DELTA

THE HANG GLIDING HANDBOOK

JEAN-BERNARD DESFAYES

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HASSNER

FOREWORD

When, in 1948, he first filed for the patent that bears his name, Francis Melvin Rogallo was perhaps not aware that he was about to make a decisive contribution toward the realization of one of the oldest dreams of mankind: that of flying. Flying with one's own wings...

The passenger in today's airliner is not flying: he is traveling. The pilot sitting at the controls of some monstrous machine is not flying; he is watching his instruments and doing his best to ensure the comfort of the voyagers in his craft. The aviator and the glider pilot taking to the airs in more and more perfected, rapid and complicated vehicles are not really flying; their pleasure in doing so is hampered by more and more severe regulations.

In this respect, Rogallo has upset hierarchy: he has given the skies to a legion of enthusiasts who previously could only look up at them with longing from below. He has revealed their true beauty to others who had only experienced it from within the narrow confines of a cockpit. He has made them accessible to those countless numbers hardly predisposed to emulate Icarus but who, one day, in the California dunes or in the French or Swiss Alps, fell in love with his strange machine.

The meteoric success of the delta wing - an obvious tribute to the near-perfection achieved in the original plans - and the

enthusiastic reactions that it provokes wherever it appears have incited the authors, at first through curiosity, then through conviction, to examine the phenomenon at first hand. And what one discovers can be, depending upon the point of view, stunning or alarming!

There is the foolhardy madcap who, for his first flight and for the first flight of his glider, will launch himself from some mountaintop at over 2000 meters (6600 feet), confident that he will learn how to fly on his way down.

There is, on the other hand, the thoughtful, prudent fellow, progressing stage by stage, trying out all the various types of gliders, whose scrupulous carefulness borders on mania. No accidents for him!

There is the joker who, one day, for a laugh, drops a dummy over the heads of a crowd to give them a thrill.

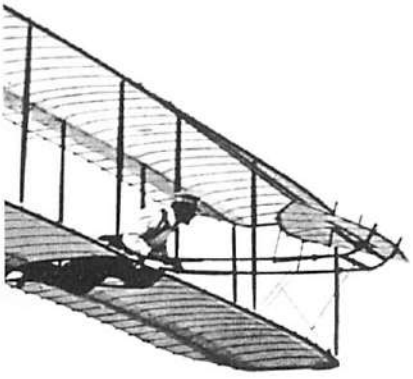
There is the fanatically enthusiastic mechanic who sells his garage to follow his calling, in other words to make hang glider instruction his main livelihood.

One could continue at length the list of authentic "exploits" performed daily within the small, ebullient hang glider community.

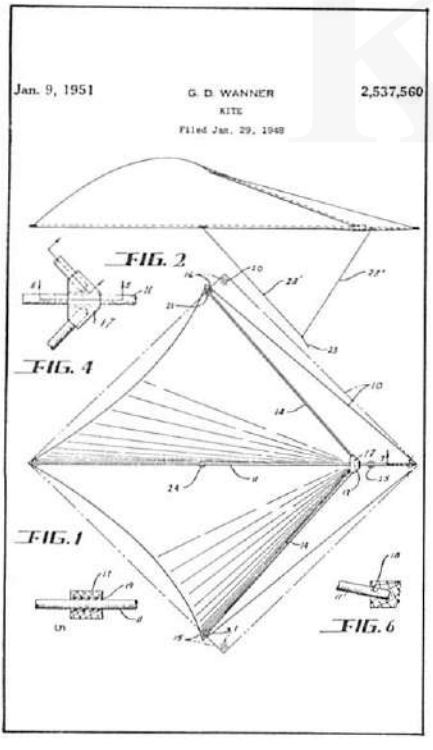
But why write a book about them? For quite a few good reasons. The first one is that there are not many books treating the question. Whereas the countless number of serious mistakes committed every day on mountain slopes or on beaches may indeed be due to recklessness, but in the main they are due to an almost total lack of knowledge of the elementary laws and principles of aerodynamics and meteorology. The rashness of these suicide candidates is linked to ignorance and nothing else.

Another reason: the need for a simple but clear explanation of how a glider is used, how it is built, assembled and tested. In this sense, this book should fill a gap.

Those readers who might not feel particularly inclined to hang from a few aluminum tubes and a few square meters of nylon



Wilbur Wright (in photo) and his brother Orville testing the glide flight craft which they subsequently successfully motorized.



In January 1948, some ten months ahead of Rogallo, an American by the name of Wanner filed for a patent for a kite whose shape is not unlike classic delta wings. This inventor's name was not to be retained by posterity.

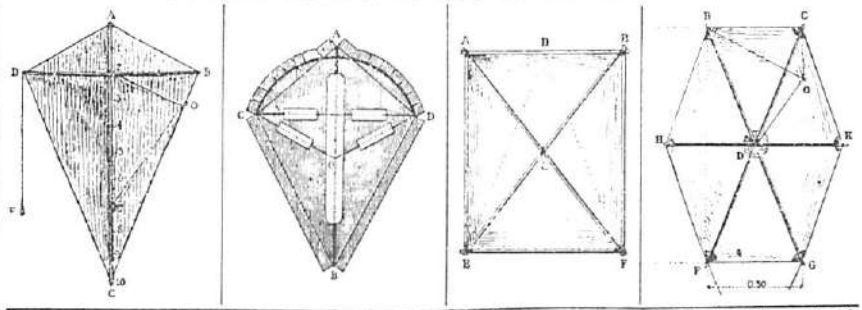
glider, is the American Samuel Pierpont Langley, the astronomer and director of the famous Smithsonian Institute. His unfortunate experiments over the Potomac in Washington made him the laughing stock of both public and press. But if we mention him here, it is because he allows us to bridge the gap between the works of the end of the nineteenth century and those of the second half of the twentieth. How? Simply because it was in the research center that bears his name, the Langley Research Center, that the limp wing was born, thanks to a highly gifted aerodynamics technician, Francis Melvin Rogallo, and his wife.

At this point, before starting the chapter devoted to contemporary research, the more or less informed reader may be terrified by this long enumeration of dramas and accidents of all kinds that have marred the history of the conquest of the skies. Need we mention in this connection that the beginnings of aviation were undertaken under conditions that are in no manner comparable to those prevailing today? The materials employed were far from the "Airworthy" quality that is a rule at present. And piloting in an environment that was still hostile - the air - was carried out according to studies and knowledge that were largely based on rule of thumb methods. In all these areas, progress since then has been gigantic, even if there is still room for improvement in certain respects.

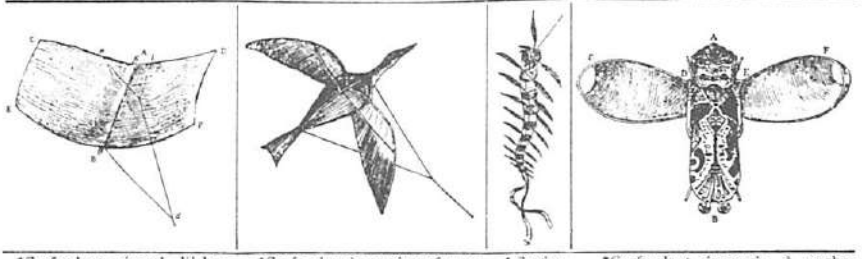
ROGALLO'S OBJECTIVE

Rogallo's objective was quite different from that of the "Skysurfers" that the enthusiasts of his delta wing have become today: he was trying to devise a wing that would be the least cumbersome possible when folded along the sides of craft that were to be recovered, that is, during the launching and their actual flight; an airfoil

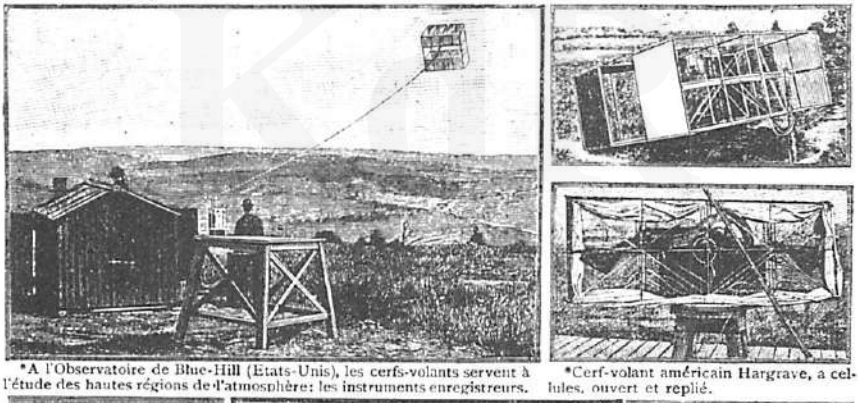
LE CERF-VOLANT. LE JEU ET LA SCIENCE



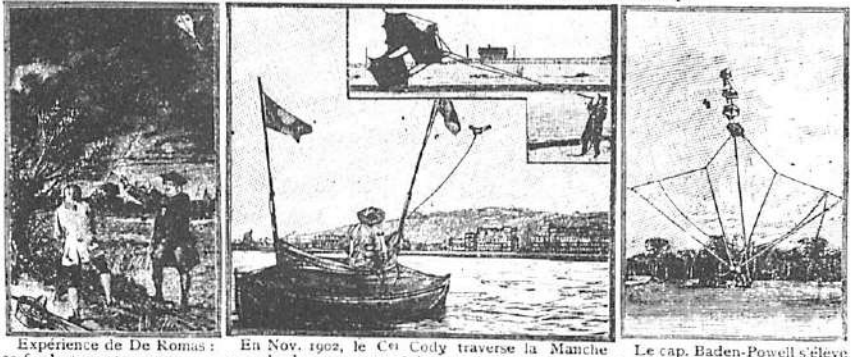
*Cerf-volant Esterlin, en roseau et osier très stable. *Cerf-volant allongé, dit en *foire*, en châtaignier aminci. *Cerf-volant rectangulaire, russe, à baguettes. *Cerf-volant polygonal, américain, hexagone irrégulier.



*Cerf-volant oriental, dièdre, avec bambou et vergues. *Cerf-volant japonais, en forme d'oiseau, en bambou fendu. *Cerf-volant chinois. *Cerf-volant japonais, à poches trouées, en bambou fendu.



*A l'Observatoire de Blue-Hill (Etats-Unis), les cerfs-volants servent à l'étude des hautes régions de l'atmosphère: les instruments enregistreurs. *Cerf-volant américain Hargrave, à cellules, ouvert et replié.



Expérience de De Romas : cerf-volant paratonnerre. En Nov. 1902, le Cel Cody traverse la Manche en 12 h. dans un canot tiré par un cerf-volant. Le cap. Baden-Powell s'élève à une hauteur de 90 mètres.

Fig. 658 à 671.

* Extrait de LECORNU, *Les Cerfs-Volants*. (Hubert, Nouy et Cie, editeurs.

PROVERBE : **Attends, quelque chose adviendra.**

In 1906, the Hachette almanac published under the title "The Kite, The Game and The Science", an article that ended as follows: "Perhaps some day the string will be done away with because the kite will have become the Aeroplane! Man will have found the wings that nature had refused him!"

that could unfold without damage and according to specified, complicated norms at speeds up to Mach 4.9 (or nearly five the times of the speed of sound); a wing that was to slow down the craft (of considerable mass) to speeds under 100 km/h (60 mph) with a coefficient of safety and reliability at least equal to that of the parachute.

March 20, 1951 G. S. ROGALLO ET AL 2,546,076

FLEXIBLE KITE

Filed Nov. 23, 1948

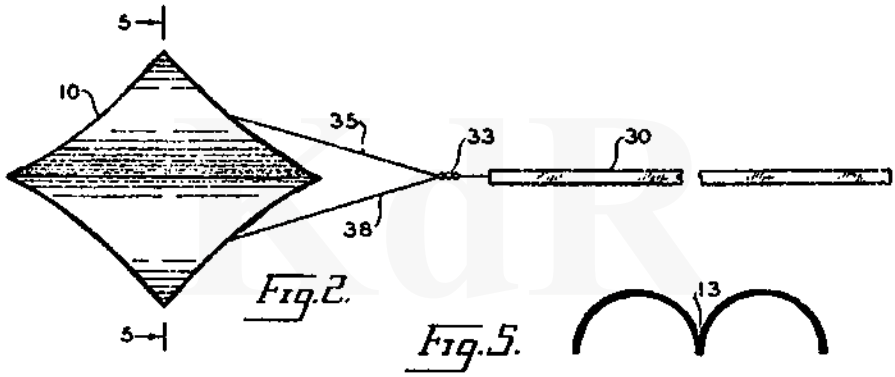


Fig. 2.

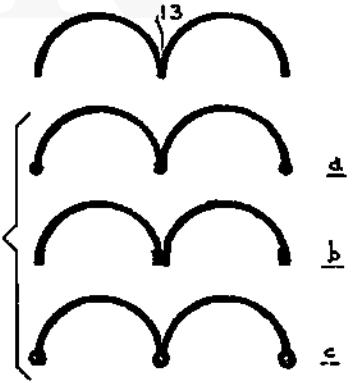


Fig. 5.

Fig. 6.

