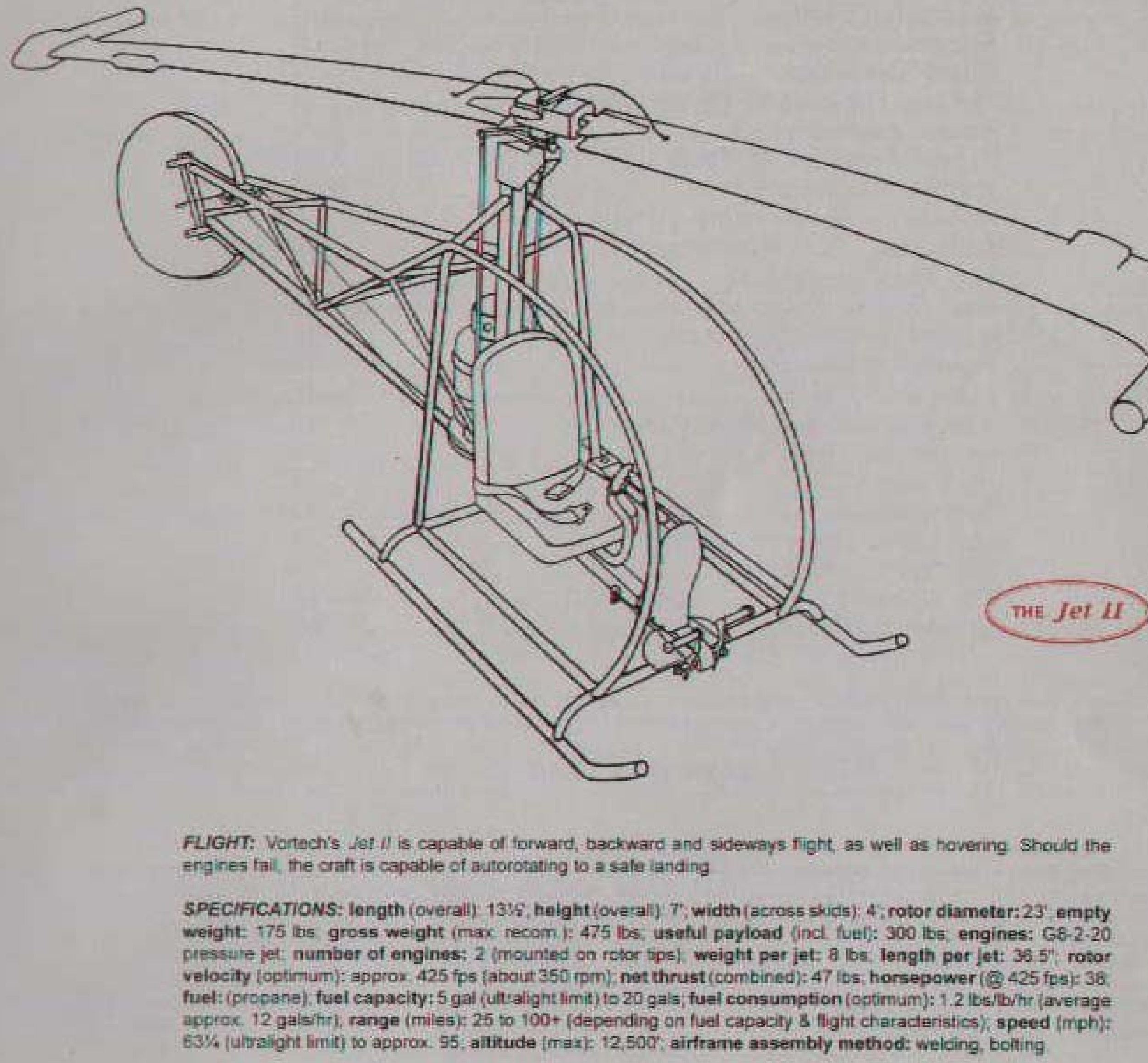
THE CONSTRUCTION OF A SMALL
JET HELICOPTER



FLIGHT: Vortech's *Jet II* is capable of forward, backward and sideways flight, as well as hovering. Should the engines fail, the craft is capable of autorotating to a safe landing.

SPECIFICATIONS: **length** (overall): 13½'; **height** (overall): 7'; **width** (across skids): 4'; **rotor diameter:** 23'; **empty weight:** 175 lbs; **gross weight** (max. recom.): 475 lbs; **useful payload** (incl. fuel): 300 lbs; **engines:** G8-2-20 pressure jet; **number of engines:** 2 (mounted on rotor tips); **weight per jet:** 8 lbs; **length per jet:** 36.5"; **rotor velocity** (optimum): approx. 425 fps (about 350 rpm); **net thrust** (combined): 47 lbs; **horsepower** (@ 425 fps): 38; **fuel:** (propane); **fuel capacity:** 5 gal (ultralight limit) to 20 gals; **fuel consumption** (optimum): 1.2 lbs/lb/hr (average approx. 12 gals/hr); **range** (miles): 25 to 100+ (depending on fuel capacity & flight characteristics); **speed** (mph): 63¼ (ultralight limit) to approx. 95; **altitude** (max): 12,500'; **airframe assembly method:** welding, bolting

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INTRODUCTION

The building and flying of small jet helicopters is rapidly growing in popularity among aircraft enthusiasts, for reasons easy to understand. With its remarkable flying abilities, such as its ability to hover in midair and to fly backward and sideward as well as forward, the helicopter can provide a sense of physical freedom and a general flying experience unattainable with any other kind of aircraft. The small jet-powered helicopter offers, additionally, a simplicity of design, a low cost of construction materials and a handling ease in the air unrivaled by its piston-engine counterpart. Elimination of heavy piston engines, complicated gears and transmissions not only give the jet design a cleaner appearance, but allow a comparatively heavier payload plus lower cost of construction and upkeep. Probably the biggest advantage is the absence of the torque problem: that tendency of the fuselage of fuselage-mounted piston-engine helicopters to rotate contrariwise to the rotor. Methods used to counteract this problem only add more complexity to the piston-engine design. Although the advantages of the jet design had, in the past, been offset by high fuel consumption, the development of the G8-2 Pressure Jet has virtually eliminated this shortcoming. For these reasons we are concentrating on the jet means of propulsion.

This monograph is dedicated to the amateur enthusiast who is looking for the qualities described above at the greatest possible economy. Upon completing construction, let us hear about your experience building and flying this aircraft. We will pay $20 and up for each photo of a completed *JET II* we're able to use.

We wish you the greatest success with your project!

STRUCTURAL FACTORS

The basic design and dimensions offered in this monograph are a given example and may be adapted to suit the builder's purpose—e.g., enclosing the cabin, fitting with lights, adding avionics, etc.—as long as the basic criteria given below are adhered to.

The following fundamental factors must be considered in the construction:

1. **CENTER OF GRAVITY.** The helicopter should be constructed so as to balance from its point of suspension. That is, the center line of the rotor shaft should be the axis at which the entire helicopter's weight is concentrated. A good way to check this is to suspend the entire helicopter, including pilot, fuel tank(s) and accessories, from this center point by a cable. Any necessary adjustments in exact placement of seat, fuel tank(s) or accessories can then be made.

2. **POWER-TO-WEIGHT RATIO.** The helicopter should be designed with reserve power. Approximately 12 lbs. per horsepower, or, for jet engines, per pound of dynamic thrust (roughly, at typical rotor-tip velocity), would be the basis used in construction. In order to obtain maximum results from a given engine system, rotor blades must be constructed, balanced and mounted with the utmost accuracy. Clearly, such factors as strength and stress of all weight-bearing structures of the craft will also determine the total permissible load. Never exceed these limits.

3. **METHOD OF CONSTRUCTION.** The frame of the helicopter may be primarily welded or bolted together. No matter what method of construction is used, frame joints must be strong. Where frame is to be welded together, it is advisable for the amateur to contract a certified aircraft welder.

4. **MATERIALS USED IN CONSTRUCTION.** Overall, the goal is to keep the frame as strong, yet light as possible. Structurally, aircraft-quality, "normalized" 4130 chrome-moly steel (available in tubing, rods, sheets) is one possible choice. Tubing of this material may be used for the fuselage and tail section. However, an excellent, though lighter material that could be used for the frame is 6061-T6 aircraft aluminum tubing. Specific materials are noted in the various assembly drawings.

SOURCES

Tubing, cable, pulleys, hardware, etc. will be found at your local metal, hardware, automotive, aircraft, or surplus-parts supplier. Check the yellow pages of your phone book. Your local library should have lists and catalogs of manufacturers and suppliers of bearings and almost anything else you'll need. For example, see the *Thomas Register,* available at most libraries. Also, it should prove helpful to speak with an ultralight aircraft parts supplier, who can likely guide you in your choice of structural materials. Some other suppliers are listed below (write to them directly for information).

Aircraft Spruce & Specialty Co., Box 424, Fullerton, CA 92632. Phone: (outside California) 1-800-824-1930, (within California) 1-800-824-1934.
Huge selection of aircraft and ultralight equipment and accessories: frame and structural metal, plywood, fiberglass, phenolic, foam, AN hardware, bearings, cable, instruments, seat belts, etc. Send $5.00 for catalog.

Gas Supply Inc., 2238 Edgewood Avenue South, Minneapolis, MN 55426. Phone: (outside Minnesota) 1-800-328-5677, (within Minnesota) 1-800-742-0678.
Large selection of propane equipment: tanks, gauges, fuel line, connectors, valves. Write or call for catalog.

Whitey Co., 318 Bishop Road, Highland Heights, OH 44143.
Manufacturer of valves and fittings. Write for catalog.

Acco Industries, Inc., 200 Industrial Drive, Milan, TN 38358. Phone: (901)686-0831.
Manufacturer of standard and custom cables. Write or call for information.

Wunderlich's, Inc., 306 W. 16th Street, Lockport, IL 60441. Phone: (815)838-0450.
Manufacturer of rotor tachometers. Write or call for information.

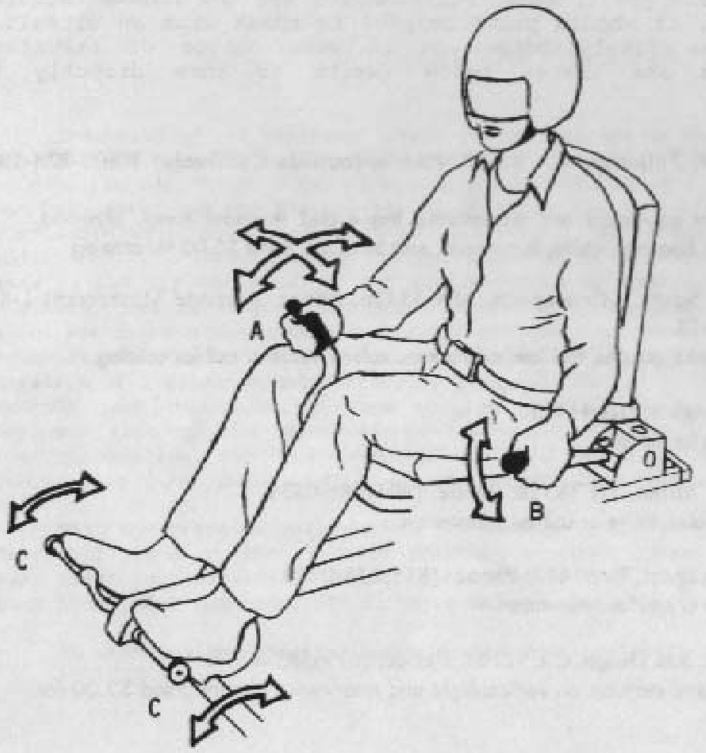
John Roby, Bookseller, 3703 Nassau Drive, San Diego, CA 92115. Phone: (619)583-4264.
Offers huge selection (800+) of books and manuals on vertical-flight and rotary-wing aircraft. Send $2.00 for list.

FLIGHT OPERATIONS

No flights should be attempted before all structures and systems have been fully checked for soundness of construction and safety. The first test under power must be made with the craft tied securely down. This would involve spinning the rotor at 0° pitch for extended periods of time, then disassembling (where possible) and stress checking the major power and control systems. If all proves sound, subsequent testing would be performed with the craft tethered to within 2 feet of the ground, giving the blades just enough pitch to barely lift off for brief moments until not only the control system has been mastered, but additional stress checks prove all is intact. We urge that *no free flights be made by the amateur without instruction by a Certified Flight Instructor (C.F.I.) with a helicopter rating and a thorough check of all structures and systems by a certified aircraft mechanic.* Before each period of flight the major structures and controls should be re-checked. Never exceed manufacturer's recommendations for bearing or blade life (hours of usage). Always securely fasten seat belt before every flight.

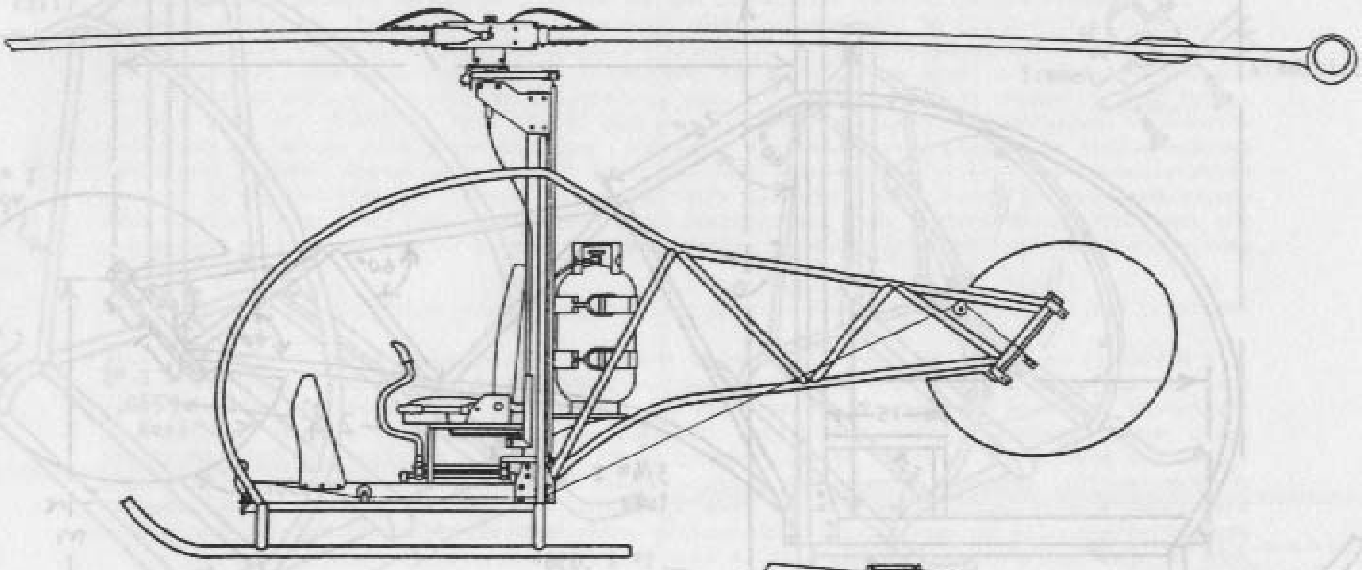
Actual flight operation is essentially identical to that of conventional helicopters, *which must be studied beforehand.* With the blades at 0° pitch the engines are started and the rotor allowed to reach optimum flight r.p.m., the throttle slowly advanced, as necessary. For the G8-2- powered jet helicopter this will be roughly 375 r.p.m. (the actual optimum should be determined by experimentation for each specific rotor system). The joystick should be in the neutral (no-tilt) position. Pitch is then gradually and smoothly given to the blades by lifting the collective stick while, simultaneously, the throttle is gently advanced to maintain flight r.p.m. (the tachometer should be consistently observed). As the craft leaves the ground, forward flight is initiated by *easing* the joystick forward. Raising the collective stick while adjusting the throttle will cause the craft to ascend. Yet the controls are interdependent: joystick movement primarily controls horizontal flight, but will also affect the craft's altitude. Smooth, coordinated operation is imperative to properly control the craft's flight. Moving the joystick backward or sideways will cause the craft to fly in those directions, yet any such change in flight direction must be made *gradually, after* pausing in hover. To hover, the joystick is essentially placed in its neutral position while altitude is maintained, although slight motions of the joystick (as well as the collective stick and throttle) will be required to compensate for wind or gusts. Yaw control -- rotating the craft around its axis during flight — is accomplished by operation of the rudder pedals: pressing the left pedal will cause the craft to turn to the left, and conversely with the right pedal.

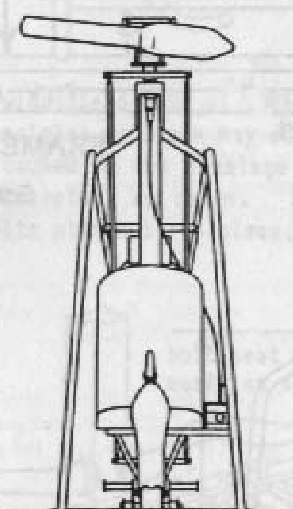
For a complete explanation of helicopter flight and control systems we strongly recommend: *Basic Helicopter Handbook*, available from VORTECH.

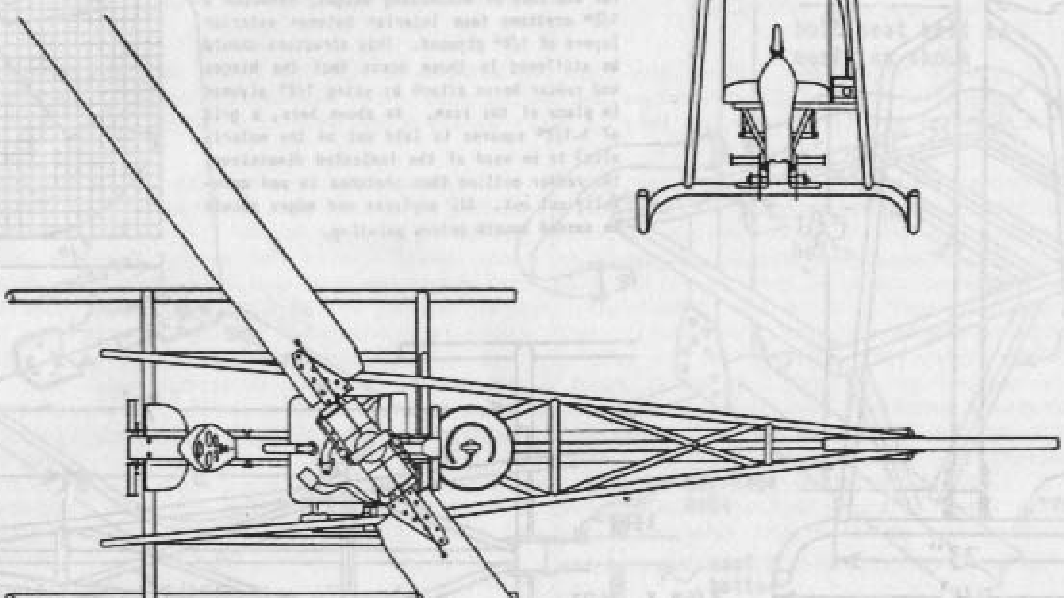


Illustrated here are the basic jet helicopter controls and their movement: A) the joystick, which moves forward, backward or sideways, for flight in those directions; B) the collective pitch/throttle control, which increases or decreases rotor pitch and r.p.m. for altitude and speed control (mainly); and C) the rudder pedals, for left-right directional control. See text, above.

