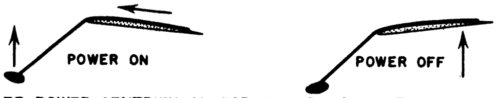
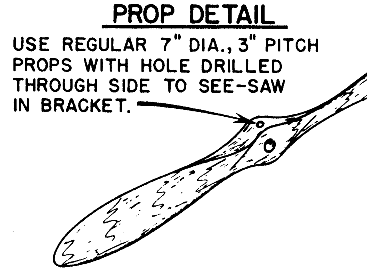
HOW IT WORKS

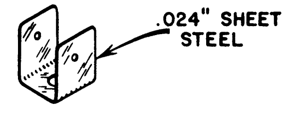


UNDER POWER, CENTRIFUGAL FORCE INCREASES PITCH OF MAIN ROTOR ABOVE HORIZONTAL, CONTRIBUTING TO LIFT OF SMALL PROP. WHEN POWER IS OFF, THE ROTOR CONTINUES TO SPIN IN THE SAME DIRECTION DUE TO AIR PRESSURE ALTERING ANGLE OF BLADE, PLUS DYNAMIC WEIGHT SERVING AS A "GOVERNOR" ON ROTOR SPEED.

WITH POWER ON IN FLIGHT, ANY GUST DISTURBANCE IS MET BY SHIFTING OF BLADE POSITION, WHICH CREATES AN OPPOSING FORCE. THUS THIS MODEL CAN BE FLOWN UNDER POWER IN A WIND WITH GOOD RESULTS, HOWEVER, WHEN POWER IS OFF STABILITY IS CONSIDERABLY LESS, INCREASING THE RISK OF DAMAGING THE MODEL ON LANDING DUE TO EXCESSIVE DRIFT. THEREFORE FLY IN CALM OR "LIGHT AIR" WEATHER, AND KEEP AWAY FROM TREES AND BUILDINGS AS ROTOR WILL "SUCK IN" DUE TO LOW PRESSURE AT THE TIPS.

