REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPROVED

G & H TECHNOLOGY, INC.
BLUEPRINT CONTROL
PRODUCTION RELEASED
FEB 6 1980

3 2 3 Application Procedure

Apply the solution liberally to the aluminum surface. For paint-bonding coating, use two applications. For corrosion-resistance in unpainted work, four applications. Allow approximately one minute reaction time between applications and before final water rinsing.

3.2.4 Rinsing of Part after Application of Solution

3.2 4.1 The excess Alodine No. 1200 solution should be removed by either of the following methods:

3.2 4.1.1 Thorough flushing with clean water, followed by air drying or wiping dry with clean cloths.

3.2.4.1.2 Wiping with water-damp cloth followed by wiping dry with clean cloth.

4.0 NOTES OF CAUTION:

4 1 Do not store Alodine No. 1200 solution in mild steel, lead, glass, tin, or galvanized containers. Containers for the solution should be constructed of stainless steel, plastic, or rubber.

4.2 A fire hazard exists when rags, sponges, swabs, etc. used for applying or removing the Alodine solution are allowed to dry. Immediately after use they should be thoroughly washed in water before discarding.

ITEM NO		
*	4.3	Avoid physical contact with solution or inhalation of its vapors.

LIST OF MATERIALS

GRAY & HULEGUARD • INC •
SANTA MONICA CALIFORNIA

PROCESS SPECIFICATION FOR TOUCH-UP COATING OF ALUMINUM PARTS WITH ALODINE 1200 PROTECTIVE COATING

JRA	3-2-60
Y. Katano	3-2-60
RAH	3-2-60

CODE IDENT. NO.	SIZE	
99447	B	999-013

SCALE	WEIGHT	SHEET
		1 of 1

PROCESS SPECIFICATION FOR
TOUCH-UP COATING OF ALUMINUM PARTS WITH ALODINE 1200 PROTECTI

APPLICATION:

This process to be used, when specified on drawings, on all aluminum parts re touch-up type of protective coating.

MATERIALS:

Wash-off Deoxidine No. 624 or Special Deoxidine per MIL-M-10578
Manufacturer: Amchem Production Co., Niles, California (No. Code Ident. No.

Alodine No. 1200
Manufacturer: Amchem Production Co., Niles, California

Solvent - Methyl-Ethyl-Ketone

PROCESS SEQUENCE

Preparation of Part

Pre-cleaning

When no corrosion is present, wipe thoroughly with clean MEK solvent.

When touch-up of abraded or damaged areas on previously anodized or alodized parts is required, wipe areas with MEK solvent.

When corrosion is present, remove grease, oil, and corrosion products with Wash-off Deoxidine (No. 624) or Special Deoxidine MIL-M-10578.

Rinsing after Pre-cleaning

When Deoxidine pre-cleaning is used, the excess solution and contaminants must be flushed from the surface with clean water prior to the application of the Alodine solution.

Coating of Part

Preparation of Solution

Alodine No. 1200 Liquid is to be used as received.

Methods of Application (use one of the following)

Brush solution on the surface using a nylon bristles brush.

Swab solution on the surface with sponge or cloth.

QTY REQ	NEXT ASSEMBLY	MO

UNLESS OTHERWISE SPECIFIED

TOLERANCES
LINEAR XX — ± .03 XXX — ± .005
ANGULAR ± ½°
DRILLED HOLES PER ANDI0387
SURFACE ROUGHNESS PER MIL-STD 10
FINISH ALL SURFACES ✓
IDENTIFY PER G & H SPEC. 999-012
MEET DIMENSIONS BEFORE PLATING
MACH CORNER & FILLET RADII .010
REMOVE BURRS & BREAK SHARP EDGES

FINISH

HEAT TREAT

24C

SAFE-T-POXY®

An epoxy system for room temperature curing laminates.

SCOPE

Any industrial reactive chemical product can potentially cause an allergic response or dermatitic skin irritation. Safe-T-Poxy® has been especially formulated to minimize such problems by advanced state of the art materials. Before use, the following precautions should be read and understood.

INTRODUCTION

Until a comparatively few years ago, the use and availability of thermosetting resin systems have been in the hands of knowledgeable professionals and commercial manufacturing companies.

The increasingly available leisure time and sophistication of the adult sport oriented toys has led a whole new group of people into personally building complex devices such as light aircraft, surfboards, sail boats, automobile bodies and the like.

The greater number of these ambitious efforts are undertaken by non-technical and uninformed individuals who can follow a set of instructions and, by purchase of a kit, eventually achieve their goals.

Inasmuch as any thermosetting resin system is chemically reactive by nature, it is obvious that the possibility of interaction of such materials with the human organism on contact is likely. These reactive resin forming systems are normally used as impregnants for fiberglass, graphite, Kevlar and other fibers in various forms to produce desired shapes which means that relatively large resin-fiber surfaces are probably exposed during layup prior to cure. The tools used for mixing and laminating will necessarily become contaminated and, during cleaning, could permit the resin to contact the skin.

Since a large number of applications are non-commercial the amateur builder will possibly set up his operation in a garage space which in winter is probably poorly ventilated. This will greatly enhance inhalation exposure to the uncured resin, clean-up solvents, sanding dusts, fiberglass, other fibers and particles of broken glass bubbles which can become airborne during mixing with the resin and other similar potential inhalation exposures.

The aim of this note is to warn of the possible effects of these potential hazards and how to avoid them, if possible.

Initially, one can categorically state that the human body exists in a hazardous environment, irrespective of industrial materials. Allergic reactions to poison oak, bee stings, household dusts, etc. can cause prompt physiological response in the form of local irritation or respiratory distress. It should not be so surprising, therefore, that other foreign chemical materials can cause similar problems.

SKIN CONTACT

The reaction of the intact skin barrier to materials and, in particular, liquid, depends on the nature of the exposure which can cause different types of inflammatory conditions.

A. Contact Dermatitis can result from contact with an alkaline or acidic substance, such as acid, or a caustic, such as with an aliphatic amine similar to ammonia.

   The concentration, temperature and time of exposure as well as the chemical nature of the irritant to develop cutaneous cell damage are all inter-related. The point of contact is essentially the only area affected due to the concentration rapidly decreasing below the threshold level due to dilution effects in adjacent tissues.

B. Irritant Dermatitis can develop with weak irritants used over a long period such as those hairdressers who use shampoo all day and machinists using cutting oils constantly.

   The use of strong active solvents and detergents to clean the hands will defat the skin. The stratum corneum constitutes the main protective layer. The flexibility of the skin is maintained by the water content which is protected by cell wall lipids that can be removed or damaged by frequent solvent exposure or washing. The skin then becomes dry and cracks and becomes highly susceptible to further attacks or bacterial invasion.

   The epithelium of follicular root sheath and the sebaceous glands can absorb fat-soluble chemicals which can lead to subcutaneous inflammation.

C. Allergic Contact Dermatitis is an inflammatory process of the skin due to contact with a chemical class to which the skin has undergone an acquired specific alteration of its reactivity. Such a sensitization reaction is not directly proportional to local concentration, but is an allergic response which can be very active with any contact of very low concentrations of the sensitizer, or by respiratory absorption.

The list of known, active sensitizing agents reportedly involved in the etiology of contact dermatitis antigens is very large and includes soaps, metals, amines, antibiotics, oils, paints and the like.

A further complication to this situatio is the fact that some chemicals absorbed by the skin can cause an abnormal sensitivity to sunlight and develop photo-allergic reactions which produce sunburn-like conditions.

The obvious answer to this potential situation is to avoid contact of any chemical product with the skin. Do not use solvents for accidental contamination, other than a wipe with a paper towel moistened with alcohol or mineral spirits to remove stickiness and do not wash with harsh soaps excessively. Use a hand cream containing lanolin at the end of the day to keep the skin of the hands pliable.

BARRIER CREAMS

There are available a large number of skin creams that are proported to protect against skin irritation.

The commercial formulations vary considerably in composition and the degree of protection is dependent on the nature of the potential soiling material. The chief advantages are that removal of resin is facilitated and that the skin is lubricated. However, it is not recommended that reliance be placed on the anticipated protective nature of any cream against dermatitis.

GLOVES

Cheap vinyl or polyethylene gloves provide little protection against dermatitis because of a small cross section which, upon stretching, becomes very thin. The permeability to chemicals is also quite high, especially with low molecular weight solvents, specific chemical products and vapors.

For increased protection against irritation, the use of heavy-duty butyl rubber gloves and cotton liners is recommended. The gloves are resistant to the permeation of epoxy resins and curing agents and have been found to offer the greatest protection of any gloves tested. The cotton inner liners are designed to be used in conjunction with the gloves. The combination of the roomy butyl glove and a soft cotton liner reduces the tendency of the hands to perspire inside the glove and provides extra comfort when working long hours. Although these gloves provide protection from solvents such as MEK and acetones, it is suggested that soap and water be used for clean-up.

For short term protection, an inexpensive glove made of high quality rubber latex may be used. The cotton liner described above should also be used with the latex gloves. The combination of glove and liner will provide good protection, but the rubber latex is neither as durable nor as resistant as the butyl rubber glove and therefore is recommended only for smaller projects involving shorter exposure time.

Barrier creams should not be used under tightly stretched, thin gloves. Problems will arise due to excessive sweating on the hands, even with no chemical contact, due to blockage of the pores.

STEROID CREAMS

Recently there has been made available non-prescription preparations for topical use that contain active ingredients with cortico-steroid physiological effects.

Primarily, they have been used on dermatoses for the anti-inflammatory action. However, they are potent drugs and must be used sparingly. If applied over large skin surfaces for prolonged periods, severe systemic and permanent physiological changes can occur.

Application to the back of the fingers strictly on the affected area has been known to produce remission, but cannot prevent recurrence of dermatoses of allergic origin.

Under no circumstances should surgical tape or tight plastic gloves be used over a topical application of a steroid cream because of the possibility of systemic absorption and the development of local infections.

The foregoing is not a recommendation for use, but is intended as a warning against misuse.

INGESTION

Ingestion of potentially harmful substances into the body systems could be via various routes, such as inhalation, oral ingestion and skin absorption.

INHALATION

Inhalation via the respiratory system requires either of the following:

A. Air supported dusts, fibers, sanding particles and the like that could accumulate in the lungs.

   Most operations where laminates are made involve sanding at some stage to develop a specific shape or surface finish. The sanding dust can contain sharp, minute fibers of the reinforcement that can cause respiratory distress or, if allowed to remain on the skin, can cause mechanical irritation dermatitis.

   Glass bubbles are sometimes used in slurry form to fill the holes in foams. A certain percentage of the bubbles consist of very thin, broken glass which can become airborne during incorporation into a resinous mixture. If these glass fragments become lodged in the airway, considerable respiratory distress can result.

   The simple solution is to wear a dust mask during sanding, fiber handling or when mixing bubbles.

B. Chemical irritation from primary irritants in the form of fumes, such as those from aliphatic, low molecular weight diamines, typically ethylene diamine or diethylene triamine which have been used for epoxy hardeners in the past. High vapor pressure solvents such as acetone, when used in a confined space, can create respiration difficulties.

If an excessive amount of room temperature setting epoxy resin and hardener are allowed to remain in the mixed form in a container, especially on a hot day, a high exotherm can result which might possibly result in the decomposition of the resinous mixture. The fumes given off are quite irritating and inhalation could cause a sensitization to the components. Such an exposure could result in a practical prohibition of further work on <u>any</u> epoxy system because of allergic systemic sensitivity.

The solution would be to not allow more than a hundred grams or so of a mixed resin to remain in a paper cup beyond the useful pot life. If more material is required, use a metal mixing vessel, such as a can, and place in a pan of water.

On a hot day, the pot life is much shorter and the exotherm higher.

Also, wear an organic vapor mask, if possible.

C. <u>Allergic Sensitization</u> can occur under the high temperature conditions described above or by exposure to large surfaces of uncured resin-fiber combinations with poor ventilation.