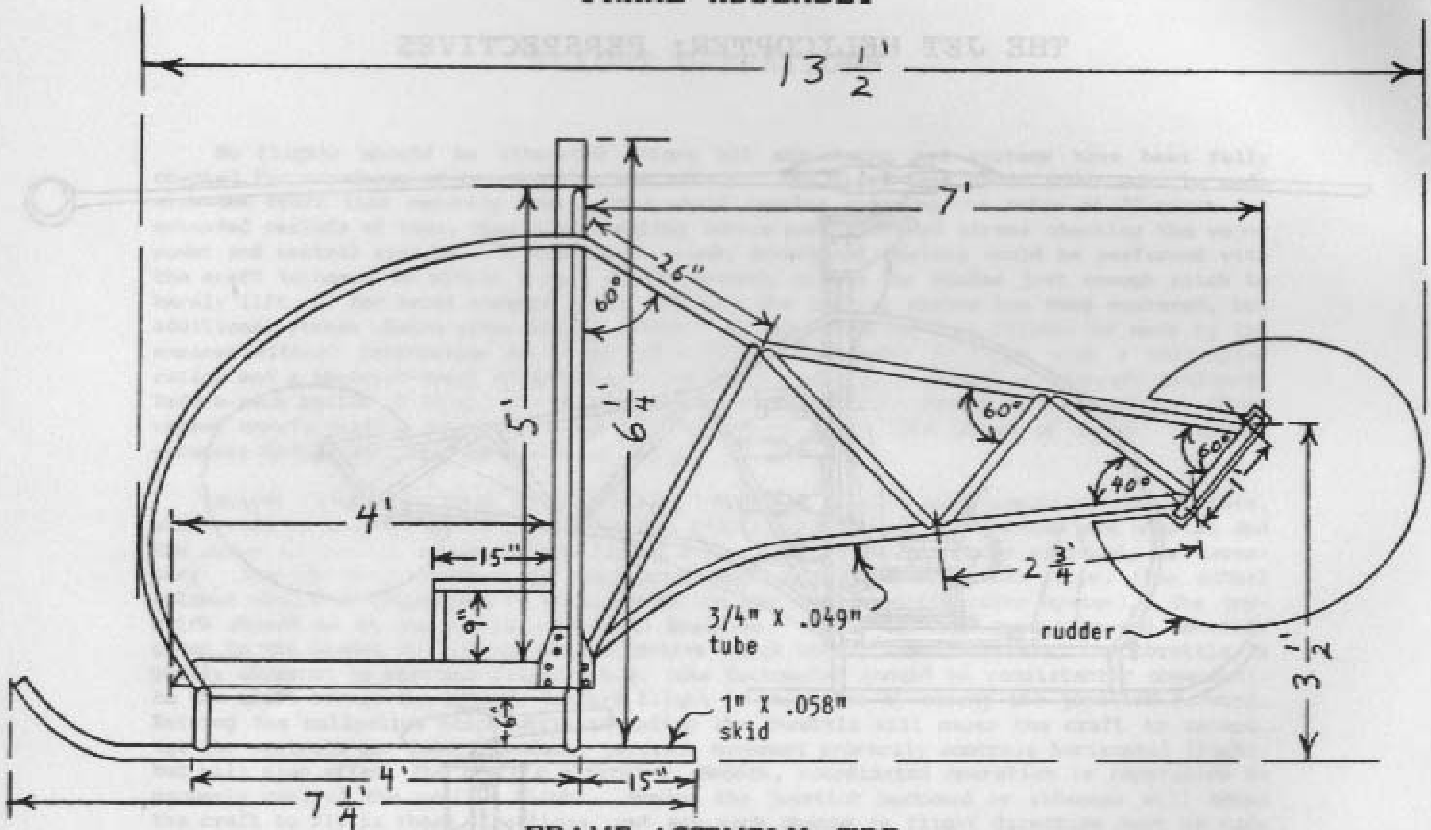
THE JET HELICOPTER: PERSPECTIVES







FRAME ASSEMBLY

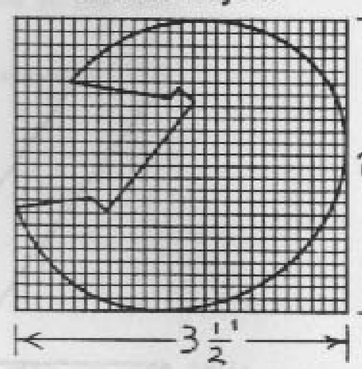


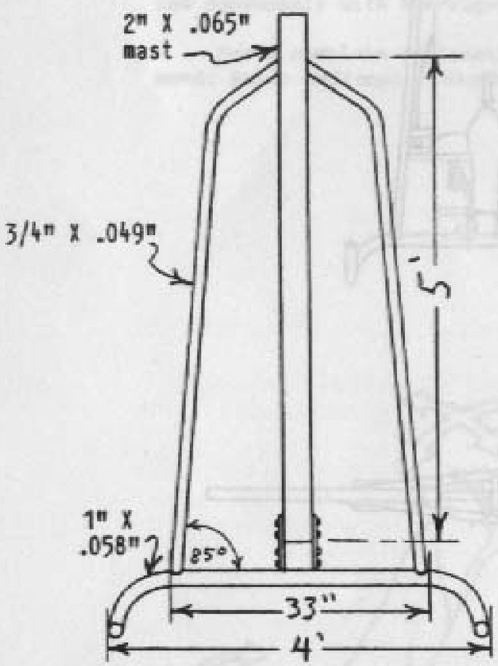
FRAME ASSEMBLY: SIDE

Scale: ½" = 1'

The rudder may be cut from 3/8" marine plywood (kaya mahogany is an excellent material). Or, for the sake of minimizing weight, sandwich a 1/2" urethane foam interior between exterior layers of 1/8" plywood. This structure should be stiffened in those areas that the hinges and rudder horns attach by using 1/2" plywood in place of the foam. As shown here, a grid of 1-1/2" squares is laid out on the material(s) to be used of the indicated dimensions, the rudder outline then sketched in and carefully cut out. All surfaces and edges should be sanded smooth before painting.

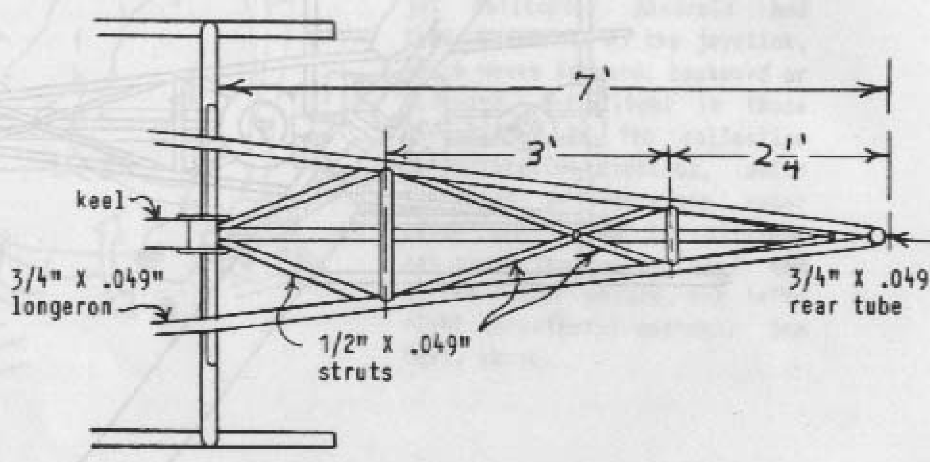
Rudder Layout





FRAME ASSEMBLY: REAR

Scale: ½" = 1'

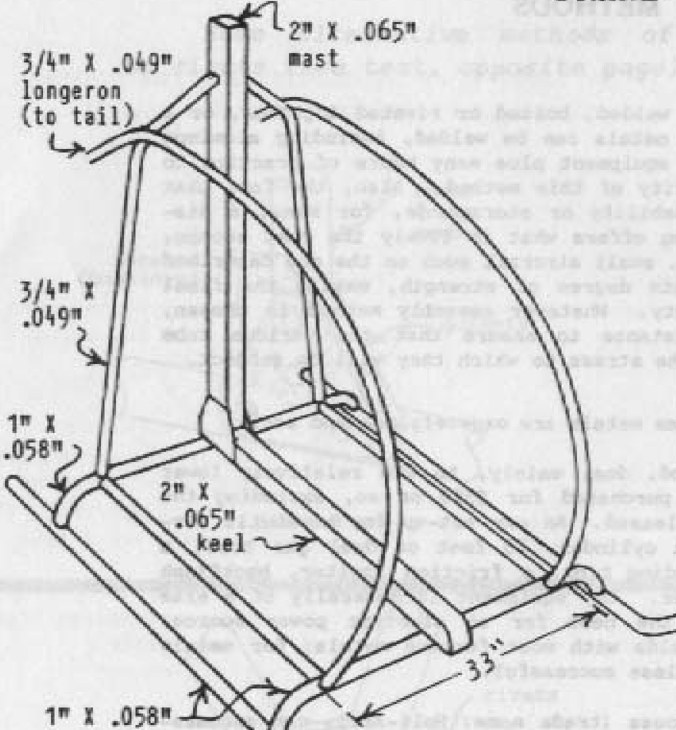


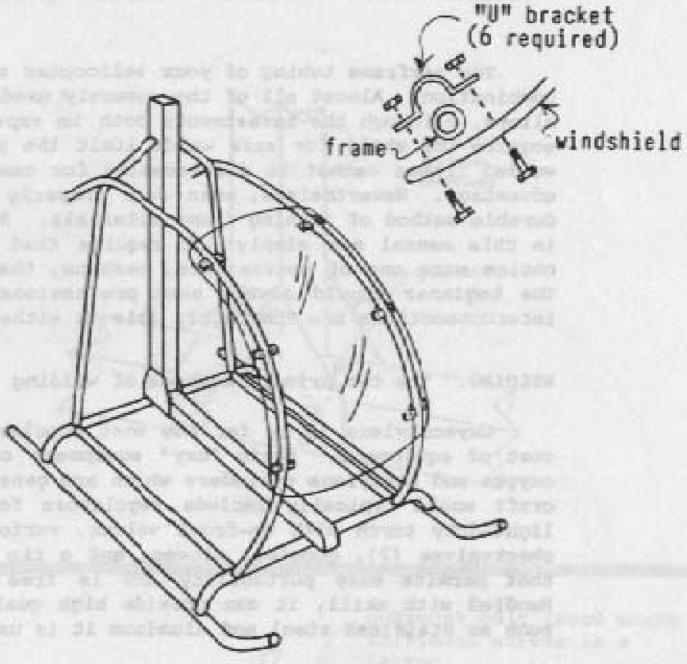
FRAME ASSEMBLY: TAIL

Scale: ½" = 1'

4130 steel is the recommended structural material unless otherwise stated

FRAME ASSEMBLY

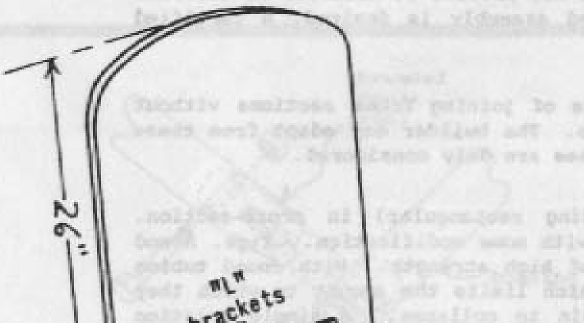


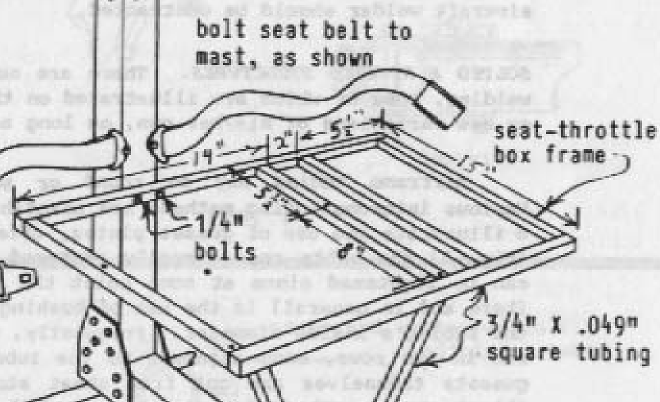


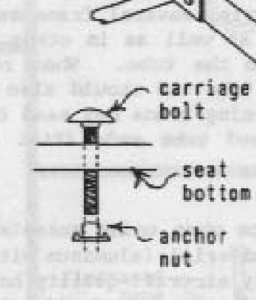
A windshield made of .125"-thick Plexiglas or Lexan may easily be attached to the fuselage of the helicopter, as shown. Six "U" bolts attach it in place.

FRAME ASSEMBLY: FUSELAGE
Three-quarter view

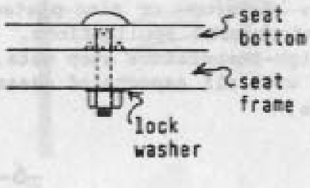
Scale: none







Seat is formed of 1/2" marine plywood, as shown. Bottom is drilled in alignment with holes in seat frame; four 1/4" X 1-3/4" carriage bolts are permanently secured through these holes to the seat via anchor nuts. Then, seat is upholstered. Total thickness of seat bottom (including plywood) should be about 3", total thickness of seat back should be about 2".



FRAME ASSEMBLY METHODS

The airframe tubing of your helicopter may be welded, bolted or riveted together, or a combination. Almost all of the commonly used frame metals can be welded, including aluminum alloys, although the investments both in expensive equipment plus many hours of practice to acquire the skill for *safe* welds limit the popularity of this method. Also, the fact that welded frames cannot be disassembled for easy portability or storage is, for many, a disadvantage. Nevertheless, *when done properly* welding offers what is likely the most secure, durable method of joining frame materials. And yet, small aircraft such as the one described in this manual may simply not require that ultimate degree of strength, making the final choice more one of convenience, perhaps, than safety. Whatever assembly method is chosen, the beginner should always seek professional assistance to assure that the various tube interconnections are thoroughly able to withstand the stress to which they will be subject.

WELDING. The two primary methods of welding airframe metals are *oxyacetylene* and *arc*.

Oxyacetylene is by far the most popular method, due, mainly, to the relatively lower cost of equipment. Basic "oxy" equipment can be purchased for $500 or so, excluding the oxygen and acetylene cylinders which are generally leased. An oxy set-up for homebuilt aircraft would typically include regulators for each cylinder, 25 feet of dual gas hose, a light-duty torch with up-front valves, various welding tips, a friction igniter, backflash checkvalves (2), goggles, gloves, and a tip cleaner. Oxy equipment is generally of a size that permits easy portability and is free from the need for an electric power source. Handled with skill, it can provide high quality welds with most ferrous metals; for metals such as stainless steel and aluminum it is usually less successful.

Arc welding, particularly the gas-tungsten process (trade name: Heli-Arc), can successfully weld any metal the oxy process can *as well as* such nonferrous materials as aluminum and stainless steel. While it is likely the most versatile process, its usefulness is limited by such factors as high equipment cost (usually over $2,000) and nonportability due to its weight and need for a 220-volt power source. Some of the equipment required for gas-tungsten arc welding: a complex power supply, a current adjustor (amptrol), a water-cooled torch with cable, argon cylinders (usually leased), a heat exchanger, a gas-flow meter. Protective clothing and a welding hood are necessities.

The amateur inexperienced with either process should not presume to assemble an airframe as his or her first welding project; rather, if a welded assembly is desired, a certified aircraft welder should be contracted.

BOLTED & RIVETED STRUCTURES. There are numerous methods of joining frame sections without welding, some of which are illustrated on the facing page. The builder may adapt from these or use variations of his/her own, as long as joint stresses are duly considered.

Airframe tubing may be round or square (including rectangular) in cross-section. Various interconnecting methods are adaptable to either with some modification. Figs. A and B illustrate the use of gusset plates, offering joints of high strength. With round tubing (Fig. A) the bolts are generally centered, as shown, which limits the amount to which they can be tightened since at some point the tube will begin to collapse. A simple solution (here and in general) is the use of bushings, such as lengths of rod with a diameter that of the tubing's inside diameter. Frequently, with square or rectangular tubing the bolts may be run in two rows, each adjacent to the tube wall, which acts as a buttress (Fig. B). The gussets themselves are cut from sheet stock heavy enough for the given purpose. Fig. C illustrates a method of securing several frame members together with gussets. Rivets (shown) or bolts may be used (here as well as in other methods). Note that for greatest strength the gussets are contoured to the tube. When round tube members are joined (for example, Figs. A, D, E) the abutting tube end should also be contoured (Fig. F). When tubing is run at angles (Fig. G) a reinforcing brace may need to be used in conjunction with the brackets. Joints comprised of flattened tube ends (Fig. H) offer little strength and have limited usefulness.

The recommended practice when using gussets, bushings and washers is to use the same kind of metal as the frame material (aluminum with aluminum, steel with steel) to discourage electrolytic corrosion. Only aircraft-quality hardware should be used in airframe construction, such as "AN" bolts and nuts (obtainable from aircraft-supply stores). These combine high tensile strength with proper ductility for reliable assemblies. Ordinary hardware-store bolts should *not* be used. Cadmium- or zinc-plated or stainless steel hex head AN bolts are commonly used for most structural applications. AN nuts may be of the self-locking type, such as the elastic or high-temperature stop nuts, or plain hex type requiring either a lock washer or check nut. As with all aspects of assembly, the structural function should determine ones specific choice.

FRAME ASSEMBLY METHODS

Some alternative methods of joining frame members with bolts or rivets (see text, opposite page).