PROP DETAIL



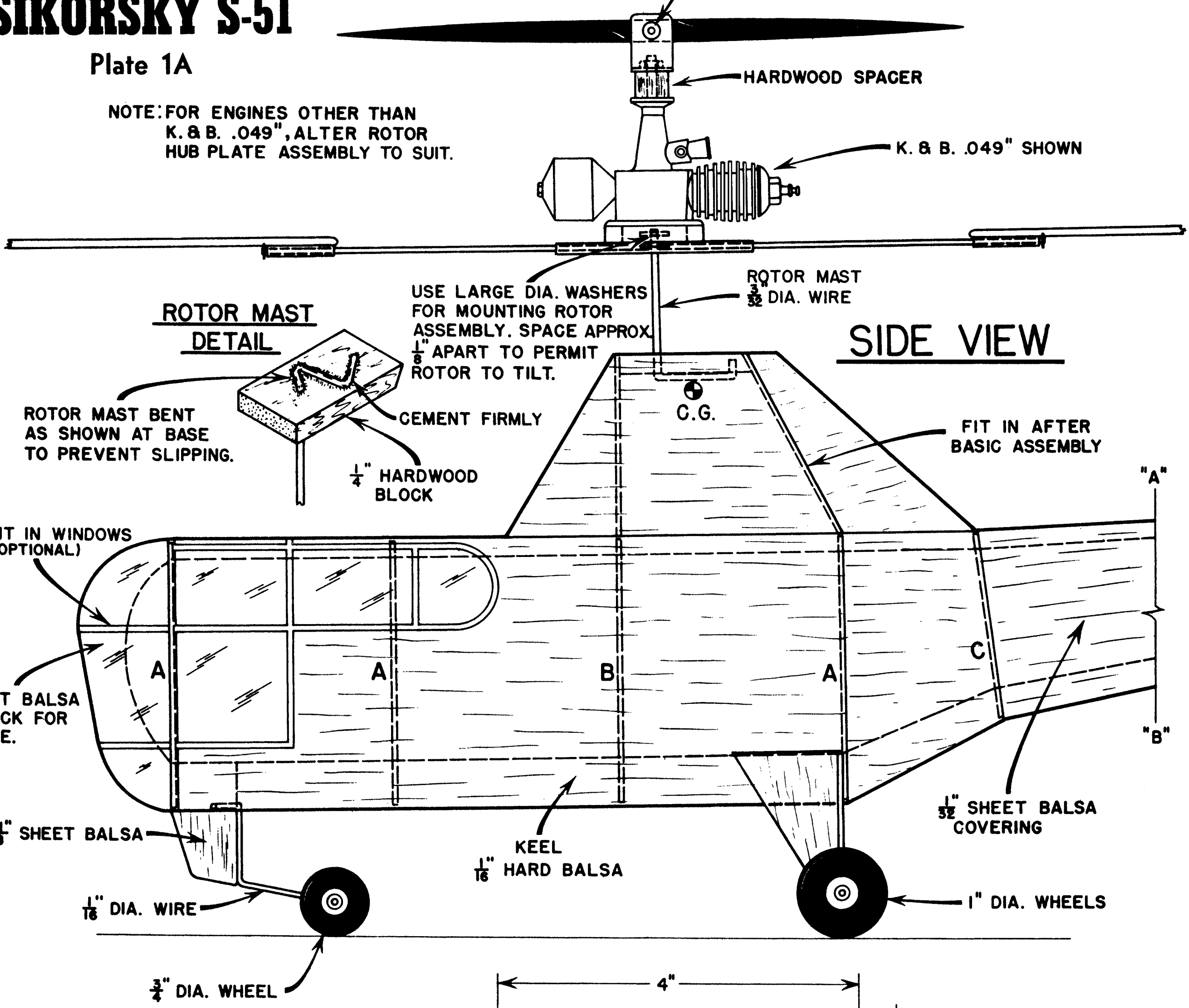


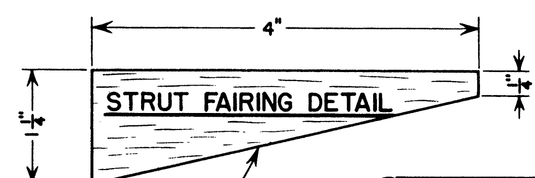
PROP BRACKET DETAIL

SIKORSKY S-51

Plate 1A

NOTE: FOR ENGINES OTHER THAN K. & B. .049", ALTER ROTOR HUB PLATE ASSEMBLY TO SUIT.

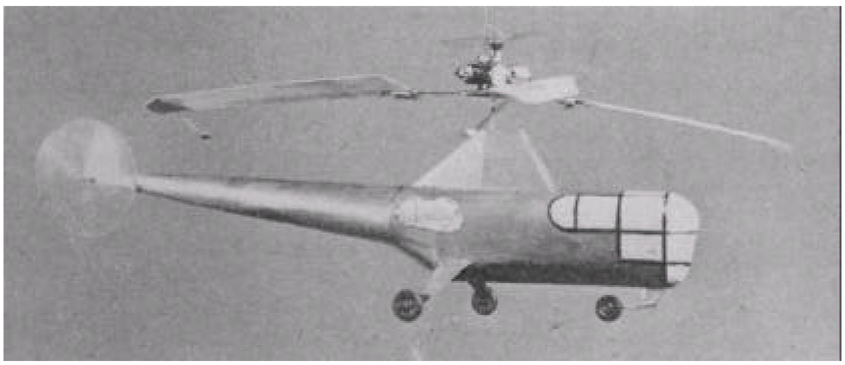




FOR THE EXPERIMENTER

ORDINARILY A BRAKE IS REQUIRED ON DRIVES OF THIS TYPE TO PREVENT FUSELAGE FROM SPINNING IN BLAST OF SMALL PROP. THIS DESIGN IS NOT SUBJECT TO THIS CONDITION BY REASON OF ITS SHAPE. HOWEVER, FOR AN ORIGINAL DESIGN YOU MAY REQUIRE ONE.

P. D. G.



Above: A shot of the full-scale Sikorsky S-51 helicopter in flight. About the only real difference between the real one and the model is that the aft rotor on the model does not turn. Instead, it is replaced by a celluloid disc that supplies ample stability to keep the model flying straight.