Epoxy resins and reactive diluents used to reduce viscosity are relatively high molecular weight chemicals whose molecular size will not permit passage through the intact skin barrier. The vapor pressure is low and the boiling point high.

However, during the manufacture of these resins there are residual, low molecular weight, chemically active components measured in parts per million that cannot be reduced in concentration much further without a considerable increase in selling price. With all commercially available liquid resins there are at least 10 to 20 of these active species of different compositions, including chlorohydrins, which are known or suspected sensitizers.

So even if an epoxy laminating resin were specified as being 100% diglycidyl ether of "Bisphenol A", it could still contain 1 to 100 parts per million of chlorohydrins and be an active sensitizer. The sensitization route could be by excessive inhalation of the fumes from a warm surface or by absorption through the skin by prolonged exposure, such as the use of contaminated gloves or the bad practice of washing off the hands in solvent previously used for cleaning up tools or resin spills.

Hardener problems with Safe-T-Poxy®, if encountered, are generally related to careless handling and gross or excessive skin contamination. The hardener is essentially neutral in nature and does not constitute a chemical irritant, nor is it known to be an active mutagen or carcinogen. However, excessive direct skin exposure can easily create an allergic condition due to the presence of an aromatic diamine.

FIRE

Do not dispose of any resin-containing material in a fire where the products of combustion can be inhaled. Sensitization is possible from absorption of the gaseous products of combustion.

SKIN IRRITATION

The resin and hardener separately have been submitted to an independent biological science testing laboratory for patch testing on albino rabbits. The conclusion was drawn that the products can be considered as non-irritant to the skin.

ALLERGIC DERMATITIS

Allergic dermatitis is possible after excessive contact or careless handling which is common to all epoxy resins. The epoxies in Safe-T-Poxy® have been carefully formulated with this in mind and any known content of low molecular weight chlorohydrins reduced to an irreducable minimum. Once a person has become sensitized, however, a minor exposure is all that is needed to provoke a reaction.

ACCIDENTAL INGESTION

Accidental ingestion should not create a crisis since no primary irritants are present and no cellular destruction is expected. The resin-hardener composition contains no unusually potent physiological agents.

Induce vomiting and, if needed, gastric lavage. Toxic hepatitis has been reported in rats fed substantial amounts of aromatic amines over a long period of time.

RECOMMENDATIONS

1. Develop good work habits. Practice intelligent hygiene.
2. Do not permit resin or hardener to remain in contact with skin.
3. Wear heavy gloves, such as butyl rubber, with cotton gloves underneath. Launder cotton gloves daily or use disposable type.
4. Do not use harsh solvents or soaps to clean hands.
5. Wear dust respirator when sanding.
6. Make layups under good ventilation conditions and/or wear an organic vapor mask.
7. At end of day, wash hands thoroughly with soft soap and apply an emollient lotion.
8. Get medical attention if problems arise.

NOTICE

The foregoing information is offered in an effort to be helpful and attempt to point out possible sources of problems in using any epoxy resin.

Responsibility for use of the resin systems and application of the application suggestions reside strictly with the user. Definitive technical information can be found in the references on the following page.

Safe-T-Poxy® is a registered trademark of Applied Plastics Company, Inc., El Segundo, California.

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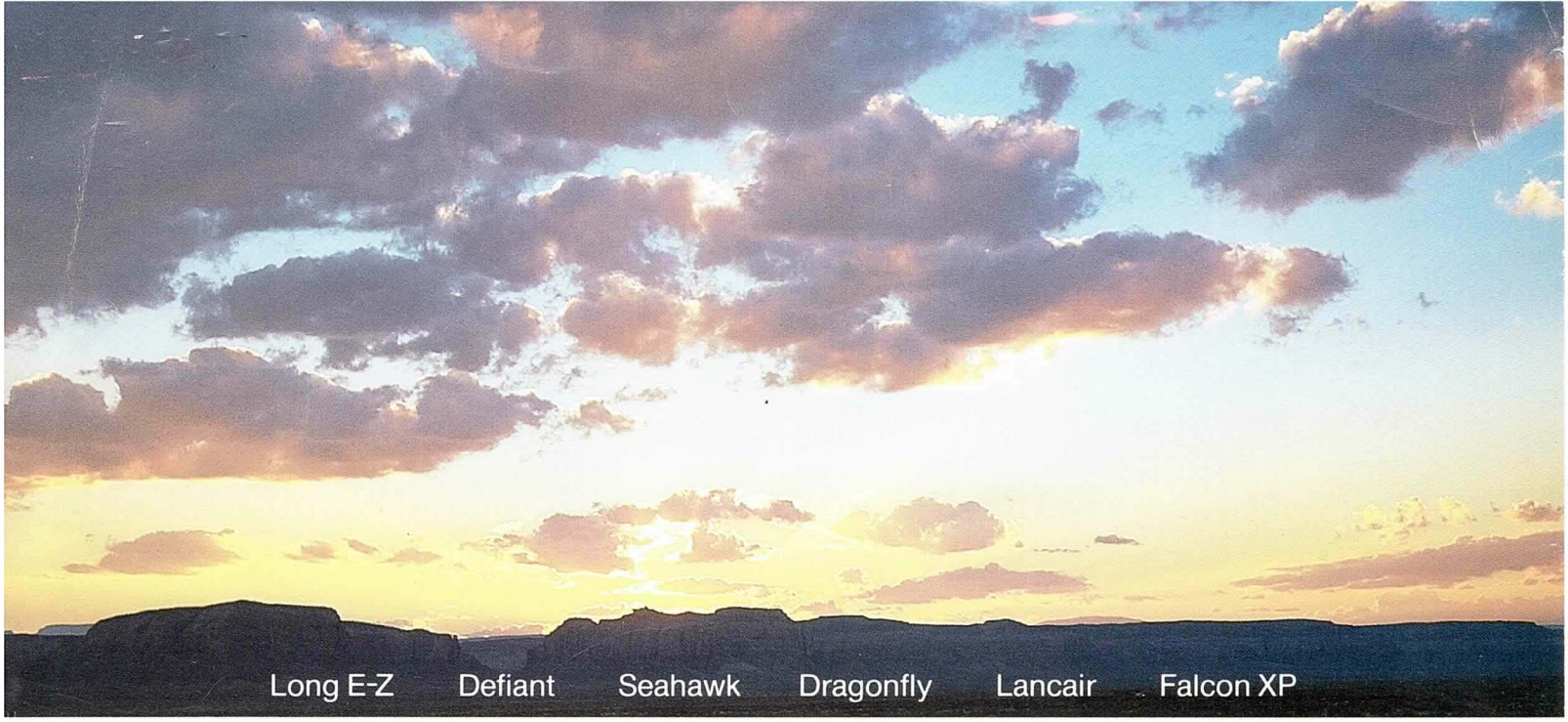

Without Hexcel, The Skies Would Be Empty.

Hexcel's composite fabrics and laminating resins make possible Sport Aviation, as we know it today.

In truth, modern aviation is absolutely dependent upon composite structures and components. These materials provide affordable, lightweight construction with exceptional strength and unmatched performance.

In the Sport Aviation industry, the number one composite fabric supplier is the Trevarno Division of Hexcel Corporation, offering bidirectional and unidirectional weaves in a variety of fibers including glass, Kevlar® and graphite. And don't be surprised to learn that the leading resin supplier to Sport Aviation is also Hexcel Corporation and it's Resin Chemicals Group, with APCO Safe-T-Poxy.® Hexcel's fabric and resin combination is so dominant that it's used to construct more than nine out of every ten composite sport aircraft built today.

Hexcel's Trevarno fabrics and Safe-T-Poxy laminating resins are actually specified by an overwhelming majority of sport aviation's designers and manufacturers as the only acceptable materials that assure the structural integrity these aircraft demand. In fact, Hexcel's composite materials are major structural components of Burt and Dick Rutan's exotic Voyager, conceived to circle the globe non-stop, non-refueled.

Dominance of Hexcel's magnitude is possible only with technology of the most advanced kind, with products reflecting all the benefits of that scientific knowledge.

Our record of leadership in the composite field speaks for itself. For decades, Hexcel has been involved in countless, diverse and highly sophisticated areas. Many of the products we developed for aerospace applications have become industry standards. Our materials are used to manufacture some of the most advanced medical devices. We're on the forefront of plastic tooling and filament winding technology. In fact, wherever advanced composite technology is used, you'll find Hexcel.

It's this background of leadership that Hexcel brings to Sport Aviation. Trevarno's composite fabrics and Safe-T-Poxy laminating resin systems are engineered, formulated and manufactured for perfect compatibility to insure the ultimate in advanced composite construction.

Imagine Sport Aviation without composite materials from Hexcel. There would be nothing but empty skies.

HEXCEL®

RESIN CHEMICALS GROUP
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The New Advanced Composite Reinforcements

HEXCEL®

ATTRIBUTES

	Best	⟶			Least
Cost	E Glass	S Glass	Kevlar	Graphite	Ceramic
Weight (Density)	Kevlar	Graphite	S Glass	E Glass	Ceramic
Stiffness	Graphite	Kevlar	S Glass	Ceramic	E Glass
Heat	Ceramic	S Glass	E Glass	Kevlar	Graphite
Toughness	Kevlar	S Glass	E Glass	Ceramic	Graphite
Impact Resistance	Kevlar	S Glass	E Glass	Ceramic	Graphite

S-2® GLASS

The chemical formulation of S glass is different from E glass. S glass is stronger, tougher and stiffer than E glass and retains these properties up to 1500°F. It costs about $5/lb. S glass is easy to work with and is in the same weight range as E glass. Used in recreation and marine applications including surfboards, power boats, fishing rods and rackets.

KEVLAR®

Kevlar is an organic fiber from DuPont which chemically is part of the aramid family of compounds. Nomex is also an aramid while nylon is a close cousin. Kevlar is yellow in color and soft to touch. It is extremely strong and tough and about the lightest structural fiber on the market today. However, it must be vigorously cleaned or scoured (Hexcel treatment F100) before it will bond to resins. Its price is moderate at approximately $10/lb. Kevlar is the most resistant fiber to impact and abrasion damage available on the market today. Its compressive strength is low. Used extensively in marine, sports aviation, and often with glass and graphite.

GRAPHITE

Graphite fibers begin as PAN (polyacrylonitrile), rayon or pitch fibers which are stretched to high tension and slowly heated to extremely high temperatures (over 3000°F.). This process causes all the molecules in the fiber to change into long parallel chains of carbon atoms. The results are fibers which (1) have low density (weight/unit/volume), (2) are very stiff (modulus) and (3) strong (tensile). Current cost runs from $25/lb. for high strength fibers to over $70/lb. for super high modulus version. Used in race cars, recreation equipment, golf shafts, fishing rods, tennis rackets and bicycle parts.

CERAMIC

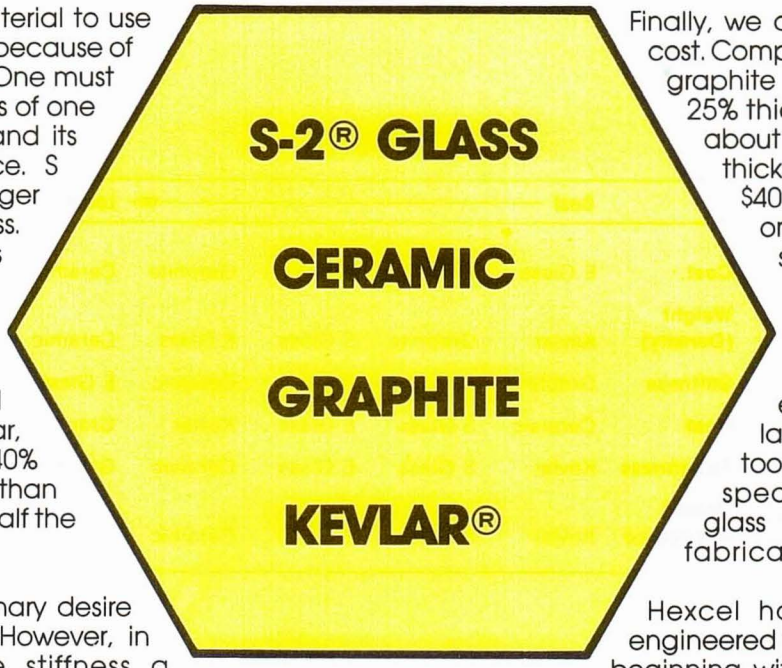
A number of fiber manufacturers have recently developed the technology to produce continuous filaments of inorganic (mineral) fibers which can be woven into cloth. These fabrics produce laminates approaching the mechanical properties of S glass plus they can withstand temperatures of almost 3000°F. Their handling is similar to fiberglass. Ceramic fibers are currently in use as lightweight fire protection barriers replacing heavier metal on many of today's newest aircrafts. Also used as insulation blankets for metal heat treatment. The cost is over $90/lb.

