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technical notes

11/1974

Aerolite glues in
Caley glider replicas



Aerolite® glues in Cayley glider replicas

There is a legend in the Yorkshire village of Brompton that their one-time squire frightened the wits out of his coachman by launching him into the air in a primitive flying machine, half-a-century before the Wright brothers first flew at Kitty Hawk.

The squire was Sir George Cayley. When Anglia Television produced a documentary about Sir George, they set out to prove his theories with the aid of replicas created from his notes and sketches. They succeeded in re-enacting that legendary flight, with a remarkable machine which surpassed the most sanguine expectations of its performance. CIBA-GEIGY wood glues were used in the construction of all the replicas

"A prophet is not without honour, save in his own country." There can be few men for whom that statement is more appropriate than it is for Sir George Cayley (1773-1857). This scholarly Yorkshire baronet presaged our era of flight at a time when his contemporaries were exploiting the newly created canal transport system—their eclipse by the railways had barely begun when he died.

Perhaps it is because his ideas were so far ahead of his time that they were almost totally ignored, and his achievements remained unrecognised for nearly a century after his death. Even now, when almost every schoolboy knows the achievements of Orville and Wilbur Wright, few even know the name of Sir George Cayley.

Thankfully, the bulk of his manuscripts survived to be discovered by the late J. E. Hodgson, who was perhaps the first to recognise his true stature in aeronautical history and to make it more widely appreciated. He was instrumental in having the Cayley papers deposited in the Royal Aeronautical Society's Library, where they are now accessible for serious study.

Among those who have devoted such study to them are his noted champion and biographer, Charles H. Gibbs-Smith, and Commander John Sproule who has for many years made exhaustive studies of Cayley's ideas and has successfully proved their validity with the aid of flying models.

Cdr Sproule's interest in Sir George was sparked by that legend of the frightened coachman, with which he first became familiar as a young employee of Slingsby Sailplanes at Kirbymoorside in 1936. As so often happens, that interest lay dormant for several decades until it was adequately re-stimulated by acquaintance with the writings of Gibbs-Smith¹ and Capt J. Laurence Pritchard who, in 1961, published the first biography of Sir George Cayley².

In a paper³ recently published in the *Aeronautical Journal*, Cdr Sproule writes: "Being very familiar with the Cayley country around Brompton and his Scarborough birthplace, it was fascinating to speculate where Sir George's inspiration had come from. . . I am quite certain that the happy chance that Sir George was born on the north Yorkshire coast played a great part in directing his thoughts to the possibilities of human winged flight. Anyone who has visited the windy resort of Scarborough will be familiar with the squadrons of gulls which glide so elegantly on motionless wings along the steep cliffs only a few feet away from the spectator. I have watched the Scarborough gulls wheel and soar for hours myself—they look at you and wink as if to say 'what fun this is'—and I am convinced that their ancestors were the spark which set the young and imaginative Cayley off on his fifty years of aeronautical experiment.

"One other happy circumstance of Cayley's birth and youth at Scarborough I am also quite sure of, and this was the presence of the seaport, which in Sir George's time would abound with sailing ships of all kinds. Here was the only technology, apart from the wind-

mill, which derived power and force from the wind. How natural to turn things around 90°, so to speak, and thus create the sail-wing—the basis, long before Rogallo, of all the Cayley flying machines.

"Quite early in my study of Sir George Cayley, it occurred to me . . . to make a replica of one of his machines to see if it flew, and if it did, to fly it from the original place in Brompton Dale. From all accounts no one had ever done this before. . . It was not until the summer of 1971, however, that I began to put thought into practice, spurred by the fact that now . . . I had lunchtime access to Sir George's original papers and sketches in the Society's splendid library—a priceless opportunity.

"The machine I had selected to build from the start was the so-called Riding Rudder glider of 1852, a large unpowered sailwing model of remarkably modern configuration. It was fascinating to pore over Sir George's original sketches of this machine to try and glean every scrap of detail as to how he had made the various components.

"After considerable effort to keep the weight down to the stated 16 lbs, the machine was finished in April and tested on the South Downs near my home at Shoreham-by-Sea. As all dimensions, CG and materials etc. are quite authentic, it follows that it must be a true facsimile of the original. Preliminary tests showed that the machine flew astonishingly well, so on the next available holiday a family expedition was mounted to Yorkshire to fly it in the Brompton Dale.