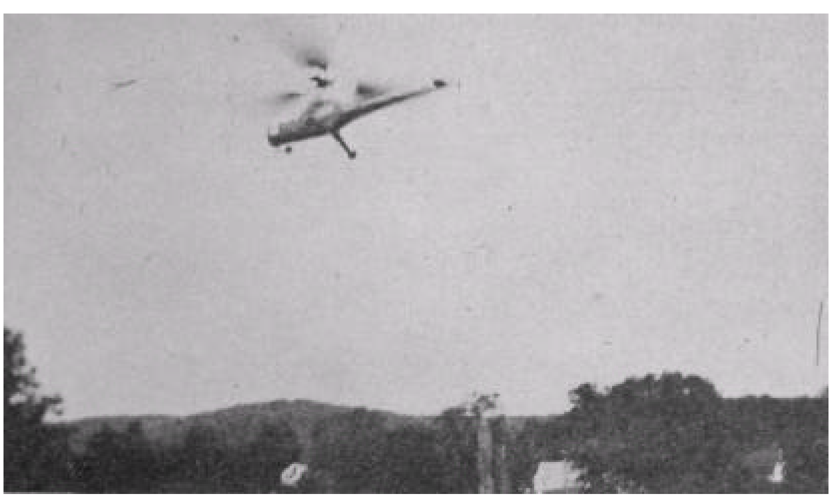
Left: A still shot of the model hanging from a string. The prop was held rigid for this shot so as not to tilt the model: The working prop is mounted so that it will swivel on the prop shaft, as shown on the plans. The ship is made of sheet balsa sides cemented to sheet balsa formers, with a simulated cockpit.

SIKORSKY S-51

by Roy L Clough, Jr.

In answer to many requests for a realistic helicopter that actually flies, we offer this semi-scale Sikorsky.

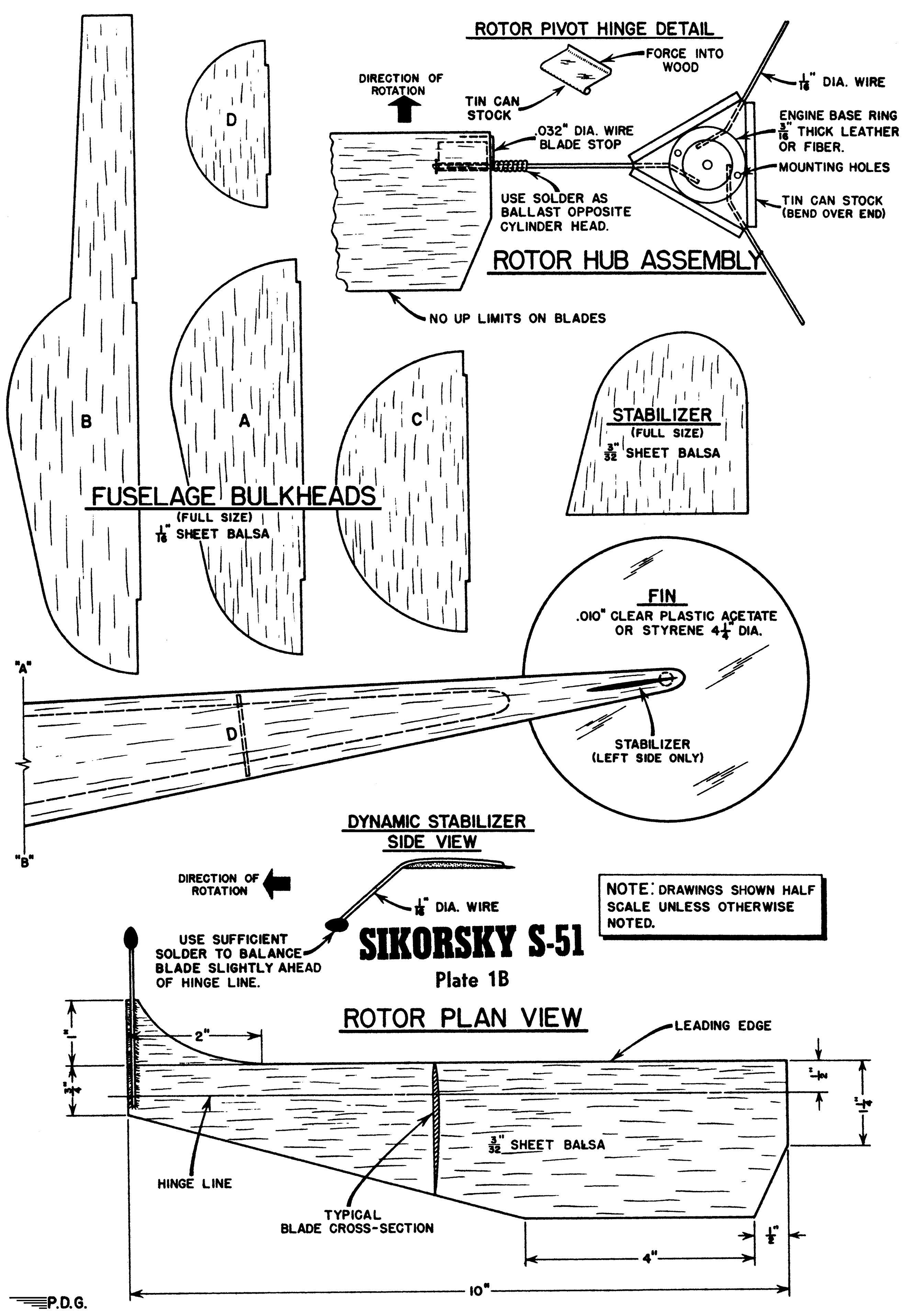
A good action shot showing the model in actual flight. Performance is realistic with no danger of hard landings when the engine cuts as freewheeling vanes ease the model down.



