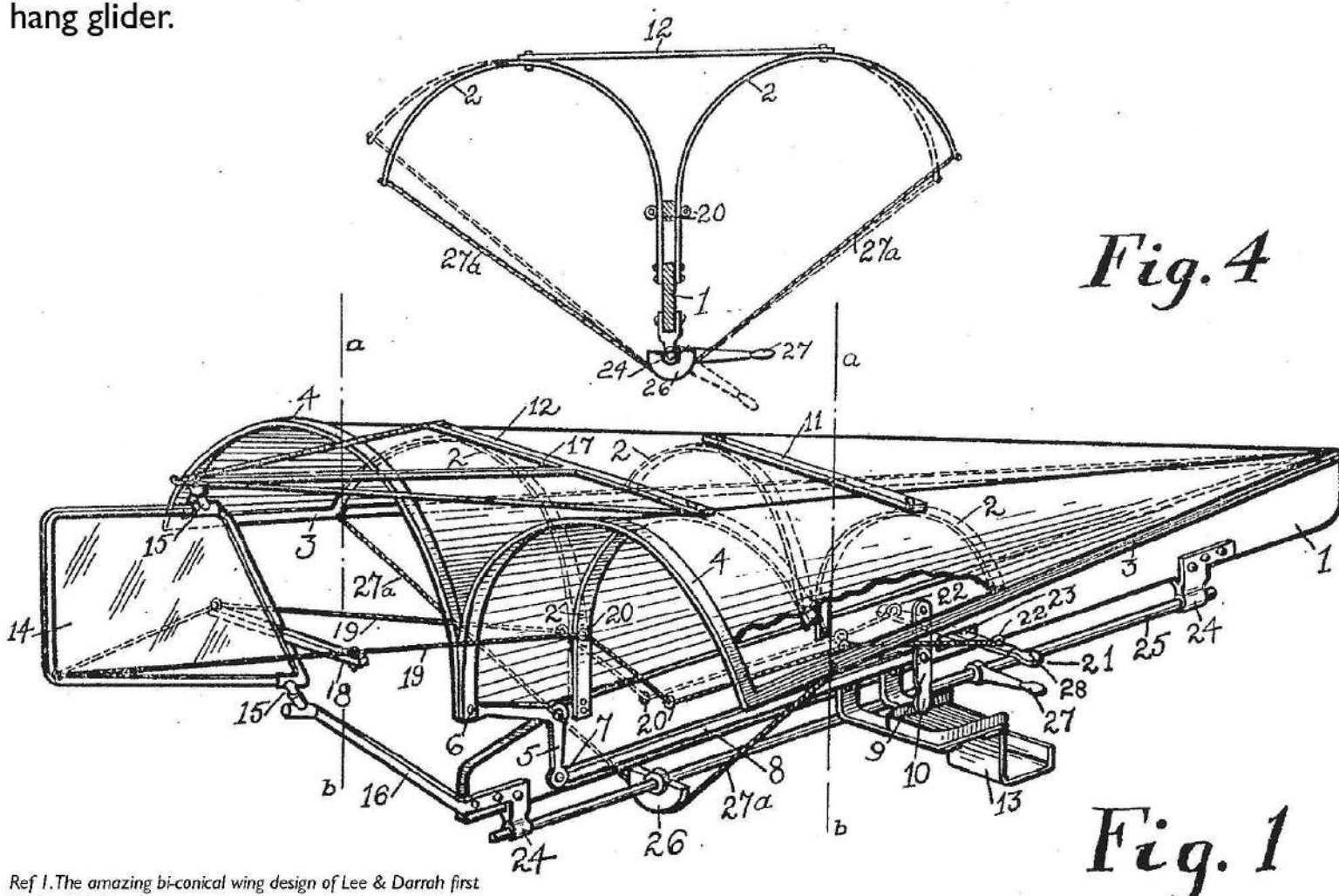


Did we really fly Rogallo wings?

Mark Woodhams and Graeme Henderson look at the first design ideas and patents that led to the development of the flexible wing hang glider.



Ref 1. The amazing bi-conical wing design of Lee & Darrah first filed in 1910.

989,786.

Fig. 4

U. G. LEE & W. A. DARRAH.
FLYING MACHINE.
APPLICATION FILED FEB. 16, 1910.

Patented Apr. 18, 1911.

