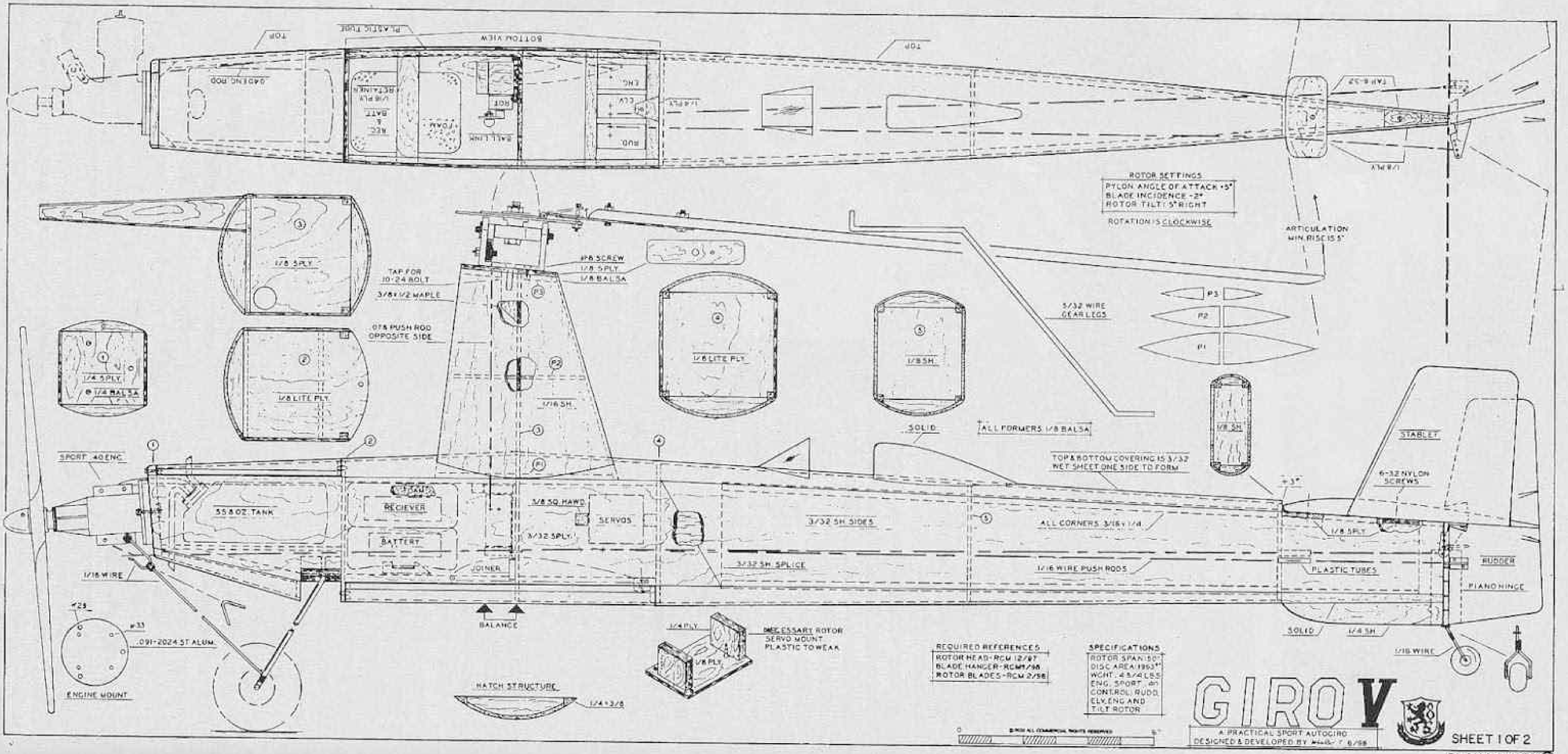
GIRO V

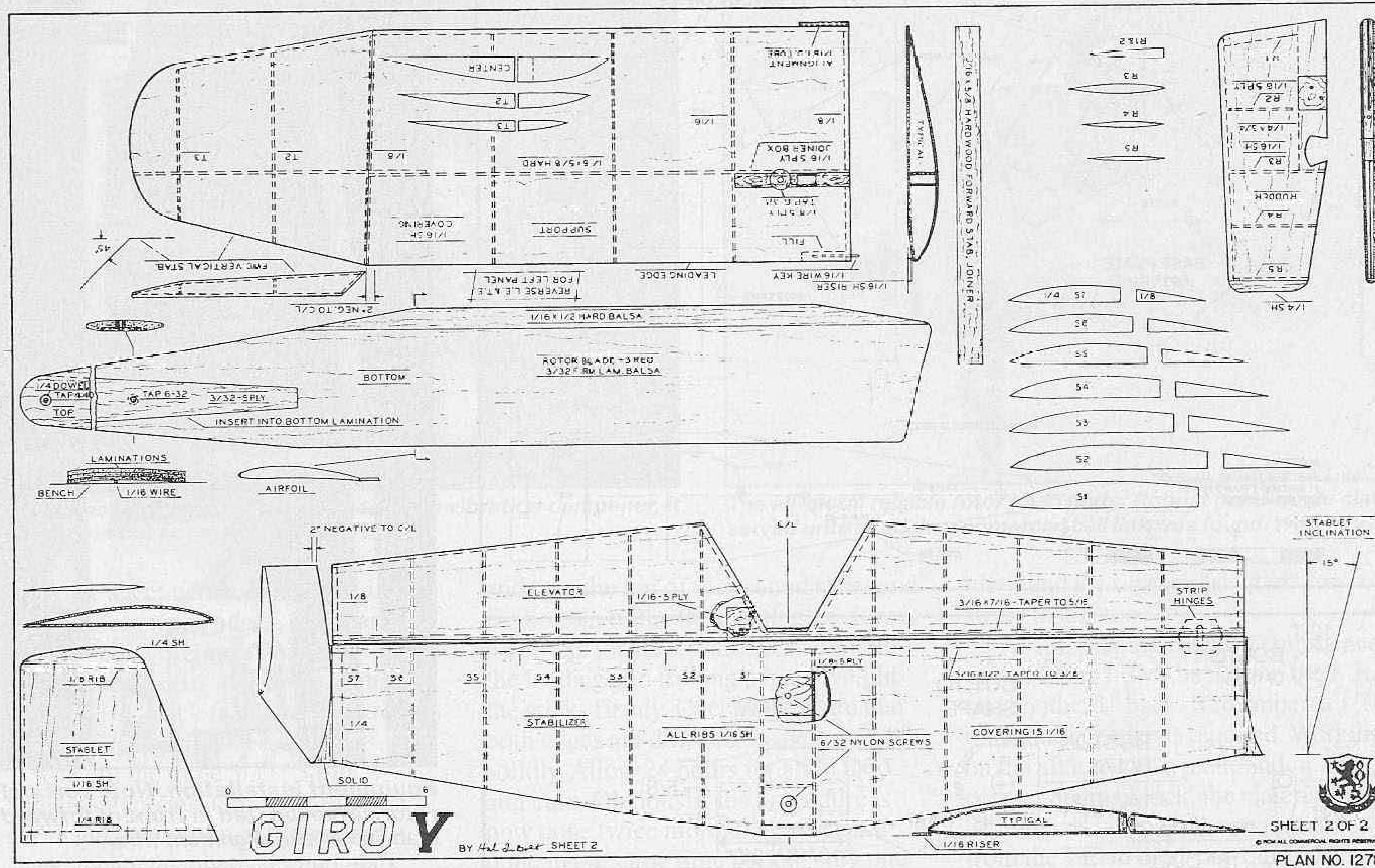
SPORT AUTOGIRO FOR .40 ENGINES

By Hal deBolt



PLAN NO. 1278 (2)

FULL-SIZED PLAN AVAILABLE, SEE PAGE 189



LEFT: Giro V Mk 1. Forward vertical stabilizers added considerable lateral stability and are removable for so-called "wingless" flight. BELOW: Giro V about to touch down for a "no roll" landing.

In the 20's, Cierva of Spain felt a safer aircraft (for that time) was possible. He labeled his conception "Autogiro" and his development effort proved frustrating. He finally found the necessities and had success.

Over two years ago, our 20 year hiatus from autogiros ended when we found others interested and enjoying working with them, so it seemed time to return. My thought being to advance from the '77 effort; Giro V represents the result.

Every project effort should have an objective. I have always felt the result of anything done should be attractive and usable by the average modeler. Thus, my goals for the new Giro venture were established.

First, control should include "Tilt Rotor," then the Giro should be as easy to use and fly as the modeler's pet airplane. Also, it should be as flyable in any tolerable weather as his airplane is. Plus, as a miniature, it should be easily capable of duplicating full-scale performance in its entirety.

Always striving for the goals, we encountered one mystery after another, and it soon became apparent that the desired craft saw far stronger forces than other modelers had seen. However, persistence can pay off, and finally the 5th version proved to be more than hoped for. Giro V is a fine performer which most RC'ers would appreciate having in their stable.

As development progressed, we reported our findings in RCM 11/97 to 8/98 and, for those interested, it would be worthwhile to review those reports, as they are in detail.

The Giro itself is different from an airplane with its rotating wing and lots of clever gimmicks. It is not a speed craft; top speed of Giro V being in the 50 to 60 mph range. The difference is the low-speed performance where some maneuvers are accomplished at no forward speed!

Let's see if a potential flight might tickle your fancy. Begin with a take-off in a few feet directly into the wind, climb steeply to some altitude and do a 180° turn into a full speed pass at altitude. Do another 180° turn into the wind, reduce power and enter a "stand still" hover. From the hover, cut to idle speed and perform a vertical descent. When close to the ground, add a bit of power to stop descent and continue with a slow fly-by at walking speed; during the fly-by, drop in for a touch and go, then go to full power and use a pylon style turn into a full speed fly-by; then, at the end, pull into a near vertical climb. At altitude, rudder into a wing over, reducing power on the downward leg; then, on recovery, make another pass to a near vertical climb to altitude. Up there, display some more hovers and vertical descents, have fun! While at altitude, position your Giro for a chosen landing spot and enter a hover, then a vertical descent to the spot; at last instant, stop descent with a bit of power, allowing the Giro to drop into a no roll landing, grin and taxi back to pits. Impressive? Surely different and exciting!

This experience can be yours with no more than a normal effort and at little expense! The Giro V features should be understood, so let's commence at the forward end:

Power: Any sport .40 is more than sufficient! Prop size is a 12 x 6 for max thrust at low speeds.

GIRO V

Designed by:
Hal deBolt
TYPE AIRCRAFT
Autogiro
ROTOR SPAN
50 Inches
ROTOR BLADE CHORD
3-1/2 Inches
ROTOR DISC AREA
1958 Sq. In.
BLADE AIRFOIL
Davis 5 Reflexed
OVERALL FUSELAGE LENGTH
43 Inches
RADIO COMPARTMENT SIZE
(L) 9" x (W) 3" x (H) 3-1/4"
STABILIZER SPAN
24 Inches
STABILIZER CHORD (inc. elev.)
6-1/2 Inches (Avg.)
STABILIZER AREA
190 Sq. In.
STAB AIRFOIL SECTION
Flat Bottom
STABILIZER LOCATION
Top of Fuselage
VERTICAL FIN HEIGHT
4 Inches
VERTICAL FIN WIDTH (inc. rud.)
2-1/2 Inches (Avg.)
REC. ENGINE SIZE
.40 (Sport)
FUEL TANK SIZE
8 Oz.
LANDING GEAR
Conventional
REC. NO. OF CHANNELS
4
CONTROL FUNCTIONS
Rud., Elev., Throt., Rotor Tilt
C.G. (from L.E.)
1"-2" (Forward Stab)
ELEVATOR THROWS
1" Up — 1/2" Down
AILERON THROWS
—
RUDDER THROWS
1-1/4" Left — 1-1/4" Right
SIDETHRUST
—
DOWNTHRUST/UPTHRUST
5° Downthrust
BASIC MATERIALS USED IN CONSTRUCTION

Fuselage .... Balsa & Ply
Rotors .... Balsa & Ply
Rotor Head .... Alum. Alloy 2024 T3
Blade Hangers ..... Alum. Alloy 2024 T3
Empennage .... Balsa & Hardwood
Wt. Ready To Fly ... 76 Oz. (4 Lbs. 12 Oz.)
Rotor Disc Loading ...... 5.5 Oz./Sq. Ft.

