An intriguing and ingenuous huge helicopter, for 8-Channel, modeled after the Sikorsky S-64 "Skycrane". Still undergoing pre-flight tests as we go to press, free-flight version flew at Nat's, has placed well in contest since. Ken invites 'copter enthusiasts to band together, via mails, to further development. Fine idea!

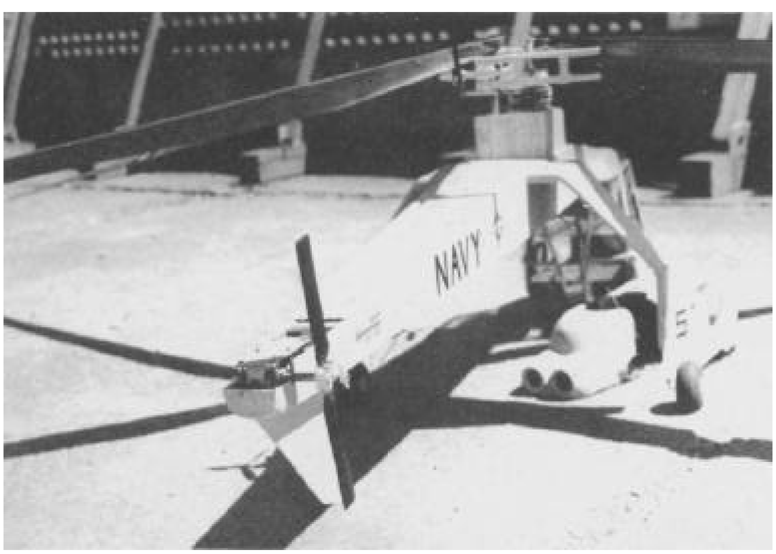
Above: Three bladed props for cabin clearance, as two .049 Cox swing 99" rotor around. Designed in Denver, extreme altitude has been a big problem, slowed development. At right: Ken displays how blades are free to seek own level in flight. Cyclic and collective pitch, note four controlling flaps on blades.

KEN NORRIS'S experimental

SIKORSKY S-64

"HEXI-COPTER

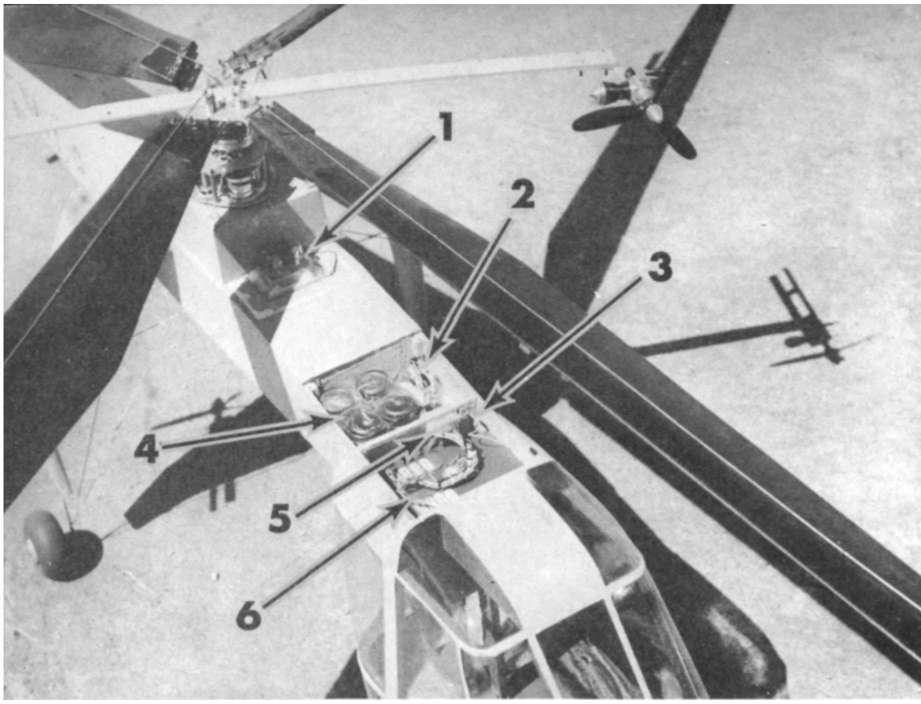
Eight Channel-Radio Controlled-99" Rotor Span

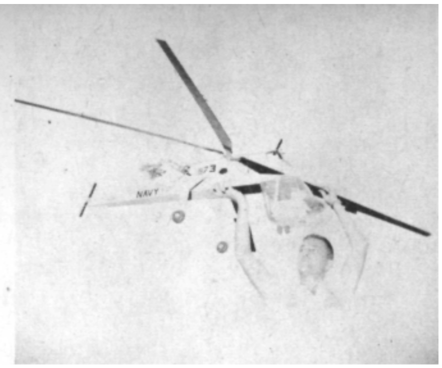


Tail rotor, adjustable in pitch, deserves close scrutiny. Electrically driven at a constant r.p.m. pitch is controlled by R.C., completely articulated, servo actuated.

Model helicopters have long been of great interest to most serious modelers, but the lack of available information has made experimentation slow and often unrewarding. In the following article I will describe my experiments with "a new kind" of helicopter. This model is the result of over three years experimentation with many flight helicopter designs (excluding torque reaction). As you will see this has not been an overnight project, it has been in the design and construction stages for over a year. Ball bearings, gears, screws and motors etc., were purchased from local sources. I used my own lathe to construct most of the machined parts, and borrowed a milling machine for the others. The vacuum forming dies (required for the cockpit enclosure), and their associated parts were constructed in my workshop, but here again I borrowed facilities to complete the job. Although, I completely designed and constructed

SIKORSKY S-64





Above: 1: Two A.B.C., 1 A.M. batteries; 2: D.P.D.T. micro switch; 3: Single pin antenna lead, crosses to right side of fuselage, behind this former; 4: Eight A.B.C. V.O. 180 batteries, only six needed; 5: Fifteen pin Cannon connector; 6: The F. & M. 8 Eight Channel Receiver.

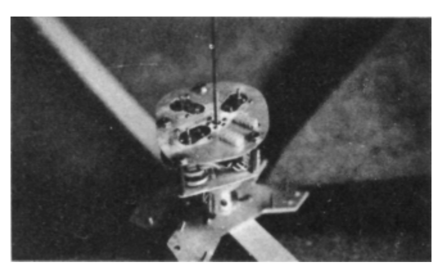
Below: Not the same ship. This one is free flight, a few inches smaller. Suffered damage at Nat's moments after this photo, when rotor shaft was lowered, and rotating Cox tore cabin to shreds. Denver plateau to Dallas required adjusting. Design took a third since. A Navy photo.

Below: Rotor head fairing, hatch shown removed. Design is of interest to all builders in approach to variety of unusual helicopter problems.