HEXCEL®

THE NEW ADVANCED COMPOSITE REINFORCEMENTS

Which family of these hi-performance fabrics are you using? **Hexcel offers them all**. The comparative data shown here can help you choose. In addition we provide maximum quality and service. Design of custom fabrics can be made to suit your needs.

Often, the choice of material to use for a laminate is difficult because of the required properties. One must consider the advantages of one material over another, and its anticipated performance. S glass is about 30% stronger and 15% stiffer than E glass. It has 20-25% the stiffness of graphite, and is as strong, but it's 30% heavier. S glass, though, has only half the strength and stiffness of Kevlar and twice the weight. Kevlar, on the other hand, is 40% stronger and 25% lighter than graphite but it has only half the stiffness of the fiber.



Stiffness is often the primary desire for many applications. However, in building in adequate stiffness a material could be over-designed for strength.

By blending different materials such as S glass/Kevlar or glass/graphite in the laminate, it is possible to achieve a proper balance of properties. Since stiffness is proportional to the cube of the thickness, the stiffness of a foam or honeycomb core construction can be met without excess weight gain, by using different materials to maximize properties and minimize cost. A good example of this procedure would be a boat hull which uses Kevlar and glass for the outside skin for toughness and abrasion resistance, and graphite on the inner skin to take the structural loads.

Finally, we come to the question of cost. Comparatively, if a laminate of graphite costs $100.00/sq. yd., a 25% thicker part of S glass costs about $20-25/sq. yd., and a 40% thicker Kevlar part would cost $40.00/sq. yd. These costs are only relative and are exclusive of resin and labor costs. Obviously thicker laminates require more resin. Glass, graphite, S glass and ceramic are easier to use in hand layup than Kevlar. Special tools for handling Kevlar and special hybridized Kevlar/glass weaves can assist the fabrication of a Kevlar part.

Hexcel has been a weaver of engineered yarns for over 3 decades, beginning with fiberglass. A weaving plant in Seguin, Texas continues to serve a network of sophisticated distributors throughout the United States.

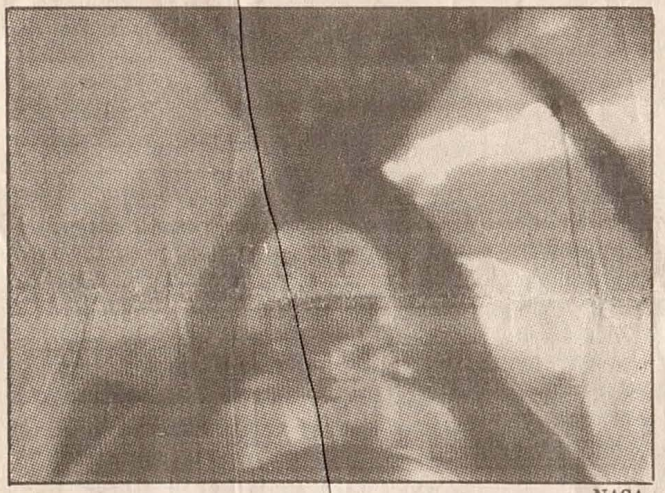
Rapid response to customer needs by enthusiastic and knowledgeable personnel has helped Hexcel's growth in the marketplace. A network of trucks and warehouses supports this efficient distribution team.

A full line of advanced composite reinforcements is now available from your Hexcel distributor.

FOR FURTHER INFORMATION CONTACT:

Science / Medicine

Cockpit camera captures the moment as lightning strikes the F-106B fighter jet behind seat of co-pilot Bruce Fisher, a NASA engineer.



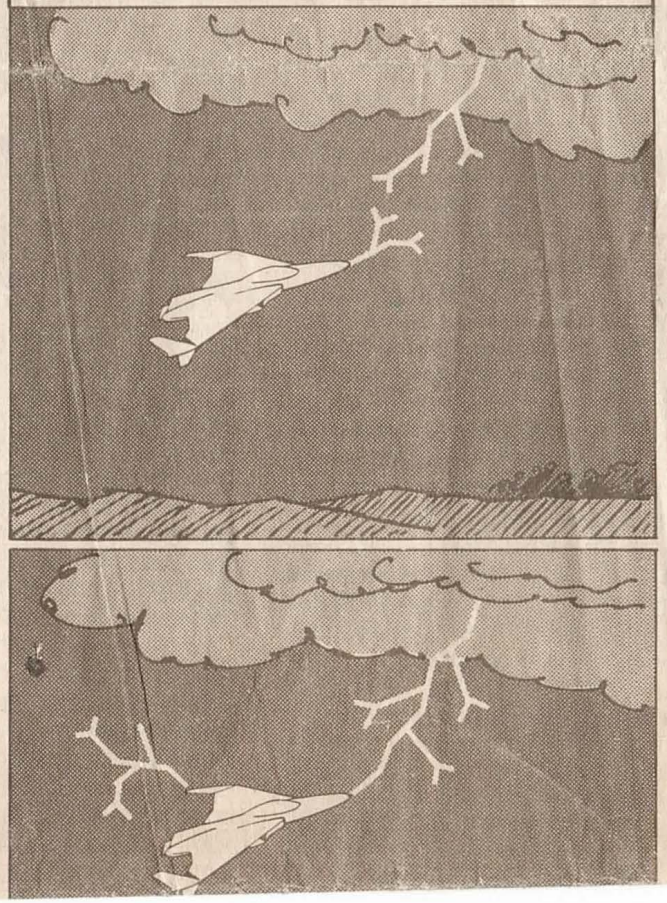
NASA

Wings of Fire

Composite materials being used in new airplanes are strong and light but can be a hazard if

LIGHTNING FOLLOWS 'THE LEADER'

Physicists now believe that lightning strikes begin with "leaders"—regions where electricity has just begun flowing. The leaders grow toward each other simultaneously, forming a path for the electricity. At top, the leader from the nose of the aircraft draws the strike. Center, the plane's metal skin conducts the electricity, until it connects with another leader on the ground, bottom.



81 on board. That disaster, the only one caused by lightning in U.S. commercial aviation, prompted the FAA to require that aluminum wing surfaces of fuel tanks be at least .08 of an inch thick.

Protecting a composite airplane, on the other hand, is more complicated. Engineers are concerned with lightning's direct and indirect effects. Direct effects refer to the damage inflicted by the lightning flash, which is hot—up to 20,000 degrees Celsius—and delivers a shock wave that can dent metal and be heard miles away as thunder. Indirect effects are caused by the huge, rapidly changing currents and electromagnetic fields of a lightning bolt, which can create unwanted currents and voltages in any unprotected electrical wires inside the airplane.

"The concern was if you had a lightning strike that coupled into a wire, a component could be damaged, and feasibly you could damage a 50-cent electronic chip and the airplane would fall out of the sky," said Gary DuBro, assistant director for studies and analysis at the Office of Naval Technology in Arlington, Va.

Some jets, like the Air Force's F-16 fighter and the new Airbus A320 airliner, cannot fly without sophisticated flight computers that continually adjust the engines and control surfaces.

For safety, wires leading to essential electronic controllers are all connected to devices that limit sudden, potentially damaging surges of voltage and current. The wires themselves are usually shielded with metal to further limit surges.

To protect the plane itself from the direct effects of a lightning strike, a thin coating of aluminum, copper, or nickel is applied to all composite surfaces. The idea is to conduct the current from the lightning away from the immediate area of the strike, spreading it out over the fuselage.

Another method of protecting composites starts with fine metal wires, which are woven into the composite material itself. Beech Aircraft Corp. in Wichita, Kan., used this technique on its new all-composite Starship airplane, which had a live encounter with lightning on a test flight in May.

"All we can say is that it did occur and that the

lightning strikes the craft.

By GLENN ZORPETTE

Pilot Robert A. Rivers remembers one thing clearly: They were not the sort of clouds he expected to see lightning leap out of. But it did, and it nearly wrecked his airplane.

Rivers, a research pilot with the National Aeronautics and Space Administration, was approaching the Los Alamitos Army Aviation Facility on Feb. 24, 1987. Behind him was astronaut Brewster H. Shaw Jr., a veteran of two space shuttle flights and Rivers' co-pilot that day.

As the plane, a T-38A jet trainer, passed about 2,500 feet over Seal Beach, Rivers took off his gloves to open a flight manual. About the same time, Shaw's hair began standing on end, not an uncommon occurrence during the static buildup before a lightning strike. Then, at 12:33 p.m., with the plane about 11 miles from the runway at Los Alamitos, there was a bright flash and a loud thump.

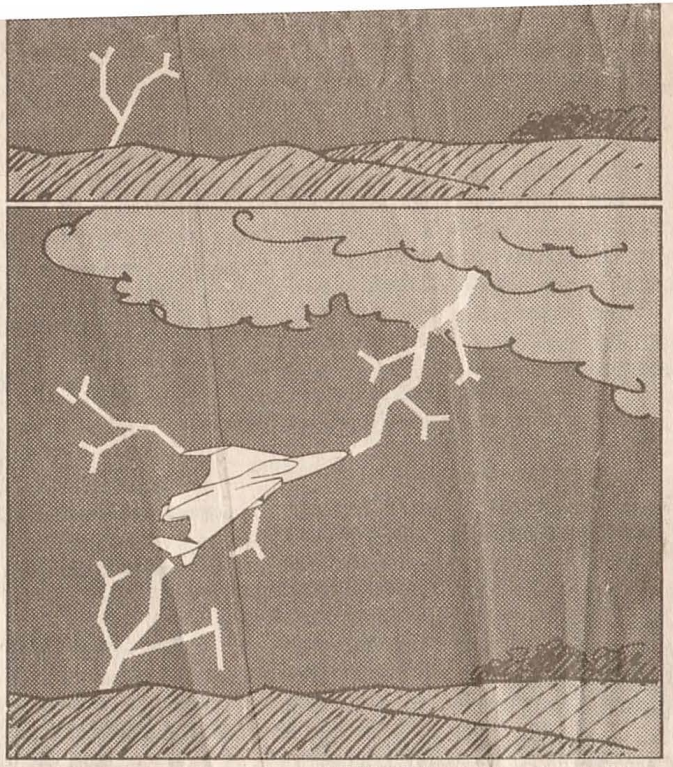
"I remember feeling the shock through my hand on the throttle," Rivers recalled. "We were pretty sure it was a strike." Almost instantly, there was a second thump, and a warning light indicated fire in the right engine. Rivers shut the engine down and managed to land the balky aircraft at Los Alamitos. "I don't think we could have made it much farther," he said.

Leaping out of the burning airplane, the two saw a gaping hole behind the co-pilot's seat. The second thump had been the sound of a fuel tank exploding and ripping off the top of the fuselage.

Although few encounters cause that sort of damage, lightning strikes at least a few planes around the globe every day, according to experts at NASA and the Federal Aviation Administration. The vast majority of strikes are not life-threatening because until recently most airplanes were built of aluminum, which protects them.