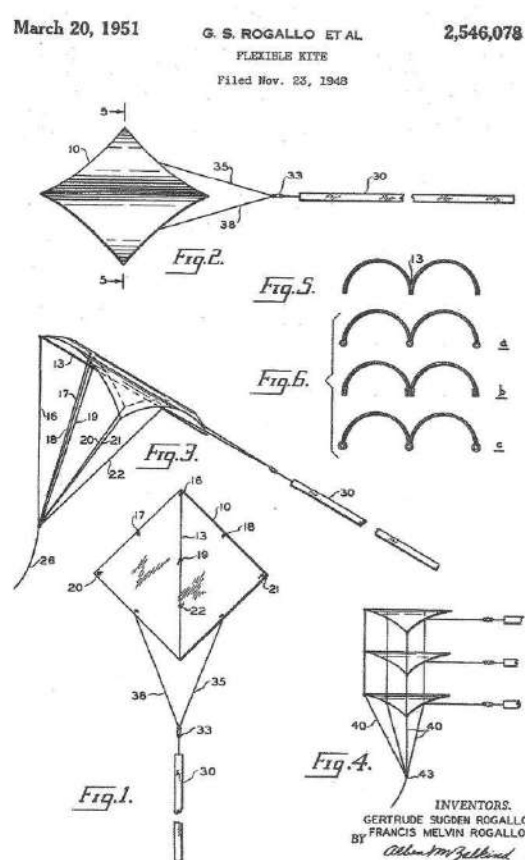
2 SHEETS-SHEET 1.

Fig. 1

When I first saw a print of the original 1948 Rogallo patent for a flexible kite, (Ref 2) I was struck by how much it didn't look like a hang glider. I came into the sport in 1974 and the hang gliders we flew then were called 'standard

Rogallos'. The conventional wisdom then was that Dr Francis Rogallo designed the first flexible wing, and under his direction this wing was developed at NASA for use in returning space capsules back to land from Earth orbit. Subsequently NASA dropped the Rogallo wing in favour of clusters of conventional round parachutes for returning capsules to the oceans, but not before photographs of Rogallo wings were released to the press, a willing band of home-builders seized upon the idea of 'popular aviation' and hang gliding was born. And when I say born, I mean born in the USA.

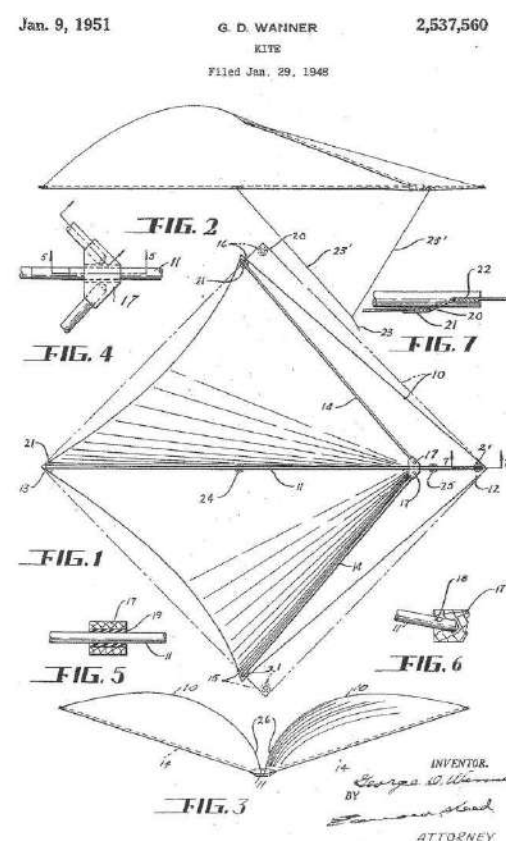
of a combination auto-airplane. When the airplane alighted, the wing would simply be folded up, chucked into the baggage compartment and forgotten.' Rogallo had been invited to contribute to this publication, we assume, because of his expressed



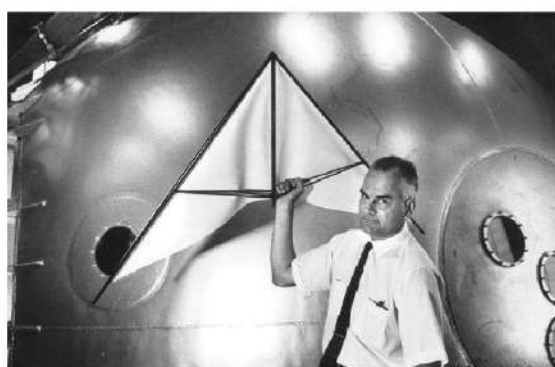
Ref 2. The original 1948 Rogallo patent that supposedly led to the sport of hang gliding.

