

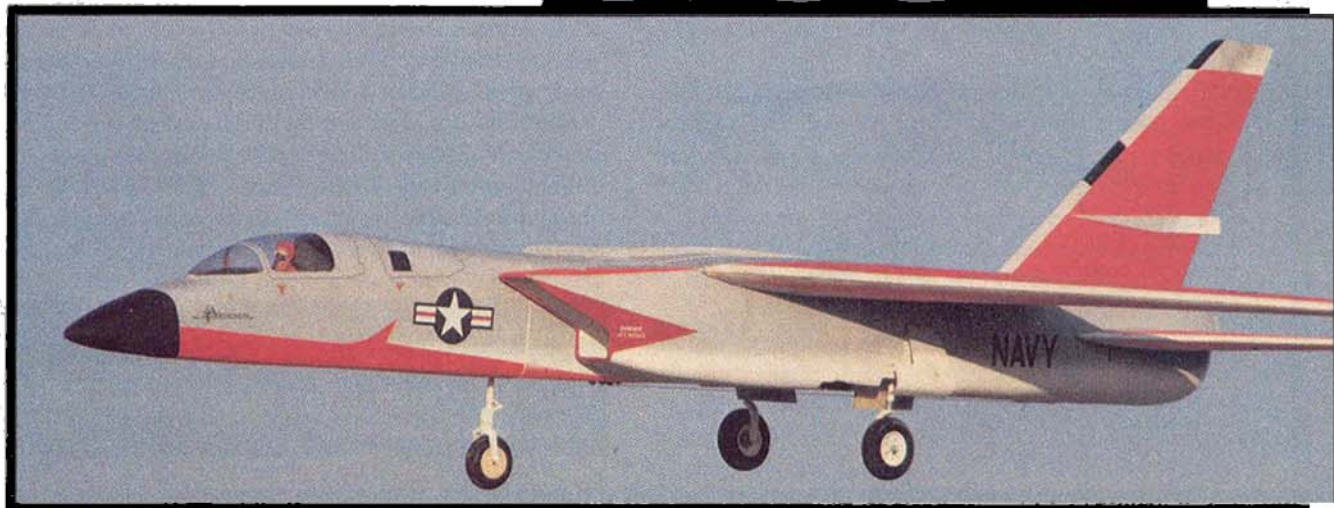


*An exciting design done in  
1/4 Scale for two ducted  
fan units. Photos by Jim  
Lipshutz, Frank Gonzales  
and Bill Kennedy*

By Mark A. Frankel

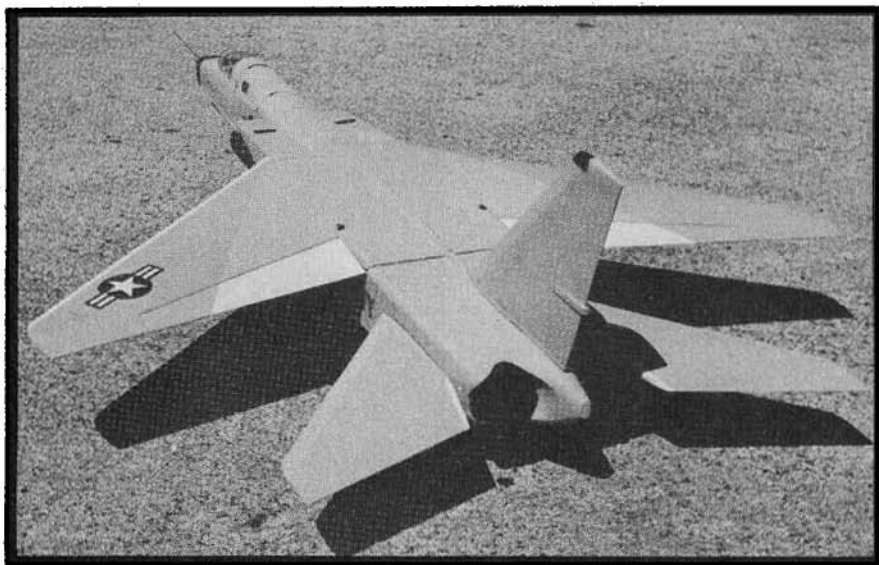


# A3J-1



## Introduction

In August of 1958, when jet technology was rapidly advancing, the Columbus Division of North American Aviation flew a prototype aircraft so sophisticated that 25 years later many of its features were just being assimilated into the current generation of fighters and bombers. The A3J Vigilante was conceived as a supersonic bomber with aircraft carrier capability. It was powered by two General Electric J79 dash 2 engines and possessed very exotic aerodynamic features. For instance, roll control was provided by a complex



### NORTH AMERICAN A3J-1 VIGILANTE

#### Designed By:

Mark A. Frankel

#### TYPE AIRCRAFT

Stand-Off Scale

Ducted Fan Jet

#### WINGSPAN

66 1/4 Inches

#### WING CHORD

Root 24"

Tip 6"

#### TOTAL WING AREA

1126 Sq. In.

#### WING LOCATION

Shoulder Wing

#### AIRFOIL

NACA 2400 Series

#### WING PLANFORM

Swept Double Taper

#### DIHEDRAL EACH TIP

0°

#### O.A. FUSELAGE LENGTH

90 1/2" (Without Nose Boom)

#### RADIO COMPARTMENT SIZE

Ample

#### STABILIZER SPAN

38 Inches

#### STABILIZER CHORD (inc. elev.)

17 1/2" Root

#### STABILIZER AREA

264 Sq. In.

#### STAB AIRFOIL SECTION

Symmetrical

#### STABILIZER LOCATION

Mid Fuselage

#### VERTICAL FIN HEIGHT

14 1/2 Inches

#### VERTICAL FIN WIDTH (inc. rud.)

15" Root

#### REC. ENGINE SIZE

(2) 7.5 ABC

#### FUEL TANK SIZE

(2) 12 Oz.