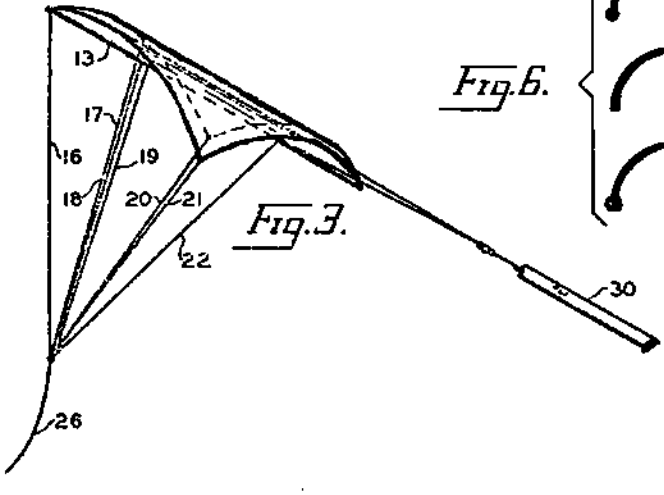
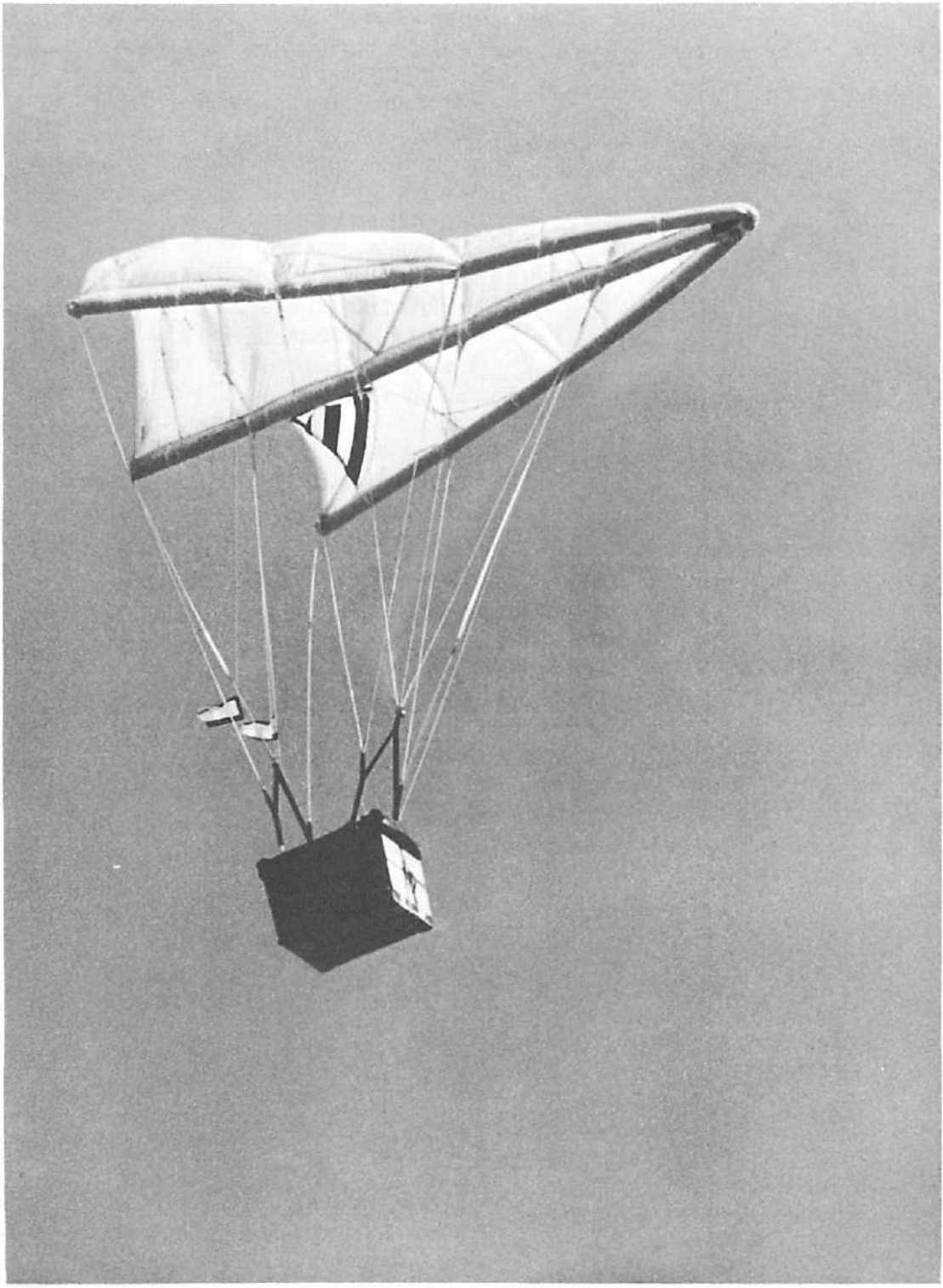
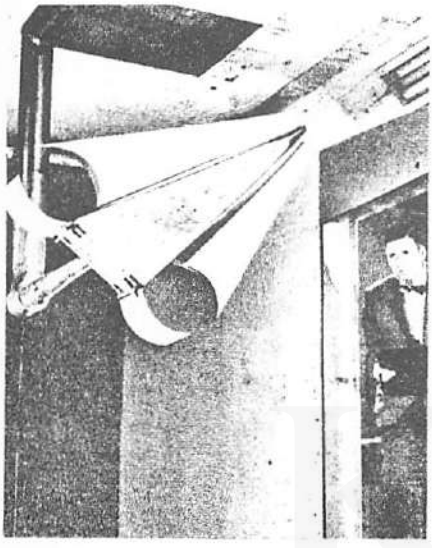


Fig. 3.

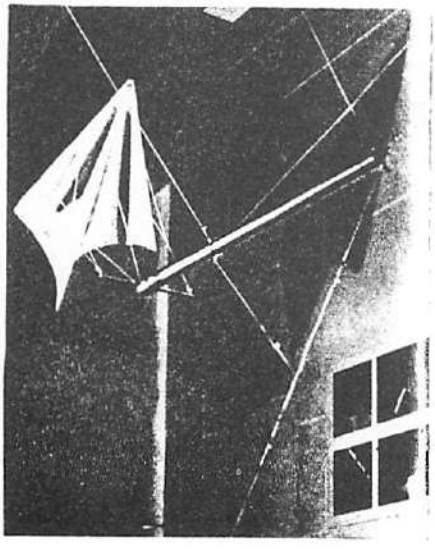
The main idea of the Rogallos is contained in these drawings that appear on the cover page of their patent, filed in 1948 and accepted in 1951.



Precision parachuting with a Ryan Flex-Wing. Thanks to the electronic equipment contained in its cargo compartment, the craft automatically lined up on a radio beacon situated in the landing zone.



Metallic airfoils (above) and flexible sails made of woven metallic threads treated with a silicon coating were among the first NASA projects for the recovery of space capsules.



One can imagine the problems of overheating and stability involved! Quite attractive in theory, his solution was to prove totally inadequate in practice; the flight tests carried out with models ended in catastrophe more often than not. An engineer who took part in these tests relates that most of these towed models finished their flights in spectacular crashes, which resulted in his personal undying skepticism as to the safety of these "deathtraps".

At high speeds, flexible wings made of woven metallic threads treated with a silicon coating were to be used; ejected in a fraction of a second from their container, the wings were stiffened by inflatable tubes. For the recovery of the first stage of "Saturn" it was even planned to place curved metallic airfoils along the sides of the fuel tanks, that were to unfold upon the rocket's reentry into the atmosphere.

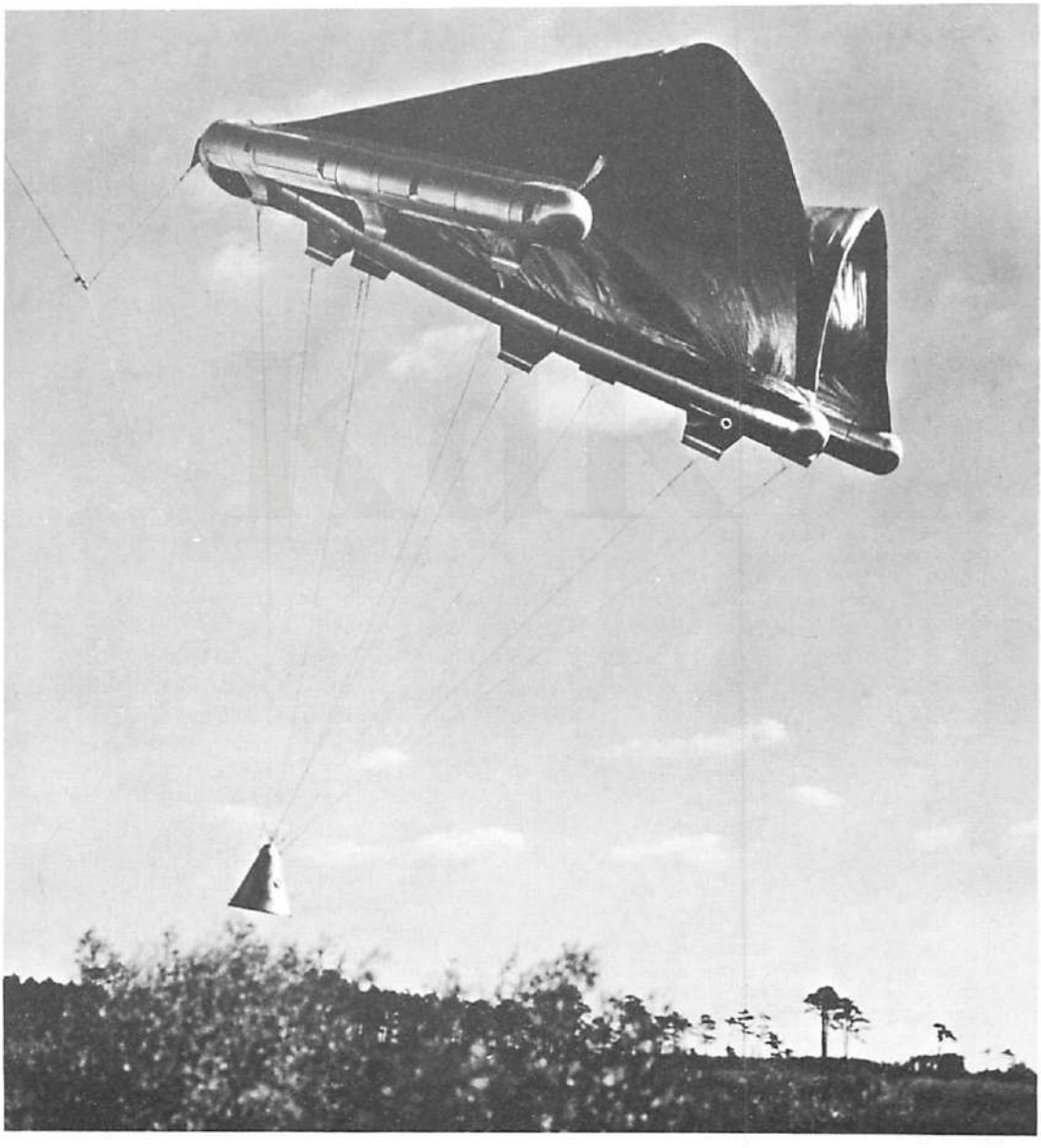
As is usually the case in the United States, once the basic studies had been undertaken in the governmental laboratories, private companies were made a party to the development of the Rogallo concept, in particular Ryan and North American Aviation.

Ryan - who was, in 1927, the builder of the "Spirit of Saint-Louis" of the first transatlantic flight made by Lindbergh - received, in the early sixties, contracts from NASA, the Army and the Marine Corps to develop the limp para wing and to find new applications for it. Many tests were made in flight and in wind tunnels. These tests proved that it was possible for a heavy helicopter of the period, the Piasecki H-21 "Work Horse"- called the "flying banana" in France - to take 'in tow' a weight to eight tons hanging under a Rogallo wing, without losing any of its flight performance.

There was even a plan to equip helicopters and vertical take-off craft with these wings, as a rescue of recovery device.

Ryan hit upon a first model called "Flex-Wing", developed under contract to the U. S. Army Transportation Research

Command; it flew for the first time on May 23, 1961. The wing was of the usual delta shape; the sail was attached to the keel tube and to the leading edges that could be either stiff or inflatable. Equipped with a 100 HP and later 180 HP motor, the "Flex-Wing" took off in 150 meters (495 feet), its speeds reached 97 km/h (58.2 mph), whereas its



One of the first test models of the Rogallo wing in early 1962, with a mock-up of "Gemini" that is not a very close likeness.

May 25, 1965 F. M. ROGALLO 3,185,412
FLEXIBLE WING VEHICLE CONFIGURATIONS
Filed April 29, 1963 7 Sheets-Sheet 2

FIG. 9

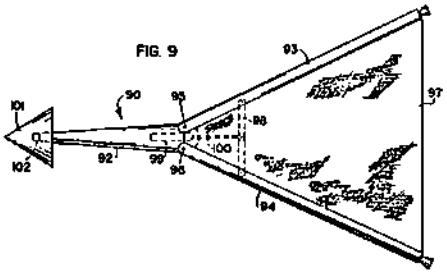
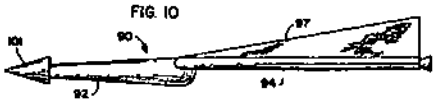


FIG. 10



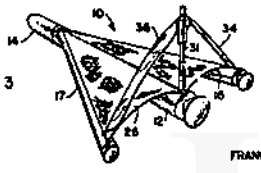


FIG. 3

INVENTOR
FRANCIS M. ROGALLO
BY
ATTORNEYS

May 25, 1965 F. M. ROGALLO 3,185,412
FLEXIBLE WING VEHICLE CONFIGURATIONS
Filed April 29, 1963 7 Sheets-Sheet 5

FIG. 11

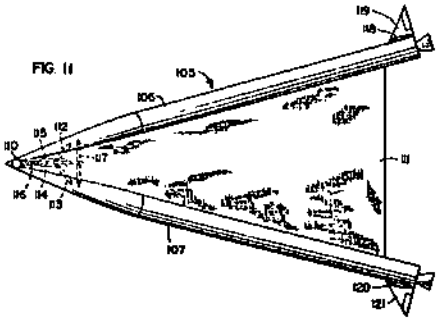


FIG. 12

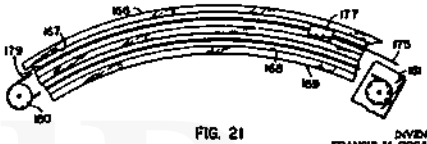


FIG. 21

INVENTOR
FRANCIS M. ROGALLO
BY
ATTORNEYS

April 21, 1970 F. M. ROGALLO 3,507,464
CONTROL DEVICES FOR FLEXIBLE WING
Filed March 18, 1969 4 Sheets-Sheet 1

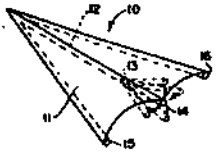


FIG. 1

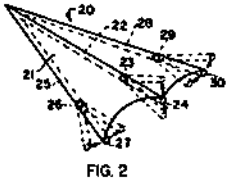


FIG. 2

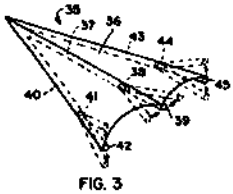


FIG. 3

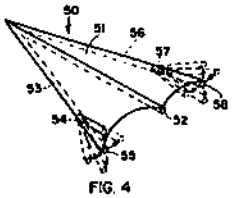
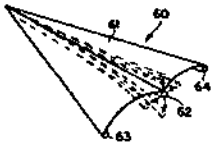


FIG. 4



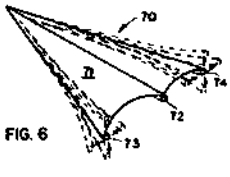


FIG. 6

April 21, 1970 F. M. ROGALLO 3,507,464
CONTROL DEVICES FOR FLEXIBLE WING
Filed March 18, 1969 4 Sheets-Sheet 2

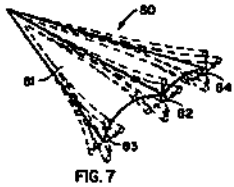


FIG. 7

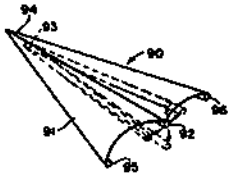


FIG. 8

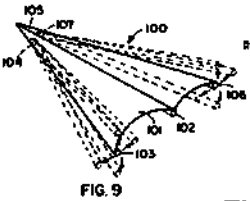


FIG. 9

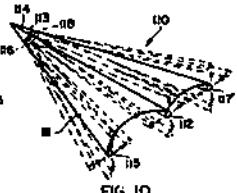
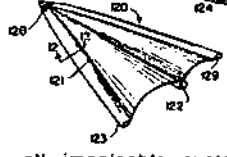


FIG. 10

FIG. 12



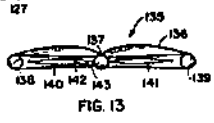


FIG. 13

One lobe, two lobes, double keels, variable geometry, all imaginable systems were researched and patented by Rogallo.

stalling speed was estimated to be at 39 km/h (23.4 mph).