A must is an absolutely reliable idle, since so much flying is done at low speeds!

Engine Mount: Simple, small, light, and unbreakable.

Down Thrust: Set at a 5° angle which aids in transition from hover to full speed; without it, there would be a "zoom."

Fuel Tank: Assurance at idle speeds, a normal flight only uses about half of it.

Landing Gear: Note forward spreader bar. This gear evolved as a means to hold heading, especially on rough runways.

Forward Vertical Stabilizers: As some photos show, the Giro V performs satisfactorily without the forward stabs. However, the forward stabs enhance lateral stability, making "hands off" flying duck soup.

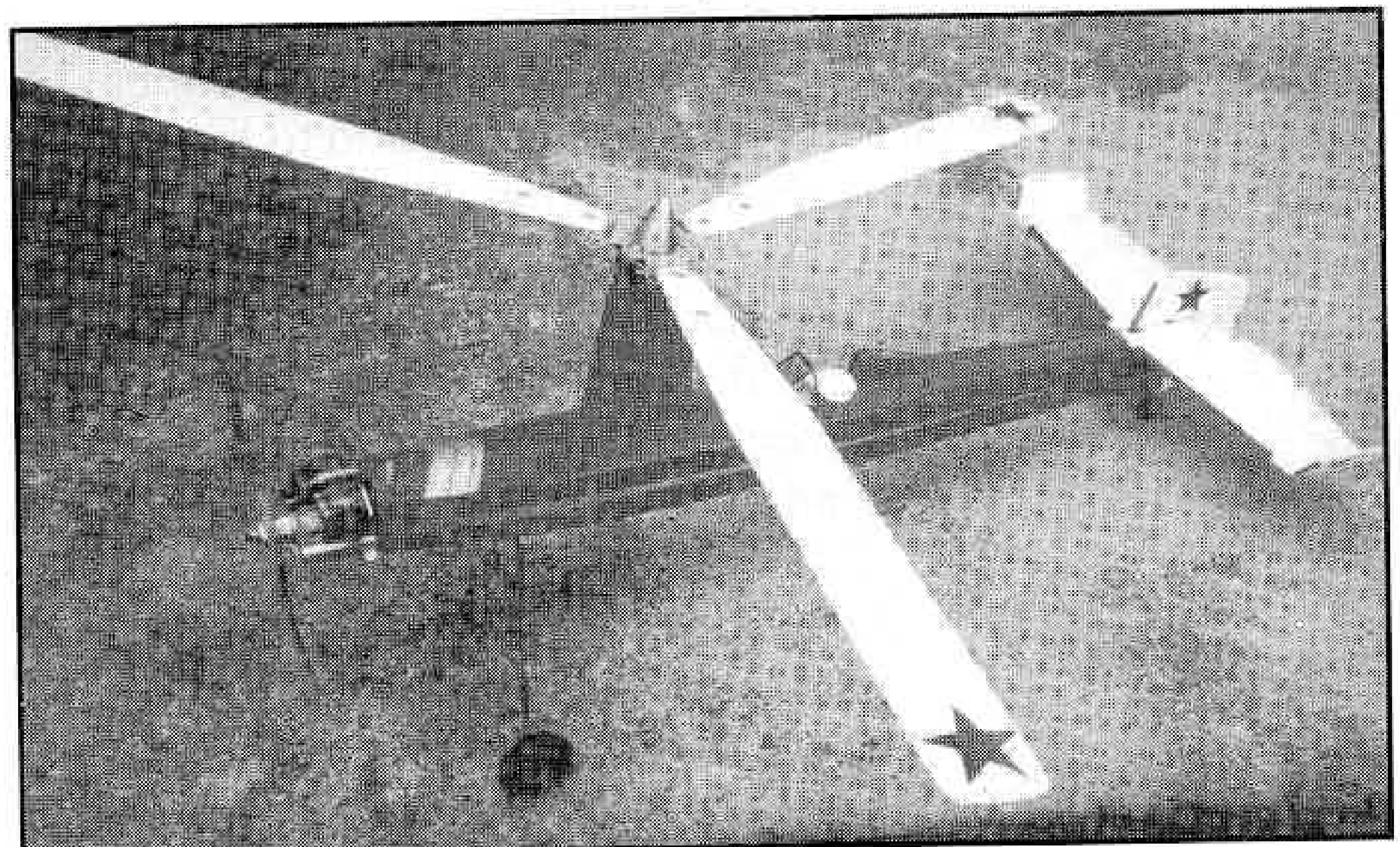
Rotor Head and Blade Hanger: These are robust and precise mechanisms found necessary to withstand the strong forces which affect the rotor.

Rotor Blades: These blades evolved to meet the necessities encountered. Lamination increases tensional and torsional strength. Airfoil provides max lift at normal blade speeds. The reflex creates a counteracting force to another which can cause "blade strikes."

Horizontal Tail: The size, airfoil, and incidence provide lift in proportion to rotor lift so that flight attitude does not change when speed does.

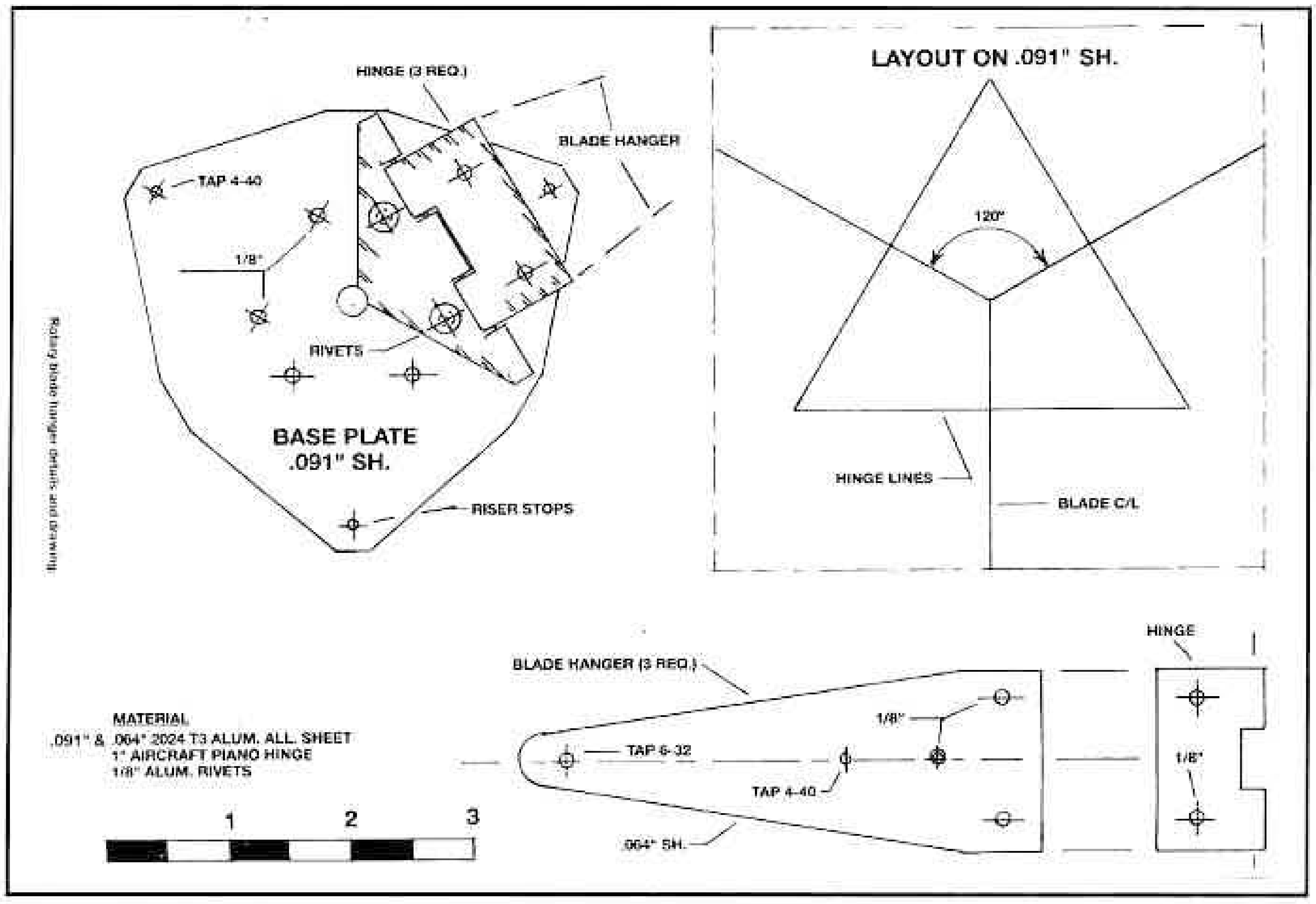
Vertical Stabilizers: These are arranged in "winglet" style (Stablets?) which add to efficiency. Note that the forward stabs are also winglets. These features were all seen as solutions to numerous "whirlygigs" encountered throughout the long development of Giro V.

It should be said there have been two Giro Vs. Mk I logged many flights until it was destroyed while testing a completely different rotor. Mk II provided the opportunity to use some minor modifications which seemed worthwhile. At the time of this writing, Mk II has logged many, many enlightening flights.

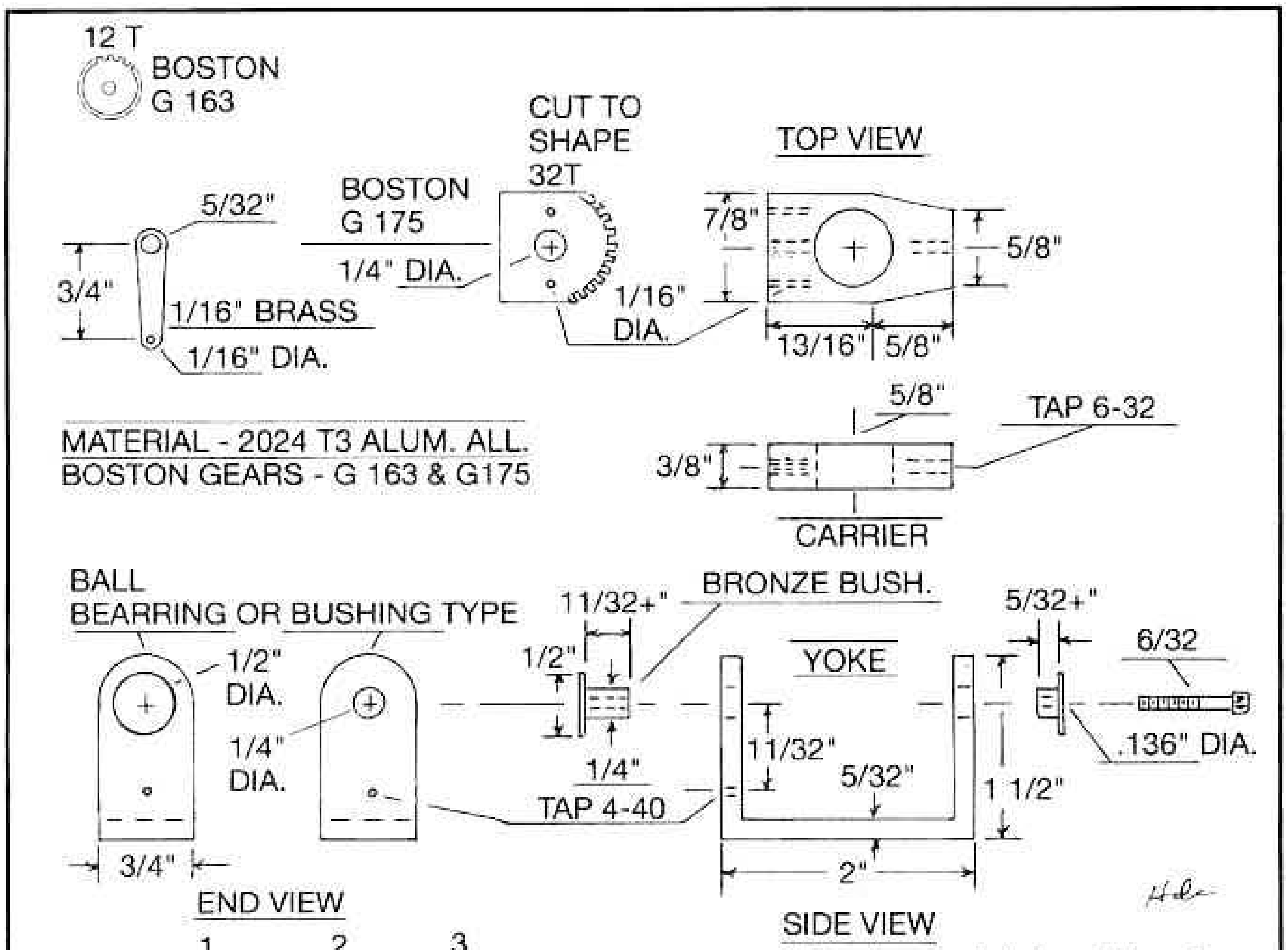


Note the pre-spin spinner. This is the Mk 1 version with the rotor pylon on the right side. The Mk II version has the pylon on the left side, and has proved superior.