"On the evening of the 18th August, 1971, I heaved the 16 lb Cayley glider off the high

eastern slope of the beautiful little Yorkshire valley and it sailed away in stable graceful flight, exactly as its ancestor must have done about 120 years before. A quite unrepeatable experience; even my wife, who is somewhat hard-boiled as far as my projects are concerned, was thrilled. We all remarked on the curious privacy and calm of Sir George's flying ground, even though the dale is situated right in the middle of Brompton village, just opposite the Hall where Sir George Cayley had lived.

"Here again was a happy chance in the Cayley saga. For only a few minutes away from his workshop-cum-study in the Low Garden at the Hall, was an ideal testing ground for his models. Anyone who has ever made flying models will know that there is a knack in making things fly which is only acquired by long practice. I am sure Sir George had this knack. With the greatest of convenience, he could try model after model in the nearby dale and learn how to achieve lateral stability with a high mounted wing or dihedral angle, and to balance nose heaviness against negative tail incidence. And how natural to make bigger and bigger models so that one day a ten year old boy could be floated off his private hill—and later a full grown man."

Cdr Sproule subsequently constructed a

COVER PHOTOGRAPH The replica man-carrying Cayley glider in full flight across Brompton Dale, re-enacting the coachman's legendary flight for television

1 Cdr Sproule launches the Riding Rudder replica across the Dale, much as Cayley himself must have done 120 years before



replica of what he considers to be one of Sir George's most important flyers. This is the kite-like "skimmer", which he depicted and described in 1818, over 30 years before the other. The layout of this one is based on the traditional Chinese bow-kite, with a smaller one behind it set at a slightly negative angle of incidence to counteract a suspended weight at the nose. This is the first known example in the history of aeronautics of the use of wing dihedral to enhance lateral stability, one of the many "firsts" which Charles Gibbs-Smith attributes to Cayley.

The Cayley papers include a rough sketch which shows a man "between the shafts" under a long fore-and-aft pole with a small kite-like tail at the rear. With the insight of an essentially practical man into the "sketch-book shorthand" of the engineer's hasty attempts to depict an idea pictorially rather than diagrammatically, Sproule interprets this as a representation, with the obscuring wing surface omitted for clarity, of an enlarged "skimmer" adapted as a primitive hang-glider.

If this was ever put into effect, it would certainly make this simple device one of the most significant of all Cayley's designs. It would have anticipated Lilienthal's similar achievements by the better part of a century. Sproule is convinced that the "skimmer" was capable of being progressively "scaled-up to man-carrying hang glider proportions, as it is so easy to make in any size. Certainly there is mention in the notes of loads up to 90 lb having been carried in this kind of machine".

As a result of these activities, Cdr Sproule was approached late in 1972 to assist in the making of a television documentary about the life of Sir George and his aeronautical achievements. "I was asked if I would assist with my existing Cayley glider and any other models I had, and in particular, if I would care to recreate a replica of one of the large man-carriers." The idea was to re-enact, if possible, the legendary flight of the coachman in Brompton Dale.

Because of programme timing, it was necessary to research, design, build and test this device in under 8 months—a considerable undertaking.

It is not recorded which of the many potential man-carrying gliders depicted in the Cayley papers was the one reported to have carried the timorous coachman. After some deliberation, it was decided to reconstruct the large monoplane "governable parachute" outlined in the *Mechanics Magazine* of 1852.



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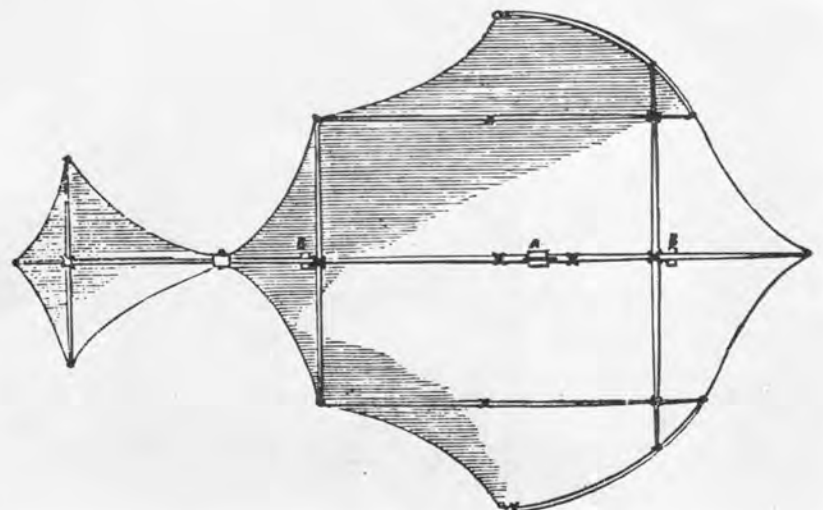
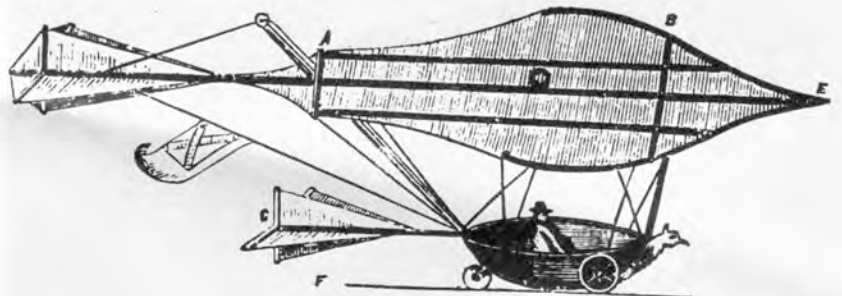
Mechanics' Magazine, **MUSEUM, REGISTER, JOURNAL, AND GAZETTE.**

