The R.101 story: a review based on primary source material and first hand accounts

by

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The editorial assistance of Dr Giles Camplin and Mr Crispin Rope is acknowledged.

Abstract

The airship R.101 was designed and built at the Royal Airship Works, Cardington, under the Imperial Airship Scheme, to shorten journey times to the Dominions. It crashed near Beauvais in northern France at 2.08am on 5th October 1930 while on a proving flight to Karachi (then in India). After hitting the ground, the airship caught fire, killing 48 of the 54 persons on board, including the Secretary of State for Air, Lord Christopher Thomson.

This paper describes the development of the R.101, the background to the Imperial Airship Scheme, the accident and the subsequent Inquiry, largely through quotations from contemporary documents, both official and personal, and interviews with people involved.

Preface

This paper is the result of a long period of research into the circumstances relating to the Imperial Airship Scheme and the loss of the R.101 in October 1930 during a proving flight to India. Rather than subject myself to the limitations of commercial publishing and with regard to the limited market for the subject at this depth, the authors have decided to place unbound copies with the major archives in the UK for the benefit of future researchers.

The paper cannot be conclusive due to uncertainty over the precise cause of the accident and the loss of all those on board with detailed knowledge of the final few minutes over France. However, drawing from material held in various archives and quoting from numerous contemporary sources, we have drawn together what we believe to be an objective review, punctuated with comment and explanation based on our close association with the subject over many years.

Although familiar with many more recent published interpretations we have tried, wherever possible, to rely only on primary source material or evidence gleaned from those who sought the first hand recollections of those directly involved at the time.

We welcome further dialogue and debate on these matters and continue to offer technical lectures on the subject. As with many contentious historical events, misconceptions and genuine errors do creep into the historical record. We hope to have countered some of these and thrown light on others. None of this should detract from our appreciation of the efforts made by those aeronautical pioneers working under pressure in the conditions of the time.

The amount of detail contained in this document makes it unsuitable for conventional book treatment and the amount of comment and conjecture mitigates against its presentation as a learned research document or the final word on what happened to R.101. However, for those with a serious interest or some prior knowledge, the author hopes it sets out much of the primary source material for further analysis.

Contents

Glossary and list of people cited

AGC - Airship Guarantee Company
AMSR - Air Member for Supply and Research
DAD – Director of Airship Development, Royal Airship Works
DCA - Director of Civil Aviation
NPL - National Physical Laboratory
RAW - Royal Airship Works, Cardington
S of S - Secretary of State

People involved in the Imperial Airship Scheme, the accident and subsequent inquiry

Atherstone, Noel Grabowsky (Grabby) - R.101 First Officer
Bairstow, Professor Leonard - Airworthiness of Airships Panel – Professor, Imperial College
Baker, Sir John, later Lord Baker of Windrush – R.101 design team
Bateman, Harry – NPL Scientist and Assistant Observer survived R.38 disaster
Bell, A. V. – R.101 engineer, aft engine car (Survivor)
Binks, J. H. – R.101 engineer, aft engine car (Survivor)
Booth, Ralph – R.100 Captain
Brabazon, Lord (Col. J. T. C. Moore) - Inquiry assessor
Brancker, Air Vice-Marshal Sir Sefton W. - Director of Civil Aviation (DCA)
Bulman, Major G. P. – Air Ministry, Director of Engine Development
Burney, Commander Sir Dennistoun – Entrepreneur, founder of AGC and author

Campbell, C. I. R. - Designer R.23-38
Cave-Browne-Cave, Wng/Cmdr. Thomas R. - RAW Powerplants
Church, Sam – R.101 rigger (Survived until 8/10/30)
Collar, Roderick - NPL Aerodynamicist
Collins, T. S. D. - RAW Design team, Head of Stressing Office
Colmore Wng.Cmdr. Reginald B. B. – RAW Director of Airship Development (DAD)
Cook, A.J. – R.101 engineer, port midship engine car (Survivor)
Darling, George - Englishman staying near Allonne who was among first to arrive at the wreck site
Dean, Sir Maurice - Assistant Principal, Air Ministry (received the 0230 message from Disley) Organised the Ministry response to the accident.
Disley, Arthur - Electrician/Wireless operator R.101 (Survivor)
Dowding, Air Chief Marshal Hugh C. T. – AMSR at time of crash (From 31/8/1930)
Dyer, J. W. W. - RAW Head of Fabrics, RAW expert and chemist
Gerrish, A. E. – Shed Manager RAW
Griffith Brewer, - Hon. Advisor to the Airship and Kite Balloon Services, 1915-18
Hall, Arthur Henry, - RAW officer in charge of Production over Gerrish, 1926-28
Higgins, Air Marshall Sir John; AMSR 27/12/1926 to 31/8/1930
Hoare, Sir Samuel – Secretary of State for Air 1922-1923, 1924-1929; Chairman of the Airship Committee 1922-23
Hunt, G. W. – R.101 Chief Coxswain
Irwin, Flt.Lt. H. Carmichael - R.101 Captain
Johnston, Sqn.Ldr. Ernest L.- Navigator on R.100 and R.101
Johnston, E. A. - Son of Sqn.Ldr. Johnston, Navigator
Jones, Dr. R. - Aerodynamicist NPL
Leech, A. H. – R.101 foreman engineer (Survivor)
MacDonald, Ramsay - Prime Minister at time of R.101 crash
Meager, George – R.100 first officer
Nixon, Sqn/Ldr. S. - RAW Administrator, became head of the technical staff at RAW after the accident.
North, John Dudley. - Chairman and Managing Director of Boulton and Paul Limited.
Norway, Nevil Shute – R.100 Calculator and novelist
Pippard, A. J. Sutton - Airworthiness consultant to the Ministry, Professor Bristol University
Pugsley, Sir Alfred, FRS - a Technical Officer at Cardington 1926-31
Rabouille - French witness
Radcliffe, W. G. – R.101 rigger (Survived until 6/10/30)
Reynolds, Major Louis - Thomson's Principle Private Secretary.
Richmond, Lt. Col. Vincent C. – R.101 designer
Rogers, Woodis, Captain – i/c RAW gas plant
Rope, Crispin - son of Sq/Ldr. Rope
Rope, Sq/Ldr. Frederick Michael – RAW, Assistant to DAD (Technical)
Roxbee-Cox, Dr. Harold, later Lord Kings Norton – R.101 design team
Salmond, Air Vice-Marshal Sir Geoffrey - AMSR 1922- 27/12/1926
Savory, V. – R.101 engineer, starboard midship engine car (Survivor)
Scott, Major George Herbert - RAW Asst. Director of Airship (Flying and Training) AD(FT)
Simon, Sir John - Chairman of R.101 Inquiry

Speed, Les A. - RAW Draughtsman
Steff, Maurice H. – R.100 and R.101 second officer
Thomson, Lord Christopher - Secretary of State for Air 1924, 1929-1930
Uren, J. – RAW Head of Drawing Office
Villiers, Major Oliver - Brancker's Assistant at Department of Civil Aviation
Wallis, Barnes Neville – R.100 Designer

Other persons cited

Bergel, Hugh - Author
Boothby, Commander Robert - Politician, broadcaster and author
Brooks, Peter - Historian and author
Chamberlain, Geoffrey - Historian and author
Higham, Dr Robin - Historian and author
Masefield, Sir Peter – Aviation administrator and author
Mowthorpe, Ces - Historian and author
Robinson, Douglas - Historian and author
Rosendahl, Admiral C. E. - Officer commanding U.S. Naval Airship Station at Lakehurst, NJ
Topping, Dr A. D. - Historian and author
Ventry, Lord - Historian and author
Walding, Roy - Historian

1. Introduction

The loss of His Majesty's airship R.101 on 5th October 1930 marked a turning point in the development of long distance air travel. The accident stopped the development of rigid airships in the United Kingdom and heralded the development of the aeroplane for all aspects of commercial air travel.

In the 1920s the government was concerned with Imperial communications, particularly for mail and financial transactions. Oceanic journeys were all by ship and therefore slow. At this time aeroplanes were severely limited in payload and range; range was between 300 and 500 miles and they flew only by day, with very unreliable engines. In 1927, Lindbergh was only the third person to cross the Atlantic, non-stop, by aeroplane, and then only eastbound, assisted by prevailing winds.

By that date, over a hundred persons had crossed by rigid airship in both directions. The potential lifting power of the rigid airship, which needed no runways and whose inherent buoyancy made it safe in the air, independent of engine power, made it attractive to the British Government.
The Imperial Airship Scheme was conceived to shorten journey times for those few passengers and documents requiring safe passage to the Dominions, in particular, India,

Canada, Australia and South Africa. After long deliberations between 1921 and 1924, the Air Ministry decided to initiate design, production and flight testing of two competing designs of airship. A common specification was issued to both the Royal Airship Works at Cardington, near Bedford, and to the Airship Guarantee Company, a subsidiary of Vickers, at Howden, Yorkshire. Once designed and constructed, both airships would undergo flight trials at Cardington prior to route proving.

The reader should appreciate the size of the R.101; longer than three Boeing 747s with a girth that would just allow passage beneath Tower Bridge. The Canary Wharf tower is six feet shorter than the R.101 in its final configuration. Two enormous airship sheds remain at Cardington, near Bedford, home of the then Royal Airship Works (RAW).

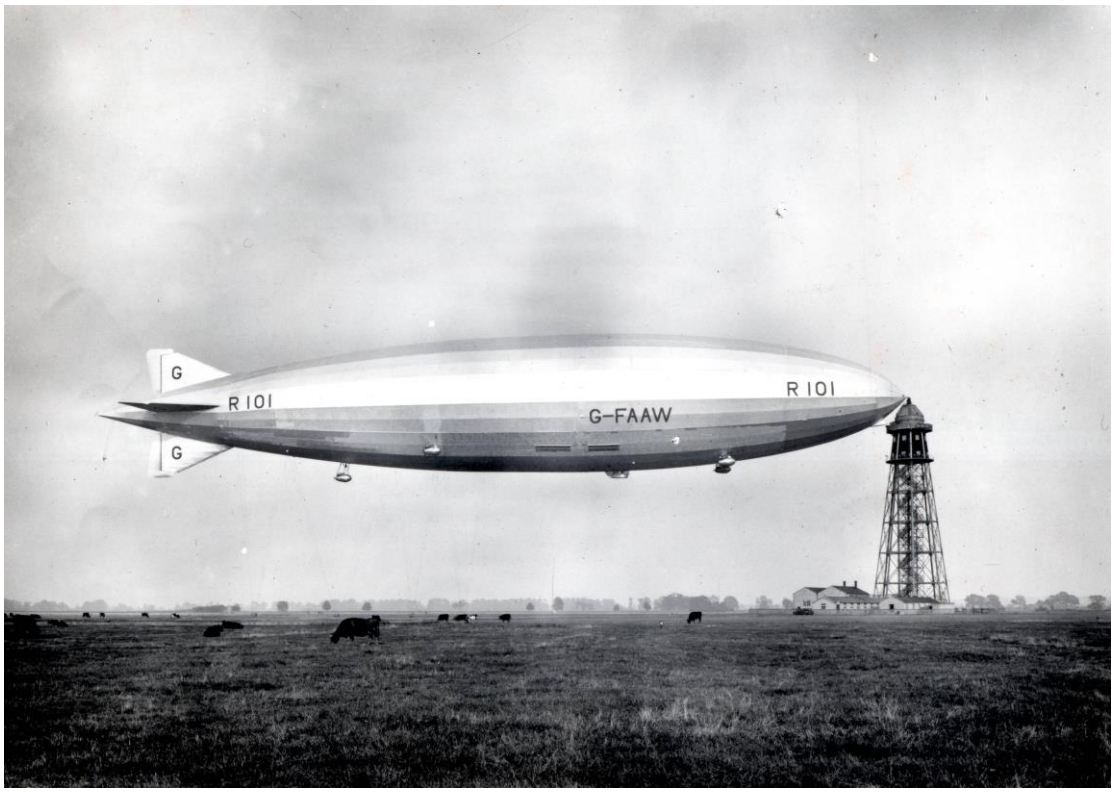

Figure 1 The R.101 at the mast at Cardington Photograph

In late 1929 both the completed prototypes, running late and over budget at a time of approaching recession, were found to be severely limited in lifting capacity and recognised as being really only a stepping stone on the way to a commercial solution. The Vickers product, R.100, was fairly conventional and based on Zeppelin practice. It succeeded in making a risky but commendable return flight to Montreal in the summer of 1930, whilst the more innovative R.101 attempted the more difficult overland flight to Karachi (then in India), as specified in the original contract.

A number of coincident factors and errors of judgement resulted in the R.101 striking the ground at night near Beauvais, France with the resultant fire killing 48 of the 54 on board. The victims included the Secretary of State for Air, Lord Christopher Thomson, and the Director of

Civil Aviation, Sir Sefton Brancker, plus many of the experts responsible for the ship's design and construction.

Lord Christopher Thomson of Cardington, a loyal friend and colleague of Prime Minister Ramsey MacDonald, was in his second term as Secretary of State for Air. Having supported the launch of the programme in 1924 he found it running late, and over budget, on his return to office in 1929. A supporter of the airship scheme and favoured as the next Viceroy of India, he was almost obsessive over the R.101.

The emotional effect of the disaster was on a scale not seen since the Titanic. The public outpouring of grief and sympathy in the immediate aftermath and the subsequent inquiry, coupled with media and technical speculation, marked the end of the programme in 1931. The accident to the Zeppelin 'Hindenburg' in 1937 had a similar global effect. The onset of World War Two, which forced the rapid development of larger aeroplanes and the construction of long paved runways, secured the future for heavier-than-air flight.

The publication of various written records, notably Sir Peter Masefield's *To Ride the Storm* (Masefield, 1982) and Neville Shute (N S Norway)'s *Slide Rule* (Shute (Norway), 1954) have added both fact and, occasionally fiction, to the story. Further study, as more public records have been made available and first generation sensitivity has dissipated, have led to a deeper understanding of the programme and its consequences. This paper attempts to cast light on the major issues whilst acknowledging that, as nobody from the R.101 control car survived, we will never know exactly what happened on that fateful night over northern France.

Pertinent comments from Masefield's writings include (from the Masefield Archive, Brooklands*):

> *"Close analysis, from an objective aviation viewpoint (with some knowledge of the people concerned) leads to a clear pattern emerging of two airships which were, both, very much experimental prototypes; neither of them meeting in full the design specifications optimistically laid down in 1924. Both were, however, capable of further development and improvement, given sufficient time and money."*
>
> *"There were some who went out of their way to denigrate R.101 and its design team for complex personal reasons but – taking into account the fact that, from the start, R.101 was deliberately intended to be an experimental prototype in which to try out new and advanced ideas (to compare with the more conventional R.100 – not of geodetic structure, incidentally) as that great German designer, Ludwig Dürr, rightly stated, it was exceedingly well conceived and built."*

Masefield to Dean, 21/3/1977 (Masefield Archive, Brooklands):

> *"... the correction of historical myths and misconceptions which for devious reasons have grown up around the R.101 story and repeated I see (one from another) by*

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* The Masefield Archive is not organised systematically, merely boxed by subject, so a more detailed reference cannot be given for many of the quotations from this archive

Neville Shute Norway, Robin Higham, Jack Morpungo, David Beatty and Montgomery Hyde. It really is time that all that nonsense was put right."

In his lecture to the RAeS in 1962 Cave-Browne-Cave comments on Shute's writings:

" The public understanding of the important period of R.100 and R.101, I think, has been distorted by a widely read, but in my opinion unreliable, account written by a novelist…He was eminent as the author of most attractive fiction. He included his airship story in his autobiography for that purpose – not as authentic history."

2. Politics

Flight 19/5/1921:

"There is little doubt that for long-distance non-stop journeys the airship scores over the heavier-than-air type of craft, and while to organise an 'all-red' route to India and Australia or South Africa would be a difficult undertaking with aeroplane and/or seaplanes, a few mooring masts and one or two more permanent bases would be practically all that would be required to start an airship service to these Dominions overseas."

Flight correspondent, following a flight in R.36, 14/6/1921:

"During my short span of years I have journeyed fairly long distances by boat, train, motor-car, and aeroplane but have never experienced such travel-comfort as in an airship – no dust, no smoke, no sway, no draught, very little noise and practically no vibration. We could sit in our arm-chairs – or stroll about – and talk without the slightest difficulty."

Burney to Hoare 18/10/1923, Airship Guarantee Company (AGC) Archive (The AGC was set up as a subsidiary company by Vickers, under Sir Dennistoun Burney, to enable the construction of R.100 at Howden, Yorkshire):

"I have been negotiating with the British Government on the project of the England-India service for the past two years. If, therefore, negotiations for setting up airship lines to Australia, Canada, New Zealand and South Africa are likely to take a comparable length of time, it seems advisable that such negotiations should begin now, so that by the time the first ship has made a flight to India, we should be in a position to proceed with any contracts which might have been arranged in the interval."

Flight editorial 20/11/1924:

"We have got to make airships pay, certainly, but above all we have to make them safe."

Sir Samuel Hoare, Flight 20/11/1924:

"We are very conscious of the fact that in the past there had been many airship disasters, and they were determined to check each constructional step in every way

possible as it was made, the main object always being to make sure, if somewhat slow, progress."

Wallis to Lloyds Register Staff Association 10/2/1926 (Paper No.5 'Some Technical Aspects of the Commercial Airship' R.101; Box B Masefield Archive, Brooklands)

"To discuss the advantages of airship transport is not within the scope of this paper. The advantages of speedy intercommunication are obvious to all who have studied the political economy of a scattered Empire such as ours; and the airship is now admitted to be the ideal vehicle for this purpose even by those who have devoted their interests to the development of its only rival – the aeroplane."

Flight, 25/11/26 p769, during an Imperial Conference:

"This first ship does not aim at the ultimate ideal in every direction. Some desiderata have had to be postponed for further research. One such matter is the provision of a substitute for goldbeater's skin in the gasbags. It would not be worthwhile to hold up the ship pending the result of the research now in progress."

Prior to the agreement on Air Estimates for 1929 that included the Airship Continuity Programme 27/1/1928 (AIR11/23*):

"As far as can be seen at present R.100 will carry out the first Canadian Demonstration Flight; R.101 the first flight to India, and the South African Demonstration flight, and that R.101 will probably be employed from October 1929 to March 1930 carrying out operations from Karachi"

Lord Thomson following his second flight 18/10/1929 (The Times 19 November 29 and Masefield (1982) p.130)

"Much work and many further trials remain to be completed and, so long as I am in charge, no pressure will be brought to bear on the technical staff – or anyone else – to undertake any long-distance flights until everything is ready and all is completely in order. Subject to this, I hope that perhaps it may be possible for me to travel to India during the Parliamentary recess after Christmas. But whether this is possible or not, the whole policy of the airship programme is "safety first" – and "safety second" too."

Although it is clear that Lord Thomson exerted considerable pressure on the two teams, particularly the R.101, those at Cardington clearly saw him as their champion. His reputation and cross-party popularity also equipped him to exert pressure on the Treasury to continue their financial support, based often on his own charisma in the House of Lords and his close relationship with Ramsay MacDonald.

Without Thomson's backing the scheme might never have started and would certainly have faced cutbacks in the face of an approaching recession.

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* References of the form 'AIRn/n' are to files in the National Archives, formerly the Public Records Office.

It is clear that had Samuel Hoare exerted similar pressure in his terms as Secretary of State for Air the programme would not have fallen as far behind by Thomson's return in 1929. However, Thomson was always under extreme pressure from the Treasury and had to use his considerable charm and persuasion to balance the need for expenditure against future requirements.

Masefield to Bergel 7/3/1983, (Masefield Archive, Brooklands):

> *"Christopher Thomson always emphasised that, making allowance for his desire to press the programme, he would invariably rely on the technical judgement of his officials*."

Lord Thomson and the Director of Civil Aviation, Sir Sefton Brancker, were both air enthusiasts, driving Air Force expansion, the creation of flying clubs and the 1929 Schneider Trophy bid. Thomson was Chairman of the Royal Aero Club from 1926-29 so retained his influence and interest in aviation when out of office. As Secretary of State for Air from January to November 1924 and from June 1929 to October 1930, Thomson enjoyed rare cross-party support. Sir Sefton Brancker, champion of Britain's need for air-mindedness, cautioned against the India flight without further testing and the building of additional intermediate mooring masts, but without success. He was, however, keen to participate in the prestigious journey to India.

Thomson to the House of Lords on 3/6/1930 (Hansard; HL Deb 03 June 1930 vol 77 cc1341-68, particularly col 1360)

> *"This is one of the most scientific experiments that man has ever attempted and there is going to be no risk, while I am in charge, of this being rushed or of any lives being sacrificed through lack of foresight. It is far too scientific and important a matter for that. ...*
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> *I have always been an enthusiast in these matters. I take special pride in the fact that I introduced the programme and I want to see it through to ultimate success. ...*
>
> *It is essentially a vehicle for going over wide-open spaces. It is not much for going over land. It would link up our Empire overseas in a way that – so far as I can see no other means of transport can approach."*

Atherstone comments before the MP's flight on 20/11/29 (unpublished diary, copy with Airship Heritage Trust):

> *"This wretched attempt to lunch 100 MPs onboard and fly them round for a couple of hours is still seriously being considered, but how on earth its going to be done I simply don't know. The ship really hasn't got the lift to do this kind of stunt and its damned unfair of the Air Ministry to lurk us in this way. The ship has not finished her trials, has not got her Certificate of Airworthiness and has not got enough lift to cart 12 tons of humans about with any degree of safety. It is only a cheap and vulgar form of eyewash at the least, and it doesn't say much for the brains at the Air House if this is the only way they can think of for getting Parliamentary support for airships. I hope something will happen to prevent this stupid flight, because it is really stretching things too far*

and only asking for trouble. I wonder if Reynolds realises what Irwin is up against, because if he does then he ought to be publicly shot for putting such almost impossible tasks on to us. The trouble is that nobody up at the Air Ministry understands anything at all about flying a ship like this one, and they haven't the decency to ask the men who have to do the job, if it can be done."

On 23/11/29 Atherstone reflected after the flight (unpublished diary, copy with Airship Heritage Trust):

"The Air Ministry were terribly bucked at having pulled off this stunt, but I fail to see that it can have served any useful purpose. The whole show was merely stupid. A lot of illegal things were done in order to gain enough lift to carry this load, amongst others taking the emergency and tinned rations and parachutes out of the ship!"

Atherstone, though an officer, gives us a glimpse of how such publicity exercises were perceived by the workers at RAW and how it tainted attitudes to the Ministry. Even as late as July 1930, Thomson was fielding demands for pleasure flights in both ships – he rebutted them thus (National Archives, AIR2/349):

"My reason is that both ships are still doing their experimental flights and the only people who should travel on them are experts, with the possible exception of myself."

Maurice Dean recalled to Peter Masefield 22/3/77 (Masefield Archive, Brooklands):

"I still come back to the point that (strange as it may look now) the one thing no one worried about in connection with the airship was safety. When I was given the chance of a trip in R.100 (which, as you know, turned out to be a 50 hour endurance flight) I was so excited that I could barely sleep. And, I promise you that my feelings were not concerned with being burnt up in an airship crash. On the contrary the feeling was one of total exhilaration.

'Of course the R.101 should never have taken passengers at all on such a flight for all sorts of reasons that I need not elaborate. Therefore from the start the passenger list was bound to be minimal, thus extinguishing the hopes of youthful aspirants like Maurice Dean.

In the end, as you know, there were six passengers namely, Thomson (and incredibly his valet) two Dominion Liaison Officers plus Brancker and Bishop who was Chief Inspector of the Airworthiness Department. My clear recollection is that the original passenger list excluded Brancker and that his name was only added after very substantial pressure had been applied by him. All of us are fallible but to me the idea that Brancker was a reluctant passenger is 100% nonsense."

Masefield to Baker 18/11/1975 (Masefield Archive, Brooklands):

"There seems no doubt that the decisions to let out the bags, to resort to padding and to add the extra bay were all forced on Colmore and Richmond to achieve the minimum performance required to get to India and back. Even so, the atmosphere was certainly one of confidence and determination right to the end."

> *"It is not true – (as has been stated in the past) that the Treasury was pressing for a chop in the financial allocation to airships. Indeed, Henry Self (who was the Finance Officer concerned) told me that further funds were on the point of being allocated for R.102 and to keep the Cardington team active – and I have now come on a note of the sum to be allocated for the financial year 1931/32."*

Edwin Mowforth lecture to the Newcomen Society 28/11/1973 *The airship: a technical history* Joint meeting at the Institution of Mechanical Engineers, London, on Wednesday, 28th November, 1973:

> *"The whole programme suffered, however, from too much publicity and too little time, and conditions were not suitable for adequate development of the special features."*

Norway on R.100 flight to Canada, Blackwood Magazine, May 1933:

> *"Considered purely from the technical aspect, it was not prudent for either airship to attempt a long flight at that stage of development. We [R.100] did it, and got away with it*."

Sir John Higgins, Air Member for Supply and Research wrote to the Secretary of State for Air 1/29:

> *"We should arrange that, if the further flying of R.100 and R.101 shows that there is no reasonable prospect of airships offering a successful solution of the problem of Imperial communication, then we must close down the experiment and cut our losses at the earliest possible stage."*

3. The Rigid Airship explained

In a rigid airship the external shape is defined and maintained by a skeletal arrangement of girders that contain gasbags filled with a lifting agent at ambient atmospheric pressure. A non-rigid is merely a gas tight bag with accoutrements; engines, accommodation, etc., slung from it. The internal pressure alone maintains the shape; non-rigid airships are entirely unsuitable for large vessels but cheap and versatile for many roles.

In any lighter-than-air vessel, weight is a critical factor. The successful but short-lived Zeppelins of World War One used both wood and metal frames and defined different strength requirements for those intended to operate at low level in contrast to the high-altitude 'height-climbers', whose more fragile structures needed very careful handling in the denser air at low level. The wartime Zeppelins were designed for military purposes and a relatively short life, rather than running to a reliable timetable for fare paying passengers.
The primary structure of a rigid airship was formed by a series of vertical rings, known as frames. These carry all the major loads; engines, accommodation, control surfaces and fuel/ballast tanks. Normally each element of a frame was constructed of three strong tubes braced by cross girders, with the elements bolted together to form a polygonal ring. The number of sides varied but, in general, the more circumferential facets there were the heavier

and more robust the structure would be. Offsetting this extra weight was a more streamlined external profile for the ship.

On large rigid airships these vertical ring frames were assembled lying flat on the shed floor before being hoisted into predetermined stations with as many of their fixtures as possible pre-fitted before erection. At each frame element joint was attached a longitudinal girder, normally of narrower triangular cross-section, to link one frame with the next, thus creating what is termed as a 'bay'. By working sequentially from the centre, adding forward and aft frames, each new bay grew the structure towards the fore and aft extremities. The size of the ring frames diminished towards its nose and tail (Figure 2). The tail structure included the fins and control surfaces, which were constructed separately and joined as the relevant main frames were added. The entire outer framework was sheathed in doped cotton fabric to provide protection from the weather and create a streamlined profile.

Within each bay was installed a gasbag. Each resembled a large circular cheese. These were constrained by wires to minimise movement and abrasion on the framing. The wire harnesses also transferred the lift evenly to the structure. It was essential to monitor and control gas pressure variations due to leakage, contamination and changes of temperature and pressure. Such large vessels were highly influenced by wind and the heat of sunlight, even when anchored. The airship even had to be monitored when tethered and floating in the shed, particularly in cool night time conditions. Control was maintained by the use of pressure relief valves on each bag and, when necessary, ballast tanks allowing the release of water. If urgency dictated, gas could be vented, normally to prevent over pressure caused by solar gain.

Most of the earlier rigid designs were tubular in appearance with all the central frames of the same size and merely a tapered nose and tail. As the science of aerodynamics, still in its infancy, evolved and engineering skills matured, the ability to conceive of more bulbous designs of varying diameters led to the more familiar shapes still in use today. There was an increasing understanding of dynamic lift. The proposed profile of R.101 was tested at the National Physical Laboratory by the end of 1926.

To reduce internal noise and the risk of the hot engines coming into contact with hydrogen gas, the engines were suspended outboard of the main body of the airship, contained in enclosed power cars, each with their own resident engineer. Instructions were given using maritime telegraphs from a control car attached to the underside of the ship.

The original Imperial Airship Scheme specification prohibited the use of petrol engines for tropical operations due to the low flash point of petrol. The R.100 designers elected to experiment with a hydrogen-kerosene engine, the theory being that a portion of the fuel would then provide lift until used. This admirable aspiration stalled when development was slower than anticipated. Limiting R.100 to the Atlantic route suited the Scheme's protagonist and Chairman of AGC, Sir Dennistoun Burney, who had an eye for transatlantic business rather than links with the Empire. R.100 therefore was exempted from this engine requirement. The Rolls-Royce petrol-fuelled Condors fitted to R.100 by AGC were tried and tested whereas the Beardmore diesels on the R.101were still in development.