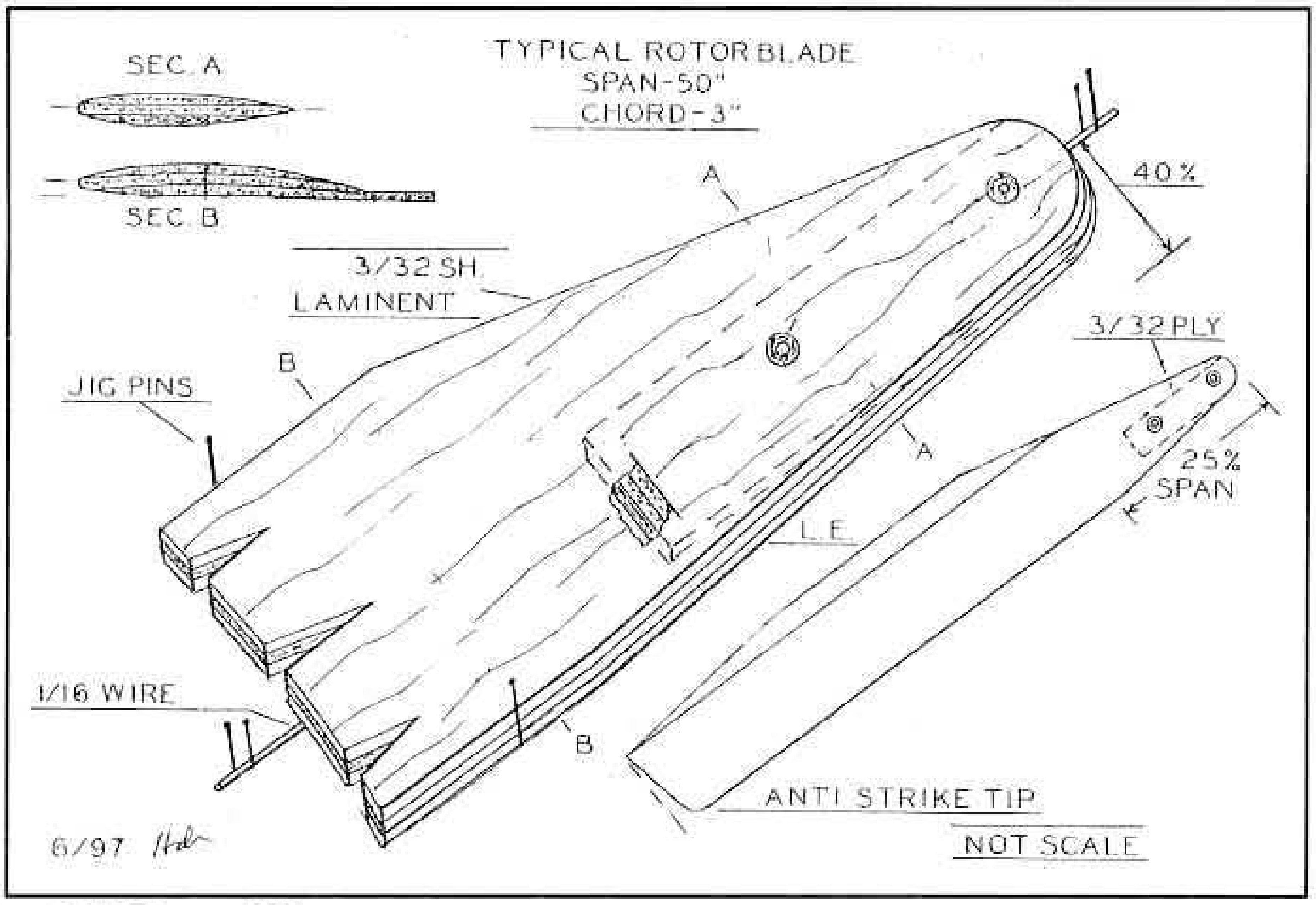
Tom McCoy pre-spins rotor for another uneventful take-off.

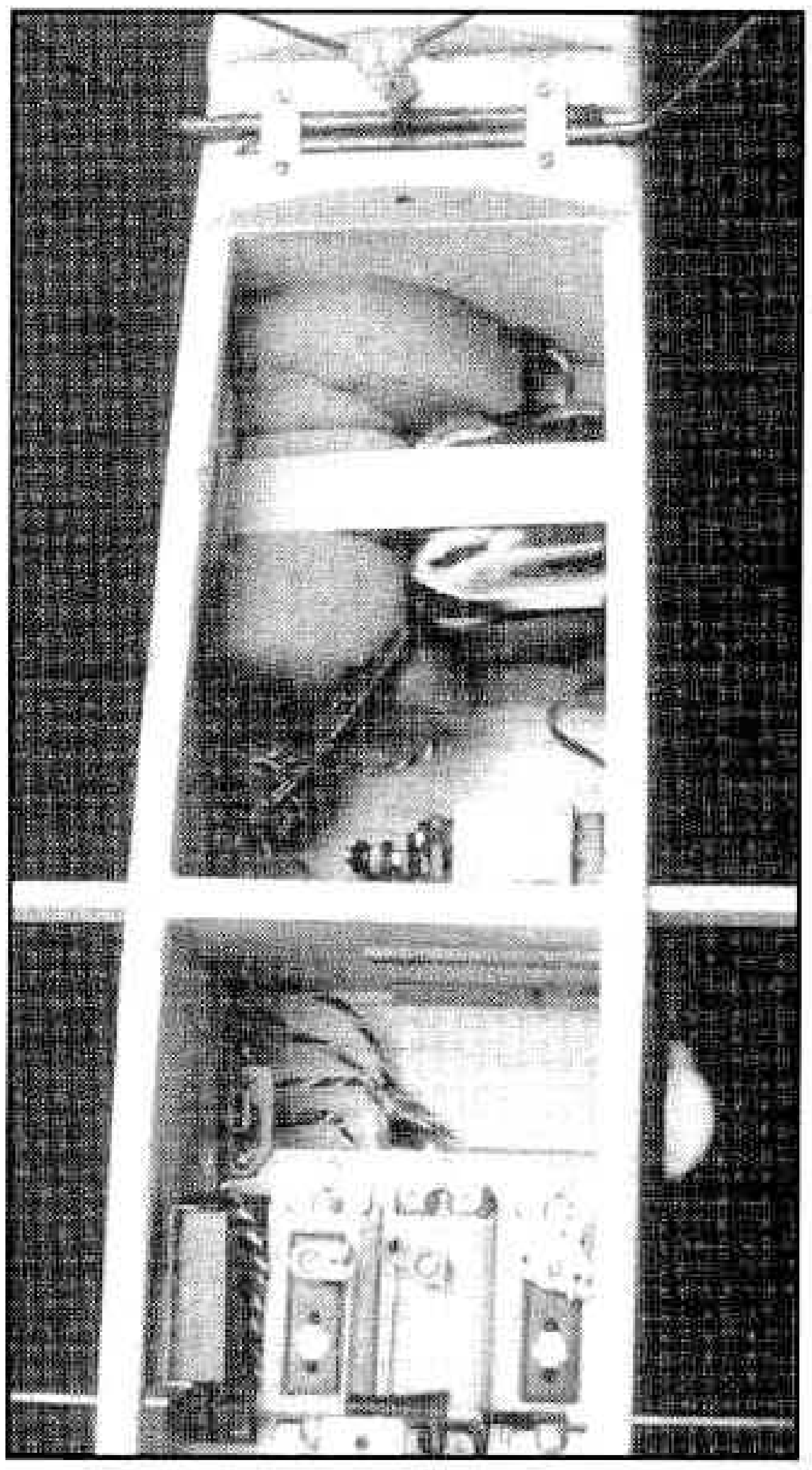


Rotary blade hanger details and drawing.



Rotor heads detail and drawing.





Equipment installation. Note vertical rotor servo located in front of forward stab. joiner and alignment wire.

An accomplished R/C pilot should have no difficulty flying an Autogiro, since basically, it can be flown like an airplane. However, "giro flight" is unique, and knowing the difference and a Giro's capabilities is where Giro shines. Perhaps the flying instructions will offer clues and broaden your knowledge.

As an "airplane man," you would have little knowledge of rotors and/or rotary wings, yet the rotor is the heart of a Giro. It must be assembled and operated properly.

CONSTRUCTION

It should be obvious that Autogiros may be beyond the novice RC'er's abilities, but are well within any average accomplished RC'er's realm.

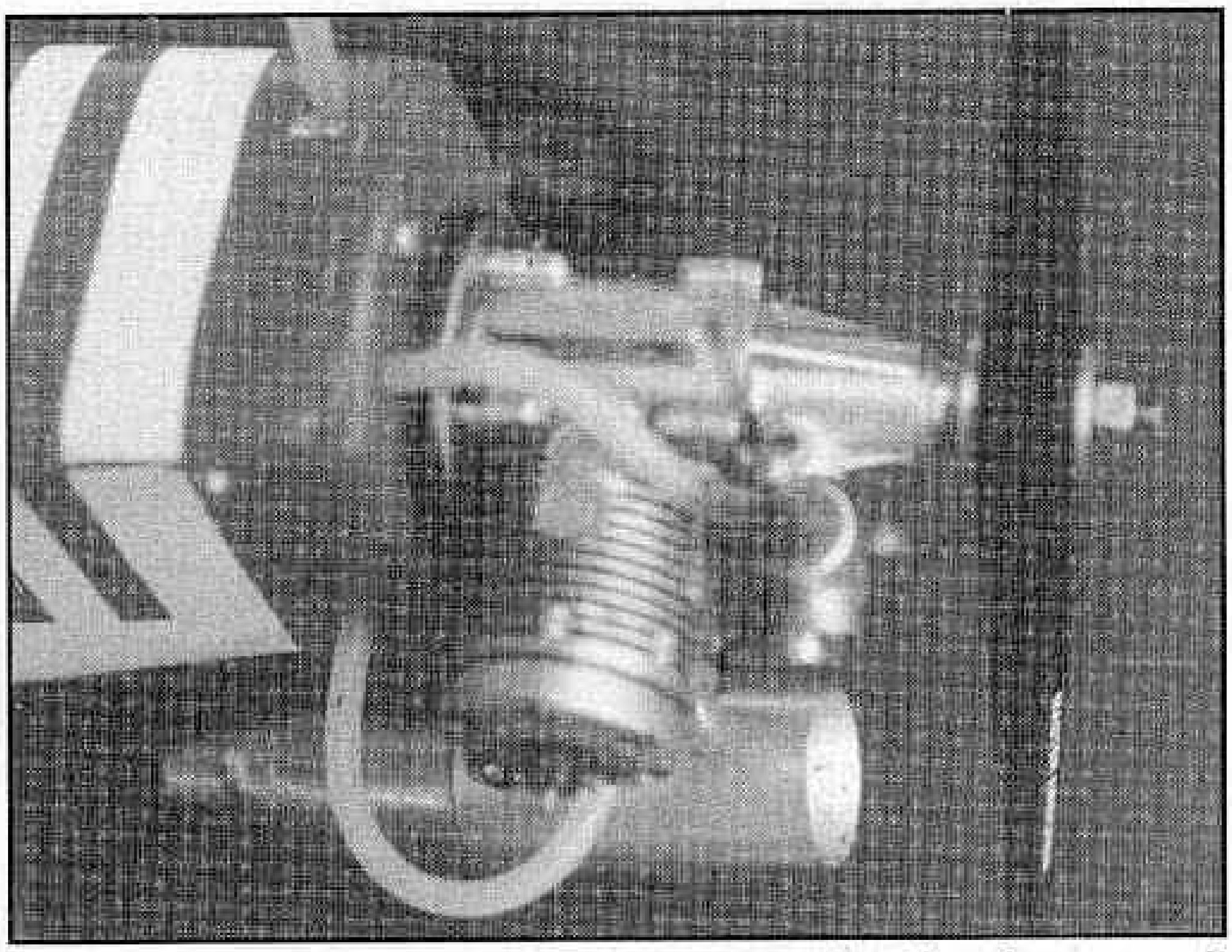
Rotor Assembly

This rotor was developed over a considerable time period to fill the needs seen during development. Again, we should note that the "whys and wherefores" were reported in *RCM* in a series of articles, starting in November 1997.