A bit of digging showed that it didn't happen quite like that. The original flexible wing design with Rogallo's name on it, or actually Mr and Mrs Rogallo's name on it, was filed for patent on November 23, 1948 and bore the number 2,546,078. This was for a completely flexible kite whose canopy shape was supposed to be created by the balance of aerodynamic forces pulling upwards against the bridle lines pulling downwards. If the material was too limp the only allowable stiffening in the patent drawings and text was along the keel and all the way round the edges of both leading and trailing edges. The hatched lines in fig 3 of the actual patent drawing show where this stiffening might occur.

When Rogallo wrote about these early designs it is quite clear that what really interested him was the idea of creating a flying aerofoil that was completely flexible, without any hard structure within the membrane sail to support it. He talked in his March 1951 article in the Ford Motor Company's 'Ford Times' of the 'intriguing possibility of using this non-rigid wing as the lifting component



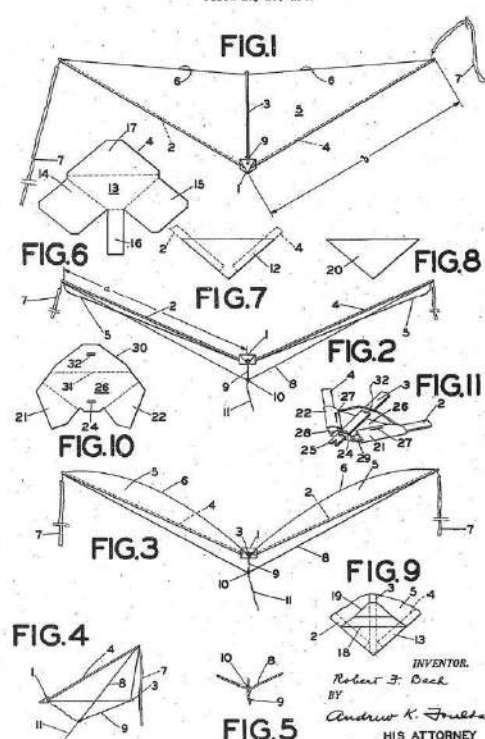
Ref 3. The kite design of G.D. Wanner that bears a remarkable resemblance to a hang glider wing.



March 1, 1949.

R. F. BACH
"FLYING WING" KITE
Filed May 29, 1947

2,463,135



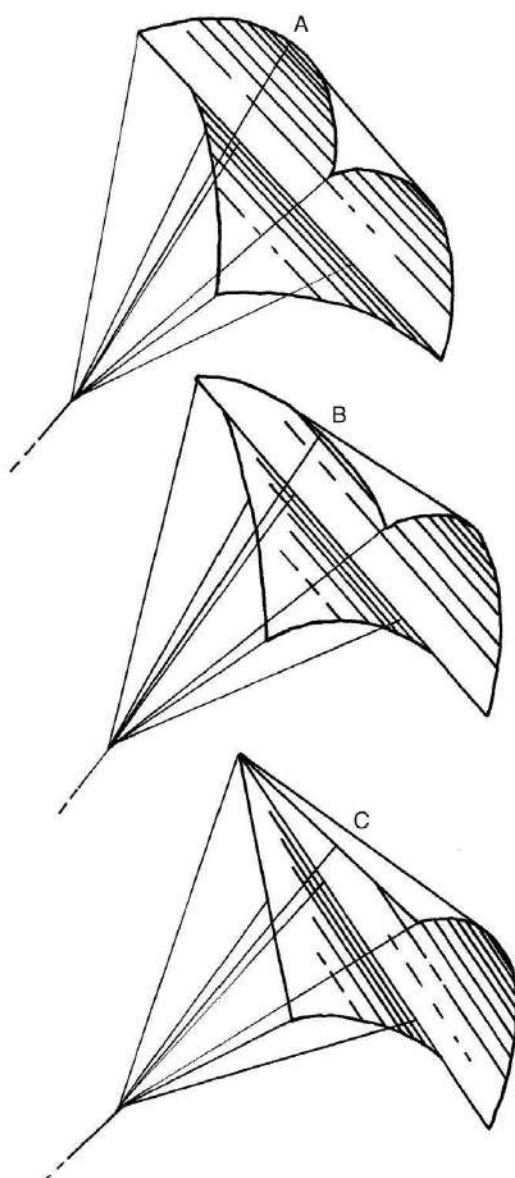
Ref 4. The high aspect ratio kite design of R. F. Bach and a later flexible wing design held aloft by Francis Rogallo show marked similarities. (photo NASA)