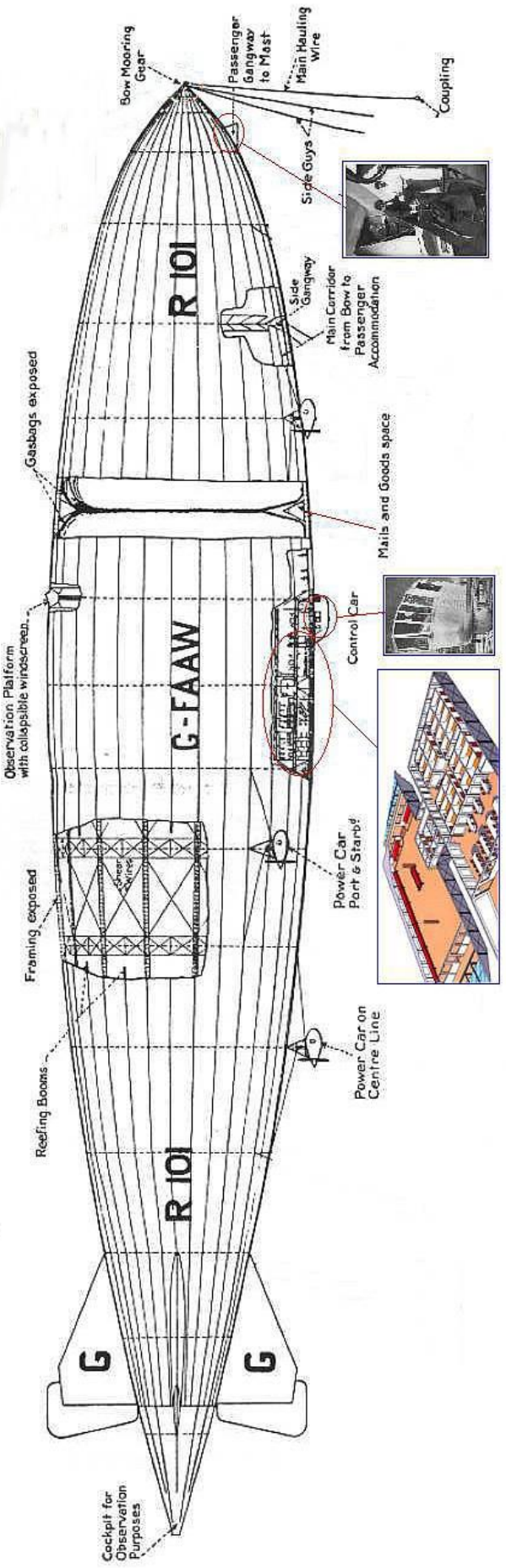

Figure 2 R.101 cutaway drawing www.airshipsonline.com

Mechanical controls actuated the elevators and rudders, of considerable size, mounted on the cruciform tail fins. One engine on R.101 was positioned on the centreline, just ahead of the lower tailfin, to increase the airflow across the lower rudder. On R.101 each engine was contained in its own car, while on R.100 two engines, a pusher and a tractor, shared a car and were overseen by a single engineer thus reducing weight and drag.

The passenger accommodation on both airships was internally suspended within the girder framework structure, situated roughly amidships to reduce the effect of personnel movement on the centre of gravity. The style was intended to replicate the comfort of the main competition, the ocean liner, though the ambience was often cosmetic with thin fabric walls and balsa wood features. Those who travelled reported the experience as 'serene' with little noise or vibration; indeed, the lightweight cane furniture was not even bolted down. The weight of this accommodation was a critical factor as the deck sizes were set from the beginning when capacity was demanded for 100 persons. Promenades and side windows were provided for 'watching the world go by' seen as a pleasurable pastime for passengers on long journeys at low level to exotic places.

To cater for the specified carriage of 100 persons, silver service catering was provided with, on R.101, a fully equipped galley on the lower deck and a dumb-waiter lift to a dining room for fifty persons, beside the spacious lounge. The Chief Steward was recruited from the maritime fleet and was assisted by a galley boy. Once it was realised that neither ship could lift its full payload, the weight of these facilities might be seen as excessive. As the substantial accommodation decks were integral to the total structure, only minimal measures were possible to reduce weight. Reducing the size of the accommodation decks at such a late stage would have been too expensive and time consuming. Had it been accepted early on that both ships were merely prototypes requiring a basic crew complement, more rudimentary facilities would have reduced structural weight and freed more space for gas capacity.

Crewing was based on Royal Naval traditions. Three watches, each comprising a watch officer and height and steering coxswains, were based in the control car, plus an engineer in each engine car, and several riggers who patrolled and inspected the entire ship at frequent intervals. Even in the shed, an inflated rigid required a crew to monitor gas pressures and temperatures to ensure stability in pitch, trim and elevation. When on the mooring mast, weighed down at the tail but free to pivot with the prevailing wind, the airship had to be flown by a crew. On the long international trial flights both R.100 and R.101 found weight and space restrictions allowed only two watches to be carried, the engineers and riggers sharing bunks. For R.100's trip to Montreal the third watch was sent on ahead to Canada by steamship, but allowed to fly back on the return leg. This limitation, combined with the overall shortage of suitably qualified personnel, deprived the R.101 of important crew members at critical times, in particular First Officer Noel (Grabby) Atherstone, who was sent to supervise R.100's ground-crew in Canada during the R.101's preparations for India.

3.1 Earlier rigid airships

Within weeks of Alcock and Brown's open cockpit biplane making the first direct

transatlantic crossing to national acclaim in 1919, the British airship R.34 made a double crossing carrying 30 crewmembers in comparative comfort, plus the famous stowaway and a cat. Captained by Major Scott it established Britain's long distance reputation and Scott's heroic position in the public eye.

The lightweight British-built R.38 was designed for the Royal Navy to operate at 22,000 ft, but was sold to the US Navy before completion. It was designed on the lines of the Zeppelin 'height-climbers', which were produced to out-climb and operate above the British fighter aircraft that had destroyed so many conventional Zeppelins. In their enthusiasm to accelerate the flying trials and hand R.38 over to American crews, the newly built ship was manoeuvred too vigorously at low altitude on a test flight over the River Humber in 1921. The ship broke up in mid-air, killing its designer, Campbell, most of the crew and many technical experts of the day. The resultant inquiry re-wrote the airworthiness strength requirements to prevent any recurrence. These rigorous new rules, when applied to the nascent R.100 and R.101, added to the structural weight and threw out some of the preliminary calculations altogether. It also reinforced the fears associated with using petrol.

As the R.38 had been built at Cardington, many critics later hinted that her designers, primarily Campbell and Lipscomb, repeated the errors on R.101. This is completely wrong. The R.101 team was freshly convened under Vincent Richmond and Michael Rope. Only one design staff member had worked on the R.38 and, notably, it is reported that Richmond, if faced with a problematic design issue, might start the discussion by asking him how it was done on the R.38? This met with a detailed response which Richmond would then dismiss with 'well, we won't solve it that way then' which became something of a party piece.

A. H. Ashbolt, Agent-General for Tasmania, The Journal of the Royal Society of Arts, 23/12/21:

> *"In connection with the proposals for an Imperial Airship Service that I was placing before the British and Dominion Governments, I visited the ships and sheds at Pulham and Cardington. When at Cardington the R.38 was in shed undergoing some slight repairs necessitated by the previous flight. Mr Campbell showed me the principle structural differences between that ship and R.36 and the German Zeppelin L71. Subsequently, on thinking matters over, I felt uneasy on the subject of building commercial vessels on the lines of R.38, and had a further interview with Mr Campbell at my office in London. I expressed my doubt on this point and asked him whether in the event of an Imperial Service being established he would design on the lines of R.38. Before I could express myself further, Mr Campbell exclaimed 'Good God, man, no! R.38 was specially designed in accordance with Admiralty instructions for purely war purposes to over-fly and out-fly all existing Zeppelins. We have, therefore, built her as light as possible to attain maximum heights, and she has very considerable engine power. When we build for commercial work maximum height and maximum speeds are not essential. With a war craft, if she serves her purpose during hostilities for, say, six months, she has achieved all that one can ask from her, but for commercial purposes you want strength and stability instead of lightness and height. For commercial purposes we would simply elaborate R.33 and R.36"*

The French airship, the war reparation Zeppelin (L-72) rechristened 'Dixmude', was lost over the Mediterranean in 1924, probably due to severe weather breaking its similarly lightweight structure.

Flight, 3/1/24 following the loss of 'Dixmude':

> *"It is known that the Dixmude was designed {as the German L72} for bombing raids at great altitudes and in fine weather only. Consequently, as much structural strength as possible would have to be sacrificed in order to obtain the "ceiling" necessary. Something very similar was the case with R38 whose girders failed and which subsequently caught fire from sparks from the girders and electrical cables."*

4. Air Ministry v Admiralty

Air Vice-Marshal Sir W. Geoffrey H. Salmond, Air Member for Supply and Research (AMSR) advised the Secretary of State on 15/4/24 (AIR5/1006):

> *"After the Conference which I had with the Admiralty this morning, I have come to the following conclusions:-*
>
> *a) The Admiralty are prepared to support any scheme which is likely in the end to give them, instead of the Air Ministry, airship control.*
>
> *b) With this end in view Admiral Fuller made every effort to discredit the competency of the Air Ministry.*
>
> *c) For this reason the only scheme they would agree to was one which involved placing Commander Burney at Cardington in charge of construction, and so producing only one ship; and would not have anything to do with a scheme which would produce two ships because this involved one ship being designed and constructed by the Air Ministry."*
>
> *"I do not consider that one Government Department should impugn the competency of another, and although I might have replied with the example of the R.38 (which Mr Payne admitted was an Admiralty design) I refrained from doing so as I did not wish to enter into such a matter…*
>
> *…I fear that the prestige of the Department has now become involved in consequence of the attitude taken up by the Admiralty at this morning's meeting."*

Arguments revolved around crewing and mission. The Admiralty wanted Reconnaissance and the Air Force an Aircraft Carrier. Burney wanted Admiralty control but Commercial purpose. It is surprising anything constructive or consistent came out of it.

AMSR wrote to Director of Airship Development Fellowes on 20 November 1924, AIR 2/262, showing something of the civil/military conflict of opinions:

> *"I wish all concerned at RAW to understand that R.101 is to be, under present policy, a Service airship. It will be designed to carry troops and to this extent it will have, to a certain degree, the attributes of a commercial airship. On the other hand, as Admiralty*

and Air Staff requirements become clearer, there will have to be special provision for wireless, Army and Navy observers and Navigating officers possibly.

One of the principal functions of a Service airship will be that it should be capable of carrying aircraft." (later defined as twelve Siskins)

Royal Airship Works Director of Airship Development (DAD) Fellowes explained some of these conflicting factors to AMSR after discussions with Wyn-Evans and Richmond. This resulted in a concluding minute on 12 December, still overly demanding (AIR2/262):

"Finally it is understood that your wishes are that R.101 when first completed should contain all the features which will enable her to carry out the following functions:- Naval reconnaissance, ambulance, troop carrier and commercial services, and when she is modified, after her return from India, she will be able to carry a certain number of aircraft and to have her fuel system modified to give an extended range for reconnaissance."

5. Specification

The Imperial Airship Scheme called for a gas volume of 5 million cubic feet, a payload of up to 100 passengers, cruising at not less than 60 knots for 48 hours, and a still air range of 2880 miles allowing one-stop to India via Egypt. The use of heavy oil or diesel engines was specified though work on hydrogen-kerosene fuelled engines was ongoing. Highly inflammable petrol vapour had caused previous casualties and was seen as a significant hazard, particularly in the tropics.

The Ministry decided to build two prototype airships, one on conventional lines from Vickers on a fixed price contract (R.100) and one at the Government Royal Airship Works, Cardington, with maximum innovation (R.101). Combined flight trials would tease out the best of both for future fleet development. This was in response to Burney's plan for Vickers to build six ships commercially (see later). Public/Private partnerships/competition was seen as the economic way forward.

AIR5/908 9/9/30 describes the reasoning behind the engine choice:

"On the other hand, for various technical reasons, the engine and its auxiliaries are considerably heavier than anticipated, so that the weight of the power installation in R.101 amounts to over 17 tons as compared with under 9 tons in R.100, and 7 tons in the Graf Zeppelin. But against this excess weight of the power plant must be set a great gain in fuel economy both as regards weight and cost. For a range of 2,500 miles in still air under standard conditions, R.101 requires about 17 tons of fuel at about £5 per ton [£85], as against 23 tons at about £23 per ton [£529] for R.100."

Bulman, AD/RDE Paper on R.101 engines marked 'secret' 10/6/1929 (Cave-Browne-Cave papers, Imperial War Museum):

"The airship staff from the inception of R.101 has been adamant in its insistence on the

exclusive use of heavy oil as a fuel notwithstanding that development of the Compression-Ignition (C.I.) engine for air use was clearly a problem of enormous difficulty."

F. W. Musson, Private Secretary to Higgins, drafted the background to the Imperial Airship Scheme. The record is in AIR5/14, and includes Ministry impressions of Commander Burney, but no mention of long distance qualifying flights:

"The final objective of the present airship programme is the inauguration of a company to operate airships commercially. The stages to this end may be summarised as follows:-

(a) To demonstrate that airships of a reasonable size can fly successfully.

(b) To demonstrate that such airships can use a mooring tower for general operating purposes over a wide range of weather conditions.

(c) To demonstrate that the ship can operate with reasonable regularity.

(d) To demonstrate that the ship has a reasonable life and is not unduly expensive to maintain.

(e) To demonstrate that the ship can be handled on the ground in a practical manner.

(f) To demonstrate that 'prima facia' (at first glance) airships can be made a commercial proposition.

(g) To create an atmosphere in which the public will give financial support to an airship operating company.

(h) To find an individual or individuals who will accept the responsibility of floating and operating such a company.

...This is the explanation of the fact that Burney is the only active representative of the business community at the moment. One recognises, of course, his enterprise and fertile imagination but where concrete facts of business are concerned it cannot be said that the Air Ministry (or presumably Vickers) have any reason to be particularly impressed with his ability. If airships are to prosper, it is of vital importance that the operational experiments with R.100 and R.101 in the coming months should be carried out in a thoroughly practical manner. Nothing could be more out of place than stunts and the sort of extravagant atmosphere which Burney never fails to excite. A programme of flying based on a time-table which is within the capacity of the airships is essential. The vital point is to demonstrate that the airships are capable of flying to a regular schedule, the load they can carry is a secondary consideration, for this after all is a function of the weight of the structure, engine efficiency, propeller design and other technical points on which progress is inevitable. The crux of the matter is whether the airships can operate with regularity and they should be given every opportunity to prove themselves in this respect all other considerations notwithstanding. There is everything to be gained by keeping this as a clear issue and recognising such points as the carrying of passengers as a subsidiary detail.

If this suggestion is carried out and the airships are successful, data will be available on which the commercial possibilities of airships can be estimated. ..... Assuming,

however, that the experiment is a success a state will have been reached at which for the first time serious businessman could be expected to become directly interested.

At this juncture the stimulating effect of a man like Burney would be of distinct value...".

On 10 October 1930 the Air Council (139th meeting) discussed the case (AIR2/379). In an explanation of the differences for both airships between estimated and achieved empty weight, it concluded:

"The weight of the passenger accommodation – approximately 12 tons in either ship, was more than anticipated, owing to the provision being made for too many passengers on an elaborate style."

A 'Flight' editorial 20 November 1924 commented:

"We simply cannot afford to risk the new airships being failures. They have got to be successes, whatever the cost and whatever the unavoidable delays in producing them."

6. Construction

Components for the construction of R.101 were manufactured by Boulton and Paul Ltd. (AIR5/904) refers to the Aeronautical Inspection Department (A.I.D.):

The procedure followed was that Colonel Richmond's staff at Royal Airship Works, Cardington indicated to the firm the general arrangement of the girders and the stresses to be provided for in each member. Messrs Boulton and Paul then designed a suitable girder, the drawings being submitted to Cardington for approval. The firm were therefore primarily responsible for the designs but the Royal Airship Works checked them and accepted final responsibility. After approval the girders were manufactured by the firm under A.I.D. inspection and transferred to Cardington for assembly.

AIR2/364 lists the following as some of the new features which are to be in H.M.A. R.101:-

1. *Improved Shape.*
2. *Stiff ring construction.*
3. *New System of Gasbag wiring*
4. *Improved shape and construction of fins.*
5. *Use of stainless steel.*
6. *Tubular girder construction.*
7. *Bolted joints allowing improved method of erection and repair.*
8. *Extensive interior passenger accommodation.*
9. *Double deck control car.*
10. *Bow mooring deck*
11. *Heavy oil engines.*

12. *Steam cooling for engines.*
13. *New type gas valves.*
14. *Automatic pressure regulation for outer cover.*
15. *System of mechanical tautening for outer cover.*
16. *Improved method of flap control.*
17. *Electrical recorder in Control Car for forces on the Bow.*

The designers of the two airships, having been set the same fundamental problem, have solved it, in certain directions in an entirely different way. The following table [AIR2/364] *shows essential points of difference:-*

Items	H.M.A. "R.100"	H.M.A. "R.101"
Girder construction	Duralumin strip wound into tubes.	Main girders stainless steel with duralumin webs or cross-tubes and steel wire bracings.
Transverse Frames.	Shallow frames (2'6" diameter) radially braced by wires, with axial girder.	Deep frames (10'6" diameter) inherently stiff and un-braced.
Gasbag wiring.	"Mesh panels"	"Parachute" system.
Power cars.	3 cars each with 2 engines and 2 propellers and detachable sections for changing engines at tower.	5 cars each with one engine.
Power system	6 R.R. Condor 650 h.p. petrol engines.	5 Beardmore Tornado 585 h.p. compression ignition engines, using heavy fuel oil.
Reversing system.	Gear boxes for reversing 3 propellers.	Designed for variable pitch propellers. At present 2 engines are of reversible type and others will be modified later.
Outer cover tautening.	Is pulled in by a system of taper and wires.	Is pushed out by "reefing girders"
Accommodation	A 3-deck structure slung in one bay between frames 5 & 6.	A 2-deck structure slung in two bays between frames 6 & 8.

There are two important respects in which the [R.101] engine differs from those used in other airships:

1. The fuel used is a heavy fuel oil of which the flashpoint is considerably higher even than the oil used as fuel in ship's boilers. ……

2. The engine is of the water-cooled type, but is arranged so that instead of circulating water through a radiator, steam only passes to a condensing radiator. …..

The Diesel type engine in addition to the greatly increased safety which it gives through the use of heavy oil, has the advantage of increased reliability through the elimination of carburettors and magnetos. It is also economical both as regards the quantity and the price of the fuel it consumes. A given quantity of oil fuel gives about 25-30% greater range than does the same weight of petrol.

Lord Kings Norton 1995, (Masefield Archive, Brooklands):

"I had no doubts, personally, about the integrity of the structure. It [R.101] was a perfectly sound flying machine."

Pippard to Reynolds, Final airworthiness report 7/11/1929 (AIR5/921):

"The fins on R.101 are unusually efficient and are consequently smaller than those on R.100."

"The gasbag wiring system is highly praised, and it is stated that weight can probably be saved here."

"The novel design of ring and gasbag wiring has been adequately established as sound."

The first flight of R.101 was on 14 October 1929 carrying non-essential guests over central London. These included Higgins, Fellowes, Colmore, Richmond, Rope, Cave-Browne-Cave, Giblett and Wann, Captain in R.38. In anticipation, on the 14th, Thomson wrote outlining his desire that various political individuals and even a group of 100 MPs should be taken up to strengthen 'support' for the programme. He specified the need for advanced notice and certain dates. No realization of the vagaries of weather, technical delays or the structured test programme. Significantly, the Wall Street Crash occurred two weeks later. The subsequent economic crisis affected the national appetite for innovative investment.

Atherstone comments on the distractions of media and political point scoring in his diary for 6/11/29 (unpublished diary, copy with Airship Heritage Trust):

"Storm routine was lifted at 0800 and preparations were put in hand for giving lunch on board to a bunch of Dominion Delegates to Conference on Empire Legislation. All these window dressing stunts and joy rides during the ship's trials and before she has got an airworthiness certificate are quite wrong, but there is no-one in the RAW executive who has the guts to put their foot down and insist on trials being free of joy-riders."

6.1 Test Bay

The entire R.101 structure was a new concept so a complete test section was installed against the shed door to prove the ring/girder design and, once fitted with a bag, was tilted and loaded, while a series of complex measurements were taken.

Detail can be found in *Some Modern Developments in Rigid Airship Construction* read at the Spring Meetings of the Sixty Ninth Session of the Royal Institute of Naval Architects, 30 March 1928, by V.C. Richmond:

> *"a complete replica was built of a centre bay of the ship, consisting of two transverse frames and the connecting longitudinals and shear wires. Special electrically recording strain gauges were developed with the co-operation of the Cambridge Scientific Instrument Co., which enabled the strains in the various members to be watched during the progress of the tests, all the girders having been previously calibrated for strain during the girder tests referred to above. One of the transverse frames was subjected to a large variety of loading tests before being assembled into the bay, both in a horizontal and a vertical position.*
>
> *The complete bay was attached to the door of the shed by means of a flexible end plate on each longitudinal girder. The bay was allowed to project from the door as a cantilever without any other support than its fixing to the door. Tests were carried out with the bay empty of gas with loads slung from the bottom of the ring remote from the door, thus shearing this ring downwards with respect to the door. A gasbag was then inflated in the bay and all weights removed so that the full upward shear caused by the lift of the gas came on the bay. No strains were anywhere recorded in the transverse frames higher than the calculated values."*

First component was delivered April 1926 and the bay was assembled in May 1926. Tests were complete by December 1926 and the girders were then used in destructive testing.

It seems that the benefit of this thorough analysis, pre-construction, was not appreciated by Norway or AGC even though, today, it would be seen as a vital precaution. In the Journal of the Royal Aeronautical Society, October 1987, Vol.91, No. pp343-349 and May 1988, Vol.92, No.915, pp200-202, Keith Burbridge, Sir Alfred Pugsley and Peter Masefield conducted a published conversation that highlights the misconceptions relating to R.100 and R.101. Pugsley (a Technical Officer at Cardington 1926-31) disagrees with much of Dr. Burbridge's comments thus:

> *"Firstly, referring to the loss of the R.38, he [Burbridge] remarks 'The Air Ministry design team was not censured, no-one lost his job, and that same team was entrusted with the design of the R.101'. This is incorrect; the chief designer of the R.38 and some of his staff were killed in the accident, and for the design of R.101 a new team was formed at Cardington under Lt. Colonel V. C. Richmond."*
>
> *...Secondly, the Open Letter quotes N. S. Norway as recounting 'bitterly that £40,000 was spent constructing a section of the vessel, only to scrap the section as unusable'...This was purely experimental. It was a bay of the proposed hull structure between two frames, and was used for a number of purposes – a trial assembly of the proposed frames and longitudinal girders and of the gasbag wiring; then of the behaviour of the wiring when filled with an inflated gasbag, and for structural tests on the section."*

Photographs exist showing the entire structure tilted to simulated displacement due to pitch that provided reassurance on all counts. This might be one of the earliest uses of electric strain gauges of this type.

Cave-Browne-Cave's RAeS lecture in 1962 contains this endorsement RAeS Journal August 1962 :

"The construction of this trial section in its test under conditions so nearly representative of those in flight was a most important step in the development of this novel system of construction and indeed in the whole practice of structural engineering design."

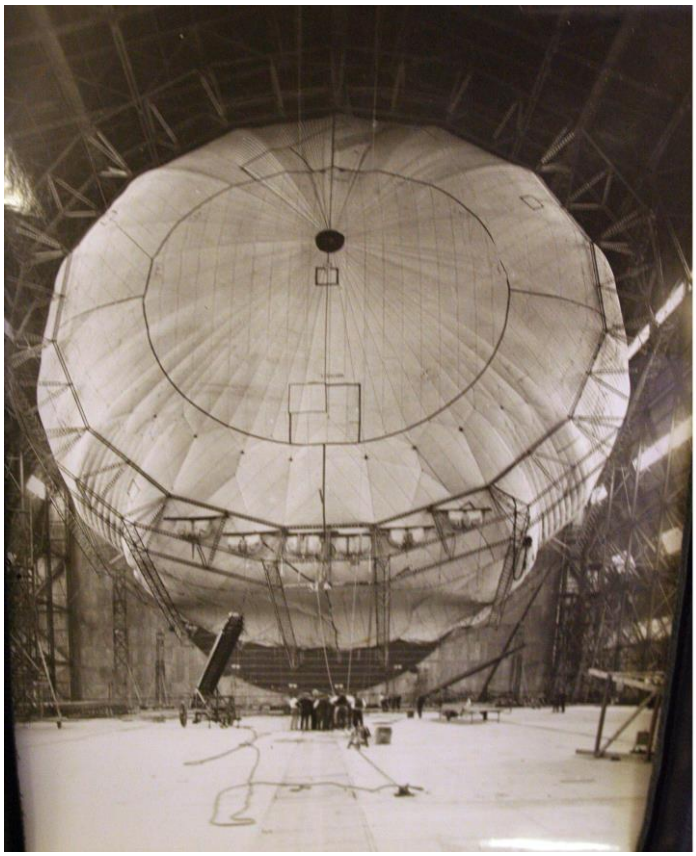

Figure 2 The test bay mounted on a door of the airship shed at Cardington
Cardington Boxes RAF Museum

6.2 R.101 weight reduction and insertion of an extra bay

It was obvious to all soon after completion that both airships were well short of their estimated payload. The science of weight estimation was in its infancy. Until the ships were completed and weighed in their sheds it was impossible to know their exact weight.

AIR5/14 includes a transcript from a Richmond letter on 22/1/30:

"Although I have no doubt DAD has fully acquainted you of the technical position, I should like to take this opportunity of putting my views in a few words.

(1) The air-worthiness regulations set a new standard in hull strength, (after the R.38 accident) nobody could foresee what this would mean in weight. Now we know pretty definitely and in playing for safety I do not think we have exceeded appreciably the weight implied in those regulations. The hull weights of the two ships are almost identical and Bairstow says they are of equal strength.

(2) In future we may save a few tons by refinement of design such as in the fins and passenger quarters. The deliberations of the new Stressing Committee may also ease the strength requirements, but I do not look for too much in this direction.

(3) The important question of the effect of choice of machinery on weight and consumption is well known. R.101 with five engines and good propellers would attain about the same speed as R.100 and any limitation of range caused by the

weight of the engines is compensated for by decreased consumption, etc. The range of neither ship is sufficient, certainly with any payload during the bad months.

(4) What all this comes to is - that a 5 million cu.ft. airship according to current British ideas is not suitable (inherently) to carry 100 passengers over journeys to the East of 2500 miles at all times of the year. This may be a serious conclusion in view of what the British Public has come to expect, but I do not think the particular airships which have been produced can be blamed, nor do I think the position could have been wholly foreseen in view of the highly experimental nature of the job.

Either we must have our stopping places closer together or our ships larger or both. I am afraid there is no doubt about the second, but I naturally hope very strongly that the size will not have to be so large that a lot of new fundamental research work has to be undertaken. One would like the chance to perfect the present type."

Major Teed produced a 95 page report on 6 April 1931 (AIR5/919) that confirmed the structural weight of R.101 was 110.1 tons against a specification of 90 tons and a gross lift 3.4 tons less than anticipated. Hence, with 23.5 tons to make up, drastic measures were required.

Colmore reported to AMSR Higgins on the lift limitations on 18 November 1929 (AIR5/904), with recommendations for weight reduction, letting out the gasbags and adding an extra bay. He also outlined the dates restricting flights to Egypt and India due to temperature. The 45 foot long bay, numbered 8A, would give an additional gross lift of 15.2 tons and be inserted aft of the accommodation bay at the point of maximum diameter. If agreed, components could be in place by June 1930. Figure 3 shows the final layout with the extra bay.

Higgins passed the summary to Thomson who responded thus on 28/11/29. (AIR5/904):

"I am of the opinion that no good, and quite possibly some harm, might be done by a flight to India in the early months of 1930. The best course would I think be:

(a) To make the various alterations you suggest in para 3 of your minute.

(b) To insert the extra bay.

(c) To make every effort for a flight with 55 tons disposable load to India and back at the end of September 1930."