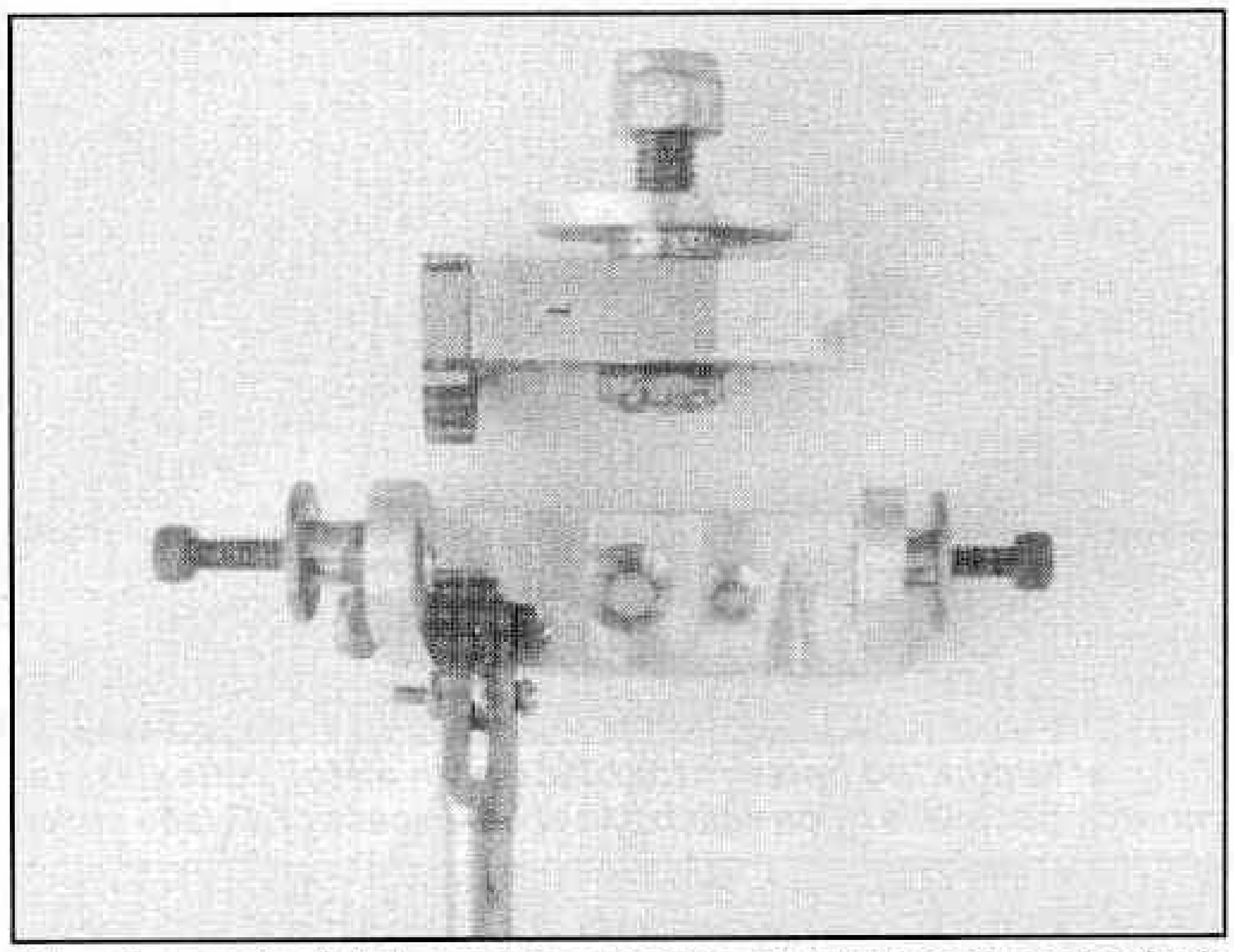
Blades

Let's start with the blades, which use a structure that adequately fills all needs. The blades are laminated from three sheets of 3/32" x 3" firm, but not hard, balsa. The airfoil requires undercamber which is achieved during lamination.

Begin by laying a correct length of sheet balsa on the assembly board.



Simplistic engine mount uses a neoprene vibration dampener, it works fine but not really necessary.



The all-metal reliable rotor head parts. Robust hand-made clevis served until suitable commercial ball link was found. Weight 2 oz.

Lock the sheet in place with jig pins around the outside edges, and mark the forward edge. Remove the sheet, then lay a piece of 1/16" dia. wire on the board 1-1/4" back from the forward edge and lock it in place with pins.

Cut out the three 3/32" 5-ply attachment plates. On top of the first sheet and the bottom of the second sheet, locate the ply plates and mark around them. When applying glue, leave those areas dry.

Spray top side of first sheet with "Windex" window cleaner. Laminating is done with aliphatic resin glue (Elmers Carpenter Glue or Tite Bond, etc.). Determine how much water to thin the glue with to get a good brushing consistency. You do not want it too thick or thin! Place the first balsa sheet in the jig, spray the top of a second sheet, and wipe off the excess. Evenly brush on a coat of glue to the top of the first sheet and the bottom of the second one. Place second on top of the first. Spray the top of the third sheet and coat the top of the second sheet and the bottom of the third with glue. Lay in place and locate a "yardstick" on both the leading and trailing edges. Weight the sticks firmly. Check to be sure that both edges are down to the board solidly. Allow 24 hours for all to dry and cure. Obviously, the procedure is now done twice more. If all three are done in the same time period, only one waiting period is required.

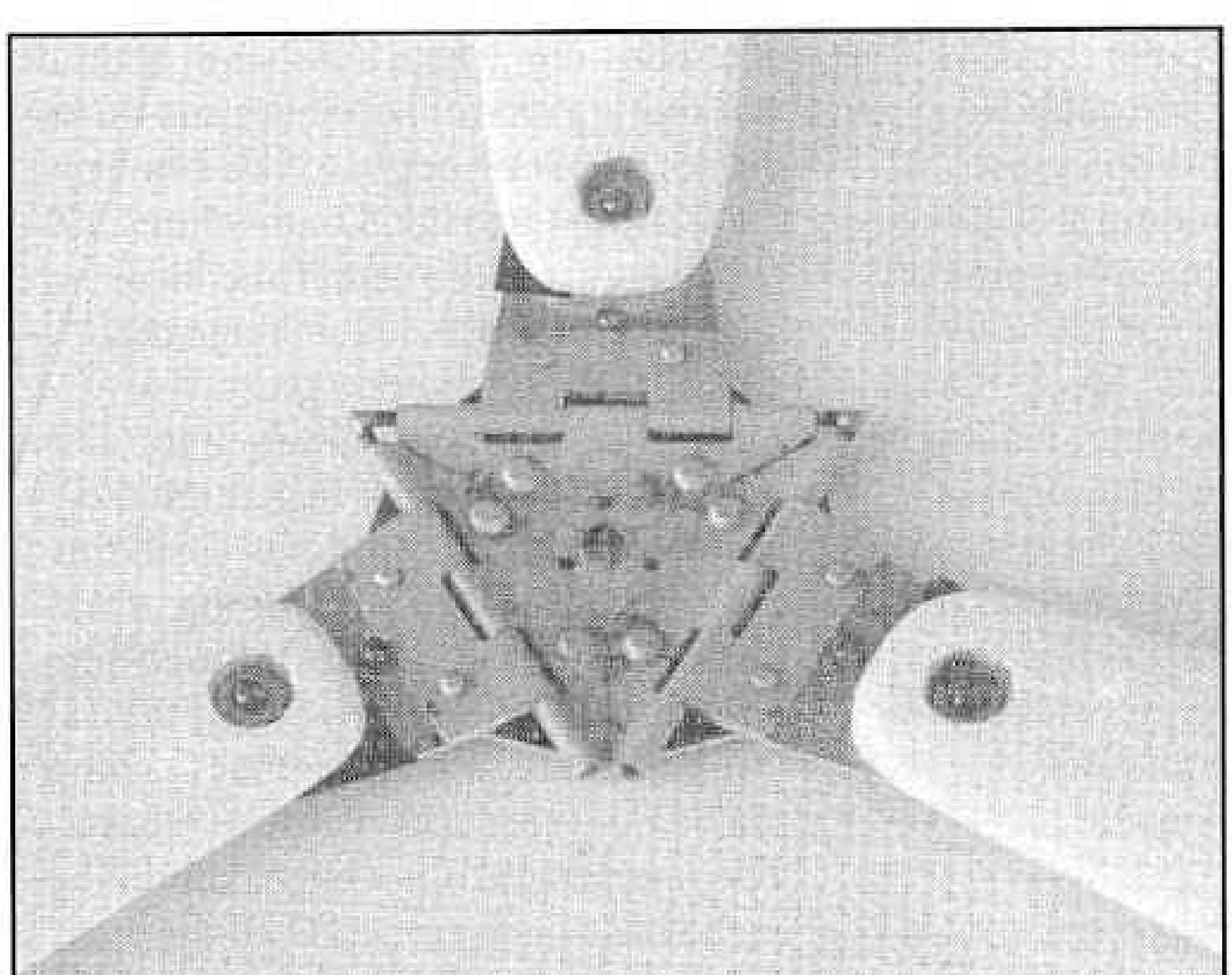
Next, the plywood attachment pieces are added. Mark a spanwise centerline on the ply. Next, on the blades, 1-1/4" back from the leading edge, scribe a spanwise line on the bottom. Align the centerline of the ply piece with this line, pin in place. Using the plywood attachment piece as a guide, carefully cut through the bottom sheet only, remove the cutout and glue the plywood piece in place using aliphatic glue.

The inner portion of a rotating wing produces more drag than lift, so that portion is tapered as seen in the plan view, and the tips are "slanted" for strike insurance.