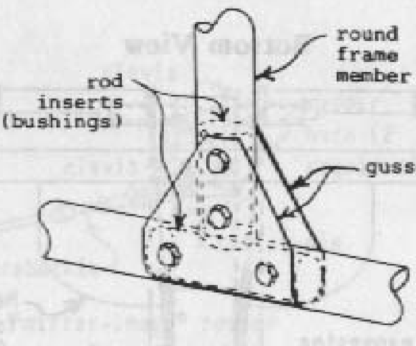


FIG. A

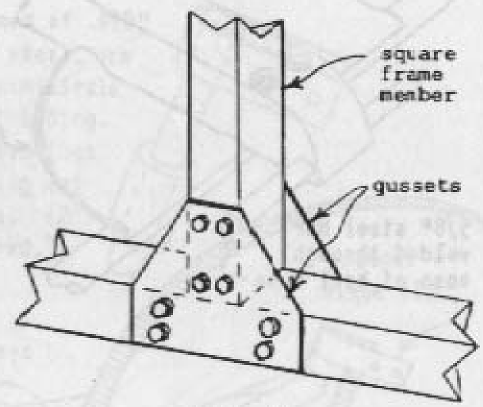


FIG. B

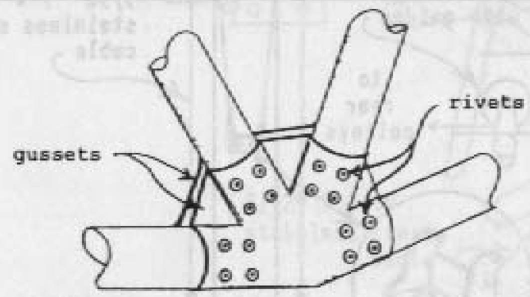


FIG. C

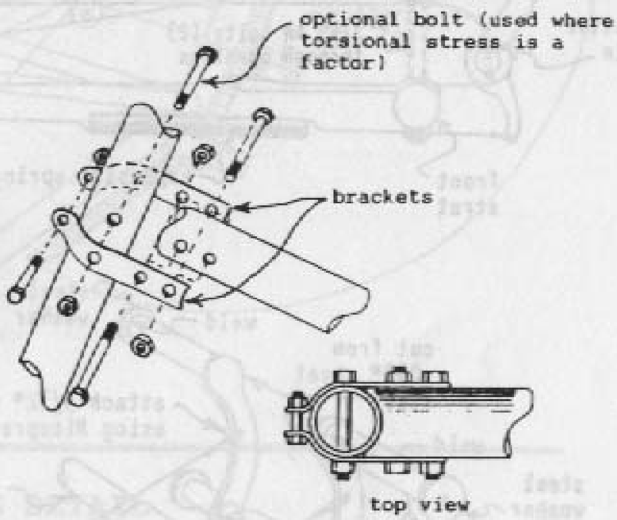


FIG. D

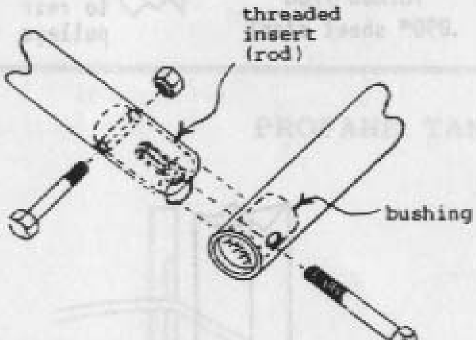


FIG. E

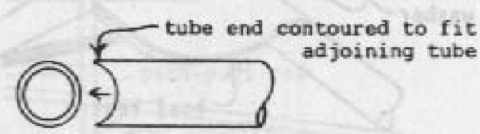


FIG. F

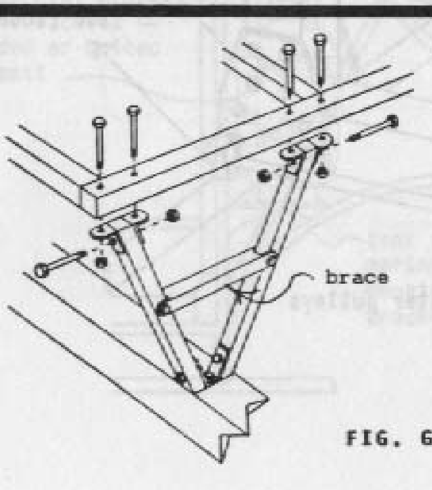


FIG. G

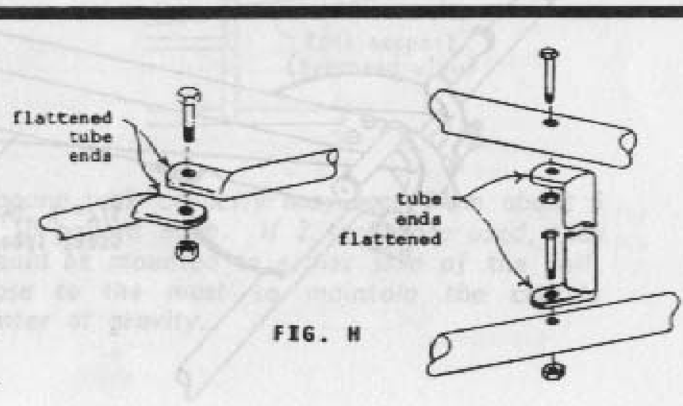
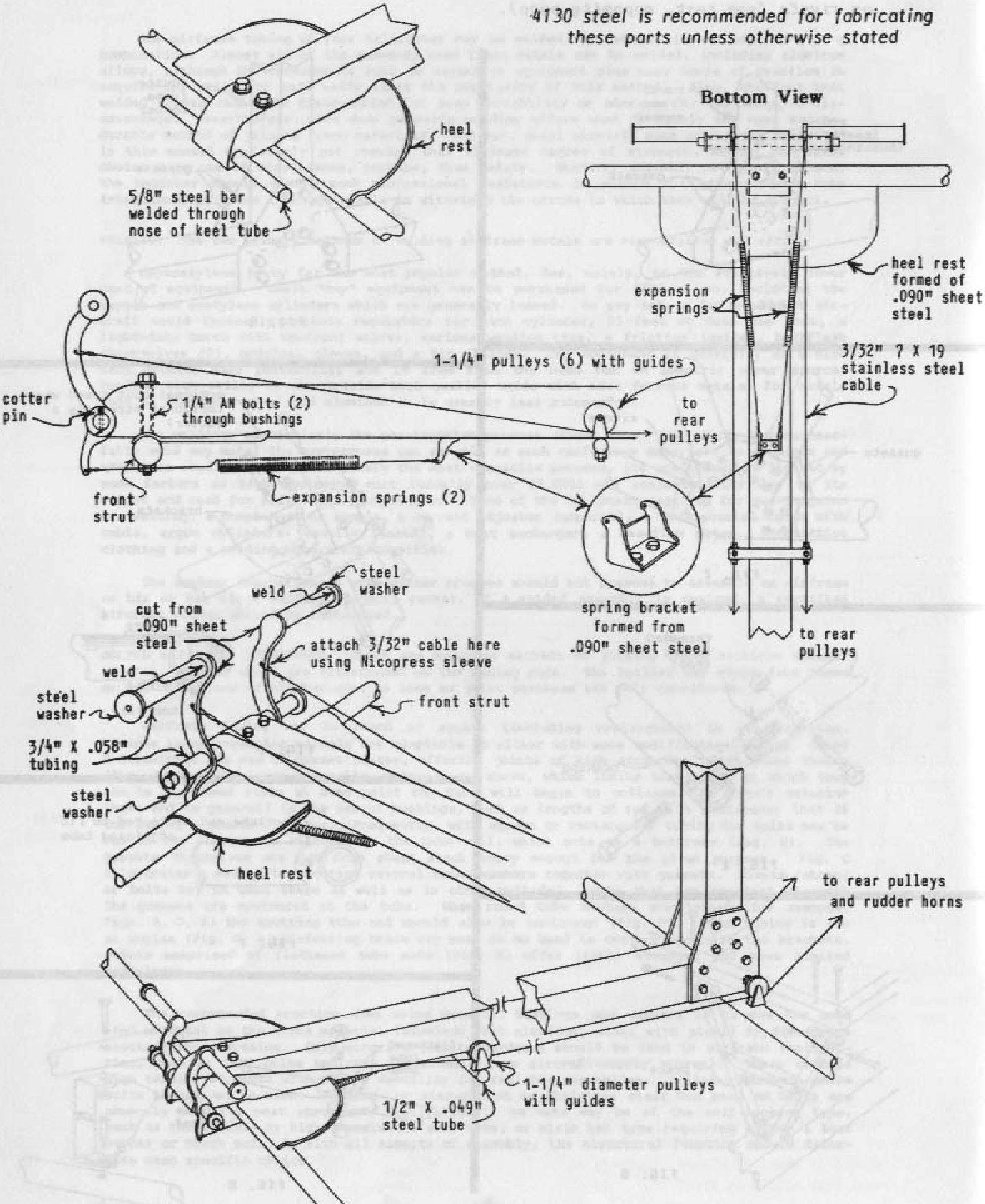


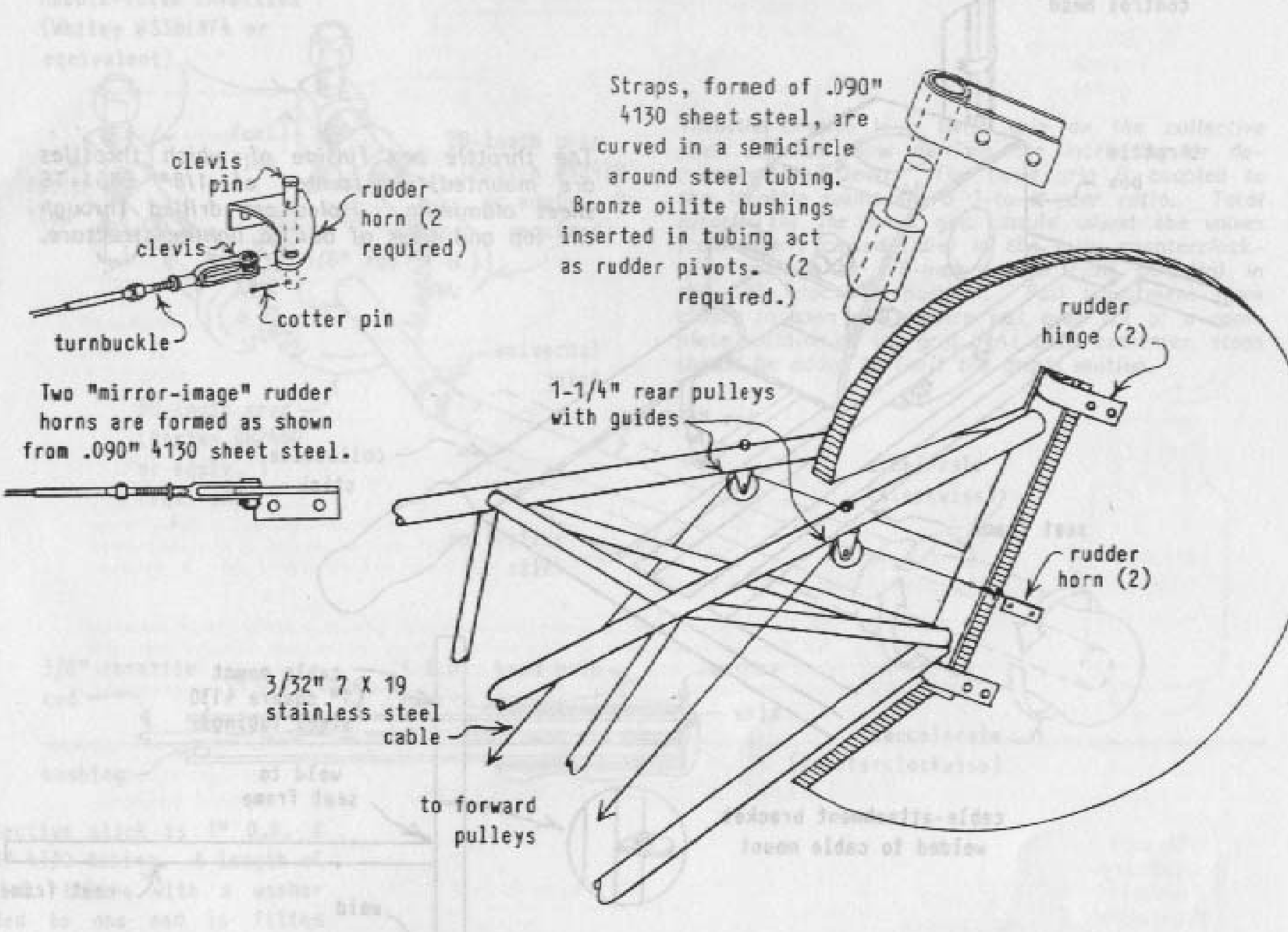
FIG. H

THE RUDDER MECHANISM

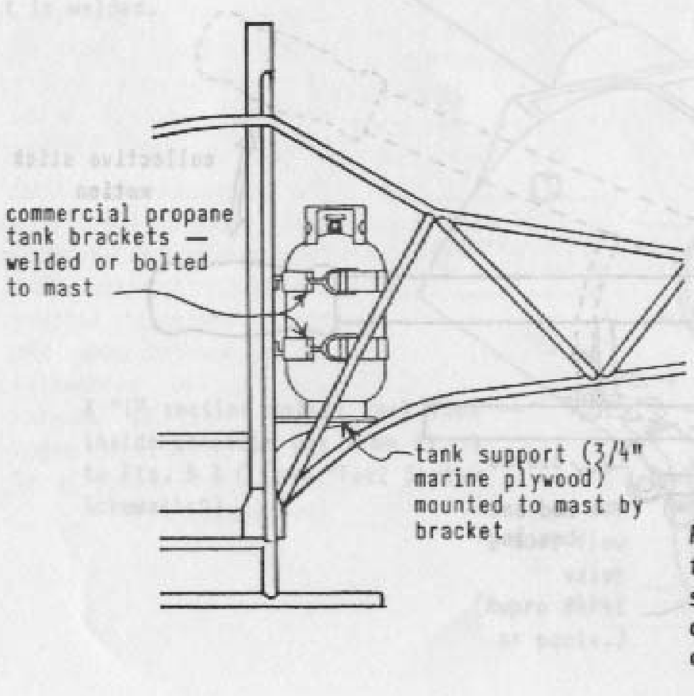
4130 steel is recommended for fabricating these parts unless otherwise stated

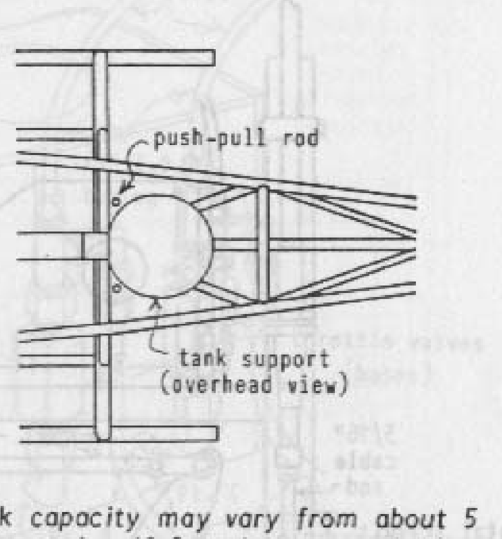


THE RUDDER MECHANISM



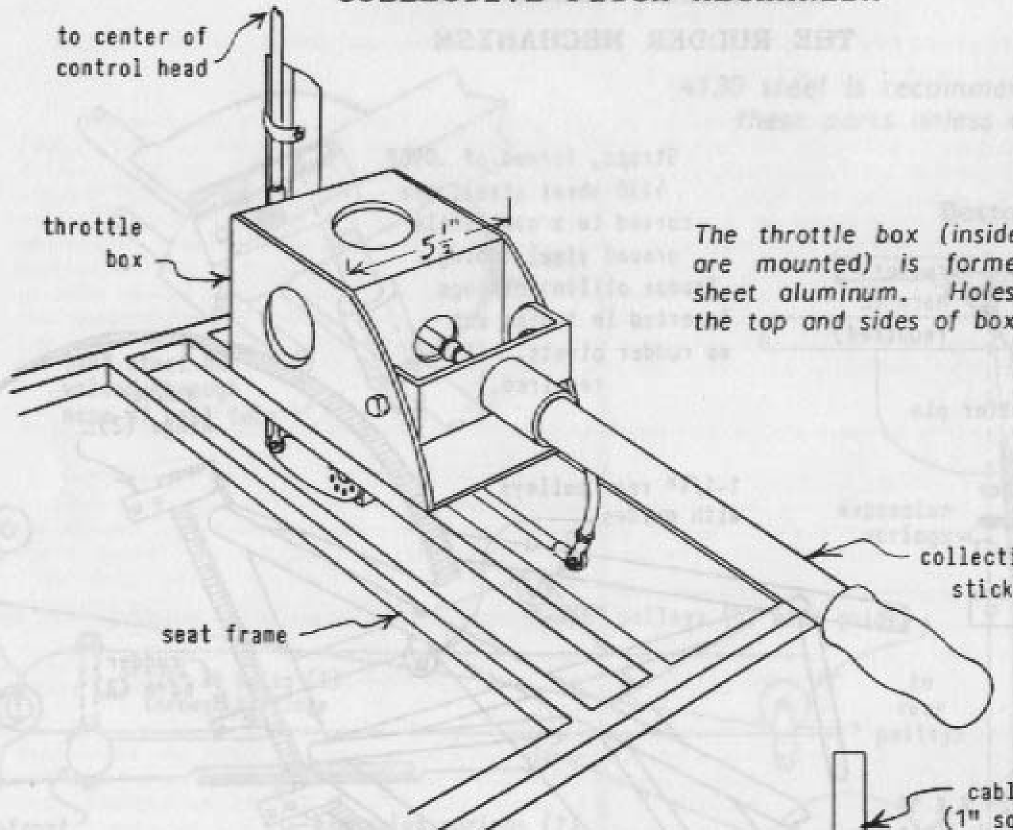
PROPANE TANK MOUNTING DETAIL



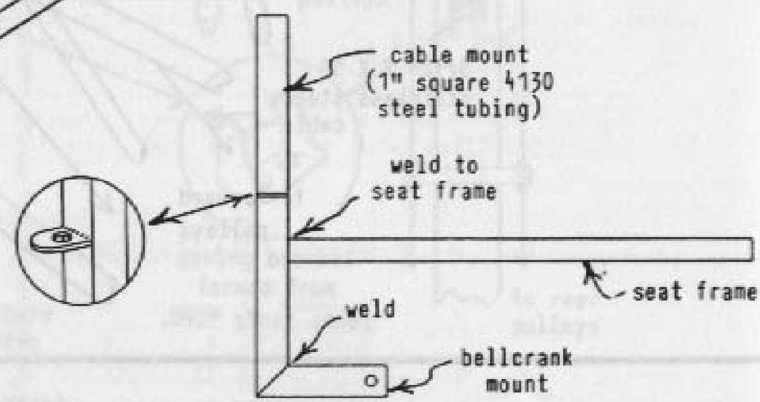


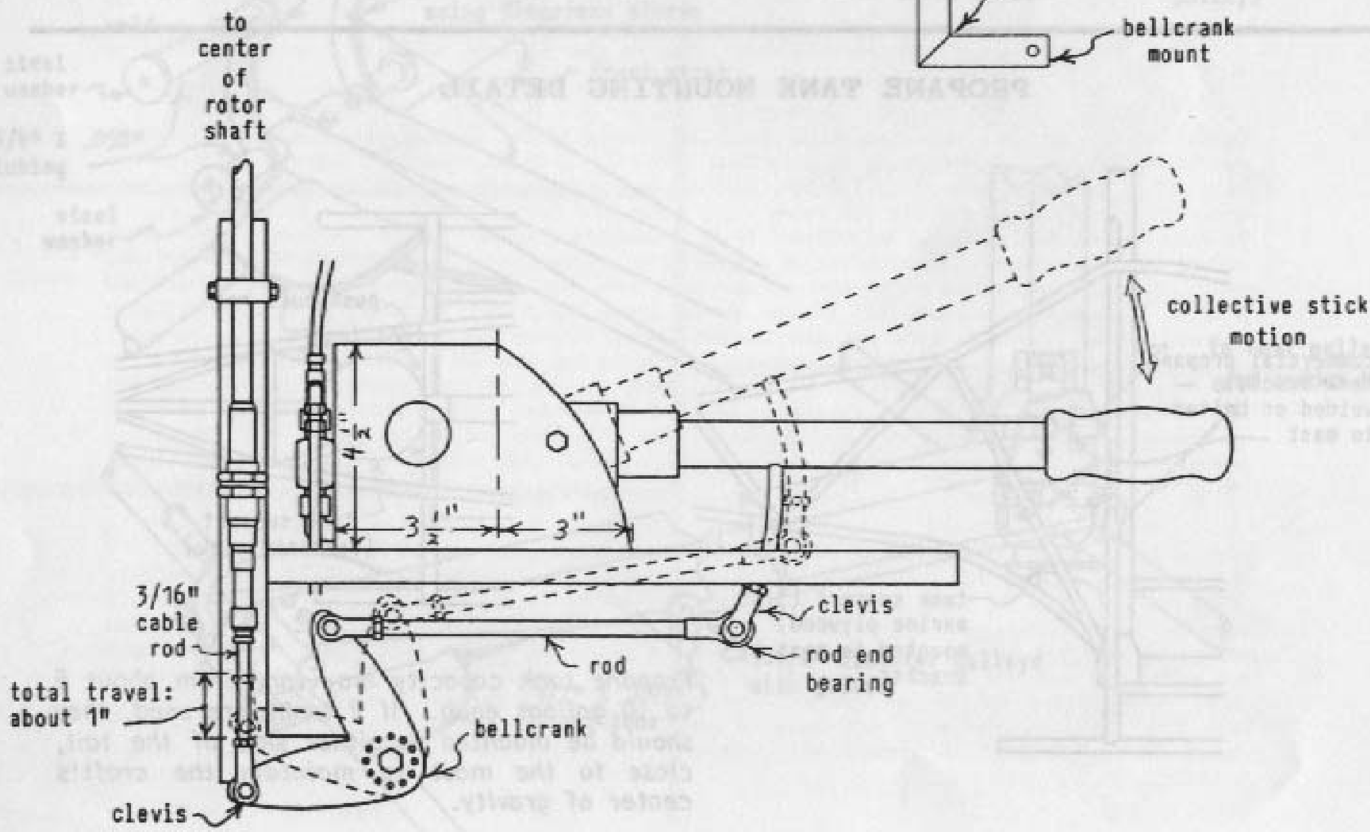
Propane tank capacity may vary from about 5 to 10 gallons each. If 2 tanks are used, they should be mounted to either side of the tail, close to the mast to maintain the craft's center of gravity.