Some elements, like the passenger accommodation and engine installation, were fixed, though lessons would be learned on future designs. Hence, a programme of weight reduction was created, mainly affecting minor elements like sanitary fittings and decorative elements. Individually these made minor improvements but batched together they all added up. Both airships had been over optimistic in their passenger aspirations, solely in order to meet the specification. If it had been accepted in December 1929 that no extraneous persons (crew or passengers) were to be carried, then there would have been adequate time to remove fixtures and fittings as part of the weight reduction programme. The way in which the accommodation decks had been integrated with the primary structure meant that the removal of the enormous decks themselves was a step too far. Given earlier realization or more conversion time a very

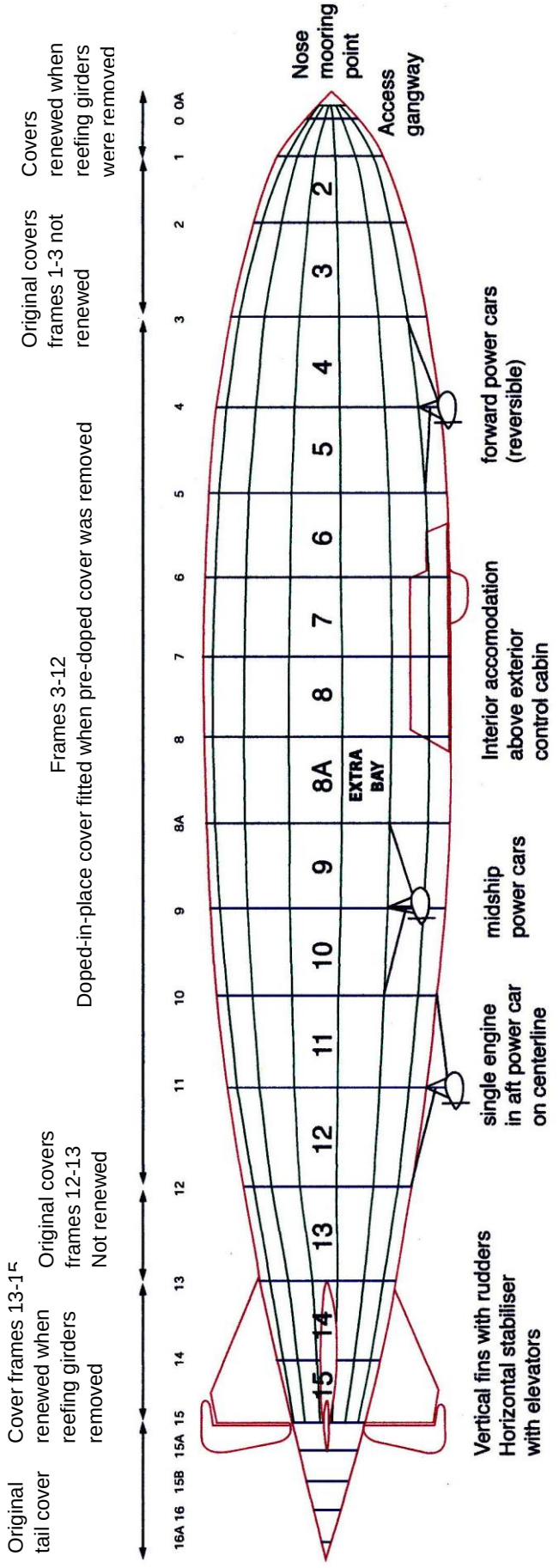

Figure 3 Layout of R.101 with additional bay installed. This diagram also shows the status of the cover for the different bays.

Drawn by Davison from original plans held at the PRO

considerable weight reduction could have been made and more gas space created. However, with the accommodation being internal and integral to the structure, this was impossible.

This explains why a risky decision to let out the gasbag wiring was accepted without question. Without this, there could be no long distance flights and public perception would see the scheme as a failure even though the accrued technical knowledge was substantial. Rope's original concept kept the gasbags clear of the outer structure. Once the restraining wires were let out to increase capacity, they rubbed and rolled within the structure.

Ces Mowthorpe, airship historian explained the wiring variation in *Hot Air and Pipe Dreams* (Mowthorpe, 2010):

> *Brief mention now of Rope's gasbag harness in R.101. Zeppelins and R.100 had the lift from their multiple gasbags transmitted to the hull by netting which went over the top of the gasbags, being secured to lower main hull longitudinals. The gasbags themselves could not move forwards or backwards because of the radial wiring of each radial ring-frame (a slight movement was, of course, possible due to the flexing of the gas). R.101 was radically different. Her hull contained no radial wiring because the stainless steel radial rings were themselves stronger, rendering radial wiring unnecessary. Sqn.Ldr. Rope designed an ingenious 'parachute-type harness' which enveloped each individual gasbag and was so designed that when that bag was properly inflated it transmitted the lift directly through its harness, yet the gasbag itself did not directly come into contact with the main hull at any point."*

Colmore summarized the current work schedule to Higgins, *Parting the ship* (Colmore-Higgins 11/7/30; National Archives AIR2/364):

> *"We are anxious to avoid too large a concentration of work in the shed during August and September and we should like therefore, to part and set up or position the ship for the new bay next week. There is certain work which can be started immediately the ship is parted, such as modifications to longitudinal ends, alterations to lift wiring, outer cover work etc. A.M.S.R's approval will be obtained before this work is commenced.*
>
> *It is impossible to give a firm estimate of the time required for joining up the new frame in the ship but we are programming to complete the ship by September 22nd. Every effort will be made to complete the ship as quickly as possible but we have no allowance in our programme to cover unforeseen delays."*

Lord Thomson responded to John Higgins 14/7/30, AIR2/364:

> *"As long as R.101 is ready to go to India by the last week in September this further delay in getting her altered may pass.*
>
> *I must insist on the programme for the Indian flight being adhered to, as I have made my plans accordingly."*

RAW list of weight reduction modifications to R.101, 18/11/1929 (AIR8/111):

> *"Item 13*

It is now considered that the cover from the bow to Frame 1 and between frames 13 and 15 is adequately supported without the use of reefing boom girders and that they could therefore be removed.

Weight saving 1,280 lbs

This would entail making new covers for the portions of the hull referred to.

Item 17

When the present gasbag wiring system was designed, it was considered a matter of certain amount of speculation as to whether the bag would take up precisely the shape predicted. It was therefore thought desirable to so design the wiring system as to leave ample clearance between the wires and the girders of the hull. It has now been found that the shape taken up agrees extremely closely with that predicted and it is therefore possible to reduce the clearances referred to. This will mean lengthening a certain number of the wires but not all. No new fittings will be required.

Additional lift 6,720 lbs."

Richmond's diary 22/1/1930 relating to correspondence with Harry Bateman, Assistant Observer at the NPL (unpublished diary, RAF Museum):

"Having heard from Bateman that Dr. Jones was anxious about the effect of the new bay on stability, Sq/Ldr Rope spoke to Dr. Jones today, and Dr. Jones upholds the view that the effect would be an adverse one, and is making his own estimate of the effect which he will communicate to us in a few days' time."

Higgins had accepted the need for further flights as early as December 1929 (AIR5/904):

"We are proposing to put in another bay during the summer and then to carry out the first flight along the Indian route after the airship has done some further flying trials with the new bay fitted."

AIR2/349 predicts likely payloads:

Egypt:	*7.5 tons between May & October*
	3 tons November to April if best time of day selected.
Karachi:	*10 tons between May & July*
	5-7 tons November to March.

Cave-Browne-Cave's draft R.101 document in the Masefield Archive (Cave-Browne-Cave, 1969) summarises his opinion:

"An airship working under these test conditions should <u>never</u> carry more than a dozen passengers as expert observers in addition to her essential crew. In the design of R.101, however, provision had been made for carrying 100 passengers. The weight involved in providing this accommodation would have been infinitely more valuable as useful lift to meet the difficult conditions of flight."

6.3 Stability and Dynamic Lift

One indication of the smoothness of passage in the airship is obvious when images of the lounge are interpreted. The furniture, necessarily of lightweight construction, was not secured to the deck. Thomson also remarked that he felt more able to work on board than in his busy office. Following the July test flight the only stability issue raised concerned the preservation of crockery, not the ship.

In July 1930 Scott was sent a note (AIR5/904) requesting:

> *"During the very bumpy weather experienced the necessity of fitting some form of batten down the centre of each dining table is thought desirable to prevent the table gear from falling off. The existing beadings along edges of tables will require to be made deeper."*

The effect of dynamic lift is often misunderstood. The reliance on an airship being able to slow or stop to undertake repairs or await improved weather conditions suggests that the effect is minimal and, therefore, insignificant. In reality, when the margin of lift available tends towards zero, dynamic lift becomes essential to maintain altitude. With increased weight due to wetting of the cover, and the possible reduction in gas volume due to leakage in rough weather, the need to maximise forward movement and dynamic lift can become critical.

The Inquiry commissioned Reports and Memoranda R&M1400 (Jones and Bell, 1931) and 1401 (Williams and Collar, 1931) from the Aeronautical Research Council to evaluate the motion of the R.101 using a much more accurate model than used previously. The authors of 1400, R. Jones and A. H. Bell, concluded:

> *"The equilibrium calculations show that the ship had ample control surfaces for keeping its axis pointing upwards at the nose even after (1) a considerable gas leakage forward, (2) a possible damage to the outer cover had caused an increase in drag, or (3) a decrease in thrust.*
>
> *..... the addition of the extra bay in itself was a sufficient justification for desiring further experiments on a model of the airship as she was before starting on her last flight."*

The R.101 without enlargement was similarly evaluated in R&M 1168 (Jones and Bell, 1926) and 1169 (Jones and Bell, 1927).

R.101 was chosen to appear at the 1930 Hendon Air Display once it was clear that R.100 would make the summer trip to Montreal. At the end of a test flight she arrived over Hendon to great acclaim and dipped her nose in salute to the King. However, some observers suggested that this was caused by instability in pitch. R.100's First Officer, George Meager, who was on his only flight in R.101 then had to release ballast to assist the height coxswain during the return to Cardington who was 'fighting' to keep her level. Although Captain Irwin considered this unnecessary, the experienced Meager described it as 'the only time he ever got the wind up in a rigid' and requested not to fly in her again.

Meager comments in *Leaves from my logbook* page 55 (Meager, 1961):

> *"This should have warned them at Cardington that something was radically wrong somewhere. I am afraid, however, that the ship was so much the 'apple of their eye,' that they thought nothing could be wrong with her in spite of this heaviness at the end of each flight being a regular experience, judging by the amount of ballast that was dropped on each occasion."*

Richmond's diary 27/6/1930 (unpublished diary, RAF Museum):

> *"It was noticeable that the ship which was flying at a comparatively low speed had to be pitched up with the nose considerably and was rather unstable in pitch generally. A considerable amount of water ballast had to be dropped on landing."*

An RAW note from 11/5/31 credited to Booth and Collins, on reaction to dives/pitch instability (AIR11/23):

> *"On the trial flight prior to the rehearsal flight the ship's flight path was very uneven at one time and this was put down to the bumpy conditions prevailing at the time, and the fact that the ship was slightly unstable in pitch at slow speeds. There is very little evidence available as to whether previous ships were subject to diving but it was reported that L.59 on the flight to East Africa dived between 3-4,000 feet in the vicinity of Khartoum before being brought under control."*

Rigid Airship Manual, III-7 (US Navy, 1927):

> *"... if an airship model is placed in a wind tunnel so that it is free to turn about its c. g., it is found that it will increase its angle of inclination to the air stream up to about 40°, then steady down and remain in a stable equilibrium at about that angle. That is, at great angles of inclination the pressure on the leading side near the stern ... becomes so great as to neutralize the other moments. However, up to about 40° the model is unstable. Therefore, it can be said, that an airship, regardless of its length, rigid or non-rigid, is in general aerodynamically unstable in all planes ... Thus a light ship tends to dive and a heavy ship tends to climb ; also if ship yaws off its course it tends to increase the yaw."*

It is also stated that a design choice, exercised and agreed by Richmond and Rope, was that steady flight was preferred at the designed cruise speed of 60-70 mph and sacrificed at slow speed. (AIR11/23). Hence, the pitch instability at Hendon and in bad weather over Beauvais was, to some extent to be expected. R.101 was designed for a fast cruise regime.

Richmond's diary 18/9/1930 (unpublished diary, RAF Museum):

> *"Visit of Bairstow and Pippard re airworthiness of R.101. Satisfied them on all points, except that they have raised as a new issue the question of the ship pitched down by the nose with one gasbag deflated. Promised to send further notes on this."*

Richmond's detailed response, on 24 September 1930, survives in AIR5/904; one part includes:

"Before one gasbag became fully deflated, it is certain that the pilot would have ample time to get his ship up by the nose, and there is no doubt that he would proceed to do so. The condition of the ship down by the nose, therefore, could only arise from suddenly flying into a vertical current. My own opinion is at the moment that we have no reliable means for estimating the loading produced on the ship by flying into a vertical current,"

6.4 Covers, gas bags and valves:

6.4.1 Covers

To maintain its aerodynamic form, R.101 maintained positive pressure within the outer cover by means a series of ventilation holes situated in a high-pressure area at the nose. This created an internal airflow that purged any escaped gas, expelling it through gill like openings amidships and further vents at the tail. Non-structural, adjustable reefing girders were installed between the longitudinals to smooth the aerodynamic profile. These could be adjusted on the ground to tension the cover fabric from within. Some of these were later removed to save weight but others, in the nose, remained. R.100 relied on wires to tighten the cover with no internal pressure space, hence the issues on cover flapping and its concave shaping between the longitudinals. Any escaped hydrogen on R.100, however, was released directly outside the envelope. R.101, with an enclosed though vented space between valves and envelope could contain a volume of hydrogen air mixture. This pressurised space kept the outer cover smooth and more aerodynamically efficient.

The covers of both ships let in the rain so there is no doubt that cover and gasbag material was in need of major improvement had development proceeded. Dyer, the RAW fabric expert, was wedded to his technology and denied any weakness both to the Inquiry and in later life.

Meager writes in *Leaves from my logbook* p. 42 (Meager, 1961) regarding the cover of R.100:

"The outer cover leaked badly. This meant that the gasbags became soaked if the airship flew or was moored in rain. This was a potential danger as the gasbags were not designed to withstand wetting."

Scott & Richmond, 1923 (*A detailed consideration of the effect of meteorological conditions on airships* R.38 Memorial Prize paper, Royal Aeronautical Society, London):

"No reliable measurement of the weight effect of rain on an airship has been made so far in England. This effect is naturally less in a wind than in stagnant air, but in either case it rapidly reaches an equilibrium value. The maximum heaviness caused in R.33 at the mast by rain appears to have been about 1.5 tons."

An anticipated gale caused the cancellation of a full 4 engine speed trial (at this stage the fifth engine was kept solely for reverse). John Higgins wrote, 23 October 1929, (AIR5/14):

"We do not anticipate any trouble arising out of this, but the fact remains that the behaviour of the outer envelope (at that time 'new'), with four engines running at full speed, has yet to be ascertained, and it would, in my opinion, have been culpably foolish to run the risk of having this tried out for the first time in a violent gale."

6.4.2 Fabric deterioration

Estimates for cover longevity were in years rather than weeks so the short span from November 1929 to October 1930 seemed safe. Michael Rope commented that the winding out of the non-structural reefing girders to avoid cover flapping might be hiding a reduction in cover strength. Not only was Rope technically expert; he was also politically astute enough to recognise the growing pressures on Thomson to deliver the dream of Imperial communications.

Higgins seemed to have grasped the cover issue on 23/6/30 (AIR5/14)

"The most forward part of the outer cover from the nose to frame 3 consists of fabric doped in place, and the splitting has occurred in the forward part of the pre-doped cover, just at the point which would be most severely affected by weather conditions, vis, at the top of the airship and in front of the maximum diameter. [Did this create complacency as to the resilience of the forward section?].....Eventually, however, I think we must replace the pre-doped fabric in any panels likely to split, and action has already been taken to get the fabric for this."

He wrote a cautionary note headed *The outer covers of R.101 and R.100 in relation to the operational programme* to Richmond and Colmore, Director of Airship Development, in June 1930 (Cave-Brown-Cave papers at the Imperial War Museum) that included five pages of measurements and statistics and concluded:

"Laboratory experience cannot account for the deterioration and the only explanation which suggests itself is that, throughout the history of these covers, permanent extension has taken place locally rather than uniformly along the weft. Calculations and small scale laboratory experiments may be liable to large errors – but what scant information is available from these and other observations in the shed suggest that there is no margin of safety for flight in rough atmosphere.

It is for consideration as to whether the risk involved in sending either ship on a long overseas flight is or is not greater than is justified by the need to fulfil public expectation"

This prophetic statement was not passed up to the Ministry, nor quoted at the Inquiry. The document survives at the Imperial War Museum.

Atherstone describes the outer cover on 2/7/1930 (unpublished diary, copy with Airship Heritage Trust):

> *"I examined some of the outer cover which has just been taken off the top of the ship and find it is completely xxxx.(unreadable) It can be torn without using any force at all just like paper. I don't understand how any of it stayed on the ship at all. This cover is very much worse than I expected it to be and to have ordered the ship to fly with a cover in such a rotten condition is, in my opinion, a totally unjustifiable risk."*

Richmond's diary 24/9/1930 (unpublished diary, RAF Museum):

> *"Discovered that rubber solution in conjunction with dope on the outer cover has a tendering effect and consequently gave orders for reinforcing strips to be stuck over all places where rubber solution had been used."*

6.4.3 Gasbags

Michael Rope's ingenious gasbag wiring, so thoroughly tested in the full-size test bay, restrained the bags and transferred the lift effectively whilst maintaining physical separation from the structure. This allowed the hull to rotate slightly around the bags and reduced rolling and surging in turbulent air. Inclinometers and strain gauges had proven the system at severe angles of pitch before construction began.

With confidence that all the gasbags would remain clear of the external structure there was less need to avoid rough areas on the inner facing structure. Hence, the fixing bolts for the longitudinals had threaded ends facing the bags. When the innovative parachute wiring was relaxed to increase gas capacity it was too late to remedy this design decision.

This was not entirely new, as Captain Irwin reported on 23/10/29 soon after the first flight, AIR5/919:

> *"There appeared to be a good deal of movement of the gasbags and gasbag wiring when the ship was rolling at the tower, the hull appeared to roll around them. This caused a fair amount of chafing on the bag all round the inner ridge, and a lot of padding will be necessary here. There is a clear mark on each bag where this has taken place, and it may be worthy of consideration as to whether the bag should not be slightly reinforced at this point."*

Rather than redesigning the bags, extensive padding was introduced and gas losses were reduced to a similar level as those on R.100 with its more conventional structure. It was widely accepted that gasbag and cover material was a weak point but no alternative had been developed. R.100's cover leaked very badly between Canada and Cardington, causing discomfort and later, corrosion. Even at Howden AGC kept varnishing R.100 throughout the build programme, the shed was always damp and, in many ways, in very poor condition.

Design Memorandum 38, received by Bairstow on 17/9/30, copied from AIR5/904:

"In view of what was originally thought to be the difficulty of predicting the precise curvature taken up by the gasbags, considerable clearance had been allowed between the gasbag wiring and the main hull structure. After inflation this clearance was found in fact, to exist. It was then estimated that by slightly increasing the general radius of the cylindrical portion of the gasbags (a matter which was easy to carry out by lengthening the main circumferential wires), a gain of 3 tons could be obtained in the gross lift – a figure which was subsequently confirmed by results."

The airworthiness report (Bairstow and Pippard) of 7 April 1931 comments on the chafing issue (Ventry Archive, National Aerospace Library):

"Although the letting out of the gasbag wiring was not sufficient to cause the bags to exert any appreciable loading on the structural members of the hull, it was sufficient to permit the bags to chafe against certain projections in the girder work. It was found, therefore, after one or two flights with the modified wiring that holes were occurring in the gasbags. As a consequence of this, each bag of the ship was carefully surveyed in turn, and all projections were padded – a somewhat extensive operation. It would appear desirable in future ships to pay special attention in the detail design of the girders to the elimination of projections which might cause chafing, so that the gasbags may be permitted to fill the structure to the greatest possible extent without risk of damage"

In July Airworthiness Inspector McWade, of the Aeronautical Inspection Department (AID) similarly expressed concerns about the padding of structural protuberances and the risk to gasbags but he was over-ruled by Colmore and Higgins.

McWade to VCR, 3/7/30, *Report of the R.101 Inquiry*, p.50 (Simon, 1931):

To The Secretary, Air Ministry, Adastral House, Kingsway W.c.2
For the attention of D.A.I. (A.I.D.) through C.I.A. (A.I.D.)
Ref. 2/A.2/30/AID
Subject: Confidential

H.M.A. R.101
Airworthiness of above 'ship.

"On the 26.6.30 I handed over the 'Permit to Fly' dated 20.6.30 – valid until 19.7.30 to D.A.D.

Owing to the modifications which have recently been carried out on the wiring system, the gasbags are now hard up against the main longitudinals, and rubbing very hard on the nuts of the bolts positioning the stirrup into which the tie rods are screwed. Further, the gasbags foul very badly the heads of the taper pins at the joints of the main and intermediate struts at the inner ridge girder ends. This matter, in my opinion, has become very serious, as the points of fouling occur throughout the ship, and amount to thousands.

Padding has been resorted to by wrapping fabric over the parts mentioned above, and this is the usual recognised method used in isolated cases. Padding to the extent now necessary is, in my opinion, very unsatisfactory, because the bags move when the ship is in flight, and the padding becomes loose, and the projection complained of is again exposed.

Although the gasbags have recently been reconditioned, and were in good order when placed in the ship a few weeks ago, there are now many holes in them.

The next point is that where the fabric is wrapped round a joint it may be difficult to know what is happening underneath the wrapping. (I have in mind the corrosion question.) The fabric will become damp, and, in many cases, wet when the ship is in flight. Therefore there will be alternate processes of wetting and drying of the fabric which must be detrimental to the metal underneath.

I am fully aware that to remedy the faults complained of is in the nature of a large undertaking, and it may be necessary to remove the bags from the ship. Until this matter is seriously taken in hand and remedied I cannot recommend to you the extension of the present 'Permit to Fly' or the issue of any further permit or certificate."

Colmore responded on 8 July (Masefield, 1982, p.226):

" I feel sure you will agree that we cannot accept, as a matter of principle, that the gasbags in an airship should be clear of all girders…we can accept padding as being a satisfactory method of preventing holes"

The bolts on the perimeter girders faced inwards to protect the outer cover, leaving the threaded ends facing the bags. On a future ship this could have been avoided. It is clear that both ships were seen by their teams to be prototypes and that all the various lessons learned would be incorporated into a 'next generation'.

Richmond's diary 1/7/1930 (unpublished diary, RAF Museum):

"Searched for holes in the [R.101] gasbags – which revealed the fact that there was a very large number due to the fact that now the wiring had been let out, the bags were pressing on sharp projections on the longitudinal girders and radial struts. Decided to institute extensive padding. The question of the valves is being looked into."

Richmond's diary 30/6/1930 (unpublished diary, RAF Museum):

"It was decided to substitute chains for the lifting bridles. The symptoms displayed in flight were carefully analysed, and the conclusion was reached that the ship was losing lift at a considerable rate due either to holes in the gasbags, and, or valves being opened by the excessive amount of flapping apparent in the outer cover."

T. S. D. Collins said at the Inquiry: (Masefield to Brooks 6/2/80; Masefield Archive, Brooklands):

"After careful consideration, I do not think that the disaster was caused by loss of gas

(leakage). There were on board two people who were colleagues of mine, Colonel Richmond and Squadron-Leader Rope, who would have known that the ship was losing gas, because it would have been flying pitched up."

Barnes Wallis to Lloyds Register Staff Association (Paper No.5 'Some Technical Aspects of the Commercial Airship' R.101; Box B Masefield Archive, Brooklands)

"In my opinion Squadron-Leader Rope knew more about what I might call the mechanics of handling an airship than anyone else on board and that his mind would have reacted to a thing like that immediately and he would have reported it. Therefore, I think that if the ship was gradually losing gas, it would have been known. Squadron-Leader Rope and Colonel Richmond would have known and they would have told Wing-Commander Colmore and he was the sort of man who would have acted upon it. If the ship had been in that condition, I am quite sure that instead of finding the ship on her course, I would have found her turned round the other way and coming home."

Lord Baker to Masefield, (Masefield Archive, Brooklands):

"I am glad you have formed a high regard for the Cardington work on R.101. I believe Rope must be given much of the credit for this – at least on the structural side. Not only was he brilliant but he was punctilious. No corners were cut – and this leads to what, for me, is the real mystery in the R.101 story. In the original design we went to endless trouble to remove as many as possible of the imponderables present in a Zeppelin type structure. All loads were applied at the nodes, no transverse load was allowed on any main member so that all main members were subjected to axial loads only – chafing of gasbags was eliminated by Rope's complex wiring system. Then apparently all these precautions were cast aside and even the shape of the ship, and thus the forces on it, was drastically altered. How could the staff which, when I knew it, had taken such care with the original design, amend it so crudely?"

6.4.4 Gas valves

Collins, comments on the R.101 Inquiry (AIR5/910):

"Here there is an attempt at direct comparison between the valves of R.101 and those of R.100. It should be noted, however, that the valves of R.100 were designed (according to contract) to permit of a rate of rise of 2,000 ft. per min. It was the fact of having to provide a valve to cater for 4,000 ft. per min. which led to the type of valve used in R.101 owing to the difficulty experienced in overcoming the mechanical defects of a spring loaded valve which would give the required rate of discharge."

Cave-Browne-Cave in *A century of British aeronautics* (Cave-Browne-Cave, 1966):

"When the ship rolled violently these valves leaked by reason of inertia forces on the valve discs caused by rolling. The trouble would have been cured completely by a simple mass balance which would have been fitted if time had been available."

Booth to Cave-Browne-Cave May 1968 (Cave-Browne-Cave archive, Imperial War Museum):

> *"On the last flight Rope must have had the valves in mind, in fact he made a comment to Leech about the ship rolling more than usual quite early on. Was he (and the other officers) still anxious or had the defect been made good?*
>
> *If only a small weight was required to rectify the defect Rope (could) easily have these made up from a sketch and fitted them himself. Many things went on in the shed without referring to the "top office"! This would have satisfied Irwin, Atherstone etc. and it would be interesting to find out if "valves" were ever mentioned in his diary, if not this particular headache was cleared – it cannot have been overlooked.*
>
> *Rope's primary duty on his flight was presumably to carry out frequent inspections of the valves (if still suspect) – after all he was the designer; and also to be able to report on the movement of the gas bags under bad conditions. This means climbing round the ship, which was not too difficult in the deep frames, and if all this gas was about why did nobody report the smell? ... I stick to your original suggestion (at the RAeS lecture). Leaving the other trained personnel out of the argument it is to me quite impossible to believe that Rope did nothing about his pet valves for six months and then went off light heartedly to India knowing they were suspect?"*

Collins, Comments on the R.101 Inquiry (AIR5/910):

> *"On this same point it should be noted that the valves of R.101 were extensively type-tested. Tests were made with a valve in a bag of R.33 in the shed at Pulham and two valves in a trial inflation of bag No.10 in R.101. An endurance test of 40,000 oscillations was also carried out on the bearings of the moving parts. On the other hand, referring to tests on R.100's standard Zeppelin valves, the Report of the Airworthiness Authorities states "A certain number of tests were carried out ... but the tests are rather inconclusive." ..."*

AIR5/910 contains a detailed assessment of the worst case of gas leakage through valve chatter undertaken by T S D Collins and Randle of the RAW design office on 10/12/30: He estimates the case of valves opening to their full extent continuously due to rolling on the whole flight (2466 oscillations). The maths gives a potential loss of 7.9 tons. This makes no allowance for damping due to skin friction or tail fins. Reducing the tendency to roll by 50% as well brings the figure down to 2.63 tons. The NPL considers that a loss of lift of 13 tons was required to be the sole cause of an unstoppable dive; hence, another causal factor is required.

In a University of Glasgow lecture in 2002, Alan Simpson summarized the innovation issue thus (Masefield Archive, Brooklands):

> *"Four areas in which novel features were incorporated into the design of R.101 have been outlined. The question of whether or not there was too much novelty is difficult to answer. Michael Rope's new gas valves did not give rise to any serious problem, although minor worry was expressed about their response to the rolling motion of the ship. The gasbag wiring system was criticised in certain quarters for allowing too much scope for gasbag movement leading to chafing of the gasbag by girders (only after*

letting out). But, as stated above, time for fine tuning of the system was not available because of the impossibly short time scales imposed by the politicians for reasons which certainly had little to do with engineering matters."

7. Preparations for India

Once the new bay was installed and reversible engines fitted, the weather prevented R.101 from being removed from the shed for the essential trial flight. The weather cleared on 1st October and the flight was arranged to allow AID inspection, a full speed trial and recognition that all was well with R.101c (the initial ship was described as R.101a; following the weight reduction it became R.101b; and finally R.101c with the extra bay and reversing engines). A 24 hour flight was envisaged but a faulty oil-cooler prevented the five engine full speed trial. Having replaced longstanding AMSR Fellowes, the newly appointed Dowding was on-board his new charge, though the flight was curtailed after 16 hours, allegedly so he could attend a meeting (AIR5/904). Gas needed to be valved prior to landing suggesting that the padding regime had significantly reduced leakage due to chafing (AIR5/919).

Following that curtailed test flight on 1st October, RAW were keen to judge the performance of the enlarged R.101c. Very little was recorded. A rare letter confirmed opinions.

Captain Woodis Rogers, senior officer on the hydrogen plant, wrote, AGC Archive October 1930:

"I saw Scott about 3pm on the afternoon of the day she sailed: as I had heard nothing on how the trial went I asked him and he seemed very confident about it being OK. I also saw Rope and asked him about how the lift came out compared with the estimated gain. He said they'd lost a ton somewhere, probably in the estimate of the proportion of dope evaporated, but that the fuel consumption was so good that it made up for this: he also seemed to be quite happy."