• Probably the most famous design of pioneer helicopter builder Igor Sikorsky, the S-51 helicopter has racked up an impressive record in life-saving and rescue operations, both at home and abroad. It is the standard unit of Los Angeles Airways, first airline with scheduled helicopter operation, and has been manufactured in England by Westland under license from the parent company. In addition to its performance record, it is generally agreed to be the most beautiful rotary wing craft ever built, with clean flowing lines that adapt themselves readily to scale model practice.

The big ship uses a three-bladed rotor of the type known in the trade as the "flapping blade" or articulated system. This rotor type has an extreme degree of maneuverability with rapid control reactions and is quite stable in normal cruising flight. The torque effect of the

(Please turn to Page 34)



ROTOR PIVOT HINGE DETAIL
FORCE INTO WOOD
TIN CAN STOCK
DIRECTION OF ROTATION
1/16" DIA. WIRE
ENGINE BASE RING 3/16" THICK LEATHER OR FIBER.
.032" DIA. WIRE BLADE STOP
MOUNTING HOLES
USE SOLDER AS BALLAST OPPOSITE CYLINDER HEAD.
TIN CAN STOCK (BEND OVER END)
ROTOR HUB ASSEMBLY
NO UP LIMITS ON BLADES
D
B
A
C
STABILIZER (FULL SIZE)
3/32" SHEET BALSA
FUSELAGE BULKHEADS
(FULL SIZE)
1/16" SHEET BALSA
FIN
.010" CLEAR PLASTIC ACETATE OR STYRENE 4 1/4" DIA.
"A"
D
STABILIZER (LEFT SIDE ONLY)
"B"
DYNAMIC STABILIZER SIDE VIEW
DIRECTION OF ROTATION
1/16" DIA. WIRE
NOTE: DRAWINGS SHOWN HALF SCALE UNLESS OTHERWISE NOTED.
USE SUFFICIENT SOLDER TO BALANCE BLADE SLIGHTLY AHEAD OF HINGE LINE.
SIKORSKY S-51
Plate 1B
ROTOR PLAN VIEW
LEADING EDGE
2"
1"
3/4"
1/2"
1 1/4"
3/32 SHEET BALSA
HINGE LINE
TYPICAL BLADE CROSS-SECTION
1/2"
4"
10"
P.D.G.

SIKORSKY

(Continued from Page 16)

rotor is nullified by a small rotor attached to the tail boom which produces a counteractive side thrust and is used as a heading control.

This arrangement is fine for a full-scale craft, but the unstable hovering characteristics of an articulated rotor limits its usefulness to piloted craft—it is not the best system to use on a model which must fly independently and has no pilot aboard to correct disturbances due to gusts or roughness in the air which are present under even the most ideal conditions. Therefore we must use a rotor, which has a degree of automatic stability if we wish our model to fly for more than a few seconds without skating wildly in all directions and finally crashing.