#### LANDING GEAR

Rotor Tricycle Retracts

#### REC. NO. CHANNELS

5

#### CONTROL FUNCTIONS

Stabilator, Ail., Throt.

Retracts & Nose Wheel Steering

#### BASIC MATERIALS USED

Fuselage	Balsa, Fiberglass
Wing	Balsa, Foam
Empennage	Balsa, Foam
Wt. Ready To Fly	288 Oz.
Wing Loading	36.8 Oz./Sq. Ft.

series of spoilers and deflectors on the wings coupled with differential stabilators instead of conventional ailerons. The limited lift provided by extremely thin wings was augmented at low speeds by leading edge flaps and boundary layer control which was bled from the high pressure section of the J79 compressors. Weapon delivery was accomplished by ejecting a bomb rearward through a tunnel located between the engines.

The A3J evolved into the RA-5C during the mid-1960's and served in an active reconnaissance role until the late 1970's. While the RA-5C has a certain resemblance to the early A3J's, its appearance is distinguished by a deeper fuselage profile, increased air inlets and larger wing area.

I chose the A3J as a scale ducted fan subject because of its dramatic appearance and the feasibility of modeling it in a simple balsa structure. Since I was unsure of whether a twin engine jet of this size would fly, I wanted to avoid the effort and expense of making a fiberglass structure.

While the Vigilante offers simple lines that can be modeled easily with conventional balsa techniques, there are several problems that prevent it from being a serious AMA scale subject. First, the complexity of the full size control system would be

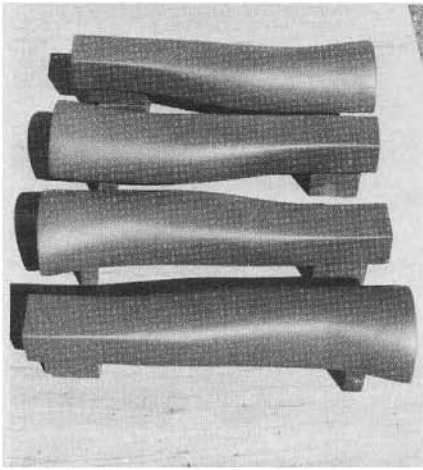
difficult, if not impossible, to model. The wing thickness had to be increased for structural reasons, and the main landing placement and retraction sequence is slightly incorrect. These deviations from true scale limit the model to a stand-off or sport scale role.

While the airframe is "traditional balsa" for the most part, there is also some fiberglass molding. The air inlet ducts describe a very shallow S-curve and their cross section changes from rectangular at the entrance to circular at the fan face. This shape can only be achieved in fiberglass. Therefore, before starting the Vigilante, the builder should feel confident with fiberglass lay-up techniques. Furthermore, vacuum forming is used to mold the canopies, and foam core cutting is required on the flying surfaces.

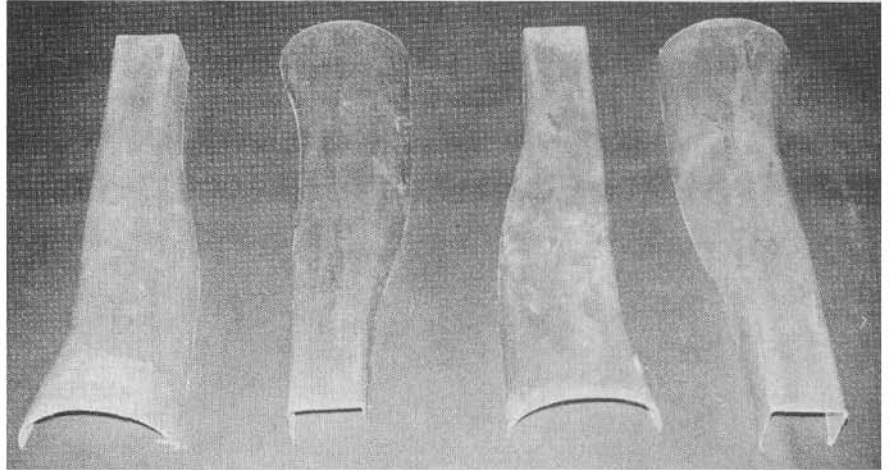
In terms of flying ability, the Vigilante should be preceded by some jet experience with models such as the Jet Hangar or Byron series of ducted fan fighters. Twin engine experience is not essential since the Vigilante's centerline thrust is identical to flying a single engine model.