The lack of a full-speed trial requires a little explanation. The early problems with variable pitch propellers that broke repeatedly during shed tests meant that fixed metal props were fitted. This led to the need for an engine to be set permanently in reverse to facilitate slowing down on approach to the mooring mast. All the extensive flight testing was done in this mode whilst development of a reversible diesel engine progressed. Hence, this was about the only flying trial that was never completed. Installing the reversible engines was combined with the extra bay insertion so the only opportunity for a full speed trial on R.101 was on the curtailed test flight just before departure.

Collins to Masefield (Masefield Archive, Brooklands):

"Irwin and Rope both knew that much more test flying was required after the extra bay had been installed. Irwin and Rope were concerned and Rope said he would be in the rigging."

Teed's report, AIR5/919 6 January 1931, concludes:

"The second series of alterations (R.101b-R.101c) was of a very comprehensive nature. The trial following the above alterations (1/10/30) constituted no proof whatever of the reliability and controllability of the airship when flying at speed for a protracted period in rough weather."

The crew were subject to severe baggage limitations. However, Lord Thomson not only bought aboard food and drink for a banquet on arrival at Ismailia, but a 'talisman', a Persian carpet weighing 149 lbs to impress his guests; he was, after all, paving the way for a promised appointment as Viceroy of India. The carpet was too long for proper stowage, and was reportedly laid in the companionway. Thomson was an eligible bachelor and the carpet bore sentimental memories of his love for the married Romanian Princess, Marthe Bibesco. Another personal item, one of her shoes, was in his baggage. This gave rise to press conjecture that a woman was on board when it was found in the wreck.

Lord Thomson to Princess Marthe Bibesco, September 1930 (Masefield Archive, Brooklands):

"R.100 has given me pleasure. R.101 will I hope give me joy. To ride the storm has always been my ambition – and who knows but we may realise it on the way to India. But not – I hope – with undue risk to human lives."

7.1 Staffing Provision

DAD Colmore outlined the requirements to AMSR Higgins in AIR11/23 on 5/7/27:

"Only 2 crews for the trials based on these assumptions:

a) That the ships will be manned as far as possible by civilian crews. These are the present instructions.

b) That the RAF personnel who are attached now to this department or who were attached to this department for flying carried out with R.33 will be available for the trials and Empire demonstration flights.

c) That the Home Trials of both airships will be carried out concurrently but that only one ship will be out of the sheds at the same time."

Officers presently available were listed as Scott, Booth, Irwin, Johnston and Meager, and one more was required. Atherstone, Watts and Hart were being interviewed in Australia. Other comments include:

"Trial crew of each ship to be two ships officers, a three watch flying crew with previous experience being available.

At the mast the trial staff and the ship's officer will be in charge.

By utilising the same trial staff (Scott & Johnston) for both ships a more accurate comparison will be obtained.

Reliefs will be available when at the mast.

No provision for sickness; relief will be an ex RAF officer with rigid experience temporarily attached to this dept."

"As soon as both ships have completed their trials, two three-watch officer crews will be necessary to carry out experimental operational and demonstrational flying. This will mean the engagement of three additional officers."

"It is proposed to postpone the engagement of these officers until just prior to the first trial flights but not later. They will then have the opportunity of gaining the necessary experience during the trials and at the mooring tower, to enable them to carry out the duties of watch-keeping officers when the ships are commissioned at the conclusion of the home trials."

Steff was possibly one of those intended for training; no other potential officer candidates are identified, and the whole project suffered from a lack of trained staff, a lesson that should have been learned from the R.38 disaster.

The accepted norm for the rigid airship's cruising altitude was at least twice the ship's length; for R.101 around 1500 ft. If a ship strays too high then the increased pressure within the gasbags has to be released, via balanced control valves. Any subsequent loss of hydrogen cannot be replenished in the air so height control is essential. The height coxswain, helmsman and navigator are skilled to interpret the effects of landscape, weather and buoyancy in maintaining safe passage.

T. B. Williams, *Airship Pilot No28* pp194-5 (Williams, 1974):

"The Federal Aviation Commission of the United States summarized its findings on their airship losses, in these words: 'While the record of the airship has been marked by a number of disasters as a matter of common knowledge, each of them appears to have been due either to errors in navigation or airmanship, which were in no way inevitable, or to a serious miscomprehension of the capacities of the airship. The operation of airships is a highly specialized art, requiring long experience and the highest order of skill.'..."

Lord Ventry: 1939 (*The importance of training* in The Airship 6 (21), p.12, The Airship Association, London).

"It is no good having modern airships flown by inexperienced crews. Experience has shown that a good crew can do wonders with a "dud" ship, but there is no case on record of a bad crew making an efficient airship do anything worthwhile."

8. The accident

Sir Peter Masefield arranged for a number of computer simulations of the motion of R.101 during the accident to be carried out by Professor Alan Simpson and the computer department at Bristol University. Following these and detailed correspondence with Johnston, a timed

version of the surmised events were published in 1986, based on a combination of records and the computer simulation of the accident (Presented at The 1st International Airship Convention, Airship Association, Bedford, July 1996, published by HMSO/DERA).

4/10/1930, 1836 hrs GMT.
R.101 slips the mast at Cardington carrying 54 souls (including five officers and 37 crew). To clear the mast, four tons of forward water ballast is dropped and a further 2 1/2 tons are dropped before setting course for London and beyond. Despite this adjustment, R.101 still departed with more ballast than R.100 carried for Canada.

1919 hrs GMT.
R.101 crossed Clophill Cross having completed a circuit of Bedford. Given the turbulent, worsening conditions, Scott could have returned to base and delayed 12 or 24 hours; a difficult operation but, with hindsight, the right decision.

2021hrs GMT.
Routine message: 'Over London. All well in moderate rain'

2135hrs GMT.
Crossed the Sussex coast at 1,000 ft and, against a 26 knot headwind, set course for Pointe St Quentin, a 57 mile crossing.

2336 hrs GMT.
Crossed the French coast, perfectly on course, Johnston, the experienced Navigator had used calcium flares to gather drift data and First Officer, Noel Atherstone, had reminded the height coxswain to maintain at least 1,000ft. The most efficient maximum altitude, or pressure height, was 1,500ft; approximately twice the length of the airship.

Midnight.
The famous message was sent to Cardington; 'After an excellent supper, our distinguished passengers smoked a final cigar and, having sighted the French Coast, have now gone to bed to rest after the excitement of their leave-takings. The crew have settled down to their watch-keeping routine.'

0200 hrs 5th October.
In line with standard procedure the watch was changed, although the weather was even worse, cruising around 1,200 ft, just below the cloud base, all was well as they passed Beauvais.

Arguably the least experienced officer, Maurice Steff, took charge, with a fresh height coxswain and helmsman. Due to the nature of airships it always took time for a new man to get the feel of the ship. The height coxswain stood facing sideways at the controls to increase his sensitivity to variations in pitch. The fact that all was well is confirmed by the fact that the previous watch, and senior staff, retired to bed.

In AIR5/921 T. S. D. Collins affirms:

> *"In this connection it is necessary to point out that a coxswain who required time to get the 'feel' of the ship under normal flying conditions would be at a considerable disadvantage in the case of emergency or sudden crisis'.*

So, all was well, despite the weather (though it was the worst ever encountered by a British rigid over land). The departing watch (except one) retired to rest, all engines were running smoothly and they were on course, albeit slightly late due to the headwind. The forecast was good along the Mediterranean to Egypt and beyond.

0204 hrs 12 seconds.
From the computer analysis this seems to be the start of the problems. Just east of Beauvais, and approaching the infamous Beauvais Ridge that often gave trouble to aircraft on the London-Paris route, the consensus of expert opinion is that a large split developed in the forward upper outer cover, the area most vulnerable to the weather and that which had not been replaced during the refit. The ship was slightly heavy, the cover soaked and some water would have got in via the nose ventilation holes, designed to part pressurise the space between gasbags and cover and vent any gas-air mixture from leakage, a common phenomenon.

0204 hrs 21 seconds.
Additional down elevator was applied to prevent the ship rising above pressure height and thereby losing gas, there might also be a fear that the tail might strike the ground.
A torn envelope would increase drag and, progressively, reduce airspeed and dynamic lift.

0206 hrs 35 seconds.
With the perceived reduction in lift and a need to apply up-elevator to correct the nose-heaviness, 2.75 tons of ballast was dropped from frames 6 and 11, fore and aft of the centre of buoyancy.

0207 hrs 24 seconds.
The nose was now down by 11.6 degrees and up-elevator was being applied at 0.75 degrees/second. Diving through 1064 feet the airship was probably hit by a down gust. Given the enormous length of the airship, 777ft, weather effects can impinge differently fore and aft. Not only did it force the nose further down but, on entering the torn, flapping outer cover, damage was caused to the forward three gasbags, expelling hydrogen. The descent was now 1410 ft/min and the altitude 884ft. The elevators were still being wound up to maximum.

0207 hrs 37 seconds.
The only remaining ballast on automatic release, forward of the control car, was now four tons of fuel, this was discharged from frames 3 & 5 and, at 584 ft with the elevators almost fully up, she was only 6 degrees nose down.
0207 hrs 40 seconds.

Having arrested the descent, though the cause was unclear, rigger Church was sent forward to release, manually, half of the remaining ton of forward ballast in the nose. Chief Engineer,

and survivor, Harry Leech, who was in the smoking room, had time to replace a decanter and glasses that had slid off the table though the ship, though horizontal, was still descending at 290ft/min.

0208 hrs 8 seconds.
Realising that the ship would come to ground, Steff ordered the jettisoning of the remaining 6 tons of fuel ballast from amidships, frames 8A and 10, to slow the descent and soften the landing.

0208 hrs 32 seconds.
Power was reduced; using a sequence of telegraph signals lasting over a minute, to reduce forward impact. Rigger Sam Church, sent forward to manually release the forward ballast had failed to reach the nose, possibly his path was obstructed. No other measures being available, Chief Coxswain George Hunt left the control car to alert the crew; famously calling 'were down lads'. He woke the electrician and survivor, Arthur Disley, asleep in his bunk, who recalled tripping one of the two main circuit breakers. Leech and Disley recalled no sense of panic or real urgency. The computer simulations reveal that the ballast release and reduction in power caused a second dive with no corrective elevator now available.

0208 hrs 50 seconds.
R.101 grounded softly at 18.1 degrees nose down with a forward speed of around 12mph. She bumped forward around 60 feet and, with the tail still 258 feet in the air settled such that a young sapling remained standing in the wreck (Figure 4). With the forward engines set at 'Slow', they were still turning on impact; one engine car was forced up and into the hull. Witnesses reported a number of explosions and rapid fire; without the fire the crash was probably survivable.

Johnston calculated the structural compression resulting from the impact (Masefield Archive, Brooklands). There were two impacts; the first broke the mooring cone, buckled the nose and the whole ship compressed 88 feet longitudinally before settling almost vertically with the aft section staying clear of the ground. Examination of the wreckage showed a single sapling left standing within the wreck. The crunch crushed the nose access corridor and the forward starboard engine gondola was pushed up into the hull structure.

The main longitudinals seem to have stayed intact though the forward section compressed as the short girder sections of the intermediate reefing girders acted like crumple zones, popping out at each frame intersection. The main skeletal form survived apart from between frames 6 and 8A where the weight and flammability of the centre section caused almost complete collapse (Figure 5).

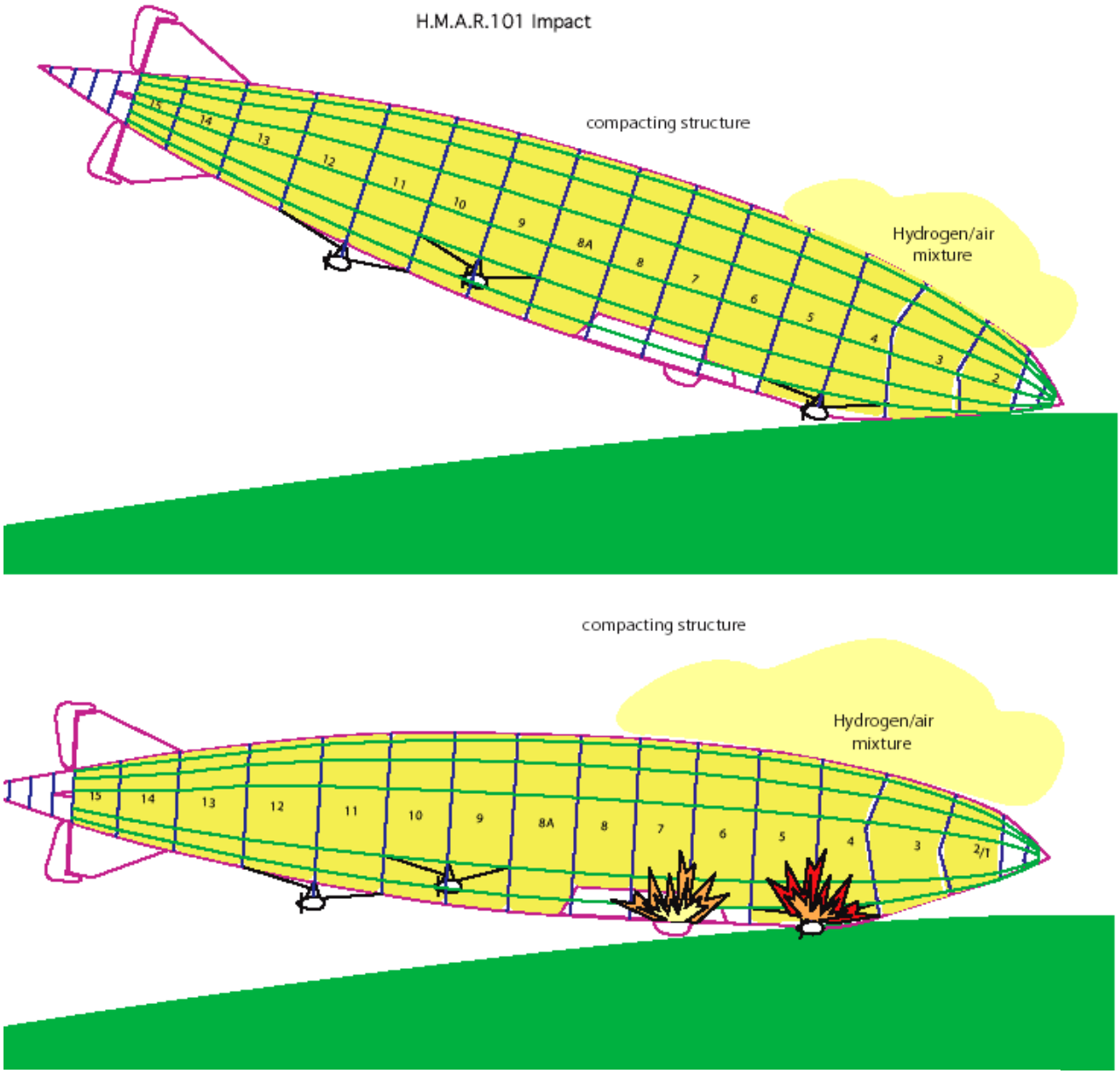

Figure 4 Probable impact sequence and locations of fires
(Countdown to Disaster, Aeroplane, October 2010)

8.1 Survivor and eye-witness evidence

There were no survivors from the control car so we can never know for certain what was known or done in those vital minutes prior to the crash. However, Disley and Leech, who were within earshot, provided vital testimony, in particular to their colleagues and the inquiry. Some remarks, picked up or even fabricated by an imaginative press, are of less value.

Statements made by the other survivors were also vital, although, because of the detached nature of the engine cars, these men can only confirm the behaviour of the ship as they saw it or what instructions were received by telegraph.

Figure 5 The wreckage at Beauvais (Central News and used 10 October 1930 in Flight)

The circumstances of the entire programme, at the Air Ministry, at Howden and, of course, at Cardington, are most reliably reported by those who were there at the time and in the contemporary primary records that they left behind. Once one strays into second-hand accounts there is a risk of vested interests and selective research.

The recollections of the academics who cut their teeth on the project but lived long enough to reminisce first hand, particularly to Sir Peter Masefield, combined with Masefield's meticulous record keeping, make their evidence, and that of L. A. Speed and the Cardington widows, of great value.

It is also worthy of note that Britain was more class conscious in this period, so, just as Masefield may have been kinder to Lord Thomson, a crew member might favour the worker. We already know that the compassionate inquiry was keen to avoid blaming any one or any group of individuals for the accident.

Sam Church, the injured rigger [very incoherent and unfit to be questioned, shortly before he died in Beauvais] AIR5/903:

> *"The second watch had just come on, and I was walking back when the ship took up a steep diving attitude.*
>
> *At this moment I received an order to release emergency forward water ballast (half ton) but before I could get to it the crash came."*

Was this instruction based on a damage report, if so, by whom? The most likely candidate would be Michael Rope who had the knowledge to judge the effect of forward damage and was known to be up and about.

Harry Leech, Foreman Engineer, Statement AIR5/903:

> *"I went to the smoke-room for a cigarette. I had been there 10-15 minutes when the ship's nose went down very rapidly to an angle of 40 degrees. Tables and all loose articles slipped down towards the forward bulkhead. I slipped from centre of my settee to the front end which was against the bulkhead. Ship dived a considerable distance before resuming on an even keel. Remained on an even keel for a minute or less, engine still running at cruising speed: then dived again same angle as before.*
>
> *Between first and second dive I picked up some glasses and a siphon and laid them on table.*
>
> *Engine telegraph rang after 2nd dive began. Crash came a moment later. Shock of impact not great – more a crunch than a blow – I was not even shaken.*
>
> *Within 2 seconds of striking, a blinding flash of fire appeared to originate from above the control car. I saw the mass of flame through the door of the smoke room [facing port]"*

R&M 1401 (Williams and Collar, 1931) investigated alternative causes for the second dive; including the use of ballast:

> *"As the aerodynamic lift decreases then either the elevator is turned upwards or the angle of pitch becomes less. With a light airship the tendency to rise would have to be balanced by a negative aerodynamic lift and this would accompany a negative angle of pitch with a pitching moment tending to turn the nose of the airship downwards. Paradoxical as it may seem, the results of calculations in R&M1401 showed that it was easier to account for the final dive of the airship by assuming ballast dropped, which is confirmed by these general considerations and by steady motion results."*

No survivor mentioned any major ballast release though the engine telegraph bells were widely reported. Each engine telegraph had to be rung separately by winding several complete turns of their corresponding handles in sequence. An acknowledgement gong was required from each car's engineer before moving on to the next engine. The central tail-car engine (No5) was normally rung last to maintain airflow over the lower rudder.

Leech continued:

> *"Upper passenger deck collapsed on to the tops of the settee backs, leaving me a space of 3 feet full of fumes and smoke but no flames. I heard people screaming and moaning in the crews quarters and upper passenger deck, which was then blazing.*
>
> *I tore a settee away from the bulkhead and scrambled through the opening, and found myself inside the hull on the starboard side. The outer cover had then been completely burnt away from that section, except for the cellon windows which were still blazing and through which I had to force my way."*

The tail stood intact for hours; a little fabric remained on the elevators. These were still wound fully up, and a torn RAF ensign fluttered from the tail cockpit. All the victims, recovered within hours by the local gendarmerie, pompiers and townsfolk, were burnt beyond recognition. The accommodation walls were, of course, fabric and the only relevant 'hard' structure that would have blocked escape routes was the cellon windows referred to by Leech. One would have to get to the promenade decks to encounter such a barrier. This suggests most of the victims may have died almost instantly where they lay.

Disley Statement from Beauvais Hospital 9/10/30 AIR5/903:

> *"At about 22.30 hrs I turned in, but some time before this, possibly half an hour, I happened to be in the control room and heard Commander Atherstone tell the flight coxswain (I think it was Oughton) not to let the ship go below 1,000 feet. I saw him take the wheel and pull the ship up to this height, which change of height I actually read from the altimeter. At that time Major Johnston was taking drift readings using calcium flares. While I was there Major Scott came down into the room and passed on into the control car.*
>
> *At about 23.00 hours Atkins, the wireless operator, came to me and asked if I could make up a suitable message for Croydon thanking them for what they had done. I did not leave the switch room again after I had turned in at about 22.30 hours and I must have been half asleep when I became conscious of the ship dipping a little, not more than it had done before, and this change of altitude seemed to be corrected immediately. At that moment Hunt, the Chief Coxswain, came into the switchroom and said 'We are down lads' and just as I was trying to get up the ship went into a steep dive which threw me back on to the bed. I then heard the engine telegraph bell ring and very shortly afterwards the crash came. I would say the crash was more of a crunch than a violent or sudden impact. I have a faint recollection of 'tripping' one of the field switches before the crash came. The first explosion followed immediately on the crash and was very violent, the two which followed being far less violent."*

Time estimates vary for this calm walk by Hunt who, having been on duty on the control car, must have been absolutely certain that he could do no more to prevent the grounding or he would have stayed at his post. RAW staff considered this a 25 second journey though the time line suggests almost twice that. Perhaps Hunt encountered Church, or even Rope, in the corridor or even stepped forward of Frame 6 where, with his experience, he might well have verified the damage and in-rush of air from the bow. The exact nature of when and by whom Church was sent forward is unclear. He certainly escaped from forward of the accommodation area having failed to reach the nose ballast that lay above the entrance gangway beside the mooring observation point. There was certainly insufficient time for Hunt to warn or save sleeping passengers on the deck above; a fire was not expected.

If Hunt passed through the 'officer corridor' he would have woken at least Irwin who had only just retired to bed. This might well resolve one witness statement suggesting Irwin was seen on station during or immediately after the grounding though the short 20 seconds available prevented him from having any influence on events.

J.H. Binks (engineer, aft engine car), Beauvais hospital AIR 5/903:

> *"Just as the second dive started the [No 5] engine telegraph called for 'slow'. The engine was immediately put to slow by Bell and almost directly after this the crash came. Our engine seemed to land quite lightly on the ground and skid along only a very short distance. The outbreak of fire occurred immediately and the explosion which I heard did not seem to be a very violent one."*

Since Binks and Bell were in the aft car their recall of a quiet explosion is, to some extent, due to them being some150ft behind the control car and even further from the forward engines. This adds weight to the idea that the initial, and loudest, explosion was from the forward area even though the most intense fire was amidships where the combustible fixtures and fittings were.

Leech observed from outside the airship [amended at the Inquiry] AIR5/903:

> *"The main structure of the ship was more or less in its normal shape from bow to stern above 'E' girders, which are just below the centre line of ship. No telescoping of the structure in an inwise direction.*
>
> *Both forward engine cars were turned back to front but not upside down."*

Engineer Sam Cook, port midship car, AIR5/903:

> *"Did not notice any marked change in the trim of the ship till after I had got an order by Engine Telegraphs to 'slow'.*
>
> *I was actually reducing speed when machine took up a diving attitude: I looked out of the door of the nacelle towards the ground, and while I looked the ship struck the ground.*
>
> *After the first impact, Ship seemed to rebound and then crashed again and then became enveloped in flames. My car sank on the ground quite an appreciable time after the ship struck; I had time to stop the engine.*
>
> *I remember pieces of structure falling on to and round the car.*
>
> *My first attempt to get out was unsuccessful."*

Even the bursting of a gasbag creates an explosive sound but the source of the fire is unclear. The remaining live electrical circuit could create a spark as the structure compressed and collapsed. The turning airscrews and hot forward engine would have struck the stainless steel girders. A relatively small quantity of petrol was used to fuel a Ricardo starting engine in the forward port engine car, and evaporating petroleum fumes are explosive. The midship port side car showed signs of an internal explosion and the on-site investigation (AIR2/379) *"stated that the explosion was more pronounced on the port side than on the starboard side".* Survivor Leech maintained that the fireproof box of calcium flares in the control car had been left unopened. Designed to ignite on contact with water, the 2½ inch water ballast pipes that routed above the car might well have fractured in compression and doused the flares. It is probable that two ignition sources set the fire in the forward and central sections. It is clear from the state of the wreckage that the accommodation area collapsed completely in the fire.

It was the heaviest region and contained the most inflammable material; portions of the starboard promenade deck survived relatively unburned, the weight of the deck girders crushing the lower deck and control car and their contents. It is my considered opinion that the primary ignition was the petrol fumes on the port side followed almost immediately by the water/flares combination midships. The intense fire in the accommodation causing the collapse of the central structure once grounded.

Hydrogen burns rapidly upwards, dragging in fresh air from below; this will have helped the survivors, all in the bottom of the ship or rearward engine cars, to escape. Survivors Joe Binks and Arthur Bell, together in a midship car, were doused by a fracturing water tank above the engine car whilst standing over the car's undamaged petrol tank. Leech describes escaping through the wall of the smoking room and exiting the starboard side.

M. Patron, Gendarmerie at Beauvais (AIR5/903):

> *"I saw burning fragments floating in the air after the crash and these must have been thrown up a great height. At the moment the ship passed Beauvais it was not raining heavily (I was in my night attire and did not get very wet) but the wind was strong and gusty. A heavy rain squall fell shortly after the crash. A man working on the Town Hall brought a small piece of the wreckage with him when he came to work on Monday morning and I understand that this had been cut off a piece of girder about one metre long which had been picked up in the village of Laversines."*

Miss Moillez, age 14, statement in Beauvais (AIR5/903):

> *"After the explosion the sky was filled with pieces of burning wreckage and these floated away from the spot slowly sinking; it looked like a large firework going off."*

Air Ministry preliminary report on the scene (AIR5/906):

> *b) Gasbags and Outer Covering.*
>
> *Practically nothing remained of the fabric of the gasbags and outer covering, the wreckage having been gutted by fire, except in the region of the elevators. Nearly all the fabric on the underside of the elevators was in place, and a few small pieces were still attached to the starboard horizontal fin. The uniformity of the discoloration or blackening caused by burning fabric over the whole framework of the fins, elevators and rudders, the charred fragments at the cording points and the burnt edges of the fabric which remained in place afforded conclusive evidence, in our opinion, that no part of the covering of the fins, elevators or rudders had stripped off or become detached in the air.*
>
> *Nearly all gasbag valves, particularly those on the port side of the ship, were extensively damaged, the centre portion being crumpled and driven outwards by extreme internal pressure such as would result from an explosion. Several valves had become partly melted up. Most of the siphon pipes were burst open along their length.*

The RAW report of 19 November 1930 in AIR5/906 contains comment on the possibility of valve leakage:

"Except for that incident over the Channel there is no mention by any of the survivors that the behaviour of the ship was anything but normal until the two final dives, except Leech's conversation with Squadron-Leader Rope. This conversation is really of great importance, for it shows that Rope had realised the ship had rolled more than usual. This being the case he would undoubtedly have had a look at the valves as he was mainly responsible for their invention. Knowing what a careful man Rope was I do not think he would have let any serious leakage at the valves pass without reporting the matter. He was on board for that very purpose and was not a man who would not see and admit any fault in articles of his own design."

Amongst all the local criticism of Steff, it appears that by reducing power when the ship dived he followed Scott's prescribed action and, without the fire, might well have achieved a soft landing with much reduced casualties.

Cave-Browne-Cave on discussions with Leech in August and October 1962 (Cave-Browne-Cave archive, Imperial War Museum):

"Leech, characteristically, went down to each engine car 'just once more' to make certain finally that all was entirely well. He returned to the smoking room for a cigarette before turning in. He was there for about 10 mins before the crash at 2.10 am."

"The smoking room is so close to the Control Room, the Control Car and the Crew space that he would certainly have heard if anything alarming or which needed prompt action had occurred. He did hear the engine telegraphs and the reply gongs when the engines were slowed immediately before the crash."

"Previous to the crash, Leech had felt no structural shock as would have arisen from structural failure. When in a much earlier flight of R101 to the R.A.F. display, one gas bag restraining wire had failed, Leech had clearly felt the shock although he was some distance away."

Cave-Browne-Cave written comments 1962 (Cave-Browne-Cave archive, Imperial War Museum):

"If we assume that all exits from the outer cover are sealed and that gas leaves some of the bags from leakage caused by chafing or by valves opening under activation, the quantity of gas and air inside the outer cover will be unchanged. The buoyancy lift will be unchanged. The captain will have no indication that the ship is getting heavy. The liberated gas will tend to find its way to the top of the ship where it will be free to run forward or aft according to the attitude of the ship. If the ship's head is put down the gas will run aft and make it difficult to pitch her up again by the elevator."

Doug Robinson to Masefield 11/8/1985 (Masefield Archive, Brooklands):

"Even experienced German elevator men would have trouble sorting out what was happening, feeling that with the heavy ship nose-up she must be heavy aft, and the light

nose-down ship had to be heavy forward.' 'I can see that the situation was too much for them to figure out in the few minutes they had before going into the ground."

Captain George Meager, family papers:

"The effect of the up-elevator was, first of all, to depress the stern of the airship before it brought up the nose into a climb. If the nose of an airship drops, through turbulence or some other cause, the effect of engine power is, of course, to accelerate the downward path until up-elevator can start to restore height after some loss of altitude. If these effects are combined with the throttling back, then there seems almost enough explanation in itself to have contributed to putting R.101 on the ground."