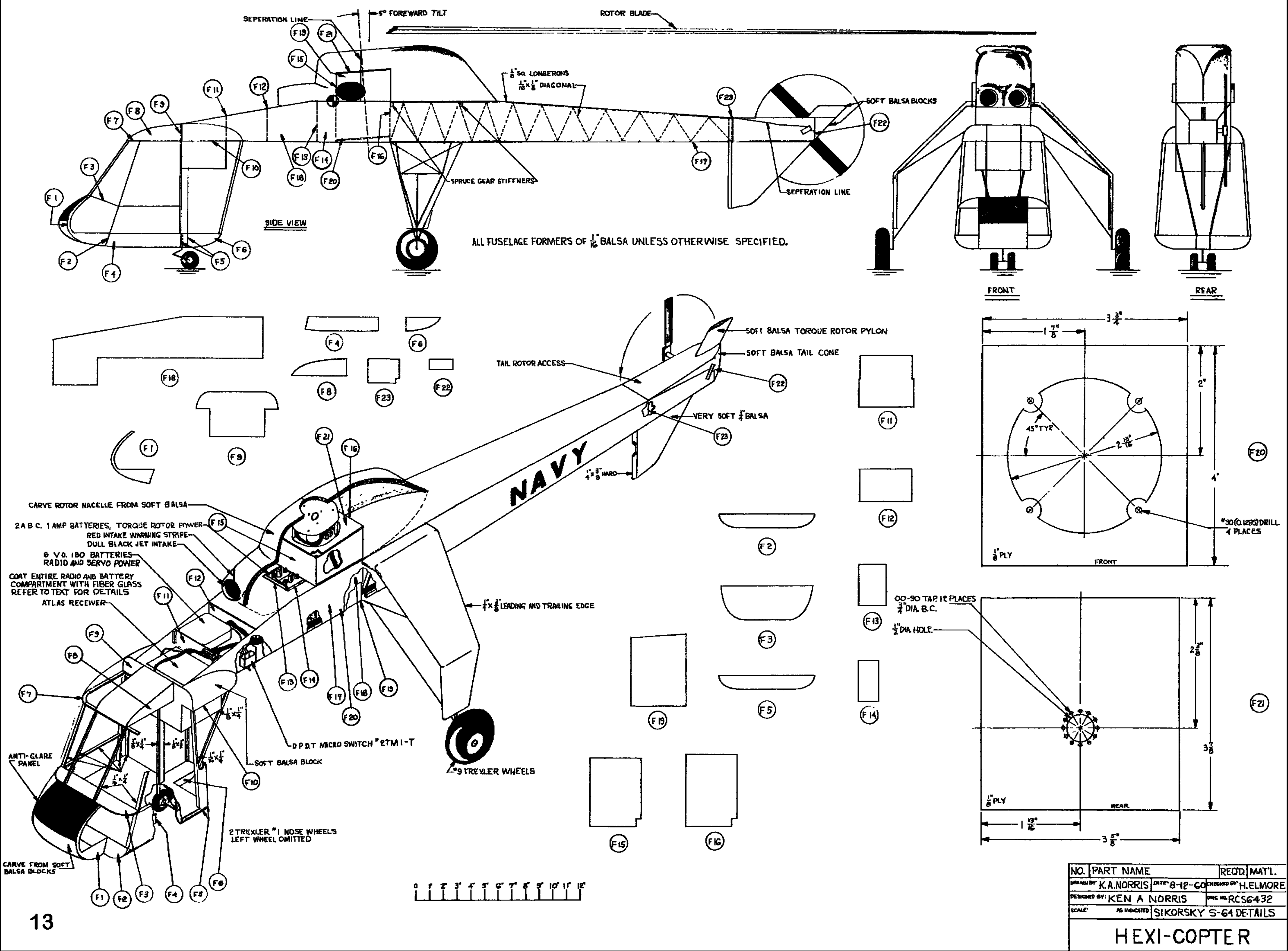
this model, the project could not have been completed without the help of many persons. Some helped with advice, others with criticism, some with facilities. Others helped just by being interested.

Model helicopter experiments can be traced back through history for several centuries. The first undisputed model of a helicopter is credited to Launoy and Bienvenu, in 1784. This model is also credited with being the first model airplane (excluding the kite) to fly. The spring-powered model had two rotors with four feathers each for blades. It flew!

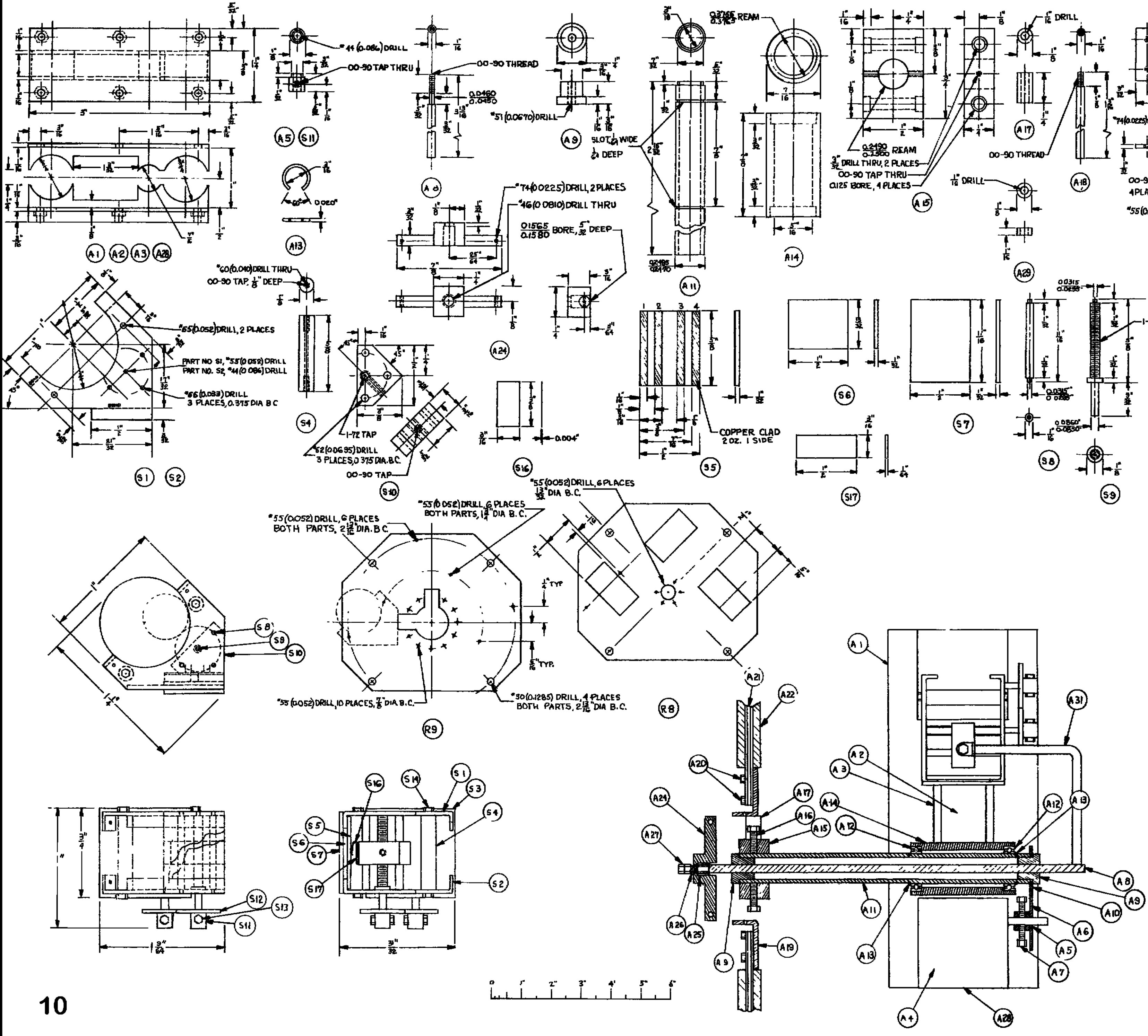
For many years after this, successes were few and of minor significance. It would seem that until the time of the Focke-Achgelis FA-6I, the helicopter did not receive the engineering attention that the fixed wing airplane did. However, with the successful demonstration of the German FA-6I, development progressed rapidly. Igor Sikorsky soon flew his first fully controllable helicopter. It was the predecessor of the famed R-4, which was used in WW II, and trained many of today's helicopter pilots. Since that time Sikorsky Aircraft has been a leader in the field. The S-60 and S-64 Skycranes, are two of their current ventures. The first Skycrane was the reciprocal-powered S-60, with a lifting capacity of five tons. One of the most prominent differences between the skycranes and other helicopters is the lack of bulky central fuselage, which is unnecessary weight and drag when moving bulky loads. Instead, the design utilizes a bridge type fuselage, connecting the cockpit and the tail rotor. Cargo of great bulk can be carried externally, by suspending it from a winch located below the center of gravity. Cargo can also be carried in pods or packages, which are quickly attached or detached from the fuselage. "People pods" have been used which demonstrated an almost complete lack of vibration. The pods are suspended from four hard points on the (*Continued on Page* 31)

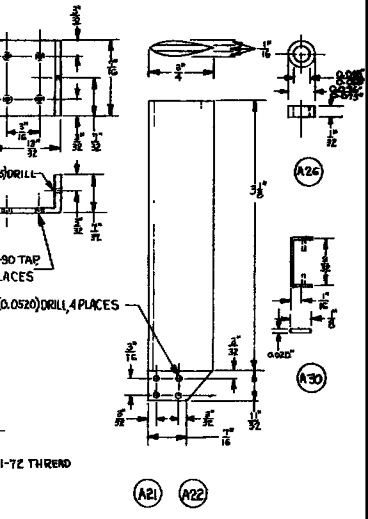


Three servos are housed in the rotating head.