COLLECTIVE PITCH MECHANISM

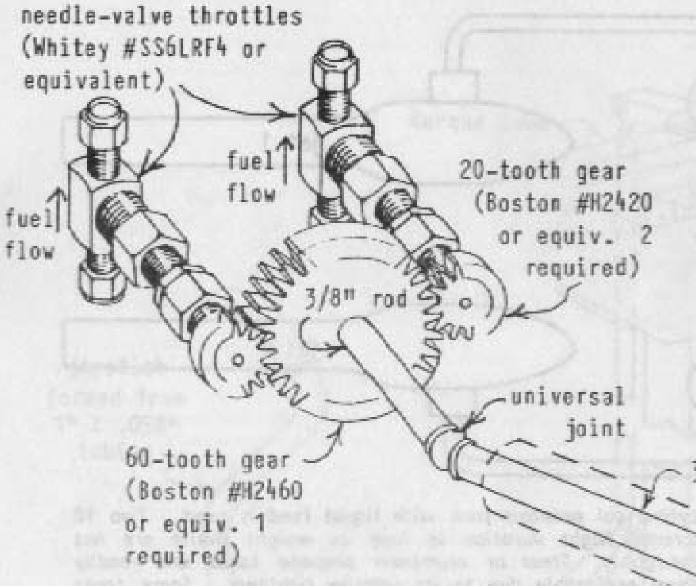


The throttle box (inside of which throttles are mounted) is formed of 1/8" 6061-T6 sheet aluminum. Holes are drilled through the top and sides of box to lighten structure.

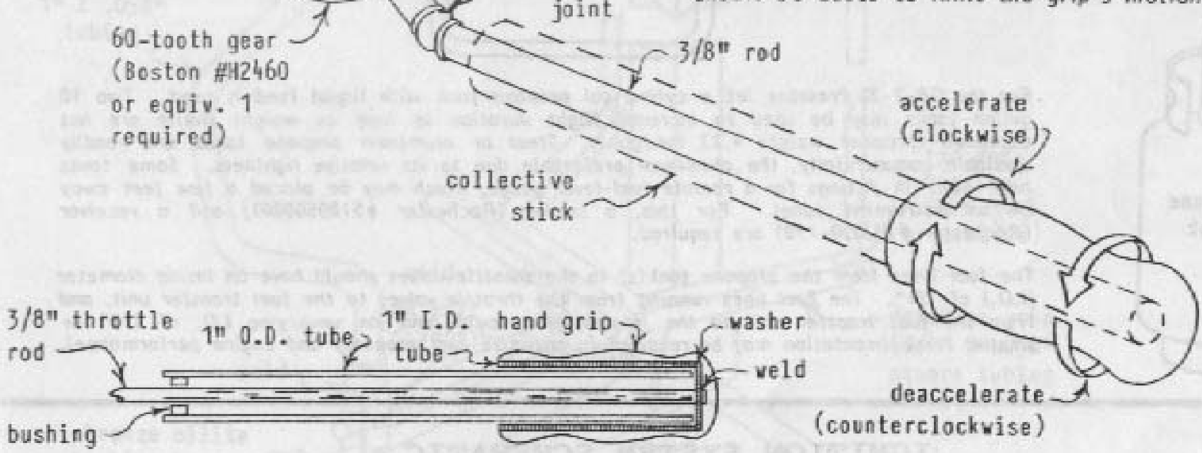




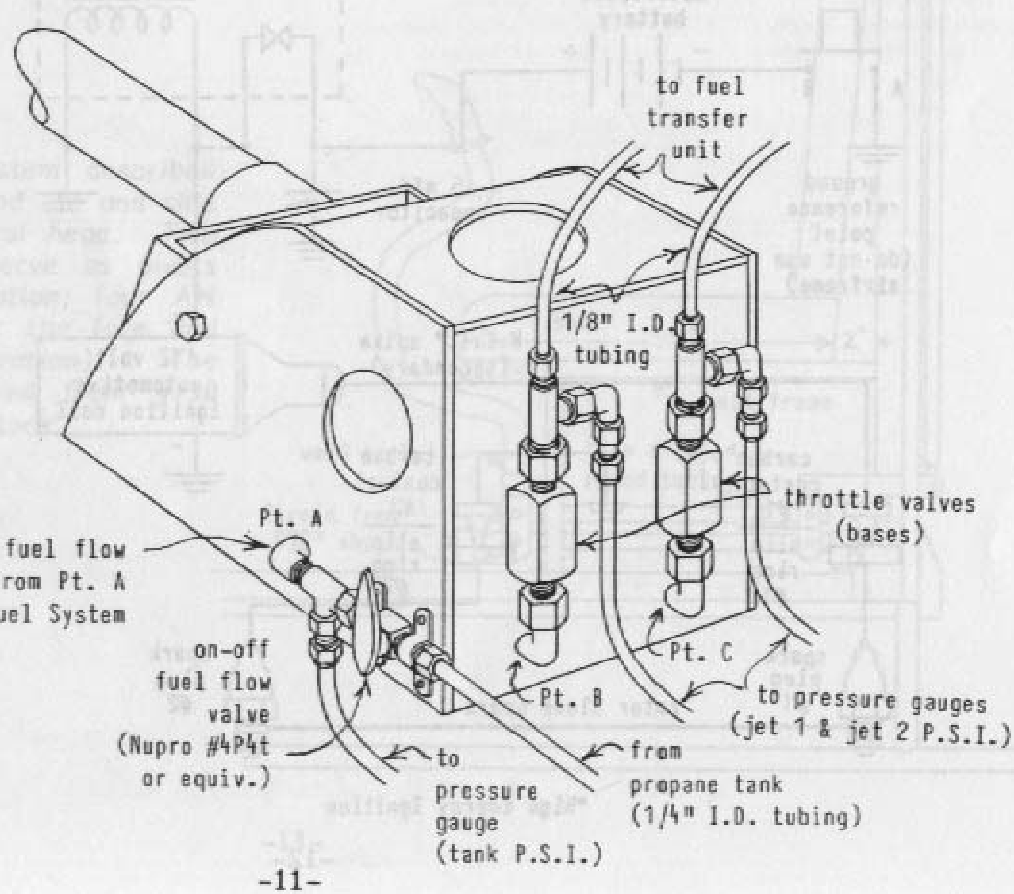
THE THROTTLE SYSTEM



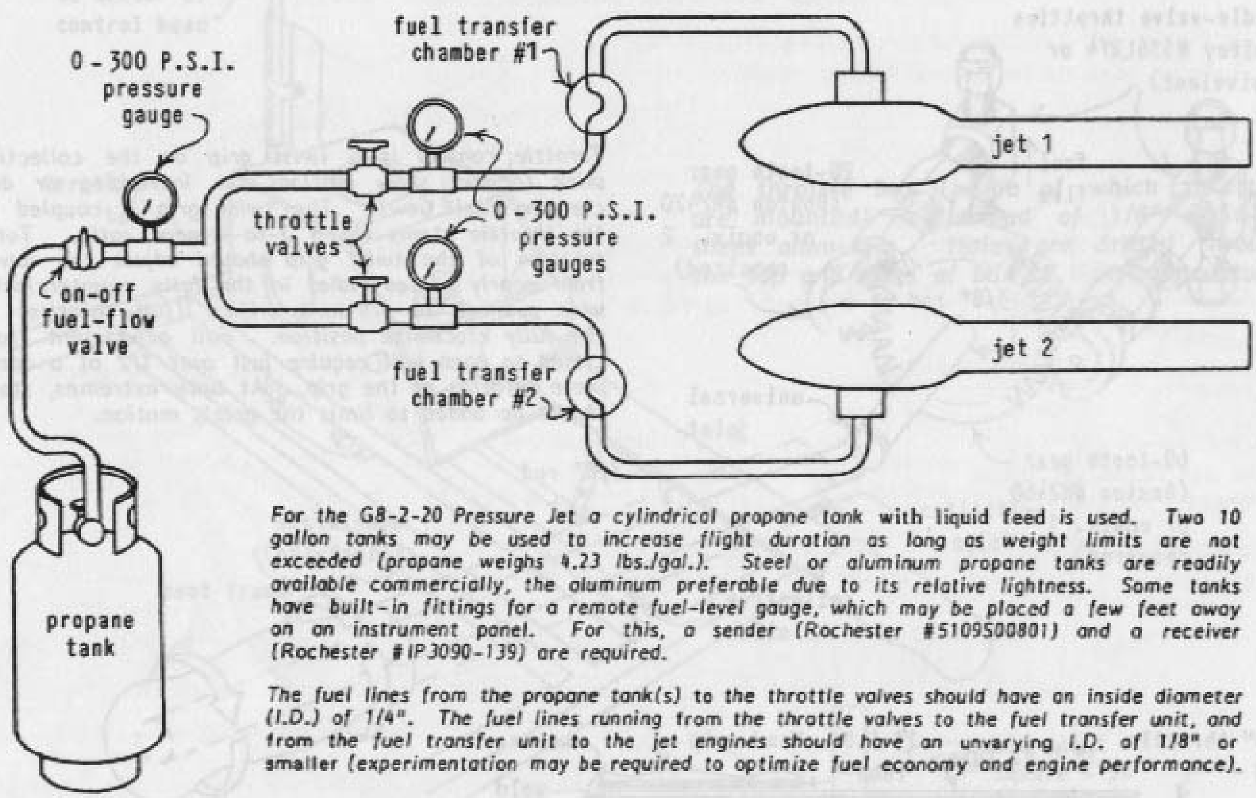
Throttle control is a twist grip on the collective stick (arrows show motions for increasing or decreasing fuel flow). The twist grip is coupled to the throttle stems via a 3-to-1 gear ratio. Total rotation of the twist grip should adjust the valves from nearly closed (idle) in the fully counterclockwise position to 1/8-inch orifice (full throttle) in the fully clockwise position. Full adjustment from closed to open will require just over 1/2 of a complete rotation of the grip. At both extremes, stops should be added to limit the grip's motion.



Collective stick is 1" O.D. X .058" 4130 tubing. A length of 1" I.D. tubing with a washer welded to one end is fitted (loosely) over the collective stick. The 3/8" throttle-control rod terminates at the center of this washer, to which it is welded.



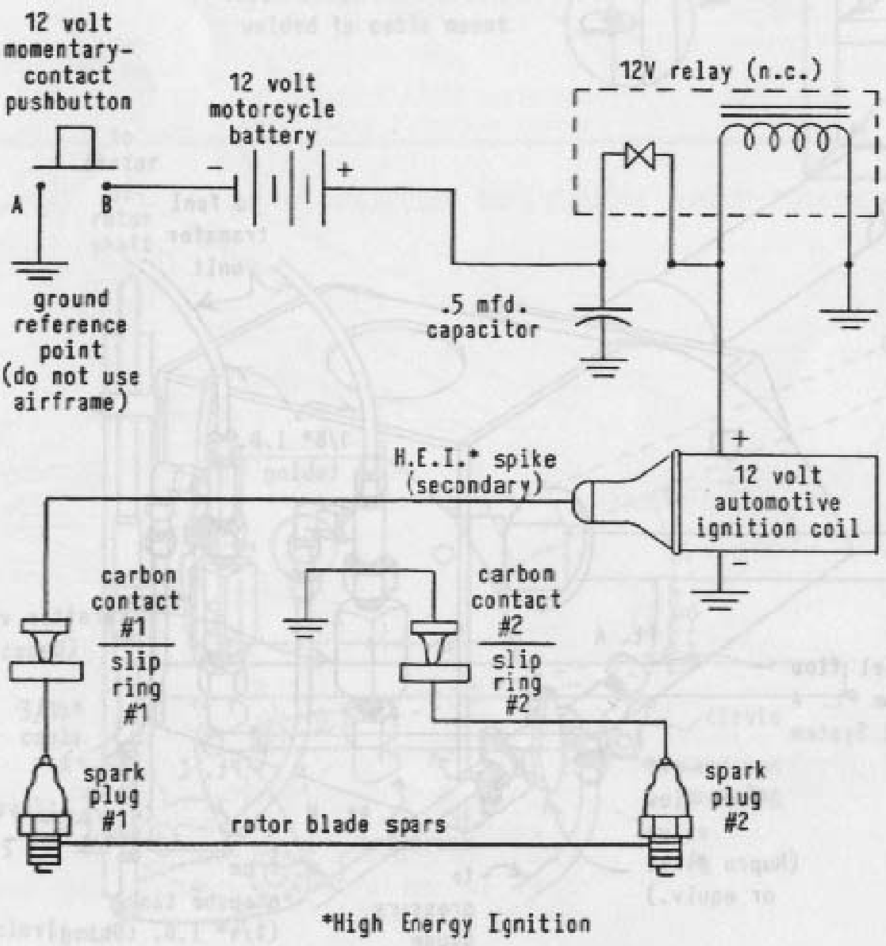
FUEL SYSTEM SCHEMATIC



For the G8-2-20 Pressure Jet a cylindrical propane tank with liquid feed is used. Two 10 gallon tanks may be used to increase flight duration as long as weight limits are not exceeded (propane weighs 4.23 lbs./gal.). Steel or aluminum propane tanks are readily available commercially, the aluminum preferable due to its relative lightness. Some tanks have built-in fittings for a remote fuel-level gauge, which may be placed a few feet away on an instrument panel. For this, a sender (Rochester #5109500801) and a receiver (Rochester #IP3090-139) are required.

The fuel lines from the propane tank(s) to the throttle valves should have an inside diameter (I.D.) of 1/4". The fuel lines running from the throttle valves to the fuel transfer unit, and from the fuel transfer unit to the jet engines should have an unvarying I.D. of 1/8" or smaller (experimentation may be required to optimize fuel economy and engine performance).

IGNITION SYSTEM SCHEMATIC

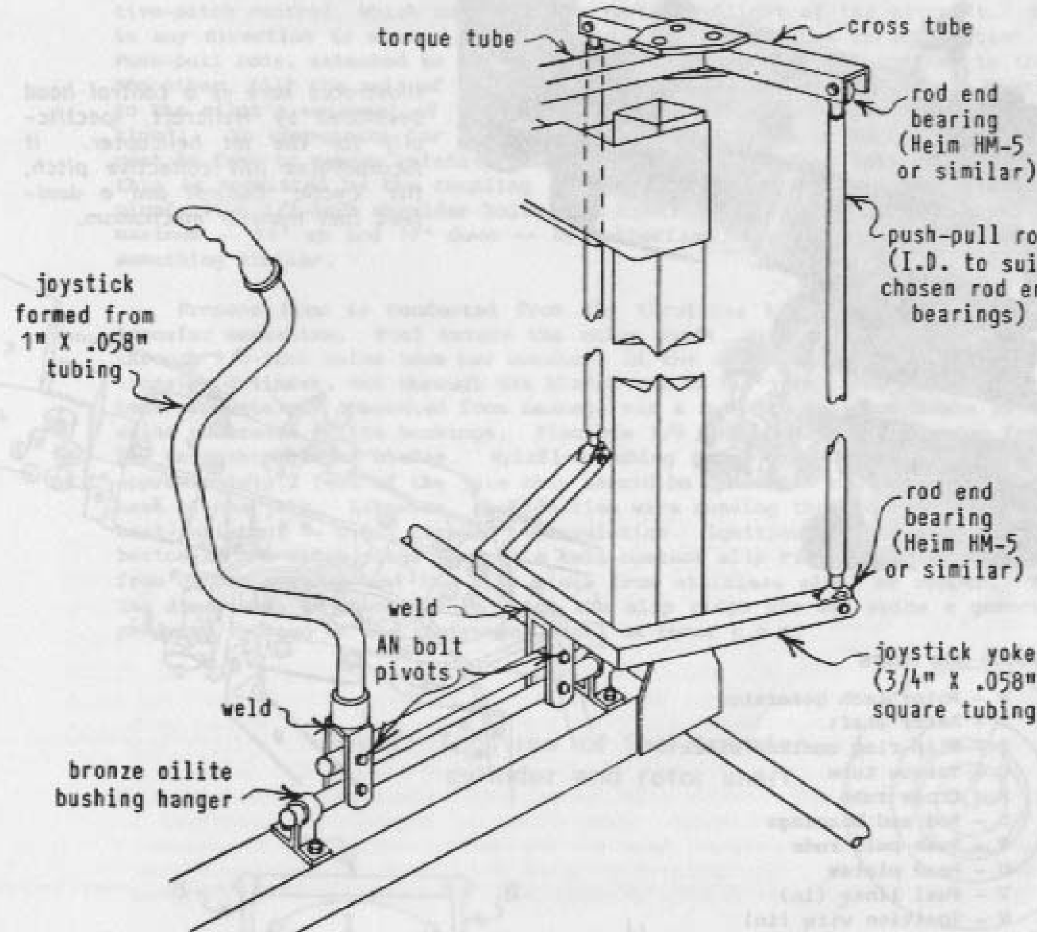


NOTE: Do not use airframe as ground. Ground symbols (⏚) indicate negative battery terminal at contact "A" of the pushbutton switch. Bases of spark plugs are interconnected through metal spars of rotor blades.

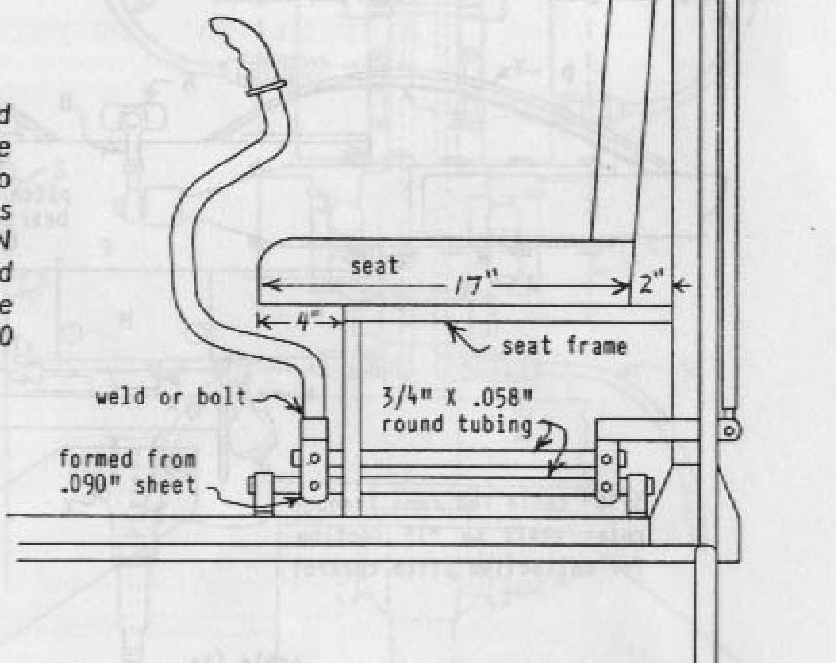
The carbon contacts used were brush-spring units from a GM H.E.I.* distributor. A bracket for the motorcycle battery may be mounted under the seat. The pushbutton starter may be mounted on the instrument panel or atop the handgrip of the joystick.

*High Energy Ignition

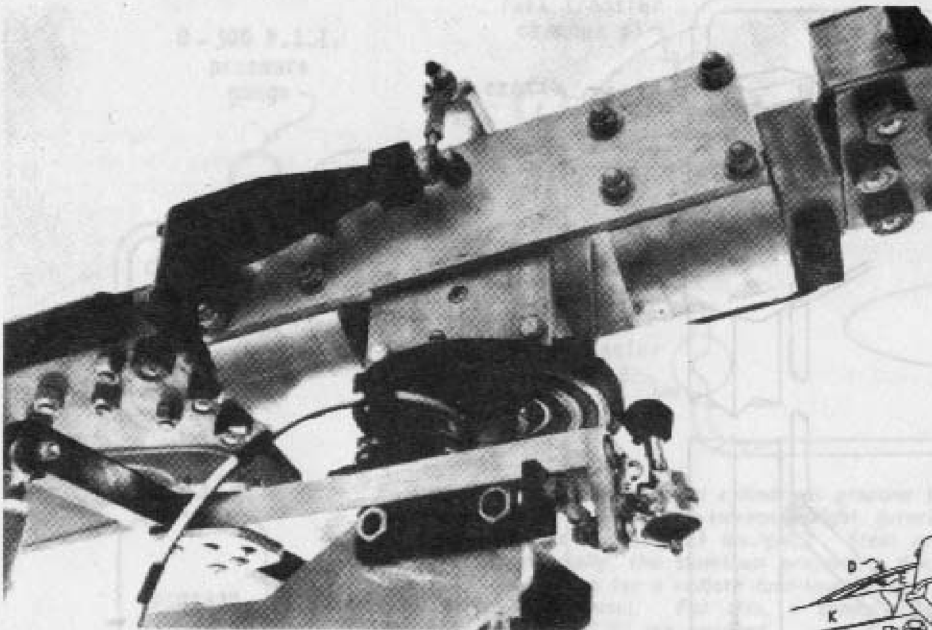
JOYSTICK MECHANISM



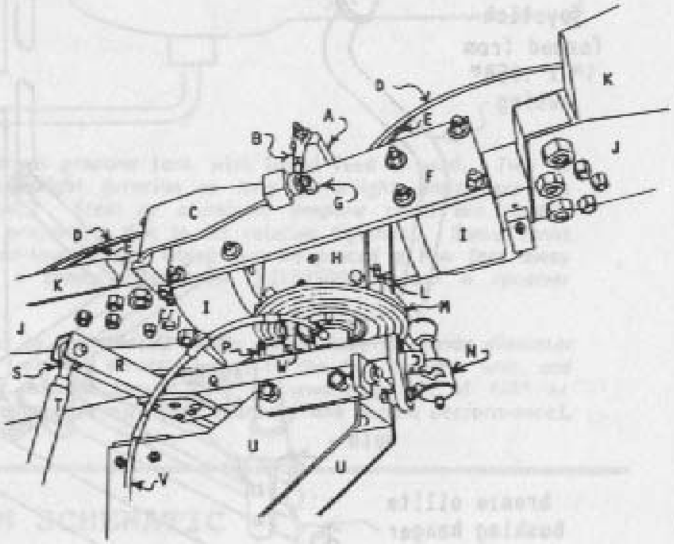
The joystick control system described here permits full fore and aft and side to side tilt of the control head. Two bronze oilite bushings serve as pivots for the side to side motion; four AN bolts serve as pivots for the fore and aft motion (see illustration). The primary parts are formed from 4130 steel tubing and sheet stock.