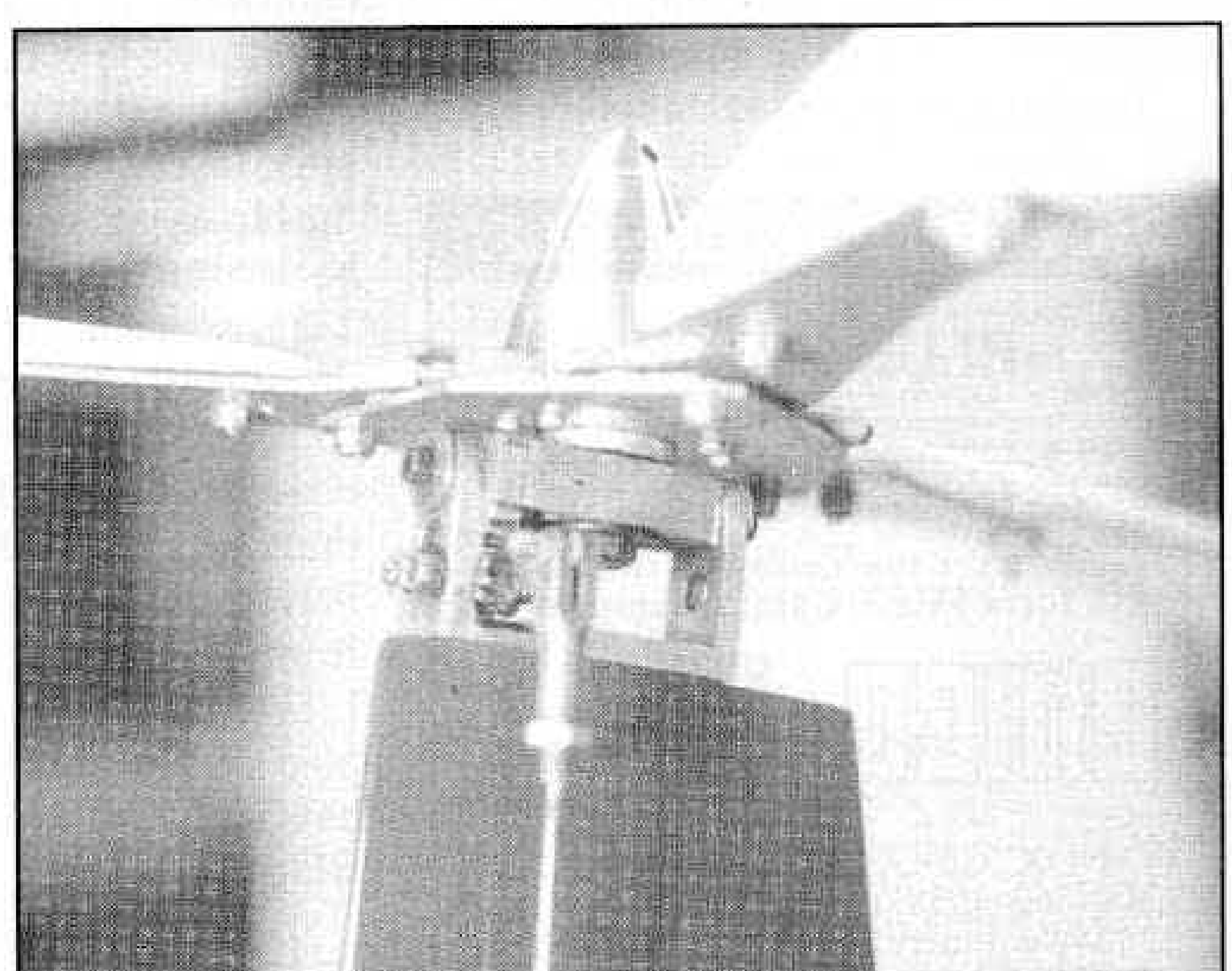
Airfoil shaping can now commence. Scribe a line 1-3/4" back from the L.E. and another 1" back. Remember, a 1/16" thick trailing edge is required. Working on the aft top with a plane and/or a long coarse sanding block, the material can be removed in an almost straight line from the T.E. to the 1-3/4" line. Using the center sheet leading edge as a guide, the front portion is blended airfoil style from the 1" line to the top edge of the middle sheet. The flat area between the 1" and 1-3/4" lines can then be blended to flow into the others to complete the upper airfoil shape.

The forward bottom is shaped to meet the bottom edge of the center sheet. Round the leading edge, and the outer foil is completed. Inward in the taper area, the foil is progressed to symmetrical, use the center sheet edges as a guide.

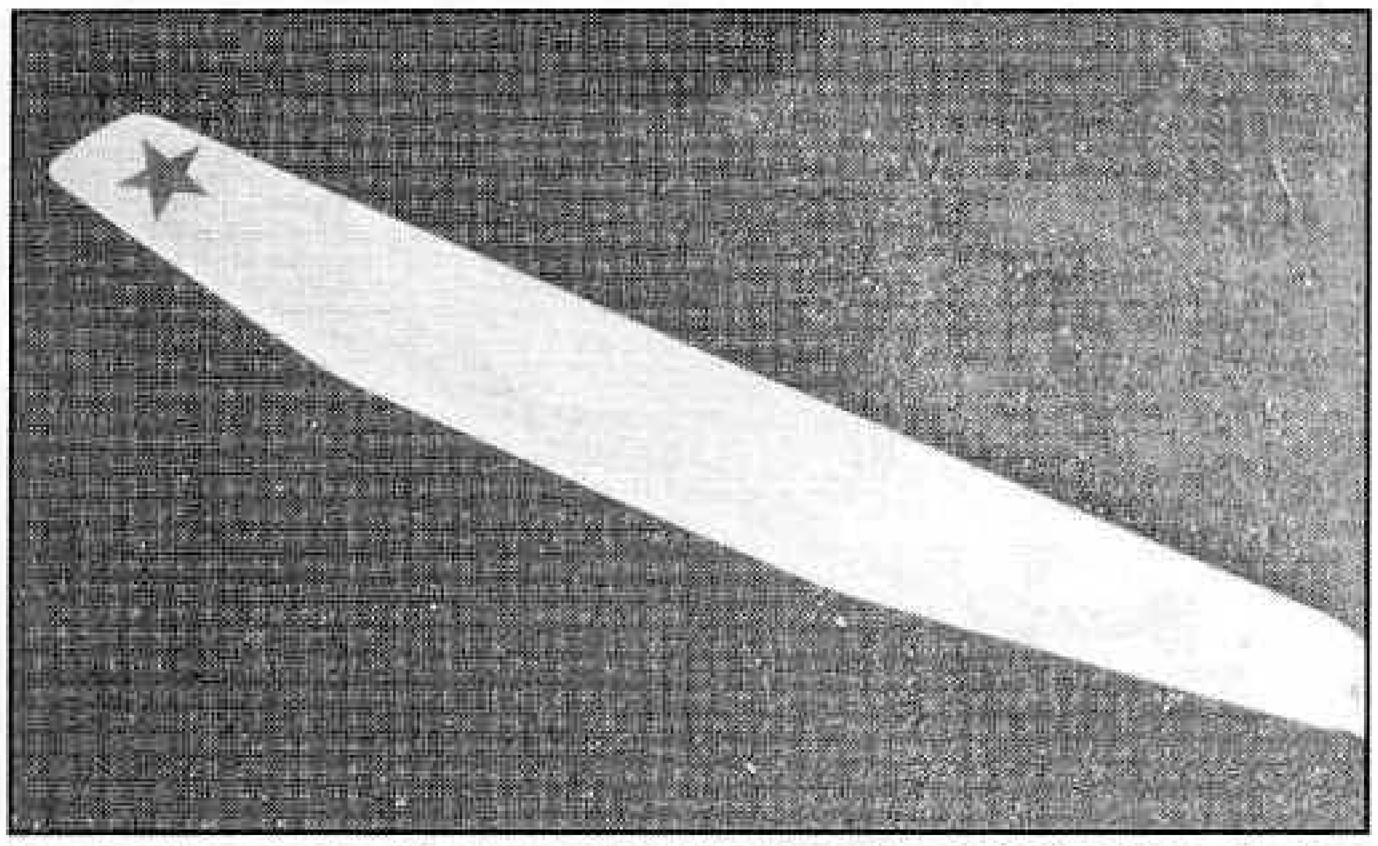
A drill guide is easily made from any sheet metal. Scribe a centerline on



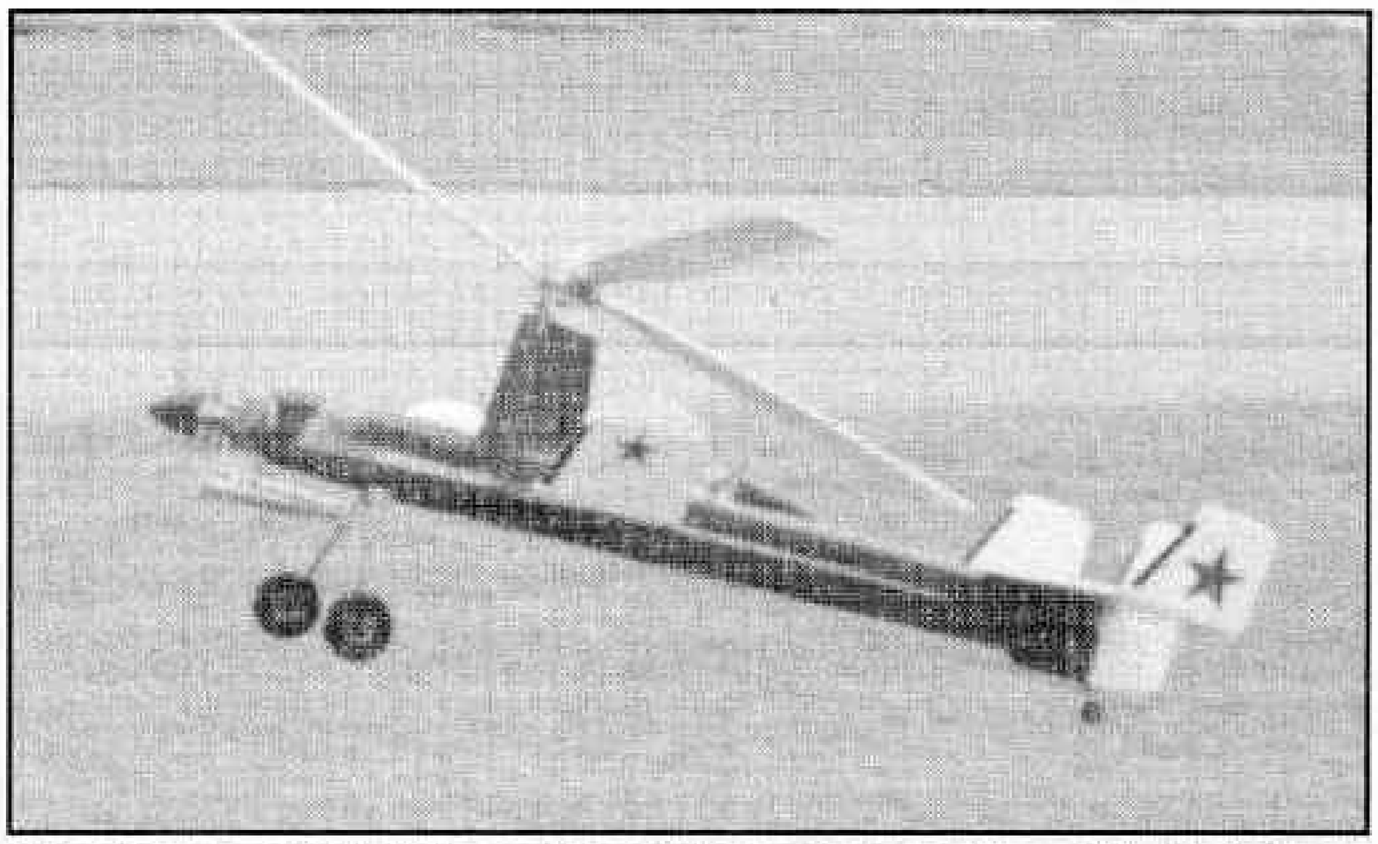
Blade hanger fabricated from sheet aluminum and piano hinges.



Rotor head and blade hanger installed, ready for flight.