SEPERATION LINE
5° FOREWARD TILT
ROTOR BLADE
1/8" SQ. LONGERONS
1/16" x 1/8" DIAGONAL
SOFT BALSA BLOCKS
SPRUCE GEAR STIFFENERS
SEPERATION LINE
SIDE VIEW
ALL FUSELAGE FORMERS OF 1/16" BALSA UNLESS OTHERWISE SPECIFIED.
FRONT
REAR
SOFT BALSA TORQUE ROTOR PYLON
SOFT BALSA TAIL CONE
TAIL ROTOR ACCESS
VERY SOFT 1/4" BALSA
1/4" x 3/8" HARD
NAVY
CARVE ROTOR NACELLE FROM SOFT BALSA
2 A B C. 1 AMP BATTERIES, TORQUE ROTOR POWER
RED INTAKE WARNING STRIPE
DULL BLACK JET INTAKE
6 V.O. 180 BATTERIES RADIO AND SERVO POWER
COAT ENTIRE RADIO AND BATTERY COMPARTMENT WITH FIBER GLASS REFER TO TEXT FOR DETAILS
ATLAS RECEIVER
1/4" x 3/8" LEADING AND TRAILING EDGE
D P D.T MICRO SWITCH #2TM1-T
#9 TREXLER WHEELS
SOFT BALSA BLOCK
ANTI-GLARE PANEL
2 TREXLER #1 NOSE WHEELS LEFT WHEEL OMITTED
CARVE FROM SOFT BALSA BLOCKS
3 3/4"
1 7/8"
2"
4"
45° TYP
2 13/16"
#30 (0.1285) DRILL 4 PLACES
1/8" PLY
FRONT
00-90 TAP. 12 PLACES 3/4" DIA. B.C.
1/2" DIA HOLE
2 3/8"
3 7/8"
1/8" PLY
REAR
1 13/16"
3 5/8"
F1 F2 F3 F4 F5 F6 F7 F8 F9 F10 F11 F12 F13 F14 F15 F16 F17 F18 F19 F20 F21 F22 F23
0 1" 2" 3" 4" 5" 6" 7" 8" 9" 10" 11" 12"
NO. PART NAME REQ'D MAT'L.
DRAWN BY: K.A.NORRIS DATE: 8-12-60 CHECKED BY: H.ELMORE
DESIGNED BY: KEN A NORRIS DWG. NO. RCS6432
SCALE: AS INDICATED SIKORSKY S-64 DETAILS
HEXI-COPTER