But nearly all airplanes designed in recent years use some non-metallic materials called composites, which are plastics reinforced by fibers of graphite or some other material. Composites are stronger and lighter than aluminum but, by themselves, offer little or no protection against lightning.

Therefore, to better protect the next generation of aircraft, researchers have recently undertaken the most ambitious programs ever to understand lightning's effects.



Source: Gary DuBro, U.S. Navy PATRICK LYNCH / Los Angeles Times

Airplanes using composite materials perform better and consume less fuel than comparable all-metal planes. Such features have put the materials into all kinds of new aircraft, from eight-passenger business jets to 350-seat airliners. And most military jets of the next decade, including the so-called stealth aircraft, will rely heavily on composites.

Despite their many advantages, composites lack one important feature: They conduct electricity poorly or not at all. When a metal airplane is hit by lightning, the huge electric current of the bolt typically enters through an extremity like the nose or a wing tip and is immediately conducted through the surface of the plane, spreading out all over like water flowing over the outside of a bottle. Then the current leaves the plane through the tail or some other extremity.

By instantly spreading out the electric current, the metal skin effectively protects the airplane. However, the metal must be thick enough to keep lightning from entering a fuel tank, as it did in a Pan American 707 just before 9 p.m. on Dec. 8, 1963. The plane was hit over Maryland by a bolt that ignited fuel in the reserve tank, blowing the left wing off the plane and killing all

Mike Potts said. An industry source familiar with the event said damage to the Starship was minor.

The use of composites is most pronounced in business jets like the Starship, but airliners also use them. The Boeing 757 and 767 use composites in their noses, nacelles (the rounded engine casings that hang below the wings), in fairings and in all control surfaces on the wings.

U.S. military jets of the 1990s are also going to be built with composites, according to sources at Boeing Advanced Systems, Northrop Corp. and McDonnell Douglas Corp. Both competing designs for the advanced tactical fighter, which will take over as the Air Force's main combat jet sometime in the 1990s, rely heavily on composites. And stealth aircraft, like Northrop's B-2 (or "advanced tactical") bomber, recently unveiled by the Air Force, also use composites.

Stealth aircraft—so named because they are hard to detect—are designed to minimize the reflection of radar waves from their surfaces. Compared to metal, composite materials are poor reflectors of radar waves.

These composite aircraft have had the benefit of a wealth of new information on the effects of lightning on aircraft. Since the late 1970s, several joint research programs have been carried out by the Air Force, the FAA and the National Oceanic and Atmospheric Administration.

But some of the most impressive findings came from the Storm Hazards Program run by NASA's Langley Research Center in Hampton, Va. Pilots and engineers there flew a specially hardened and equipped F-106B airplane, a 1960s-vintage jet fighter, directly into thunderstorms.

From 1980 to 1987, the flight team logged 714 lightning hits, producing the first direct measurements of how fast the electrical fields and currents change on an airplane being hit. Those changes are what cause lightning's indirect effects on airplanes. Based on information from the NASA project, the FAA is setting new regulations for protecting electronic flight systems from lightning's indirect effects.

NASA itself has incorporated the findings into new "launch-commit" criteria for officials at the Kennedy Space Center in Florida to help them determine when it is safe to launch rockets and the space shuttle. The space agency is hoping to avoid another incident like the one on March 26, 1987, when a rocket carrying a Navy communications satellite was hit by lightning just after launch, causing a $160-million loss.

Glenn Zorpette is a free-lance writer in New York City.

San Francisco Examiner
April 20, 1986

Image

e Magazine of Northern California

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TAKING OFF
Plane Folks and Their Home-Built Flying Machines

DAVID BROWER
Man Apart

A GUIDE TO THE TEA CEREMONY

Sasha Munir with her home-built VariEze

PLANE

BY MICHAEL PARFIT

Barry Fell with his Solitaire, a kit-built powered

Photography by Michael Parfit

SASHA MUNIR'S FAVORITE ROOM IS ABOUT 40 feet long, 36 feet wide and made of steel. The "yard" is a stretch of cement on the easternmost edge of Concord. The room is carpeted with shag that previously occupied several guests' quarters in the Concord Sheraton. It contains two filing cabinets and a refrigerator on which is glued the slogan "From Prague with Love." There's a card table, folding chairs and white wine in the refrigerator. The room would be stark, except that it contains one other thing: an airplane.

On some sunny weekends Munir pushes the big doors open and lets people wander in and visit. They come in, and—although Munir herself is a very pretty, cheerful person and pleasant to be around—they don't spend much time talking to her. They prowl about the airplane, which sits lightly poised above the shag. They run tentative, appreciative hands across the polished wings, peer into the narrow cockpit, crawl underneath to look at the way the nosewheel retracts. They muse to each other about why it looks as if the whole thing was built in reverse, with the tail on the nose and the engine on the back. And some of them no doubt glance aside at Munir and think to themselves: This slender woman with the nice smile must have something special, a quality of doggedness, something I don't have, surely; a tremendous, mighty discipline.

But if Munir heard those thoughts she would laugh, as she did one afternoon when I asked her about it.

"Discipline?" she said. "Discipline? There is no discipline. It is obsession!"

We were sitting at the card table in the big room, which despite its comfy appearance is actually a hangar at Concord's Buchanan Airport. The airplane was there with us, a dominant third at our conference. Munir looked delighted at the idea that she had done anything under the burden of discipline; the plane, all shiny white with a red stripe down the middle, looked light and eager, as if it couldn't wait to take off and go flitting around the rafters.

The plane was a VariEze, made of foam and fiber glass rather than aluminum. Finished in 1983, it can carry two people at a speed of 180 miles an hour. But the most remarkable thing about this plane is not its looks, but the fact that there are several hundred other VariEzes flying in the skies above the United States, and not one was built on an assembly line. All were put together in garages, hangars, even living rooms, by people whose professions are not the manufacture of aircraft.

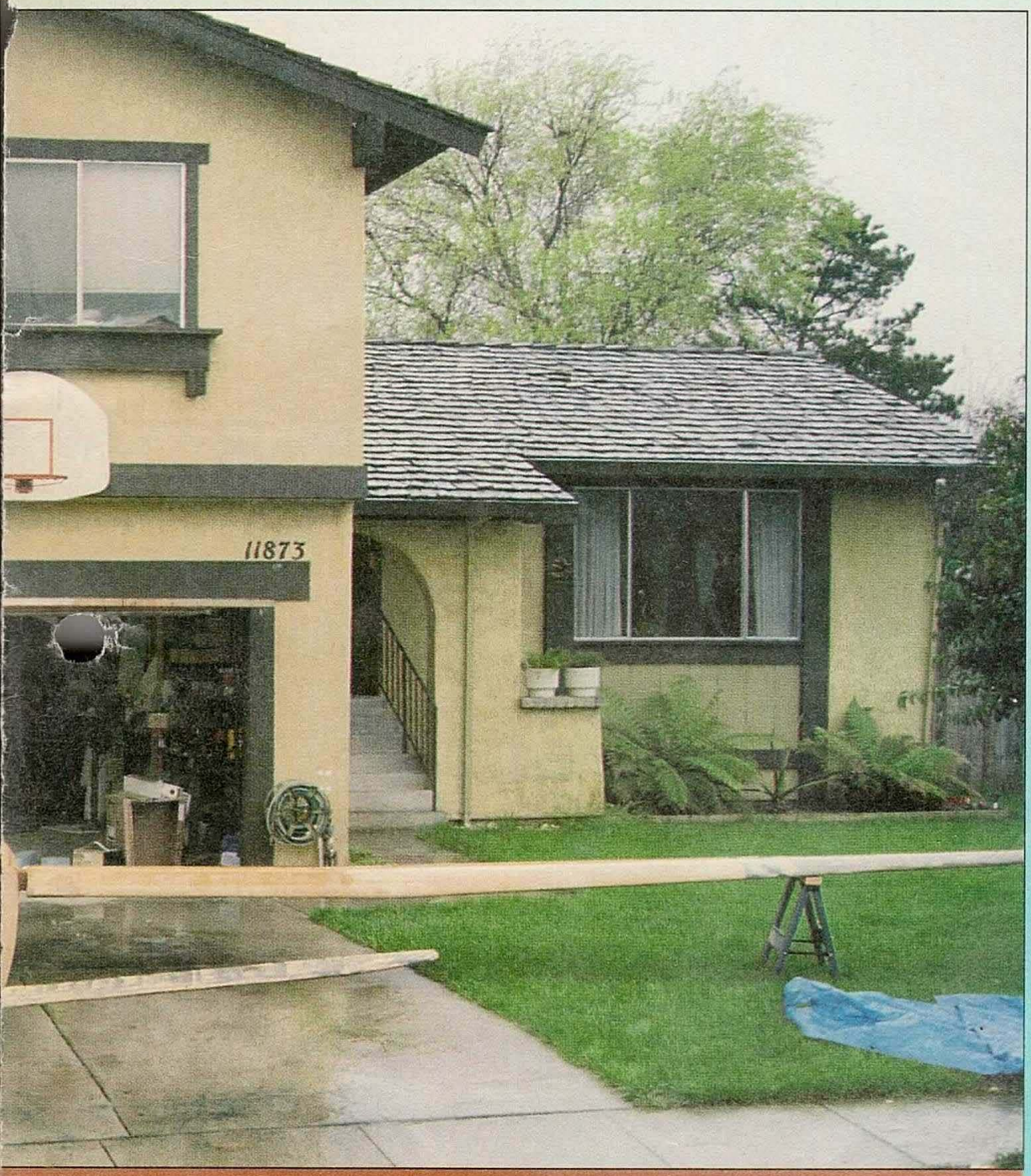
THE VARIEZE IS AMONG THE MOST POPULAR of all "home-built," "amateur-built," or "experimental" aircraft (all ways of describing planes built by people at home). There are more than 150 active businesses in the United States that will put this and other aircraft plans in the mail for you, and more than 30 other companies that offer kit airplanes, which arrive on your doorstep, in pieces delivered by the UPS truck, all ready (so you hope) to just glue together and fly.

No home-built aircraft, however, is quite that simple. "Houses are easier than airplanes," Gordon Jones once told me. Jones is a member of the Livermore Chapter of the

Michael Parfit flies a Cessna Cardinal and is the author of South Light: A Journey to the Last Continent, *published recently by Macmillan, Inc.*

FOLKS

Getting off the ground with the build-it-yourself flyers



sailplane, which is nearly finished and ready to fly.

Experimental Aircraft Association (EAA), to which almost all builders belong. Jones was one of the chapter's first members to finish a Long-EZ, sister ship to the VariEze. "It took me ten months to build a house," he says. "The plane took five years."

Sasha Munir, whose real first name is Alexandra, didn't take that long. There's no "typical" time, in fact, that it takes an aircraft builder to complete a craft; the construction process is so idiosyncratic that no two builders work in the same way at all.

Munir, a nurse, is assistant manager of the Surgery Center at John Muir Hospital in Walnut Creek. Her determination goes beyond just wanting to fly; she is a former Czechoslovakian refugee, who fled her homeland in 1968 during the revolution, reached the United States in 1970 and subsequently earned a bachelor's degree in health system administration in 1978.

In 1981, while taking flying lessons, she flew to the Nut Tree airstrip out along Highway 80 in a friend's home-built aircraft. When she crawled out of the cockpit and walked away, something about seeing the strange little plane parked there caught her imagination. She thought with a sudden and powerful longing: That could never happen to me, that I could build an airplane with my own hands and have it parked in front of that little fence at the Nut Tree.

"It was like wanting to go to the moon," she said to me in the hangar. And yet it was something that just might be done. She found a VariEze that had been crashed, bought the wreck for $10,000 and started to reconstruct it. The plane was so damaged that it was like trying to put a horse back together out of dog food, but she persisted.