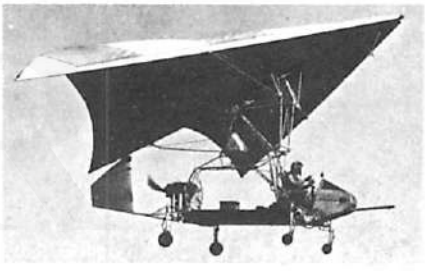
As a result of these successful tests, Ryan received a second large contract to study the construction of two prototypes of a sort of second-generation craft: the "Fleep", a contraction of "Flex-Wing" and "jeep". Tests began in July 1963 at Yuma base in Arizona. Compared to the preceding model, the "Fleep" had new control systems, designed by the engineer Peter F. Girard to better the craft's maneuverability. It was widely said at the time that the ground crew, used to maneuvering hoisting contrivances, could easily learn how to fly this type craft. They, unfortunately, never got the chance to prove the truth of this statement, as the "Fleep" was never mass produced. Thus frustrated, perhaps today they are flying among the cliffs of California.

In the same field, Ryan obtained a few sizable contracts for the study, construction and testing of a dozen flexible wings and of six para wings from the Army, whereas the company perfected the "Flex Bee" for the Marine Corps, and electronically guided reconnaissance craft. None of these projects was ever mass produced.

As for the precision para wings, their load capacity was 220 kilos (484 lbs.) and they could be dropped from a plane or helicopter at altitudes varying between 150 and 6,000 meters (495 feet and 19,800 feet). The delta wing was spread seconds after launching. Thanks to the electronic equipment in its cargo compartment, the craft was taken in charge by a radio beacon and automatically guided to the target area. In 1964, "Real" tests were carried out in Thailand for high priority material.

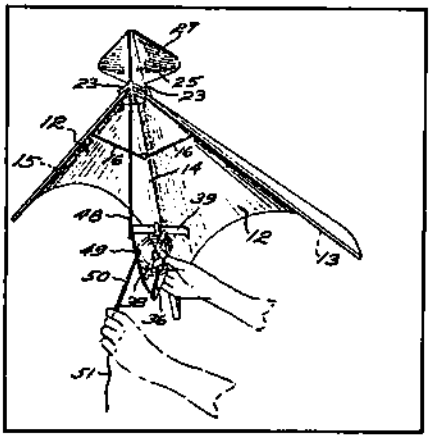
In the meantime, the North American Company was no less active and, at the end of 1963 and the beginning of 1964, this firm, the contracting party for the "Paraglider" recovery system intended for the "Gemini" capsule, was testing half-scale models in flight. Equipped with its inflatable wing and

The first prototype of a Ryan Flex-Wing, equipped with 100 HP motor.

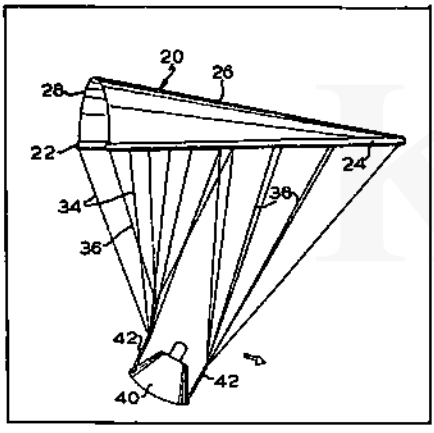


The Ryan Flex-Wing equipped with a 180 HP motor.

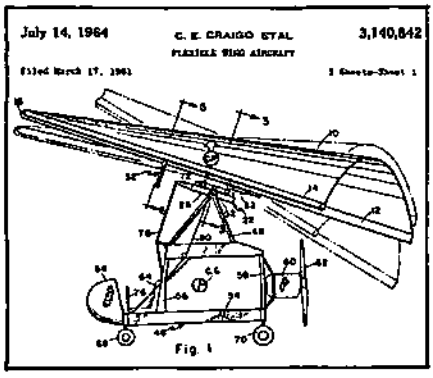
The Ryan Fleep.



Reduced-scale models of the delta wing were not neglected (here with a duck tail up front).



One of the main difficulties in using the Rogallo wing for space capsules was in extracting and spreading it; various patents were filed dealing with this problem. Here is a drawing from one of them.



Drawing of a patent filed in 1964 by C. E. Craigo and his colleagues concerning an airplane equipped with flexible wings.

piloted by H. P. Hetzel, the capsule was towed by a Sikorski H-37 helicopter above Salt Lake near the Edwards Air Force Base.

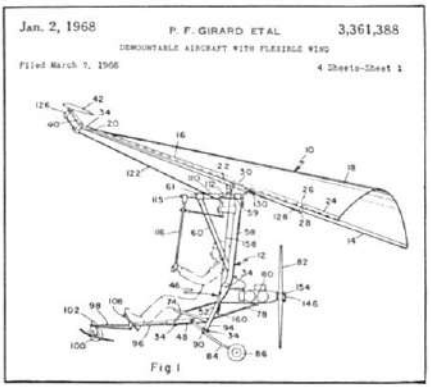
The system devised by North American was the following: the capsule was to reenter the atmosphere using its heat shield. The shape of "Gemini" and the angle at which it encountered the thicker layers of the atmosphere would give it a glide angle of 0.5. After passing through the maximum heat zone, a parachute was to open, stabilizing the capsule. At 21,300 meters (70,290 feet), the pilot was to open the Paraglider.

This device, quite similar to the Rogallo wing, was in fact a parachute with rigid elements, consisting of inflatable bars fastened to the capsule by five cables. Length: 9 meters (29.7 feet); span: 13 meters (42.90 feet). Roll and pitch stability was corrected by winding or unwinding cables operated by the same controls that the pilot used to determine the height of orbit of the capsule. He was thus enabled to change his direction or to increase or decrease his horizontal or downward speed. The best glide ratio was reached at 75 km/h (45 mph) and, it seems, it did not respond too quickly...

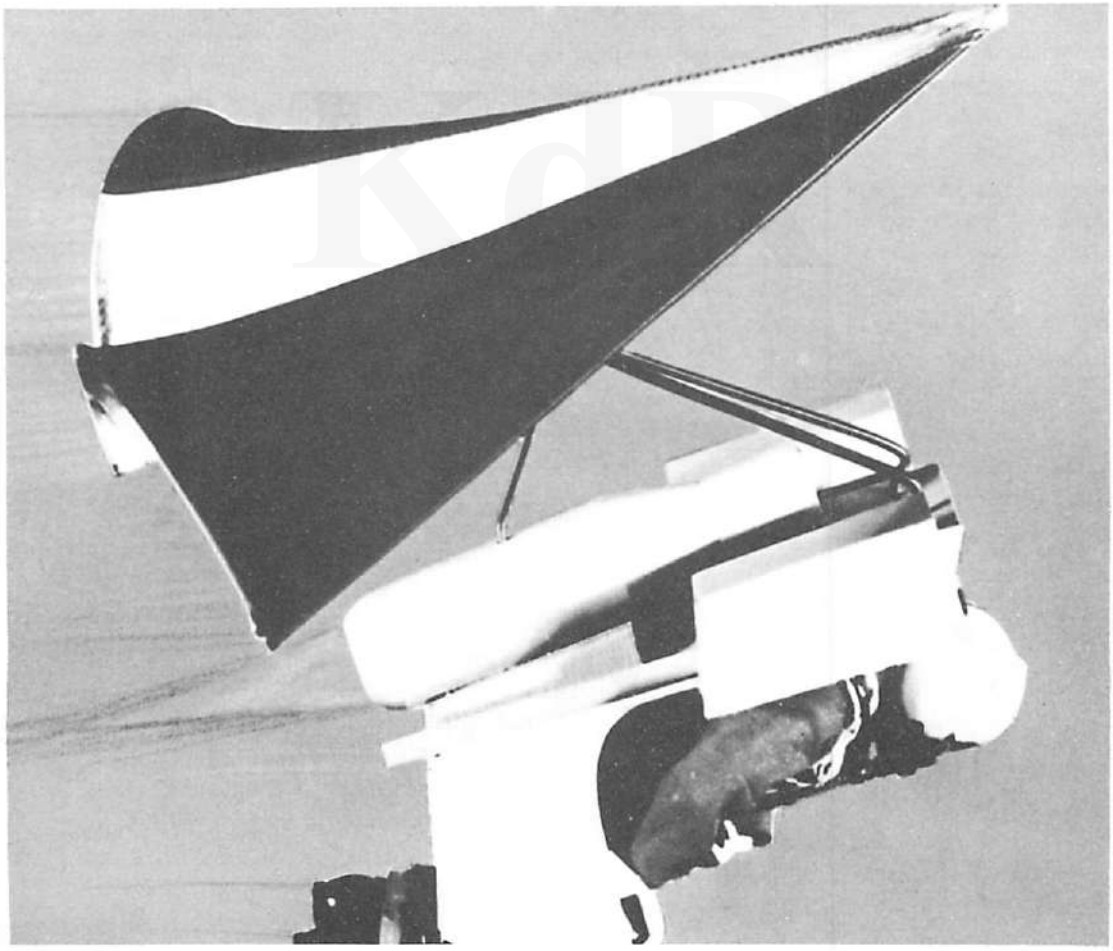
A final point of interest: the contract given to North American involved some twenty million dollars...Allowing research that today's wing constructors could never afford, of course, but from which they have largely benefitted ever since. And free of charge!

In 1968, at Wallop's Island, Virginia, NASA continued testing para wings, using a remote-control container weighing 15 kilos (330 lbs.) and 1.80 meters long (5.94 feet), that was dropped from a height of 1,200 meters (3,960 feet). There were still plans at that time to use these techniques for the recovery of inhabited space capsules of the second generation. Since then the "space shuttle" has been invented, a veritable airplane that does not need para wings.

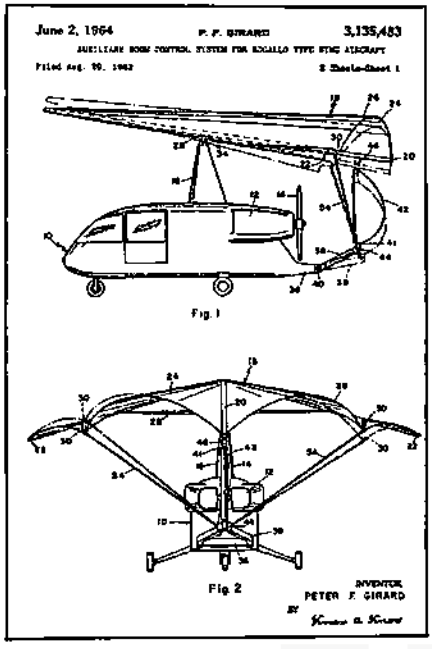
The final appearance of the Rogallo wing, at least in its military form, was to be as an adjunct of the ejectable pilot's seat. In this scheme, intended to greatly increase the possibilities of recovering shot down pilots, the wing was to unfold in back of the pilot, still strapped to his seat. He was then enabled to fly back towards his own lines, at least as long as the fuel in the seat lasted. When it ran out, he was to abandon wing and seat, and parachute to the ground. This system was never tested in full-scale size; recent studies tend more toward the solution of built-in helicopters or autogyros folded into the seat itself. A solution that is far


Jan. 2, 1968 P. F. GIRARD ET AL 3,361,388
DEMOUNTABLE AIRCRAFT WITH FLEXIBLE WING
Filed March 7, 1966 4 Sheets-Sheet 1
Fig 1

P. F. Girard and his colleagues from the research department at Rian, instructed to research flexible sails, came up with a great number of two and even four lobed models (see following page).



Ejectable seat equipped with a Rogallo wing. this project, that dates from 1969, was conceived by the Wright-Patterson laboratory (USAF), and was designed to permit the pilot to get away from the zone where his plane had been shot down and even fly back to his own lines.



more complicated than the delta wing...

And that is the sad story of the limp wing as far as military or spatial use goes. The Rogallo wing is dead! Long live the delta wing!