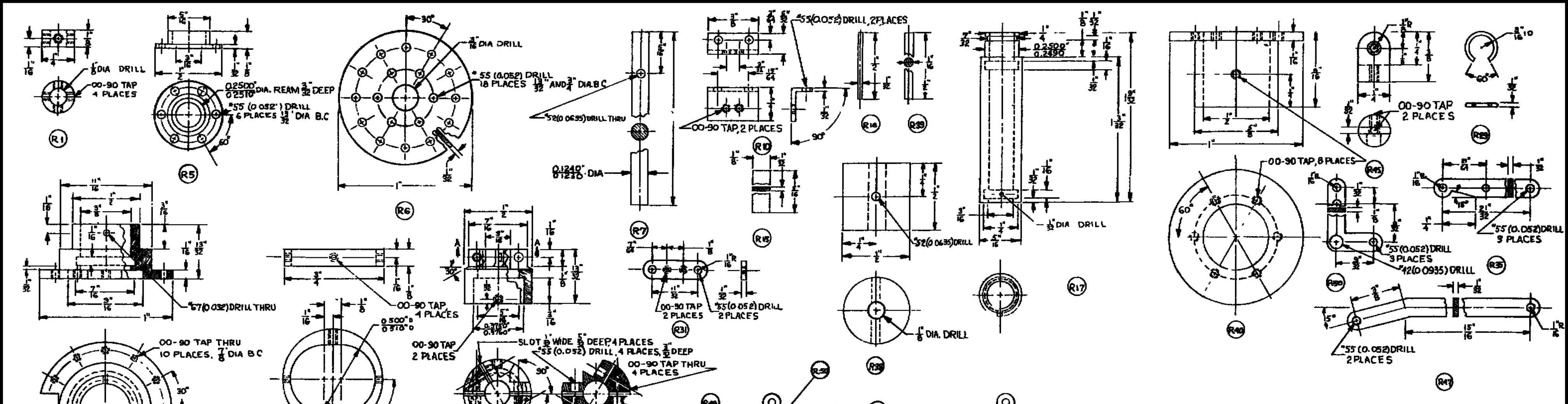


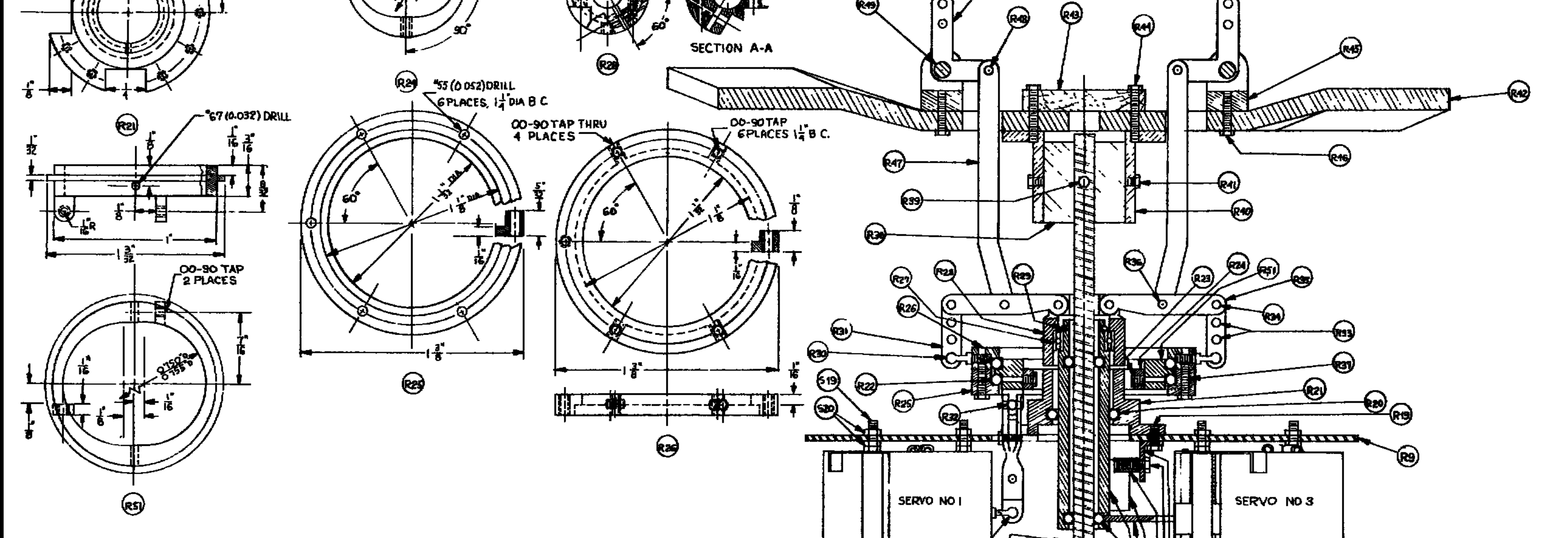


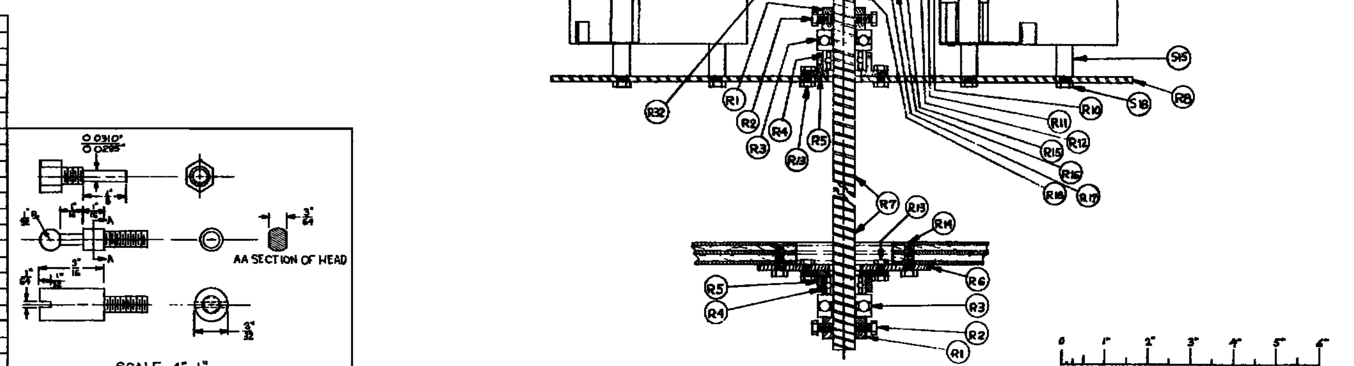
S20	MOUNTING NUTS 00-90	24	BRASS
S19	MOUNTING STUDS 00-90	6	BRASS
S18	MOUNTING SCREWS 00-90	4	BRASS
S17	BRUSH SUPPORT FF-89 (6)	4	FORMICA
S16	BRUSH	8	BRONZE
S15	MOUNTING SPACERS	6	BRASS
S14	SCREW 00-90	16	BRASS
S13	SCREW 00-90	16	BRASS
S12	GEAR (1)	8	BRASS
S11	HUB	8	BRASS
S10	SLIDE BLOCK (9)	4	NYLON
S9	JACK SCREW	4	BRASS
S8	GUIDE	12	BRASS
S7	BACKING PLATE LEN-15 (7)	4	FORMICA
S6	SPACER LEN-15 (7)	4	FORMICA
S5	LIMIT SWITCH FF-81 (6)	4	FORMICA
S4	POST	8	ALUM.
S3	MOTOR	4	AS SUPPLIED
S2	BASE, LOWER	4	ALUM
S1	BASE, UPPER	4	ALUM
A31	CONNECTING LINK	1	BRASS
A30	PITCH LINK	2	STEEL
A29	BEARING	2	TEFLON
A28	NUT PLATE	1	BALSA
A27	NUTS, PITCH SHAFT 00-90	2	BRASS
A26	SPACER	1	BRASS
A25	BEARING MPB 832½CHH (6)	1	S. STEEL
A24	PITCH HUB	1	ALUM.
A23	NUTS, BLADE SHAFT 00-90	4	BRASS
A22	BLADE FACES	4	BALSA
A21	BLADE CORE	2	PLYWOOD
A20	SCREW 00-90	8	BRASS
A19	BLADE MOUNTING PLATE	2	BRASS
A18	BLADE SHAFT 00-90	2	BRASS
A17	BEARING (4)	2	TEFLON
A16	SCREW 00-90	2	BRASS
A15	ROTOR HUB	1	ALUM.
A14	HOUSING	1	ALUM.
A13	SNAP RING	2	STEEL
A12	BEARING MPB SSG14CHH (2)	2	S STEEL
A11	SHAFT	1	BRASS
A10	GEAR (1)	1	BRASS
A9	BUSHING (3)	2	TEFLON
A8	PITCH SHAFT	1	BRASS
A7	SCREW 00-90	2	BRASS
A6	GEAR (1)	1	BRASS
A5	GEAR HUB	1	BRASS
A4	MOTOR	1	AS SUPPLIED
A3	SUPPORT	4	PLYWOOD
A2	SPACER	2	BALSA
A1	BASE	2	PLYWOOD
NO.	PART NAME	REQ'D	MAT'L.

DRAWN BY: K.A. NORRIS	DATE: 8-19-60	CHECKED BY: P. TROUTE
DESIGNED BY: KEN A. NORRIS		DWG NO: RCS6435
SCALE: AS INDICATED	SIKORSKY S-64 DETAILS	

HEXI-COPTER







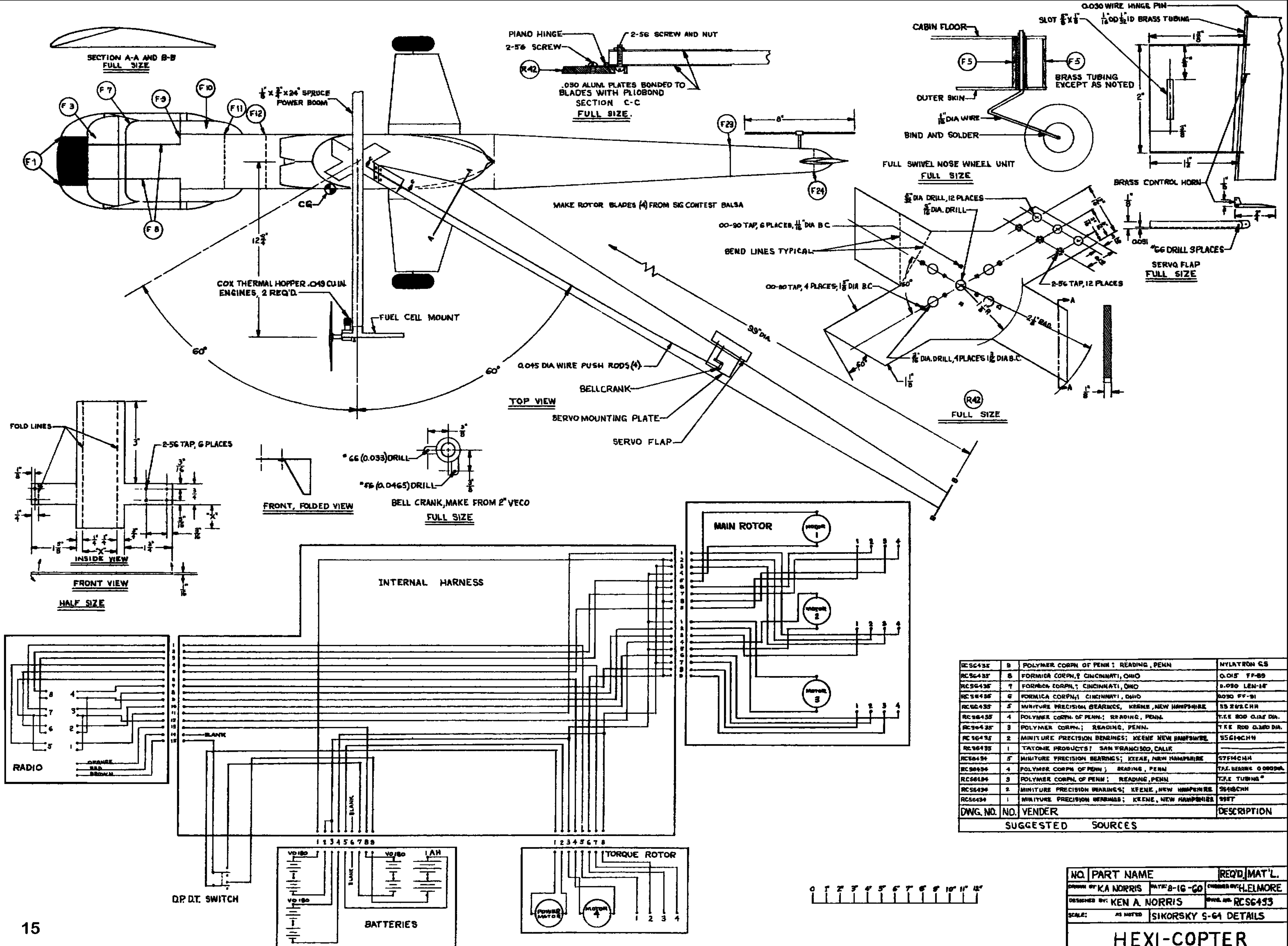
S19	NONE	00-90	0.250	NO	3
S18	HEX	00-90	0.250	NO	NONE
S14	HEX	00-90	0 125	NO	NONE
S13	HEX	00-90	0 125	NO	NONE
A20	HEX	00-90	0 125	NO	NONE
A16	HEX	00-90	0 187	NO	NONE
A7	HEX	00-90	0 125	NO	NONE
R52	HEX	00-90	0 093	NO	NONE
R49	SLOT	00-90	0 125	SEE DETAIL	NONE
R48	HEX	00-90	0. 187	NO	2
R46	HEX	00-90	0.250	NO	NONE
R44	HEX	00-90	0 313	NO	NONE
R41	HEX	00-90	0 063	NO	NONE
R37	HEX	00-90	0 250	NO	NONE
R36	HEX	00-90	0.187	NO	2
R34	HEX	00-90	0.125	NO	1
R33	HEX	00-90	0.125	NO	1
R32	SPEC	00-90	0 125	SEE DETAIL	NONE
R30	SPEC	00-90	0 125	SEE DETAIL	NONE
R25	HEX	00-90	0 063	SEE DETAIL	NONE
R19	HEX	00-90	0.125	NO	NONE
R14	HEX	00-90	0 187	NO	NONE
R13	HEX	00-90	0 125	NO	1
NO	HEAD	THREAD	THD LGTH	SPECIAL	NUTS REQR