No. 1520.]

SATURDAY, SEPTEMBER 25, 1852. [Price 3d., Stamped 4d.]

Edited by J. C. Robertson, 166, Fleet-street.

SIR GEORGE CAYLEY'S GOVERNABLE PARACHUTES.



2 Cdr Sproule with the Skimmer model, the earliest known design to incorporate dihedral for lateral stability

3 Facsimile of the illustrations, as they appeared in the *Mechanics Magazine* of 1852, used as the basis for the design of the man-carrying replica

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This included a very carefully draughted plan of the sail-wing, with a clear indication of Cayley's intended method of constructing it.

From the outset, Cdr Sproule set himself the objective of building the machine in the manner in which Cayley himself might have done it, using materials that were available to him, and constructional techniques known to be in use at the time, or to have been described by Cayley himself. He had, indeed, shown a remarkable inventiveness in describing lightweight constructional methods in wood and wire and canvas, eschewing metal as far as was possible. There were no light alloys in Sir George's time.

One invention which demonstrates the brilliance of his thinking along these lines was his tension-spoked wheel for aircraft undercarriages, now familiar to all of us in the everyday bicycle wheel. But to Sir George's contemporaries it was a complete reversal of all their thinking and tradition in wheel construction, as represented by the waggon and cart wheel. Sir George also demonstrated a keen appreciation of the need for streamlining, even though the word itself could not have been known to him. And he knew the value of diagonal bracing as "the secret of a light and rigid structure".

All of this was important to Cdr Sproule in designing the replica. He realised that the construction team would have to "pay particular attention to weight, as Sir George had quoted a figure of 160 lb for a machine of 460 sq. ft of (wing) area and 40 ft length."

The team selected to build the machine were Southdown Aero Services at Lasham.

4. Mr Ken Fripp (left) with two of his team of experts from Lasham, appraising the finished car for the replica man-carrier

5. A close-up of one of the tension-spoked wheels on the car. The rim was made by rolling up a 32 ft strip of ash coated with Aerodux

This organisation, under the direction of Mr. Ken Fripp, is normally devoted to the repair of gliders and is widely experienced in all techniques of lightweight construction, and the ingenuity required to "make and mend" in order to solve awkward problems.

In order to meet the filming deadlines, the team allowed themselves one major liberty in the construction of the machine. They used CIBA-GEIGY Aerolite® and Aerodux® glues. Undoubtedly Sir George himself would have welcomed them had they been available in his day,* not only for the greater strength and durability they would have given his creations, but for the complete reliability and speed with which they could be put together. This was of critical importance to the Lasham team, who needed the confident assurance that a component or assembly glued together one day could be safely taken out of the clamps and worked on the next. And the work could be speeded up still further by the judicious use of chemical accelerators or the application of heat to the joints.

These glues were, in fact, used very extensively in the construction of the machine. The main structural elements comprised two masts, the long longitudinal boom on which

*A view confirmed by Cdr Sproule: "As he mentions the use of 'marine' glue in his notes, I used Aerolite without hesitation as I am sure a sensible chap like Sir George Cayley would have used it as 'marine glue' had it been available in his day". Readers of Technical Notes are, of course, well aware of Aerolite's established reputation as a most excellent marine glue.



the sail wing was supported, and a number of smaller booms and spars to shape and support the wing. Many of these were of hollow box construction, and of streamlined section where the airflow was around them and not along their length. Spruce and ash were the timbers used, selected according to the characteristics most appropriate to the particular application.

The accommodation for the hapless coachman of legend was a simple three-wheeled car of boat-like form and construction, again built as light as possible with planking of spruce a mere 0.1 in thick. The whole contrivance was well stiffened by a considerable number of wires and cords.