"I didn't know anything about tools," she remembered. "I had to learn everything from scratch. How to use power tools, how to use a regular wrench." And how to use sandpaper, sandpaper and more sandpaper. Since it's a fiber glass plane, the VariEze must be sanded smooth, and Munir's sandpaper bill alone finally ran to $340. Because of this, some builders have called the plane, with exasperated affection, the "Vari-Tedious."

She worked every night after work, every weekend and most of every vacation for two years, and spent a total of about $18,000. Obsession. And she was driven by more than just that longing to land her own plane at the Nut Tree. "I sometimes forget how much fun it is to see how things grow in front of your eyes," she said, her Czechoslovakian accent still strong. "It's a positive reinforcement of work well done, I guess." But some things were not so reinforcing.

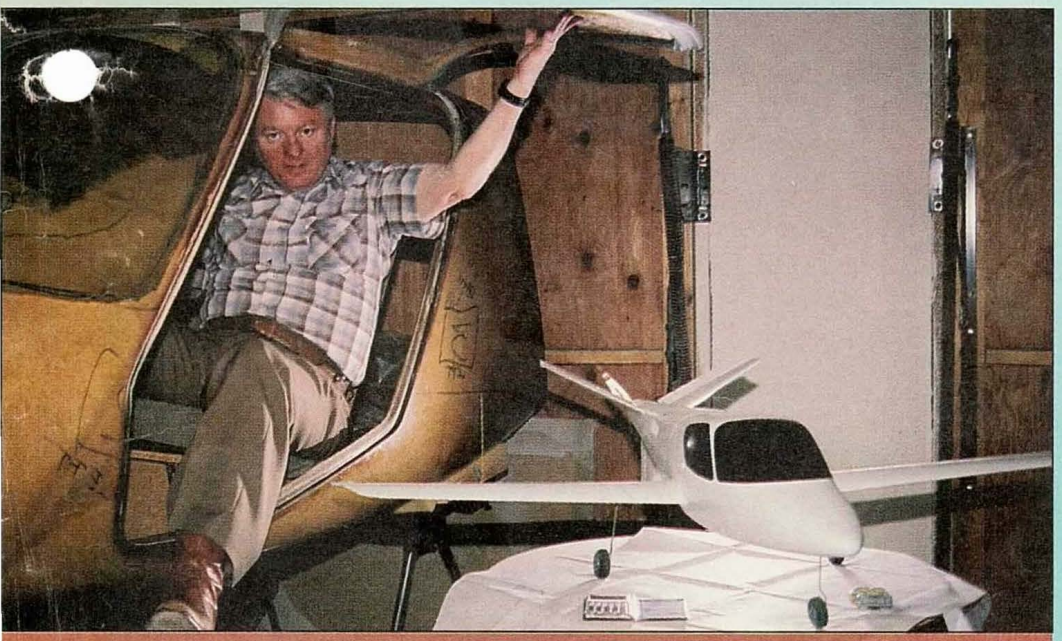
"In the beginning the men didn't accept me," she explained with a smile, outlining the skepticism of the male members of her EAA chapter (only three of the 125 people in the organization are women). "Was raised eyebrows," she said. "For a good year I was often crying because of stupid remarks." She laughed. "But I have to tell you: Now, I'm one of them. I think men didn't realize that women can do anything." They do now.

"Sasha did a year and a half of the most intense work you ever saw," Lyle Powell, a Walnut Creek ophthalmologist who builds cars, planes and motorcycles in his spare time, had told me earlier. And another male EAA member had said simply: "She's got more guts than any two people I know."

OF COURSE, ONE OF THE GUTSIEST THINGS IN this whole process is climbing into the machine you've built and trying to fly it. I was

some work space, expend hours of time, gallons of epoxy, patience and planning. While building a plane at home applies surprisingly well to these garage aerodynamicists.

Darrel Jones at work on his old-fashioned Pietenpol in his family room.



Tom Moore tries out the cockpit of his original design, the Fantom.

planes. Trouble was, he hadn't finished the design, and when it turned out to be more complicated than he had thought, the whole enterprise collapsed around him, leaving the home-built industry, which had begun to boom with the BD-5 enthusiasm, choking in a cloud of mistrust.

One of those who had trusted Bede was a United Airlines pilot named Tom Moore, who lives in Danville. Moore built most of a BD-5, then when the last parts and the engine did not arrive, sold it and began to design his own.

Moore is a quiet, pleasant man of 48, as unspectacular as Sasha Munir is flamboyant. He is so casual about his own obsession that he sometimes seems to be apologizing for it. Yet he has been putting this airplane, called a Fantom, together for five years, first in sketches, then in plans, then with a test model and now at last in fiber glass. With so many plans for sale, few builders go so far as to design their own planes, but Moore wanted something special.

"The only plans available were not to my liking," he explained one day when I dropped by his garage, where the plane's unfinished cockpit rested on blocks. "I wanted a relatively fast airplane, good comfort, good visibility and relative quiet," he explained. Most home-builts tend to be cramped and noisy. So the cockpit that Moore built has more of the sleek but capacious simplicity of the face of the Boeing 767, which Moore flies for United, than the lean lines of Sasha Munir's airplane.

But designing an aircraft is more than just sticking a wing and tail on a place to sit; an improperly designed plane might soar like an eagle but land like an elephant. To avoid that, Moore studied. "I'm sort of self-educated," he said. He calculated the first equations by hand, and only later turned to an Apple II computer. "I would design each phase and put it together. Everybody uses the same formulas, anyway."

That may indeed be true, but in the past few years the home-built aircraft industry has sold more designs than the aircraft factories have sold small planes. EAA members like to point out that more experimental aircraft (10,839) were registered in 1984 than 1985's total sales for factory-built planes. And many of the home-builders unquestionably get more performance out of their planes than anything made on the assembly line. "We hold fuel- and speed-efficiency contests—during the Oshkosh 500 in Wisconsin, the annual meet for experimental aircraft enthusiasts—with both home-built and factory-built planes every year," said Ben Owen of the EAA. "The home-builts always run away with the contest."

ONE EVENING TOM MOORE TOOK ME TO A meeting of the Livermore Experimental Aircraft Association chapter. About 25 members were gathered in the garage in the pleasant suburban home of Don Coughlin, a retired electrical engineer. There wasn't even one car in the three-car garage. Instead it was occupied by the brown-and-golden unpainted form of a plane called the Q-2, which sat high above the group with its wings outspread like a protective mother hawk.

The metaphor is apt; the EAA itself is a broad, encompassing support group, encouraging its members by providing expert advice on the use of aluminum, fiber glass and fabric, and counseling on the building of everything from VariEzes to Pietenpols to Q-2s. Three chapter members once pitched in to help Moore complete an eight-hour fiber glass job.

"Home-builders are innovative," Moore said. "Every day they have to figure out how to do something." Often it's simply where to work. "I'd give anything for a three-car garage," said a member who was building a thirteen-meter sailplane in a space more suited to two Toyotas. Ingenuity in using all available space runs rampant among these people; when I wandered out to Coughlin's

backyard I found a Revmaster 2100 RD aircraft engine bolted to the garden fence.

This was the hit of the evening. Before the meeting began, most of the members stood in a semicircle in the dark around the engine like participants in a curious ritual. Coughlin, high priest of the machine, called out "Clear prop!" The motor thumped, wheezed and rumbled to life. The men, walking carefully clear of the lighted golden disk of the propeller, moved in and watched Coughlin tinker with controls on an instrument panel also mounted on the fence. The engine, roaring king of the garden, blew leaves off the tree behind it.

"I haven't had any complaints from the neighbors," Coughlin said later. "But I've been a little prudent about when I run it."

Building a plane at home might seem foolhardy to some, but the word prudent applies surprisingly well to these garage aerodynamicists. One of those tinkering with the engine that night was a licensed aircraft mechanic named Dave Dent, who is an official EAA technical counselor. He inspects projects when asked and looks out for dangerous mistakes. Each chapter has at least one counselor, and the system has worked so well—both insurance rates and accident statistics for home-built aircraft are close to those of factory-built planes—that the Federal Aviation Administration recently eased rules requiring step-by-step inspections. Now the FAA inspector only sees the plane once, when, as one inspector said, "it's sitting on the runway waiting to crank up the rubber band and take off.

"We look for good construction techniques and aircraft-quality materials," the inspector went on. He was Del Ott, an inspector for the FAA Flight Standards District Office in Oakland. He said, "We look at things like the welding and ask, 'How did you do that?' If it is assembled in a sanitary manner we let him fly it."

Finally, after all the months or years of work, comes the magic moment when the plane lifts its builder into the sky.

Carlos Amspocker above the Bay Area in his home-built VariEze.

FIRST FLIGHT! ALL THESE MONTHS—ALL these years—this thing has been a heap of foam and a few gallons of epoxy, or a pile of aluminum sheets and steel tubing. Now it looks like an airplane and it roars like an airplane, but it has not yet tested the air. First flight!

Worry about the first flight is one of the reasons that some home-builders say every completed aircraft has a divorce behind it. When I visited one builder in his garage, his wife came out on her way to a dental appointment to tell him that their two boys were napping, and I asked her what she thought of the project. "Don't ask me," she said. "don't ask me." Then she blurted out with a quick laugh: "I'll be glad when it's finished. Then I'll be afraid."

But trepidation does not flutter just the onlookers.

"The first flight is something else," said Carlos Amspocker, a Concord EAA chapter member who has been flying his VariEze for six years. Amspocker flew Sea Furies and Hell Cats for the Marine Corps during World War II, but his first flight in his home-built was special.

"You get out there, you point it down the runway, and you think: What am I doing here? You think: What have I forgotten? Then you put the throttle forward."

The FAA inspector has instructed home-builders on their inaugural flights to take off over the water, to stay clear of all populated areas. "Our responsibility on the first flight," Del Ott said, "is to protect the public." The control tower, if there is one, is attentive to first flights; if there is a fire station on the field, at least one truck is often there waiting for what could happen.

The machine leaps ahead. The engine runs smoothly, the needles in the gauges hold steady. The airspeed indicator climbs to 60. You raise the nose. And the moment of flight, the lift from the gravel to the silk, is as sure as the moment of birth.

When Sasha Munir first flew her VariEze the day was overcast. In case she became flustered she had strapped a written list of instructions to her left leg: "1500 RPM; Fly it in." But the plane she had built was full of grace. It wheeled in the air as if it had been born there. Later she would write in the diary of the years of construction: "Only now and then the dream comes true. It happens." Later she would fly it to the Nut Tree and look at her own plane parked there behind the little fence. But now she just flew. On the radio she could hear the voice of her ground crew telling her that it was time to bring it in to land: "Come back. Come back." But on she flew, borne by wings she herself had fledged and polished. All that sandpaper. All that time. Now the air was hers to command. She just might stay up here forever.

"I thought I was the happiest person who was ever born," she remembered one afternoon in the carpeted hangar, thinking of that time and the good hours that came later. "It is a joy airplane. I'm proud of it. It changed my life. It made me a happy person." □

Boom in Home-Built Craft

63K .20

Kit Planes: Amateur Pilots' Dream Ships

By LEE DYE, *Times Science Writer*

Lots of folks couldn't believe heir eyes when Larry Lam's sleek irplane suddenly appeared in the riveway in front of his Palos 'erdes home.

After 11 years, the retired aero-autical engineer was ready to see the plane he had designed and uilt inside his garage would fly. ike thousands of others in a rowing national movement, Lam ad built the plane with his own ands, and he was ready to realize a ilot's dream of flying his own reation.

But it had been a long, long 11 ears.

"My family was really glad to see go," Lam said.

And when it rolled out of his arage, his neighbors stood in awe.

"We collected a crowd in a urry," said Buck Buchanan, a pilot ho had agreed to test fly Lam's ane, called the Wanderer.

Brief Test Flight

The plane was hauled aboard a ailer and carted to an airport at hino, and a few hours later it eared briefly on a six-minute test ght, proving that it was of sound eronautical design, although ightly underpowered.