SCREW DETAILS

R52	SCREW 00-90	2	BRASS
R51	OUTER GIMBAL RING	1	ALUM
R50	BELL CRANK	4	BRASS
R49	SCREW 00-90	4	BRASS
R48	SCREW ASSEMBLY 00-90	4	BRASS
R47	LIFT ARM	4	BRASS
R46	SCREW 00-90	4	BRASS
R45	BELL CRANK SUPPORT	4	ALUM.
R44	SCREW 00 - 90	6	BRASS
R43	POWER BOOM	1	SPRUCE
R42	ROTOR HEAD	1	ALUM.
R41	SCREW 00-90	4	BRASS
R40	CAP	1	ALUM
R39	PIN	1	BRASS
R38	SPACER	1	ALUM
R37	SCREW 00-90	6	BRASS
R36	SCREW ASSEMBLY 00-90	4	BRASS
R35	PITCH LEVER	4	BRASS
R34	SCREW ASSEMBLY 00-90	4	BRASS
R33	SCREW 00-90	8	BRASS
R32	BALL SCREW 00-90	4	BRASS
R31	LINK	6	BRASS
R30	BALL SCREW 00-90	4	BRASS
R29	RETAINER RING	1	STEEL
R28	COLLECTIVE PIVOT RING	1	ALUM
R27	BEARING MPB SS614CHH (5)	1	S. STEEL
R26	UPPER OUTER GIMBAL RING	1	ALUM
R25	LOWER OUTER GIMBAL RING	1	ALUM.
R24	CENTER GIMBAL RING	1	ALUM
R23	SCREW 00-90	4	BRASS
R22	BEARING (4)	2	TEFLON
R21	INNER CYCLIC GIMBAL RING	1	ALUM.
R20	BEARING (4)	1	TEFLON
R19	SCREW 00-90	10	BRASS
R18	BEARING (4)	2	TEFLON
R17	COLLECTIVE TUBE	1	BRASS
R16	COLLECTIVE LIFT LEVER	1	STEEL
R15	FIN	1	BRASS
R14	SCREW 00-90	12	BRASS
R13	SCREW ASSEMBLY 00-90	12	BRASS
R12	STUB COVERS (3)	2	TEFLON
R11	GUIDE STUBS	2	BRASS
R10	GUIDE FRAME	1	BRASS
R9	SERVO MOUNTING PLATE	1	ALUM.
R8	SERVO MOUNTING PLATE	1	ALUM.
R7	SHAFT	1	BRASS
R6	BEARING MOUNTING PLATE	1	ALUM.
R5	BEARING RETAINER	2	ALUM
R4	BEARING MPB SS418CHH (2)	2	S STEEL
R3	BEARING MPB SS3T (1)	2	S STEEL
R2	SCREWS 00-90	8	BRASS
R1	RETAINER COLLAR	2	BRASS
NO.	PART NAME	REQ'D	MAT'L.

DRAWN BY K A NORRIS	DATE: 8-9-60	CHECKED BY P. TROUTE
DESIGNED BY KEN A. NORRIS		DWG NO. RCS6434
SCALE AS INDICATED	SIKORSKY S-64 DETAILS	

HEXI-COPTER



DWG. NO.	NO.	VENDER	DESCRIPTION
RCS6435	9	POLYMER CORPN OF PENN ; READING , PENN	NYLATRON GS
RCS6435	8	FORMICA CORPN,; CINCINNATI, OHIO	0.015 FF-89
RCS6435	7	FORMICA CORPN,; CINCINNATI, OHIO	0.030 LEN-18
RCS6435	6	FORMICA CORPN,; CINCINNATI, OHIO	0030 FF-91
RCS6435	5	MINITURE PRECISION BEARINGS, KEENE , NEW HAMPSHIRE	SS 2&2CHH
RCS6435	4	POLYMER CORPN. OF PENN.; READING , PENN.	T.F.E ROD 0.125 DIA.
RCS6435	3	POLYMER CORPN.; READING, PENN.	T.F.E ROD 0.280 DIA.
RCS6435	2	MINITURE PRECISION BEARINGS; KEENE NEW HAMPSHIRE	SS614CHH
RCS6435	1	TATONE PRODUCTS; SAN FRANCISCO, CALIF.	———
RCS6434	5	MINITURE PRECISION BEARINGS; KEENE, NEW HAMPSHIRE	S7F14CHH
RCS6434	4	POLYMER CORPN OF PENN ; READING , PENN	T.F.E. BEARING 0.080 DIA.
RCS6434	3	POLYMER CORPN. OF PENN ; READING , PENN	T.F.E TUBING*
RCS6434	2	MINITURE PRECISION BEARINGS; KEENE , NEW HAMPSHIRE	S648CHH
RCS6434	1	MINITURE PRECISION BEARINGS; KEENE, NEW HAMPSHIRE	SSFT

SUGGESTED SOURCES

NO.	PART NAME	REQ'D.	MAT'L.
DRAWN BY: K.A NORRIS	DATE: 8-16-60	CHECKED BY: H.ELMORE	
DESIGNED BY: KEN A. NORRIS		DWG. NO. RCS6453	
SCALE: AS NOTED	SIKORSKY S-64 DETAILS		

HEXI-COPTER

SIKORSKY

(Continued from Page 12)

fuselage. This lack of vibration has been called "a major breakthrough". This design allows, "mission pods" to be changed rapidly, thus increasing the helicopters versatility.

The S-64 when completed will be a much improved and aerodynamically cleaner version of the S-60. It will utilize two; free shaft turbine engines, and has a lifting capacity of over eight tons.

Experimentation continues to be an important part of helicopter development. Much of the progress made in the past twenty years can be attributed to the sharing of information and ideas among the helicopter manufacturers. This, surely, would also profit model helicopter builders. I sincerely hope those of you with interest, ideas, or constructive criticisms will write to me, at 2575 Harlan, Denver 15, Colorado, with the hope a loose knit organization will result. This organization could help circulate ideas and information, which could make progress more rapid, and avoid countless disappointing, duplicate experiments. Knowledge could be made available to those wishing to try model 'copters, and answers found for questions unanswered at present. Other sections of our hobby have prospered, because many modelers of like interest can be found in a small area. However, it is unusual to find more than one 'copter modeler in the same region. For this reason we should band together and with a group effort advance our sport beyond its present state of almost non-existence.