Our first S-51 model, therefore, used a dynamically stabilized rotor of the so-called "feathering" type. That is, the blades did not flap up and down, but rotated within limits in a span-wise plane, allowing flight deflections to register as pitch changes instead of flapping movements. The pitch changes served to maintain the stability of the machine by adjusting the lift of the rotor from side-to-side as required, since the blades were independent of each other and, to a limited extent, of the rotor shaft. Pitch was determined by rotational speed (centrifugal force) and the model used a rear torque correcting propeller.

The power was rubber and thrust was transmitted through a bevel gear drive to the main rotor and by pulley to the tail rotor. This model flew very well, was stable and able to cope with rough air without upsetting or going into a wild dance. However, the duration was very limited and the altitude attained was not very great, due to the complexity of the machinery required and the rather sharply limited output of twisted rubber bands.

We decided to scrap this design in favor of something that could be powered by a ½A engine, on the theory that builders would rather have a much simpler model with greater performance, and would be willing to sacrifice a bit of scale appearance to get it.

By using the torque-reaction drive, we eliminated gearing and clutches and the need for a torque prop. The dynamic stabilizers, which govern individual blade pitch, were retained, giving a good, positive and fully automatic auto-rotational let-down when the motor quit—an important factor in models having any considerable weight and power. The torque prop, an outstanding feature of the original, was replaced with a clear disk of plastic, which serves as a fin. The result is a model which is quite realistic in flight, more rugged in construction, and actually much simpler to build than the original rubber-powered version.

Construction: The fuselage is a straightforward semi-monocoque keel-type affair. Build one side over the keel on a flat surface to insure good alignment, then put on the half-bulkheads on the other side and finish the job. Attachment of the landing gear and rotor shaft should be quite clear from the plans. Note that the landing gear struts have been omitted since we want a springy gear to absorb landing jars. Window details are best painted on with a contrasting color—plastics do not take kindly to the spray of fuel and oil from the engine (yes, you can use a 1/4" sheet profile fuselage if you want extreme simplicity—but move the CG ahead about 3/8" to allow for altered fuselage effects).

The rotor mechanism and engine hook-up is quite a simple affair, but study the plans carefully and make certain you know how it works before tackling it. The hub is tin-can stock, the blade arms 1/16" steel wire soldered carefully in place. All bearings and bushings may be made of brass tubing, or simply rolled around a music wire form with flat nose pliers, using thin brass or tin-can stock material.

Make the rotor blades from a good tough variety of 3/32" sheet balsa and be sure the rotor blades' tip weights (dynamic stabilizers) are securely cemented in place and bent to the proper angle. The amount of weight should be just enough on each blade so that the blade will tip forward to maximum "down" pitch when at rest. This weight will vary somewhat from model to model, but is not critical within wide limits as long as only a reasonable amount is used.

Understand how these weights operate—under centrifugal force they ride up, increasing blade pitch, if the model tilts they alter the blade pitch to provide a corrective side thrust and, lastly, when the engine runs out of fuel they govern collective pitch and throw the rotor in auto-rotation to bring the machine down safely and slowly.

The recommended engine for this model is the K&B .049. It is recommended because of the ability of this engine, which has a longer stroke than some, to carry a very large prop without killing out—a very important consideration in torque-reaction-drive helicopter models. It also has a very handy mount and the gas tank comes in the right place for this sort of model. Balance the cylinder with a blob of solder on the blade holder arm opposite the tank.

The finished weight is of much greater importance in a helicopter than in any other type of model. This model should weigh at least 4.5 ounces and less than 5.5 ounces for best scale-type performance. If it is too light it will zoom up much too rapidly to be properly enjoyed, and if it is too heavy it may be sluggish about rising—particularly on hot days.

When the model is finished (up as far as the special engine shaft rotor, and we're saving that to describe last for a good reason), check it over for good blade tracking and alignment.

This model flies not only vertical, but *forward* as well. In order to get it to do this without incorporating a cyclic control mechanism we took advantage of the shape of the thing.

Forward flight is produced by the reaction of the downwash from the engine prop against the flat front of the rotor pylon which creates a force which *tends* to tilt the nose down, and the reaction to this tendency to tilt by the main rotor blades results in an automatic shift of pitch which propels the model forward.