ambition for his invention to be used as a combination auto-aeroplane.

The Rogallo patent text insists that whatever is used to stiffen or reinforce the kite surface, the resulting shape must be 'symmetrically arcuate'. That is to say, viewed from the front, the leading and trailing edges should be the same curved shape. This particular shape is known as 'bi-cylindrical', because each of the two sides or wings of the kite can be seen as forming part of two parallel cylinders (see A in Ref 5). The Rogallo patented no other kite design that related in any way to hang gliders – but plenty of others did.

For instance G. D. Wanner, in patent number 2,537,560, filed January 29, 1948 – some time before the Rogallo patent was filed, describes a remarkable kite design that does look very like an early flexible wing hang glider's wing. And R. F. Bach's even earlier kite patent filed May 29, 1947, again looks much more like a hang glider, albeit a high aspect ratio version. As an avowed kite enthusiast, it is unlikely that Rogallo was ignorant of these designs but at that time they were not particularly relevant to him because the Rogallo design was totally flexible and 'bi-cylindrical'.

So why on Earth were the early flexible wing hang gliders called 'standard Rogallos' and not standard Wanners, or standard Bachs? The main reason seems to be that Sputnik 1's launch by the Russians in October 1957 inaugurated the space race between the superpowers to the extent that NASA presided over a huge research budget dedicated to launching space vehicles and returning them safely to Earth. Rogallo worked for NASA and held the patent for a flexible kite that looked as if it might provide a steerable and



Ref 5. The effect of shortening the mid leading edge bridle line converts the wing from bi-cylindrical to bi-conical. (diagram © Mark Woodhams)

landable alternative to parachuting capsules into dangerous and potentially inaccessible oceans. Rogallo had already offered NASA access to his privately held patent and been turned down, but now they saw his invention as a possible substitute option to the problem of returning an unguided round canopy payload into a hostile environment.