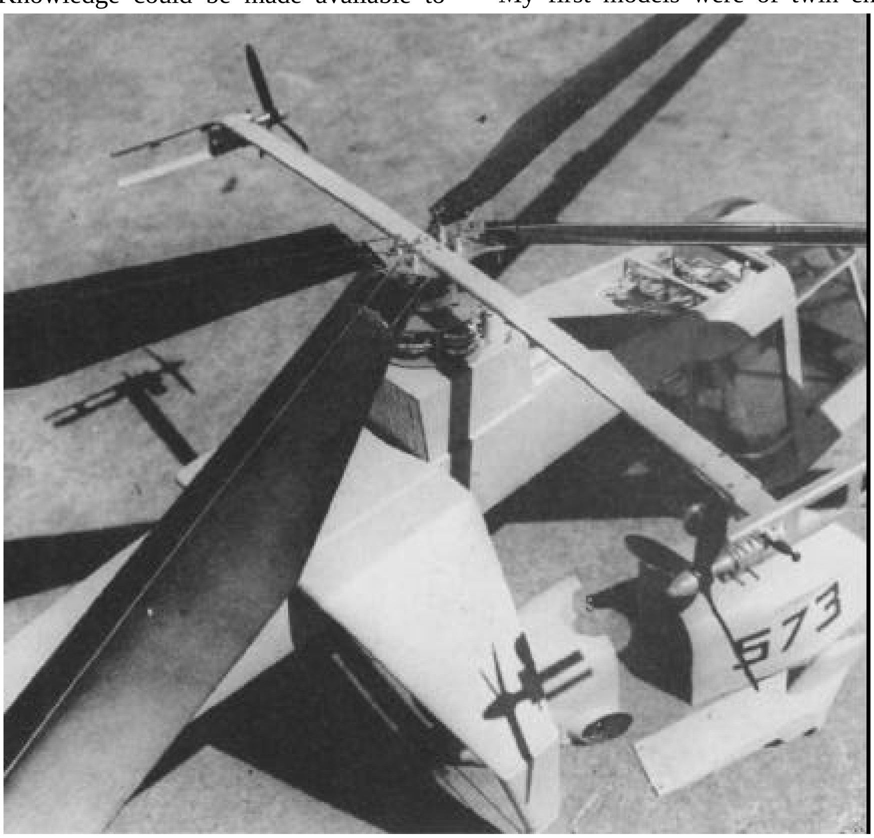
Jetex 'copters are well established as good performers, and when built light, they are even capable of thermal flying. The basic design used by most of these, is the work of Francis G. Boreham, of Great Britain. This model type uses solid fuel reaction units mounted directly to the rotor by an arm or power boom. The reaction motors have only one drawback; the length of motor run is far too short. The rotor system I present here is basically the same as designed by Boreham and only slight changes have been made. The most important of these being the use of twin internal combustion engines, which gives the model much greater endurance, without the benefit of thermals.

My first models were of twin engine and twin blade configuration. They were very successful. I have never been an advocate of "copters having a fuselage length of twelve inches and a rotor diameter of six feet. The present rules require the model to resemble a real 'copter which excludes ping-pong ball fuselages and the like. The rules also require all flights to be R.O.G., which means the model must be kept as light as possible. With these requirements and Boreham's design in mind, I decided to try something new—to make the fuselage as large as practical and the rotor as small as possible. This presents a problem, if we reduce the rotor diameter, what will we do with the unused power? With short blades the R.P.M. will be increased and this is all right. The disc loading (approximately the same as wing loading will also increase, thus decreasing the probability of autorotation and constant flights. However, if we increase the solidity ratio, that is, the ratio of the blade area compared to the disc area (area of the circle described by a blade tip), we will be able to utilize the unused power, and still have blades closer in proportion to the fuselage. Thus the HEXI-COPTER design evolved. After several successful models the design seemed worth further expansion, which lead to the evolution of the R.C. S-64.

Past experience dictated several requirements; (1) the model must be designed with a high center of gravity. (2) The rotor shaft must be supported as high as possible. (3) Space must be available close to the rotor head for the control mechanism. (4) The fuselage must be rugged yet light. (5) The landing gear must be capable of absorbing powerful landing loads. Along with these requirements which the S-64 satisfies, it has clean functional line Since the full scale S-64 hasn't been completed at the time of this writing, details of it's design are rather sketchy. The design presented here cannot be represented as true scale, but is based on the S-60 and written descriptions of the S-64. This design built light should make a realistic free flight, capable of contest performance.

s. Before going further, the principles involved in building should be understood.

(Continued on Page 37)



Above: The rotor *is* driven in clockwise direction, viewed from above. F & M Electronics Eight Channel Atlas receiver, housed above cabin.

SIKORSKY S-64

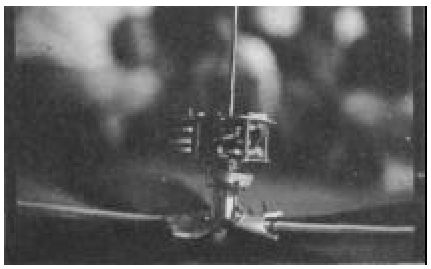
(Continued *from Page* 33)

Airframe: The airframe is constructed in standard model fashion. Select the wood carefully. The electrical harness must be installed in the fuselage during early construction. Remember, the landing loads will be down, with only a slight forward component. The load must be sustained between F-9 and the main landing gear,

with only minor loads imposed between the main gear and F22. The fuselage forward of F-9 is designed to carry no load. Glass cloth is used only in the radio and battery compartments, which are covered inside only with Trevarno 2P181 glass cloth and impregnated with Reichold Polylite 8037 polylite resin. Two coats of this same resin are applied to all external surfaces and hatches. Finally apply Polar Grey Glidden Butyrate Dope. Use dull black lacquer for anti-glare panes. The cocktail enclosure is vacuum formed from 0.030 thick, clear, butyrate sheet.

Radio and electrical: The antenna and radio leads plug into separate Cannon connectors installed in F-ll. The antenna is permanently installed on the right side of the fuselage and extends to F-23. The harness is installed on the left side. Remove the metal shields from all connectors and bond the two halves together with Polymer Corp. Nylaweld adhesive. Install connectors as indicated on the wiring diagram. Number 22-stranded copper wire is used throughout with Polymer Corp. T.F.E. teflon spaghetti tube sleeves used over every soldered joint. The six ABC VO 180 batteries are encapsulated in clear polyester resin along with one half of their connector. This unit is vibration trouble free. All components are removable for easy inspection and maintenance.

The servos are trimmable. They have proven very satisfactory in tests to date. The heart of each servo is the Micromax motor of 60:1 gear reduction. It is held to the frame by safety wire that is twisted to draw it tight. The copper clad limit switch may be etched with ferric chloride, or the copper may be removed with a sharp knife. The center strips must be trimmed, 2 at the bottom, 3 at the top, to insure no more than one-eighth inch travel both ways from center. Use care when soldering wires to the copper strips. The numbers above each strip on the detail drawing correspond to the numbers used on the wiring diagram.