THE CONTROL HEAD

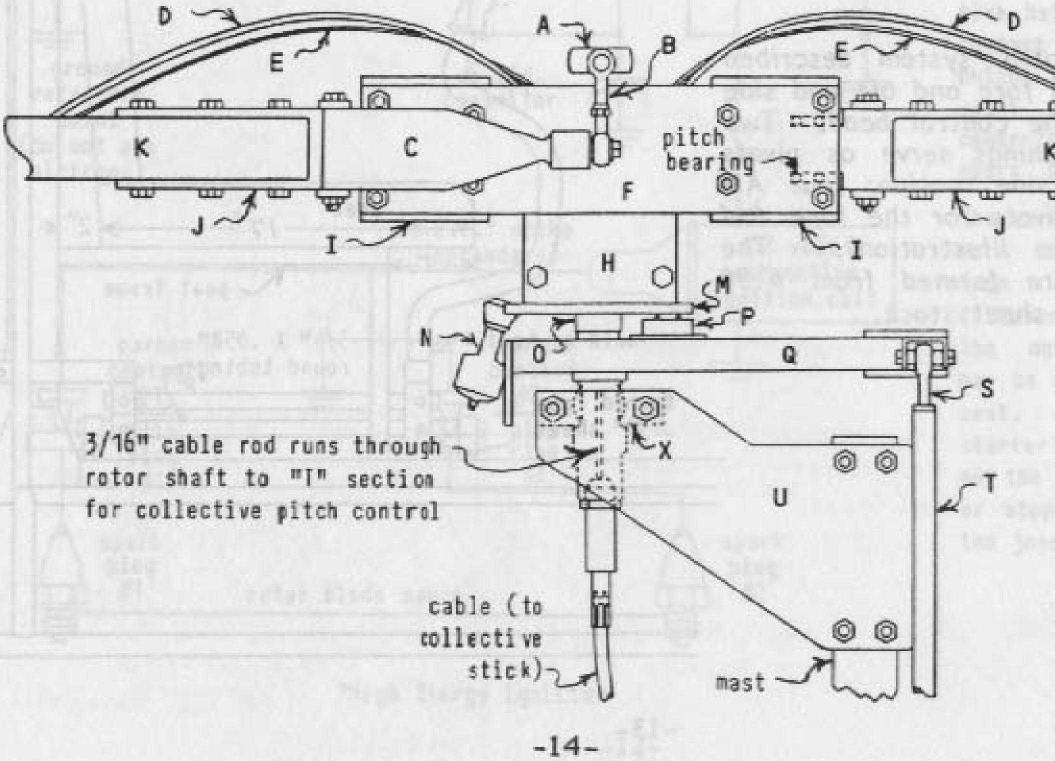


Illustrated here is a control head developed by Helicraft, specifically for the jet helicopter. It incorporates full collective pitch, tilt "cyclic" control and a dual-feed fuel transfer mechanism.



CONTROL HEAD/ROTOR HUB PARTS

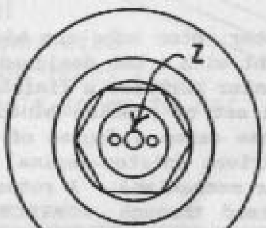
- A - Pitch "T" section
- B - Pitch links
- C - Pitch horns
- D - Fuel lines (out)
- E - Ignition wires (out)
- F - Hub plates
- G - Teeter bolt
- H - Cheek plates
- I - Pitch bearing blocks
- J - Blade grips
- K - Rotor blades
- L - Main bearing block
- M - Slip ring/tach gear
- N - Rotor tach generator
- O - Rotor shaft
- P - Slip-ring contact block
- Q - Torque tube
- R - Cross tube
- S - Rod end bearings
- T - Push-pull rods
- U - Head plates
- V - Fuel lines (in)
- W - Ignition wire (in)
- X - Gimbal bearing
- Y - Fuel transfer unit
- Z - Pitch rod channel



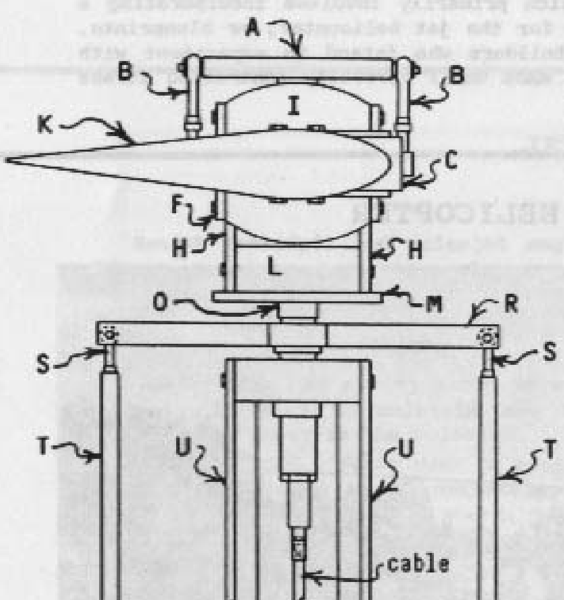
THE CONTROL HEAD

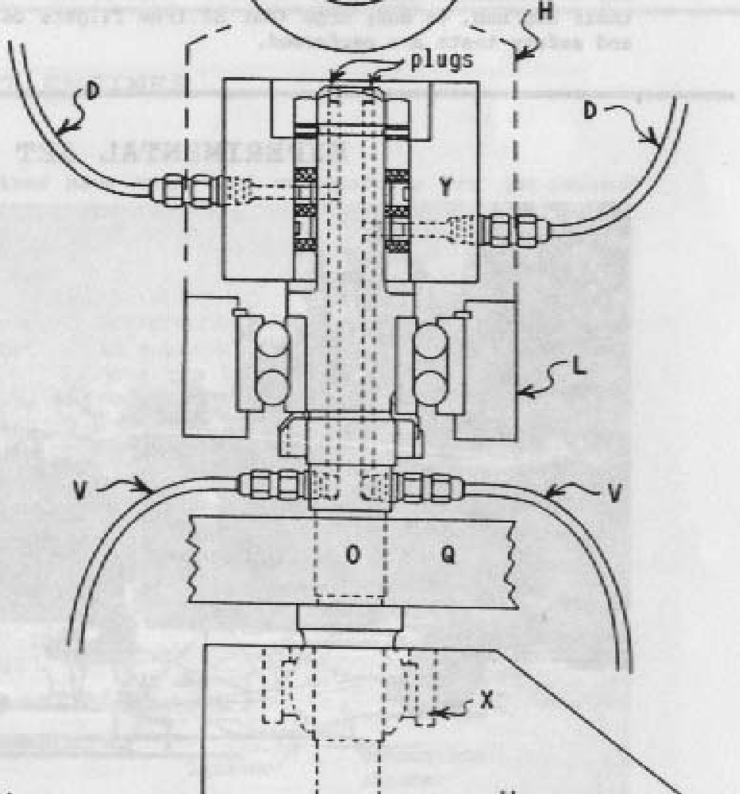
DESCRIPTION OF CONTROL HEAD/ROTOR HUB: Rotor blade pitch is varied by the raising and lowering of the pitch "T" section via a cable run through the pitch-rod channel and controlled by the collective stick; pitch links connect the "T" section to pitch horns, and these oscillate the blades on pitch bearings from 0° pitch to a maximum of 20°. This is collective-pitch control, which controls the vertical flight of the aircraft. Horizontal flight in any direction is controlled by a cyclic tilt mechanism through motion of the joystick. Push-pull rods, attached to the joystick yoke at one end and coupled to the torque tube at the other, tilt the axis of the control head on its universal (gimbal) bearing corresponding to the pilot's movement of the joystick: fore and aft or side to side (see "Flight Operation"). To compensate for imbalances that normally occur during flight, the rotor blades must be free to seesaw relative to the rotor shaft as they spin in the main bearing block; this is permitted by the coupling of the hub plates to the cheek plates via teeter-bolt pivots (two 1/2-inch shoulder bolts were used). This seesaw motion should be limited to 20° maximum -- 10° up and 10° down -- by rubberized "stops" vulcanized to the hub plates, or something similar.

Propane flow is conducted from the throttles to the jets through a dual-feed fuel transfer mechanism. Fuel enters the rotor shaft, passes through separate channels, pulses through 1/8-inch holes (one per chamber) in the shaft to the twin chambers of the rotating transfer cylinder, out through the blades and to the jets. The chambers in the transfer are kept separate and prevented from leakage via a system of carbon seals as the transfer unit spins on bronze oilite bushings. Flexible 1/8 inch I.D. tubing is run from the fuel transfer unit through the blades. Nylaflow tubing is an excellent choice here; however, within approximately 2 feet of the jets this should be connected to copper tubing to withstand the heat of the jets. Likewise, the ignition wire running through the blades must have a highly heat-resistant -- e.g., ceramic -- insulation. Ignition current is conducted from the start button to the spark plugs through a twin-contact slip ring mechanism; the contacts are made from carbon brushes and the slip rings from stainless steel or copper. The outer edge of the disc (made of phenolic) in which the slip rings are set spins a generator; the current produced is read on the instrument panel as rotor r.p.m.



Right: Top view of fuel transfer cylinder and rotor shaft

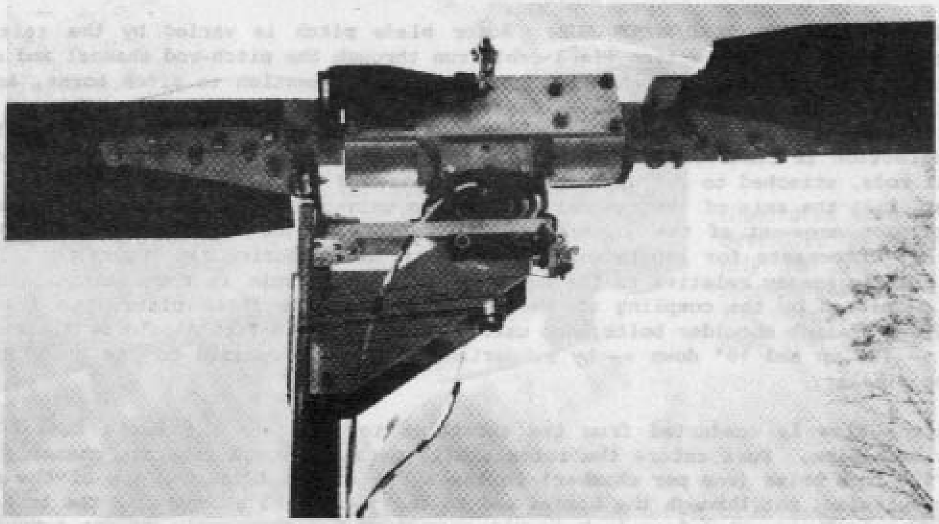




Above: Control head, front view

Right: Fuel transfer mechanism

THE CONTROL HEAD

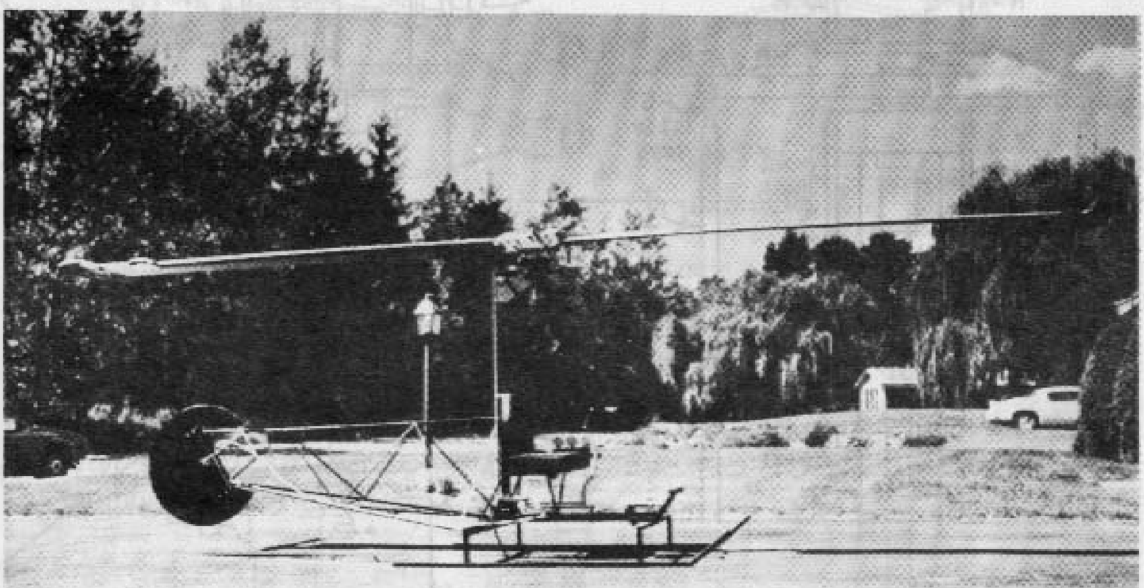


The integration of control head and rotor blades

All described bearings and materials are commercially available. Strength is a primary consideration in hub materials and construction, as the entire helicopter suspends from this point. The pitch arms, head plates, "T" section, fuel transfer cylinder, cheek plates, hub plates, bearing blocks (pitch and main), torque tube and cross tube may be formed of 6061-T6 almuminum; the rotor shaft, rotor blade shafts and blade grips of 304 stainless steel. Bearings must be of aircraft grade. Overall, the control head must be symmetrical.

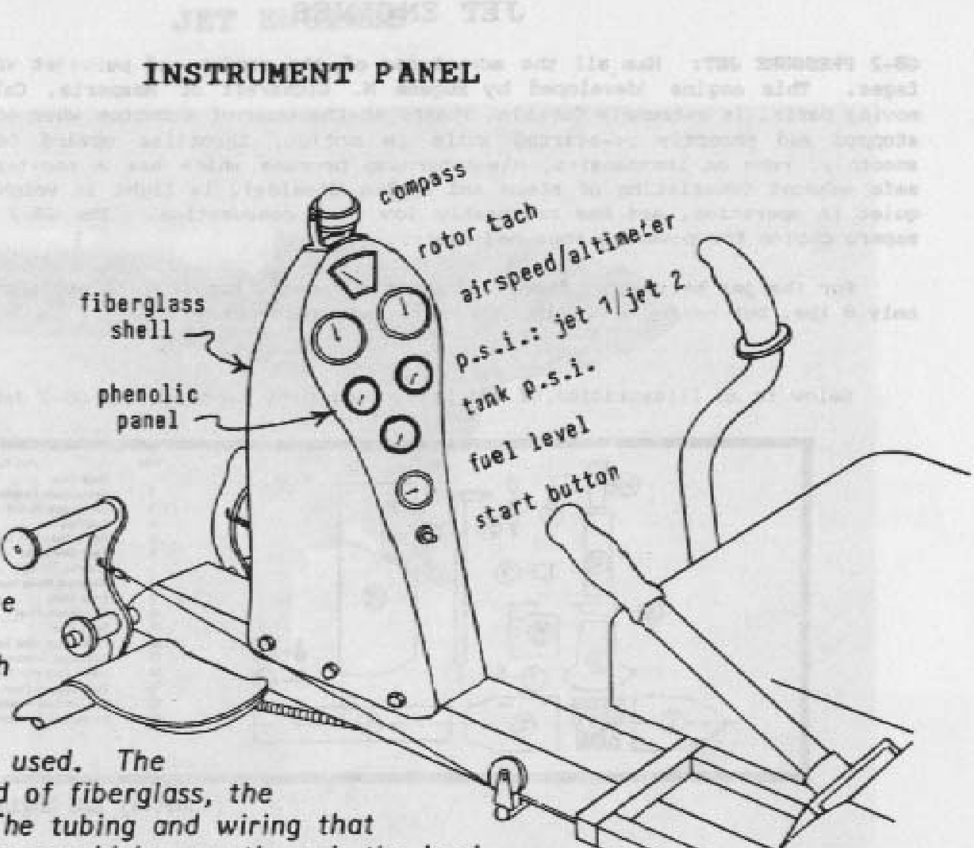
Helicopter rotor hubs are highly complex, critical structures; the amateur should *not* attempt flight with a hub designed and assembled without expert assistance. We advise that the experimenter purchase a finished, proven rotor hub, or, if adequate shop facilities are available, a set of precise blueprints. Several highly efficient designs are available, though in some cases a degree of modification might be necessary (such as to adapt a hub from shaft-driven [piston-engine] to jet design, which primarily involves incorporating a fuel transfer mechanism). A rotor hub/control head for the jet helicopter, or blueprints, may be obtained through VORTECH. For *advanced* builders who intend to experiment with their own hub, we must urge that no free flights be made until carefully controlled stress and safety tests are performed.

EXPERIMENTAL JET HELICOPTER



A test jet helicopter developed by Helicraft

INSTRUMENT PANEL



Illustrated here is one possibility for an instrument panel with a suggested layout of meters and gauges that could be used. The shell could be formed of fiberglass, the panel of phenolic. The tubing and wiring that leads to various gauges could be run through the keel tube and emerge into the fiberglass shell through grommeted holes drilled through the keel. Drill well-spaced small holes (e.g., two 3/8" and one 1/4" hole) rather than one large hole so as to not weaken the keel tube.

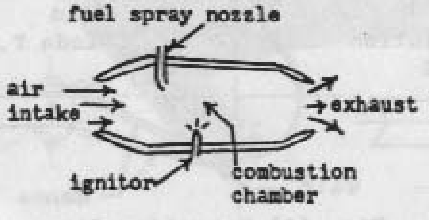
JET ENGINES

Ramjet (athodyd) and pulsejet engines have been used successfully for jet-powered helicopters and are here compared:

RAMJET

ADVANTAGES: No moving parts to wear out, is easy to maintain and not quite as noisy as the pulsejet.

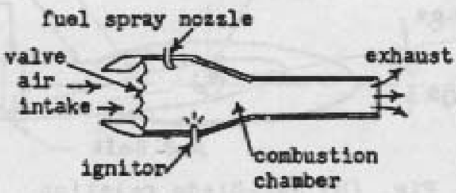
DISADVANTAGES: Rotor must be spun by external source at approximately 150 r.p.m. before jet will start. Ramjets have an extremely high fuel consumption.



PULSEJET

ADVANTAGES: Somewhat more efficient at rotor speeds than ramjet. Pulsejets can be started with the rotor motionless and use less fuel than ramjets.

DISADVANTAGES: Because of valve, pulsejets vibrate vigorously in operation and make an ear-shattering noise; valve requires frequent replacement.