More research and development of flexible wings

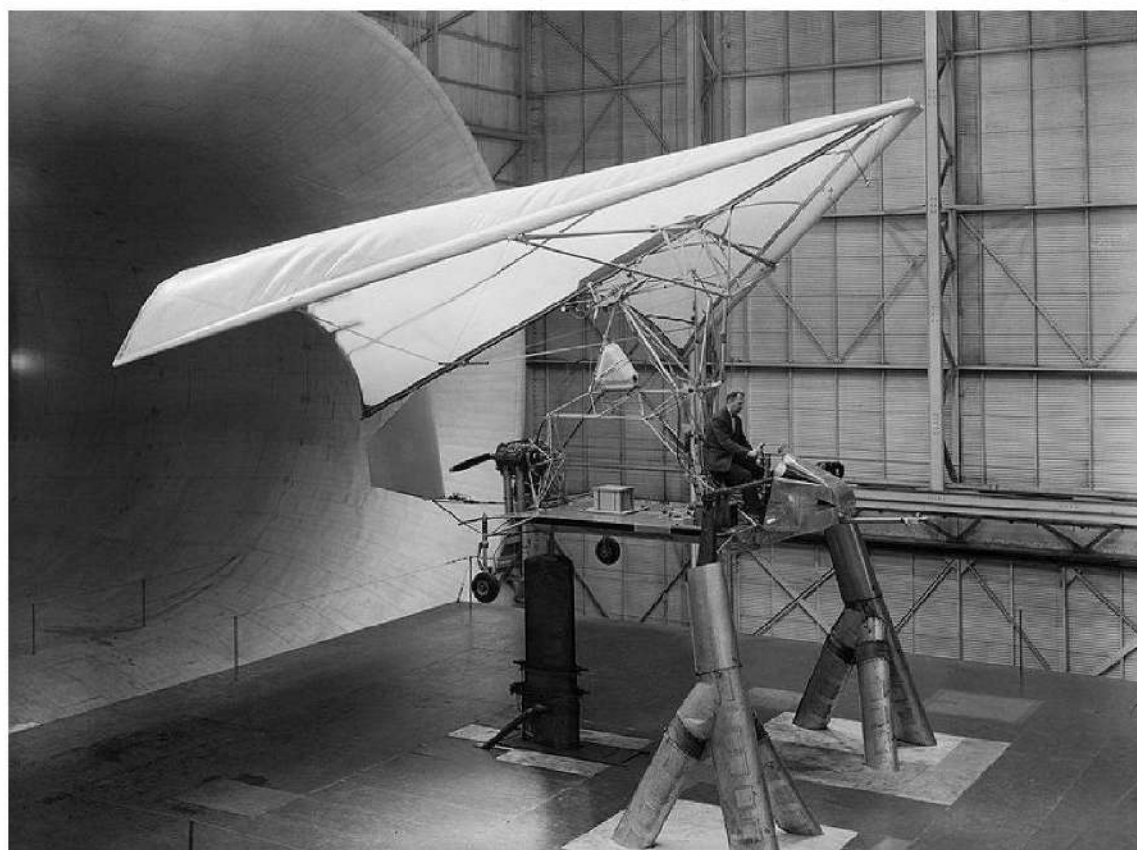
was carried out then than at any other time in history. Literally millions of dollars were spent. It is ironic that the flexible wing only really came of age after NASA abandoned it to the enthusiasts and back-yard builders. Whilst Rogallo's patent may not have led directly to the flexible wing hang glider, the work carried out at NASA as a result of his championing the whole gamut of braced and unbraced flexible wings created an industry which for about fifteen years explored the concept in complete detail. The earlier designs of Wanner and Bach were deemed by history as small beer compared to this effort.

The development teams at NASA discovered that the kite described in the 1948 Rogallo patent did not work well for the applications they were designing. The leading edges and keel needed to be stiffened independent of the trailing edge which was left free to billow against the aerodynamic load initially, and finally to have the billow of the sail fixed at a given slackness by a cross boom. In a relatively short time the flexible wings that NASA were developing bore little resemblance to the original Rogallo patent.

I have found no photograph of any Rogallo designed kite that resembles the 'bi-cylindrical' design shown in the 1948 patent. Most of the images of Rogallo kites of the 1950s relate to kites that are known as 'bi-conical', because each of the two sides or wings of the kite can be seen as forming part of two converging cones. However, it can be shown that the 'bi-cylindrical' design can be converted to the 'bi-conical' design by re-rigging the bridle lines so that the leading edges are held straight. The resulting shape does indeed resemble an early hang glider canopy, but 'bi-conical' kite designs are not the subject of the original Rogallo patent. Ref 5 shows how straightening the leading edges of the kite can transform the kite design from 'bi-cylindrical' to 'bi-conical'.

As an experiment specifically for this article I constructed a replica kite as close to the 1948 Rogallo patent as I could. Mylar didn't become available until 1953 so I used a plasticised shower curtain for the body of the kite, and Rogallo has mentioned this sort of material in some of his early documents. I followed the drawings and text of the original patent as closely as I could.

The top photo in Ref 7 has no stiffening within the body of the kite at all, and I have to say that



Ref 6. The resemblance of the Ryan Aeronautical Co's 'Flex-Wing' of 1961 to the 1910 Lee & Darrah design is inescapable. (photo NASA)

it was not a success. In low winds it hung in the air with the front fairly distorted due to the material's inability to resist the compression loads exerted longitudinally along the keel. I feel that Mylar might have been stiff enough to resist this buckling, or perhaps a heavier shower curtain would have had the same effect, but then how flexible is flexible?

The middle photo shows exactly the same kite and bridles but with the keel stiffened, in this case with thin wooden dowel. This degree of stiffening is allowable within the terms of the 1948 patent. The kite flew better but I noticed that left to its own devices the leading edges wanted to become more curved than the trailing edge. Restraining the leading edge by shortening the mid-edge bridle merely distorted the shape it wanted to be. It was as if the kite was trying to behave like a 'sled' type kite design.