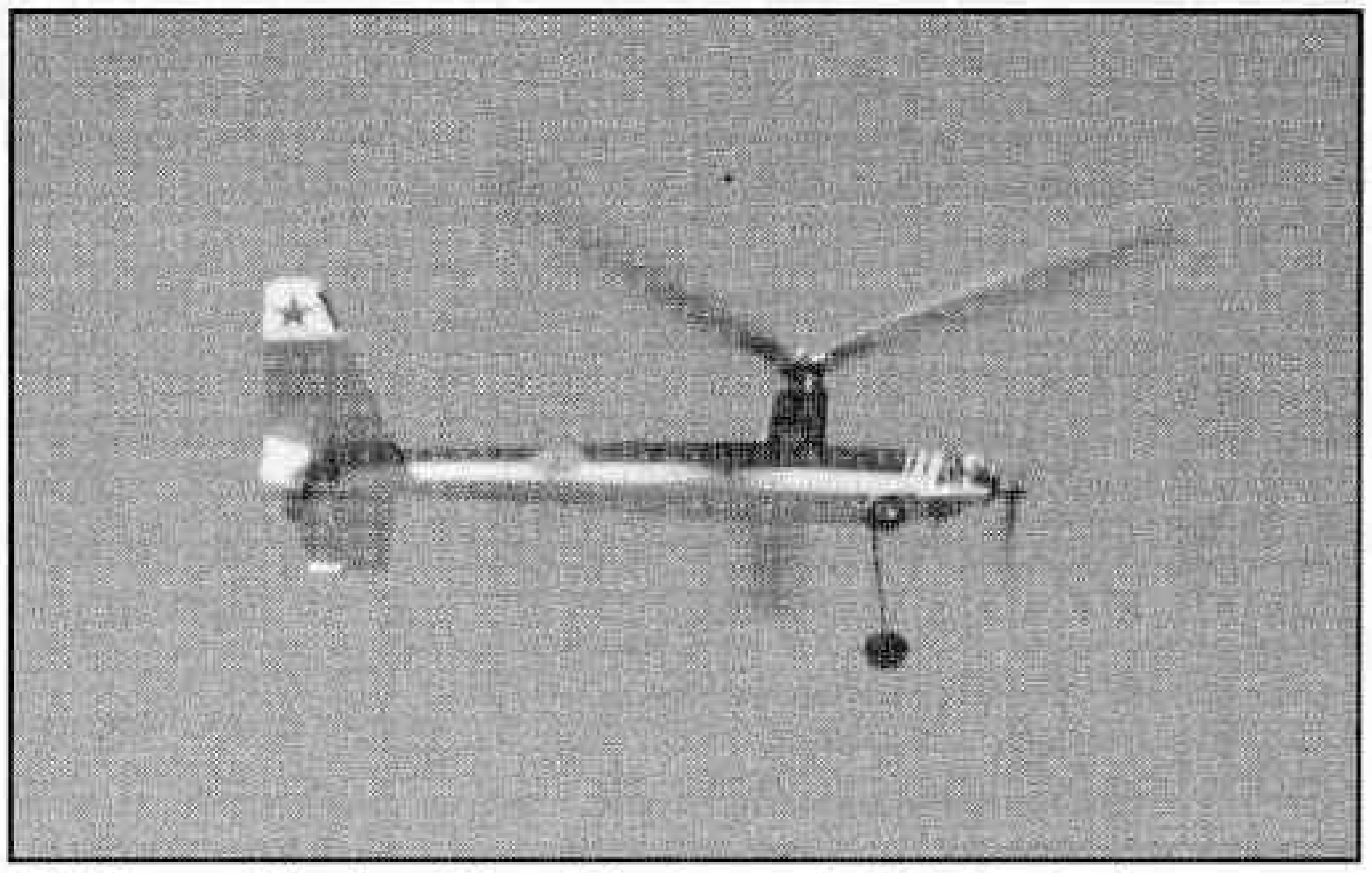


Typical laminated balsa rotor blade with airfoil reflex. Outer mounting screw is nylon which can shear in case of a blade strike.



Giro V on a quick take-off is airborne in less than 15'. Note how the extremely strong airstream forces the forward blades.

A slow fly-by.



A full speed fly-by without the forward stab. Control movement had to be reduced 50% to get acceptable control sensitivity.

a strip about 3-1/2" long. From one end, mark at 5/8" and 2-7/8", then drill 1/16" holes at these marks.

On each blade, place the drill guide on the ply attachment plate centerline with the 5/8" end aligned with the inner end of the ply and drill 1/16" holes. Using a 1/4" dia. brass tube, sharpened on the end as a hole punch, center the punch on the top of the blade, over the 1/16" holes, and cut down to the plywood, but do not cut the ply! Remove the plugs, then glue maple dowels in the holes. Drill and tap the inner hole 4-40 and the outer 6-32.

To complete the blades, a reflex is added in the form of 1/16" x 1/2" hard balsa. To install, anchor the aft bottom of the blades to the edge of the assembly board so the forward 2/3 hang over the edge. Pin the reflex piece flat to the board and glue. When removed, the reflex will be flat to the bottom with enough "up angle" on the top to accomplish its purpose.

To complete the blades, trim the reflex to flow into the center taper and 3" in from the tip taper to nil at the tip.

The blades must be balanced chordwise and later as a rotor. Chordwise is done now, but the rotor head is needed for the 2nd balance later. Insert a straight pin spanwise into the blades at the root and tip 1/1-4" back from the L.E. Support the pins on 1/2" risers and you will see the T.E. will drop. Take a 1/8" dia. x 3" piece of lead solder, and tape it to the outer leading edge. Gradually reduce the length of the solder until the blade balances horizontal on the pins. Measure 2" in from the tip and make a notch in the L.E. to accept the solder, then CA it in place. Set blades aside for later balancing on the rotor head.

Blade Hanger

As development progressed, whirlygigs encountered indicated a robust, precise blade hanger was required, so I used 2024 ST aluminum alloy and produced a quality hanger. Required is a 5" x 5" x .091" piece and three pieces 4-1/4" x 1-1/2" x .064", plus 12" of 1" aircraft piano hinge along with some 1/8" and 3/32" rivets.

Refer to the drawings included for details on this assembly. Begin by locating the center on the .091" piece. From the center, scribe three lines at a 120° angle. One inch out on each 120° line, scribe a line 90° to it. These are guide lines for assembly. Next, cut three pieces of piano hinge three sections long. Make another drill guide and mark a crosswise centerline on the guide; from one edge, scribe a line 3/16" from the edge. On this line, 1/2" each way from the centerline, drill two 3/32" dia. holes. At each hinge piece center segment, mark a crosswise centerline. With the guide's 3/16" edge held against the hinge furl, align the guide and hinge centerlines. Drill the 3/32" dia. holes. Repeat for the other two hinge pieces. Take one hinge and align its centerline with one of the 120° lines on the base plate so that the hinge pin center lines up with the 90° line. The inner edge of the hinge should be at the base plate center. Drill the 3/32" dia. holes through the hinge and the base plate. Insert 3/32" dia. rivets in holes to temporarily secure the hinge. Repeat the process for a second hinge. Note the two will overlap. Trim excess from each for a neat flush fit. Repeat the process with the third hinge and fit it to the first two. Be sure everything looks neat and correct. Enlarge the holes to 1/8" dia. and rivet in place. Carefully enlarge the base plate center hole to 1/4" dia.

Three two section hinges are required to mate with the three section hinges. Mark the center of them distinctly. Using the drill guide, drill the rivet holes and temporarily attach with hinge pins.

The blade hanger tabs are fabricated from the .064" aluminum. When laying them out, scribe distinct centerlines. When the outlines have been cut, stack and clamp all three hangers together and match outlines. Next, number each tab and its hinge. Take tab No. 1 and fit the inner end against the hinge furl and align centerline with hinge center and the base center. Clamp and drill the rivet holes. Install the rivets with their head on the bottom of the tab. Repeat for remaining tabs. On the blade hanger tab centerline, 1/4" from the edge of the hinge, drill a #43 hole through the tab and base. Tap the base to 4-40 and enlarge the tab hole to #33. Now, note the base plate where the 4-40 holes are. Leaving material around the 4-40 holes, remove all excess base material. The result should resemble the base plate in the drawing. Install the 4-40 riser screws.

Using the rotor blade drill guide, butt the 5/16" end against the 4-40 screws. Align the centerlines and drill the two holes. Tap the inner holes 4-40 and the outer 6-32. Repeat for other blade hanger tabs.

The blade hanger must be balanced and a prop balancer works fine. Not much balancing should be needed. Allow the hanger to oscillate until one side shows as heavy. On that side remove material from the base plate edges. If that should get out of hand, switch to the outer end of the blade tab. Any great amount needed indicates something is wrong, check! The hanger is in balance when, while cycling, it will stop with any blade tab pointing up.

Rotor Head

As with the blade hanger, development indicated a robust and precise operating mechanism was needed. With the extremely strong forces the rotor is affected by, the gear mechanism was developed to increase the servo power, and to help isolate the servo from vibration, etc.

Again 2024 ST aluminum alloy is used. This is bar stock which is available, along with all else, from Aircraft Spruce and Specialty Co., or you can check with your local aircraft supply.

Don't let the aluminum scare you; if you cut wood well, you can also cut metal, it just takes longer.

Tools required: Drill press with bits and reamers, disc sander, hacksaw, and coarse and mill 12" metal files, and a bit of persistence! If you should have access to a machine shop, do not hesitate to use it, the main difference would be time saved, but just so you will know it can be done, the prototype was produced without machine shop access.

This rotor head is produced using a simplistic "cut and try" method. The yoke is fabricated and all else is then fitted to it. There are only two close tolerances involved: bearing fit and carrier end play. This text will provide the procedure; refer to the drawing for details.

Yoke

The material for this is bar stock aluminum measuring 3/4" x 2" x 3". On the flat side, lay out the internal shape. Inward of the layout, close to the lines, drill adjacent 1/4" holes. Now, by hacksawing through the holes you can remove the excess material. Using a sander and files, finish the internal shape. Throughout production be sure to maintain squareness.

Next, mark the outside; the 5/32" wall thickness is not critical. Saw to a "rough outline." Using a disc sander, sand to the bottom of the outline, making sure that it is parallel to the inner edge, then finish-sand the two ends in the same manner.

The gears used are Boston Gears #G163 and #G175. The #G163 is a 12 tooth gear, and #G175 is a 32 tooth gear. The gears are the guide which locates the carrier pivots. Take the #163 gear and ream its hole to 3/16". Cut a piece of 3/16" dia. steel rod 3/16"+ long, then drill and tap it for a 4-40 screw. Center the gear on the inside of one end at the bottom of the yoke. Drill and tap the yoke to 4-40 to anchor the gear.

For the next steps, commence with a small "pilot" drill. Mesh the large #175 gear with the small one; centered on the yoke. Drill a pilot hole for its pivot. Now, erect the yoke vertically on the drill press; using the existing pilot hole, drill the opposite end of the yoke. To complete the operation, drill and ream both yoke pilot holes to 1/4" dia. if bushings are used. If ball bearings are used, enlarge the holes to a press-fit for the bearings.

If bushings are used, make them from 1/2" dia. bronze rod. Note that the shank of one is longer. Center drill the rod with a #29 drill bit. Turn the shanks to 1/4"+ dia. and, using the yoke as a guide, reduce the shank to a slip fit in the yoke holes. The shorter bushing is cut off about .003" longer than the yoke thickness; nominally 5/32"+. The longer bushing is about .003" longer than the yoke wall plus the #175 gear thickness.

If ball bearings are used, ream the yoke holes for a press fit. Press the bearings into the yoke so that their outer rim is flush with the yoke inside surface.

Carrier

Cut a piece of 3/8" x 1" bar stock 1-7/8" long and put a centerline on it. 11/16" from one end, drill and ream for a press-fit for the two rotor shaft bearings. (A double race bearing would also be suitable.) Mounted vertically in the drill press, and centered on each end, drill the holes and tap to 6-32 for the pivot screws.

Place a centerline on the #175 gear. Spaced 3/8" from center on the line, drill two 1/16" dia. holes. With the bushing or, in the case of bearings, a suitable piece of 1/4" rod, attach the gear to the carrier. Using the gear holes as a guide, drill the carrier 3/8" deep. The gear is locked to the carrier with 1/16" wire pins in these holes.

Next, the outline of the carrier is shaped with a hacksaw and the sander. Leave the length slightly oversize. With judicious use of the sander, reduce the length to a slip-fit in the yoke. Now the excess #175 gear material is removed to match the carrier shape.

To complete, fabricate the control arm from brass for wear purposes. Drill its pivot hole using a #35 bit. Assemble the head with carrier in "neutral" and adjust the control arm so it is also "neutral." Mark a gear tooth and the arm for reference. Remove the gear and arm. With "Sta Brite" silver solder, tin one side of the gear and the arm. Using the guide marks, sweat solder the arm to the gear.

Assemble the head and check operation; it must move freely, if not, check for interference and adjust.