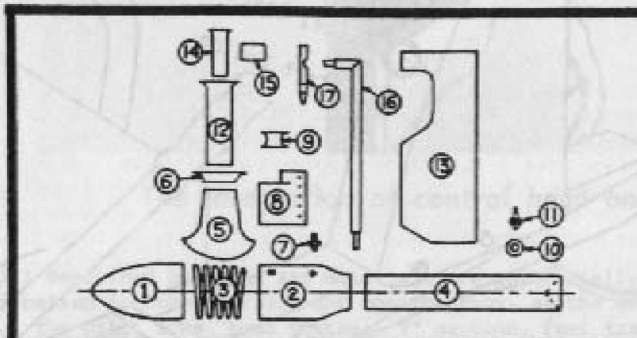


JET ENGINES

G8-2 PRESSURE JET: Has all the advantages of the ramjet and pulsejet with few disadvantages. This engine (developed by Eugene M. Gluhareff of Hesperia, California) has no moving parts, is extremely durable, starts at the push of a button when motionless, may be stopped and promptly re-started while in motion, throttles upward to maximum thrust smoothly, runs on inexpensive, clean-burning propane which has a non-toxic, ecologically safe exhaust (consisting of steam and carbon dioxide), is light in weight and relatively quiet in operation, and has reasonably low fuel consumption. The G8-2 is, in short, a superb choice for powering your helicopter.

For the jet helicopter described in this manual, two G8-2-20 engines -- each weighing only 8 lbs. but having a 20+ lb. thrust -- are recommended.

Below is an illustration of the basic component parts of the G8-2 Jet Engine.



Item	Part Name
1.	Nose Cone
2.	Combustion Chamber
3.	Coil (Super Heater)
4.	Tail Pipe
5.	Intake Duct (3rd Stage)
6.	Flare (3rd Stage)
7.	Metering Fitting
8.	Mounting Plates Assembly
9.	Brace Plate
10.	Boss (Spark Plug)
11.	Spark Plug
12.	Intake Duct (2nd Stage)
13.	Aluminum Cowling
14.	Intake Duct (1st Stage)
15.	Duct Support Plates (2)
16.	Hot Gas Line Assembly
17.	Nozzle & Tube Assembly

(Courtesy EMG Engineering Co.)

The following drawings illustrate method of attaching the G8-2 jet on rotor tip. Center of gravity (CG.) of burner assembly (A) must be located at 25% of blade chord. Jet mounting plates must be bolted directly to the load-carrying steel straps, which run on top and bottom of blade at 25% chord, transmitting jet centrifugal load directly to blade root. To minimize drag, jet must be positioned at 0° while blade is at 8° (see Fig. B). The tail pipe, also subjected to centrifugal force, must be attached to trailing edge of blade (T.E.) with a retention ring (see Figs. A and C). Ring must fit loosely over tail pipe, allowing it to slide freely (it may move up to ½" as tail pipe lengthens from heat). Retention ring is made of normalized 4130 steel and is heliarc welded to holding bands.

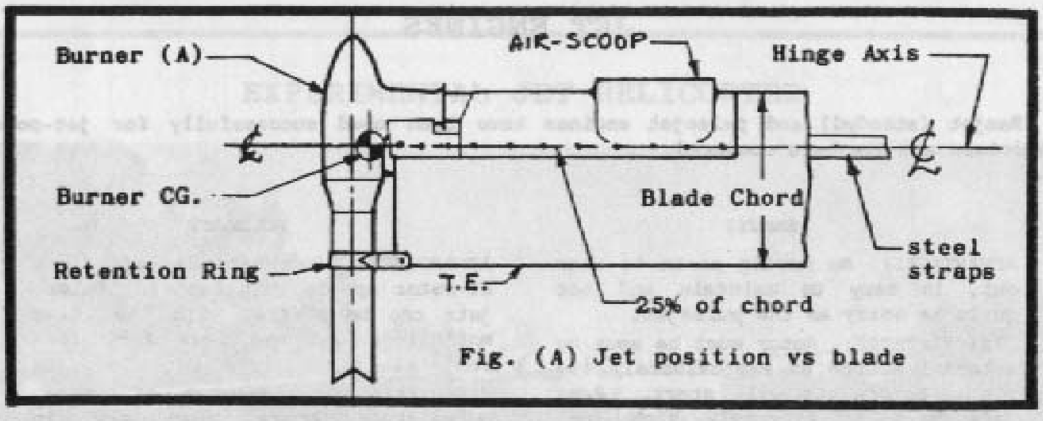


Fig. (A) Jet position vs blade

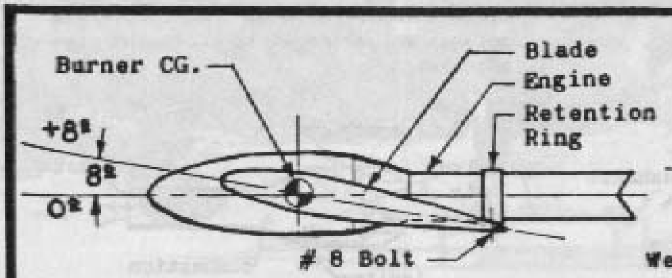


Fig. (B) Jet-Blade relation

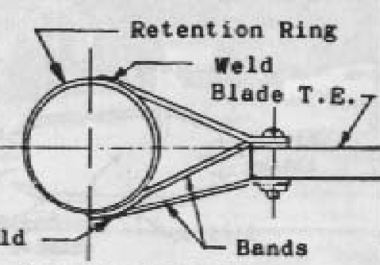
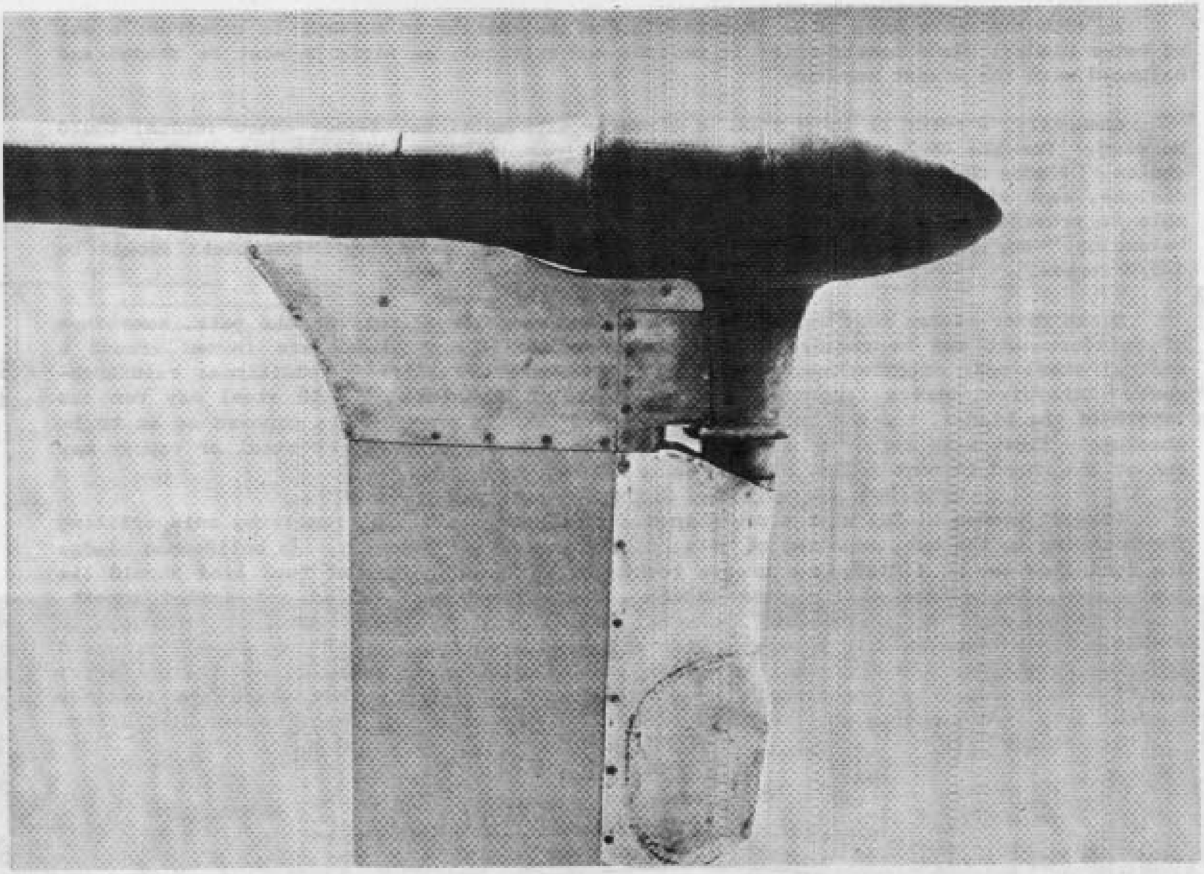
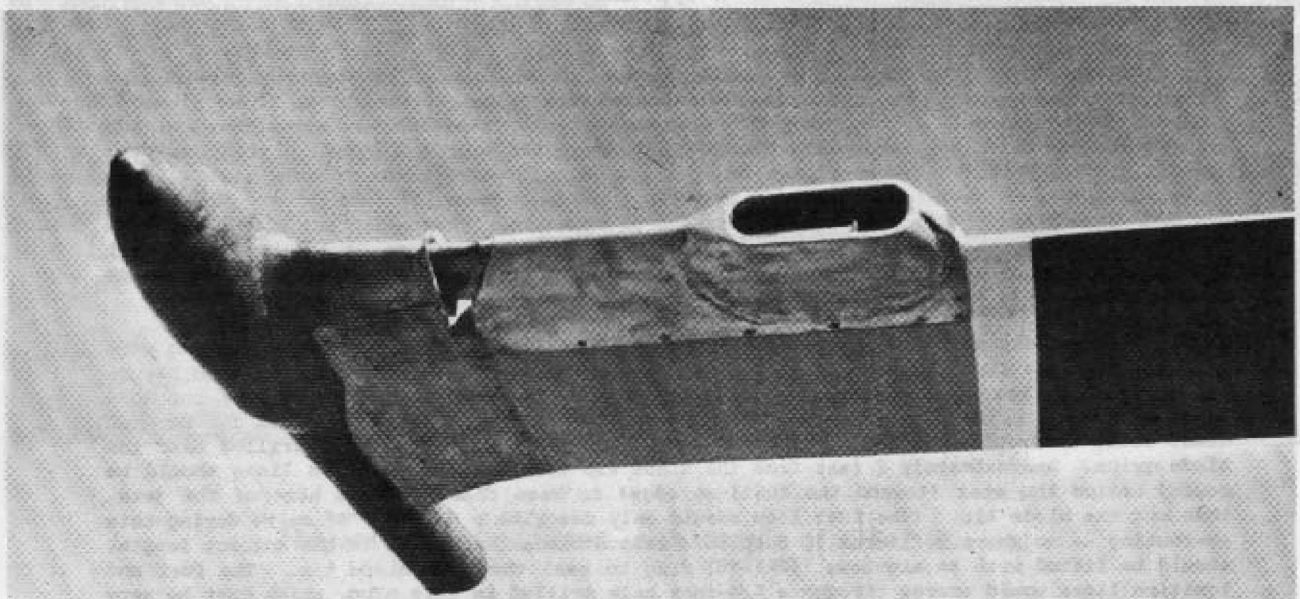


Fig. (C) Retention Ring

(Courtesy EMG Engineering Co.)



These photos illustrate the proper mounting of the jets on the rotor blades. Note the airscoop in the lower photo.



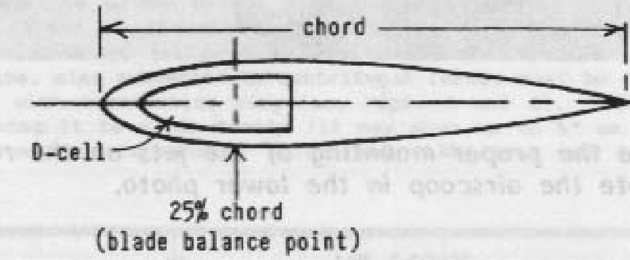
ROTOR BLADES

As with the rotor hub, it is inadvisable for the amateur to attempt to construct a set of rotor blades; blade construction is tedious and critical, as airfoils must be shaped and balanced with the utmost accuracy.

Generally, a rotor 22 to 24 feet in diameter with an 11 to 14-inch chord (width) could be used. For the G8-2 Pressure Jets a 23-foot long, 13-inch wide rotor is an excellent choice. Blades formed to the NASA 0012 airfoil will yield good results -- as will other designs, each with its own flight characteristics. Companies providing blades should be able to provide performance and weight-bearing figures, as well as hints for mounting and balancing. For proper fitting of jets the blades' maximum camber (thickness) should be 1-5/8 inches.

Since rotor blades must support the weight and centrifugal pull of the jets, some form of reinforcement may be required along their length. Many blades are formed around a central steel spar or other such strengthening spine and require no additional reinforcement. Otherwise, straps (approx. 1-1/2" X 3/16") of stainless or 4130 steel may run the length of the blades, top and bottom, at 25% chord; straps are glued in grooves so as to be absolutely flush with camber of airfoil; a 3/8" to 1/2" cable or rod of steel or copper may run at 25% chord through hollow blades, securing root to tip.

Pre-cut wooden blades with a pre-shaped airfoil are available, requiring only drilling for mounting to the hub, mounting of jets, fiberglassing and painting. In solid-wood blades the fuel line may be fitted in a groove routed at 25% chord. Top of fuel line should lie just below the surface of the rotor blade, then covered with filler and sanded smooth. Blades should then be fiberglassed and must be carefully balanced. The fuel line used in flexible blades must be able to comply with its bending motions; a 1/8" nylaflow line would be excellent. With blades formed around an open spar, fuel line may be run through spar. Ignition wire could be run through trailing edge of blade, glued in place and smoothly covered over. An asbestos or fiberfrax firewall must be used to protect wooden blades from the heat of the jets.



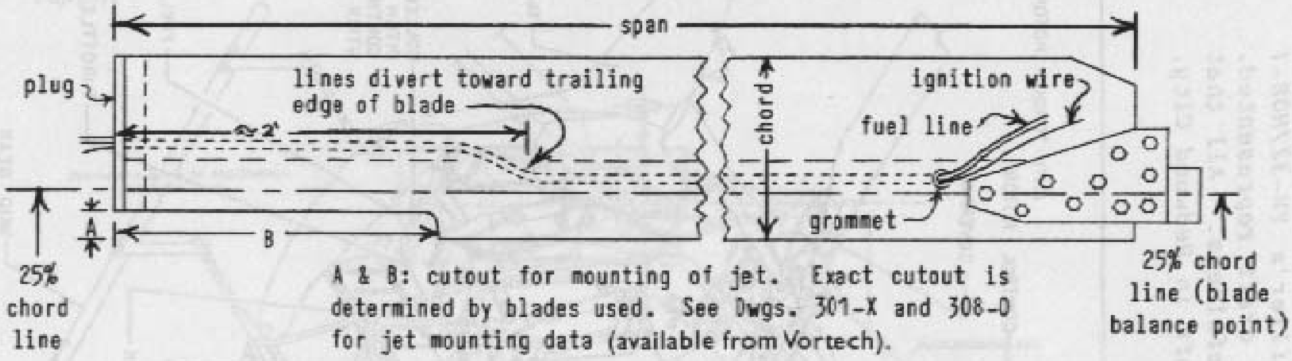
Cross section of a typical rotor blade

As an alternative to homemade or wooden blades the builder might locate a set of used or surplus blades that conform to the recommended chord/span/camber specs (for example, blades used for the Bell 206 *Jet Ranger*). Surplus blades, in general, have either reached or are close to their expiration time (often 2,500 to 3,500 hours) or have in some way been damaged. While such blades may often be obtained at a low cost, the builder should avoid blades that have fully expired or those in which the structure or airfoil shape has in any way been undermined. Often, damaged blades can be found that have an intact section of sufficient length for the jet helicopter; or, *nearly* expired blades can be located that still have 100 hours or more of useful life left. Only obtain and use such blades *if* their soundness or useful life have been verified.

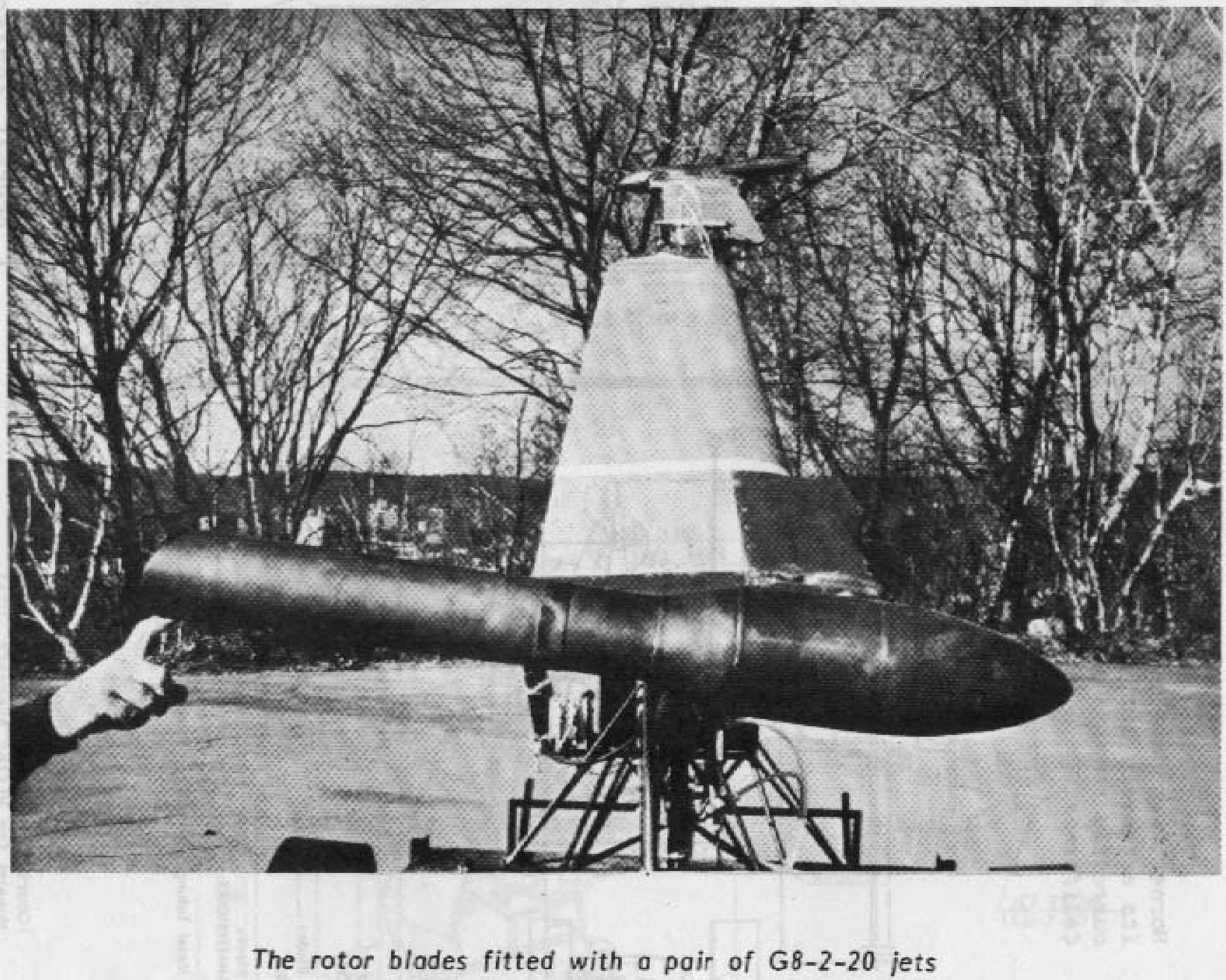
Surplus blades are often formed of aluminum and may incorporate a "D-cell" leading edge through which the fuel line and ignition wire can be run. These lines could be held secure by injecting a foam solution, via a long nozzle, down the length of this cavity; the foam will expand and solidify, adding very little weight. The lines, emerging from the control head, could enter the blades through the end or through a grommeted hole drilled near the blade grips. Approximately 2 feet from the blade tip the fuel and ignition lines should be routed *behind* the spar (toward the trailing edge) to keep them from the heat of the jets, then out the blade tip. (The fuel line should only describe a *gradual* "S" curve during this re-routing -- no sharp 90° turns.) Surplus aluminum blades, once cut to the correct length, should be fitted with an aluminum (6061-T6) plug to seal the open blade tip. The fuel and ignition lines would emerge through a 1/4-inch hole drilled in this plug, which must be very snugly and securely fitted and bolted or riveted in the blade end, using reinforcing brackets if the aluminum skin is especially thin.