The bottom photo shows the same kite but this time both the keel and the leading edges have been reinforced with thin wood dowel, and the resulting kite departs markedly from the patent description. The leading edge bridle lengths had to be altered and of course the kite has become bi-conical. The experiment does not absolutely prove that there were stability problems with the original all-flexible kite, but I certainly could not get it to perform very well.

Rogallo's FlexiKite range of kites which were sold for a time in the later 1950s, were rigged

as 'bi-conical' wings and made of the new DuPont wonder material 'Mylar'. This material had the advantage that it was sufficiently stiff that the keel and leading edges needed no extra reinforcement. However, its relative stiffness and the loss of 'symmetrical arcuateness' in the kite design diverged considerably from the original patent and almost certainly lost its protection. Rogallo never patented the new design and there seem to be several good reasons for this. These were of course the pre-existing patents of Wanner and Bach, but perhaps more importantly the amazing patent 989,786 of U. G. Lee and W.A. Darrah first filed February 15, 1910! (shown at the beginning of this article).

The flying machine shown in the Lee and Darrah patent drawing is clearly the forerunner of the 'bi-conical' wing. Perhaps the biggest clue of all is given in patent number 3,140,842 of 1961 which is for the design of the 'Flex-Wing' by Ryan Aeronautical Co's designer/engineers Craig, James and Hand. The references cited in the file of their patent specifically indicate the influence of the Lee and Darrah patent. Indeed Rogallo himself specifically cites the Lee and Darrah patent in two subsequent patent applications. Within the text of the Ryan/Craig

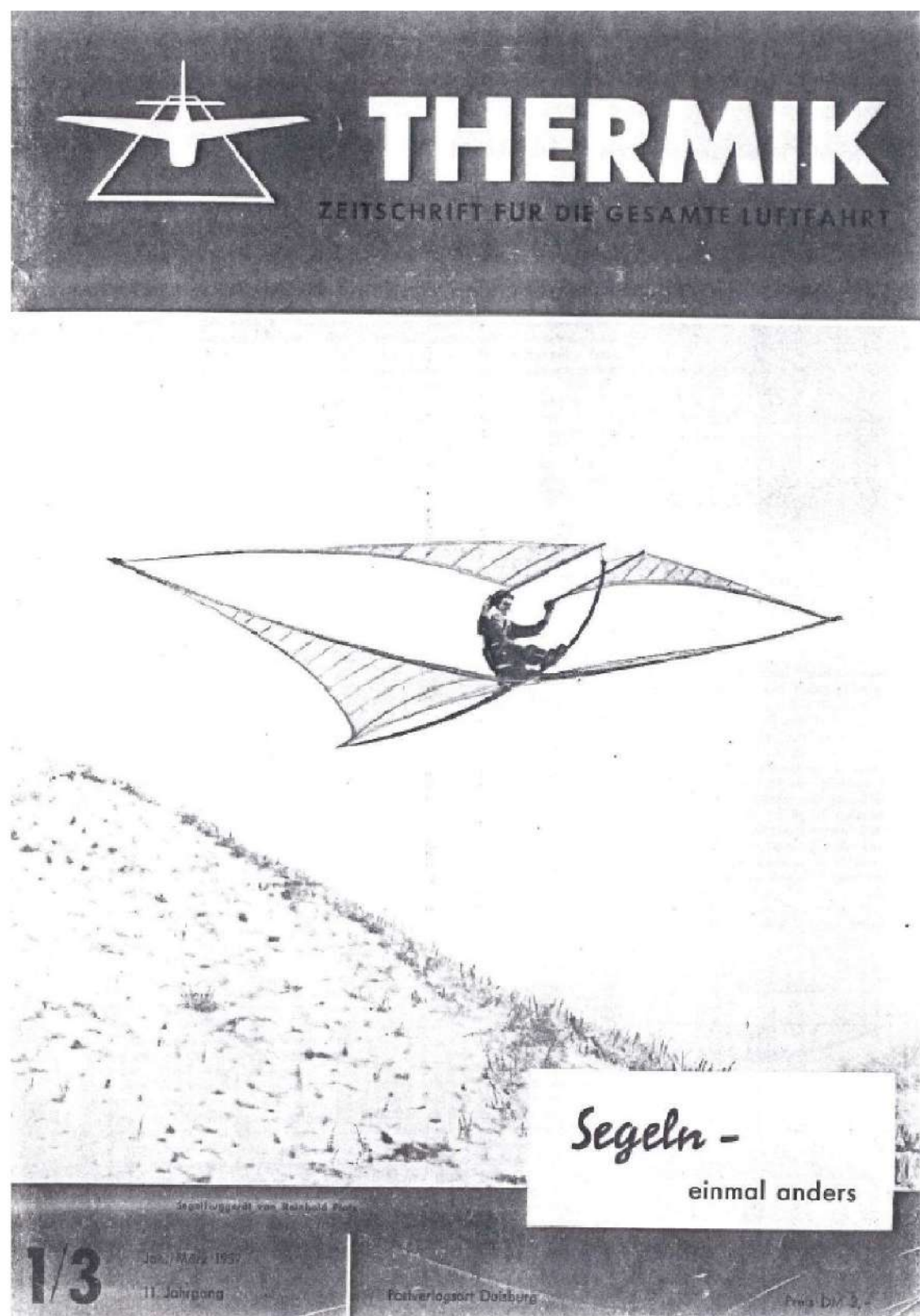
patent, reference is also made to the wing of the 'Flex-Wing' as a development of the original Rogallo patent 2,546,078 – which it clearly is not, because it used 'bi-conical' flexible wings. Since the 'Flex-Wing' was subject of a NASA contract to Ryan Aeronautical and one of the existing flexible wings developed by NASA called Parasev had already evolved to include stiff leading edges and keel, one must assume that Ryan thought the flexible 'bi-conical' wing was a specifically Rogallo or NASA invention.