The replica was completed and "rolled out" on the 10th of July. It was, as Cdr Sproule says, "a good deal heavier than the 160 lb quoted by Sir George. In mitigation all I can say is that for a filming job such as this, we had to make a repeatably usable article which was not likely to collapse about our latter-day coachman's ears. We did, however, manage to keep the wing loading adequately below the one pound per square foot which Sir George Cayley did not like to exceed."

It had originally been intended to carry out initial flight testing of the device "in ballast", to avoid exposing a pilot to the risk of an accident in such an unusual aircraft. However, Derek Piggott, the Chief Flying Instructor at Lasham and a highly experienced pilot of unusual aeroplanes (he did much of the flying in "Those Magnificent Men in their Flying Machines"), expressed his willingness to act as human ballast from the start. As the machine was inherently stable, very lightly loaded and apparently robust, this was agreed to.

It was first necessary to balance the machine so that its centre of gravity was in the right place. Since Cayley's notes did not define this, Cdr Sproule had built a 1/6 scale flying model to determine the best position for it. This proved to be just aft of the forward spar position; with Derek Piggott in the pilot's position as far forward as was practicable more ballast was still needed, which further worsened the excessive weight problem.

Nevertheless, a few adjustments dictated by the results of early tests with the craft towed behind a car at Lasham made it possible to get it airborne at about 28 mph. And in one notable



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6 Assembling the sail-wing supporting framework, which has a remarkably modern appearance in the detail of its design

7 Roll-out. In its own way, almost as historic as that of Concorde

8 Preparing for filming at Brompton Dale

ake-off. The glider sets out across the Dale

test run, a misunderstanding with the towing crew resulted in the replica reaching an altitude of 50 ft or so, fortunately without mishap. Derek Piggott reported it as "quite thrilling".

With these successful trials accomplished all was set for the expedition to Yorkshire for the week of filming. The remainder of the story cannot be told better than in Cdr Sproule's own account:

"Needless to say, this coincided with a week of the nastiest and wettest weather of the whole summer.

"Our preliminary sojourn at Holme-on-Spalding, by great courtesy of Hawker Siddeley, to try to obtain some really long sustained tows for filming purposes, was an epic of long trundles at walking pace to find new take-off runs into shifting winds. Here were also hurried sail furlings in pelting rain to save the machine from being blown away. In due course, however, we moved to Brompton for the final episodes and re-rigged the machine in clearing weather in the shelter of the trees at the southern end of the little dale. On the last available filming day, Sir George must have used his great influence in high places—and the sun shone and a breeze blew right up the south eastern slope which village legend has it to this day is the 'coachman's hill'.

"We had decided to launch for filming purposes with an elastic rope engaged on an open hook on the nose of the car, in normal glider launching fashion. Sir George's large machines no doubt were launched quite similarly, but using ordinary ropes pulled by volunteer helpers to roll them down the hill into the wind; his machines were very light indeed so they must have become airborne very easily. So, after some preliminary filming

of a professional actor in coachman costume for the purposes of the documentary, Derek Piggott took his place with 'influencer' in left-hand. Our six farmhand volunteers—three on each side of the rope laid out like a 'V' with the hook at the apex—took up their appointed launching stations. On the command 'run', away they went down the hill and the car was released by three helpers holding it back.

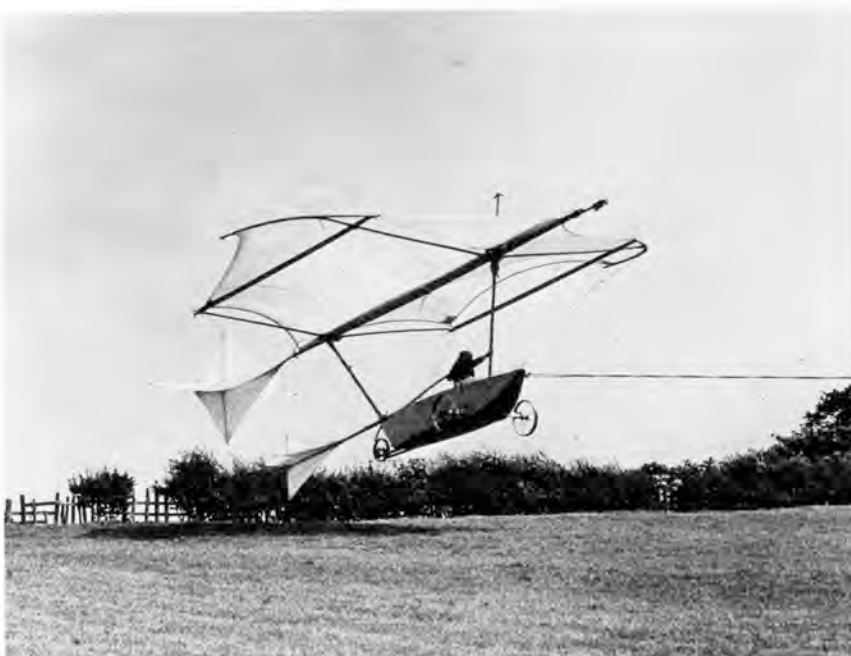
"The replica leapt forward and in a few yards once again a Cayley-type glider carrying a man became airborne in the Brompton Dale for the first time for over 120 years. The first flight was, it is true, only for a few yards at a maximum height of five feet or so, but the machine looked magnificent. It was quite a moment for us all, and this time three professional cameramen were recording the scene.