Eighty five years on, this sequence of events has not been widely read and misleading reports still find their way into the media. As ever, the accident can be seen to be a coming together of a multiplicity of factors, the absence of any one might have seen a different outcome. Hindsight cannot change the result, but re-appraisal of the event is worthy of consideration and study.

Rabouille, signed statement to Gendarmarie 1930 (AIR5/903):

"I am sure it was a sudden gust of wind which actually blew the dirigible down as she was nearing the ground. I remember after she settled on the ground the middle part collapsed as if she had broken her back. I think there were three explosions in all, one terrible one and two lesser ones."

Almost every theory requires a random 'gust of wind' to bring the airship down, even when the many variables have been tweaked to fit the evidence.

8.2 Failure of the cover and gas bag

Preliminary study of the accident, Section 4C (AIR2/375):

"Failure of the outer cover at bow or fins might prejudice aerodynamic control but the trouble would decrease if the speed was eased.

It is perhaps significant that the steadiness of the outer cover depends on a positive internal pressure supplied through comparatively small orifices at bow and tail. Any damage to the outer cover, say amidships, would release this pressure and perhaps cause flapping and further failure and would considerably increase the fabric tension in the bow. The dynamic effect of heavy rain might increase the tension in the bow fabric.

If the ship was becoming heavy due to fall of barometer and to general moisture and if full speed was used to obtain more dynamic lift the loading on the bow fabric might considerably exceed that to which it had ever been subjected since the removal of the support girders in the bow. The reason for the local deterioration of the fabric in the forward part of the ship does not appear to be fully explained and it is possible that

there was loss of strength in places besides those which were discovered and reinforced.

If failure of the bow fabric occurred, It is quite possible that the inrush of air striking the forward gasbags would cause comparatively rapid deflation of bags exposed to the air-stream."

"If, however, the ship is descending while gas is escaping from the bags, the gill will not open and there will be little or no excess internal pressure to cause flow through the cowls. The hydrogen will therefore remain inside the outer cover and will, if the ship is pitched down, gravitate aft towards the tail thereby aggravating the bow heaviness caused by loss of gas forward.

The presence of this explosive mixture outside the gasbags might render ignition much more probable and lead to an explosion rather than the comparatively steady burning which would be expected if hydrogen only began to escape at the moment of the crash, and the breakage of electric wires."

Professor C. E. Inglis wrote a memorandum countering suggestions of serious surging in December 1930. It is held in AIR5/910:

"A suggestion put forward from various quarters to the effect that R.101 might develop instability owing to longitudinal movements of the gas bags has received most careful attention.

Owing to the fact that the novel gasbag wiring of R.101 provided bulkheads of a 'slack' variety, longitudinal surging of the gasbags to a limited extent is a possibility.

It would appear however from drawings and information supplied from Cardington, that, under extreme conditions, the longitudinal movement of the centre of gravity of a gasbag could hardly exceed 3 feet, and even if a considerable number of the gasbags were sufficiently deflated to enable them to participate in this movement, the reduction in fore and aft stability would be relatively insignificant…. This movement however is limited in extent and by itself is quite insufficient to account for a serious loss of control, even in the tempestuous conditions which prevailed at the time of the disaster."

….. " The first dive in fact offers fairly convincing evidence that something catastrophic had happened to upset the trim of the ship and probably also her speed through the air, and this conjecture is substantiated by her subsequent behaviour. After this long first dive the ship was brought into a horizontal position for a short space of time, but she seemed to have lost the ability to climb. If she had been in a normal condition there is no reason (except that the elevators were already full up) why she should not have pointed her nose upwards and regained altitude, and from the fact that she did not do so it may be argued that she was by then crippled beyond recovery. Very soon she started the second and final dive and the action of the Chief Coxswain, Hunt, in leaving the control room to warn the crew indicates that his assistance there was no longer any use and that those in control knew there was nothing they or he could do which would prevent the ship from stranding. All that remained was to minimize the impact and accordingly orders were given to stop (?slow) the engines and release ballast."

The initial dive, around 2.04 am, masked by the general buffeting, was probably caused by such a tear followed by collapsing gasbags. It should be noted that slits in a bag are unlikely to cause rapid deflation though there would be severe drag. The gas in a rigid airship is under low pressure and the rate of escape subsides; only large holes in the upper area, like a balloon rip panel, or multiple incisions, can cause a total collapse.

The possibility of a large tear occurring is supported by Meager in *Leaves from my logbook*, page 4, (Meager, 1961) though it occurred in the shed during the inflation of bag 4 on R.100 which had a different bag restraint system:

> *"a huge rent, fifteen feet in length, was torn in the bottom of the bag owing to the line anchoring the bottom of the bag to the corridor not having been cast off."*

Similarly, on page 43, during the flight test period on 23 March 1930:

> *"Duty Cox'n Hobbs, came and informed me that No.7 bag had split from top to bottom, to use his own words…we found an enormous hole in the forward end of the bag measuring 20 feet by 2 feet"*

In 1921 the British R.33 had survived a bag collapse. This is described by Flight Sergeant Greenstreet to Sir John Simon, AIR5/906:

> *"I am a Flight Sergeant R.A.F. and Chief Coxswain of the R.100.*
>
> *On the 22nd April 1921 I was steerage coxswain of the R.33 on a flight for swing ship purposes, i.e. compass correction. The flight was from Pulham Aerodrome and took place in the vicinity of Norwich. We were flying at about 2000 ft.*
>
> *No 13 gasbag (aft of centre of ship) was reported to be losing gas and a rigger went to inspect; also the chief coxswain went to investigate. Before any report could be sent to the control car the rigger, who was inspecting the gasbag, fell through the bag making a large hole. The bag rapidly deflated, I was in the control car the whole time. When the bag deflated the ship fell bodily with the tail down for about 500 ft. As soon as she started falling the elevator helm was put hard down and the engine speed increased, water ballast being discharged from aft at the same time. The ship was brought to flying trim and rose to 3100 ft. The flight was continued to the base and the mast mooring was satisfactory"*

This page of evidence was presented to the Inquiry; pencil notes in the margin include the question *'Who was on the elevator control?'* The word *'Hunt'* is written nearby and was ticked in a different hand. This suggests that Hunt might have had this previous experience in mind on 5/10/30. Knowing the likely drop and lower cruising altitude it may explain his immediate reaction that grounding was inevitable following the first dive particularly as he knew the conditions at the time.

As for the unexpected dives, the official inquiry concluded the cause to be a major loss of lift forward of the CG, probably caused by a catastrophic failure of the cover. The effect of this was increased by the associated drag, a gust, or broken structure damaging one or more of the fragile forward gasbags.

Sir Peter Masefield postulated a theory that, had the engines been put to full power after the first dive, R.101 might have climbed despite the damage and limped back to safety. Re-enforced by computer simulation in 1984, this recalled an incident in a hailstorm on 6 June 1930 when Dr Eckener did just that with the intact Graf Zeppelin, though this was in daylight and on a known route through high ground. Considering the concerns over the stability of airships over land, it is interesting that the Zeppelin works was landlocked on the edge of the Alps and no plans were made to relocate to a more coastal location.

The early Zeppelins, being more tubular in shape, benefitted less from dynamic lift than the more bulbous designs of the late 1920s. As knowledge of airflow and lift generated by forward motion, previously applied through the aerofoil shaping of the wing, was understood as applicable to the shape of the envelope, extra lift from the moving envelope was incorporated in performance calculations. As slowing the engines was the accepted procedure it took great courage and confidence to add power in an emergency, particularly when close to the ground when the effect of any impact would increase risk dramatically.

Had the R.101 incident occurred in daylight and fair weather it is highly probable that the alleged outer cover and gasbag damage might have been pulled in and tied off as in R.33 to reduce drag and prevent further damage. R.101 might then have limped back to Cardington or even been brought down for a surface landing at, say, Paris Orly where ground crew and gas supplies were available (AIR2/364). Had the nose area suffered damage a mast mooring would have been impossible anyway. However, at night in a storm with a tired crew there really was little option but to slow down and attempt a soft grounding. Arguably this was achieved successfully as it was the fire that caused the loss of life.

There are clearly arguments for the different strategy of increasing power to regain control. Firstly Reports and Memorandum R&M 1401 (Williams and Collar, 1931) who were relatively close to the 1930/31 Inquiries into R.101, certainly seems to imply that full power could have saved the situation and that an extra factor, other than forward damage and drag, was required to cause the second dive. When a gasbag failed on R.33 the engines were immediately put to full power and all was well.

Finally, the computer simulations carried out by Professor Alan Simpson and the computer department at Bristol University indicated that there could have been a possibility of saving R.101, but the action in regard to the engines would have had to be taken within a very short interval of time and, while the airship might have been saved, the probability of this was only modest.

The contrary arguments are less in number, but possibly more compelling.

Firstly it is said that Standing Orders were to slow/stop the airship if there were severe problems over buoyancy. It has not been possible to find any hard evidence of this being the policy that had been laid down for R.101. There is, however, hard evidence in the US Navy Rigid Airship Manual, page IX - 38, which was written by Hugo Eckener himself (US NAVY, 1927):

"If, through loss of gas, the ship becomes heavy by the bow, stop all motors at once, if you cannot hold her to her altitude."

Also page IX - 28:

"Once a heavy ship runs away from you (stalls) upwards or downwards, it is advisable first of all to slow the motors to half speed ..."

Secondly, in view of R.101's low height above ground and the perceived likelihood that a soft landing could save the lives of all on board, slowing the engines was absolutely the correct decision.

On the other hand, looking back with the knowledge that a relatively soft landing could still cause a fire with great loss of life, a decision to put the engines to full power could have been justified in that all lives would have been saved if this strategy had been successful. This is despite the relatively limited probability that it would be successful.

Certainly it seems difficult to criticise the decision to slow the engines, but perhaps indicative of the dangers of flying relatively low over land in bad weather. In May 1931 the Aeronautical Research Committee published two reports, R&M 1400 and 1401 investigating the motion of R.101 under certain assumed conditions and the effect of slowing the engines (Jones and Bell, 1931; Williams and Collar, 1931). Paragraph 37 of R&M1400 summarizes thus:

"All the above analysis then, tends to show that the controls provided on the airship were more than adequate (if not perhaps to enable the airship to maintain height in these conditions) at any rate to keep the head of the airship well up even after losing lift to a considerable extent; it definitely indicates that some additional assumptions other than loss of gas should be sought in order to explain the final motion of the airship before she struck the ground."

In R&M1401 various case studies were studied involving the airship descending nose first. Fifteen options of gas loss, elevator application, power reduction and ballast release were evaluated. The conclusion that came closest to the evidence from survivors assumed that some escaped gas remained inside the cover and ran back to the tail adding to the nose-down moment when a final gust struck her down.

On 15 January1962 Cave-Browne-Cave addressed the RAeS Historical Group; saying (Cave-Browne-Cave archive, Imperial War Museum and RAeS Group Records, NAL. RAeS Journal August 1962):

"The airship was in continuous heavy rain during the flight. Much of the water would strike horizontally on the bow and much of it would pass through the pressure regulating holes and on to the two forward gasbags. Its weight would have two effects. It would add constantly increasing load some 250 ft ahead of the c.g. thereby explaining the gradual increase in bow heaviness. It would also increase the fabric weight of the two foremost gasbags, increasing their tendency to tear under acceleration and finally to rip completely. The gas in these two bags, which were

interconnected, gave a lift of four tons. If all this were released by a big rent and with the ship pitched 10 degrees down this gas would run right aft into the tail, a distance of 500 ft giving a change of downward pitching moment of 2,000 ft/ton. This would be far greater than that assumed in the investigation appended to the Report and, in conjunction with the bow heaviness, far greater than could possibly be overcome by the use of elevator."

Cave's theory of gas rushing to the tail is not seen as likely if the top cover had torn away though any trapped gas could migrate aft during the dives. The vents in the top cover were not, however, designed to cope with massive escapes.

R.100's Captain Booth commented at the RAeS on 15 January1962 (RAeS files, Group Reports, NAL): and pointed out that:

"There is no doubt that the seams must have been seriously weakened by saturated air coming through the bow holes so that the slightest friction between the forward bag and the structure would have caused a rent."

And yet J. W. Dyer, the Royal Airship Works fabric expert, did not support the theory of a major gas escape. In his evidence to the Inquiry in November 1930 he stated that:

"... you can let this fabric lie under water for several hours, and then test it, and get your specification value for the strength of your seam ..."

8.3 Source of the fire

WJ Still of Ealing wrote AIR5/916:

"In reply to Sir John Simon's request for suggestions as to the cause of the ignition of gas during the crash of R.101 I venture to call your attention to a characteristic pertaining to heavy oil engines.

This is that carbon in a more or less oily state becomes deposited on the exhaust ports of manifolds and this is consumed at more or less frequent periods by the excess oxygen which escapes unconsumed from the engine.

In some Diesel types the carbon on the pipes and ports may build up for days or even weeks before it starts to burn off and will then make the pipes red hot and cause the emission of clouds of red hot, even white hot flaming particles.

In an engine I was associated with this was so serious as to burn holes in the deck awnings when in dock, with only the auxiliary engines running and what seems to me to be of especial interest is that this emission of flaming particles from the funnel never took place to any extent when the main engines were on full load but always commenced whenever they were reduced to say half power or below this.

For instance only a trace of an occasional spark would be seen from the funnel during a 7 days voyage but as soon as the engines were slowed down for the ship to enter port

a shower of flaming particles would be emitted and these would fall on the deck and glow brightly for some time.

As the deck is many feet from the funnel top this gives an indication of their igniting power.

My information as to the behaviour of the engines used in R.101 is not sufficient to enable me to say if they behave in the manner described but suggests that they would do so.

The evidence that ignition of gas followed quickly on the order to reduce engine power is very suggestive and it may well be that the use of heavy oil engines carries with it a greater danger than that due to the use of petrol as a fuel, for petrol engines seldom emit sparks with the exhaust gases."

Darling, Beauvais resident, according to East Anglian Daily Times 6/10/1930:

"I managed to climb into that end of the airship which was farthest from the fire by breaking a glass door, and got as far as I could along the inside of the structure. Ultimately I got to the cabin where the machinery was. This [engine car] was quite intact, and was not on fire, so I went further on through the ship to see if I could save anyone. But it was burning furiously at the other end, and the flames drove me back. Leech and the other men joined me inside the airship, but it was hopeless to do anything for the victims. We saw one man, who was evidently trying to get out of a cabin, but he was terribly burned, and we saw him fall back helpless into the flames."

Cave-Browne-Cave on discussions with Leech in August and October 1962:

"The fire started immediately; there was no explosion but a great "whoosh".

Rabouille, eyewitness statement to Gendarmarie (AIR5/903):

"As soon as that part of the ship which is half way between the nose and the middle touched the ground I heard a terrific explosion, while a giant flame swept the envelope from front to tail and I was knocked down on my back"

M. Fauqueux, one of the first on the scene, reported in East Anglian Daily Times 6/10/1930:

"the airship was burning in two places – in front and also in the central cabin"

Possible causes of the fire include sparks from the two forward engine cars still running at reduced revs, as they hit the structure, hot carbon emitted from the diesel engines as they were throttled back in sequence, or the tank of petrol for the Ricardo starting engines in the base of a forward car. This may have vaporised and been ignited by a spark as the props or girders clashed. The starboard engine car was inverted and rammed up into the structure on impact. The port midship car showed signs of an internal explosion although this did not come up in the Inquiry; was this a petrol explosion?

We will never know for certain. Leech saw a blinding white flash outside the smoking room; possibly the calcium flares, seen earlier in the open container, doused with water from

fractured piping; a 2½ inch main ran through the car, but was this the primary fire or a secondary ignition? The only eye-witness, a French poacher, claimed the fire started forward with several 'explosions'.

8.4 The weather

The weather on that 4th October night was the worst ever encountered over land, in free flight, by a UK rigid airship. Remember that with an airship nearly 800 ft long, gusts can differ from bow to stern. Flying at between 1000 and 1500 feet, just below the cloud-base was normal practice but hazardous at night. A Croydon-Paris aircraft later reported very rough weather in the area.

Masefield (1982) records a statement from a French witness on the ground thus:

> *"The wind was very violent and the rain was rather strong. The wind was coming in gusts – a tempest from the South-West, very strong, but not lasting. The wind was in heavy gusts and changing in direction."*

The French newspaper 'Le Petit Parisien' for 6th October is almost the only French paper that breaks off from the gruesome tales of fire and death to mention the weather. The phrase 'alourdi par la pluie, ballotte par les rafales' 'heavy with the rain and tossed by gusts' backs up the evidence of Masefield and local witnesses.

The complete paragraph reads:
"D'apres ce qui a ete dit des circonstances dans lesquelles s'est produit l'accident, on peut presumer que le R.101, alourdi par les pluie, ballotte par les rafales, par suite aussi de la condensation de son gaz provoque par le fraicheur de la nuit, n'a pu conserver une hauteur suffisante, ce qui expliquerait pourquoi, passant au-dessus de Beauvais, il n'etait guere qu'a 300 metres". ["Regarding what has been said of the circumstances of the accident , one can presume that the R.101 , weighed down by the rain, tossed by the gusts , also the contraction of the gas caused by the coolness of the night, could not maintain sufficient height , which would explain why passing over Beauvais , it was hardly at 300 meters."]

Most of the witness depositions from residents of Beauvais concentrate on the explosion and fire but one, by Lucien Lechat, a 36 year old jeweller had stayed up specifically to watch R.101 pass over Beauvais, AIR2/375 contains a transcript:

> *"I followed her flight as she passed over. At this moment the wind was blowing in squalls. The airship seemed in difficulty, flying at a very reduced speed and seemed to be bearing on her left."*

Flying over water was considerably easier than over land, the air being generally less turbulent. Most British rigid experience to date had been gained offshore or over familiar territory. Hugo Eckener, Zeppelin pilot wrote in '*The Airship*' (Eckener, 1935):

> *"This is the only effect of a storm, at least over the ocean, where the disturbance of the atmosphere is small. In a storm over land, air movements following the contours of the*

ground, of course carry with them great turbulences of the atmosphere, which cause the airship to pitch more or less heavily. The effect is comparable to the action of a surface vessel in a high swell."

With this in mind, policy makers envisaged an air system based on coast-to-coast airship services combined with trains and aeroplanes for overland operations.

AIR5/919 contains a summary of the forecasts for 4th October:

At 1600 hrs wind direction was 270 to 240 degrees at 20-30 mph in Northern France, cloudy with local rain, 8 to 10 tenths at 1000 to 1500 ft.

At 1836, post departure. Ridge of high pressure moving east, 240 degrees at 40-50 mph at 2000 ft.

Teed adds with hindsight (AIR 5/959):

"It would also be very clearly in the minds of these officers that the ship had never flown under circumstances in any degree comparable with those forecast, while it would be within the recollection of some of them, that no British rigid airship had ever operated over land under such unfavourable conditions."

Still in their comfort zone over Bedford one can only assume that Scott chose to press on; to throw in the towel so soon was unthinkable.

Robinson, 1983 (Masefield Archive, Brooklands):

"September 1925, Shenandoah encountered turbulence of unprecedented severity over southern Ohio, and broke up in flight with 14 of the crew killed. Nothing of the kind had occurred to German or British rigids flying in a maritime environment, and the Shenandoah disaster underlined the unsuitability of rigid airships for low altitude flying over large continental land masses, with their severe orographic phenomena and vertical currents during the summer and fall months. Had the ship been inflated with hydrogen instead of helium, she would have burned in the air with the loss of all 43 persons on board."

Masefield (handwritten) draft text for *To Ride the Storm (Masefield, 1982)* (Masefield Archive, Brooklands):

"The loss of R.101 had its parallels, before and after, in the disasters to the Shenandoah, the Akron and the Macon in the United States. In the conditions prevailing on the night of the 4/5th October R.100 would probably not have survived."

Met Office letter to Masefield 14/8/1978 (Masefield Archive, Brooklands):

"With a mean wind speed of about 45mph over the generally rough terrain, the level of turbulence (vertical and horizontal gustiness) would have been severe."

Booth to E. A. Johnston Re: R.100 flight to Canada 11/1954 (Masefield Archive, Brooklands):

"I was thankful as the right place for airships is over the sea and I never fancied the trans-Europe or Cairo-India trips."

R.101 radio communication Midnight 4/10/1930:

"The wind is from 245 degrees 35 miles an hour in continuous rain. Cloud is nimbus at 50 feet, we are flying at 1,500 feet. All well."

Cave-Browne-Cave written comments 1962 (Cave-Browne-Cave archive, Imperial War Museum):

"The instruments at the French stations were not capable of recording gusts, but did show that she [R.101] met wind speeds of 40-50 which probably had similar gustiness to perhaps 70."

Lord Amulree replaced Thomson as Secretary of State for Air. On 20 April 1931 he comments on the effect of weather, National Archives T161/563:

"Finally, the weather on the night of October 4, 1930, though bad, was certainly in no way exceptional; yet it more than halved R.101's ground speed. The R.100's arrival at Montreal was delayed for almost 24 hours by bad weather over the St Lawrence. Speed is the chief, if not only, justification for airship transport, but what is the use of speed if bad weather counteracts 50% of its advantages?"

Although some significant rigid airships have been lost to the weather, others have coped well in adverse conditions. In wartime, just as with later bomber operations, the forecast weather was a deciding factor in starting a mission, with Zeppelin raids preferring cloud cover.

The Met Office chart below (Figure 4) of wind speed and direction shows the peak of the storm just after 0200 hrs.

AIR5/997 contains the following passage from RAW in December 1930 plus other examples of severe weather encounters:

"The meteorological conditions at the time of the accident to the Shenandoah were exceptional, the storm wrecking bridges and blowing trains off the railway lines, even under these conditions the opinion was freely expressed that the real cause of the disaster was the breaking of the structure by internal pressure.

The German Airships have no doubt encountered very bad weather over land from time to time. The Bodensee on one occasion carried the mail when all other means of transport was stopped on account of snow. The Graf Zeppelin also encountered the full force of the mistral (50 mph) on the occasion of engine failure when she had to make an emergency landing at Cuers-Pierre, near Toulon."

"In June 1919 after the Danzig and Baltic flight, on her return to England, R.34 experienced heavy weather in the North Sea going astern for nearly six hours. Wind 50/60 mph."

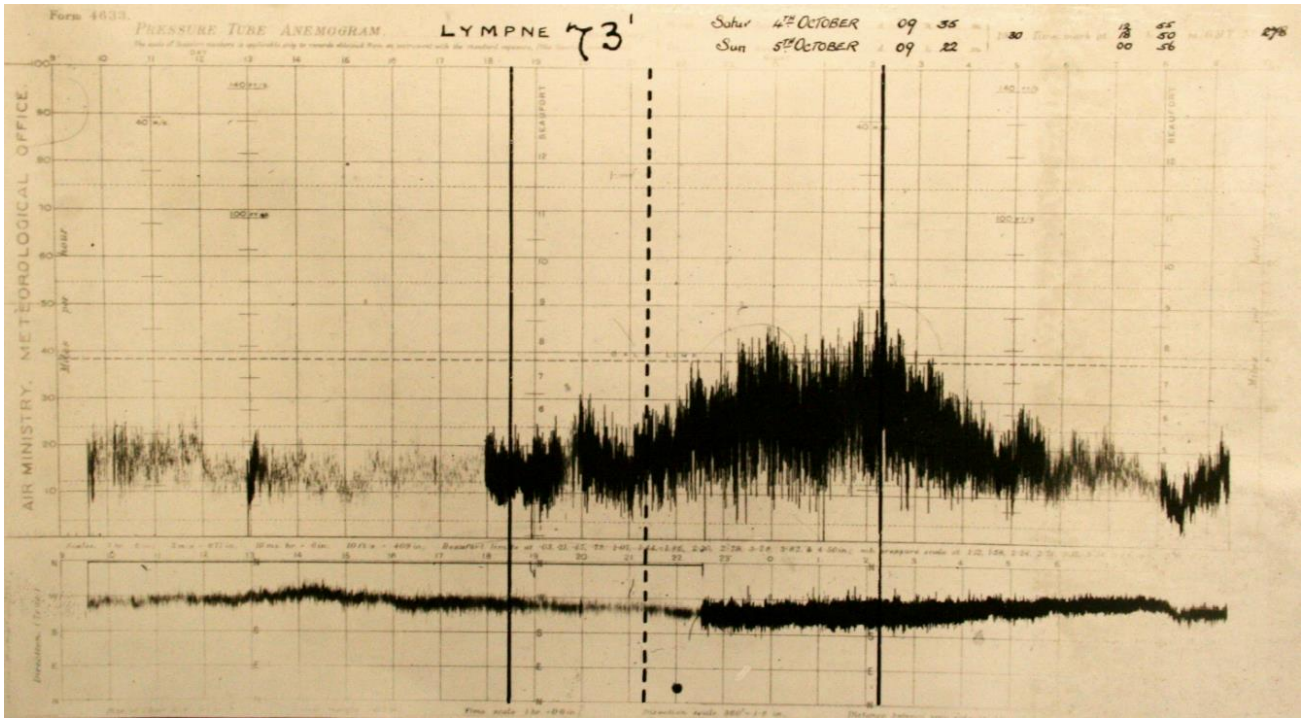

Figure 4 Meteorological Office chart of wind speed and direction at Lympne AIR5/919

9. R.101 Inquiry

9.1 On-site investigation

Immediately after the accident a team from RAW was tasked to investigate in cooperation with the French authorities and the UK Air Attaché, Colonel R.J. Bone. This team included Cave-Browne-Cave, Nixon (Administrator, route planning and infrastructure), Booth and Meager, assisted by Gerrish (RAW Shed Manager), Dyer (Fabric expert), Collins (Naval Architect), Uren, Randle and Hayes (all three from the drawing office). Their investigations, led by Major Cooper, can be found in AIR2/365.

9.2 Recorded comments on some of those involved

9.2.1 Wing Commander Reginald Blayney Bulteel Colmore OBE

Director of Airship Development

Seconded as Deputy Director of Airship Development in 1924 under Fellowes to help draft the Imperial specification. Served on the R.38 Inquiry. He became DAD in early 1930 and immediately inherited the problematic scheme in a time of approaching austerity. It is understandable that he might be reluctant to voice immediate criticism or bring bad news but, given that Thomson relied on his expertise, it was his responsibility to decide how far up to pass information and whether each flight should proceed.

Speed to Masefield 19/4/1977 (Masefield Archive, Brooklands):

"Colmore disliked flying and he was especially unhappy about R.100s flight to Canada

on which he flew as a passenger. He was, by contrast, fully confident about the flight to India by R.101. Speed recalled that Colmore was a quiet administrative man, "the best type of naval officer", but not able to sway Richmond and unwilling to acknowledge Scott's lapses."

Dowding wrote after the accident:

"My appointment was just after the conference on the 29th August, between the Secretary of State, Wing Commander Colmore and the Secretary of the Air Ministry, at which it had been decided to try to be ready to begin the flight to India by 4th October or before if possible. Just before I took over my appointment, Sir John Higgins my predecessor told me about Colmore and said that I need not be afraid that Colmore would ever err on the side of rashness. I never had any reason to doubt the correctness of this estimate.

As DAD Colmore was my advisor and I cannot recollect any occasion on which I did not accept his advice. Colmore was in daily touch with Major Scott, who probably knew more about the actual handling of airships than anyone in England at the time, and Col. Richmond whose reputation as an airship designer was world-wide and who had himself designed R.101.While I had a good deal of experience in aeroplanes I had no practical experience on airships, and I considered that my duties were best performed by accepting Colmore's advice whenever I considered it reasonable and by endeavouring to prevent his judgement from being biased by any outside pressure."

" I raised the point that she didn't do a full power test during the trial flight and ought to do one near home on the actual flight, so that she could return if everything was not satisfactory.

We then discussed various alternative methods of return for the S of S in the event of the ship being delayed at any stage of her journey.

At the end of the interview Lord Thomson appeared to be absolutely confident in his own mind that he would be back in London on the 20th. I thought it wise to point out to him that he must not be too certain on this point and that there was a definite chance that the ship might be delayed at some stage of her journey. Weather conditions were principally in my mind when I spoke.

After the interview I again mentioned to Colmore the question of full speed trials and told him I wished them to be carried out as soon as possible after leaving the mast. From the messages received from the ship it appears that they were not done. There may have been some good reason for this but I should certainly have questioned Colmore on the subject on his return." (This contradicts Irwin's version of events)

Nixon gave evidence regarding Colmore's character:

"As I have been intimately connected with Wing Commander Colmore since 1919 in all matters connected with his proposals for airship development, it may interest the Court to understand the thorough manner and way he arrived at important decisions such as advising the departure of R.101 for India after only a short trial flight. If I may be permitted to make certain statements outlined later, I wish to say at the outset that if he

were here, he would have accepted full responsibility for the decision himself and would have in no way in the slightest degree endeavoured to say that he had been wrongly advised by any of his staff. If some of my statements may appear to be irrelevant as to the matter before the Court, it is only in an endeavour to give a true and correct impression of a Director who had as his main object in life the development of the airship on lines of safety, although he had to carry out this work under very difficult circumstances. The Treasury and political aspect was always prevalent. He was not merely a paid Government official, but devoted all his time and energy with one thought in mind – the formation of airship transport lines throughout the Empire."