Another reason for the association of the name Rogallo with flexible wing hang gliders was his willingness to be allied with promoting the concept of all flexible aerofoils. The document "Flexible Wing Research and Development", presented in 1962, shows that Rogallo's name was already becoming generic to the whole range of flexible wing vehicles described.

Within the presentation Rogallo appears to be distancing himself from this generic use, but by 1972, when one of the more widely read presentation documents entitled "Flexible Wings for Transportation" was published, the struggle for accurate terminology is still apparent. Paraglider, Parawing, All-flexible parawing, Gliding



Ref 7. Top: Rogallo replica kite without any stiffening. Middle: Exactly the same kite but with keel stiffening only. Bottom: The same kite but with leading edge and keel stiffening and rigged as a bi-conical wing.



Ref 8. The 1922 Platz sailwing design was subject of an extensive article in the 1959 issue of 'Thermik'.



Ref 9. John Dickenson flying his glider design in 1965 in the form which became known as the standard Rogallo.
(photo courtesy Rod Fuller)

parachute, Fabric wing and Flexible wing are all terms used within the NASA reports and presentations. History seems to have decided that the name Rogallo wing is to be the 'catch all' to describe the many flexible wing variants explored by NASA, despite the fact that the original 1948 patent that Rogallo owned was for a design that wasn't used.

Rogallo was the author of the 1972 "Flexible Wings for Transportation" and he instances the flights of Americans Barry Hill Palmer and Dave Kilbourne, particularly within a section on hang gliding developments. No mention is made of the pioneering work of Australian John Dickenson, or even of fellow Australian Bill Bennett who introduced the Dickenson-designed flexible wing hang glider to the USA in 1969. John's design with its control triangle, folding cross boom and leading edges, and weight shift swing seat subsequently became known as the 'standard Rogallo' worldwide. Not only did Rogallo know of Dickenson's hang glider development in 1963 but the two corresponded quite regularly for a number of years. In fact Rogallo initiated the communication with Dickenson in 1964 and requested copies of the Australian's design and offered to buy a manufactured example. In response to Rogallo's request, Dickenson sent complete drawings and specifications to him in November 1964. In January 1965 Rogallo confirmed receipt of the documents and intimated that 'he or some local groups might build a glider like yours locally'. I have dated copies of the correspondence between the two men.