Because the velocity of the rotor blade decreases along its length from tip to root, often the blade is manufactured with a slight twist to equalize forces of lift; this might be between 7° to 11° per blade.

ROTOR BLADES



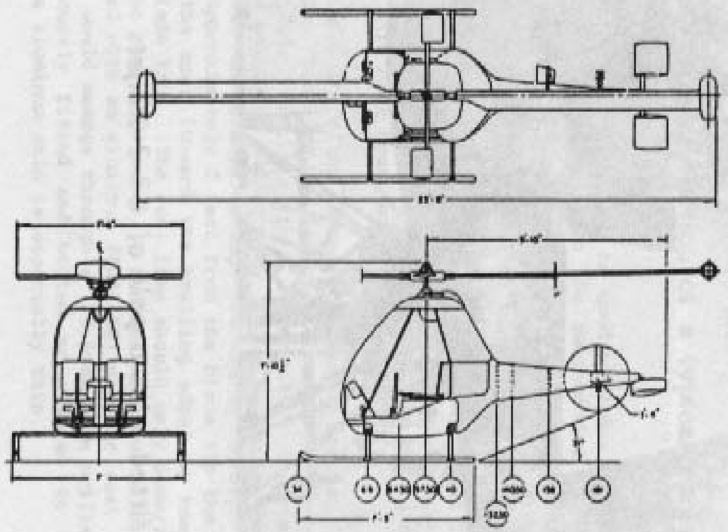
Typical rotor blade layout for the jet helicopter



The rotor blades fitted with a pair of G8-2-20 jets

THE HILLER HORNET

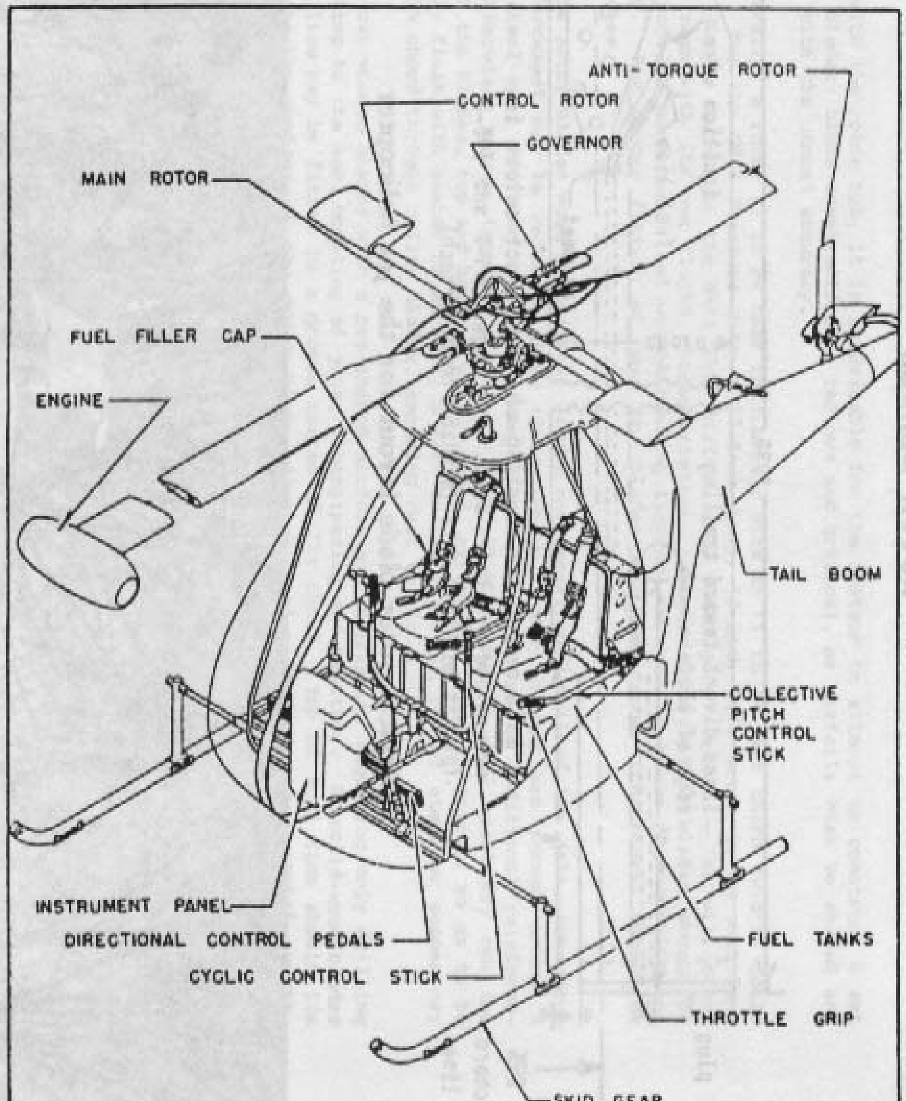
The first ramjet-powered helicopter used by the Army and Navy, Hiller's YH-32/HOE-1 Hornet, was developed around 1950. Despite the design breakthrough this craft represented, its extremely high fuel consumption (see specs) limited its practical usefulness. All that currently remains of the Hornet is housed at the Museum for Hiller Aircraft in Redwood City, California.



WEIGHTS:
Gross 1080
Empty 544
Useful Load 536
MAIN ROTOR:
Diameter ....23 ft.
Number of Blades 2
TAIL ROTOR:
Diameter ....2 ft. 8 in.
Number of Blades............1
GENERAL DIMENSIONS:
Construction............
Metal Tubing, Fiberglas

Length ....23 ft.
Height (to top of rotor)....7 ft. 10 in.
POWER PLANT:
Make ....Hiller BRJ2B
Number of Engines 2
Pounds of Thrust......40 at 550 rpm
Fuel Capacity ....50 gal.
PERFORMANCE:
Cruising Speed ....60 knots
Rate of Climb @ S/L..........700 fpm
Service Ceiling ....6900 ft.
Range ....28 miles

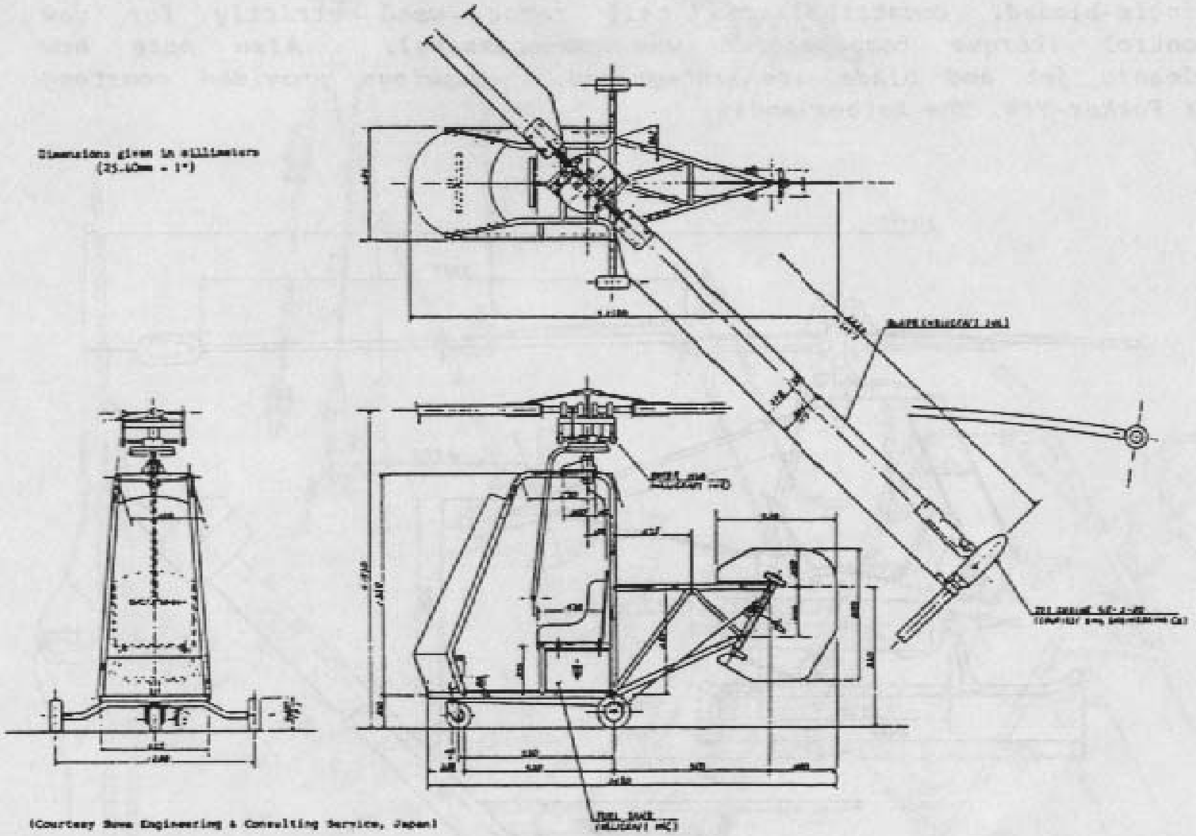
(Courtesy Wayne Rossiter, curator
Museum for Hiller Aircraft, USA)



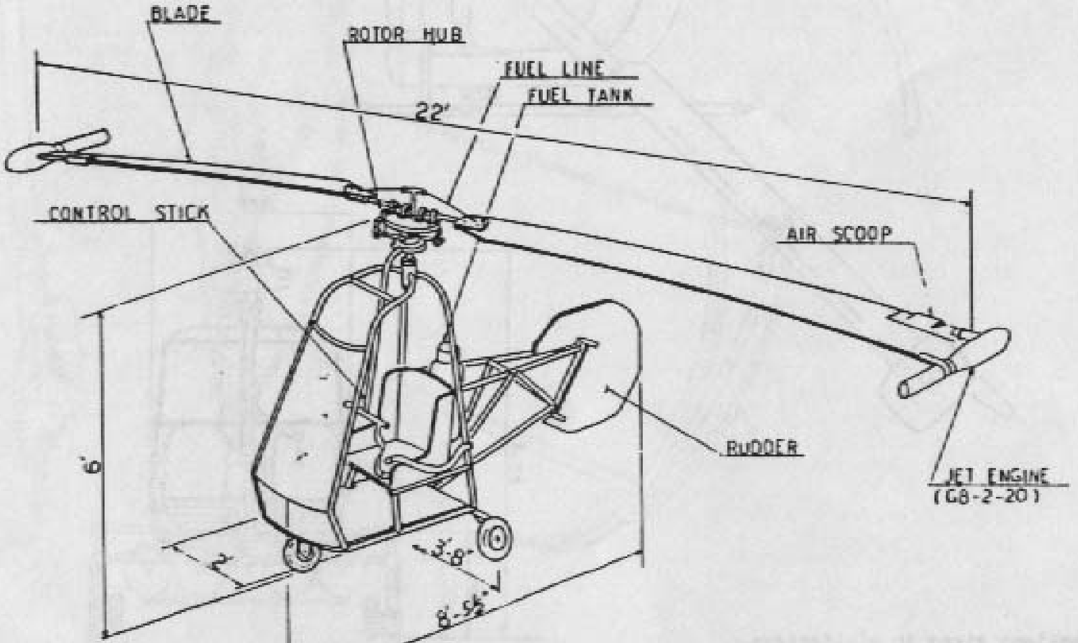
GENERAL ARRANGEMENT

THE SUWA MICRO HELICOPTER

Illustrated below is a design based upon an original HELICRAFT jet-powered helicopter concept, provided courtesy of Suwa Engineering & Consulting Service, Japan.

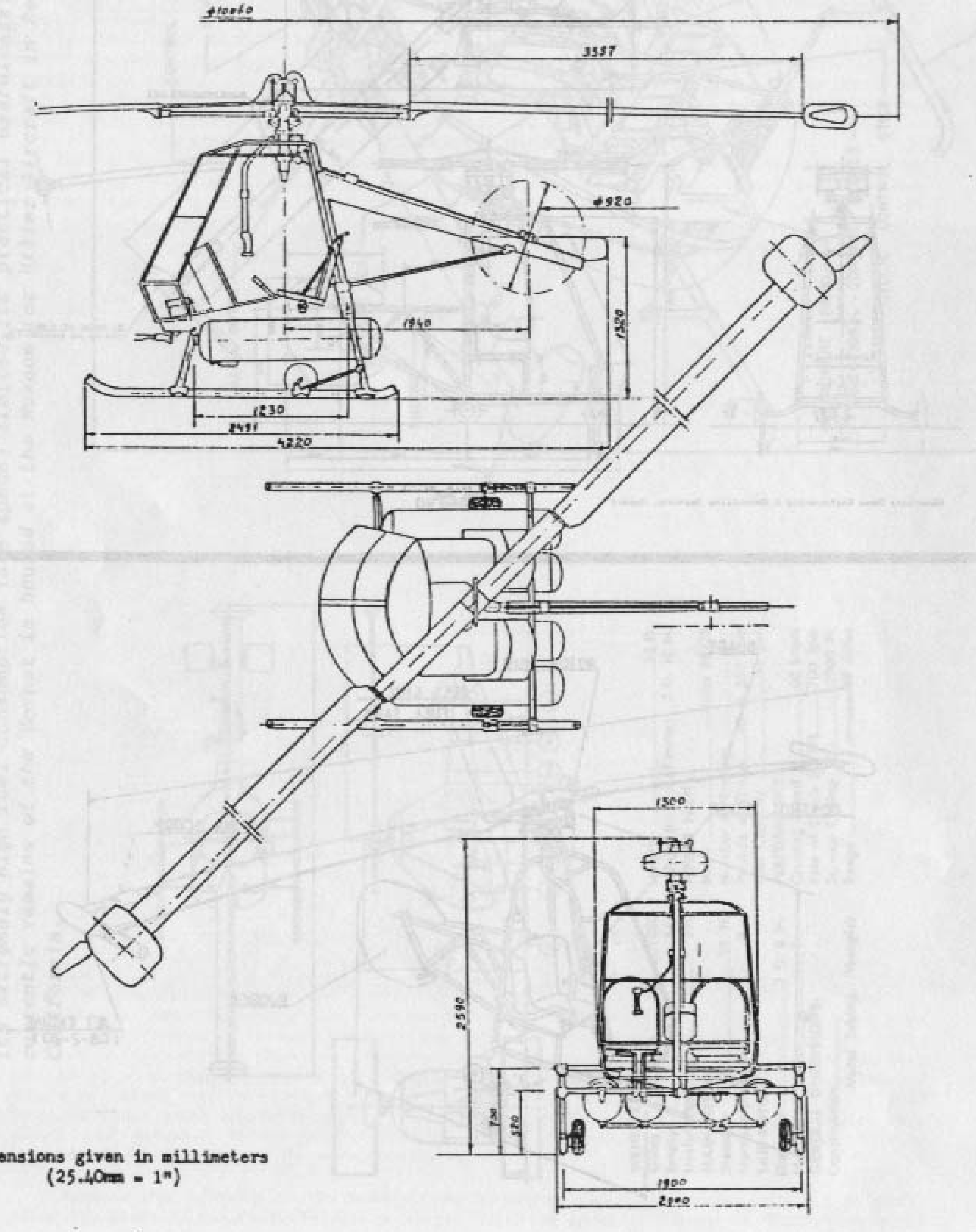


(Courtesy Suwa Engineering & Consulting Service, Japan)



THE KOLIBRIE JET HELICOPTER

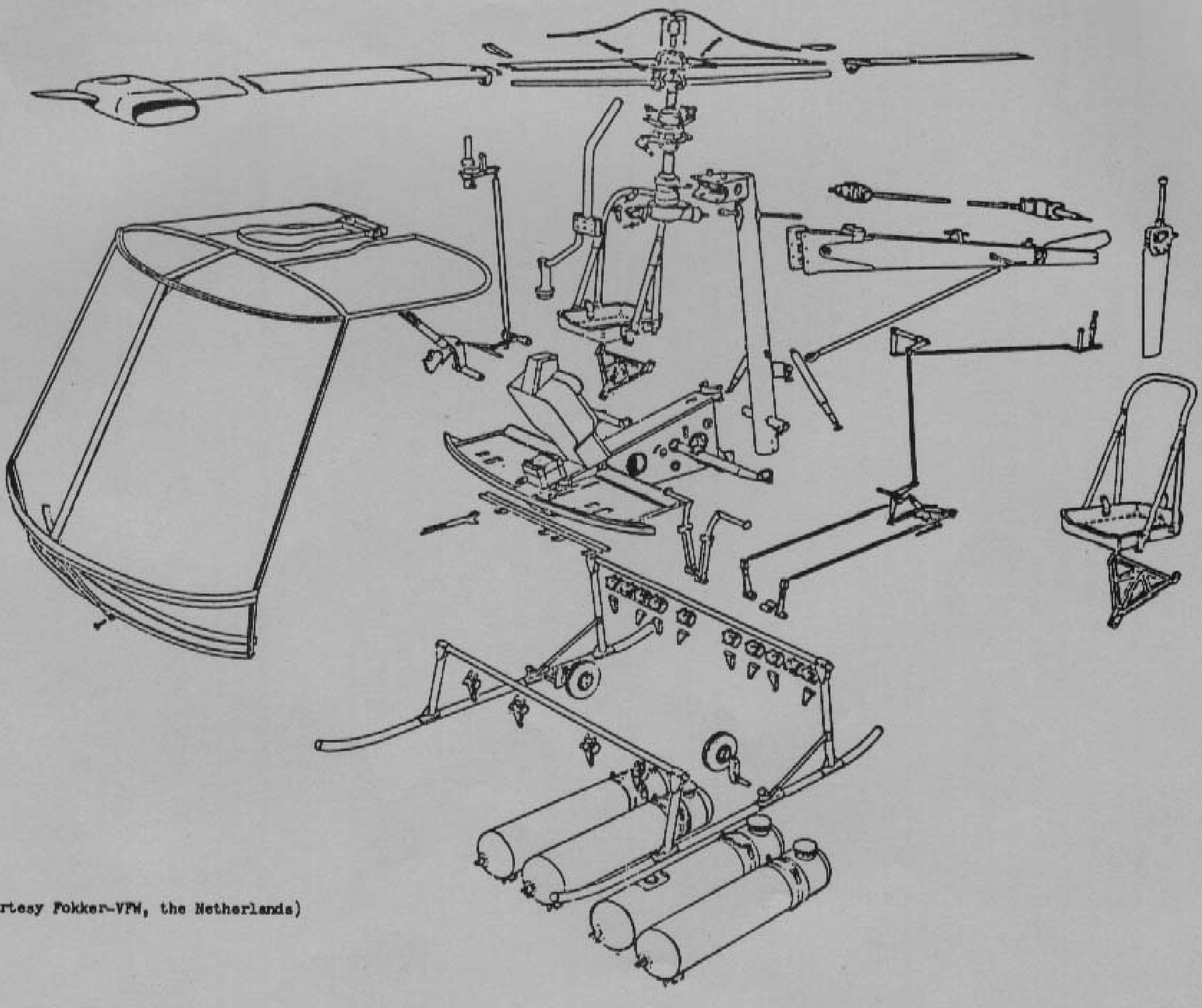
This 2-person ramjet-powered helicopter was developed in the 1950s and went out of production around 1960. The cylindrical tanks carried such fuels as gasoline and fuel oil. Note the single-bladed, counterbalanced tail rotor -- used strictly for yaw control (torque compensation was unnecessary). Also note how cleanly jet and blade are integrated. Drawings provided courtesy of Fokker-VFW, The Netherlands.