There are several materials called for on the plans that are not available through normal hobby channels. These include low viscosity epoxy and cloth for the fiberglass lay-ups, and

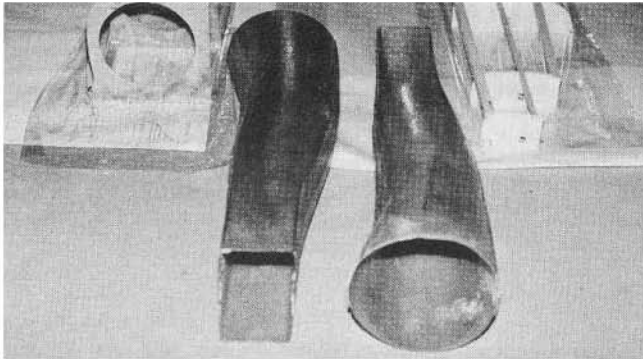




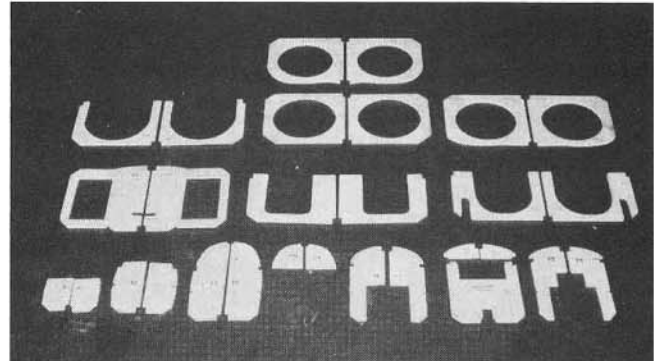
*Inlet duct plugs after waxing.*



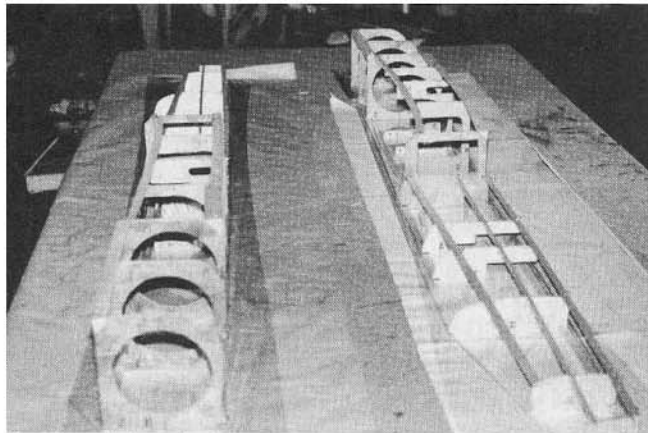
*Inlet duct halves after release from the plugs.*



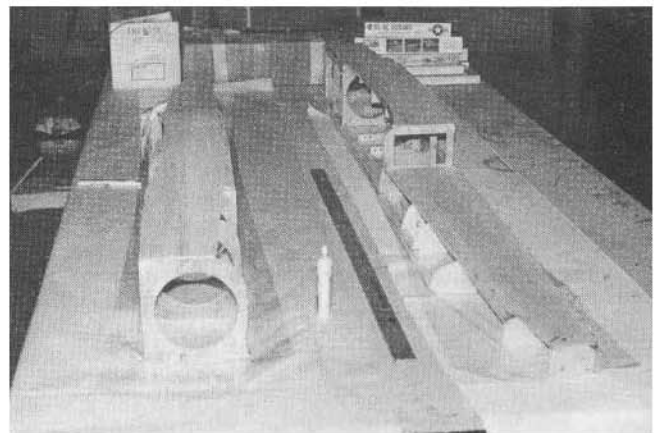
*Inlet ducts after joining halves with glass tape.*



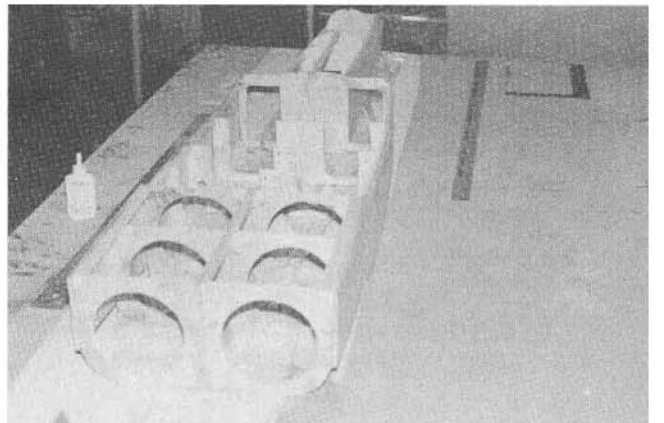
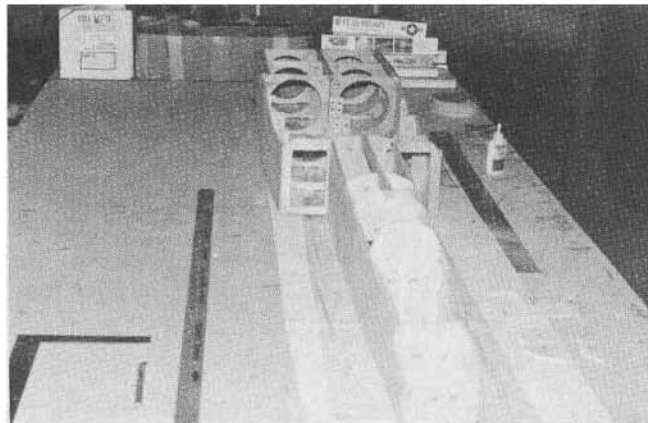
*Complete set of fuselage formers have been cut.*