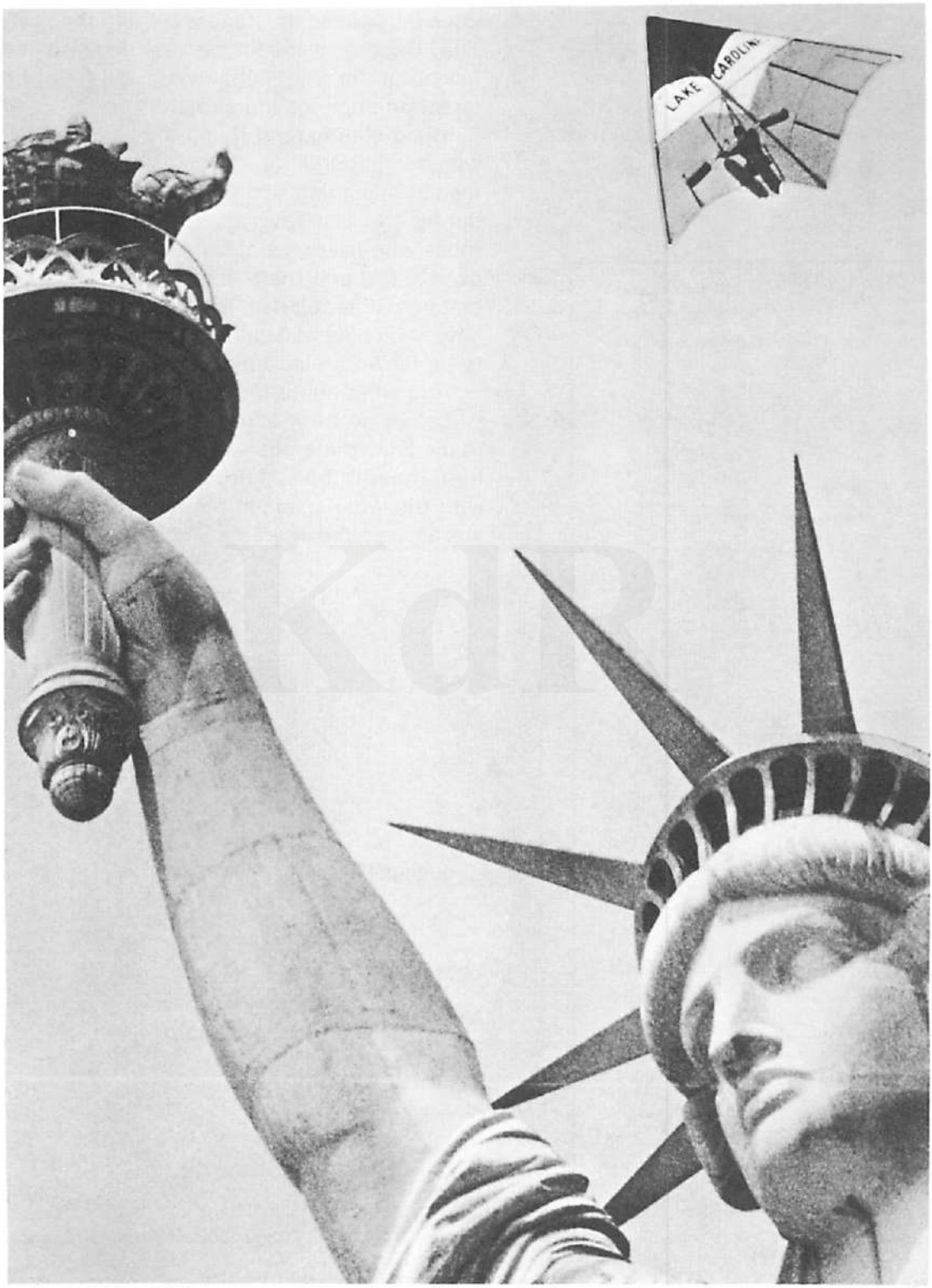
There is a direct relation between the American research of the early sixties and what is to be seen today, and it can easily be traced: Bill Moyes, an Australian, experimented with a reduced scale kite of the same type as those NASA had worked with in the United States. As opposed to other kites, those that Moyes experimented had the distinct advantage of being able to gain altitude regardless of the speed of the towing vehicle.

At about the same time, an American, Richard Miller, built the "Bamboo Butterfly", a Rogallo type wing made of bamboo and polyethylene that cost him nine dollars and many bruises and sprains...

It was to be four years before word was to spread beyond limited intimate circles or across the Pacific of the exploits of these two pioneers.

In April 1969, 116 years later, Moyes' partner, Bill Bennett, once again carried out the mission of Cailey's coachman; he was instructed to go to the United States to give demonstrations there with the craft invented by Moyes. During the American water-skiing Championships at Berkeley, Bennet was a resounding success. Three months later, on the fourth of July, Independence Day, he caused a sensation when, towed on his water skis near the Statue of Liberty, he flew over the monument and landed in the field at its feet. From them on the wing was under way, and well under way. All the more so since the towed delta wing was quite soon replaced by the autonomous take-off delta wing, in other words, on foot. The inventor: Dave Kilbourne.

Unlike the American craft that were all equipped at that time with parallel bars along which the pilot moved his body to modify the center of gravity, the Australian



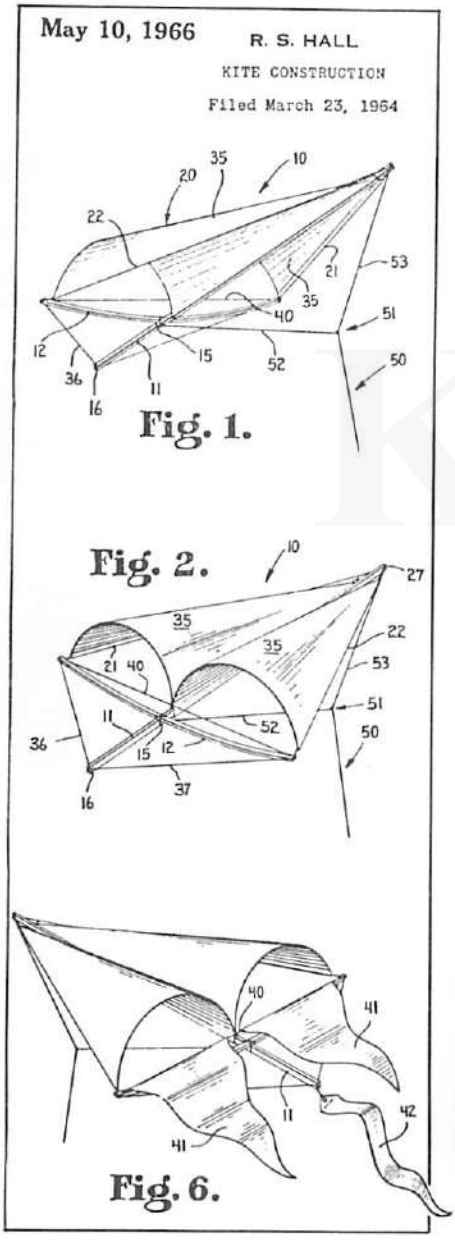
The Australian, Bill Bennett caused a sensation by flying over the Statue of Liberty in New York on the Fourth of July, 1969.

kites introduced the trapeze bar and the seat. The trapeze was to be as decisive an invention for the delta wing as was the direction-stick for the airplane.

Hang gliding (and flying ultra-light, stiff-winged gliders) is, proportionately, the fastest spreading sport in the United States during the last few years. The number of those who have tried it on occasion must be over 20,000 and there are some 15,000 who practice it regularly. Thousands of wings have been built and sold and the craze seems to be far from slackening.

And what about Europe in all this?

Let us go back somewhat in time again. In the immediate post-war years, the French firm Hurel-Dubois, known for its research with the wide-spanned airplanes HD-30, 31 and 32, became interested for a while in limp



We keep coming back to kites...

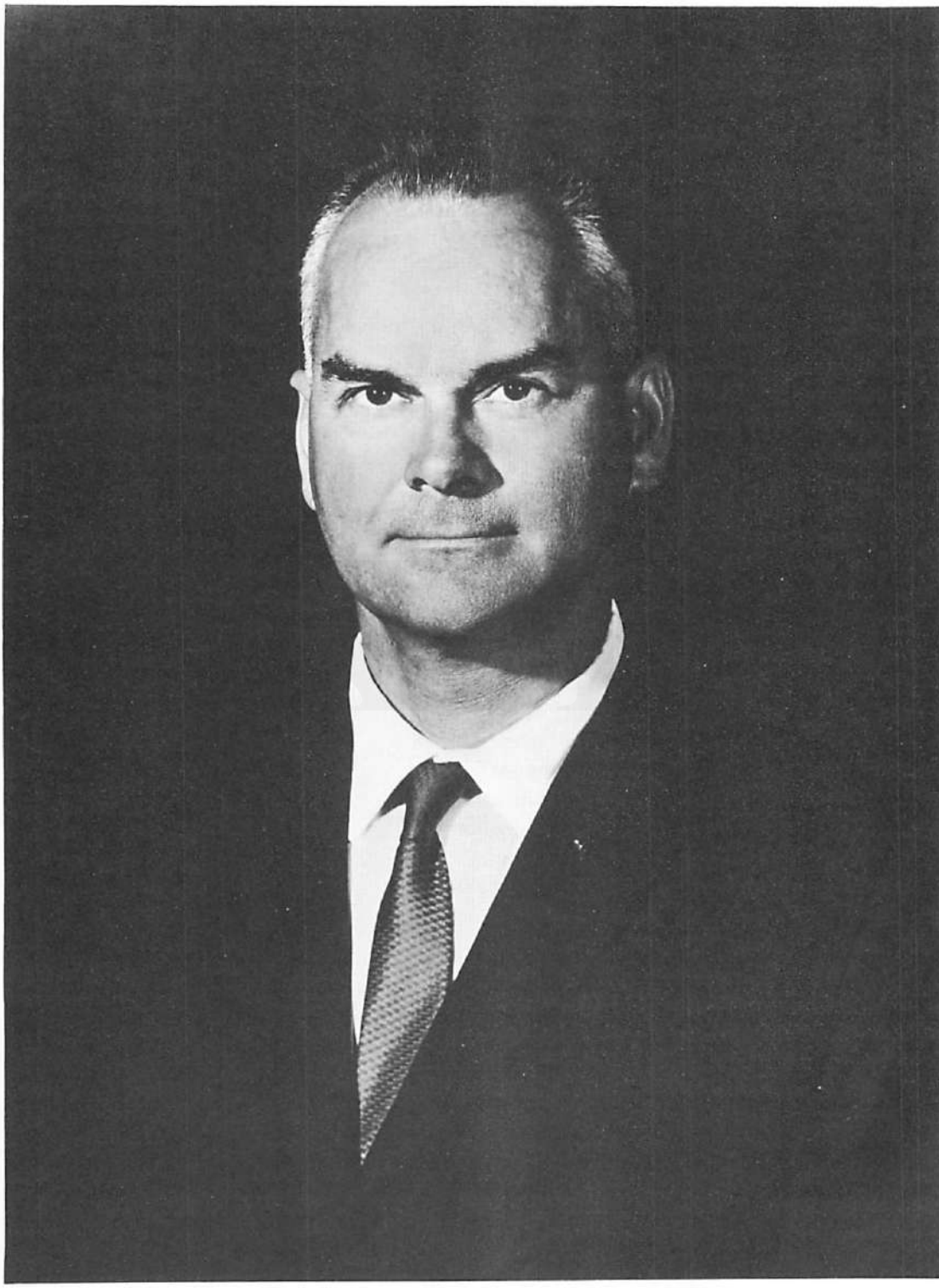
The French parachutist Leo Valentin thought that he could develop a type of wing that would allow him to dispense with the use of his parachute on landing. He killed himself in Liverpool in 1956.

sails, and collaborated a few years later with the Ryan firm that we mentioned above. This seems to have been enough to convince certain Frenchmen that they were the inventors of the craft.

But France has nonetheless many other reasons for well-deserved pride: in the Fifties, a staff sergeant in the French Army, Leo Valentin, became famous for his spectacular free-fall jumps during which he used to the utmost the aerodynamic characteristics of the human body. He gradually increased the airfoil by spreading out a sail attached to his flying suit. The end result of his research was the construction of a wooden, short-spanned wing weighing about 10 kilos (22 lbs). A number of relatively successful gliding tests convinced him that one day he would be able to land without opening his parachute. Which is just what he did, prematurely (and accidentally, both of his parachutes having failed to open one after the other), in Liverpool, on May 22, 1956, in front of a crowd of 100,000 people.

And it is also France that subsequently showed the way in Europe, thanks to Yannis Thomas first of all, whose exploits never fail to create a sensation, and then to Christian Paul-Depasse and the Danis group, to which one must add the Swiss Etienne Rithner.

And what then? Well, that is where we're going now. Look sharp.



Francis Melvin Rogallo, former head of the wind tunner research division at the Langley Research Center in Hampton, Virginia, and inventor of the wing that bears his name.

2 THEIR ADVENTURE

OUR MASTER'S VOICE

It seems to us only fitting, in view of the pleasure that pilots and spectators alike derive from the delta wing, to devote a bit of our time to the one whose idea it was; thanks to the journalist Jacques Poget, we now know a little more about this engineer whose modesty almost equals his talents in aerodynamics, and who seems to have a certain genius for protecting his private life. And yet, in the public mind, the word "Piper" is linked to a small, high-winged airplane, fit for two or three passengers in relative comfort. It will perhaps be the same in a few years for the Rogallo wing; we will say "a Rogallo," as we say "a shoe" or "a taxi." A word in common use for a most uncommon reality!

Francis Melvin Rogallo could have made the "business deal of the century" if he had really wanted to protect his inventions; but he decided to limit his activities to the technical side, which is at once reassuring for us, profitable for the "constructors" who can use his ideas to their heart's content, and indifferent to Rogallo, who doesn't receive one penny's worth of royalties from the thousands of wings now flying in the four winds of the earth.

Rogallo was born in Sanger, a small California town, on January 27, 1912. He was seven years old when he saw his first airplane flying by. A biplane that he doesn't remember much about... We will therefore never know which model it was that was the source of his vocation. He built toy planes and then, when he was 13 years old, went for his first flight in a Curtiss Jenny. He was by then a confirmed enthusiast.

He studied at Stanford, where he received a BA in 1932 and a degree in "mechanics-aeronautics" engineering in 1935, after writing a thesis on a propellor. (It is to be noted that another brilliant engineer, Marcel Dassault, also began his career in aeronautics with a study of a propellor.)

In 1935, the job situation was not too promising for a young engineer fresh out of college. He worked for a few months for Shell, then for Douglas. But his real chance came in 1936, when he joined the Langley Research Center, in Hampton, Virginia, the only governmental aeronautics laboratory existing at the time, where he was to remain until 1970, 34 years later.

He was soon directing a wind-tunnel research group that was to become the "7 by 10 foot tunnels branch." The latter period of his official career was spent planning and supervising theoretical and experimental aerodynamics research as well as those relating to the development of airplanes at the Center. He has written a considerable number of papers, most of them devoted to stability, airfoils, controls, rudders, ailerons and limp wings.

Although he has flown many airplanes, he never applied for a license. However, he does fly regularly with the wings that he invented. Everyday. At least when weather permits! Where did he get his inspiration? He has read all of the classics, of course, but not systematically. "I read what I found; I admired the Wright brothers, I was interested by Lilienthal and Glen Curtiss, but I never really pored over them. I only note that I have not invented anything fundamentally new. Unlike most people who consider hang gliding as a secondary field, I think that it can be an aim in itself."

