

I had done all of our normal checks. The radio range checked OK, the engine was running properly, the idle was right . . . everything worked perfectly for the first high speed taxi test. Both model and pilot were set for the first flight. I taxied out, give it the needle, and lo and behold, I had the fastest tricycle in the world! The nose gear would not lift, the aircraft would not get light. What a dejected test pilot I was. So home I went.

I had in my possession the Japanese-English translation of the test pilot's report, and the CG was stated therein as 13% of the center chord rib. This would give us a CG of about 2-1/2 inches back of where we were carrying it. I thought, if the Japanese test pilot survived, our *Shinden* would survive.

I didn't move it back to 13%, but I did move it back to 12%. I also took one degree of nose down thrust out of the engine. Lo and behold, I did get liftoff flight with that configuration. However, the engine started to sag immediately after liftoff, and I started my downwind leg . . . but didn't make it! She went into typical aft CG uncontrolled flight and was demolished!

The aircraft was rebuilt, the CG was moved from 12% to 10%, and it was again ready for flight. It did get off in approximately 200 paces. The aircraft flew about three large circles. At about 1,000 feet, it again went into typical aft CG uncontrolled flight, and was totally destroyed.

Well, it was dejection time again, and back to square one. The aircraft was completely rebuilt, and the configuration that gave successful flight is on the plans. However, I will repeat the contributing factors here.

- An additional 4-1/2° of incidence, was put in the canard.
- The main wing structure was left alone because of the wing saddle: it is too difficult to reposition the wing.
- I went from a zero thrust line 4-1/2° tail down thrust.
- The CG was again moved forward to the position shown on the plans.

With this configuration, I did get successful flights and successful landings.

Just to make sure that we both understand what we're talking about with this thrust and incidence aspect, let's see the model down on the table, walk around behind it, look at the propeller, and look straight forward. Now let's discuss it.

The canard is sitting at 7-1/2° positive incidence. The center chord of the wing is sitting at one degree positive incidence. The mean aerodynamic chord at both fins is sitting at zero degrees incidence, and the wing tips themselves are at negative three degrees incidence. We are using a conventional counter-clockwise rotating engine with a pusher prop. With that, the torque will have the airplane turn to the right. However, because it is a pusher airplane, and we are revolving around the center of gravity, we have to point the front end of the pusher engine's crankshaft to the right. It is pointed three degrees to the right and 4-1/2° down, which gives us tail down thrust and nose up thrust. In other words, from the prototype of the real airplane, we changed the canard incidence 750% (from one degree to 7-1/2 degrees). The wing remains the same; the engine thrust we changed from one degree nose down thrust to 4-1/2° tail down thrust.

The flight control movements are as follows (remember for the canard elevator, "up" is down and "down" is up):

	Up	Down
1. Elevator	1 inch	1-1/4 inches
2. Aileron	1/4 inch	1/4 inch

Here are three things that we have learned from the *Shinden* project: (1) lightness is next to godliness; (2) don't take anyone's CG location, not even Kyushu Aircraft, Japan, for granted; (3) Latex house paint is the way to go!

I hope you are excited with canards and the canard concept, and I am sure you will have great fun with your own experimentation.

MISCELLANEOUS FACTS ABOUT THE SHINDEN

We are close to the maximum power loading ratio, so use the strongest .61 possible: a 90 would only add more weight fore and aft!

My stable of R/C gear looked like something that came over on the *Mayflower* (two six-channel Orbits, 1972 vintage). This would not do for the *Shinden*, so a search was conducted. I live within twenty minutes of four of the largest R/C companies in the world, and my decision was to go with an Airtronics system. I will only say their system is superb!! You cannot touch the sticks without servo movement, there is absolutely no slop in the gears, and you have any dual rate, exponential, or coupling arrangement imaginable available to you. Oh yes, I bought my radio, and I am more than pleased!

Flaps on the main wing panel have not been used for flight yet. They were used on a high speed run and the aircraft wheelbarrowed! The only reason the flaps are on is to get a sure 10-point option!

During your approach and landing, keep your throttle in use and your speed relatively high! Approximately 1/4 to 1/2 throttle on touchdown! Keep the final approach shallow and final flare easy!

Good luck and let me hear from you!

Colonel Bob Thacker. •