"Two more repeat flights were made; for the last one it was decided to stretch the elastic cord by means of a car—out of camera of course—as our willing Brompton farmhand helpers had to go back to their duties. Accordingly the machine, with Derek Piggott again at the helm, was positioned as far as possible up the east slope with the tail in the hedge. As all had seemed well in the previous flights, and Derek had by this time proved to himself that the influencer could indeed influence (at Holme-on-Spalding he had successfully avoided an errant cameraman by its use), it was decided to go for a somewhat stronger launch.

"There is no denying that in the event it was for the car sped off down the hill and, with rope stretched to the limit, the Cayley was airborne immediately. At an altitude of 30 ft or so the machine sailed across the Dale to the western side in Cayley's words like a 'noble white bird'. Across the valley towards the rising ground, the nose dropped, there was a loud bang as the front axle broke, and the tail fell off. All very dramatic, but our latter-day coachman was quite unhurt and was heard to observe on his recording transmitter the words 'Oh dear'. So that was that.

"However, everyone was pleased that the flying in the Dale was so successful and that everything that we had set out to do had been accomplished and filmed."

It has not been proved that the legendary flight of the coachman actually did happen, but it has been shown that it could have happened. More importantly, it has been amply demonstrated that Sir George Cayley, half-a-century before the Wright Brothers, had all the essential understanding of aerodynamic principles, and of lightweight constructional techniques, to have achieved his dream of sustained flight. It was as he said in 1852: "But for lack of a light and powerful prime m





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10 The actor coachman looks appropriately trepid at the "helm"

11 Like a 'noble white bird' in mid-flight, with a bewigged Derek Piggott in control

12 If Sir George's ghost still haunts the shell of his old workshop, he must have felt some belated satisfaction at the re-enactment of that flight which sparked the legend which provided the sole flimsy thread of continuity to his memory for over a century



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sustained mechanical flight would be at hand." Sadly the invention of the internal combustion engine was several decades away, and could not be rushed.

Sir George Cayley died peacefully at Brompton Hall on 15th December 1857, shortly before his eighty-fourth birthday, after what must have been a life of almost total fulfilment. Few men have achieved more, and it is sad that he received so little recognition from history until recent times. He has well been called the Father of Aerial Navigation.

We are indebted to Anglia Television Ltd and Southdown Aero Services for their help in preparing and illustrating this article, and to Cdr Sproule and the Royal Aeronautical Society for permission to draw from information published in the Aeronautical Journal. And we are honoured that, through the use

of CIBA-GEIGY glues, we have been enabled to play some small part in establishing Sir George Cayley in his rightful place as "the veritable inventor of the aeroplane".

References

- 1 Charles H. Gibbs-Smith, "Sir George Cayley, Father of Aerial Navigation (1773-1857)"—lecture given to the Historical Group of the Royal Aeronautical Society, reprinted in Aeronautical Journal, April 1974 also "Sir George Cayley's Aeronautics", Science Museum, 1962
- 2 Capt J. Laurence Pritchard: "Sir George Cayley: the inventor of the Aeroplane", 1961
- 3 Lt Cdr J. Sproule: "Making and Flying Replicas of Sir George Cayley's Gliders", Aeronautical Journal, July 1974

POSTSCRIPT We are pleased to learn that Sir George Cayley has joined those distinguished personalities who are forever enshrined in the International Aerospace Hall of Fame at San Diego, California. His pioneering contribution to "the aeronautical sciences and man's progress in flight" is thus acknowledged.

Published by **Plastics Division**

CIBA-GEIGY (UK) Limited

Duxford Cambridge CB2 4QA England Telephone Sawston (022 03) 2121

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