Why does he have this point of view? He doesn't know. As a matter of fact, when he started his research it was not with the aim of developing the delta wing. What interested him was the flexible wing, for which he saw applications in all the fields of aero-

nautics, including motorized planes. Gliders, para wings and hang gliders came later. It takes a long time to get Mr. Rogallo to admit that he is, after all, the originator of today's delta wing - it seems to make him suffer in his modesty - and that he foresaw, as early as 1948, its possibilities as a sport.

In 1949, he wrote: "Portable delta wings will give birth to a popular sport." Only a few months earlier, under his own name and that of his wife, Gertrude Sugden Rogallo, he had filed for a patent for a flexible kite, diamond-shaped from a top view, and evolved from two cylinders from a front view. The patent was granted in 1951, but it was not to be exploited until much later - 8 or 10 years - when its inventor thought to use its principles for the recovery of the space capsules "Gemini" and "Apollo" and the first stages of the "Saturn" rocket.

"I'm sorry the idea wasn't accepted; it still seems like the good solution to me today. Recovering space vehicles on land would have avoided quite a few difficulties, not to mention costs. It's obviously outmoded now, since the future space shuttles will land like airplanes."

But he is not at all bitter: "I did what I could; I think it's a shame the system wasn't used, but I can't do anything about it."

Two years ago he moved to Kitty Hawk, North Carolina, the very site where the Wright brothers made their first flights. He wants to continue research on the delta wing. There are, according to him, two areas to be explored:

- better performances: endurance, distance, manageability. This may mean more complicated wings, in other words more expensive ones. But, apparently, many people would be willing to pay the price...
- lighter and less cumbersome, perhaps even folding models, making traveling and launching site access easier. At first, this might be achieved by slightly sacrificing flight performances, recovering them later on through more research.

"The delta wing is still in its infancy; its era has just begun. Don't forget that today's models are more or less identical to those of ten or fifteen years ago. The geometry of the current models is the same as that of Ryan's 'Flex Wing' in 1961!"

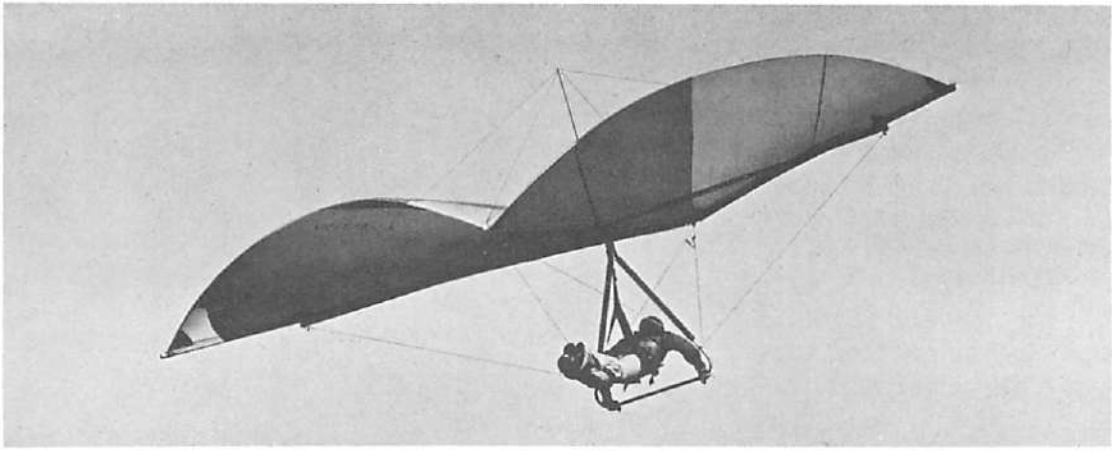
The wing's future?

"Unlimited! It will last as long as there are men to fly it. It's like swimming: an unnatural practice, but one that man will not give up after having mastered it. He has learned how to fly like the birds; there is no reason for him to give it up, now that he knows."

The primary advantage of the delta wing, according to its inventor, is its low cost, which makes this manner of flying open to nearly everyone. "And it's easy; no particular training or talent is necessary. As with skiing, individuals are more or less gifted, they need more or less time to master the technique, but it's within the possibilities of any normally capable individual..."

He also intends to continue research in the applications of the flexible wing: energy production and navigation: "If it's on a glider, a windmill or a boat, a wing, you know, is fundamentally the same thing. And everything concerning air, wind, water, fluids in general interests me..."

We can be sure that Mr. Rogallo still has some surprises in store!



Ann Welch & Gerry Breen

HANG GLIDER PILOT

HANG GLIDER PILOT Ann Welch & Gerry Breen

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Otto Lilienthal (1848–96) built various hang gliders and made some 2,000 flights on them, many from a specially built hill.

INTRODUCTION

How it began

It is in some ways a pity that flying became possible at the start of this century, when industrial and engineering progress was moving fast. Technical advancement was the cry and the first simple products of the dream to fly were swept along being made better, faster, heavier, and more expensive as quickly as it was possible to create new designs. World War I, of course, gave a powerful stimulant to the infant flying machine. The original intention—to fly with the facility and beauty of the birds—mostly faded with the original pioneers. But it never entirely disappeared, remaining quietly there alongside the high-speed technology and the thrust for power. It took no great search to discover people who continued to believe in the individual challenge of flying, and in the unique and special attractiveness of soaring.

Some of these people became famous—like Wolf Hirth, who was the first to discover how to make real use of thermals. With aeroplanes, it was Geoffrey de Havilland and his Gipsy Moth who effectively opened up the world to migratory man. But there were others who flew unnoticed, following their dream. Few now have heard of Willi Pelzner who in 1911 built hang gliders out of scrap, to escape from school and go up into the hills to fly. But he did not manage to soar.

Lilienthal almost managed it. On the Rhinow hills in the 1890s he often rose above his starting-point, remaining hovering over the ground for a considerable time. He felt quite surely that he could fly further if he 'inclined a little to one side, made a circular movement, or let himself be driven by the wind'. But another twenty years were to pass before the German Fredric Harth soared for a little over 2 minutes above a slope in the Black Forest, and the way ahead became clear.

Ferdinand Schultz was a schoolteacher who lived on the shores of the Baltic, and passionately believed that he could fly all day long over the sand-dunes, the highest of which barely reached 200 ft. He built himself a primitive aircraft which would soar no better than a rogallo, and taught himself to find lift over the rolling sand. From his first 6 minutes in 1923 he went on to achieve over 8 hours, and later 9 hours with a passenger, on a somewhat better and stronger glider. By 1926 Uncle Ferdinand, as he was called, soared along the Baltic dunes to Memel, 36 miles away. Often his wingtip barely cleared the blowing sand while trying to extract lift out of some isolated gust. To cross gaps in the dunes he flew out over the sea to use the meagre lift provided by the windward side of heavy surf.

In England, Itford Hill was chosen as the site of the 1922 *Daily Mail* Competition, with £1,000 offered for the longest duration flight in a glider. This was won by the Frenchman Alex Maneyrol on a 21-ft span tandem wing glider, having a glide ratio of probably about 1 : 9. He stayed airborne for 3 hours 21 minutes 7 seconds, a world duration record.

After this only birds soared the South Downs for the next eight

years, until Robert Kronfeld arrived from Germany in 1930 with his 63-ft span Wien. In these intervening years the performance of gliders had improved greatly, and wandering along the hills had become a reality (and is the next step for hang gliding). Kronfeld was to give demonstration flights at Itford, where the new Southdown Gliding Club had started, and he did so all that day. As the afternoon wore on he increasingly felt the urge to explore along the hills, but it was not until 5.30 p.m. that he could escape, and use the north-east wind as he wanted. He wrote later that unfortunately the wind was already dropping, with the air much cooler. The first minutes of the flight were used to gain as much height as he could over Firle Beacon, as before him was the problem of getting over the $2\frac{1}{2}$-mile valley to Cliffe Hill, north-east of Lewes. He lost height

Willi Pelzner and other enthusiasts constructed their hang gliders from scrap materials and flew from the Rhön mountains in Germany before and just after World War I.

Ferdinand Schultz's broomstick on which he soared over sand-dunes for 8 hrs 42 min in 1924.

gliding across, but after a few alarming minutes reached the ridge and began to climb; and in a strong upcurrent caused by 'the best soaring slope of the whole district' he quickly gained height and crossed over the next large valley north of Lewes to Mount Harry. He described how north of Brighton the Downs began to bend south, and how it was difficult to retain his height as the north-east wind was now blowing almost parallel to the slope. He managed to cross a further valley 3 miles wide—the Arun—but the slackening wind was making it more and more difficult to carry on. However, the flight along the ridge to Petersfield presented no real difficulty, but it was already past 8 p.m. and both the wind and the visibility were deteriorating rapidly. Kronfeld reckoned that it might just have been possible to reach Winchester had it not been so late, so he resolved to drift downwind to land at Portsmouth. To do this he had to stay airborne over substantially flat land 'with only a few hills and coppices to offer late upcurrents'. His chief difficulty was to find the place in the murk. Passing over the top of the last small hill that he could see near Petersfield he called out at the top of his voice 'Where's Portsmouth?' He saw a man below 'first turn around three times trying to find where the voice came from and at last look up. Then he pointed the direction.' Kronfeld cleared the

top of Portsdown Hill by 15 ft, but then did not like the look of what he described as the swampy outskirts of the town, so turned back and landed on the hill itself at 8.30 p.m. In later years Itford and Firle were soared by gliders from the Southdown Club until it moved to Parham in 1973. Now hang gliders soar over these historic hills.

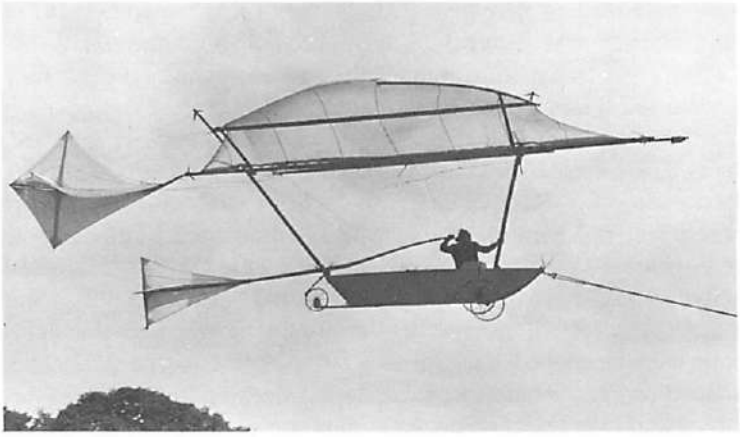
By the late 1920s performance was reaching out to glide angles of 1:20, and enthusiasm for new ideas was great. These gliding pioneers would have been delighted by the simplicity of the rogallo, fascinated by ultralights such as Icarus V and Tweetie, and awed by the incredible performance of the glass-fibre glider, now in sight of a glide ratio of 1:50. It is our good luck that out of the high-powered technology of 20th-century engineering progress has come a fantastic range of lightweight structural materials and probably the cheapest and most basic aircraft that it is possible to devise—the rogallo. Although the Chinese flew simple and elegantly designed kites more than a thousand years ago, and Leonardo da Vinci had enough knowledge to design a complex helicopter, no one developed the concept of the delta sailwing, even though suitable materials were available and the construction problem was negligible. Sir George Cayley probably came nearest to the rogallo solution with his 'Governable Parachute' the drawings for which were published in *Mechanics Magazine* of 25 September 1852. This aircraft was reputed to have been flown, unwillingly, by Cayley's coachman but nothing was certain until a replica was made a few years ago. It flew.

Almost certainly the reason why the rogallo was not invented many years before was that it needed a much more complete understanding of aerodynamics to achieve this answer. Early experimenters found it difficult to depart both structurally and in aerodynamic shape from the birds, which were the only examples of flying machines available to them. The original interest of Francis Rogallo and his wife was to develop totally flexible kites and they only later developed their ideas for the benefit of the American Space Program. Francis Rogallo started working for NASA in the forties and over the next few years filed some twenty patents, some

jointly with his wife. In the sixties the new hang glider movement had its small beginnings, and inevitably some rogallo-shaped wings were built along with copies of 1920 hang gliders and other interesting devices. In 1972 Francis Rogallo took out another patent, this time to get earthbound man airborne instead of space capsules back to earth. Since then the sport has never looked back. The performance of the rogallo is minimal, but it works because it is so incredibly simple and light, because it is robust and cheap, and because it is the next best thing to growing one's own wings.

Full circle now, we have the aircraft, but the dream must not be lost again. The need for speed and sophistication is pretty well ingrained, and the temptation to build hang gliders that are fast, complicated, expensive, or even hung all over with electronics is lying in wait. It has to be resisted. The world is already full of magnificent sailplanes and aeroplanes that can provide almost any degree of sophistication and performance that a pilot could want—or pay for. Hang gliders can be improved, but they must stay light and simple. They are for the pure pleasure of personal flying; for the delights of soaring over beautiful hills.

The original of Sir George Cayler's 'Governable Parachute' flew in 1852. This exact replica was flown by Derek Piggott in 1974.



I GETTING STARTED

CHAPTER ONE

What is a hang glider and how does it fly?

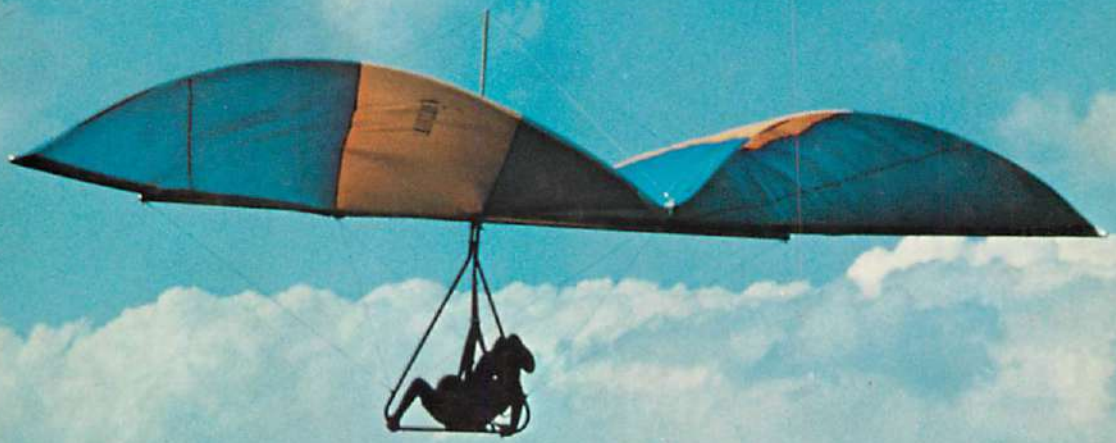
About the rogallo

The ordinary delta-sailwing rogallo is a very simple flying machine. Constructed of aluminium tube made into a rigid structure by bracing wires, and covered with a lightweight synthetic material, the aircraft is cheap and easy to build. (Fig. 1.1.) But it is an aircraft and not a toy, and like any aircraft it is potentially lethal.