A 1/4-28 aircraft hex head bolt serves as the rotor shaft. The length is determined by the attachment needs for the "pre-spin" spinner. A prop driver washer spaces the blade hanger from the bearings. The blade hanger and spinner backplate are held to the shaft with a nut and washer. Chopper people have labeled this the "Jesus Nut," so do be sure it is locked down tight before flight, the whole Giro depends on it!

Note that the rotor head is attached to the pylon with a 10-24 screw and a #6 screw is used for alignment.

After installation, the head control arm is operated directly from the servo with a straight pushrod. Note that this heavy duty rod is a necessity, as any "normal" rod will break or bend. The rod is .078" music wire. The threaded couplers are made from 6-32 steel screws. The ball links are heavy duty 1/4" balls available from Rocket City Specialties.

Fuselage

The simplicity of the "box style" is a real time saver for assembly. Note that to disguise the box a bit, both top and bottom have a curvature. The forward section is of 3/32" five-ply plywood which absorbs all loads: power, landing gear, rotor, and R/C equipment. The balsa aft section is spliced to the ply.

The "centerline" method of assembly assures a true box. First a centerline is marked on the assembly board with bulkhead stations located on it. A vertical centerline is on each bulkhead. Bulkhead locations are also marked on the pre-assembled ply-balsa sides.

To assemble, all bulkheads except the firewall are erected on the board using the centerlines, and are held erect by "CA spots" at their outer edges. The sides are formed around the bulkheads and CA'ed in place. Rubber bands are used just aft of the firewall to pull the sides together and hold the firewall in place while it is glued. Check firewall alignment carefully. Note the internal structure required and install as much of it as possible while still on the board. Using the pylon bulkhead spar, assemble the pylon structure and add the sheet covering.

"Windex" cleaner sprayed on the outside of the top sheeting will automatically help form the curvature. Place the sheeting on the fuselage and mark the plan view shape. Rough-cut the shape a bit oversize. The sheeting is attached with aliphatic glue, coating all contact edges. The sheeting is held in place with masking tape and pins until the glue dries. When dry, the CA spots are broken free with a razor blade. Once removed, any remaining internal structure is added to the fuselage. Servos and pushrods are then installed followed by the top and bottom sheeting.

Not mentioned previously are the two hatches. The appropriate openings for these are finish-sized. The hatch frames are assembled in the openings, then the frames are covered off the fuselage.

Prepare for covering by finish-sanding, be sure to round the top and bottom sheeting neatly into the sides.

Flying Surfaces

All these surfaces use the same structure, stressed skin, sheeting over ribs, and all the airfoils feature Phillips entry as an added advantage. A 1/16" jig strip under the leading edge of the bottom sheeting accomplishes this. The horizontal tail will be described in detail; all else follows the same procedure.

Install two short pieces of 1/16" wire in the L.E. support using CA glue. Install the supports including the T.E. alignment wire and press the L.E. pins against the fuselage sides to locate their alignment holes.

The forward stabs are secured in place with 6-32 setscrews as the drawing shows.

Tail

First, on the stabilizer seat centerline, using the stab hole as a guide, drill and tap the forward hole to 6-32 and attach the stab with a nylon screw. On the top center of the firewall, install a straight pin. From this pin, measure to the stabilizer T.E. at the tip, on both sides. Adjust until both measurements are equal. Drill and tap the aft hole for 6-32, and install its screw. Now, set the Giro so you can "eyeball," from a distance, the relation of the stabilizer to the forward vertical stab supports. The rear and forward surfaces should align. If not, adjust the rear stab seat until they do.

Rudder

Adjust the rudder so that it is offset 10° to the right. This offset prevents the craft from "pinwheeling" under the rotor when in the hover mode.

Rotor

For this, a simplistic gauge is required. Take a piece of 1/8" x 3" x 5" hard balsa and square both ends. On one 5" side, produce an edge that represents a 2° angle. One end will now be narrower. Mark that end **forward** and the uncut edge **bottom**.

Attach the rotor blades to the hanger and place the hanger on a flat surface (table?) large enough so the blades can be referenced to the surface. Each blade and its hanger are now (1-2-3) numbered for reference. It helps to weight the hanger so it is solid to the surface. First, note if each blade is the same distance from the surface; it should be, if not, bend the hanger tab until all are about equal.

Next, using the 5" portion of the gauge, raise a blade until the tip sets on the gauge. Lock the 4-40 riser screw so that 5" is the maximum the blade can rise. Repeat for the remaining two blades.

The alignment is then completed by setting each blade's incidence angle using the gauge. Place the gauge under one blade in the tip area. It must lay flat on the gauge; if not, the angle is adjusted with common plastic electrical tape. Perhaps the L.E. is a bit above the gauge. To correct, remove the blade and place a strip of tape on the bottom of the blade next to, and parallel with, the rear edges of the attachment holes. When rechecked, the blade should lay flat on the gauge. If not, add another strip of tape. Should the T.E. be high, the tape is placed against the front edge of the holes. For future reference, one layer of tape changes the incidence about 1°.

Repeat the process for the remaining blades. It is important that all blades lay flat on the gauge in the same manner. Variation in incidences can cause abnormal articulation and/or vibration which is not good!

Rotor Balance

The rotor must be balanced as a propeller would be. With the rotor head on the pylon, install the rotor. Lay the model on a table edge for clearance and prop the fuselage up near vertical so that the rotor can easily cycle. Allow the rotor to stop rotating; one blade will probably hang down as a heavy one. Examine the down blade for any obvious difference from the others. If it appears the same, take some 1/16" dia. x 1-1/2" finishing nails and tape one to a high blade. The static position will change, the "other" light blade should now be at the top. Tape a nail to it. Allow rotor to cycle to a stop, if one blade persists in being at the top, tape a nail to that one. Continue the process until the rotor will stop with any blade uppermost. It may take some "partial" nails to obtain perfection. Once balance is achieved, drill 1/16" dia. holes spanwise in the tips, forward of the 1-1/4" line and CA the nails in the holes.

Rotor Head

Using the fuselage hatch edges again as reference, level the Giro with the rotor head operable. Drill a 1/4" hole at the 18" mark on a yardstick. Fasten the yardstick to the head and adjust the head so that the yardstick tilts 5° towards the right (retreating

Horizontal Tail

The entire surface is assembled in one piece. On completion, the elevator is separated from the stabilizer with a razor. The assembly is simple and goes together quickly. Size the bottom sheeting and mark the rib locations on it. Pin to assembly board with the 1/16" jig strip under the leading edge. Locate and cement in place the stab. trailing edge and the elevator leading edge, then add the ribs. Install the ply screw plates, then the top sheeting can be installed, again with aliphatic glue.

Stablets & Rudder

These are assembled using the same type construction as was the horizontal tail. Note that a right and left stablet is required. When completed, solid balsa spacers are added to the stabilizer tips. On these, the curve of the stablet airfoil is scribed on top at a 2° negative angle to the craft centerline (L.E. is farther out). Cut the shape and fit the stablets. The stablets are also tilted 15° outwards. To attain the tilt, scribe the airfoil shape inward and parallel to the top shape on the bottom. Removing a bit at a time, connect the bottom line to the top edge creating the tilt at the correct angle. Remember, these stablets produce work, so the tilt angles must be identical. When the fitting is complete, cement the stablets in place.

Rudder

The rudder is assembled and finished in the same manner as the drawing shows. A piece of piano hinge is used for both the tail wheel and rudder, and both the fuselage and the rudder are slotted with a hacksaw blade to accept the hinge. After finishing, at final assembly, the hinge is glued in place in the slots using CA.

Forward Vertical Stabilizers & Support

It was found that these stabilizers add considerable lateral stability. While not necessary for flight, the advantage that they offer is useful, so they have been made detachable. Much of our flying is done to test and evaluate various rotor features and the forward stabs add insurance when reaction to different features is unknown. They also would be an aid when first learning to fly a Giro. Begin their construction by producing the hardwood joiner. Maple is preferred here, but similar wood should do. Wrap the joiner with "Saran Wrap" thin plastic, and assemble the plywood joiner boxes on it, which should be a tight fit.

Assembly is the same as for the tail except for some required alignment. First, size the bottom sheeting, note that the support portion requires a 2° angle where the vertical stab joins. To assure that both angles are alike, stack the sheeting before cutting the angle.

Anchor a straightedge to the building board (yardstick?) and place the L.E. of the bottom sheeting against the yardstick, spaced the fuselage width apart. Don't forget the 1/16" jig strip under the L.E., also be sure the angles cut are negative to the fuselage centerline (for example, the L.E. is farthest out). From 1/8" sheet, make the "jigs" with 45° angles. Using the jigs as a guide, block up the tip stab bottom sheeting so it joins the support sheeting, and CA in place. Note the location of the joiner boxes on the support sheeting and align them with a straightedge and the joiner. Notch the bottom sheeting to fit the boxes and cement them in place. Next, install the spars and ribs and follow by adding the top sheeting. Sand to the finished shape, and then CA the T.E. 1/16" dia. I.D. alignment tubes in place.

Alignment

Assuming the entire craft is built, it is now aligned before covering and finishing. The fuselage in the bottom hatch area is the guide for this. Carefully notch the fuselage sides at the forward edge of the pylon bulkhead so the joiner is a tight fit.

A yardstick is used again as a gauge and is attached to the hatch edges horizontally forward of the pylon using a rubber band. Install the forward stabilizers and check that they are parallel to the stick; if not, adjust the notches.

Next, the stab support incidence is established. Adjust each support so its bottom surface is parallel to the fuselage edge, with 0° incidence. Using the T.E. tubes as a guide, drill the locating holes in the fuselage. A length of 1/16" dia. wire through both holes aligns the two structures.

blade side). Large changes are done with the gear mesh, minor with the pushrod linkages.

Covering And Finishing

Today, most are film users, right? Know that, in the interest of expediency, Giros early in this development were film-covered. Only the tail of Giro V has film. The remainder is 3/4 oz. fiberglass and epoxy resin, which is highly recommended for its durability. Rustoleum spray enamel also is fine.

Wind Check

At this point, you may be curious whether the rotor will operate as needed. In a breeze much can be observed; 8 to 10 mph is ideal. A wind check is made by holding the Giro vertical with the bottom of the rotor facing the wind. The rotor should cycle immediately and quickly gain rpm. At about 300 rpm, a "pull" should be evident, at 400 rpm the pull should be strong, indicating ample lift. At this point, you should check for blade tracking and vibration. Any vibration should be minimal; if not, locate the cause. When viewed from the side of rotor, it should appear "solid," as if it were about 1" thick. If thicker, there could be interference at a blade's riser screw or all three incidence angles are not identical. Find the cause and correct it at this time. Such a wind check is good insurance that flight will be satisfactory.

Preflight

First, of major importance, is engine operation. Make sure that the engine operates perfectly, especially at idle speeds which are used so often with a Giro. Check your radio operation and be sure your batteries are in good condition and fully charged. Are all controls in their preset neutral positions with all the controls moving in the proper direction? For example, with tilt rotor, the right Tx stick must tilt rotor right (a Giro banks in the direction of the tilt).

Balance

The balance is checked in the fuselage hatch area by placing a riser under the Giro so it is clear of the table. Next, place a piece of 1/4" sq. balsa between the riser and the fuselage, and move the fuselage until it rocks on the stick. The balance must be in the range shown on the plans. At the forward point, flight will be ultra stable, which is a good starting point. The aft point produces maximum maneuverability, and is best left until testing is complete. It will do no harm to add ballast to bring the balance within the range shown. Finally, give it a good look-over to be sure all is in order.

Control Actions

It could be said that a Giro has two flight modes; with power on, it is similar to an airplane. At low power, it is much like a "powered parachute," with the rotor acting as a chute does. This results in a different control response which is actually nice. A forewarning can give correct anticipations.

Engine Power: For the most part with this Giro, power is used to adjust flight speed. The exception is the hover and at very low speed flight where power is used to maintain altitude. Don't expect to be tooling around at full power constantly, as is frequently done with an airplane. A Giro's attributes are best seen at partial power, only vertical climbs require full power.

Rudder: Rudder action is positive and is handy when needed. With a tilt rotor, it is seldom used in the air, but remember it is available for turning ala an airplane, and it is a must to hold take-off headings.