Colmore was in daily contact with Major Scott and Vincent Richmond, his judgement in deciding what was passed up the chain to Secretary of State for Air Thomson via Higgins and later Dowding was crucial as the departure day approached. There was nobody in the Air Ministry with any direct experience of airships to judge his advice.

Mrs Atherstone commented to Johnston when pressed about Colmore, 29 November 1954, Masefield Archive:

"Colmore was very much up in the air and remote from us minions. He was a charming man, but I don't think he counted for much in the eyes of your Father and Grabby. He seemed content to leave everything to Scott."

Cave-Browne-Cave lecture to RAeS Historical Group 'R.101 and other airships' 15 January 1962: Cave-Browne-Cave (1969) drafted a detailed document on R.101 but died in 1970 before completion. This was the concluding paragraph.

"Perhaps the fatal mistake was insistence that the ship must take the Secretary of State to India in most impressive style and get him home to tell a personal story to the Imperial Conference. Without him and without the supporting passengers and the great unnecessary weight and, if Colmore had been allowed to choose his time of departure, R.101 could almost certainly have flown to India and probably returned before the end of the Imperial Conference."

9.2.2 Major George Herbert Scott CBE, AFC, AMIMechE

Assistant Director (Flying); Officer in Charge of the Flight

Became a Major on formation of RAF. After captaining R.34 in 1919 he was demobbed and joined tech staff at RAW in 1920. Visited Canada to negotiate the building and funding of a mast at Montreal. Having conceived the mast mooring system his wife enjoyed an income from the patents after 1930.

George Herbert Scott was rightly lauded for his captaincy of R.34 on the first Atlantic double-crossing in 1919. Seen as the heroic public face of airship development (rather like Eckener in Germany in the late 20s and 30s) he was treated with deference in his early career. He later developed the mooring mast concept and was the natural choice to head the flight training programme for the R.100 and R.101. Following the disaster attention was drawn to

factors that affected his judgement in setting off at the time appointed. This close scrutiny threw up issues with Scott's personal life that might have led to his suspension in the highly regulated climate of today.

As one of the key decision makers (with Colmore and Irwin), Scott's condition on 4th October is worthy of investigation. In *To Ride the Storm* Peter Masefield is rather selective in his accounts relating to Scott (Masefield, 1982):

> *"a tough, calm, 'press-on' character, who was awarded the AFC in 1918 and CBE in 1919, Herbert Scott had a reputation in the Airship Service for determination, and also for 'ham-handedness'. He was commanding the Parseval PL-18 (no4) when it collided with its shed at Barrow, in a fog, during November 1915. He was in command of R.36 when it was badly damaged during mooring to the Pulham mast in June 1921, and he was in charge of R.33 when it hit the shed doors at Pulham on its last flight in November 1925.*
>
> *Airships are notoriously difficult to handle near the ground. Scott had demonstrated this fact dramatically with HMA No4 and in bringing to an end the service lives of R.33 and R.36. By 1929 Scott had, sadly, lost some of his force and drive and, in the opinion of his colleagues his judgement left a good deal to be desired. His reputation was such, however, as the most experienced British airship commander, that his role as one of the 'Big Three' at Cardington was unchallenged."*

Masefield wrote to Lieutenant Commander Croker R.N. in March 1983 regarding Scott's health (Masefield Archive, Brooklands):

> *"Though I have touched lightly upon it there is no doubt that the responsibility for the wrong decision lay fairly and squarely upon Herbert Scott who, by the time of the flight, was – sadly – a dipsomaniac with his judgement seriously impaired. He ought to have been grounded by Colmore and Colmore would certainly have had support had he done this. But in the naval tradition, I suppose, such a decision was left on one side with the thought that a successful flight to India and back would be a culmination of Scott's career."*

AMSR via DAD; memo to RAW Press Office 28/7/1930 (Rope Family papers and Masefield Archive, Brooklands):

> *"It would appear that the press generally are under the impression that Maj. Scott will command R.100 on her Atlantic Flight. THIS IS NOT THE CASE and I should like the position to be made clear before R.100 starts. R.100 on her Atlantic Flight will be commanded by Sqn. Ldr. R.S. Booth AFC and Maj. G.H. Scott CBE AFC will be on board in his capacity as Assistant Director for Flying. Wng. Cmdr. R.B.B. Colmore OBE will be on board in his capacity as DAD and will represent the Air Ministry while R.100 is in Canada."*

RAW Press Notes 24/10/1930, discussed at length in AIR5/13:

> *"Notes regarding the respective position of Maj. Scott Assistant Director of Airship Development (Flying) and the captains of R.100 and R.101 on flights to Canada and*

India. Press notes show Scott as "one of the officials from Cardington and seemed to imply that he was merely a passenger and had no responsibility for the flight but …" [Scott says] "if anything happens on the flight I will be held responsible." [Furthermore] Scott was "rather hurt by the impression which had been formed in Canada that he had been superseded by Booth." Signed C.P. Robertson [RAW Press Officer]"

AIR5/14 contains notes of a meeting of DAD, AMSR, Reynolds and Musson 28-7-30

Item 5. Responsibility of the Captains of R.100 and R.101:

"AMSR said he wished the Captains to have full responsibility for their airships and did not want the airships to be run by a committee. Major Scott's position when on board should now be that of an Admiral not of Captain of the ship. DAD said that Major Scott now did none of the detail work in connection with either R.100 or R.101. He gave no orders to any of the crew, but dealt only with the Captain. His value from an airship point of view was particularly in setting a course, because of his experience and meteorological knowledge. AMSR said Major Scott should give advice to the Captain, but the Captain was not bound to take it.

DAD said he had already made that clear to Squadron Leader Booth. He had told him that if he did not agree with a course advised by Major Scott he was to say so at the time. If he set the course advised by Major Scott he was automatically responsible for it.

AMSR added that he would not expect Major Scott to be on all the flights between Cardington and Ismailia during the winter."

In a letter to Lord Beswick in 6/1982, Masefield comments on Scott's health, to some extent based on discussions with his Cardington contemporaries, including Les Speed (Masefield Archive, Brooklands):

"There is more than I put in the book about Herbert Scott. He had been an outstanding officer in earlier days but, by 1929, he had deteriorated seriously and his confreres accepted that, from lunchtime onwards, he was ineffective as a result of drink.

Colmore ought to have had him retired but I fear that the 'old-boy' network was probably too strong in those, predominantly, ex R.N, circles. So far as I can find out Christopher Thomson was never made aware of this.

But it is a fact that Scott took Ernest Johnston and Maurice Steff off to lunch with him at the Bridge Hotel at Bedford at frequent intervals and that, on the day of the departure for India, they all came back from lunch 'the worse for wear'.

Irwin, the Captain; Atherstone, the First Officer; Hunt, the Chief Coxswain; and Gent the Chief Engineer were all solid, skilled and cold sober types who, obviously regarded Scott with increasing dismay. In the event, I think that Scott's impaired judgement – and I believe that at the end he was a sick man – led him to take the unwise decision to authorise R.101's start for India in the face of a poor weather forecast when, clearly,

he should have ordered a 12 hour postponement in which he would, certainly, have been backed up by not only Colmore and Irwin but also the S of S"

19/3/84 Masefield to Doug Robinson, USA (regarding a letter written on R.101 to Buoyant Flight by E.A. Johnston) (Masefield Archive, Brooklands):

"Like his father, Johnston is a 'rough, tough cookie', fundamentally introspective, inherently discourteous but - perhaps endearingly - determined to protect his father's name.

Only last week Sir Alfred Pugsley, F.R.S., (late Technical Officer of the RAW, Cardington, 1926-31) who is now the, much respected, Chairman of the Aeronautical Research Council and still Emeritus Pro-Vice-Chancellor of the University of Bristol and Gold Medallist of the Institution of Civil Engineers - a man of the highest attainments and integrity, talked to me at some length about his memories of those Cardington days.

He said, over lunch 'Of course, all of us at Cardington knew that Steff was, regrettably, Officer of the Watch in R.101 at the last, critical, moment, although this was not brought out at the Public Inquiry because Sir John Simon wished to eliminate any question of personalities. As he had done before, Steff made a mess of a critical situation. We, at Cardington, always believed that the airship could have been saved - as you say in your book and, I am sure, rightly"

"As for Johnston and Scott, not only would they both have been dead tired after midnight on that fatal day but, knowing both of them, I am sure that, after a celebratory dinner on board, neither would have been in a condition to contribute usefully to the flight further that night.'

"Scott was, I am sorry to say, a complete dipsomaniac through the latter part of 1930."

Mrs Atherstone commented to Johnston regarding Scott, 29 November 1954 (Masefield Archive, Brooklands):

"I am pretty sure that had the flight to India and back succeeded, Scott would have been grounded on his return from India - and I suspect Johnston would have been too. There would have been a pretty clear view upon them on the part of Lord Thomson and Sefton Brancker after they had seen them both performing at first hand during the long flights."

In the weather documentation for the afternoon prior to departure, Scott's signatures seem consistent and neat. If three key personnel were 'the worse for wear' then would Colmore have relied on Scott for that final decision, particularly if he was ready to retire him?

Prior to the flight, Ministry papers (AIR2/349) checking the health and licensing of projected crew members includes a note suggesting that not all the named Officers would pass the required medical. If this reference related to Scott then it might have been circumvented by re-designating Scott as a 'passenger' rather than as a serving officer. Steff's flying license was also in question; all the other officers are confirmed as fully qualified. This health issue is pure conjecture but, I think, of interest.

9.2.3 Lt. Col. Vincent Crane (Dopey) Richmond OBE, BSc, ARC, AFRAeS.

Assistant Director (Technical); RAW Chief Designer on the R.101.

Baker to Masefield 11/11/1975 (Masefield Archive, Brooklands):

"Our little design section (T. S. D. Collins, the only survivor of the R.38 team whom I hope you have consulted, Roxbee and myself) saw a great deal of Richmond. He was in and out of our room most days, discussing every kind of problem. I did not find him a 'bluffer'. I do not believe he claimed any expert knowledge or practical experience (though I think we credited him with knowing all about balloon fabric!) But his approach was sound. He surprised me at our first meeting by saying 'forget all you know' – his way of saying 'always go back to first principles'. I felt he had a hard streak from the way he treated Collins. Richmond would come into our office with some problem and say to Collins ' How did you deal with this on R.38? Collins never failed to take the bait. He would jump up, go to his bookcase and produce his old R.38 work-book. Richmond would study it, then say 'Right, we won't do it that way'. He was possibly a hard taskmaster, though I would prefer to think of him as the man who engendered the extraordinary enthusiasm we all felt."

Pugsley on V.C. Richmond (Masefield Archive, Brooklands):

"A strong but kindly leader, wholly dedicated to airships. He never passed on to us the irritations he must have felt about public attacks that he could not answer because of his position. His own penetrating mind, supplemented by the charming intuition of Rope, impressed us all. And we never heard from Richmond anything of the bitter rivalry so often alleged to have existed between the Cardington and Howden teams"

Kings Norton describes Richmond's attributes in his memoir *A Wrack Behind* (Kings Norton,1999):

"He was a man I liked very much and I believe he was a good physicist. He was not, however, an engineer. He had been associated with the design of non-rigid airships but had no experience of rigid airship design. Very few people had. In my view, he was a good picker and recruited some splendid people. To balance the gaps in his engineering knowledge and experience he had as his chief assistant a person of great brilliance and extraordinary charm – Flight Lieutenant (afterwards Squadron Leader) F.M. Rope."

AIR5/14 includes a transcript from a Richmond letter on 22/1/30:

"Although I have no doubt DAD has fully acquainted you of the technical position, I should like to take this opportunity of putting my views in a few words.

(1) The air-worthiness regulations set a new standard in hull strength, (after the R.38 accident) nobody could foresee what this would mean in weight. Now we know pretty definitely and in playing for safety I do not think we have exceeded appreciably the weight implied in those regulations. The hull weights of the two ships are almost identical and Bairstow says they are of equal strength.

(2) In future we may save a few tons by refinement of design such as in the fins and passenger quarters. The deliberations of the new Stressing Committee may also ease the strength requirements, but I do not look for too much in this direction.

(3) The important question of the effect of choice of machinery on weight and consumption is well known. R.101 with five engines and good propellers would attain about the same speed as R.100 and any limitation of range caused by the weight of the engines is compensated for by decreased consumption, etc. The range of neither ship is sufficient, certainly with any payload during the bad months.

(4) What all this comes to is - that a 5 million cu.ft. airship according to current British ideas is not suitable (inherently) to carry 100 passengers over journeys to the East of 2500 miles at all times of the year. This may be a serious conclusion in view of what the British Public has come to expect, but I do not think the particular airships which have been produced can be blamed, nor do I think the position could have been wholly foreseen in view of the highly experimental nature of the job.

Either we must have our stopping places closer together or our ships larger or both. I am afraid there is no doubt about the second, but I naturally hope very strongly that the size will not have to be so large that a lot of new fundamental research work has to be undertaken. One would like the chance to perfect the present type."

9.2.4 Sqn. Ldr. Frederick Michael Rope

Richmond's popular primary assistant in the design of R.101. Rope initiated most of the innovations on the airship from the gasbag wiring system to a simple air log for measuring airflow. Seconded to RAW under Richmond, Pugsley described him as 'an outstanding and practical design genius, but so modest and retiring that he tended to efface himself and to discount the credit which was his due.'

Speed to Masefield 19 April 77 (Masefield Archive, Brooklands):

"Michael Rope was a man of quite outstanding ability and inventiveness which, combined with a wealth of practical knowledge gained in the design and development of the non-rigid Sea Scout Zero series of airships at Capel Airship Station (near Folkestone) and at Kingsnorth Airship Station (near Ashford, Kent) during the war. He was not only exceedingly competent and hard-working but also the best-liked man at Cardington – indeed, nobody there ever spoke other than well of him."

"For all his competence and authority, Michael Rope was so diffident and self-effacing that he exerted less than the full influence of which he was capable on the higher-ups in the Cardington team."

George Meager (First Officer R.100) writes after the disaster, 20 November 1930, AIR5/906:

Except for that incident over the Channel there is no mention by any of the survivors that the behaviour of the ship was anything but normal until the two final dives, except Leech's conversation with Squadron Leader Rope. This conversation is really of great importance, for it shews that Rope had realised the ship had rolled more than usual.

This being the case he would undoubtedly have had a look at the valves as he was mainly responsible for their invention. Knowing what a careful man Rope was I do not think he would have let any serious leakage at the valves pass without reporting the matter. He was on board for that very purpose and was not a man who would not see and admit any fault in articles of his own design.

Cave-Browne-Cave in 'A century of British aeronautics' (Cave-Browne-Cave, 1966):

"Mr Leech who survived, said that during the last flight, Rope – who died in the airship – had remarked frequently that the airship was rolling in the storm much more violently than expected. This would cause the dangerous chafing and leakage which his design would have avoided."

Professor Lord John Baker FRS later wrote of Rope:

"Rope was the most remarkable man. Looking back over a long experience now in engineering there's no doubt in my mind that he was the most distinguished engineer I ever had the fortune to come in contact with. He really was a designer of genius."

9.2.5 Flt. Lt. H. Carmichael (Bird) Irwin AFC
Captain

Joined RNAS Airship Section in 1915 commanding all types of non-rigids around UK and Eastern Mediterranean. 1920 commanded R.26, R.33 and R.36, then to Air Ministry. 1925 commanded R.33 before transfer to School of Balloon Training at Larkhill 1927-28. Captain of R.101 throughout 1929-30.

Booth writes:

"Flight Lieutenant Irwin was not an engineer, but shewed great commonsense in his judgement of the practical value of technical proposals in connection with the ships he commanded."

Speed described him to Masefield on 19 April 1977 (Masefield Archive, Brooklands):

"Carmichael 'Bird' Irwin was an attractive, mercurial, Irishman, given to moods of elation and depression but regarded as a very steady airship pilot and captain of much skill and experience. He was a quiet, studious, athletic man who had been an outstanding long-distance runner; a member of the British Olympic team in 1920 at the Antwerp Games."

9.2.6 Flying Officer Maurice H. Steff
2nd Officer

4 years School of Balloon Training in UK. 2nd Officer R.100 and R.101.

AIR 2/349 contains a comment on Steff's licence currency in April 1930:

"Flying Officer Steff would be regarded as a trainee on the Canadian flight and therefore need not have a licence at once. At some time he will have to undergo an 'A' examination."

The R.100 flight log from the Montreal flight shows that Steff was Officer of the watch on many occasions; only once having his entry countersigned by Johnston. Many of these were the night watches – Steff was on duty over the St Lawrence so, arguably, had enough recent experience to confirm his place as OOW at 0200 5th October on R.101.

Meager writes in his draft of Steff as Duty Officer on the R.100 Canadian flight thus (Meager family papers):

"I was awakened by a violent thunderstorm; peal on peal of thunder with immediate terrific jagged lightning and hail beating on the window. I thought of Steff who was Duty Officer that night (9 Aug 1930). It must have been a pretty trying time for him but he managed very well and no damage was done to the ship though I believe one sudden change in the wind swung the ship round through 180 degrees."

This vote of confidence from Meager makes it more surprising in regard to R.101 when disaster struck. Steff was 'blamed' by some for throttling back and removing any chance of climbing away with serious damage. However, the slowing of the ship at impact would have rendered the crash survivable for those in the accommodation decks had no fire taken place so he could have been hailed a 'hero'.

Speed (RAW) to Masefield 3/3/1975 (Masefield Archive, Brooklands):

"Steff: A great buddy of Scott and, like Scott, a drinker – he liked to keep up with Scott on the bottle. Inexperienced and 'the man we all blamed for the crash' he went on watch at 2am and would have been sober then.

I have had a further and more highly coloured account of the Cardington affair from Cyril Watson, a senior AGC representative, who is up here on leave from R.100. Some allowance must be made for his exaggeration but I think the following account is substantially correct, Watson writes:

The alcohol which the R.101 crew got hold of was in Steff's cabin; he brought over 16 bottles of Canadian whiskey, presumably for his own use. As soon as the R.101 crew got on board they commenced to rifle the cabins, and discovered this amongst other souvenirs. They also rifled Johnston's cabin which produced a further incident later on.

Up till midnight Atherstone and Hunt were in charge of this crew and it was during this time that the drink was consumed and the fuel tanks broken.

"At 3 o'clock in the morning the handling party arrived from Henlow to put the ship into the shed. This process is normally carried out by Johnson and Steff one being in charge of the bow of the ship and one the stern. It was soon apparent that Steff had been celebrating the safe return of the ship to England, a circumstance which was indicated by the fact that he found it more suitable go about his duty on his hand and

knees, and having attained this position was unable to assume the erect position without assistance. In this condition he was not very much use in helping the ship into the shed and finally retired from the field. He was subsequently reported to the Air Ministry by the Henlow officers. I cannot find out whether there was any incident in getting the ship into the shed, but she seems to have gone in smoothly. As soon as she was safely berthed Johnston went on board and found that his cabin had been rifled and all his personal property and souvenirs stolen. He came out into the shed extremely angry and said exactly what he thought of the conduct of the R.101 crew to those members of the crew who were standing about. These men were still in a partially intoxicated condition and one of them started to take his coat off to Johnston, whereupon Johnston gave him a straight left and knocked him down, dislocating his jaw. I think you will agree that this incident is true to the tradition of the Merchant Service.

The Court of Inquiry is still sitting. Steff seems likely to get the most severe treatment as the charges against him are, first, smuggling alcohol into this country and secondly conduct unbefitting an officer and gentleman. R.101 crew are likely to escape without much action against them as they are making great play with the fact that they were struck by an officer."

The above seems like something from a cinema, but I believe it to be substantially correct."

The fact that those involved were still sent to India on R.101 indicates the shortage of experienced officers for both airships. In the RAW investigation into the Johnston 'knock down', Steff gave clear evidence acknowledging the 'imported' whisky and is named as one of two who restrained a second crew member from retaliation on Johnston. This is hardly likely if Steff himself was drunk or suffering the ill effects. Watson, from AGC, was on duty but was not called to give evidence to RAW, who interviewed everyone from Booth to the lift boy.

9.3 The Inquiry

On the 22 October 1930 Sir John Simon was appointed to hold an investigation into the causes and circumstances of the accident to the airship R.101. He was assisted by two assessors, Lieut.-Colonel J. T. C. Moore-Brabazon and Professor C. E. Inglis. The inquiry opened on 28 October 1930 and spent 10 days taking evidence from 42 witnesses. Professor Bairstow and the NPL then carried out calculations and wind tunnel tests of R.101, the results of which were presented to the inquiry in a further three days of evidence, ending on 5 December 1930. The report of the inquiry was published as Command Paper 3825 on 27 March 1931 (Simon, 1931).

The Report of the R.101 Inquiry covers the earlier history of airships; design and construction of the R.101; preliminary trials and reconstruction; the decision to start Indian flight; The final journey; and discussion of cause of disaster.

In his letter to the Secretary of State, that forms the foreword to the report, Sir John Simon states:

> *It is a matter of great satisfaction to me, as it will also be to yourself and to the public, that my two Assessors, Lieut.-Colonel Moore-Brabazon and Professor Inglis, find themselves in agreement with me on all points in the Report which I am presenting. I may be permitted to express my deep sense of obligation to them both for assistance and guidance without which the Report could not have been written. The document may therefore be taken as our joint work and opinion.*

9.4 The Inquiry conclusions

The Inquiry concluded:

> *"that the immediate cause of the disaster was leakage culminating in a substantial loss of gas from one or more bags in the fore part of the ship" and that it probably "was connected with a specific misfortune such as a ripping of the fore part of the envelope"*

Commenting on the agreed suddenness of the situation it also acknowledges:

> *"If the Captain had been conscious at that moment (0200 hrs) of any serious trouble, he would have certainly not allowed the men who were going off duty to turn in but would have ordered them to stand by. The evidence of the survivors, and in particular of the surviving engineers, is conclusive on this point."*

Masefield to Crispin Rope 2/1/1986 (Masefield Archive, Brooklands). Collar was a respected aerodynamicist and academic.

> *"I have spoken to Roderick Collar about this and he says that he thinks the reason was that there was a deliberate policy, laid down by Sir John Simon, that no-one of the crew was to be criticised in any way."*

US Congress, 1933 - Harpham :445/6 *Investigation of dirigible disasters* Joint committee of US Senate and House of Representatives (Washington D.C. USA, Congress of the United States):

> *"... unfortunately, the wreck of the R.101 wiped out almost everybody in England who knew anything about airships, leaving only two or three, and it was almost impossible for them to start again because of lack of trained personnel, either in engineering, design, or operation ..."*

Griffith Brewer to Sir John Simon on 7/11/1930 (Meager family papers):

> *"An airship seven hundred feet in length, travelling south with a west wind, points her nose S.W., so her bow travels over a path 300 feet west of the path traversed by the stern. Consequently, the bow and stern encounter different up currents which cause pitching, while it is possible for the stern to enter and continue in a long wave which may lift the stern continuously until a dangerous inclination is attained. If this occurs at a low altitude, the ship will strike the ground unless the coxswain steers promptly to the*

left in order to bring the bow into the same up current. … My experience has been confined to balloons, kite-balloons, and aeroplanes, and I have had no practical experience with airships."

Moore-Brabazon summarized his thoughts thus (AIR 5/910):

Blame

1. *Subordination of technical problems to political pressure.*
2. *Consequent starting due to unfavourable weather which was largely a contributory cause to the accident.*
3. *The introduction of many new devices, which necessitated extensive trials to try them out. Trials were shortened, nor were 'contract trials', so to speak, such as the R.100 had to go through ever performed before she was hustled off to India.*
4. *The organisation of the Air Ministry shows no over-riding power of veto on the airship colony at Cardington. Higgins and Dowding, no doubt distinguished officers, were quite unable to take a strong line on airship policy, the whole of Cardington found themselves practically forced to take the bidding of the Secretary of State. There would seem need for somebody on the Air Council strong enough and independent enough to put a veto on any project, however desirable from the political point of view, not ready from the technological side.*

On 8th April Major Teed writes from Vickers to 'Winco' at RAW on an issue of patents, ending:

"I think we all appreciate the Simon Report as not being severe on anyone, but really I do not think we are any nearer finding the solution for the accident that can be accepted without question by everyone."

Phillip Teed was unique in having responsibilities at both Howden and Cardington. He therefore had experience under Richmond and Wallis and those common to both teams, Colmore, Scott and Thomson. He was a close friend of Booth and Irwin and was asked specifically by a concerned Mrs Irwin to represent her at the inquiry to protect her husband's reputation. He was also well connected to the Zeppelin Company; his German language skills had been used in negotiations over gasbags and valves used on R.100 and Wallis filed all important contract documents with Teed at Howden, probably in connection with his translation abilities.

Between November 1930 and April 1931 Teed wrote to Sir John Simon, first requesting permission to represent the Irwins but also to explain various theories on gas loss and airship motion in connection with the incident.

Teed postulates a theory:

1. *The new cover tended to loosen rather than tighten as a result of wetting and might therefore have flapped on the final flight. This would reduce the tendency to tear but would increase the suction on the 'chattering' valves. He agrees with the sudden*

loss of gas forward but suggests that the necessary mix of hydrogen and oxygen could only have been created in the space beneath the cover.

2. *He then postulates that the chafing due to roll would create leaking holes, aligned in rows along girders, particularly transverse frames, and these might suddenly join up causing a catastrophic gas release beneath an intact cover.*
3. *The 'loose' gas in the void would upset the pitch in general and a forward rupture is the agreed recipe for the explosion on the second impact there being no practical evidence for the cover failure.*
4. *Hunt's declaration 'we're down lads' was before the second dive so the irrecoverable situation must have been known after dive one.*

Teed seems to assume that only a particular mix of hydrogen and air would ignite, expelled slowly from holes and then en masse by the first impact. He seems to ignore the highly inflammable petrol vapour from the forward engine cars crushed in the first impact, close to the hot exhausts and clashing metal girders. Once this vapour ignited the hydrogen/air, expelled or not, would surely burn.

Mrs Colmore to Sir John Simon, 7/11/30 (AIR5/909)::

"Dear Sir,

I hesitate to interfere in any way but, as you will understand, my husband's reputation means everything to me.

In yesterday's evidence, Air Marshall Dowding stated that he had instructed my husband to do full speed tests as soon as possible after leaving the mast on the day of the Indian flight. Mr Reynolds' short notes of the meeting in question point out that this instruction was in the form of a question or suggestion; which appears a different matter. My husband certainly had this impression as he detailed the conversation to me on his return home.

With sincere apologies if I have done anything irregular.

Mrs Colmore."

15/11/30 Simon to Mrs Colmore (AIR5/909):

"I have had so many letters about the R.101 Inquiry that it is impossible to acknowledge them all; but yours is in a different category. I only write to say that you may feel confident that the point which moved you to write is in my mind. It would not be proper for me to say more, except that I feel most deeply for you and the others who are bereaved, and shall do my best to remember how dear to you all is the reputation of those you have lost.

You will of course understand that I am writing in strict confidence."

Mrs Colmore, on 16/12/30 (AIR5/909):

"Dear Sir John,

I had not an opportunity of saying goodbye to you after the conclusion of the Inquiry so I felt I would like to write you a line just to thank you with all my heart for all you have done for us and for the very kind and considerate way in which you conducted the Inquiry. I do realise your great difficulties, and please believe how really grateful I am. With very best wishes for Xmas and the New Year."

Southwell to Simon 16/12/1930:

"I venture to write to you in regard to a point which came up during your interrogation of Mr Collins on the last day of the R.101 Inquiry.

In the 'Times' report of Dec 6th, there is a paragraph reading as follows "Sir John Simon said there was no question that the most elaborate care was taken both in the design, and the calculation of stresses, the inspection in great detail, and the construction of the ship. He was very sorry if there should be any other impression. He asked:- would the gasbags have been enlarged if the ship, when constructed, had given the lift that had been calculated? – No."

The statement with which you prefaced your question is so explicit that I feel almost certain that you would have used the word "estimated" instead of "calculated" if you had realised the technical point which is involved. Mr Collins ought, of course, to have been alive to it, but I think that he had by that time become slightly flustered, realising that by tendering his own ideas as evidence he had done no service to his case. The point is that only estimates of weight were made before the design of the ship was started, and in the nature of the case (observing that new materials, new methods of construction and new conditions of stressing had yet to be devised) could not have been expected to be very close: to calculate weights one would need to have complete working drawings before one, and then the same margin of error would reflect much more seriously upon the calculator. So that your question, as worded in the "Times", would suggest to the technical man an implication of error which I feel convinced (from the context) that you did not intend.

If my impressions are correct (they could of course be checked by questioning the Design Staff at Cardington), no detailed calculation of weights was ever attempted. The obvious procedure (being at once easier and more reliable) was actually to weigh every component before building it into the ship, - and this I believe was done. But the fundamental difficulty in the design of a rigid airship is that detailed design cannot be started until the gas capacity is settled, and that is a question of estimated weights: when the gas capacity has been settled, it cannot be altered except by some such procedure as was in fact employed. Knowing something of the problems involved, I do not think that any technical man would consider the margin of error in this estimate excessive. Nor would there have been any need to let out the gasbags if intermediate mooring masts had been provided: I stressed the case for these in my James Forrest Lecture of last May.