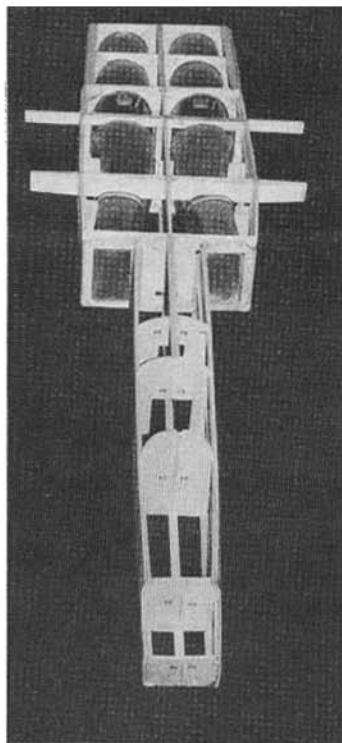
*Fuselage halves before skin.*



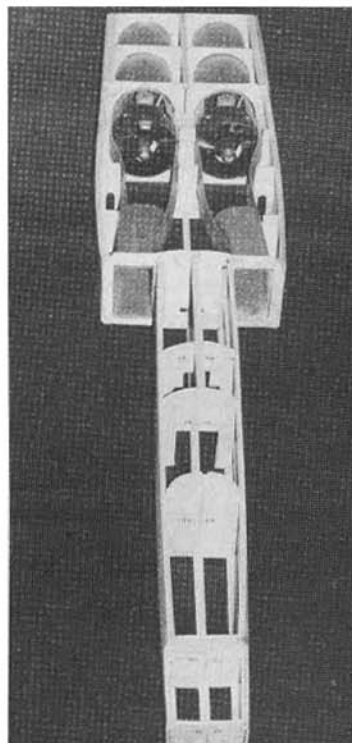
*Fuselage halves after side skin has been added.*



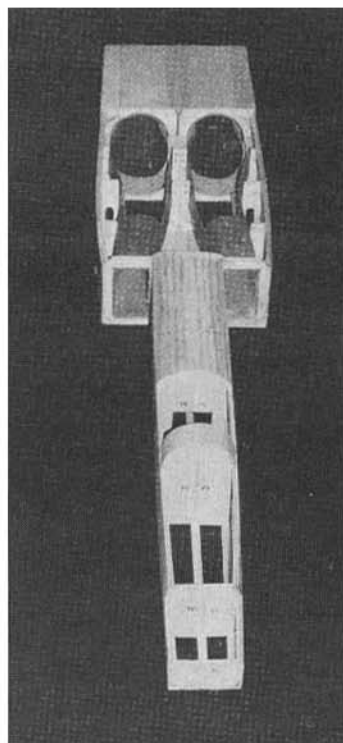
*Front and rear views of fuselage halves joined at crutch line.*



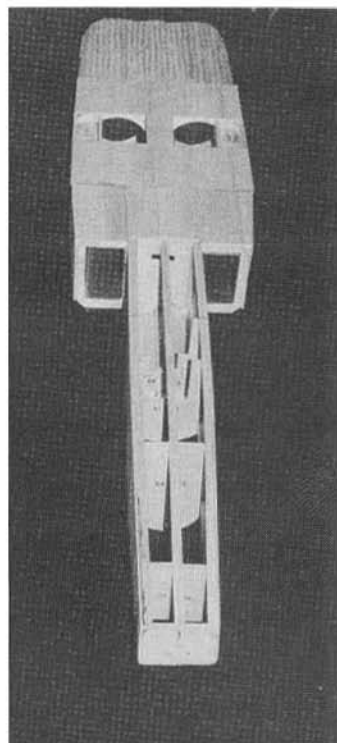
*Fuselage with wing center section in place.*



*Center section removed showing access to fans.*



*Top skin and planking in place.*



*Bottom skin and planking in place.*

polyurethane foam for the duct and canopy plugs. Aircraft Spruce and Specialty Company, P.O. Box 424, Fullerton, California 92632, is a good source for these items.

If you are hesitant to mold your own canopies or cut your own wing cores, Wing Manufacturing, P.O. Box 33, Crystal Lake, Illinois 60014, might be willing to supply you with finished parts. They will need airfoil templates and blank dimensions for the foam parts, and a well-finished male plug for the clear butyrate canopies.