SIKORSKY

(Continued from Page 34)

Now, when the model is finished up as far as the special see-saw engine rotor, it may be a strong temptation to stick a prop on it and turn it loose— just to see what will happen. If you try this stunt be sure to have a dustpan with you because you may need it. It it quite true that you *can* fly the model this way, and if your balance is good you may get away with it for half a dozen flights in dead air. But, just about as you are deciding that Clough is an overcautious old fuddy-duddy, your model may tilt over on its nose and end its career in one glorious full-throttle plunge into the ground.

The reason for this happening (with a stiff center prop) is that the main rotor blades "feather" or adjust pitch angles relative to the air pressure on them at any given rotational speed. This is a condition of neutral stability which means that the model will fly stably unless disturbed by some external force—all things being equal.

Unfortunately all things are not equal in actual practice. A gust may hit the model, or a bubble in the feed line may make the motor kick -or bump, which may set up a jiggle or tilt which will cause the rotor to shift its position.

Study the rotor a bit. Note that it functions as a gyroscope. If a condition of excessive forward speed or sidewise skid occurs, we have a strong pressure upon the tip of the lead blade (the blade which at any given moment is perpendicular to airflow on the upwind side), and this pressure produces a resultant force 90° behind the point of impingement, which is the characteristic gyroscopic reaction.

This force resolves into altered blade pitch as the weight seeks to justify its inertial forces, and this pitch alteration causes another reaction back to the front of the rotor disk which pushes the nose of the model down into a dive. Since this condition is self-propagating, there is no hope of recovery from such an attitude barring a miraculous gust of wind or engine stoppage which, by pulling power from the rotor, kills off the precessive cycle allowing the nose to ride up again as the blade shifts into auto-rotation.

At this point somebody is sure to ask: why not add little dihedral sections to the tip of the rotor *ahead* of the pivot line, so that air pressure in forward (or any directional) flight will impinge upon the tip of the leading blade, forcing it to assume a greater pitch and lifting it upward to return the model to even keel?

It won't work that way. If we try it we find that the model, instead of diving, now rolls over on its side, because when the blade pitch changes at one spot—in this case the front of the model —the reaction comes 90° behind the alteration and the model tilts sidewise and crashes (Factually there is a reverse reaction 90° ahead of the deflection in addition, since if one side tilts down the other must tilt up).

Thus the solution of this knotty little problem calls, in this case, for an automatically regulating counter-reaction that will at all times interact with the forces of the main rotor to provide recovery couples.

We do this by installing on the engine shaft a special type of rotor or propeller which is pivoted to "see-saw" gimbals. This isn't very difficult to build. Simply carve out a prop to the dimensions shown and, instead of mounting it with a hole through the center, mount it in a U-shaped pivot bearing, using a length of 1/16" steel wire for a pivot shaft, which runs through the side of the prop.

What have we here? Well, this prop has fixed pitch, it does not feather as does the big one beneath it, but it can see-saw on its trunnions. When the motor is running, it "planes" and runs flat and true. When the model starts to slide, this see-saw prop tilts back opposite to the direction of sliding. This produces a complex of forces, but essentially it serves as a drag in that the faster the model goes the more it tilts back, producing a counter-reaction and an opposing gyroscopic deflection that limits the speed of the slide to practically zero.

The model, which was neutrally stable with a stiff center prop, now becomes inherently stable with a see-saw prop because a positive reaction is obtained which produces automatic correction. This means the model will simply hover in one spot unless some other factor is added to make it fly forward, and the flat front surface of the rotor pylon takes care of that. If you want more speed in forward flight, gradually shift the CG ahead a little at a time until you get what you want.

In our experience, few things offer the satisfaction and enjoyment of a good model helicopter. This model is a good one. Build it carefully, according to plan, and it will give you performance you may have believed impossible, particularly if you have tried unsuccessfully in times past to adapt model engines to helicopter practice.

BILL OF MATERIALS (Balsa unless otherwise specified)
3-3" x 1/32" x 36" (medium)…………Fuselage sides
1-3" x 1/16" x 36" (medium hard)…….Fuselage keel
1-5/8" x 7" x 1/8" (hardwood)…………Prop blank
1-4 ¼" dia. .012 thick (plastic)………………………Fin
12" length of soft iron wire 1/16" O.D.; clean discarded tin can; loop of rosin core solder; *2,* 1" dia. rubber wheels; 1, ¾" dia. rubber wheel; leather or fibre; small washers; dope, cement, fuel proofer and decorations; K&B .049 engine.