1.1. Rogallo with a seat harness. The pilot is in the neutral position with arms bent. This allows for freedom of fore and aft control.

Rick Carrier
The Complete Book of Sky Sailing

FLY



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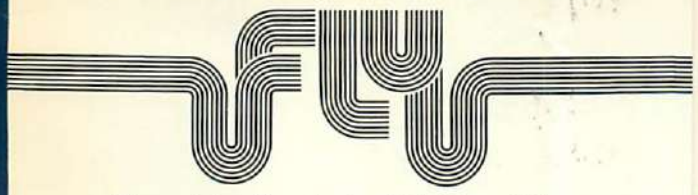


"I've watched hundreds of flights and it's still a thrill every time I see a kite take off and land. This book brings it all back—the marvelous pictures and captions are a story in themselves....It covers all the territory and subjects you need to know. A great help for anyone who wants to learn to fly safely."

Francis M. Rogallo,
inventor of the original
flexible-wing sky sail

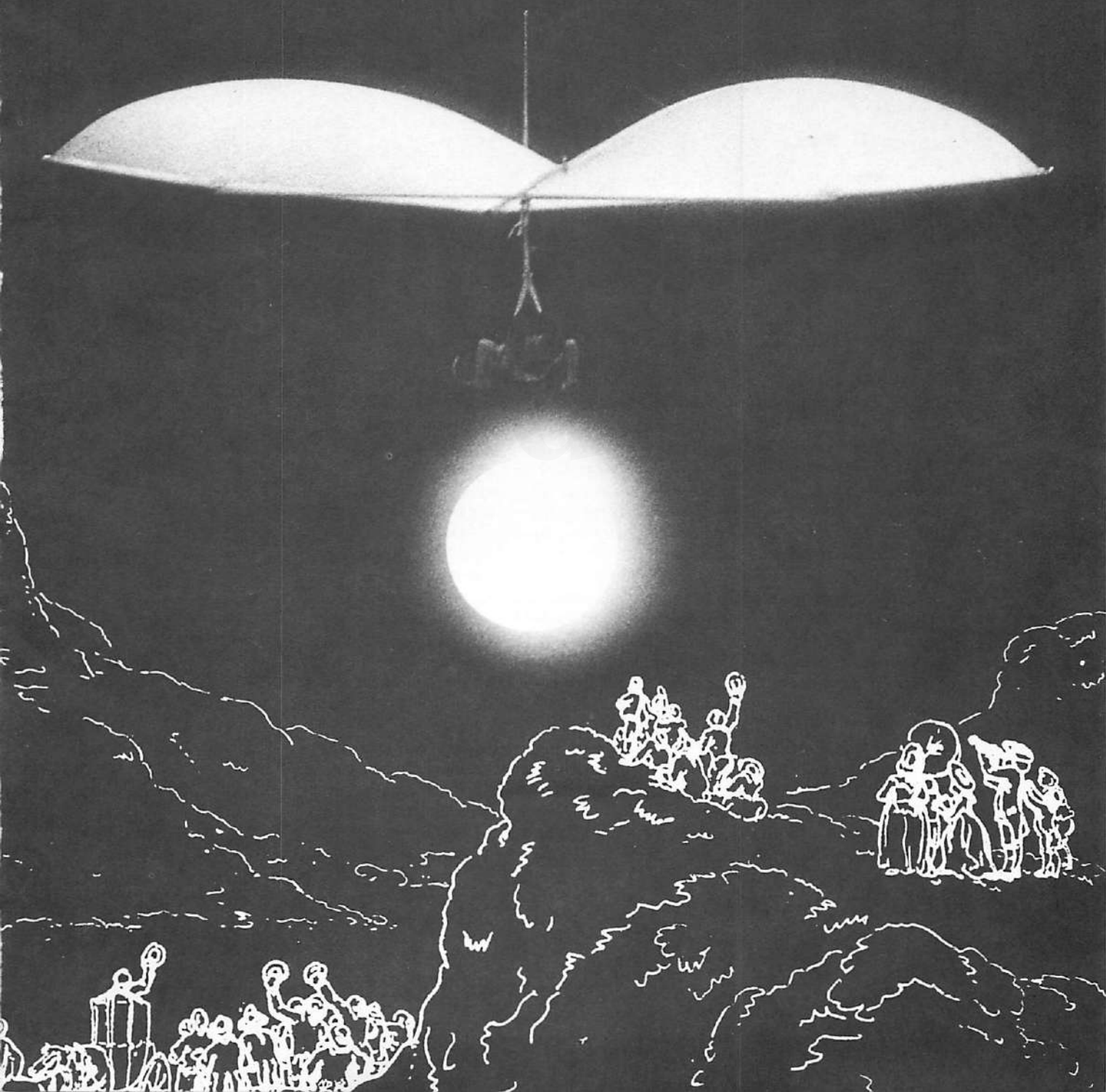
The dream of flying—to soar and dive and float freely above the earth—has haunted man's imagination from the beginning of recorded history. Now that dream, which has eluded man's efforts across the centuries, has been realized with the amazing new sport of sky sailing.

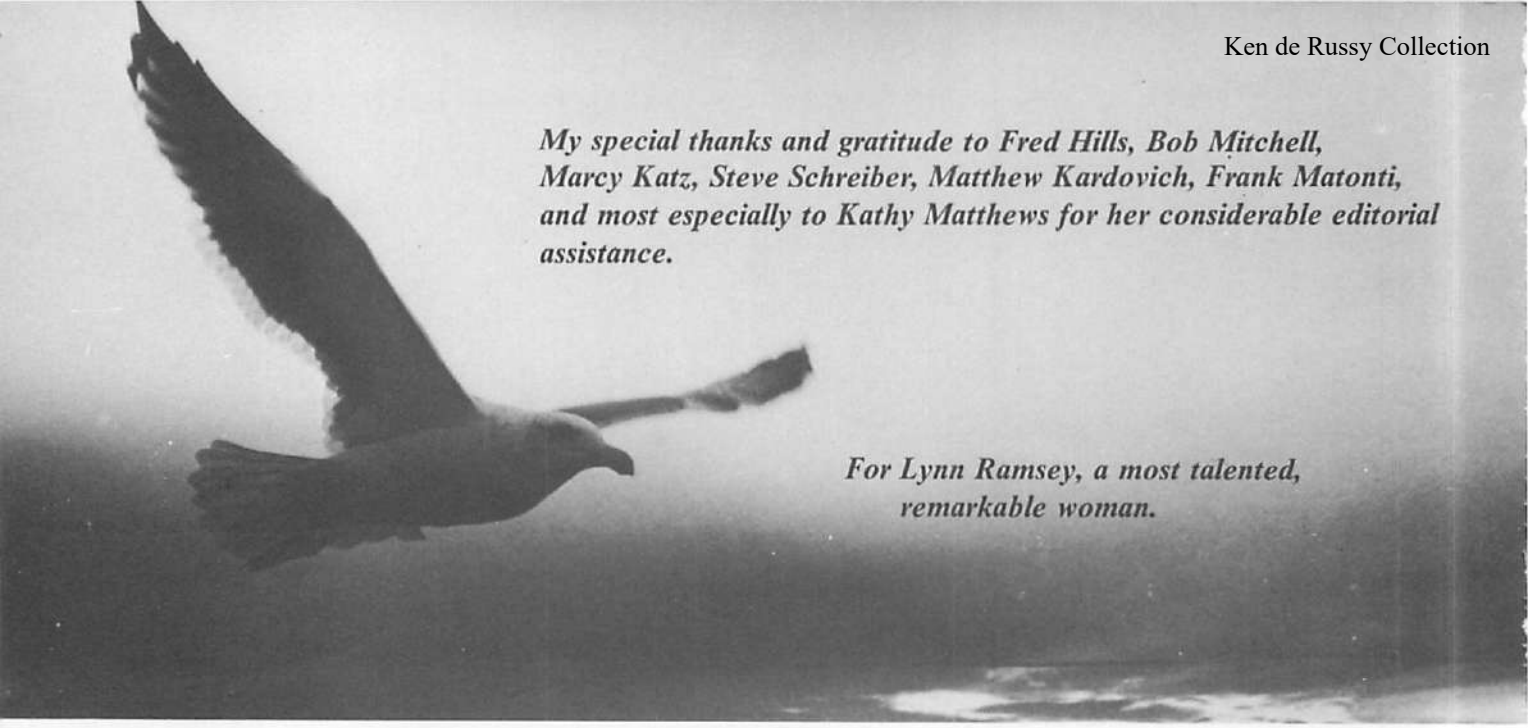
This beautifully illustrated book evokes the spirit of flight and the art and technique of sky sailing, or hang gliding—a sport that has fairly exploded in the public imagination and interest since the first Rogallo kite was flown in 1970. Borne aloft by a free-flying soaring kite, adrift on air currents, the flier is free to soar, turn, and dive at will, for the sail wing becomes an extension of himself and responds to his every motion.

Whether you want to fly at 50 feet or 5000 feet, this practical book tells you everything you need to know for safe, successful sky sailing. Clear, complete guidelines explain basic techniques of launching, soaring, and landing, as well as detailed information on kite maintenance, clubs, manufacturers, and other resources. Basic information is provided for all standard types of sky sails, including the Rogallo sky sail, rigid wing, Icarus flying wing, Quicksilver monoplane, and

(continued on back flap)

To Francis M. and Gertrude Rogallo, the inventors of the flexible wing glider, and all the pioneers of self-powered flight.





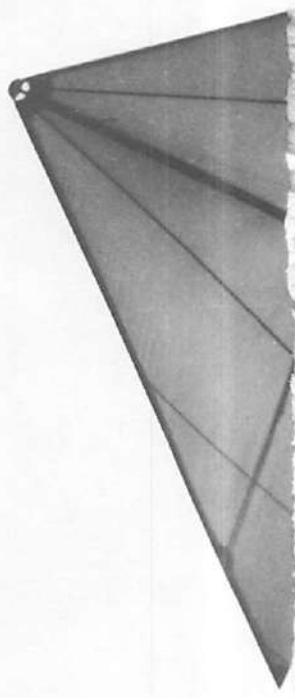
My special thanks and gratitude to Fred Hills, Bob Mitchell, Marcy Katz, Steve Schreiber, Matthew Kardovich, Frank Matonti, and most especially to Kathy Matthews for her considerable editorial assistance.

For Lynn Ramsey, a most talented, remarkable woman.

Acknowledgments

I would like to express my extreme appreciation to the Chandelle™ Sky Sail Corporation for the help they extended to me in the preparation of this work and in teaching me to fly safely. To Don Stern, Jim Galbreath, Bill Sloatman, Don Beuch, Gordon Cummings, Keith Ealy and Colleen Charles, Mike Larson, Lee Sterrios, and all the other friends in Golden, Colorado, a grateful thank-you. I would also like to extend my hand to those of the United States Hang Gliding Association in California with special thanks to Bill Allen, Lloyd Lichter and the magazine *Ground Skimmer* for praiseworthy efforts in getting to the public safe and sound flying information. For the precision and clarity of his explanations of aerodynamic principles, I am most grateful to Richard ("Old Dog") Wolters, author of *The Art and Technique of Soaring.* To Pete Brock of Ultra Light, Kent Trimble of Manta, Gerry Ross of J. G. Aircraft, Donna Ross, editor of *Wings of Rogallo* newsletter, and Ed Vickery of *Sky Sports,* I extend a grateful thank you for helping me through difficult moments in understanding the depths of the technical side of sky sailing. To the flyers—Dave Kilbourne, Donnita Holland, Karen Rowley, Chris and Bob Wills, Kim Dawson, Mike Robertson, Tom Peghiny, and Dan Poynter, Bill Bennet, Taras Kiceniuk, Jr., Sam Alexander, Ed Butz, Captain Chuck Stall of Seagull, Mike Grey, Bob Balldeck, Al Waddell—I offer a humble thank you for inspiring me to reach for greater heights and insights into this dynamic sport, sky sailing. To those of you whom I have unintentionally missed in completing this manuscript, I offer my deepest gratitude and Godspeed.

Rick Carrier

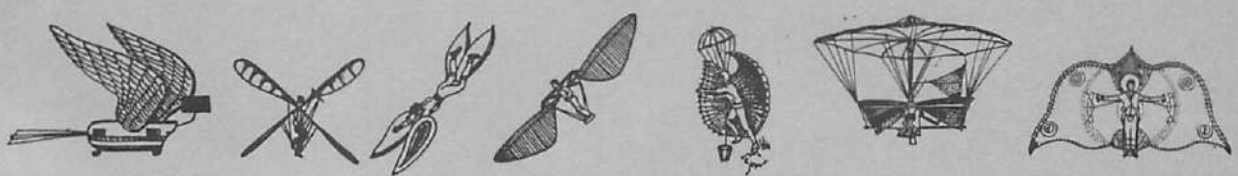


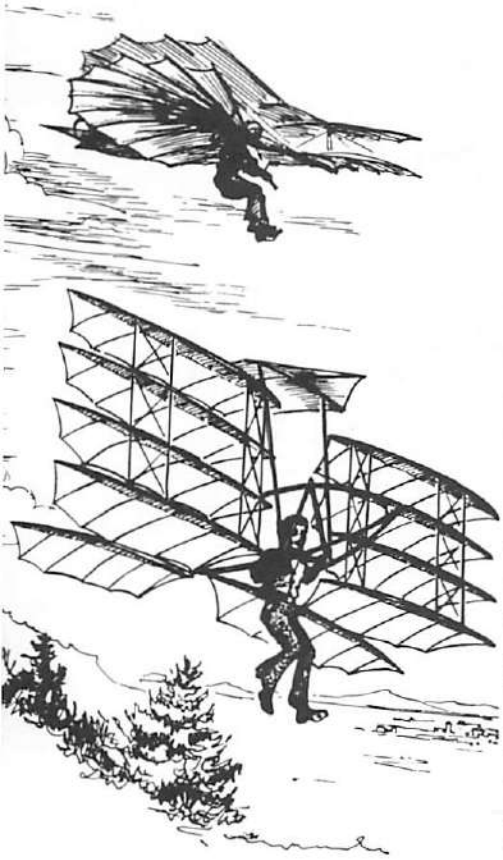
Man Acquires Wings

Early gliders were fantastic contraptions. Here is a collection that includes (left to right) one by Montgomery, two versions by Lilienthal, and one by Chanute. Otto Lilienthal wrote volumes about his sky sailing experiences and became the father of self-launching glider enthusiasts. Many of his contempories who were also experimenting with flight consulted with him—and became close friends.