#### CONSTRUCTION

##### Fuselage:

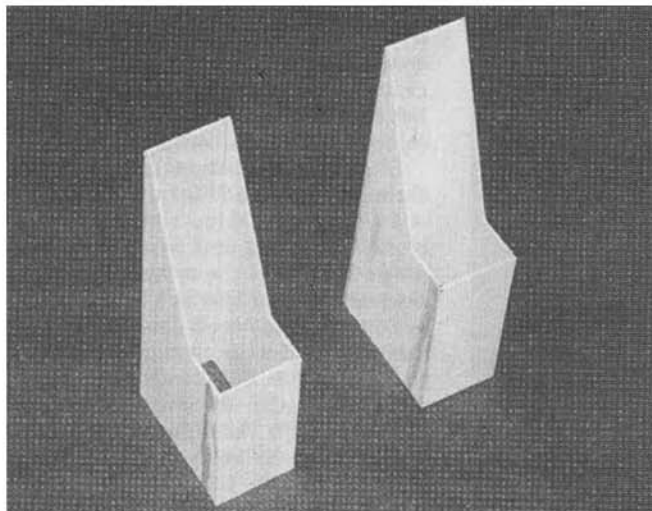
Obtain a 1½ gallon kit of Safe-T-Poxy, 2 yards of 2 ounce and 6

ounce bi-directional glass cloth, and a sheet of 1" x 24" x 48" 2 lb. density polyurethane foam from Aircraft Spruce. Make a frame for the inlet duct plugs by gluing formers D1 through D4 in place on a ¼" base. Note that you must build an upper and lower as well as a right and left plug. Fill the area between the formers with blocks of polyurethane glued in place. Carve and sand the polyurethane to conform to the formers. Coat the polyurethane with a layer of 6 ounce cloth and polyester resin (Sig, Hobbyoxy or K & B are acceptable). Then perfect the finish on the plug with additional coats of resin until there is a smooth contour from D1 to

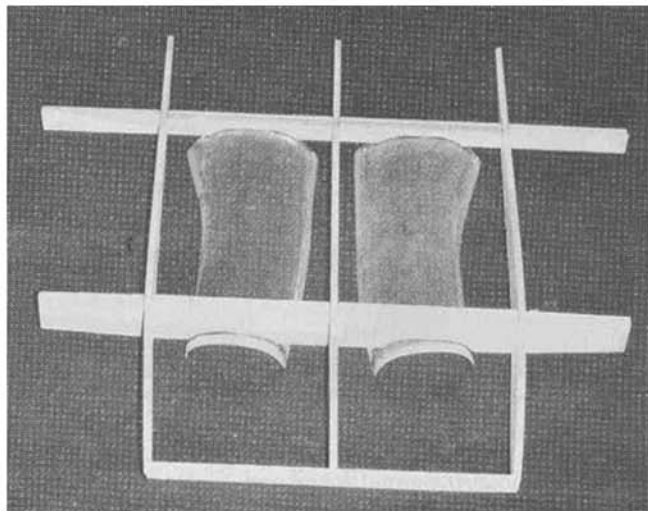
D4.

The actual lay-up of the duct halves is preceded by a careful waxing of the plugs. Butcher's furniture wax works well as a release agent with parts of this size. Be sure to coat the plug well, and buff the wax to a high luster.

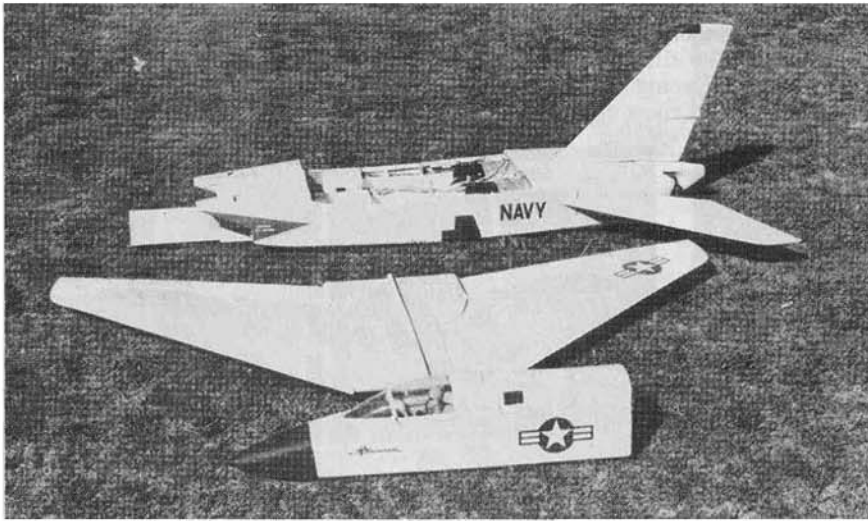
Drape a layer of 2 ounce glass cloth over each plug and brush on enough epoxy to fully saturate the weave. Follow this with a layer of 6 ounce cloth, again brushing on just enough epoxy to fill the weave. Allow the lay-ups to cure for 24 hours, then peel them off of the plugs. Trim away the "flash" and join the upper and lower halves with masking tape. To insure the fit of the ducts, temporarily insert



*Forward inlet ducts made from 1/8" balsa.*



*Wing center section with hatch covers.*



Major components disassembled for transportation.

the fan shroud at the circular end and a rectangular bulkhead at the intake end. Replace the masking tape with a layer of 1" wide fiberglass tape and saturate the joint with epoxy. Once you have a right and left inlet duct, proceed to cut out the fuselage bulkheads. Laminate 1/32" ply with Safe-T-Poxy on both sides of butt joined 1/4" x 4" x 36" sheeting to provide enough material for F6, F7, F8, F9, F10, F11 and F12. The remaining bulkheads are cut from 1/4" balsa except for F5 which is 1/4" ply. The bulkhead halves are assembled on the 1/4" x 1/2" balsa crutch. You are making a right and left fuselage half which will be joined later when the side skins are in place.