The attachment of Rogallo's name to flexible wing hang gliders was also promoted by others. The seminal west coast magazine "Low & Slow", published and edited by Joe Faust, went so far



Ref 10. The only known photograph of the 1904 Lavezzari flexible wing hang glider.

as to describe in volume 23 from 1973, both the Platz Sailwing of 1922 and the Lavezzari hang glider circa 1904 as Rogallo wings! Of course these European flexible wings pre-date Rogallo's version by several decades.

The Lavezzari glider is a bit of a mystery as we have a date and one photograph, and very little else. That it was a flexible wing hang glider there can be little doubt, but as to its performance and mode of control there is hardly a clue, and it certainly didn't enjoy further publicity. However, the Platz Sailwing designed by Fokker chief designer Reinhold Platz in 1922 has a very well documented history. It flew and soared successfully, was portable, and had a keel and two leading edges supporting a flexible wing. As far as I can discover Platz never applied for a patent for the design but, curiously, Conrad Dahl of Springfield, Ohio in the States patented a kite of very similar design in 1927.

Rogallo's private and independent kite design work was drawn into the public arena in 1958 when NASA formed the Flexible-Wing Section of Langley Research Centre. The research that followed was conducted by NASA themselves, and by the Ryan Aeronautical Co, North American, McDonnell, Flight Dynamics and Goodyear to whom many research contracts were awarded. It was the aeronautical designers and engineers within these companies who transformed the kite designs of the Rogallos and of course of the other influential designers, into the flexible wing aircraft that inspired the likes of Barry Hill Palmer and John Dickenson.

And it is to John Dickenson that the modern flexible wing hang glider can truly be attributed. The 'standard Rogallo' was his invention and became the standard form for a generation of hang glider designs that followed. He had a provisional patent filed in October 1963. The glider was designed in Australia, imported to America in 1969, and continues to be the chosen control interface for most hang gliders today.

So did we really fly 'Rogallo' wings? Not really, and in fairness Rogallo never directly claimed to have invented the wing we flew, but it is unlikely that modern hang gliding would have happened without his influence. Ironically the first design patent for a flexible wing hang glider was

awarded to Australian Bill Bennett in 1972, and as he admitted in the recent Bill Liscomb film "Big Blue Sky", that patent in truth belonged to John Dickenson.

I am indebted to Graeme Henderson for his tireless research into the many patents that apply to both kites, flexible wing vehicles and flying machines. His work in unearthing the NASA reports and presentations has been vital in the construction of this article, and I am particularly grateful to his constant availability to me via the internet.

Useful links:

www.johndickenson.net
www.australian-hang-gliding-history.com
www.british-hang-gliding-history.com
www.british-hang-gliding-museum.co.uk
www.freepatentsonline.com

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United States Patent Office

Des. 224,248
Patented July 11, 1972

224,248
PASSENGER CARRYING TOW KITE
William Edward Bennett, 12081 Gerald Ave.,
Granada Hills, Calif. 91344
Filed Sept. 24, 1969, Ser. No. 15,272
Term of patent 14 years
Int. Cl. B11-07
U.S. Cl. 234-18

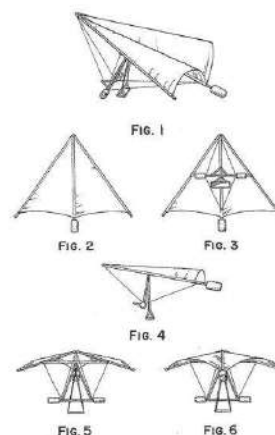


FIG. 1 is a perspective view of a passenger-carrying tow kite, showing my new design.
FIG. 2 is a top plan view thereof.
FIG. 3 is a bottom plan view thereof.
FIG. 4 is a side elevational view thereof.
FIG. 5 is a front elevational view thereof, and
FIG. 6 is a rear elevational view thereof.
I claim:
The ornamental design for a passenger-carrying tow kite, substantially as shown.

References Cited
UNITED STATES PATENTS
3,663,953 4/1963 Cella 244-3
1,194,520 7/1965 Karstam
3,295,793 1/1967 Renart
3,361,288 1/1968 Gerard et al.
FOREIGN PATENTS
1,395,715 3/1965 France 244-153
MELVIN B. FREIER, Primary Examiner

Ref 11. Bill Bennett's 1972 patent that was based on the designs that John Dickenson developed from 1963 in Australia.