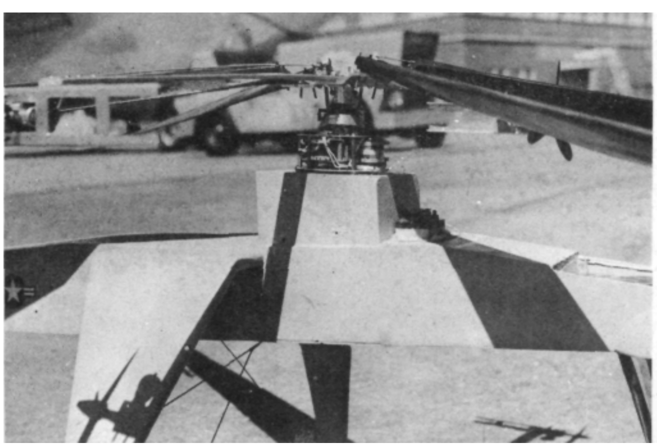


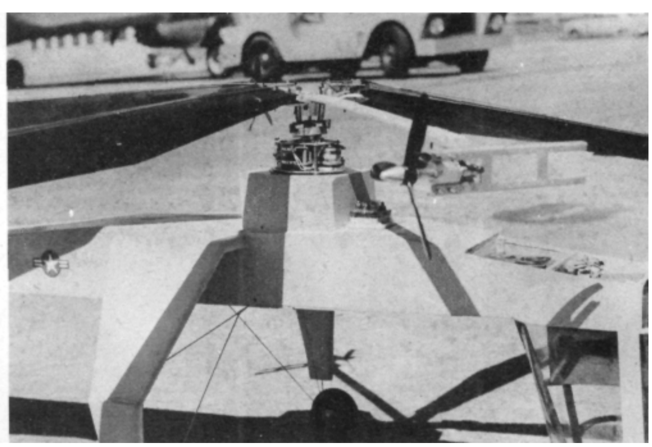
Rotor head removed, a study in compactness.

The FM Electronics, eight channel, super-heterodyne, three volt, Atlas receiver requires no modification. The following list gives the manufacturers relay designation, it's number on the wiring diagram, and it's new function-Advance engine, 1, cyclic forward. Down elev., 2, collective down. Retard engine, 3, cyclic aft. Up elevator, 4, collective up. Left rudder, 5, tail rotor left. Left aileron, 6, cyclic left. Right rudder, 7, tail rotor right. Right aileron, 8, cyclic right. The super-heterodyne receiver is used since it is not as susceptible to noise from un-bonded parts as other radios. It is necessary to relabel the functions of the keying switches of the FM Electronics Hercules transmitter to correspond with the receiver.

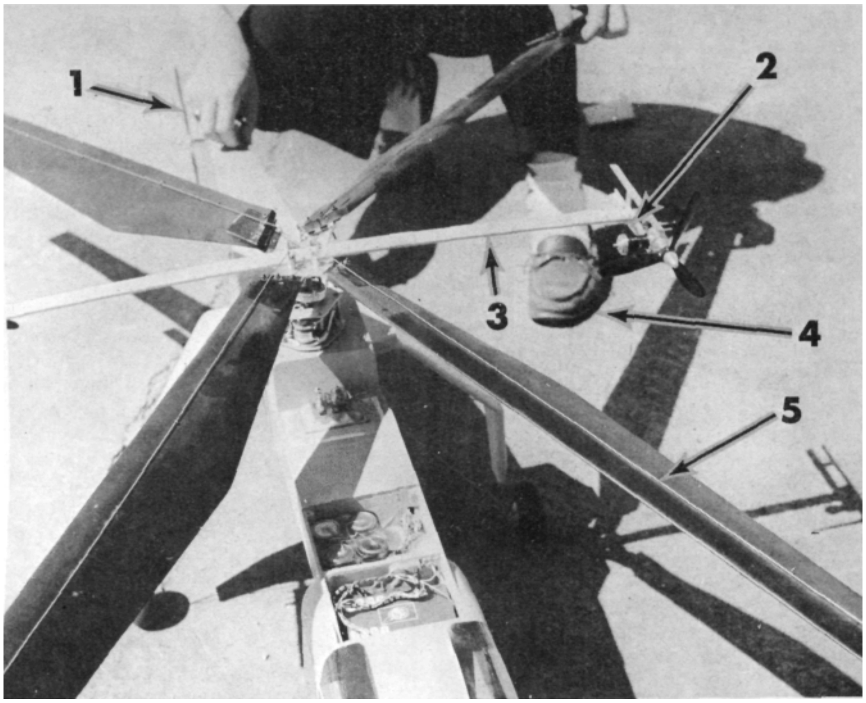
The two cyclic servos used in the main rotor head are connected to the outer gimbal ring R-51 by ball and socket joints, utilizing a connecting link similar to part R-31. This link must twist ninety degrees as shown on drawing RCS6434. Part R-17, which is silver soldered to R-16, slips into the tapped hole in S-10, and forms the connection to the collective rotor head servo. The tail rotor servo is connected to the pitch shaft A-8, by A-31, which is soldered to A-8, and attached to S-10 by a 00-90 screw. Note that the brass brushes have no abrupt bends, form the curve needed by bending around one eighth inch Dia. rod. Rotor head: The rotor head functions can be divided into two groups, cyclic, and collective. Cyclic refers to the cycle of pitch changes encountered by each blade as it moves thru each revolution. Collective refers to the pitch changes encountered by all blades simultaneously. The rotor shaft is free to rotate only, radial bearings are provided at both ends of the shaft, thrust bearings in the same locations are provided for upward and downward forces. The collective functions start with R-17, which is kept from rotating by R-15. This is silver-soldered to R-17 and rides in the saddle of guide frame R-10 which is formed by

(Continued on *Page* 40)





Above, right: Two positions during rotation. **A rotor shaft access hatch visible on bottom.**



Indicated in photo: 1: Anti-torque rotor; 2: A Cox "Thermal Hopper" .049 engine, (one of two); 3: Spruce power boom; 4: "Author's big foot", and we quote him; 5: A Serud flap pushrod. Build several, soon.

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R-11 and R-12. Part R-17 moves up and down only. R-28 is attached to R-17 by a radial bearing and not only moves up and down with R-17, but also is free to rotate with the rotor head. Teflon rings are used as bearings in R-17 and R-21 since they provide a low friction bearing for parts that rotate and slide at the same time. These bearings also stiffen the upper shaft.

The cyclic functions and parts start with R-21, which forms the base of a non-rotating gimbal ring. This gimbal allows the swash plate R-25, R-26 to be inclined in any direction. Teflon bearings are provided in the swash plate to absorb both radial and thrust loads. Ball and socket joints are used at four places on R-26. Now, we have imparted cyclic and collective control to R-35, and finally thru R-47 to R-50, where both functions seem to combine into one. Clearly, it can be seen, if we lift R-28; regardless of the inclination of the swash plate, the pitch of all blades will be increased by the same factor. Also, if we tilt the swash plate, each blade will have a different pitch change according to its position in relation to the swash plate. Thus, we achieve cyclic pitch by lifting the swash plate at some point, I.E. the front of the fuselage. The rotor and swash-plate are connected by various levers, so as a blade and the swash plate pass over the front of the fuselage, the bell-crank R-50 is pushed outward, and as the same blade passes the rear of the fuselage, the bell-crank is pulled inward. Now, to increase collective pitch (overall lift) we simply raise R-28, which changes the pitch of all blades by the exact same amount for each blade, but does not change the mean cyclic settings.

Rotor and engines: The blade hub is attached to the shaft and power boom so that all rotate as one unit. The blades are attached to the hub with piano hinges. Silver-solder the loose ends where they bend around the hinge pin. The blade root is reinforced with 0.030 aluminum plates, top and bottom, bonded by Pliobond.

The blade root is cut off at thirty degrees. This is very important. The bell-crank servo mounting plate is bonded to the rear of the blade after first flattening that portion of the blade. "U" shaped wire pushed into the blade keeps the push-pull rod from flexing excessively during operation. The push-pull rod is mounted on top of the blade to destroy any laminar flow in that area. The servo flaps are made of plywood with a brass tube bonded to the leading edge. This tube is part of the hinge. Note the considerable wash out in each tip. When the bell-crank R- 50 is pushed outward, the flap must move upward. The spruce power boom has an engine mounted on each end facing in opposite directions, to pull the rotor around.