IN the early 1800s the balloonists were kings and the heavier-than-air boys the serfs in the race to the sky. Then it happened. In 1853 Sir George Cayley designed the first sky sail wing and had it flown successfully by his skeptical and frightened coachman. The poor servant took off from a cliff overlooking a valley near Brompton Hall, Yorkshire, England, and flew it across to the other side, a distance of about fifteen hundred feet. Having had very little experience in handling the wing, the coachman panicked as he approached the other side and plowed into the turf, demolishing the machine. Terrified, but miraculously unhurt, he surveyed the path of his flight and quickly resigned his post as Cayley's coachman and pilot. The first flier disappeared into obscurity, grateful to have escaped with his life.

Others soon followed. . . .



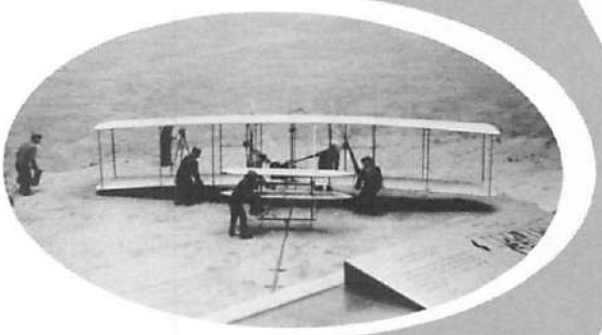


THE heat of the 1800s brought the butterflies out of their cocoons. In a span of fifty years the dreamers were airborne. From Cayley's flight in 1853 to the Wrights' chilly December adventure in 1903 on Kill Devil Hills at Kitty Hawk, the wings of man tentatively unfolded, stretched, and finally achieved the heavens. The ghosts of all those who had failed helped support those fragile wood and fabric wings of the victors.

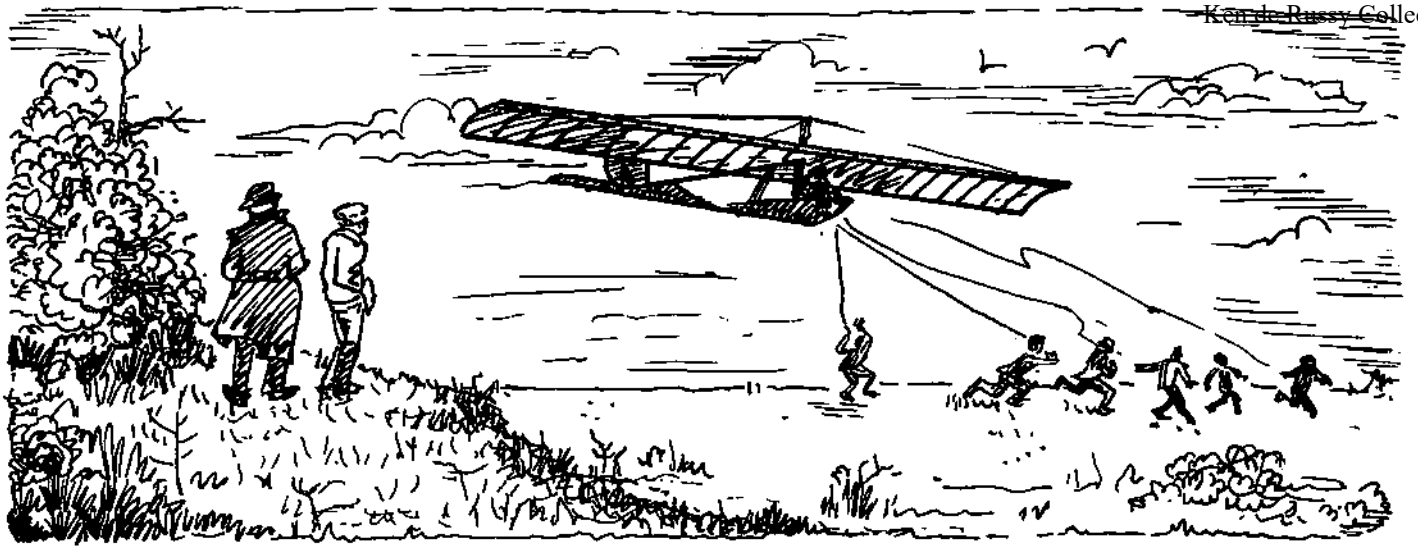
The men who achieved flight were a selfless lot. Nearly all of them died penniless. They applied for, and in many cases were granted, patents, but in the final analysis the early victors were eaten alive by the promoters and businessmen. Aviation became a carnival. Everyone tried to get into the act and the dreamers were left behind while technology took over center stage. Within the next sixty years, powered flight would take airmen to the moon. All but forgotten were the low and slow concepts of flight. Speed was macho. Speed was glory. Speed was everything.

Pioneers of Flight—Self Launch Gliders

1797	Garnerin Brothers	First successful parachute flight.
1853	Sir George Cayley	First aircraft glider launched.
1856	Le Bris	Developed lift function of wings, and flew one incorporating his design features.
1866	British Aeronautical Society founded	
1883	John J. Montgomery	First controlled flight in California.
1889	Otto Lilienthal	Made over 2000 flights in his glider monoplanes in Germany. Wrote extensively on flying.
1890	Clement Ader	Flew the "Ecole" in France.
1892	Louis Pierre Mouillard	Launched successfully in Egypt.
1893	Percy Pilcher	Flew at Cardoss, Scotland.
1895	Octave Chanute	Flew at Dune Park, Indiana. Made over 7000 flights.
(powered flight)		
1903	Wright Brothers	First powered flight at Kitty Hawk.

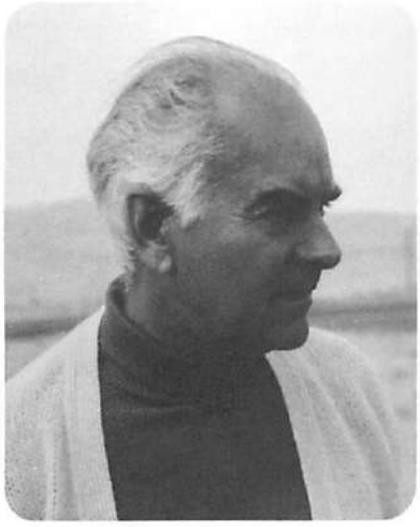


The Wright Brothers' Flyer I—the first powered heavier-than-air vehicle. It flew 120 feet in twelve seconds on its first powered flight at Kitty Hawk. Flyer I was powered by a four-cylinder engine and had an air frame made of wood and cotton.



The early glider enthusiasts counted on a lot of help from their friends. The group here is assisting a launch with elasticized (bungee) lines.

IN the new age of speed not all the engineers and scientists were sucked into the gaping maws of the jet engine. A lonely few ignored the contrails in the sky and began thinking about quiet, gentle, unpowered soaring. There was little or no commercial value to their efforts, so they were left to spend their time unnoticed by all but a few enthusiasts. Small soaring clubs sprang up around the world and remained isolated and virtually anonymous. They whittled and polished their sailplanes to a fine degree of perfection. The planes were expensive to build and required crews and a towing vehicle to launch. But they set soaring records of hundreds of miles without the aid of engines. This new breed of birdman, the soaring pilot, turned to the works of the pioneers of the 1800s and began to study their observations and findings about gliding. This rediscovered wealth of information opened up a new avenue to sport flying. The engineers and technicians, after putting away their slide rules and calculus tables at the end of the day at the huge aircraft factories, went back to the shed or garage and began tinkering with wood and fabric. Soon new versions of the old designs appeared on the hills and beaches. Not many, but enough to begin to capture the imaginations of those who watched and marveled.



A recent photograph of Francis M. Rogallo. He and his wife invented the flexible wing.

One of the fascinated scientists was Francis M. Rogallo, an aeronautical research scientist employed by the Langley Research Center, a division of the National Advisory Committee for Aeronautics (soon to become NASA). Kite flying had been one of Rogallo's hobbies since childhood, and it was this hobby that inspired him to become an aeronautical engineer. When he applied his technical knowledge to his old hobby, he became dissatisfied with the kite designs of the past. He had other ideas. Rogallo was not a pilot but a thinker. Like da Vinci, he questioned the design of the conventional rigid wings on low speed aircraft. They were, in some cases, a hindrance. A rigid wing is impossible to dismantle. Moreover, they are subject to windstorm damage on the ground. In order to protect them one needs a large hangar for storage.

Rogallo drew diagram after diagram searching for a design for an aircraft wing that could be easily dismantled and stored in a bag. He wanted to combine the shape of the supersonic airplane with the collapsible canopy of the parachute. There were heady theoretical problems to overcome. The parachute had the fold-up qualities he was looking for, but its function was in opposition to the solution. The parachute was designed to cushion the inevitable fall of an object; it was not designed to glide or remain airborne for any great length of time.

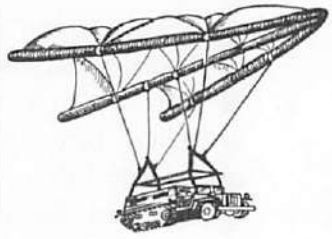
Rogallo and his wife, Gertrude, began by making paper models and tossing them into the air like gliders. They attached threads to various locations on their models and twirled them about their living room. When one flew better than the others they made a larger version out of cloth and tested its flying qualities at their seashore summer cottage at Hampton Roads, Virginia. Back and forth they went between the two locations, testing model after model, adding new refinements and discarding the failures. They worked evenings and weekends and finally one of their experimental versions flew. They set about improving it. Weekends were no longer enough time. With a 36-inch fan Rogallo built a wind tunnel in their living room. They could now devote every free moment to refining that flying model. He drew plans for modifications and she cut the cloth and sewed the pieces together.

Francis M. Rogallo flies the original 1948 model of the flexible wing. From this flying model the first patents were granted.

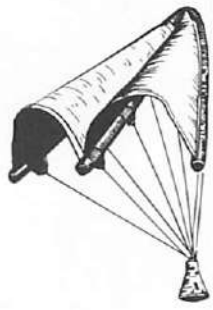
In 1948 Mrs. Rogallo traced the latest drawing onto a left-over piece of a flowered chintz curtain. She cut it out and stitched it together. They then attached the necessary strings and raided their children's toy chest for a plastic astronaut. When the toy was tied to the strings on the model, Rogallo held the wing over his head and released his grip. It flew perfectly. And it flew consistently—in the wind tunnel, on the beach, in high and low winds. The Rogallos had invented a completely new aircraft design—the flexible wing. Many patents were filed. The

Model of the flexible wing with a curved and tapered inflated frame being tested in Langley wind tunnel.

Manned paraglider. This version of the Rogallo has been flown numerous times by several pilots. All flights succesful.



Tow gliders—military vehicles under tow suspended beneath a Rogallo wing.

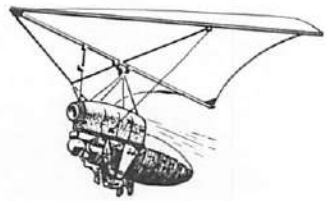


Inflated frame paraglider—50-foot Rogallo carrying a weight of 3,000 lbs (Mercury capsule). Maneuvered by radio controls.

Photo reconnaissance drone. Photos of ground objects were taken with these radio controlled Marine Corps drones.

Fleep (flying jeep) test models have been flown for over twenty-five hours. The Ryan Aircraft Company is doing research on the design.

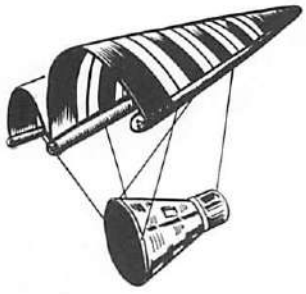
Thomas H Purcell, Jr., was among the first to fly a flex-wing airplane. Here he flies his flying boat design.



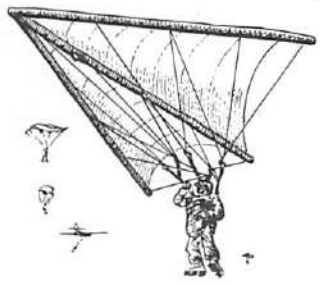
Emergency wings—a parachute substitute. An ejection seat with a jet engine attached enables the pilot to fly with a second set of wings.

first was granted in 1951, the second in 1956. A NASA report revealed: "The Rogallos have created a completely flexible lifting surface with a parachute-like tension structure in which the wing surface shape is maintained by the balance of forces between the air load on the surface and the tension in the suspension lines."

Rogallo tried to convince the aeronautical community that his flexible paraglider would be ideally suited as a reentry glider for NASA's space program. His words fell on deaf ears and little serious interest was shown. Then Russia launched Sputnik I and things began to happen. The Langley Committee on General Aerodynamics hurriedly requested Rogallo to move forward with his research and studies. From 1958 to 1972 NASA and their contractors and the Department of Defense spent over 100 million dollars on the application of the Rogallos' flexible wing invention. With the government spending a fortune on research and development, it wasn't long before news of the radically new wing concept leaked out. Versions of the Rogallos' flexible wing began to appear on the market place.

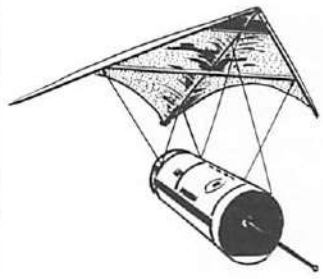


Air drop flexi-wing. A 4,000 sq ft wing carrying a loaded Gemini capsule weighing over 6,000 lbs. Radio guided to landing.

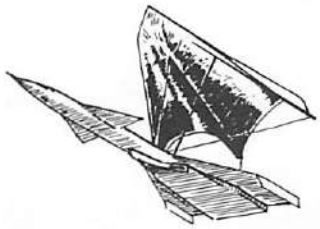


Precision paraglider being tested by the military. To be controlled by men and carried on the back like a parachute.

Paraglider to be lofted at an altitude of 700,000 feet by rocket to record micrometeoroid impacts on the sail.



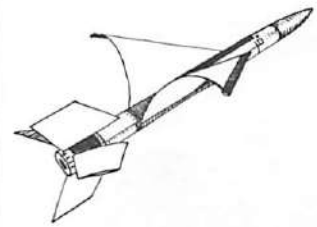
Rocket booster recovery paraglider—radio controlled after separation from rocket package for safe earth return.