This letter, of course, needs no reply, and I hope that you will not think me troublesome for having written it. I have felt that this question of estimated weights is one which may possibly be touched on in your findings, and that to attribute the enlargement of the gasbags to errors in calculation would constitute a reflection on Colonel Richmond as chief designer which I think you do not intend. I cannot, of course, claim to be officially interested in this matter; but it is a matter of deep concern to me that no injustice should be done, even unintentionally, to his memory."

Moore-Brabazon to Sir John Simon 8/4/1931 (AIR5/909):

"Now that the R.101 is over I cannot help writing you a line first of all to congratulate you and ourselves on the extraordinary favourable reception which has been given to the Report from every quarter of the Press. I think our task was a difficult one and, largely due to your wise guidance, I think we steered through the difficult shoals with consummate judgement, we have offended nobody and have yet made the position absolutely clear. Nor have we butted into any subject which was not absolutely our domain.

I cannot help saying that although the whole subject was a melancholy one the actual investigation was most enjoyable, and particularly to myself in that it gave me an opportunity of being again closely associated with you. To you, to whom most credit is due, I know that among the shoals of congratulations, not the most unwelcome will be that from – your admiring collaborator – 'Brab'"

Excerpt of a letter from Simon to Moore Brabazon 13/4/31 (AIR5/909):

"Yes, the Public and Press have received our little brochure very favourably. I was much pleased to receive a grateful letter from Miss Thomson, Lord T's sister, saying how greatly our Report had relieved the mind of herself and her mother. It is a tragic business for these people to be landed into poverty when, with a turn of the wheel of fortune, they might have been out with the new Viceroy of India. Amulree seems pleased, and Trenchard writes a characteristically downright letter of commendation."

On 16th November 1930 there is a sequence of letters (AIR20/161) regarding weights on departure. Notably, Capt. W.G. Deakin writing to Darby at the Royal Courts of Justice says:

"I gather that there is an internal desire amongst the staff at Cardington to do nothing which might leave any stigma on those who are gone."

The Registrar responds on 17th:

"Your statement that there is an intense desire amongst the Staff at Cardington to do nothing which might leave any stigma on those who are gone, is noted.

The facts are being enquired into for the purpose of arriving at the truth, and you may rest assured that nobody has any desire to cause any stigma on those who lost their life in this disaster."

10. Concluding discussion

At the time, the gestation of the Imperial Airships appeared long and drawn out but, by reference to the 21st Century's major projects, the F-35, Airbus A400M and Boeing 787, it can be seen that the longevity expectations of modern types with in-service lives of 30-50 years requires long and thorough development. With the pace of modern technological change it becomes inevitable that upgrades are regular and frequent. 'Too many innovations' in one project is still an issue today.

Alan Cobham, contemporary aviation pioneer, wrote to 'The Times' after the incident, The Times, October 11th 1930:

> *"We who have been long in aviation feel deeply the loss of our dearest friends and realise that the real tragedy is not so much the loss of R 101, but the deaths of the protagonists and experts of aviation who were on board.*
>
> *It seems a pity that on Saturday night we put all our eggs in one basket, for there is hardly a case on record where, if by some formula, brain ability could be estimated in value, so much destroyed in one disaster. The airship experts on board were a team of many years standing and between them they held the secrets of scores of experiments and because they were a team it is possible that many of their findings have not been recorded."*

Cave-Browne-Cave to RAeS Historical Group August 1962 RAeS Journal p.66:

> *"Perhaps the fatal mistake was insistence that the ship must take the Secretary of State to India in most impressive style and get him home to tell a personal story to the Imperial Conference. Without him and without the supporting passengers and the great unnecessary weight and, if Colmore had been allowed to choose his time of departure, R.101 could almost certainly have flown to India and probably returned before the end of the Imperial Conference."*

The author, like others, sees the failure of the Scheme as an unfortunate mix of coincidences:

1. Over optimistic specification.
2. Too much pressure to innovate without staged assessments.
3. Lack of experienced officers on both airships.
4. Unfortunate changes of Staff at the top.
5. Colmore's poor judgement in what was passed up to the Ministry and Thomson.
6. Thomson's personal ambition.
7. Lack of a full-speed trial.
8. The decision not to renew the entire outer cover.
9. Scott and Colmore's decision to go rather than wait 12 or 24 hours for better weather
10. The coincident financial depression.
11. The change of watch just before the first dive.

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Airship Guarantee Co. Archive, Cambridge University Library
Airship Heritage Trust
Brooklands Museum
Farnborough Air Sciences Trust
Imperial War Museum
John Frost Newspaper Archive
National Aerospace Library
Nigel Caley Collection
Papers of George Meager
Rope Charitable Trust

Royal Air Force Museum
Science Museum
Sir Peter Masefield Archive, Brooklands
The National Archives (Public Record Office)
Ventry Archive (held at National Aerospace Library)

Messrs Davison, Rope and Camplin offer no apology for the numerous references to the research of Sir Peter Masefield whose unique position and meticulous approach allowed him to gather much of this evidence from those involved in the Scheme.
The Quotations are repeated verbatim from original sources and do not necessarily represent our personal views. We welcome any further information related to this research.

The author

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Peter Davison, formerly Assistant Curator, Aeronautics, Science Museum, London and Member of the Royal Aeronautical Society Historical Group, became Curatorial Advisor to the Airship Heritage Trust in 1990. From 2004 he engaged with the subject of the R.101 following a meeting with Crispin Rope. Mr Rope, son of Michael Rope and long term correspondent of Sir Peter Masefield, suggested he follow up on the condition of Sir Peter's papers at Brooklands Museum. This investigation, and the subsequent establishment of the co-located Masefield Archive, led to a series of in depth articles for AHT's magazine Dirigible and, in cooperation with the Editor, Dr Giles Camplin, to an 80th Anniversary Lecture on 4th October 2010 at the Royal Aeronautical Society, London. This lecture, and various versions of it, have been repeated across the home counties since that date and the research that informed its content has resulted in this document.

Appendix 1: Vickers, the Airship Guarantee Co and R.100

A1.1 Burney and Wallis at the Airship Guarantee Co.

The Airship Guarantee Company (AGC) was set up as a subsidiary company by Vickers, to enable the construction of R.100 at Howden, Yorkshire. Sir Dennistoun Burney was Managing Director, B N (Barnes) Wallis the Chief Engineer and N S (Nevil Shute) Norway Chief Calculator, and later Deputy Chief Engineer.

F.W.Musson gives an insight into the Air Ministry view of Commander Burney at the inauguration of the Airship Guarantee Company (undated, AIR5/14*):

> *"Burney is the only active representative of the business community at present. One recognises, of course, his enterprise and fertile imagination but where concrete facts of business are concerned it cannot be said that the Air Ministry (or presumably Vickers) have any reason to be particularly impressed with his ability. If airships are to prosper, it is of vital importance that the operational experiments with R.100 and R.101 in the coming months should be carried out in a thoroughly practical manner. Nothing could be more out of place than stunts and the sort of extravagant atmosphere which Burney never fails to excite."*
>
> *"The crux of the matter is whether the airships can operate with regularity and they should be given every opportunity to prove themselves in this respect all other considerations notwithstanding. There is everything to be gained by keeping this as a clear issue and recognising such points as the carrying of passengers as a subsidiary detail."*

Following the Canada flight, the PRO contains this note on future policy (Source untraced):

"Remarks of a confidential nature regarding the sources of information obtained.

> *"It is a matter of considerable difficulty to obtain reliable information regarding airship development, there being a great deal of jealousy between the commercial and Air Ministry factions, represented by Lieutenant-Commander Sir Dennis Burney and Wing-Commander Colmore, respectively.*
>
> *There is no doubt that but for Sir Dennis Burney there would be no airships in the air today, but as an Air Ministry official at the Royal Airship Works at Cardington stated, although agreeing, "such a remark is heresy in this service".*
>
> *Both Commander Sir Dennis Burney and Wing-Commander Colmore when approached were found to give different answers, due to different motives. Air Ministry representatives seem inclined to discountenance, to some extent, anything that has come from Sir Dennis Burney, whilst the latter is liable to differ from others chiefly through a tendency to exaggerate, his continual task of propoganding airships being really responsible for this. Wing-Commander Colmore seems disinclined to discuss any*

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* All references of the form 'AIRn/n' are from National Archives, formerly Public Records Office.

questions with regard to the development of airships from a naval point of view. On being pressed for information of this nature, one was informed that nothing was known in the matter, as, as yet, it was not the Air Ministry policy to develop airships thus. Sir Dennis Burney in his book "The World, The Air and The Future" p57 [Burney, 1929], makes a similar charge regarding Air Ministry 'policy'.

It was interesting to note that Lieutenant-Commander Rosendahl, U.S.N. late Captain of the U.S. Airship "Los Angeles" and a man with greater airship experience than any except Dr. Eckener and one other [Scottie?], in several instances seemed to agree with the view of Sir Dennis Burney.

A more or less unbiased opinion has been found in Mr N.S. Norway. Though Sir Dennis Burney's assistant and designer, he can to a large extent be relied upon as he evidently makes it his business, when necessary, to try to keep Sir Dennis within the bounds of practical propositions. He is without doubt an able and clever man and has also a good knowledge of Air Ministry "policy". In the event of further information being required in this subject, taking into consideration that he is commercially interested, he would seem a very suitable person to approach.

With regard to the question of development it would seem that, under Air Ministry direction, it will be slow. Before the building of R.100 by Sir Dennis Burney, it is believed that they asserted that a ship of such size was at that time impracticable, and their present attitude regarding development should perhaps be viewed in this light.

On the other hand, Mr Norway points to the Royal Airship Works at Cardington as having advanced ideas regarding engines, fuel and masts.

Though it is generally agreed even by some Air Ministry officials that Sir Dennis Burney is alone capable of developing airships quickly and in putting them on a commercial basis in the near future, it appears that the Government, influenced by the Air Ministry who wish for a monopoly, favour the latter.

But it is believed to be unlikely that a decision in this matter will be taken until after the Imperial Conference."

Design Committee minutes exist in the Cambridge AGC Archive for the start of the scheme in 1924/25. These meetings were held monthly and convened by Sir Trevor Dawson, Chairman of Vickers. In the early design meetings Burney showed considerable knowledge of Airship specifications in his briefings to Wallis and Richmond. In Burney's book he quotes many reasons and statistics leading him to conclude that aircraft development was constrained by the weight of undercarriages, the limits of pilots and airframes to survive landing at much over 65 mph and the constant battle between paying payload and fuel. He considered that, apart from the flying boat, aeroplanes could not compete with airships on long haul for between 20 and 50 years.

Although Wallis was responsible for many design decisions, he was performing to a songsheet written and dictated by Burney. Unfortunately, Richmond's diary was not started till a year later or his comments might have been of interest. We know the Ministry was tiring and suspicious of Burney at this time.

Shute mentioned the conflict between Burney and Wallis in "Slide Rule" chapter three:

"These two men [Burney and Wallis] were complementary and the success of R.100 was due to their combined abilities; my own part in it was small. It was deplorable that they could not agree better, but temperamentally they were poles apart. Perhaps two geniuses in one company would always find it difficult to work together."

In October 1928 we see a sign of frustration between these two forceful personalities following some wasted work in the AGC drawing office: Burney to Wallis, AGC Archive:

"If it is the case that the Drawing Office did not interpret your design sketches accurately, the fault lies with you. I have frequently expressed my opinion that you do not go round the Drawing Office at frequent enough intervals, with the result that not only is there a considerable waste of Drawing Office time, but also, as in the present instance, there is waste in the shops.

I should be glad if you would make it a constant rule to go round the Drawing Office at a fixed time every day so as to prevent a recurrence of instances of this character."

Wallis to Burney, Gasbag drawings, 16 June 1926: AGC Archive:

Referring to a general arrangement drawing of the bags.

"I had purposely omitted dimensions of gas valves, fitting necks and lifting patches as I think it desirable to throw the responsibility for as much of these details as possible on to the Germans. Having given the required rate of rise and fall it would be up to them to submit their proposals regarding gas valves, in order that we might obtain Air Ministry approval before actually ordering. We are not well equipped at Howden for undertaking manufacture of details of this kind and I feel sure that it would be better, as regards delivery and cost to obtain them outside."

B N Wallis to Pratt at Barrow, 24/5/27 PRIVATE AND CONFIDENTIAL shines a light on Wallis' frustration with AGC, Vickers (Science Museum Wallis Papers). It was, perhaps, the precursor to his move to aeroplanes:

"My dear Pratt,

Very many thanks for your letter of the 11th of May [1927] with reference to the subject of Sir Trevor Dawson and Commander Craven's visit to these works.

Matters have developed very considerably since Sir Trevor Dawson and Commander Craven were here and as I have never had an opportunity of putting the case clearly before them I think that, it may be of some service if I try to give you a clear and unbiased account of all that has occurred for some time passed.

The whole matter really hinges upon the organisation which has been adopted by Commander Burney at these works but things were brought to a head in March last by the discovery of some faulty material which had been worked into the structure of the ship.

At this juncture I formed as I think you know, a small Committee of Investigation which reported on the 17th of March, giving the conclusions and suggesting remedies for an

avoidance of similar trouble in the future. I'm enclosing a spare copy of parts one and two of this report in case you have not already seen it, and from it you will see that we made certain recommendations in respect to the reorganisation of our Examination Department.

This report was handed to Commander Burney and there, as far as I am personally concerned the matter has been allowed to rest, for Commander Burney has made no reference of any kind to me of the troubles disclosed in this report or of the remedies which were suggested or of the steps which he has taken to meet our recommendations.

I have been given to understand however from chance advertisements and from side winds of information that Burney did in effect take action with a view to securing the services of a new Chief Examiner in place of our existing Chief, Tom Jones, and he has apparently finally settled upon Captain A. Basil Miller of who's experience and qualifications I will say more hereafter.

In the first place, however, it will make matters clear if I attempt to describe to you Burney's attitude in relation to this matter. He is in the first place very much impressed by the disaster to this Company which would ensue as the result of my illness or sudden death and he has for some time been anxious to secure the services of an adequate successor to myself.

Had this matter been taken up and had a really capable assistant been obtained for me three years ago he might no doubt, have been of considerable service by the time this contract was completed, but as no such person was forthcoming, and as under the exceedingly economical scheme of administration which we have adopted throughout in our attempt to save loss to the Vickers Company no serious attempt was made to obtain such an assistant. I have, as you know, worked through the whole design of this ship and a great part of the organisation of these works assisted only by such members of our old Barrow staff as were in a position to join me at Howden. And of course Teed, who has been invaluable.

The work as far as design is concerned is now done, and since the sole contract possessed by this Company is now drawing to a close the introduction of a highly paid stranger at the 11th hour to reap the benefits of our work and to jump over the heads of less highly paid, but faithful servants of the Company, who have toiled through the heat of the day appears to me such a gross injustice and error in policy that I am not prepared to agree to the adoption of this course in the present condition of this Company.

The importance of replacing myself by a person capable of carrying on my work has been most forcibly impressed upon Sir Trevor Dawson and I have not had the opportunity of supplying the logical answer to this idea. The actual answer is this :- That our existing design is, except in a few minor details, as good as we can get it in the present state of the art. These minor details are well known both to myself and to the staff here, but in other respects every influence is in existence to lead us, in the event of further orders being obtained, to retain the present design practically unchanged. These influences may be briefly summarised as follows:-

1. The design has been tested and proved to be highly efficient from a theoretical point of view.

2. 30% of the whole structure has been erected complete and has demonstrated that the principles of quick erection at which I aim have surpassed all anticipations in actual practice.

3. That our present ship is already beyond the limiting capacity of this shed.

4. Considerable capital has been sunk, and stocks of tools and special sections have been accumulated in the production of the present design.

From the above only one conclusion can be drawn, namely, that in the event of the Airship Guarantee Company Ltd. obtaining additional orders for Rigid Airships there is no chance of any change in design as long as such ships are to be built in the Howden Sheds, and the inevitable corollary :- that until the Airship Guarantee Company Ltd. obtains a new and larger shed they will not require the services of a new designer.

In other words, in the event of my leaving the Company from any cause our existing staff are quite competent to carry on the construction of additional ships as long as the Company retains the use of the Howden Sheds.

This answer to Burney's point has not, I think, been put before Sir Trevor Dawson or Commander Craven and it is not one which readily leaps to the mind. Burney, however, has made the necessity of obtaining a new Chief Examiner the ingenious excuse for the introduction of a new designer who after a few months training in the Examination Department shall then be fully qualified to take my position.

With this end in view he has rejected such nominees as have been put forward by Colonel Outram of the AID and others, and has set out to find a highly qualified technical man of the type I have indicated. There is, however, more in this than at first meets the eye, for during the gradually growing friction between Commander Burney and myself there has sprung up, on his part I think, a feeling of considerable jealousy accompanied by desire to possess in this Company a technical opposition to myself, who's services he may rely upon when he and I come to a point of disagreement.

One further argument which is used to justify the employment of such a person in a relatively subordinate position:- this is that in the event of our obtaining simultaneous orders for the construction of Rigid Airships in France and America we shall require personable representatives who can be sent out to these several countries to supervise the construction and erection of the ships.

The answer to this point is that since in that case Howden Sheds will become merely a detail manufactury (if even that) ample staff of proved ability and accustomed to travelling, such as Watson, Dove, Teed and myself are always available for the supervision of foreign contracts.

And that a few months experience chiefly in office work in the Examination Department will not fit a man, however able, to undertake work of the character indicated.

Having dealt as clearly and briefly as possible with the general situation I now come to a period just a month ago when, two days before our last Board Meeting, Mr Mowat,

our Secretary, received a note from Bamber in London reading as follows:- "I have pleasure in enclosing you a copy of a letter which has been sent to Mr Basil Miller from which you will see as subject to Board approval it is intended to employ this gentleman as our chief inspector. You will no doubt require this for your Board Meeting"

This was the first intimation that anyone at Howden, including the Secretary, had received, of the proposed engagement of Captain Miller. His engagement was to begin immediately at a salary of £500 per annum.

I enclose a copy of an abstract prepared by himself of his experience.

The remainder of the papers which have been forwarded to Howden do not throw any further light on his accomplishments, but no doubt the extract will enable you to form your own conclusions.

The answers to three questions which I addressed to him personally on the occasion of his visit to these works last week are however illuminating – question – have you ever had any works experience? Answer – No.

The four months shop experience referred to at the De Havilland Aircraft Company represent one of his vacations during his course at Lausanne.

Question – have you ever had any drawing office experience? Answer – No.

Question – Have you ever designed anything which had actually been manufactured? Reply – No.

In view of the fact that our Chief Draftsman and Chief Calculator are in receipt of salaries of only £7 per week the introduction of this highly paid official as a substitute for Tom Jones would have constituted a grave injustice and would have upset the balance of salaries throughout the technical staff.

Unfortunately as the papers could only be shown to me by our Secretary in strictest confidence and as, without letting Mowat down, I could not raise this matter with Commander Burney direct, my only course was with his permission to write a hasty letter to Commander Craven trusting that it's somewhat veiled references would be sufficient to lead the capital board to refuse to ratify the appointment until further investigation had been made.

The letter had the desired effect and the sequel so far as the actual visit of Sir Trevor Dawson and Commander Craven is concerned, is now known to you; actually, however, their visit did not achieve the results hoped for; so much time was spent in inspecting the works and drawings that a few minutes only was available after five o clock for discussion with me on the real issue and they were compelled to leave having arranged that an interview should take place between Miller and myself to be followed by a subsequent meeting with Sir Trevor Dawson, Commander Craven and Commander Burney.

This arrangement has fallen through and Burney actually brought Miller to Howden on the eighteenth of this month and he stayed the night with us at the Hostel.

During his visit opportunity was taken for him to be interviewed by myself, Teed, Norway, our Chief Calculator, and quite apart from his technical qualifications we unanimously agreed that he is not the type of man who would work amicably in company harness.

No doubt he is a very gallant and brave gentleman but he appeared to us to be domineering, self-opinionated and overbearing. However well informed he may be in aeroplane practice he appeared quite ignorant on Airship technique and the type of girder which we had employed although I understand that he was quite prepared to redesign this structure and set us all to rights.

As a result of a long conversation with Commander Burney before my interview with Miller I ascertained that he had, or claims to have, definitely committed himself to giving Miller a position. However anxious I may be personally to make good the word of the Managing Director (improperly given) I am not prepared to sacrifice, what in my opinion are the best interests of this Company for Commander Burney's sake, and I have intimated both to him and to Commander Craven that I am on this occasion prepared to back my opinion with my resignation. I am enclosing a copy of my report to the Board on the subject of Millers engagement in which you will see no references made to personal matters, my objections being based solely on his entire lack of practical qualifications.

I think that this puts the matter as clearly as possible from my point of view. I must leave the effect of the introduction of such an alien in the midst of an overworked but devoted band of enthusiasts such as exists and Howden to your imagination.

Perhaps you will be able to gain a better idea of our feelings in this matter by a personal visit and I therefore hope that we shall have the pleasure of seeing you here in the near future."

A1.2 Conditions at Howden

Shute describes the Howden shed thus in 'Slide Rule':

"The floor area of the two bays was seven and a half acres. Already in those early days the building had suffered from neglect; towards the completion of the ship the rain streamed through the roof upon the work with every storm."

and

"It was not possible to heat the huge [Howden] shed at all. Howden stands on low ground; in winter there is standing water on the aerodrome and in the height of summer water is found two feet below the surface of the earth. In consequence the air is always humid; a more unsuitable locality for airship manufacture would be difficult to find. Very frequently the shed was filled with a wet mist so that every girder became coated with water; mould attacked the fabrics in the store, and the corrosion of duralumin became a serious matter."

If only the Air Ministry had insisted, as a pre-contract condition, that the Howden shed be refurbished then a great deal of wastage and heartache might have been avoided to the benefit of all sides.

Teed to Fellowes at RAW 9/3/1928, AGC Archive:

> *"You have been kind enough to assure us that you would always be willing to assist if this were possible, should we find ourselves in any difficulty with regard to R.100.*
>
> *Due to our German Gasbag Contractors, the B.G. Textilwerke G.m.b.h. having disposed of their gasbag store-rooms from July next, we are placed in a very great quandary as to where to house our bags (now completed) between then and the time when we can put them into the ship.*
>
> *Unfortunately, it is utterly impossible to keep gasbags here for we have no dry, rat free, warmed rooms, nor is it possible to construct such places in the available time.*
>
> *Under these extremely difficult circumstances, we would ask you if you could possibly manage to store our bags under the conditions which gasbags require.*
>
> *Should you like to discuss the matter with all its ramifications with either Wallis or myself"*

A1.3 Exchanges of information

N.S.Norway writes in 'Slide Rule' in 1954:

> *"In the five years that were to elapse before either airship flew neither designer visited the other's works, nor did they meet or correspond upon the common problems that each had to solve."*

But there was social contact. Mary Stopes-Roe wrote (Swinfield, 2012, pp 176/7):

> *"... My father and Scottie were at one time very close." and " ... an old friend who had known Daddy and my mother for years, they were always in each others pockets. The Scotts enjoyed so much hospitality at Howden over the years."*

'Howden' implies the contact was during the R.100 period, not the earlier R.80 project.

Pugsley and Rowe wrote in a biography of Wallis for the RSA in 1981:

> *"Wallis, in the interests of commercial secrecy, for the benefit of his company, rejected all advances from Cardington by way of cooperation and exchange of information. R.B. Colmore, in charge at Cardington, tried to achieve this and encouraged Richmond to send Wallis reports on some of the work done at Cardington, but to no avail. All too was not happy at Howden, where Wallis bristled at the sometimes tactless interventions by Burney on technical matters."*

Vickers London Office and the Air Ministry were in London and were easier to get to than Howden. Fellowes to Wallis, 7/4/1927 (Wallis papers V62):

"Arranged for Scott and Rope (Richmond on leave) to meet BNW at the Air Ministry (Reynold's room) 11am 11 April."

Colmore to Wallis 14/5/1927 (Wallis papers V61):

"My dear Wallis, I overheard your conversation with Bairstow after our meeting at the Air Ministry when you were discussing the gas valves for R.100 and I heard you say you were arranging for the necessary automatics to allow a rise of about 2,500 ft/min. Unfortunately there was not time to talk it over at the Club but possibly it might interest you to know what we are arranging for R.101 … we anticipate we shall be able to get approximately 4,000 ft/min rise. If it interests you Richmond would be only too pleased to send you along details."

Richmond to Wallis 26/7/1927 (Wallis papers V58):

"As promised you by Colmore, I am sending herewith particulars of the combined automatic and manoeuvring valve which we have developed for R.101. … I am sending this information to you personally and would ask you as a favour to exercise your discretion with regard to the use which is made of it." [Note- Patents were still provisional]

Wallis to Richmond 6/8/1927, (Wallis papers V57):

"I am very much obliged by your kindness in sending particulars of the new R.101 gas valve for my information and much appreciate your action in placing this material at my disposal.' …'great ingenuity'…'strikingly original and clever'…Naturally I suppose every designer prefers his own ideas and I should not be sincere if I pretended that on the whole I did not still, i.e. until it has been shown unsatisfactory!! Prefer the arrangement which we have worked out for R.100. This remark, however, does not in any way detract from the genuine admiration which I have expressed, our own arrangement possessing very little originality and still less ingenuity, and in that respect and perhaps many others is undoubtedly inferior to yours."

Colmore to Wallis 30/8/27(Wallis papers V56):

"After your meeting with Scott and Rope at the Air Ministry in April last you said the meeting had been very helpful and you hoped that further meetings of a similar nature would be arranged from time to time."

18/3/29 Norway to Temple, AGC archive, Cambridge University:

"I have received a memo from Commander Burney asking if I would send you details of the Cardington Transverse Frame and mesh wiring scheme, as reported to us by Major Scott."

"Unfortunately I have not been able to find our copy of the Patent Specification upon this subject up here. I am writing to Bamber to ask if he will get a copy of this and let you have it direct.

Without the Patent Specification to give the precise details of the wiring it is not very easy to see how certain features of it are worked out practically, but the attached sketch shows the principle of the device.

……

You will see from this arrangement that the radial wiring is always in tension. The radial wiring is duplicated at each frame, each gasbag, having its own radial wiring system which is made fast to its own circumferential mesh. In this way the radial wiring system is always in tension since it is loaded with the lift of a quarter of the gasbag.

When one gas bag becomes deflated the adjacent bag naturally tends to bulge in the deflated bay. The radial wires, however, are already in tension due to their carrying the lift of a quarter of the bag.

……

The exact manner in which the circumferential wiring goes out of action I have not been able to discover, but I have no doubt that a reference to the Patent specification will make this clear.

Scott maintains that in this way the bulge of the gasbag is elastically restrained and no sudden surging of the gasbag takes place.

The whole system of wiring is kept in place when the ship is in pitch by a system of longitudinal wires from the circumferential mesh to the transverse frame, not shown in my sketch."

The Wallis papers (V54) also contain a note from Colmore, 11 October 1927, arranging a visit to Wallis at Howden with Scott:

"I should now be very glad to accept your kind invitation to visit Howden towards the end of this month, if that would be convenient to you. Scott could arrange to get away at the same time, and we should like to pay a joint visit which, of course, would be quite unofficial."

This is interesting as the Wallis family are reported (Swinfield, 2012) to have complained that their frequent 'hospitality' for visitors from RAW was never compensated by AGC or Government. So much for 'nobody ever came to visit'

Cave-Browne-Cave RAeS lecture 15 January1962, published in the RAeS Journal August 1962:

"It was said that there was not sufficient interchange of information and criticism between the design staffs of the two airships … On more general features a very satisfactory touch was achieved by the frequent visits made to R.100 at Howden by Colmore, then the Deputy Director, and by Scott in charge of flying operations. It is quite certain that if any further discussion had been asked for, or had appeared desirable, it would undoubtedly taken place. Both Scott and Colmore had been personal friends of Dr Wallis for many years."

A1.4 R.100 to Montreal

The more conventional R.100 first flew on 16 December 1929 and on its maiden flight to Cardington for flight trials carried most of the AGC team plus Colmore and Rope from RAW. The proven Condor petrol engines ensured a non-tropical international flight was required and Canada fitted the Empire requirement having built a mast. The Ministry was insistent that no visit was to include the USA, partly to spite Burney and his commercial aspirations.

The trans-Atlantic flight is often lauded as 'uneventful' but, in truth, it was hazardous. Serious weather was encountered in the St Lawrence valley with sudden updrafts exceeding the ascent rate limitations and violent turbulence ripping the fabric of the fins and elevators. These were temporarily repaired in flight with great bravery using spare fabric stowed on board by circumspect engineers. The need to make more substantial repairs in Montreal limited the demonstration flights and engine issues meant the return, wind assisted, flight carried one lame engine. The cover leaked in heavy rain putting the galley out of action and, at one point, she nearly flew straight into the ocean but was recovered to receive press acclamation on her return. The quest for success and the need to keep up support for the Indian adventure hid the often desperate nature of the Canada flight.