Lam was near tears when he yfully showed a videotape of that rst flight to other pilots at the onthly meeting of the Torrance apter of the Experimental Air-aft Assn. He is shopping now for more powerful engine, and he pects soon to realize the full wards of spending 11 years inside s garage.

Would he do it again?

"Of course," he said. "Now my n wants one."

Lam's story is no isolated case. ost of the small, private aircraft built in the United States this year will emerge from garages in suburban residential neighborhoods, not from the assembly lines of the nation's airplane manufacturers.

The trend has been spurred partly by economics. The price of commercially manufactured single-engine planes has soared out of the reach of most private pilots, plunging demand to the point that many companies have at least temporarily suspended building single-engine planes.

Out of the Business

Cessna Aircraft Co. of Wichita, Kan., which built the ubiquitous Cessnas that blanket general aviation airports across the land, "got out of the single engine plane business" on June 1, according to company spokesman Dean Humphrey. The firm has indicated that it may resume manufacturing sometime after 1987, but that is open to question.

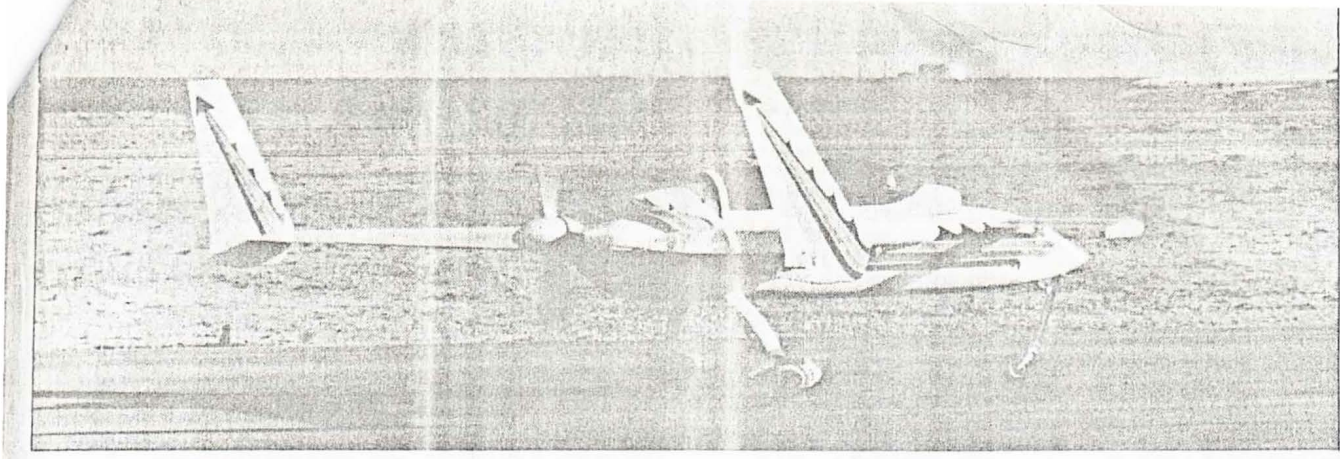
"In the late 1970s, we were selling nearly 9,000 a year," Humphrey said. That number plunged to 640 last year.

The commercial manufacturers have blamed their woes largely on the high cost of product liability insurance, which they claim has doubled the price of their planes.

Cessna's smallest plane, the two-passenger Cessna 152, sold for around $40,000 with basic avionics gear in 1985, the last year it was manufactured. Although some small planes are still being built commercially, the cost usually runs substantially more than $100,000, and some sell for as high as $350,000.

That, in turn, has added to a boom that was already under way'

Please see KITS, Page 3



GEORGE R. FRY / Los Angeles Times

A Long-EZ, a challenging home-built, taxies out for takeoff; below, Ron Schroeder works on a similar plane in his Torrance garage.

KITS: Planes Give Pilots a Special Thrill

Continued from Page 1

among the craftsmen who have turned to their talents more than to their pocketbooks.

"You can build your own airplane, a nice plane, for between $5,000 and $10,000," said John Burton of the Experimental Aircraft Assn. of Oshkosh, Wis.

But it is so time consuming that only a small percentage of those who start actually finish, according to amateur aircraft builders. And the successful ones all seem to have one thing in common: They enjoy building as much as they enjoy flying.

"You can't do it just because you want the airplane," said Ron Schroeder of Torrance. "You will never get through it."

Schroeder is building a Long-EZ designed by Burt Rutan, the innovative designer who created the Voyager aircraft that two pilots hope to fly around the world without stopping and without refueling. The Long-EZ is one of the most challenging of the home-builts, but those who complete the task end up with a plane that will cruise at 180 m.p.h. while burning less gas than a compact automobile.

Airborne Sports Cars

That high performance is one of the reasons that more and more pilots are turning to home-builts. These small, extremely maneuverable planes are like airborne sport cars. The price one pays for that performance is in the payload. Many of them are single seaters, and few carry more than two persons with about 35 pounds of baggage.

In recent years the Federal Aviation Administration has streamlined its certification process, making it far easier for amateurs to get an "airworthiness certificate" that allows them to fly their home-built airplanes. Prior to 1983, the FAA conducted "progressive inspections" at various stages during construction, but now the agency inspects only the final product.

"We won't look at it until it's done," said H. E. (Bud) Martell, manager of the FAA's manufacturing inspection district office in Van Nuys.

When it does finally inspect the plane, the FAA looks only at the quality of workmanship, not the design, Martell said.

"If he's got something that doesn't look like a wing, and he wants to try it, we'll let him," he said.

The FAA's regulations were designed to protect people on the ground, not the people who build their own airplanes, according to pilots interviewed for this story.

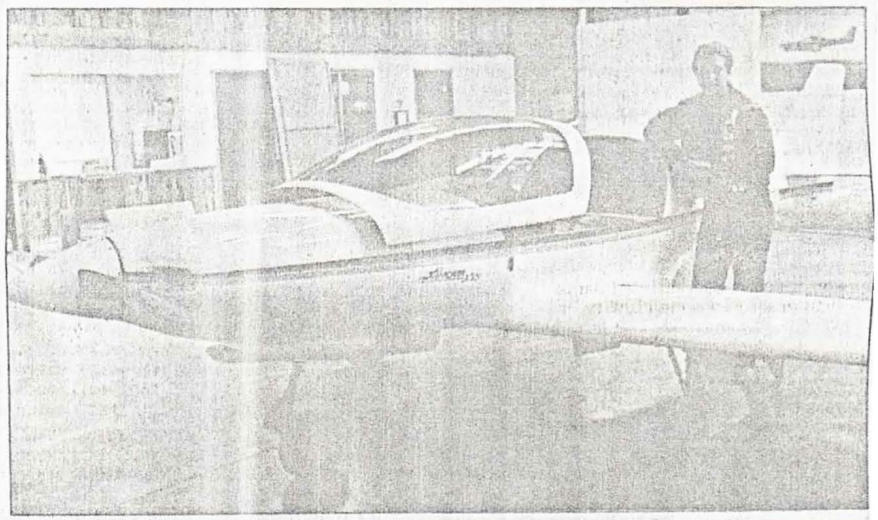
Freedom to Try

Martell added that the FAA does not "try to suppress" amateur builders.

"Our attitude is 'if you think that is good, try it,' " he said. "That's the only way this aviation business is going to grow."

If the FAA inspector is satisfied with the quality of workmanship, he will issue a "special airworthiness certificate" that allows the plane

LEE DYE / Los Angeles Times



LEE DYE / Los Angeles Times

Lance Neibauer stands beside a Lancair, which he sells as a kit from his small factory.

1985, an increase of about 9% in only two years. Last year, 117 amateur-built planes were registered in the area covered by the Van Nuys FAA office, which extends north from the San Fernando Valley to the Oregon border.

That number is expected to grow tremendously this year in the wake of an amateur building craze that may be without precedent in the history of aviation.

The growth is so great that the largest

official publication of the Experimental Aircraft Assn.

"We sold 40 kits in the first three weeks," Neibauer said in an interview in his hangar on the edge of the Santa Paula airport.

He said he has already sold 175 kits, of which 115 have been delivered.

This has been accomplished even though the kits have been in production for such a brief time that no one has completed one yet.

He has customers in six nations on three

KITS: Home-Built Dreams Take to Air

Continued from Page 3

cannot enforce. It takes about 1,000 hours to assemble a kit such as the Lancair, although all the major structural components are supplied in the kit, and Neibauer has a letter from the FAA stating that buyers can be licensed if they assemble the kit.

Neibauer admits the FAA is being lenient in its interpretation of the "51% rule," but he says it is essential if general aviation is going to survive.

"The entry level has dried up with production aircraft," he said.

For many pilots, he and others said, building their own planes may be the only way to fly.

They are aided in that effort by the availability of a wide range of sophisticated materials that have led to a new generation of sleek, high performance planes. Most kits consist primarily of premolded fiberglass parts that are either joined to form the main structure, as with the Lancair, or fitted over a homemade wooden skeleton, as with the popular KR2, manufactured by Rand Robinson Engineering of Huntington Beach.

The KR2 was designed by Ken Rand and Stuart Robinson while both were working as flight test engineers at McDonnell Douglas.

"We think there are well over 1,000 KRs flying," said Jeanette Rand, president of Rand Robinson.

The KR is at the lower end of the market in terms of price. The kit sells for about $4,000, but that does not include the motor or instruments. The plane is powered by a Volkswagen engine, which has been re-engineered for aeronautical use.

Equipped with the barest instruments, she said, the completed plane runs around $10,000, considerably less than half the cost of a Lancair. Full instrumentation, however, can push the cost much higher.

Amateur builders claim that anyone with reasonable skills and a few ordinary tools can build their own plane from a kit.

"It's about the same complexity of a model airplane kit," said Kevin Kelley, an architect who now works at Rand Robinson, "except you tend to pay more attention to the plans."

The degree of the difficulty depends largely on the type of aircraft. There are fewer and fewer pioneers such as Larry Lam these days, because most builders shy away from designing their own plane and go with a kit instead.

Amateur builders generally get high marks for safety, although crash statistics for home-built planes are not readily available.

"Most of the people who build are going to fly in it," said the FAA's Martell. "They're pretty sincere."

He said he has seen no evidence that home-built planes are inherently unsafe, and several amateur builders noted that their liability insurance is about the same for their homemade planes as it is for similar production aircraft, indicating that the insurance industry has no problem with safety.

The FAA does not require any safety equipment aboard home-builts that is not required for production aircraft. The requirements are based on the use of the aircraft. For example, certain instruments are required in order to fly in controlled air spaces and the

at air shows along the way. He was almost home when he ran into a fierce snowstorm over the San Gabriel Mountains.

He was descending through the storm when his engine failed, his wife, Jeanette, recalled. Rand, a veteran test pilot, was killed in the crash.

According to news accounts at the time, his last words were: "I'm going to hit."

Hundreds of others, however, have picked up where Rand left off, and a few of his planes can be found at nearly any air show.

What all the builders seem to have in common is a desire to create something really special.

"You have to have a love of flying and a love of building," said Kelley of Rand Robinson.

"I can't ever remember not wanting to build my own plane," said Schroeder, who is president of the Torrance chapter of the Experimental Aircraft Assn.

Those who have done it say that there is little in life that rivals the sensation of soaring above the Earth in their own creation.

"I was too busy [on] my first flight to get very emotional," said Neibauer, describing the maiden journey of the Lancair. "The second flight, after you're sure the engine isn't going to fly off, you can relax. Then it really sinks in.

"I still get that feeling, looking out the window at the wings I made, and the ground so far below. It's pretty special."

PROBE: Parks Chief Accuse

Continued from Page 3

subject of race into Deukmejian's campaign for reelection against his Democratic rival, Los Angeles Mayor Tom Bradley.

While the black mayor recently said his color should not be a "hidden issue" in the campaign, Deukmejian has repeatedly refused to discuss the role that race may play in voters' minds Nov. 4.