Elevator: Elevator action is also positive. The response is immediate but not sensitive. The elevator is primarily used to change vertical headings. If you want to climb, raise nose with elevator and go! If you want to lose altitude, don't use down elevator; instead, reduce power. "Down trim" is okay to adjust level flight. Up elevator is used to hold the nose up at very low speeds and when in a hover.

Tilt Rotor: The tilt action is similar to ailerons and is a docile control that effectively banks the Giro. Like ailerons, full rotor deflection will set the Giro on its side. However, once on its side, elevator can be used to create a pylon style turn when a quick change of direction might be desired.

Directional trim is accomplished with both rudder and rotor tilt. If the craft appears to yaw, trim it with the rudder. If flight is not level laterally (banked), the rotor is tilted to compensate. An accomplished airplane pilot quickly adjusts to the differences without mishaps plus the differences really add to one's piloting ability!

Flying

Now the fun part comes! At first it can be easy for the unaccustomed to lose orientation with the Giro. So, until you get accustomed to it, just do not fly at a distance. It you get disoriented, note the rotor disc as it is usually easy to see and will indicate attitude. Giro V Mk II had a two-tone fuselage and the difference proved to be advantageous. Giro V's flight has always been from a take-off and there never has been an abort.

A trouble-free straight and true take-off is assured when pre-spin is used, as with full-scale Giros. The rotor spinner allows the rotor to be spun up using a high-speed engine starter or, as we do, with a B&D 700 rpm electric hand drill. The idea is to attain 400 rpm or more.

Prior to engine start-up, we attach about 3 ft. of cord to the tail wheel bracket. The take-off procedure is to make a positive check of the wind direction, no matter how light. Point the Giro directly into the wind. Until experience is obtained, an assistant to wind up the rotor is a must. The pilot anchors the Giro with a foot on the cord, then with the engine at full power, the assistant pre-spins the rotor. When max rpm is seen, the starter is released and the pilot quickly steps off the cord. The elevator is left in neutral and heading is maintained with rudder. After 30' to 40', a touch of up elevator will create lift-off into a shallow climb. On climb-out, rotor tilt is used to level craft. Note: "quick offs" are possible with experience. For these, up elevator is applied at release, the Giros will lift off in about 15' into a steep climb.

At a safe altitude, tilt the rotor to create a shallow turn back. Then, reduce power to 2/3 and note the Giro's attitude. It should be level both with the horizon and laterally. If not, correct with elevator and/or rotor tilt to attain a true flight path. If the direction should be off, use rudder trim for that. This being a first flight, a smart move would be a few close in laps to get a feel for appearance and control response, then land. Once down, note where the required trim took the control surfaces and adjust the linkages to create the new "neutrals." Note, that if excessive right tilt trim was required it, can reduce left tilt action. Find the cause for the need for excessive trim and correct it. After you have your Giro trimmed for flight, the needed experience is gained by practicing slow flight. For this, start from a distance and at some altitude; then, with the model coming towards you, reduce the power until your Giro starts to sink. As this occurs, forward speed will be slow, so gently add up elevator and sink will stop. Reducing power further while using elevator to hold altitude, the Giro will be in a nose-high attitude and at a very low speed. Minimum safe low-speed flight will be with power slightly above idle speed. In this mode, experience with the control actions is gained.

The nifty Giro maneuver is the hover. This is started at a distance by reducing to about half power. If there is some sink, counteract with up elevator. As the craft approaches, reduce power further, again holding altitude with elevator. The nose will be high, but no problem since a Giro will not stall! When close by, reduce power to a fast idle and use elevator as before. If the craft starts to sink, gently increase power and the Giro will hang in the air. Forward speed will be very little, or none, if there is a slight headwind. A vertical descent is achieved from the hover maneuver. For the descent from a hover, instead of adding power to hold altitude, allow the Giro to sink. It will drop slowly, but to stop the descent, add a bit of power to go back into hover. If forward flight is desired, reduce up elevator. During these ultra-low speed maneuvers, tilt rotor is used to keep the Giro level, and rudder is used to maintain heading.

From these basics, all other Giro goodies are contrived. One note for touch and go's. Once grounded, add power quickly before the rotor speed slows down.

None of the Giro flying would be termed difficult by any accomplished pilot, but you should find it different and enjoyable, and, of course, quality will improve with practice! Do have fun while learning more and more.

Postscript To Giro V Article

It has been over a year since the Giro V concept was completed. Since that time, considerable flight time and experience has been gained. While Giro V is all that it has been said to be, more flight experience has shown the use of the forward vertical stabilizers in comparative flying to add considerable stability, control action is less sensitive, and it does only what you ask, easier and better. While both versions perform well, with the forward stabs less attention to flight is demanded. The point is, with or without the forward stabs, flight is possible and okay, but if you're not seeking a particular appearance, the "with" version is more enjoyable to fly.

Material Sources:

Aluminum — aircraft suppliers such as: Aircraft Spruce & Specialty, P.O. Box 4000, Corona, CA 91718, (909) 372-0555.

Boston Gears — Boston Gear, 14 Haywood St., Quincy, MA 02171, (617) 328-5690. Los Angeles area dist. for Boston Gear: L.A. Rubber Co., 2915 E. Washington, Los Angeles, CA 90023, (213) 263-4131, ask for Kevin Malone.

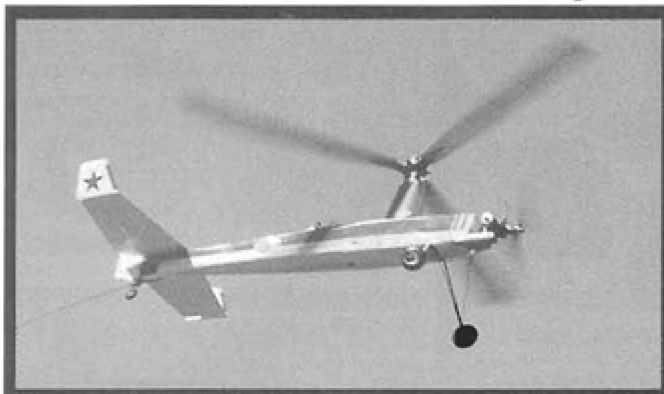
Ball Bearings — local bearing suppliers or Boca Bearings, 7040 W. Palmetto Park Rd., Boca Ratan, FL 33433.

1/4" Ball links — Rocket City Specialties, 103 Wholesale Ave. NE., Huntsville, AL 35811, (256) 539-8358.

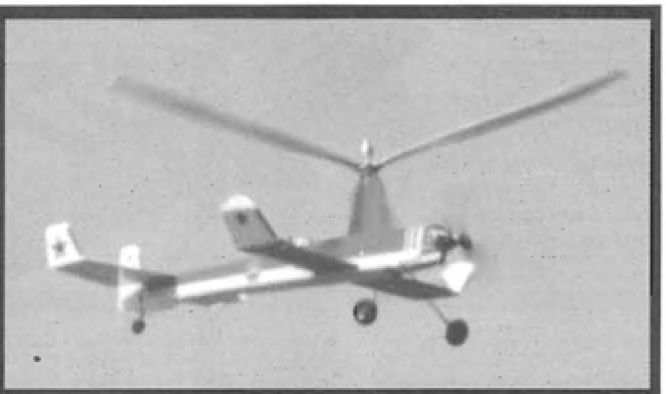
GIRO V

IMPROVEMENTS AND UPDATES

By Hal deBolt



At some altitude, from the side view, the rotor is also a help with orientation on a quick fly-by.

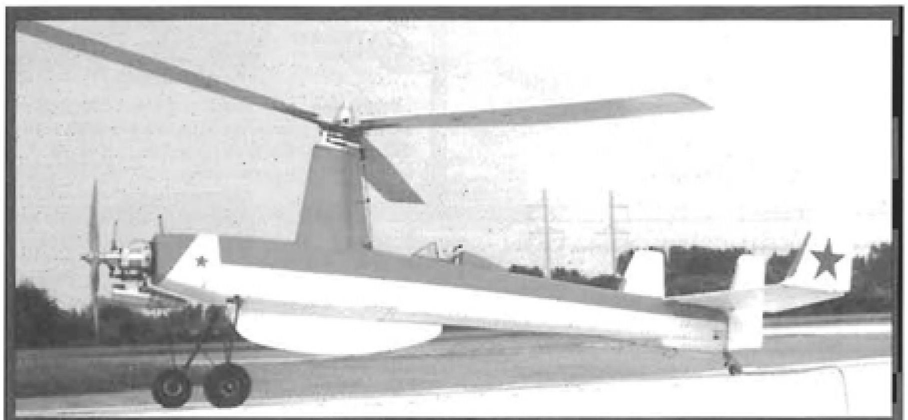


Giro V in a vertical descent. During maneuvers, keeping Giro in a level attitude requires good visibility for needed control inputs.

To determine if a "wing separator" had any effect on performance, the "wing" was eliminated and stability was as good or better. The "wing" apparently offered little help in other respects.

For our test, "winglets" were used as forward vertical stabilizers. Rod separators are "arrow shafts."

No doubt you have noted and perhaps studied the Giro V presentation in the February, 2000, issue of *RCM*. Giro V is the culmination of extensive development to produce a practical giro suited to the average RC'er. The concept was finalized over a year ago, and we have continued an ongoing effort to reach the ultimate in autogiros. After many flights, it is well proven and provides answers and appeal. Additional progress has now occurred and the findings are positive and, hopefully, helpful!



Another lateral stability experiment was a ventral fin to increase lateral area. Showed some improvement, but no equal-to-forward vertical stabs.

First, let's look at some basic improvements. A giro rotor presents a minute amount of "torque force" via rotor bearing friction. With Giro V, it was found that this miniscule force could cause the giro to spin, turn flatly (pin wheel) beneath the rotor to the left, during the hover maneuver. The cure for this was to use substantial right rudder trim. Since, for reasons encountered with current development, a desire was seen to eliminate the rudder trim and counteract torque in another way. You are all aware of the use of engine offsets. Understanding their action is required to fathom what was found.

When thrust is applied at an angle to a craft, the magnitude of the force being applied is greatest when thrust is at maximum and craft speed is lowest (example: just as the craft is released for take-off). From that point on, as the craft gains speed and thrust is full, the path with all of it in front of him while he stands still. Old habits are hard to break and your author was no exception, insisting on flying airplane style, which resulted in an occasional disorientation. I initially blamed it on "old eye sight," until another disaster brought on some serious thought. The solution was so simple, it was hard to believe. First, of course, flying "close in" is a great help and always looking at the side of the giro would be a major advantage. If you fly in a circle around you, the side view is always what you see. Instead of off to one side, you stand in the middle of the flight path. Obviously, you have to keep turning with the model, but then maybe we could all use a little exercise! Perhaps you still prefer "race track" style, which should be similar as long as you stand in the infield (middle) as with the circle. Orientation was vastly improved in this manner, but the major problem was breaking that old habit. Live and learn!

Finally, recall that with Giro V, we expounded on the value of forward vertical stabilizers (F.V.S's) for adding considerable needed lateral stability. Originally, when it was decided to try them, separation was a need. A simple way to achieve separation appeared to be a "wing-like" separator that could be removed as desired for evaluation and comparison. When comparing flight with and without the separator, with the separator was by far the better flight.

This use brought comments such as, "You use a wing, in spite of the infinitesimal size of the separator?" Ignored was the supposed value of the F.V.S's. as shown with Giro V; they do the job and are a distinct asset. However, with something new, we always wonder if it works until positive proof is established. The F.V.S's apparently work fine, but a question remains: Is that wing-like separator helping also? We are investigators, so it must be determined if the F.V.S's are the only workhorse. A way to find out is to eliminate the wing-style separator. Decision: mount the F.V.S's on rods. As the photo shows, we did just that. Numerous flights prove the point: it is those F.V.S's which create the stability!

Conclusion: forward vertical stabilizers do add distinct stability and are a most useful asset. To mount them on rods as a separator, proved a far greater and more complex chore than the "wing" had been. Flying with a "wing" is far more efficient and much easier than using the rods. Why not try the F.V.S's on a wing separator and see the difference?