Cox .049 Space Hopper engines are used. Three blade props must be used to reduce the rotor head height necessary to clear the fuselage during rotation. Each engine is equipped with a pressure tank, which is attached to the rear of the aluminum motor mounts. The tank must be on the inside of the mount, so centrifugal force will not throw it off. During the numerous tests of my helicopters I have never had a part come off during flight. The units of the rotor, during rotation develop several times their normal weight; if they flew off they could be very destructive. For this reason, if no other, the rotor must be constructed carefully. Bolt the blades directly to R-42 and balance the rotor carefully. Number each blade and its position on the hub. Always replace the blades in their proper position. Paint the rotor assembly dull black. Anti-torque rotor and controls: The anti-torque motor and shaft assembly is cemented to the top half of the bracket (A-l, A-2, A-3,' and A-28) with Ambroid. This complete unit is held in place by six 4-40 screws passing through the top into blind nuts bonded to the bottom of A-l. Cement the bottom half of the bracket into the fuselage. Special care should be taken to align the gears on the motor and the rotor shaft. Power is supplied by a Micromax motor of 14:1 gear ratio, geared up to 8:1. The blades are made of a balsa, ply, and balsa sandwich, with a streamlined symmetrical shape. Paint the blades dull black. Pitch control is accomplished by pushing and pulling A-8, which doesn't rotate. Attached to A-8 by a radial bearing, is A-24, which is free to rotate with the blades. It is necessary to "stake" the bearing into A-24. A-24 is connected to A-19 by wire links A-30. Thus by pushing or pulling A-8 the blades can be set at any desired positive or negative incidence. It is necessary to experiment to determine the center of the pitch range as the rotor must compensate when in neutral for the small amount of torque transmitted through the rotor head of the fuselage. This unit is protected during tail down attitudes by the small sub-rudder. Since my helicopter at this (Continued on *Page* 43)

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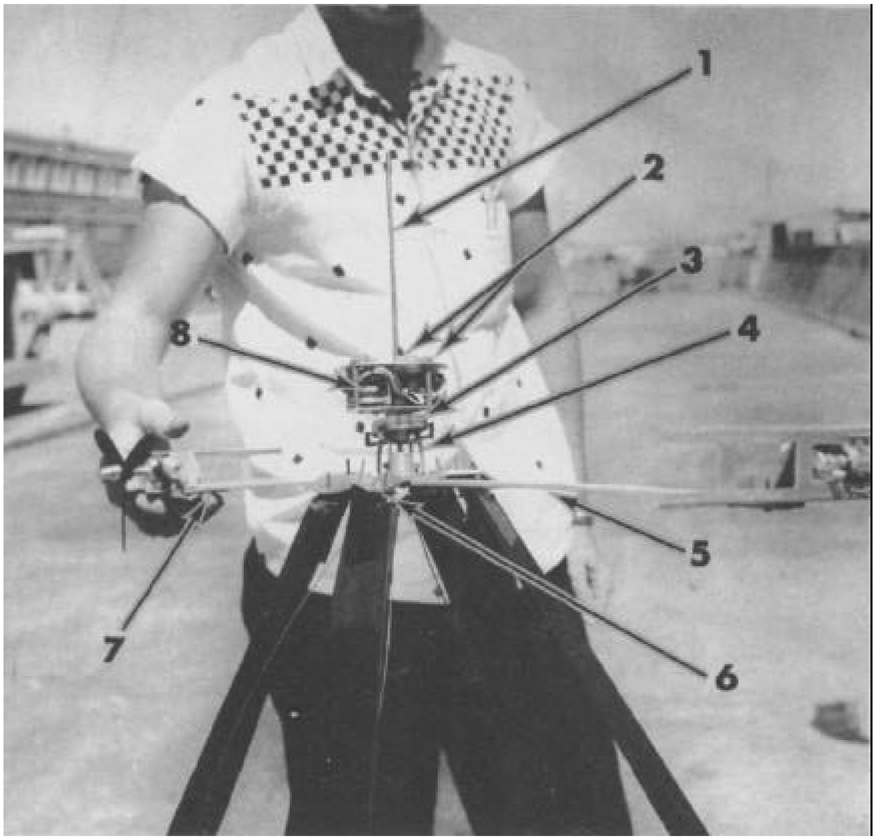
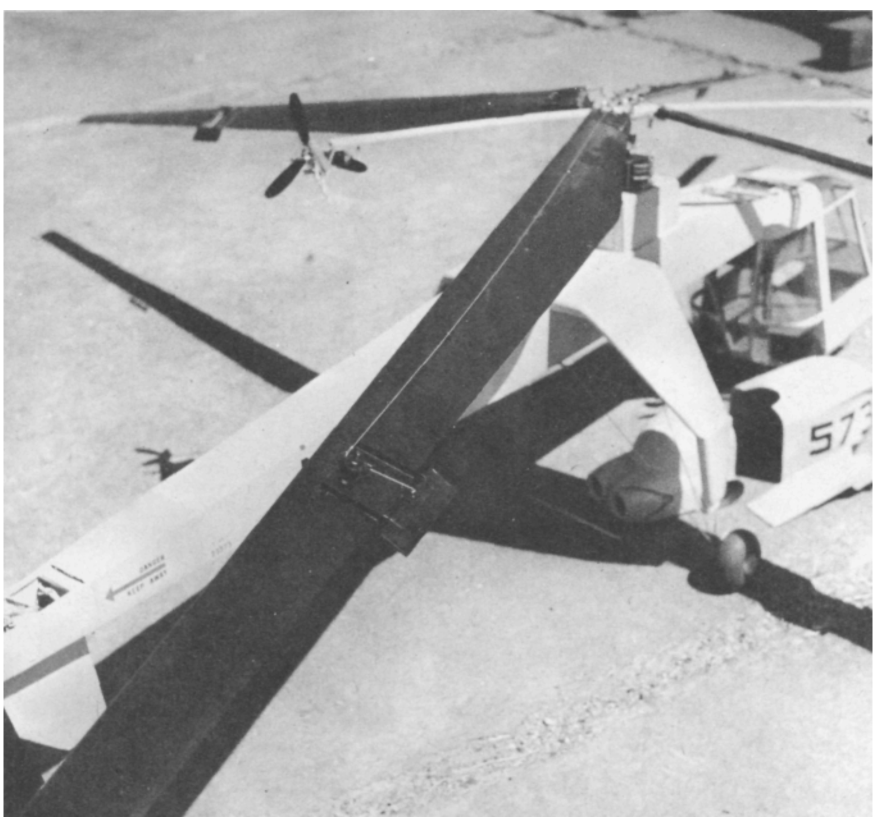
writing hasn't flown; please realize the information contained in this article is based either on theory or experience gained through free-flight helicopter models. Since the blades have a horizontal hinge they are free to flap or come up, but not allowed to flap down past a line perpendicular to the rotor shaft. This coning of the blades also changes the angle of incidence of the blades due to the rake angle of the hinge (called the Delta Three Hinge).

What I attempted to do with my model is control the cone angle of each blade individually, and all blades collectively. This is accomplished by using servo flaps, which increase or decrease the lift of each blade thus controlling the cone angle and the angle of attack. To obtain insufficient vertical thrust for upward flight the cone angle is increased, as the cone angle is decreased the lift is increased. A test stand is presently under construction, which will allow the rotor system to be "flown" on the ground where the hazards can be controlled to some degree. Until I have some practical assurance the model will respond as desired, I have no intention of turning it loose. Better to trim it first.

As you can see this model is just the start of an extremely interesting and challenging undertaking, which could reward one with great personal satisfaction. All that is really required to build model helicopters is sufficient desire and a little ingenuity. I hope you will join me. Keep in touch. •



Indicated by arrows: 1: Rotor shaft; 2: Two and Pitch levers; 3: Swash plate; 4: Nine-pin Cannon connectors; 5: Spruce power boom; 6: Delta three hinge, one of four; 7; Aluminum engine-tank mounts; 8: A Servo motor, one of three. Ken requests mail exchange of 'copter ideas.



Rotor flap close-up and actuating wire pushrod, in turn linked to bell-crank and swash-plate. Wire exposed to destroy laminar flow over rotor