Slide the inlet duct into position through F6, F7 and F8, but do not glue it in place yet. Glue the triangular stock, longerons and wing saddle in place. Note that the triangular stock between F9 and F10 is 1" stock.

Epoxy the plywood doublers to the main fuselage skin, then glue the skin in position over bulkheads F6 through F12. Glue the forward skins to bulkheads F1 through F6. Remove both fuselage halves from the building board, and join together along the crutch line. Now the fan mounts and main landing gear mounts can be epoxied in position, allowing the fan shrouds and retractors to be temporarily installed. With the fan shroud in position, the 1/64" plywood tailpipe is fit and epoxied between bulkheads F10, F11 and F12. The inlet duct hatch is cut and the duct is epoxied to bulkheads F6, F7 and F8. Be sure, however, that the duct does not adhere to the shroud.

The forward inlet ducts are simply boxes of 1/8" balsa. These are epoxied to the fiberglass ducts at F6.

The outer inlet skin is glued in place, then the top and bottom fuselage skins and planking can be

added. All corner joints are carved and sanded to the proper cross sections.

At this point the polyurethane plug for the canopies can be made by tack gluing a block of foam in position and carving it to shape. Finish the foam with several layers of polyester resin sanded smooth. The plug is then ready for vacuum forming the .030 butyrate canopies. The radome is formed in a similar manner, as is the tail fairing.

Before permanently attaching the tail fairing, install the brass tubing to F12 which serves as the stabilator pivot. Note that this tubing extends through the tail pipes, and is faired to an airfoil shape with 1/4" balsa to provide smooth exhaust flow. The tubing also supports the tuned pipe hanger.

the 1/8" lite ply nose gear well to F5 and position the nose section to the main fuselage with 1/4" dowels which plug into F5.

#### Wing:

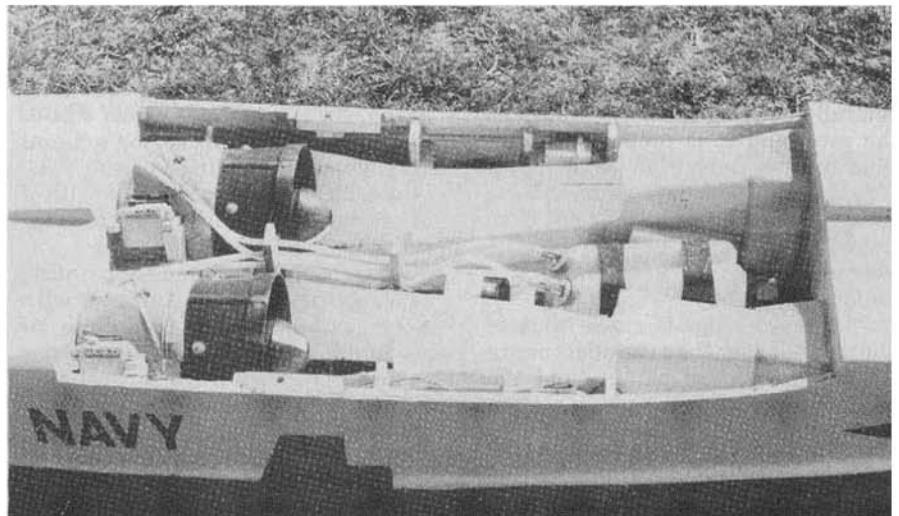
Begin with the wing center section which is composed of the forward and rear spars with the three center section ribs. Build the center section on the fuselage to insure an accurate fit. Then position the inlet duct hatches such that they mate with the ducts when the center section is in place. Epoxy the hatches to the spars allowing the hatches to remain with the center section when it is removed from the fuselage.

The wing cores are cut from 1 lb. density polystyrene foam, and covered with light 1/16" balsa. I used a thin layer of Safe-T-Poxy to adhere the 1/16" balsa skin. Epoxy allows you to carefully position the skin, it stiffens the core, and it is probably lighter than contact cement if applied in a very thin coat. Allow the skinned wing panels to cure in their shells left from the core cutting by placing weights across the entire area to insure uniform adhesion.

The leading edge is glued in place and cut to shape. Then the ailerons are cut from the wing panels, and the panels are joined to the center section with no dihedral. The center section should be skinned with 1/16" balsa. A center section fairing is built up of 1/16" sheet which blends the leading edge of the wing into F6, and the trailing edge into F9.