The Equal Employment Opportunity Commission began looking into the charges against Briner more than a year ago after Silvester Widemon, a former deputy director of the Department of Parks and Recreation, alleged that Briner had harassed her into quitting her job. Its findings are based largely on confidential interviews with department employees.

"The commission concludes there is reasonable cause to believe that charging party [Widemon] was subjected to harassment . . . because of her race and sex," according to the agency report completed in September.

The commission also said: "Witnesses state that the director openly and routinely used racist and sexist terms when referring to minorities and women. These terms included nigger, spearchucker, nip, broad, wop and spic. He also made other discriminatory jokes and statements and is said to have referred to the charging party [Widemon] as 'it.' "

Commission officials would not discuss the findings but said the agency is seeking to settle the case with Briner. Forms the settlement might take include reinstating Widemon or awarding her a sum of money. If a successful settlement cannot be reached, the commission is prepared to take Briner to court.

Briner has long been followed by charges of racism. In 1984, the Senate Rules Committee delayed his confirmat
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Fetus, Removed From Womb for Oper

From Times Wire Services

SAN FRANCISCO—Pediatric surgeons here took a 23-week-old human fetus out of his mother's womb to perform critical surgery that saved the unborn baby.

Baby Mitchell was born normally in a Caesarean section at a Texas hospital near his parents' home nine weeks after the 1985 surgery to correct a blocked urinary tract. His case marks the longest time a baby has survived after such an operation before birth, doctors said.

The same surgical team at the University of California, San Francisco, had performed similar surgery twice before. In one case, the infant died nine hours after birth because of kidney and lung damage suffered before the operation could be performed; in the other, the baby died six months later as a result of complications from an unrelated birth defect.

"It took ye
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Dr. Michael R
surgeon who
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Harrison p
Baby Mitchell
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BOOKS

63R .15

A celebration of design: Voyager, nautilus, the Veterans Memorial, the periodic table

by Philip Morrison

THE COMPLETE GUIDE TO RUTAN AIRCRAFT, by Don and Julia Downie. Third edition. Tab Books Inc. (paperbound, $14.95). **VOYAGER,** by Jeana Yeager and Dick Rutan, with Phil Patton. Alfred A. Knopf, Inc. ($19.95).

During World War II the Navy trained many young pilots out on the glaciated flatlands near Oshkosh, Wis. The vast airfield they left behind is now host every August to 15,000 aircraft and three-fourths of a million people, who gather for the world's largest aviation meet. It is not for the supersonic fighters or the jet transports the truest devotees have come; this is the Fly-In Convention of the Experimental Aircraft Association. The somewhat eclectic EAA has 100,000 members throughout the world. It remains at heart the expression of those remarkable amateurs, most of them linked in some other way with the aviation industry, who fly aircraft they have built themselves. Some 700 of those creations are certified yearly by the FAA to fly at large, a third or more of all new U.S. light aircraft.

Most of the homebuilts are slowly and carefully constructed from designs, some even from kits of parts, for prototypes that were first seen and admired at Oshkosh. The engineers and designers who conceive and produce the planes are a small group of professional innovators. These two books sum up the remarkable work of one such man, Burt Rutan (an original even among such originals), and his gifted coterie. The guide is a knowing and personal introduction to the long, demanding work in the shop and to flight itself. It is a homebuilder's look at the Rutan way. (To build a flyable aircraft at home requires a few thousand hours of work and $10,000 to $20,000 for engines and equipment; it is easy to understand that many more are begun than are in fact completed.)

The second book, a candid account of adventure and despair, meant for general readers, sets out years of single-minded effort and one week aloft in danger and aching sacrifice by the pilot couple, Jeana Yeager and Dick Rutan. At the end of 1986 they filled up the tanks of Burt Rutan's most famous design, the one-of-a-kind *Voyager,* and in nine nonstop days flew it out and back around the bulge of the world.

Voyager is much the largest of some 10 Rutan Aircraft Factory designs; all of them share family traits. They are built of composites, white, sleek and slender. This is not the old way of canvas stretched taut over spruce, nor the sturdy but intricate structures of Rosie the Riveter, a bucket of rivets, bent metal sheet, spars of forged aluminum. Layers of woven fibers, glass, graphite and aramid polymers are bound into a single immobile yet forgiving structure by the right mixture of epoxy resin polymer and its hardeners. Cores of foamed urethane shaped by hand tools give form to the light, strong skins of wings and tanks and fuselage. The scales control every part; tyros make heavy sections, and then learn to remake them. The homebuilder and the FAA inspector alike can see through the translucent forms to check the layers of lay-up and matrix.

Apt Rutan aerodynamics go with the new materials. Most of these craft are pushers; instead of a tail they have small canard wings in front of the main airfoil. The arrangement confers simple control, efficient low-drag flight and virtual immunity to stalling. These birds have no tail to drag. (A few pages by Burt Rutan give a clear, qualitative account of how all this happens.)

On top of his Dodge, Burt Rutan carries well-instrumented models. His rather low-speed wind tunnel is as long as the faster highways of southern California after midnight. Inspired designer though he is, at 44 he is no amateur but a trained aero engineer and a fine pilot. Burt's brother, Dick, a few years older, is a virtuoso test pilot, strong-minded veteran of 100 fighter missions against the little MiG's over Vietnam, and for years a record setter in one after another of Burt's prototypes. Jeana Yeager, Dick's partner, copilot and coauthor—their book is written in short passages first for one voice and then for the other—is equally skilled and sharply defined in character. Big *Voyager* was built out of just 11 sketches by Burt, and plenty of printout from his PC; Jeana created all the formal drawings from that material.

This group raised and spent a million dollars the hard way, without compromise of personal principles. They would accept neither foreign corporate sponsors, cigarette manufacturers nor any who set excessive constraints on their design, materials or route. Volunteer professionals of many specialties and a large number of individual donations complemented the well-known avionics firm, the fuel and lube supplier, an audio firm and a few others who took a chance with expensive equipment or with money.

The round-the-world plane realized the famous old flight-range formula of Louis Breguet. Long range means large lift-to-drag ratio, big fuel load for low structural weight, and high efficiency of prop and engine. "If the *Voyager* was easy to fly, Burt didn't do his job right." Stiff, pitching steadily, controls ineffectual, comfortless and crowded, *Voyager* gave up everything to haul fuel with low drag and minimal weight. But it did the pilots' joint will: after a heavy, dragging takeoff (during which wingtip fittings rubbed off on the runway), *Voyager* circumnavigated against unfavorable weather, returning to Edwards Air Force Base with 2 percent of the fuel it had carried off the two-mile runway.

The chief design deficiency seems to have been the complicated fuel plumbing, a little of it misrouted. Two engines fed by 17 tanks—gas was stored in every volume not otherwise filled—meant that the flight crew lost track of fuel use in spite of their elaborate routines to log and interpret the minimal gauges. These fliers were never free; the radio link to the Mojave was a bond tighter than they liked, but indispensable. The drama of technical brilliance and personal adventure, sociology and

character, is honestly played against the looming backdrop of a powerful paramilitary industry, itself the gainer from the work.

Dick presents one unexpected insight. "All of Burt's airplane designs have been...an extension of his fascination with building model airplanes.... The legacy of modeling is physically visible.... The methods live on...in the stage of design after the plans are drawn, the period of 'tweaking,' the 'cut and fit' method that only composites make possible. Burt always wanted...the same control over the design as model airplane building afforded.... Sometimes he was in love with the design...to the exclusion of market considerations." We hear snatches of an old tune; this is the tale of an artist and his trusting, daring friends.

THE NATURAL HISTORY OF NAUTILUS, by Peter Douglas Ward. Allen & Unwin, Inc. ($34.95).

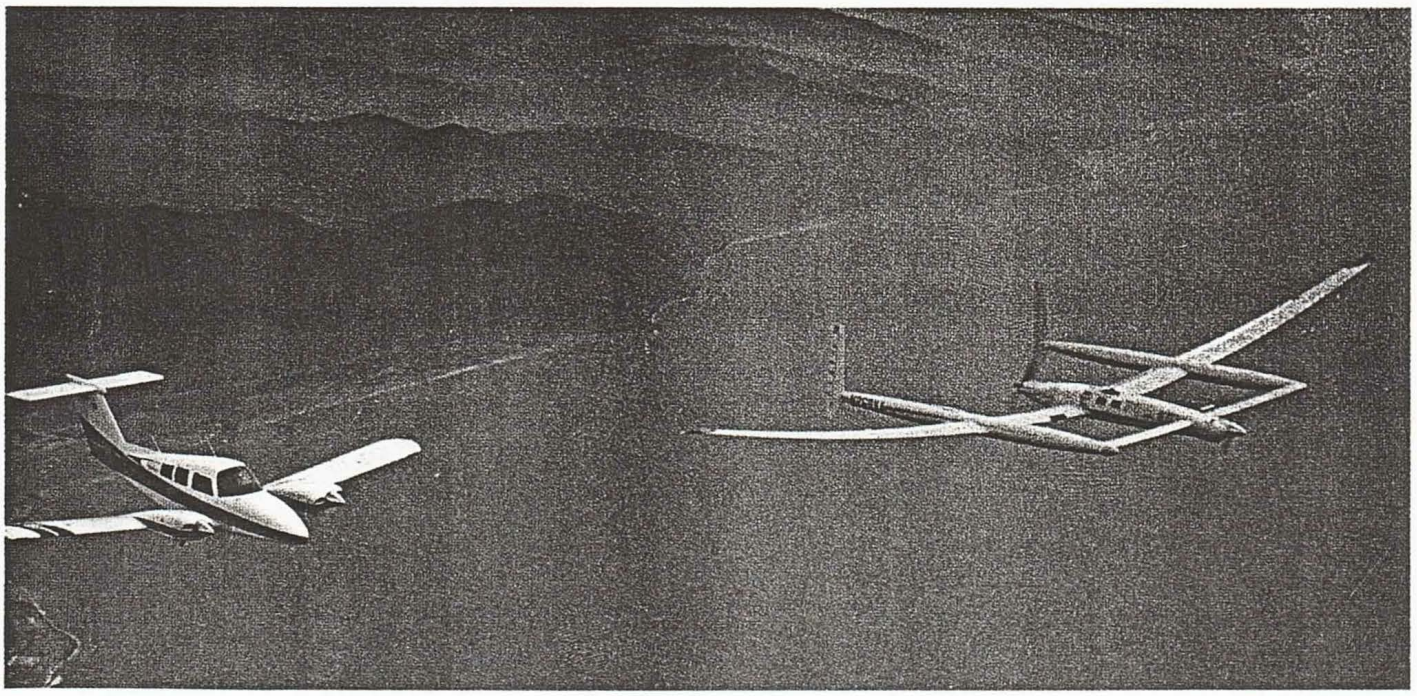
The chambered nautilus is found here and there over a wide stretch of ocean, from the Andaman Islands westward to Fiji and beyond, and from Japan south to New Caledonia. Once their kind were the masters of the ancient seas: 10,000 species and more are found in the fossil record. Now there are extant only five, quite similar species of this, the last of the shelled cephalopods. Creatures of the middle depths, they live between 150 and 400 meters down, usually along the undersea slopes of some steep coral forereef, in a band a couple of kilometers wide out from the coral shore.

This book is the work of Peter Douglas Ward, a paleontologist who has taken a field trip in time; he has gone to the modern ocean to follow living examples of the ammonite fossils he seeks to understand. His own studies and those of others conducted over some two decades have brought a certain understanding of this remarkable survivor, whose way of life is now unique. Most of what is described is recent work, documented here with graphs and photographs. There are imploded shells and X rays of air-filled chambers. There are closeups and diagrams. One illustration shows the eyes, tongue and beaky jaw of this strange pedigreed head, from which sprout about 90 tentacles, sensory, grasping and reproductive.