Flexi-wing applied to a multi-passenger jet. If an accident occurs in flight, the Rogallo wing would deploy for a slow, safe landing.

Gliding parachute here being used for towing or drop-launching cargo. Precise landings are controlled by radio signals.

Rogallo wings on rocket. The wings are designed into the rocket assembly. The vanes on the top are for steering.



Foldable flexible wings. In descent the wings are unfolded for controlled glide to a chosen landing site.

The Sky Sail

To see a strange, delta-winged object soundlessly floating through the air with a person wiggling beneath it, as though held by the claws of a huge prehistoric bird, is an awesome sight indeed. Incredible as it may seem, it is an apparition that is occurring with increasing frequency throughout the country. On many occasions where this vision has appeared fluttering over a turnpike or expressway, motorists have jammed the roadways to get a better look. The spectators cluster around their parked cars and, shielding their eyes from the glaring sun, are oblivious to all entreaties from the police to move on. Finally, the fearless, smiling visitor from the sky marches up to the highway, his sail held high over his head, and breathlessly answers questions being hurled at him by the admiring spectators. The police mill about their patrol cars, shouting into crackling radios and scratching their heads, trying to figure out what law this birdman has broken. Happily, none.
So it has finally happened. . . . .

Man sailing aloft under his own power is no longer a dream.

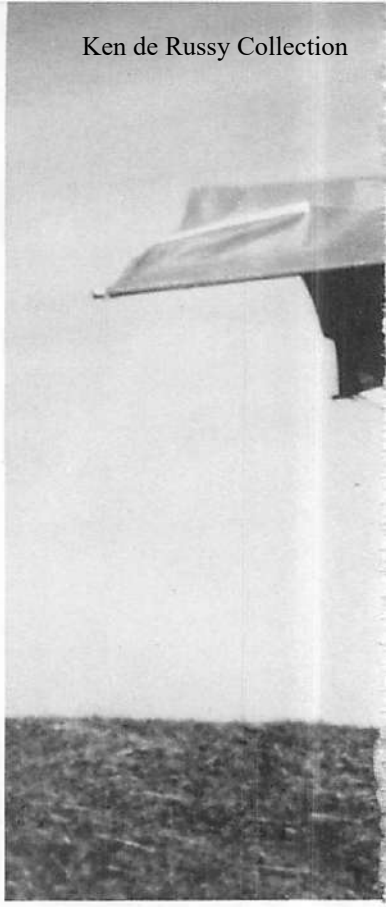
Let's take a closer look at his wings. . . .

ONCE the flexible wing formula was released to the public by NASA the adventurers who wanted to fly quickly scaled down the government's findings to the smaller size that we see today. A new era of manned flight was born.

What did the blinking eyes and transistorized memory banks of the governments' computers discover that man up to this time had been unable to see? A remarkably simple diamond-shaped wing with twin conical sails that had the same flight characteristics regardless of its size and, when scaled down and mounted on a simple rigid frame, was inexpensive to make, completely portable by one person, and could be flown from any hill that had a gentle wind blowing up its slope.

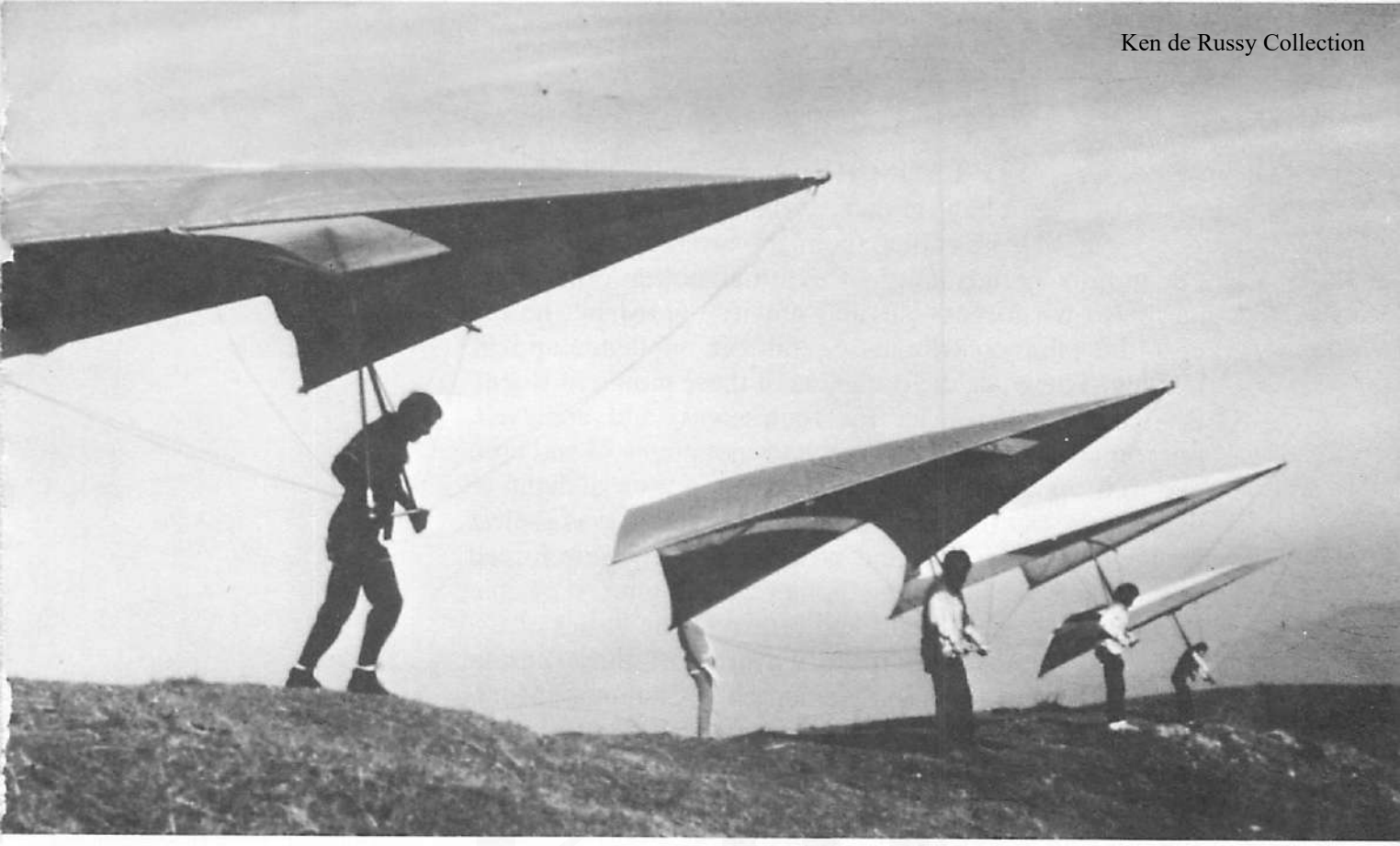
When the early sky sailing innovators charged down a hill with their miniature versions of the Rogallo NASA wing held over their heads, they discovered that after only a few steps they were airborne. Not being experienced pilots, many of them simply held on and let the wing make its own flight path. In situations where they made a mistake and held the nose too high for too long the sail simply parachuted the pilot back to earth. They quickly began to discover the flight characteristics of the sail. It would level itself rather than stall out. It would fly straight forward rather than dip a wing and spiral down when caught in a cross wind. When the pilot shifted his weight, the sail would quickly respond by turning in the direction of the weight shift. These smaller sails had the same performance characteristics as the larger NASA Rogallo wings. In these early versions, the builders attached parallel bars to their sails. The pilots supported themselves by draping their arms over the bars. It wasn't until a year or two later that the triangular trapeze bar, which had been developed for water-ski-kite-fliers in Australia, replaced the bulky parallel bars and the swing seat emerged.

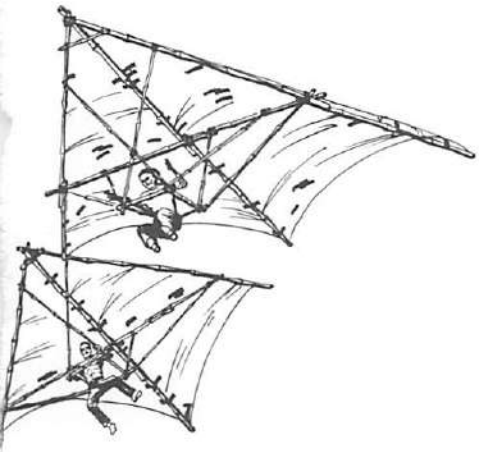
The success of these early crude sky sails stimulated a flurry of activity. The dreamers put their slide rules and pencils away and retired to the barn with their NASA statistics, their hacksaws, and drills. They emerged with bruised knuckles and a flying wing that would carry them



Ken de Russy Collection

Vintage Rogallos—1971—four of the original Rogallo fliers in the San Francisco bay area. Left to right: Gerry Ross, Dave Kilbourne, Kent Shaw, and Donnita Holland line up to launch from Mission Hills. Notice the slack lower rigging cables and the absence of a king post on the top of the sails. Design has come a long way since then.



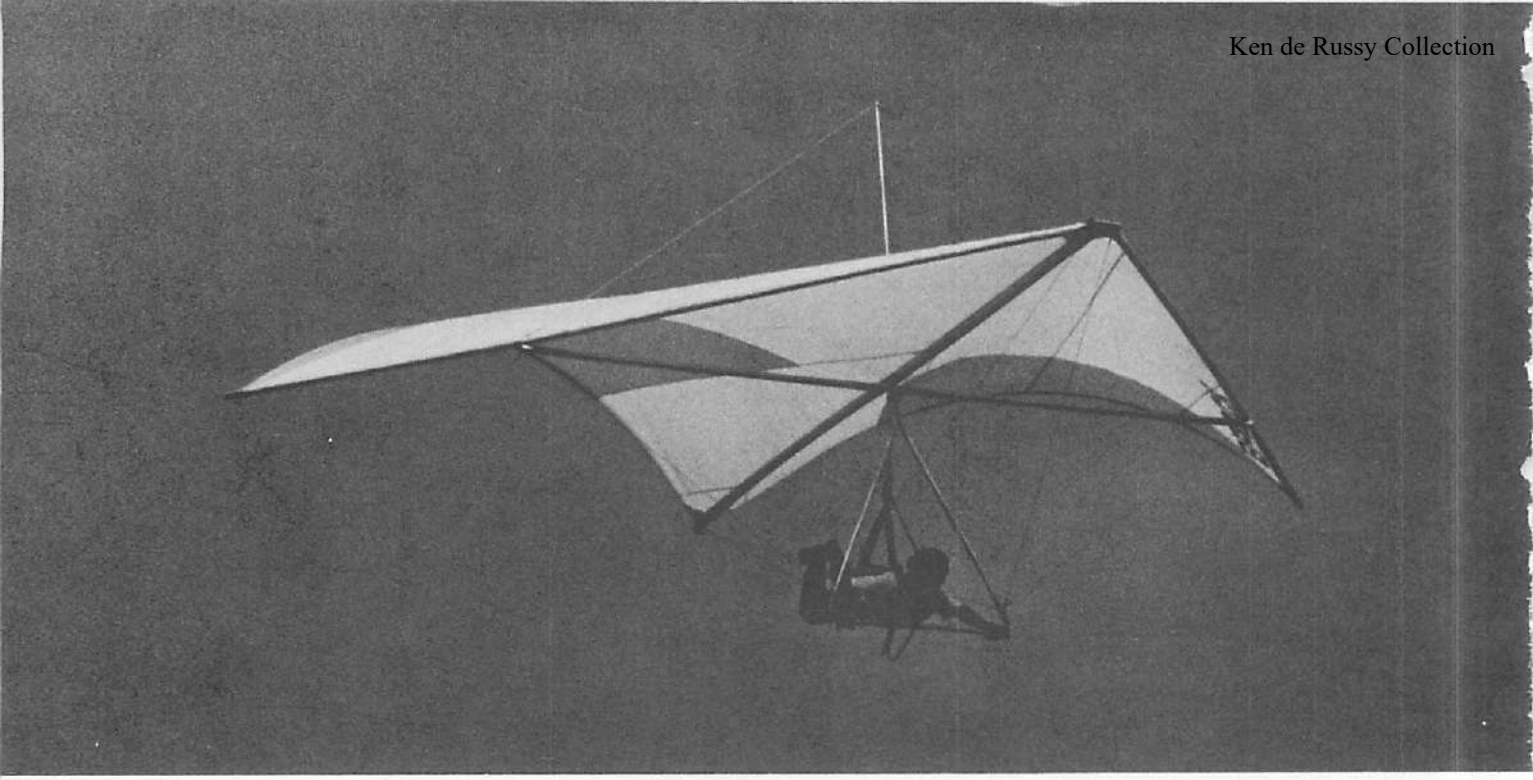


A sketch of Bob and Chris Wills low-and-slow flying their bamboo and plastic Rogallos. Notice the parallel bar controls and all that tape on the wings.

beyond their dreams; a flying wing that was to become the basic piece of equipment for the sport of hang gliding. Designers, engineers, and private companies began to file "improved" and "modified" versions of the Rogallo.

At the end of the sixties the Californians got hold of the Rogallo design, and it wasn't long until the surfers began to have some competition on the beaches. Bamboo and plastic versions of the Rogallo began to appear along the length of the California coastline. Their fliers had more guts than sense; their crafts seemed about as sturdy as toothpick constructions. But sandy beaches are forgiving crash sites, and the sport began to flourish. Each week brought more and more fliers to the launch sites. Torrey Pines, Redondo Beach, Playa del Ray became places to go to watch the crazy guys who jump off sand dunes holding huge kites over their heads.

The Rogallo sky sail was truly a self-soaring machine that was simple to construct and maintain. The wing was lightweight and had great strength combined with sensitive control. It flew very well.



Ken de Russy Collection

The Rogallo Sky Sail

THE Rogallo wing is a feather plucked from the wings of Daedalus. Its design is deceptively simple, yet the flying ability of this delta sail is remarkable. Immediately upon launching a Rogallo wing, the air current passing across the gleaming nose plate picks up a track across the top and bottom of the loose fabric and quickly billows it out into a twin conical shape. This air current lifts the wing into the air. The Rogallo sail is half parachute and half glider. This dual personality makes it extremely stable at low flying speeds. At such low speeds, the wing has a tendency to resemble a leaf fluttering gently back to earth on a still autumn day. The soft landing is one of the main reasons this wing is the easiest craft to train and fly with. This facility of handling especially in landing maneuvers is why the Rogallo leads the field in quantity and quality of the sky sails being flown today.