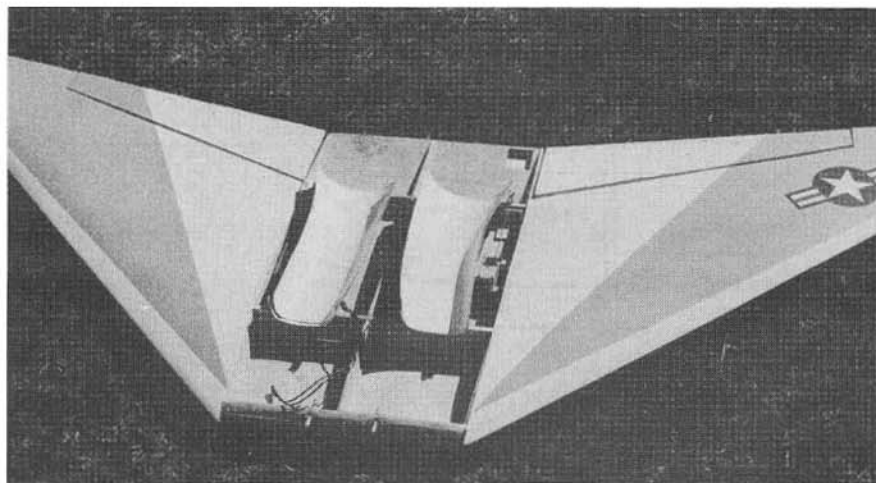
#### Empennage:

The tail surfaces are constructed from foam cores similar to the wing. The stabilator cores must have an aluminum tube imbedded to pivot on



My model has a removable nose to make the fuselage more transportable and to provide access to the battery pack. If you want a similar feature, razor saw the nose from the main fuselage between F5 and F5A. Install

the tube epoxied to F12. The fin spars are epoxied to the upper fuselage crutch and the rear of F12. The stabilators should not be permanently installed until the model is ready for painting.



### Scale Detail and Finish:

At this point the decision concerning color and markings should be made. I chose a pre-production A3J-1 as it appeared during flight tests in 1959-1960. The large areas of day-glo red paint make the model highly visible in the air. However, you may want to duplicate an A3J in squadron service. Several sources for scale information include: Air International, Vol. 9, No. 5, Nov. 1975, pp. 215-222; Airpower Vol. II, No. 1, Jan. 1981, pp. 12-23; Airprogress, Spring 1961 edition, pp. 20-21; Scale Aircraft Modelling, Vol. 4, No. 1, Oct. 1981, pp. 8-21; Famous Airplanes of the World, No. 121, Sept. 1980 (a KoKo Fan publication from Japan); also, write to manager, Public Relations, North American Aircraft Division, Columbus Plant, 4300 East Fifth Avenue, P.O. Box 1259, Columbus, Ohio 43216 for general arrangement drawings of the A3J. Plastic models also provide a wealth of information. The Advent Vigilante kit #3356 is highly recommended.

The model is prepared for painting by covering all wood surfaces with either paintable clear MonoKote, or 3/4 ounce glass cloth and polyester resin. The MonoKote is probably lighter, but it is far less durable than the cloth-resin technique.

Once all components are covered, the stabilators can be linked to the fuselage. Begin by cutting two hatches into the top fuselage skin to provide access to the stabilator bellcrank area. Slide the stabilators in place on the brass pivot, and mount the bellcranks so that they engage the actuator pin. Retain the actuator pin in the bellcrank slot with a 1/8" wheel collar. Run a semi-flexible plastic pushrod from the stabilator servo area (between F7 and F8) to the bellcrank. Use two high torque servos (I used World Engine S-11's) connected to the receiver with a "Y" harness to actuate the stabilators. You should adjust the linkage to give approximately 3/4" movement up and down (total 1 1/2") at

the stabilator leading edge. Replace the hatch cut-outs in the upper skin and continue with the finish.

Lightness is essential, therefore, a minimum of primer and color should be used. I used K & B Super Pox. The day-glo red, however, was Martin Senour automotive enamel (#7860) available at N.A.P.A. Auto Supply stores. The decals and military jet pilot were obtained from Jet Hangar Hobbies, 12554 Centralia Road, Lakewood, California 90715. Since the decals and day glo paint should be protected from the high nitro fuel typically used with jets, I misted a coat of flat Super Pox clear over the entire

### Final Assembly:

After the fan units are thoroughly bench tested (and preferably flown in another model) with the pipes tuned and idles set, they can be installed in the Vigilante fuselage. I had my engines modified by Tom Cook, 304 Silvertop, Raymore, Missouri 64083 (of F4 Phantom Fame), who installed O.S. 61VF carburetors in place of the Perrys that came with the K & B 7.5's. The O.S. carburetor provides about the same top end (22,500-23,000 rpm) but it allows a very reliable idle. After watching several video taped flights of

Cook's Phantoms with never the loss of an engine, I decided to let him set up my power system.

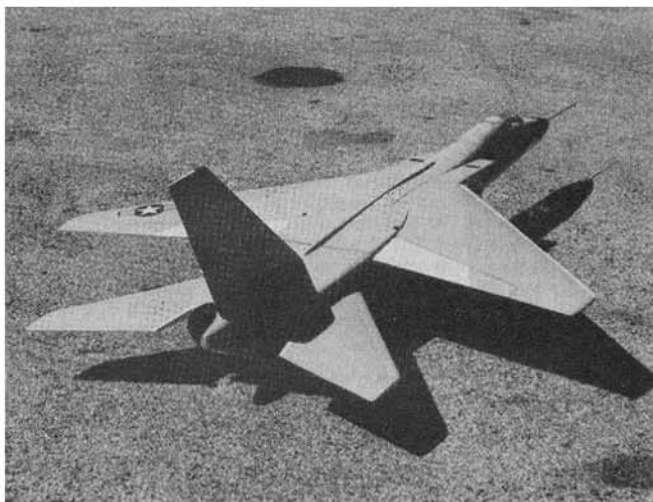
The fuel is contained in two Sullivan flat 12 oz. tanks which are wedged between the inlet ducts with rubber foam in the area of F6-F7. The fuel and pressure lines are routed through holes drilled in F8 and F9. The engine cylinder heads are shrouded with fiberglass caps which are available from Jet Hangar Hobbies. These caps must be easily removable to provide access to the glo plug and fuel lines.