These beautiful animals are rare in warm surface waters; night scuba dives on the reef fringe will disclose them. For several years nautiluses have been kept for observation in aquariums, such as the one at Noumea in New Caledonia. Even more recently Ward and others have tracked nautilus individuals in the wild for as long as a week. The surface trackers "began to appreciate the problems of anti-submarine warfare." Graphs map the vertical position of a few animals followed around the steep walls of the reef of Palau, running deep by day, shallower at night, possibly deep again at the full of the moon. Telemetry enabled the investigators to track the animals. A small ultrasonic transmitter affixed to the shell, drawing power from a tiny lithium battery, encoded the pressure readings of a strain gauge and pulsed them up for two weeks from the submarine depths to alert hydrophones above.

The eight-inch-diameter nautilus forages vigorously over hundreds of kilometers, covering a few kilometers a day. It can rise and dive swiftly, nearly vertically at a rate of a couple of meters per minute. It appears to dwell in the cool waters below the reef system, taking live hermit crabs from the deep slopes for food, and scavenging as well. Its enemies are not well known; there are big reef fish with jaws powerful enough to take the nautilus. The beast propels itself by a flexible siphon that can point in almost any direction. Swimming with head trailing is fastest. In this mode the nautilus's graceful rounded shell experiences minimal drag; it is also shaped and aligned to minimize pinwheeling, induced by the strong pulses of the off-center jet. Most fossil forms must have been far poorer and less stable swimmers.

This living submarine has a hard protective shell, an elegant pressure hull that fails by implosion at a pressure depth of some 70 atmospheres, below the working range of many a steel submarine. This hull is a complex interlayered composite of horny protein bolstered with calcareous microneedles. The lovely chambers are fully or partly air-filled; the X-ray pictures prove it. A complicated tube



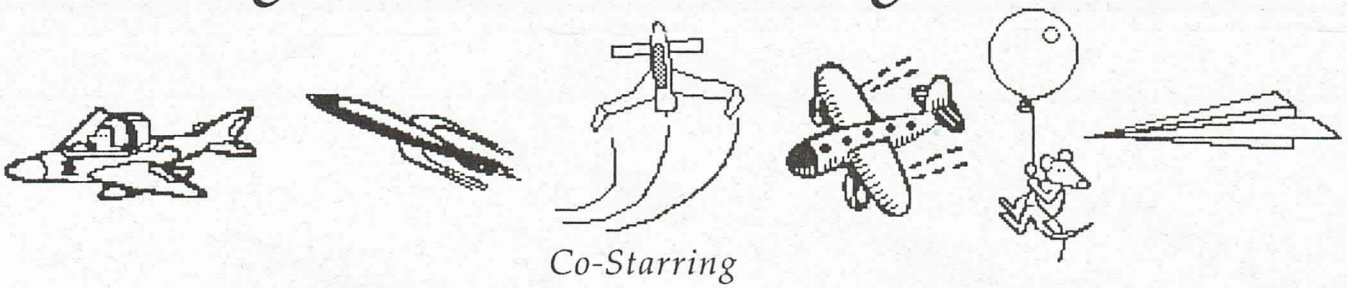
Beginning its world flight, Voyager *leaves California behind*

U R Invited 2

Burt Rutan's

BIG FIVE-ZERO

Fly-In Birthday Bash



Co-Starring

Burt's Grandson **Eli** (3), Burt's Brother **Dick** (Calif. speed limit),
Burt's Brother's fiance **Kris** (Priceless & Ageless).

"Studies have proven that people who have more birthdays, live longer."

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or Call Tonya (805) 948-7617, *or* Kaye (805) 824-4541 *or* Fax Kelly (805) 824-9575

The Good Times Roll at 10 a.m.
See ya there!

Saturday, July 10, 1993

Mojave Airport

Hangar 78

Mojave California

REASONS TO COME TO BURT:

* Even if you didn't get the egg from Burt or hatch it yourself, nobody can tell, Mojave is a public airport, come ahead and celebrate the master duck maker who bred this brood and !!!
* Meet up with a whole bunch of odd ducks!(80 canards last time)
* If you are flying a clone, there will be a lot of those too!
* If a Defiant, Central States now has record of 4 in one place!
* If a Cozy, you know Burt had to be at the duckling stage!
* Pot luck is always a good way to eat better than you bring!
* If you are still building, you are behind and need incentive!
* If you are wondering, come and see these lovely swans!
* If you are cheap, there ain't no closer, better fly-in!
* It is only one day in the sun!
* Burt may show us some new projects!

Reasons not to come:

* Mow the weeds, take out the trash, paint the mail box.
* Unsafe, lost medical, don't like airplane noise.
* Don't own a hat, sun tan lotion.
* Bachelor who can't find deli counter or soft drinks.

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AeroElectric Connection

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In 1986, I had worked in general aviation nearly 25 years before my first visit to Oshkosh, the Mecca of aviation. I was taking advantage of an invitation from good friends Bill and Celesta Bainbridge, Newton, Kansas, who own and operate B & C Specialty Products. I had done design work for Bill on system components for Voyager; a fine example of what a few dedicated individuals can accomplish with support from interested believers. However, Oshkosh was a mind-boggling revelation from the opposite end of the amateur built airplane spectrum. Before OSH '86, my impression of amateur built aircraft lingered from 1965 when local EAA member, Dick Guide, flew his VW powered Headwind into Cessna Field on a Saturday morning. All the overtime engineering people turned out to see his little airplane *(It certainly was cute. However, we were all seriously involved in the production of "real" airplanes!).* In stark contrast, twenty one years later, the airplanes I saw at OSH were fine specimens of leading edge aviation design and technology.

I learned something else at Oshkosh: While working with Bill's customers in his booth, I observed that things electrical seemed to be the least understood of all aircraft systems. After some deliberation I realized that two most personal tasks of building an airplane are choosing a paint scheme and designing an electrical system! Other aspects are fixed by airframe design. However, the box of "tinker toys" from which one selects electrical system components is huge!

For some builders, duplicating a system from a "cookbook" is sufficient. However, a very personalized, fully equipped, knob-twister's delight is not an uncommon sight at Oshkosh! Further, many builders wish to take advantage of new technology as it becomes available, generally yielding more performance at equal or lower cost; a nearly non-existent option for most owners of certified iron. On the way home that year, I began outlining a way to bring benefits of modern systems components and design philosophies within practical reach of the amateur airplane builder and maintainer.

First, it had to be more than a book. Books are static things bound between hard covers; once printed they cannot change. Further, if books alone would do the job, schools and universities would be extraneous. It should foster UNDERSTANDING and last, it had to be RELEVANT to reader's needs. Working within these requirements, the AeroElectric Connection was conceived. The AeroElectric Connection is an information service, now 6 years old and 500 readers strong. The printed portion looks like a book but it's published in a 3-ring, loose leaf binder format permitting periodic updates. Presently, thirteen chapters cover d.c. fundamentals, batteries, regulators, alternators, over-voltage protection, grounding, circuit protection, electrical instrumentation, switches and contactors, wire, wire termination, antennas and feedlines, and lighting. Appendix A lists vendors of services plus new, used and surplus components of interest to builders. Another appendix contains do-it-yourself avionics projects which may be scratch-built, kit-built or purchased assembled and tested. An expanding group of power distribution diagrams describe several design philosophies unique to plastic and metal airplanes. Chapters are being planned and written on systems instrumentation, motors, audio and transmitter control systems, custom wirebook development, failure mode effects analysis and electrical noise management.

Perhaps most important is the consulting service. Since we cannot all sit down in a classroom together, questions are answered by active dialog with readers. Over the years I've become dependent upon reader contact to guide my writing; it is impossible to answer questions when you don't know what they are! While most of the words presently contained in the 'Connection's pages are my own, it is not intended to be a gospel according to Bob Nuckolls; alternate views and concepts are welcome. Conversation and letters with readers has strongly influenced directions taken by the 'Connection. The 'Connection is intended to be a repository for good information gathered for the benefit of all.

The 'Connection fills a gap between "cookbooks" and engineering texts; not light reading, but it is fun. We don't get into discussions of sub-atomic particles but we do take things apart far enough to have an idea about how they work. The style is conversational and I often use anecdotes from my experience in Wichita aircraft manufacturing. From time to time, "Hot Flashes" (newsletters) are mailed when important subjects must be addressed between regular issues of the 'Connection.

Material currently in print, including all past newsletters, totals about 270 well illustrated pages. $42.00 ($54.00 overseas) gets a new subscriber all materials in print, a subscription for the next regular issue of new chapters plus all intermediate newsletters. Overseas airmail is extra. Calls to (316) 685-8617, Compuserve E-mail at 72770,552, or letters to The AeroElectric Connection, 6936 Bainbridge Road, Wichita, Kansas, 67226-1008 are always welcome. Bank cards accepted.

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About the AeroElectric Connection

Real Time Consulting Service: Subscribers are encouraged to write or call with questions or comments. Without *your* participation, we don't know what to write about!

Newsletters: Hot Flashes from the AeroElectric Connection are mailed periodically to cover timely topics and error correction in other printed materials. When the book is finished, the newsletters will step up to a quarterly publication rate.

The Book: Materials in print now totals about 200 pages with *lots of illustrations*. The book is 3-ring, loose leaf binder format to permit timely update of information. Unlike books nailed between hard covers which cannot change, the 'Connection is a dynamic work which grows with new technology and our collective experiences. Chapters presently cover:

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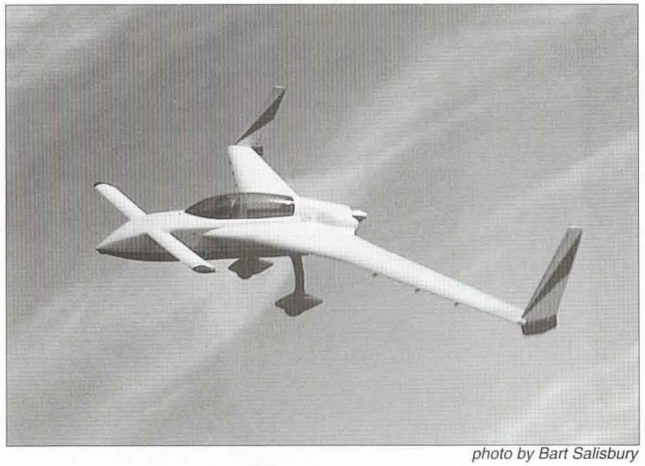
THE LOOK OF THE AIRSHOW OF THE FUTURE



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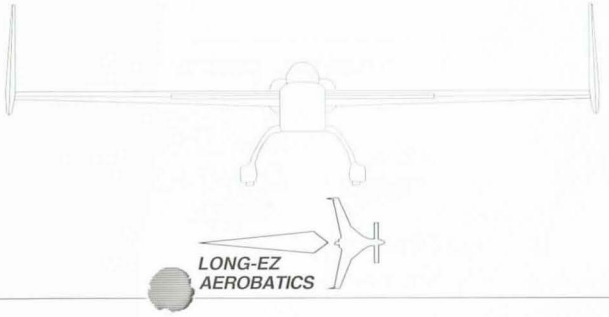

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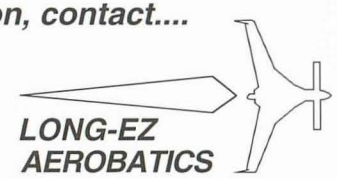

THE PILOT

Tom Staggs combines the grace he learned flying sailplanes and the skills he earned as a U.S. Navy carrier pilot. With over 2,000 flight hours, Tom has the proven ability to make any plane perform to its limits.

When not flying the Long-EZ , Tom is a Marketing Manager at AlliedSignal's Bendix/King Avionics.

photo by Bart Salisbury

THE PLANE

Wing Span	26'1"	7.95m
Length	16'9"	5.10m
Height	7'11"	2.41m
Normal Cruise	170 kts	318 kmh
Max. Speed:	200 kts	378 kmh
G-limits	+5/-2	
Weight (empty)	1000 lbs	454 kg
Weight (max)	1800 lbs	818 kg
Fuel	48 gals	181 ltr
Max Range	1000 nm	1840 km
Engine	177 h.p. Lycoming O-320