Dimensions given in millimeters
(25.40mm = 1")

THE KOLIBRIE JET HELICOPTER

Exploded View



(Courtesy Fokker-VFW, the Netherlands)

AFTERWORD / CAUTION

In order to fly most aircraft, whether of commercial or amateur construction, a license is required. Extra instruction and flying time must be undertaken to pilot a helicopter. The exception to this is covered under the FAA definition of *ultralight aircraft* (Federal Aviation Regulation Part 103): powered aircraft designed for a single occupant, intended solely for sport or recreation, weighing under 254 lbs., having a maximum speed of 55 knots (about 63 m.p.h.) in level flight and a maximum fuel capacity of 5 U.S. gallons (approximately 20 lbs. of propane) require no form of FAA approval or certification, no pilot's license to operate. For further information regarding this ruling, plus general helicopter rules, regulations and pilot requirements, contact your local FAA office, airport or flying school.

Construction of a safe aircraft requires an understanding of metallurgy, bearing load/life ratings, methods of joining, assembling and welding various structural materials, stress factors, and so on. Before beginning construction the amateur builder should familiarize himself/herself with the material and structural alternatives open to him/her, then choose—with expert guidance—those s/he finds most suitable. Then (even if the aircraft is kept within the ultralight category—for the sake of safety), s/he should inform the FAA of his/her intended project; they, in turn, will assess the construction plans, make any suggestions deemed necessary, check the near-completed aircraft for conformity to the (validated) plans, and finally, if fundamental criteria are met, certify the aircraft for flight. To find the address of your FAA district office, write to: Federal Aviation Administration, 800 Independence Avenue S.W., Washington, DC 20591.

Although the helicopter described in this monograph is based upon sound aeronautical, principles, success of a constructed version can not be guaranteed since structural options have been left open to the builder. For this reason, Vortech, Inc. can and will assume NO responsibility for any injury or fatality that results from the building or flying of any aircraft either wholly or in part based upon this monograph. Any person building or flying such an aircraft must do so at his/her own risk. No flights should be made until the mechanical operation of the craft is thoroughly understood and tested; then, many hours should spent becoming familiar with every aspect and subtlety of the control system with the craft tethered to the ground before any free flights are attempted. When flying, a parachute should always be worn. ***All possible precautions for safety should always be taken.***

CAUTION

This manual contains a set of integrated, nontechnical concepts for an EXPERIMENTAL jet helicopter. The amateur should NOT attempt to construct and fly this aircraft, or one based in any way upon this information, without expert assistance.

THE CONSTRUCTION OF A SMALL
JET HELICOPTER

• PLANS SUPPLEMENT •

The following illustrations and information describe the construction of an alternate airframe for the small one-person jet helicopter provided in our main manual of the same name. The advantage of this alternate airframe is greater simplicity of construction and lighter weight, this latter advantage yielding better overall performance and improved fuel economy. Note that this airframe is, *in general,* similar to the frame provided with our jet-helicopter kit, the *Kestrel.*

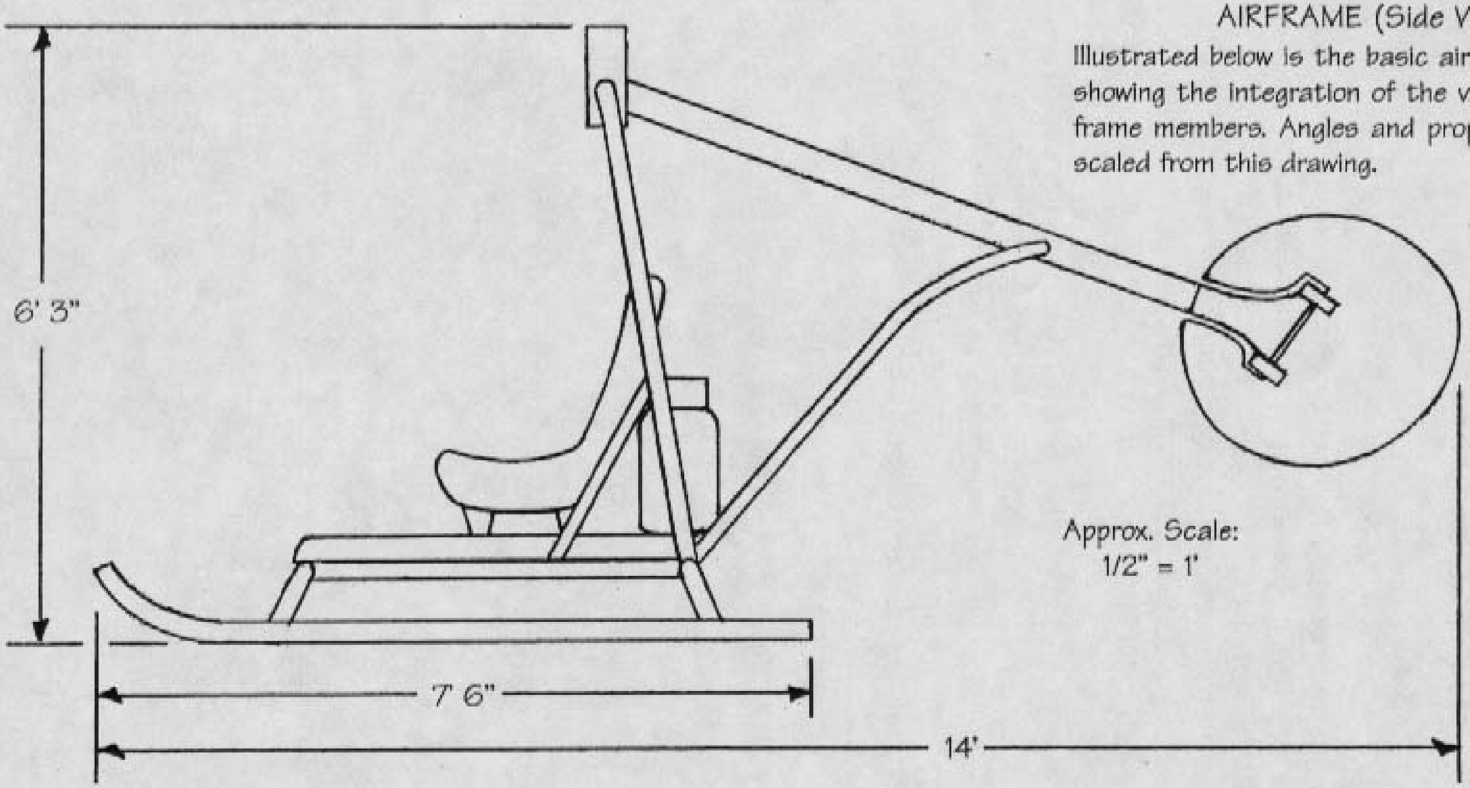
All details presented in the main manual also apply to this alternate airframe, including details of the control system, fuel system, engine throttles, rudder operation, balance, and so on. Performance specifications generally apply as well, although rate-of-climb and range will improve, and payload weight will increase. Builder may indeed incorporate variations of their own in the construction of this airframe, but the general proportions should be maintained.

The Kestrel

Airframe Details

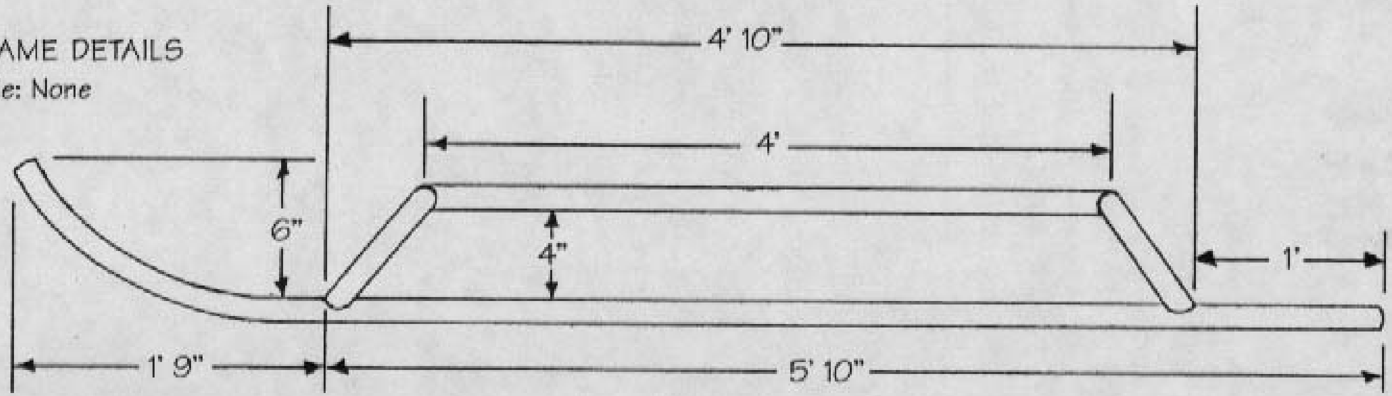
AIRFRAME (Side View)

Illustrated below is the basic airframe assembly, showing the integration of the various aluminum frame members. Angles and proportions may be scaled from this drawing.

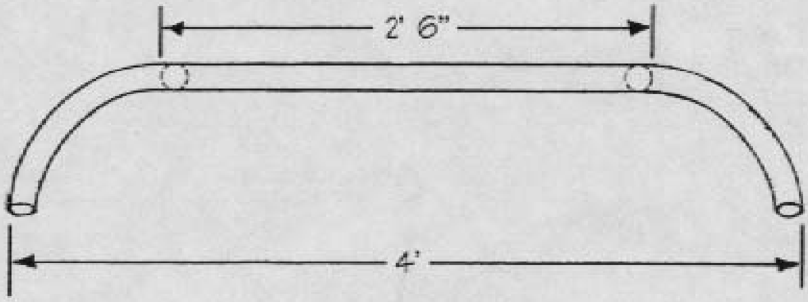


Approx. Scale:
1/2" = 1'

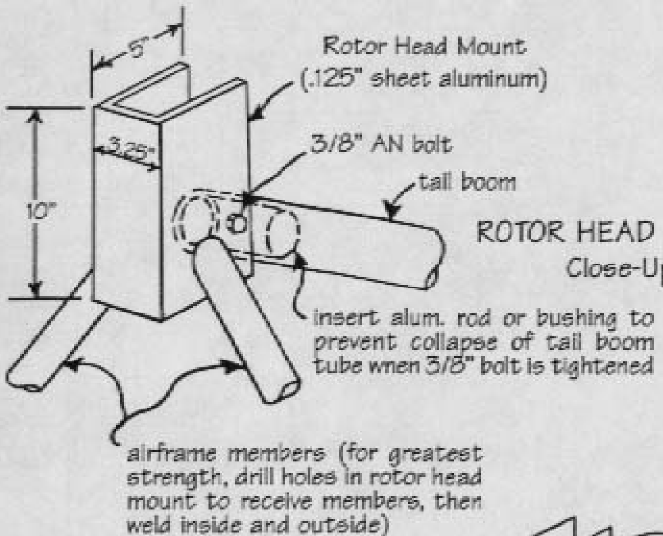
LOWER-FRAME DETAILS
Scale: None



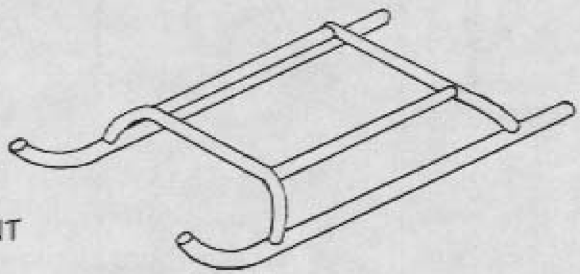
Airframe Details



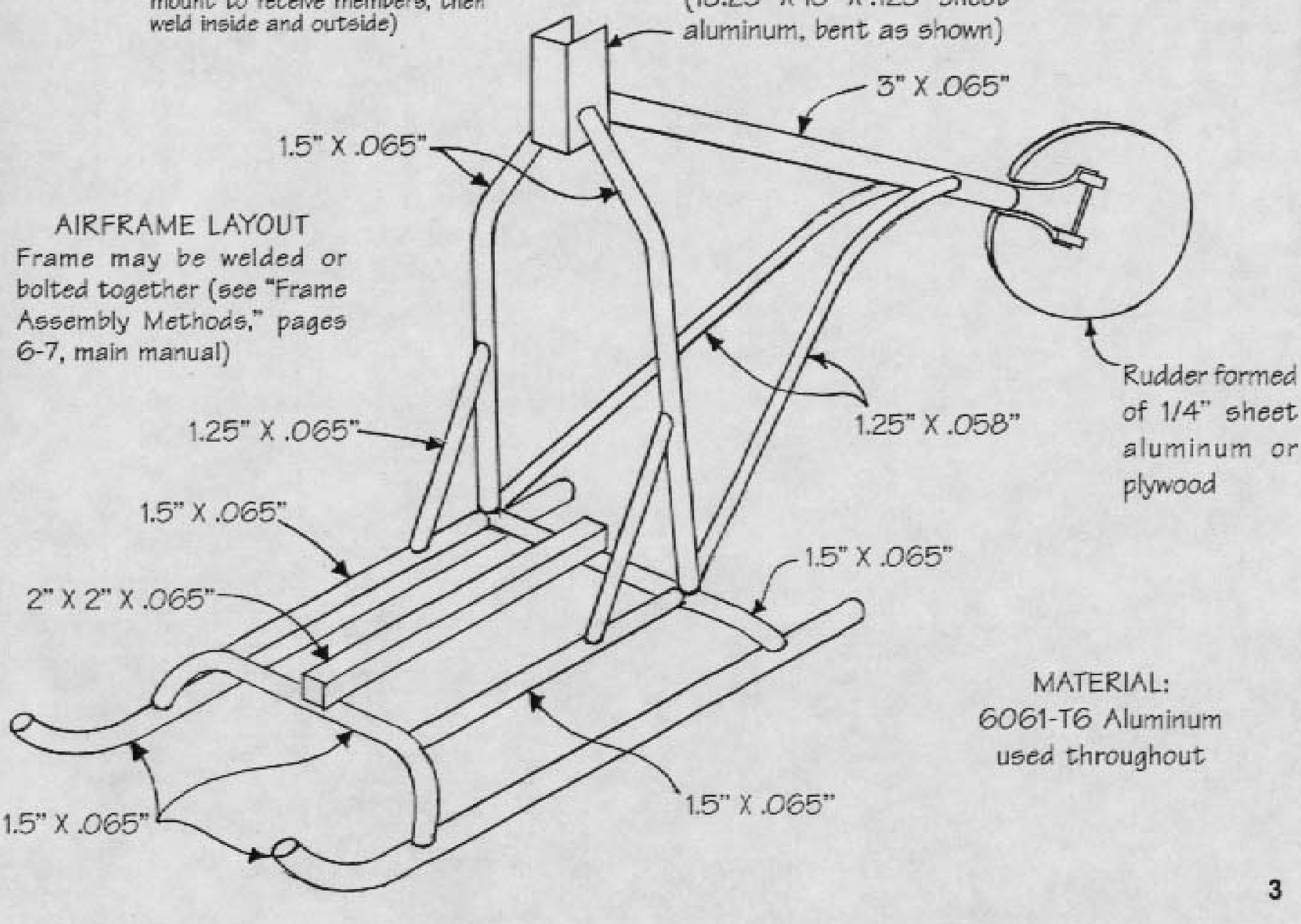
LOWER AIRFRAME
Front View minus Skids



ROTOR HEAD MOUNT
Close-Up



LOWER AIRFRAME
Perspective View

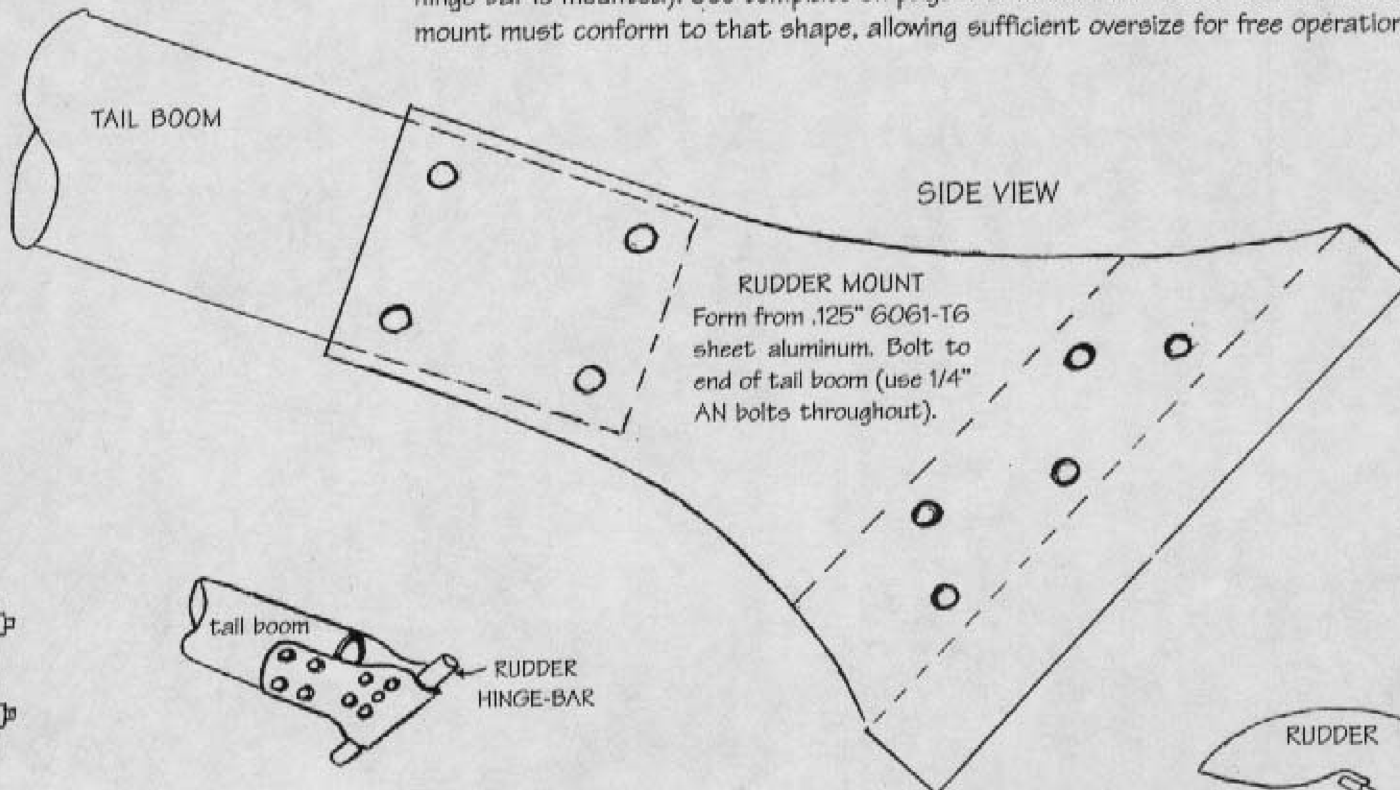


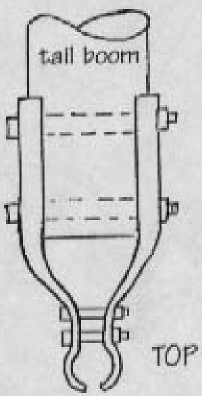
AIRFRAME LAYOUT
Frame may be welded or bolted together (see "Frame Assembly Methods," pages 6-7, main manual)

MATERIAL:
6061-T6 Aluminum
used throughout

Rudder Mount Details

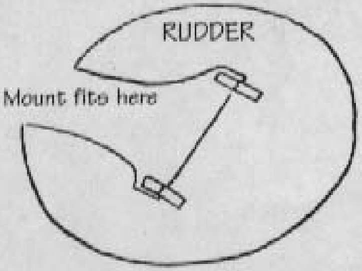
Illustrated below is the mounting of the rudder to the end of the tail boom. Please refer to the main construction manual for details of rudder formation and attachment to foot pedals; alternatively, a single push-pull cable, connected to the rudder pedals via a bellcrank, may be substituted for the cable-pulley arrangement. Rudder itself would be mounted at a 50-degree angle relative to the ground, as shown in main manual (this is the angle at which the rudder hinge-bar is mounted). Use template on page 4 of manual for rudder outline; cutout for rudder mount must conform to that shape, allowing sufficient oversize for free operation.





Shows rudder mount bolted to tail boom. Use 1/4" AN bolts throughout.

1/16" 4130 steel straps are wrapped around and welded to rudder bearings as shown above



Steel straps bolt to rudder as shown. Use 1/4" An bolts.