The retracts are bolted to their mounts with the sliding valve unit mounted aft of F6 below the fuel tanks. The air tank, as well as the receiver, is mounted in the area between F5 and F6 with a hatch cut in the floor for access. The main landing gear doors, which are molded from two layers of 6 ounce glass cloth, are actuated by nylon fishing line which is routed through 1/16" I.D. aluminum tubing. When the main gear is extended, the nylon cord (which is attached to the upper part of the gear strut) holds the doors open. As the strut moves forward upon retraction, it pulls the doors shut. I haven't rigged a nose gear door yet. However, a similar arrangement could be used. The nose gear door, however, should be closed when the nose strut is extended and make a complete cycle as the strut retracts.

The radio system utilizes eight servos: one for nose wheel steering, one for retracts, two for ailerons, two for stabilators, and two for throttles. All channels using two servos require a "Y" harness. Because of the large number of servos and their long distances from the receiver, a high capacity battery pack (1200 mah) should be used.

Probably the greatest problem in flying the Vigilante is dealing with the vibration set up by the twin fans at full throttle. I lost my second model,





**Assembled aircraft.**

and damaged my current model during a contest, because a servo extension was severed by vibration. The damage occurs where the wire is routed through a bulkhead or comes in contact with some part of the structure that can cause chaffing. Be sure to secure the wires at frequent intervals to fuselage wall, etc., and protect the wires with grommets where they pass through the bulkheads.

Note that no rudder function is used since the model turns adequately on aileron alone. At the price of additional weight the rudder could be made operable. It pivots at the same point as the stabilators, just aft of F12, and it is all moving like the stabilators.

Aileron deflection should be 1" up and down (total 2" movement) at the trailing edge. This provides a roll rate of approximately 360 degrees per second.

As I mentioned earlier, the full sized A3J did not use ailerons. It used a complex series of spoilers and deflectors located at approximately 70% of the wing chord. When activated, they killed lift on one wing and increased it on the opposite wing without causing any adverse yaw. It seems impossible to duplicate this roll control system at the 1/4" = 1' scale of this model without a tremendous penalty in weight and complexity. Therefore, I elected to use the flap surfaces as simple ailerons. You may want to mix the ailerons with a flap function and thereby achieve flaperons. However, like the rudder, this is not really necessary since the model lands slowly without flaps.

#### **Flying:**

Balance the model carefully. You should be able to achieve the Center of Gravity position shown on the plans with the battery pack located just forward of F5 attached to the top of the nose wheel well. Do not fly with the

Center of Gravity aft of the location shown on the plans. The model should weigh less than 18 lbs. without fuel. My first model weighed less than 17 lbs., but it had minimal finish and detail. The current model, my third, is flying at almost 19 lbs. I have flown two of my Vigilantes off of grass, but it takes an excessive amount of runway. I recommend flying off hard surface runways only.

The K & B 7.5's run well on anything from 10% to 25% nitro fuel. I have found OPS plugs to be the most durable; however, they should be changed at least every four flights to insure reliable engine operation.

The engines are started with the wing removed. An electric starter will fit easily in the duct with the hatch removed. Tack both engines to be sure you are receiving at least 22,000 rpm. Using a crude spring scale, I've measured the combined thrust at that rpm as 11.5 lbs.

When satisfied with the engine operation, place the wing in position being sure to plug in the ailerons.

The take-off run on hard surface with no wind is about 150 feet, on grass it is at least 200 feet. Allow the model to accelerate until a slight amount of back pressure pulls the nose wheel off the ground. The model will continue to accelerate in this rotated position for a few feet leaving the runway cleanly once it has reached flying speed. It will climb positively at a 15 degree angle. At altitude you will notice that the model responds crisply in roll, but that it is extremely stable in pitch. This is probably due to the long fuselage. Characteristically, the Vigilante will remain in the altitude it is pointed until a new pitch command is given. Maneuvers such as the Figure 8, the procedure turn, and the fly-by can be done easily with no change in altitude. Rolls are very axial. The top speed is probably 90-100 mph; however, this seems to vary

noticeably with temperature and humidity.

Landings are truly effortless. A long, final approach with a constant angle of attack is the most scale-like method. Rate of sink is controlled with engine power. Remember that ducted fans are not as responsive as a propeller aircraft to sudden bursts of power, especially at low rpm. Graceful nose high touchdowns are easily accomplished.

Loss of an engine is only a problem at low altitude and low airspeed. The model will maintain level flight and even climb slowly on one engine; however, at low airspeeds you will find it difficult to accelerate, and a landing approach should be established immediately.

After building three balsa Vigilantes, I hope to mold a glass fuselage. I suspect that glass will give me a lighter airframe (I would be very happy with a 16 lb. Vigilante). □

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