In 'My Airship Flights' George Meager (1970) highlights how officer experience counts at that time:

> *"I had been asleep about a couple of hours when I was awakened by pressure in my ear-drums…I knew at once that something out of the ordinary had happened; I jumped out of my sleeping-bag still in my 'Teddy Bear' suit, and went below to find out the reason. Booth was at the elevator himself. 'The silly young mutt nearly had us in the ditch,' he told me. He had taken the elevator himself, as the young chap who had been on it had brought the ship down to about 500 feet, had Booth not grabbed the wheel from him we should probably have headed straight into the Atlantic. The lad was quite a youngster and our latest recruit amongst the riggers. I believe it was his first trick on the elevators, which being the case, the Cox'n should really have stood by him."*

Although a great success, the idea that R.100 was an ideal solution or ready for further service is misplaced. Significant costs and time were required before she could have even returned to her pre-Canada condition. Both designs had laid the foundations for a 'next generation' that was never to be realized.

It is often reported that two petrol tanks fell from the base of the ship on its arrival from Montreal. In reality, the unfamiliar crew that received the ship overfilled these tanks and caused the damage.

The technical difficulty of making the two flights to these remote bastions of the Empire, Canada and India, was not lost on those who had to undertake them. And neither was the inherent difference between them, as witness this statement from R.100 captain Ralph Booth to Johnston 11/1954 (Johnston Papers, Masefield Archive, Brooklands):

Regarding his captaincy of R.100 to Canada 'I was thankful as the right place for airships is over the sea and I never fancied the trans-Europe or Cairo-India trips.'

Colmore to Sir John Salmond, August 1930:

"With a new and stronger cover and new gasbags, an extra bay and dieselised Condors, R.100 will be a very good ship"

Appendix 2 Biographies

A2.1 Government appointees.

A2.1.1 Brigadier-General the Lord Christopher Birdwood Thomson of Cardington PC, CBE, DSO

Born India 1875. Royal Engineers. Distinguished history in South Africa and the Balkans. Multilingual. Staff College, Camberley 1909-10. Present at WW1 armistice signing. In 1921, as Special Commissioner for the International Committee of the Red Cross, he appealed on behalf of refugees, even meeting Trotsky on behalf of Save the Children. He was a major player in the burning of the Romanian oilfields prior to the German invasion. Failed to be elected as MP but enobled to serve as Secretary of State for Air in 1924 and 1929-30. Air-minded, enjoying cross–party support as Secretary of State. Having initiated the Airship Scheme, returned to office in time to oversee completion. Well-connected friend of Ramsay MacDonald.

Lt Col E.N.Mozley DSO wrote of Thomson in March 1931:

"Christopher Birdwood Thomson, the third soldier of our time who has risen to become Secretary of State, was a man of great energy, fine intellect and living sympathy. It was perhaps through his especial ability to master foreign languages and his vivid and versatile conversation that he first forged his way to the front; but these powers alone would not have made him loved and trusted, as he was, by men naturally of other ways of life and thinking than his own. To those qualities he added an idealism so unexpected that some of his friends could hardly believe it was there: a sympathy which led him to do all he could for anyone who asked: and a driving force which, if in the end it drove him to his death, also drove his vessel in the Fleet of State in a manner unexampled in our time.

Thomson did other work of the first importance. His air journey to the Middle East, in 1924, inspired the Service and fired the imagination. His presidential support of civil air clubs and leagues and his championship of them in Parliament and before the Treasury has had enduring results. Only a man, himself an active traveller through the air, could have carried these things through so effectively. The extension of Imperial Airways was, he thought, the greatest work to be undertaken. To him the Air Ministry was not 'office'; it was service."

Thomson addressed the House of Lords on 3/6/30 emphasising the experimental nature of the project (AIR5/904):

"This is one of the most scientific experiments that man has ever attempted, and there is going to be no risk, while I am in charge, of the thing being rushed or of any lives being sacrificed through lack of foresight. It is far too scientific and important a matter for that…If the almost unthinkable happened and these ships failed on their final flights, there might be a strong movement towards scrapping of the programme. That would be heart-breaking. I cannot tell you what magnificent work has been done by the airship men. There are officers in that work today who have sacrificed promotion and many other advantages in order to get on with this great experiment. We have a body of enthusiasts at work there, and only the worst luck could interfere with the success of the experiment. If we have bad luck, I should have thought it was in the British character to stick to it still and triumph over temporary adversity."

"There are improvements to be introduced into both of these ships which will considerably lighten their loads, but those improvements will be on the basis of 'safety first'- exactly on the same basis as that on which the ships were originally constructed. 'Safety first' may not be a very paying proposition in regard to politics, but I am sure it is the right thing in regard to airships."

AIR5/904 contains the text of CBT's address to the Imperial Press Conference 27/6/30:

"In the month of September R.101 will go to India by way of Egypt. I am looking forward to going in her myself (applause). It is no particular adventure. One of Dr. Eckener's experts came over here not long ago and having been over the R.101 he said,' That is the safest conveyance on land or sea or in the air that human ingenuity has yet devised' (cheers). It is indeed a superb manifestation of applied science and engineering skill. She is a great strong thing. She is not particularly fast and we have been some time building her, but I do believe that both as regards engines and strength of design problems have been solved which could never have been solved unless the ship had been built. This much is certain; a great amount of knowledge in regard to aeronautical science has been gained that could not otherwise have been gained."

AIR2/364 contains the oft-quoted 'plans' demand of 14/7/30 CBT to AMSR:

"So long as R.101 is ready to go to India by the last week of September this further delay in getting her altered may pass.

I must insist in the programme for the Indian flight being adhered to, as I have made my plans accordingly."

Various officials, Brancker and Colmore included, made representations to Lord Thomson to delay until further en-route masts were built and that he allow the fore-gathered Dominion representatives to view the ship in the UK but Thomson (AIR2/364) was adamant:

"We have already made the first flight to Canada. Now we must do the first airship flight to India so that when we approach the Dominions for further co-operation in the Programme I can say that we have done Canada and we have done India – and now you see what airships can do".

It is clear that it was Thomson's pressure that hastened the departure on 4 October 1930 and there is no reason to doubt his commitment to 'no risks' or his admiration of those engaged on the project. One can only surmise that he was unaware of the detail or significance of the weight issue either when approving the weight reduction measures or even when taking a heavy carpet with him on the day of departure. He was an ex-engineer and a practical problem solver. Had Colmore, Scott, or even Higgins, shared the detail with him then the 'passengers' issue might have disappeared early on until a viable airship had resulted from these investigations. Similarly, without Thomson's enthusiasm and influence on the Treasury and within Government, the project might have ceased before construction even began. In his eagerness to share in the scheme's success he inadvertently contributed to its failure.

Further evidence of the lack of communication or comprehension is apparent as the day of departure approached. Comment was reported that 'visitors' (maybe the MPs) noted the lack of carpet in passenger areas. The installation of Axminster carpet on the walkway and lounge/dining areas was accepted wiping out many of the weight reduction measures. Thomson, on the day of departure, arrived with champagne for his reception and a talisman Persian carpet roll weighing over 100lbs that had to be manhandled up the stairs of the mooring tower and was allegedly stowed in the forward gangway. This had a romantic connection with Marthe Bibesco who had lost a similar piece in a fire at her Romanian Posada. Thomson was not completely ignorant of weight issues as he sent one of his ministerial work cases back to Whitehall as he had more than enough work to do on board. In the past he had declared the airship so smooth that he could work better on board than in his office with all its distractions.

A2.1.2 Air Vice-Marshall Sir William Sefton Brancker KCB, AFC

Born 1877. Bedford School 1891-94. Brancker was trained for the British Army at Woolwich, joining the Royal Artillery in 1896. He served in the Second Boer War and later for a number of years in India, where he made his first flight in 1910. On 18 June 1913 he was awarded the Royal Aero Club's Aviator's Certificate no. 525.

During World War I, he held important administrative posts in the RFC and later the RAF including Director of Air Organisation and Director of Military Aeronautics. In 1917, Brancker briefly served as the General Officer Commanding Royal Flying Corps Palestine and then Middle East. Promoted to major-general in 1918, he became Controller-General of Equipment in January of that year and Master-General of Personnel in August 1918. Royal Military Academy, South African War, Director of Civil Aviation from 1922. Air-minded champion of air-mindedness. Drove the formation of aero-clubs. First Master of GAPAN. Given his Bedford history, civil and military expertise and Middle East knowledge, his destiny lay aboard R.101 to Egypt.

A2.1.3 Sir John Higgins KCB, KBE, DSO, AFC

Born 1875. Cadet at the Royal Military Academy, Woolwich and the Royal Field Artillery in

1895 before serving in the Second Boer War. Officer Commanding 5 Sqn. from July 1913. November 1914, Higgins led RFC's training wing at Netheravon. He went on to command II Brigade RFC, VI Brigade RFC and then III Brigade RFC during the course of World War One. In the closing stages of the War he was General Officer Commanding No. 3 Area and then General Officer Commanding Midland Area.

Post War appointed General Officer Commanding RAF forces of the Rhine and then Air Officer Commanding Northern Area before becoming Director of Personnel at the Air Ministry in 1920. Air Officer Commanding Inland Area in 1922, Air Officer Commanding Iraq Command in 1924 and Air Member for Supply and Research in 1926. Advised Dowding to always rely on Colmore's advice regarding airship matters. He retired to India in 1930 but was recalled as Air Officer Commanding-in-Chief of the Air Forces in India in October 1939 at the start of World War II before retiring again in August 1940.

A2.1.4 Sir Hugh Dowding GCB, GCVO, CMG

Hugh Dowding, the son of a schoolmaster, was born in Moffat on 24th July1882. Educated at Winchester and Royal Military Academy in Woolwich. He joined the Royal Artillery Garrison he served as a subaltern at Gibraltar, Ceylon and Hong Kong before spending six years in India with mountain artillery troops.

On his return to Britain he learnt to fly. After obtaining his pilot's licence in December 1913, he joined the RFC. Sent to France and in 1915 was promoted to Commander of 16 Squadron. 1926-29 Air Ministry Director of Training.

Dowding now joined the RAF and in 1929 was promoted to Air Vice Marshal, taking command in Palestine, and the following year joined the Air Council. January to August 30, Officer Commanding Fighting Area, active pilot.

Took over from as AMSR from Higgins in September 1930. Later had exemplary career in World War Two running Fighter Command through the Battle of Britain. Self-confessed ignorance of Airships.

Dowding certainly learned fast. On 16 October 1930, soon after the accident, he was asked by none other than the Chief of the Air Staff to dispatch R.100 to India in substitution. Within 24 hours he rebutted this as nonsense. R.100 was unsuitable and in no condition to fly anywhere; nor were there any crew to make the journey.

A2.1.5 Group Captain Peregrine Forbes Morant Fellowes DSO

Born 1883. He transferred from the Navy to the new Royal Air Force in 1918. In 1921 he surveyed and opened an Air Mail route between Cairo and Baghdad so was selected to head up the Cardington department as DAD, Director of Airship Development. The first person to fly over Mount Everest in 1933, a skilled pilot and proven administrator he had surveyed the

airship route to India, Australia and South Africa in 1927. He moved on to Director of Personnel Services at the Air Ministry in July 1929; handing over to his deputy Colmore. Died 1955.

A2.1.7 Wing Commander Reginald Blayney Bulteel Colmore OBE

Born Portsmouth 1887, Stubbington House School, Fareham. Then HMS Britannia. Sub Lt RN in 1907, Lieutenant in 1909. Retired 1911 but in 1914 mobilised as Lt Com with Armoured Car Division at Antwerp, then Gallipoli in 1915 and north Africa as CO. RNAS airship section in 1916 at Barrow where he helped investigate the Zeppelin L33, then CO at Mullion. Evolved system of combined submarine control by airships, seaplanes, aeroplanes and ships.

Chief Staff Officer, Aircraft Ops with the Grand Fleet at Dundee 1918. 1919 Sqn.Ldr. RAF, Staff Officer for Airships, Air Ministry, seconded as Deputy Director of Airship Development in 1924 under Fellowes to help draft the Imperial specification. He became DAD in early 1930 and immediately inherited the problematic scheme in a time of approaching austerity. It is understandable that he might be reluctant to voice immediate criticism or bring bad news but, given that Thomson relied on his expertise, it was his responsibility to decide how far up to pass information and whether each flight should proceed.

Colmore was in daily contact with Major Scott and Vincent Richmond, his judgement in deciding what was passed up the chain to Secretary of State for Air Thomson via Higgins and later Dowding was crucial as the departure day approached. There was nobody in the Air Ministry with any direct experience of airships to judge his advice.

A2.2 RAW Staff members

As early as 1921, a note to the Secretary at the Air Ministry listed Personnel deemed essential to the ongoing collection of data on airship development despite the ‘close down’ following the loss of the R.38. On the list were Richmond, Dyer, Wyn-Evans, Gerrish, McWade, Rope and Rogers, among others, each with a specific area of expertise. This demonstrates the long term contribution these people made and the high regard in which they were held. All of them came together later to contribute to the Scheme’s development.

A2.2.1 Lt. Col. Vincent Crane (Dopey) Richmond OBE, BSc, ARC, FRAeS.

Chief designer RAW on the R.101.

Born 1893 at Dalston, London, the son of Joshua and Florence Mary Richmond. His father was a mechanical engineer and model maker. Educated at the Royal College of Science. He became an engineer for Messrs. S. Pearson & Sons working on physical and structural problems in connection with dock construction. In 1915 he joined the Royal Naval Air

Service and until the end of the War was principally engaged on the construction of non-rigid airships. Head of Inter Allied Aeronautical Commission on Airships in Germany in 1920 where he met Eckener and became increasingly interested in rigid airships. Lecturer in airship design from 1921-24 at Imperial College under Bairstow. Technical Airship advisor to Air Ministry. With Scott & Southwell on Burney's design committee.

Pugsley on V.C. Richmond , (Masefield Archive, Brooklands):

> *"A strong but kindly leader, wholly dedicated to airships. He never passed on to us the irritations he must have felt about public attacks that he could not answer because of his position. His own penetrating mind, supplemented by the charming intuition of Rope, impressed us all. And we never heard from Richmond anything of the bitter rivalry so often alleged to have existed between the Cardington and Howden teams"*

Kings Norton describes Richmond's attributes in his memoir *A Wrack Behind* (1999):

> *"He was a man I liked very much and I believe he was a good physicist. He was not, however, an engineer. He had been associated with the design of non-rigid airships but had no experience of rigid airship design. Very few people had. In my view, he was a good picker and recruited some splendid people. To balance the gaps in his engineering knowledge and experience he had as his chief assistant a person of great brilliance and extraordinary charm – Flight Lieutenant (afterwards Squadron Leader) F.M. Rope."*

A2.2.2 Major George Herbert Scott CBE, AFC, AMIMechE

Born 1888, Catford, Kent. Richmond School, Yorks. RN Engineering College, Keyham. From 1908 in general engineering until joining RNAS as a Flt Sub-Lieutenant. Served on Eta airship at Farnborough, then Kingsnorth and Barrow as Captain of Parseval P.4 in 1915. 1916 commanded Airship Station on Anglesey and Captained R.9 in 1917. Experimental Officer, Airships, at Pulham.

Air Ministry Airship Stressing Panel, originator of mooring mast system with Masterman. Became a Major on formation of RAF. After captaining R.34 in 1919 he was demobbed and joined tech staff at RAW in 1920. AD (FT) from 1924; visited Canada to negotiate the building and funding of a mast at Montreal. Having conceived the mast mooring system his wife enjoyed an income from the US patents after 1930.

George Herbert Scott was rightly lauded for his captaincy of R.34 on the first Atlantic double-crossing in 1919. Seen as the heroic public face of airship development (rather like Eckener in Germany in the late 20s and 30s) he was treated with deference in his early career. He later developed the mooring mast concept and was the natural choice to head the flight training programme for the R.100 and R.101.

A2.2.3 Wing Commander Tom R. Cave-Browne-Cave CBE, MIME, MINA, FRSA, FRAeS

Deputy Director of LTA Research, in charge of non-rigid design and construction at Kingsnorth during the First World War. His papers at the Imperial War Museum enlarge on his work on the Hydrogen-Kerosene engine and his wartime contributions to the art of camouflage. As Professor of Engineering at Southampton University he later worked with survivor Leech.

Born 11 January 1885.1 died on 26 November 1969 at age 84. Educated at Dulwich School, Dulwich, London, England. Invested as a Commander, Order of the British Empire (C.B.E.) in 1919. He was Deputy Director of the Airship Research Air Ministry between 1920 and 1921. Professor of Engineering between 1931 and 1950 at University College, Southampton, Hampshire, England. Served on the R.38 Inquiry. Director of Camouflage, Minister of Home Security between 1941 and 1945.

Appointed RAW powerplant expert, Cave-Browne-Cave wrote after the R.38 inquiry in RAeS Journal Vol. XXXI October 1927:

> *"Possible sources of ignition in the hull are largely confined to the lower part. Even if a hole in the gasbag exists, it is only on rare occasions that hydrogen will reach this space, whereas fuel gas or petrol vapour are likely to reach there whenever a leak exists. An airship using heavy oil is, therefore, very much safer than one using petrol or fuel gas."*

Cave-Browne-Cave drafted a highly critical account (Cave-Browne-Cave, 1969) of the Cardington programme but died in 1970 before completion. A copy was loaned to Masefield in 1981 which contributed valuable contemporary detail for 'To Ride the Storm' (Masefield, 1982). Masefield Archive, Brooklands.

A2.2.4 Sqn. Ldr. Frederick Michael Rope

Richmond's primary assistant in the design of R.101. Rope initiated most of the innovations on the airship from the gasbag wiring system to a simple air log for measuring airflow.

Born 1888. Shrewsbury School and Birmingham University, graduating as an engineer. British Electric Plant Co in Alloa then Rio Tinto and the railways. Joined RNAS in 1915 as Technical Officer at Capel, then Experimental Officer in charge of speed trials at Kingsnorth under Cave-Browne-Cave where he helped design the successful SS Zero, arguably the most successful of the RNAS spotter airships. Air Ministry in 1919, then to Baghdad as technical staff officer RAF Middle East Command. Seconded to RAW under Richmond, Pugsley described him as 'an outstanding and practical design genius, but so modest and retiring that he tended to efface himself and to discount the credit which was his due.' Qualified aeroplane pilot.

Baker to Masefield 11/11/1975, Masefield Archive, Brooklands:

"I cannot throw any light on the Rope incident mentioned on your page 2 because it was long after my time, but it reminds me that to my indignation Richmond often seemed to treat Rope and his advice in a high handed way. I felt that Rope, with all his courage, wasn't built to stand up to such treatment, (he was an intensely shy man)."

Speed to Masefield 19 April 77, Masefield Archive, Brooklands:

"Michael Rope was a man of quite outstanding ability and inventiveness which, combined with a wealth of practical knowledge gained in the design and development of the non-rigid Sea Scout Zero series of airships at Capel Airship Station (near Folkestone) and at Kingsnorth Airship Station (near Ashford, Kent) during the war. He was not only exceedingly competent and hard-working but also the best-liked man at Cardington – indeed, nobody there ever spoke other than well of him."

"For all his competence and authority, Michael Rope was so diffident and self-effacing that he exerted less than the full influence of which he was capable on the higher-ups in the Cardington team."

George Meager (First Officer R.100) writes after the disaster, 20 November 1930, AIR5/906:

"Except for that incident over the Channel there is no mention by any of the survivors that the behaviour of the ship was anything but normal until the two final dives, except Leech's conversation with Squadron Leader Rope. This conversation is really of great importance, for it shews that Rope had realised the ship had rolled more than usual. This being the case he would undoubtedly have had a look at the valves as he was mainly responsible for their invention. Knowing what a careful man Rope was I do not think he would have let any serious leakage at the valves pass without reporting the matter. He was on board for that very purpose and was not a man who would not see and admit any fault in articles of his own design."

Professor Lord John Baker FRS later wrote of Rope (Masefield Archive, Brooklands):

"Rope was the most remarkable man. Looking back over a long experience now in engineering there's no doubt in my mind that he was the most distinguished engineer I ever had the fortune to come in contact with. He really was a designer of genius."

Harold Roxbee Cox, Lord Kings Norton, recalled:

"To balance the gaps in his [Richmond's] engineering knowledge and experience he had as his chief assistant a person of great brilliance and extraordinary charm – Flight Lieutenant (afterwards Squadron Leader) F.M. Rope."

Barnes Wallis to Lloyds Register Staff Association referring to reports that Rope was around at 0200 on 5th October (Paper No.5 'Some Technical Aspects of the Commercial Airship' R.101; Box B Masefield Archive, Brooklands):

"In my opinion Squadron-Leader Rope knew more about what I might call the mechanics of handling an airship than anyone else on board and that his mind would have reacted to a thing like that immediately and he would have reported it."

A2.2.5 Flt. Lt. Sydney Nixon OBE

Chief Administrative Officer RAW. Later represented Mrs Jess Scott in regard to securing royalties for Scott in connection with mast patents in the USA. Held many RAW files in a cabinet that 'went missing' in 1931.

Nixon worked for Colmore and was present or informed first hand of the discussions between Colmore, Musson and Thomson regarding the time of departure. He wrote later that he thought Colmore and Scott would delay any full-speed tests until the clearer weather forecast over the Mediterranean.

Nixon became Head of the Technical Staff after the accident in 1930.

A2.2.7 Thomas Stanley Davies Collins

A Naval Architect and sole survivor of the R.38 design team, he was sometimes 'used' by Richmond as an example of how not to solve design problems by asking him how it was done on R.38. Collins was one of those best suited to evaluate the causes of the accident, AIR2/365 contains the detail of this study. He is described as Head of the Stressing Office at RAW.

Pugsley to Masefield 16/12/1981, (Masefield Archive, Brooklands):

"I am glad to see you mention T.S.D. Collins sometimes. I have always felt he has been too little appreciated.

I enjoyed my bright young colleagues like Kings Norton, but to me Collins, our immediate chief, with his courteous steadying influence – typical, as I have since learnt, of a good Naval Constructor – was a very valuable person at Cardington."

Countering the suggestion that the R.101 was 'heavy' over France, he told the Inquiry on 5 December 1930:

"I think I ought to say this also, that the late Squadron-Leader Rope had made a very careful study of the flying of airships and it is my opinion, my very honest opinion, that Squadron-Leader Rope knew more about what I might call the mechanics of handling an airship than anybody else on board, and that his mind would have re-acted to a thing like that immediately, and that he would have reported it. Therefore I think that if the ship was gradually losing gas it would have been known. Squadron-Leader Rope and Colonel Richmond would have known, and they would have told Wing-Commander Colmore, and he was the sort of man who would have acted upon it; and if the ship had been in that condition I am quite sure that when I went out on the Commission of

Inquiry (to Allonne), instead of finding the ship on her course I would have found her turned round the other way and coming home."

Collins added a note to the RAW internal enquiry where he reinforces the 0200 change of watch issue AIR5/906:

"In this connection it is necessary to point out that a coxswain who required time to get the 'feel' of the ship under normal flying conditions would be at a considerable disadvantage in the case of emergency or sudden crisis."

A2.2.8 H.B. Wyn-Evans MBE, MINA

Assistant Constructor at Admiralty and overseer of rigid airships at Cardington. Technical expert on Allied Commission in Germany. Royal Corps of Naval Constructors; intimately connected with the design and construction of rigid airships since 1915.

A2.2.9 J.W.W Dyer MSc

Air Ministry airship chemist 1914-18. Fabric specialist at Cardington with responsibilities for gasbag and outer cover manufacture. Interviewed twice by Granada TV in 1967 but withdrew his services as the programme makers would not take all the detail in his evidence. (Reference R.101 Box A, Masefield Archive, Brooklands)

A2.2.10 John Dudley North

Chief Engineer, Boulton and Paul, Norwich. North was a pioneer of aluminium fabrication for airships and aircraft. It was North who translated the exacting requirements of the RAW drawing office into the metal components manufactured for assembly at Cardington.

A2.2.11 Major Phillip L. Teed OBE, BL,ARSM, MIMM, FRSA, FIM, FRAeS, FinstMets

Born in 1889 and educated at Dulwich College and the Royal School of Mines. From 1914 to 1922 Maj Teed served with the RNAS and RAF, being responsible for the initial inflation of all British rigid airships during the First World War. He joined the Vickers Group in 1924.

As Chemist and Metallurgist, Teed was Deputy Chief Engineer at AGC under Barnes Wallis and Burney. He not only supervised the gas plant but spoke good technical German. He handled most of the contracts for the R.100's German made gasbags and valves and was guardian of much of the contractual and technical files at Howden.

In 1927 Teed chaired the Atlantic Service Committee for AGC assuming seven AGC ships providing a daily service to Lakehurst from Southampton via the Azores. He moved to

Cardington with the R.100 for the flying trials. As a Barrister-at-Law of the Middle Temple he was well equipped to serve as an unofficial advocate for Mrs Irwin at the R.101 Inquiry to protect her husband from unfair allegations. He was also an Associate of the Royal School of Mines and Metallurgy.

In the Second World War he served as Deputy Director of Material Production in the Ministry of Aircraft Production and later as Metallurgical Adviser to the Minister of Production and to the British Commonwealth Scientific Office in Washington.

Teed was deputy chief of aeronautical research and development of Vickers-Armstrongs (Aircraft) Ltd, from 1945 until retirement in January 1964. In 1953 he was awarded the Royal Aeronautical Society's Simms Gold Medal for a paper on Fatigue of Aircraft Materials with Special Reference to Microstructure. Also in 1953 he led a team to the United States to study titanium production and use.

Teed died in 1977.

A2.2.12 Frederick M. McWade

Resident AID Inspector on R.100 and R.101.

Born Glasgow 1872. School of Military Engineering and Balloon School. Construction of 'Nulli Secundus', 'Beta', 'Gamma', 'Delta' and 'Eta'. 1915-18 at Kingsnorth building non-rigids. 1920-24 Aeronautical Inspection Department Officer at Seaplane Stations, Isle of Grain and Felixstowe. 1924 to RAW. Flew on R.100 to Montreal. Died 1947.

McWade wrote a damning report about gasbag chafing and the inadequacy of the proposed 'padding' solution. Like Rope's report on the cover, this was not passed up the line with any support. McWade's AID reports on the R.101 is preserved in AIR11/255 and includes details of the sequence of Permits to fly.

E.A.Johnston surmised after his discussion with Mrs Atherstone in 1954:

> *This conversation with Eve merely confirmed the background picture which had grown up in my mind over the years: a picture of a group of hardworking, able and enthusiastic Officers growing more and more angry because of Scott's vagueness and slackness on the job, Scott's character or circumstances seem to provide the key to the astonishing affair of the hushing up of McWade's report on the gasbag chafing.*

A2.2.13 Maurice A. Giblett

Cardington's resident meteorological officer, highly experienced and regarded.

Born 1894, Englefield Green, Surrey. Universities at Reading and London MSc Meteorology. Met Officer Royal Engineers in Archangel, Russia then 1919 Air Ministry Met Office.

Detached in 1921 to duty on R.80, R.36 and R.38 projects. Superintendent of Air Ministry Office in 1925 and toured to New Zealand, South Africa, Australia and India in 1927 to set up Meteorology schemes for the Imperial Airship Programme routes to these destinations.

A2.3 Aircrew

A2.3.1 Flt. Lt. H. Carmichael (Bird) Irwin AFC

Born 1894. Attended St Andrew's College. Dublin. Joined RNAS Airship Section in 1915, commanding all types of non-rigids around UK and Eastern Mediterranean. 1920 commanded R.26, R.33 and R.36, then to Air Ministry. 1925 commanded R.33 before transfer to School of Balloon Training at Larkhill 1927-28. Captain of R.101 throughout 1929-30.

Booth writes:

> *"Flight Lieutenant Irwin was not an engineer, but showed great common sense in his judgement of the practical value of technical proposals in connection with the ships he commanded."*

Speed described him to Masefield on 19 April 1977 (Masefield Archive, Brooklands):

> *"Carmichael 'Bird' Irwin was an attractive, mercurial, Irishman, given to moods of elation and depression but regarded as a very steady airship pilot and captain of much skill and experience. He was a quiet, studious, athletic man who had been an outstanding long-distance runner; a member of the British Olympic team in 1920 at the Antwerp Games."*

One witness claimed Irwin was seen at the controls as the airship grounded; this is unconfirmed. The fact that the car was crushed on the second impact and that it is firmly established that no remedy was available well in advance of that, I think this highly speculative but typical of the mutual respect and admiration for the Captain who had no time to be actively involved having just retired to his bunk after a very long period of duty.

A2.3.2 Sqn. Ldr. Ralph Sleigh (Mouldy) Booth AFC

Captain of R.100 throughout her trials and on the flight to and from Montreal in 1930.

Born 1895, Hughenden, Bucks. RN Colleges Osborne and Dartmouth. Midshipman 1912, Sub Lt in 1914. RNAS Airship section 1915 Captain of SS and Coastals till 1918. First Officer R.24 then Commander of Mullion. 1918 -22 Airship Officer on the Inter-Allied Aeronautical Commission, Berlin.

1925 promoted from RAF Flt Lt to Sqn Ldr after his successful navigation of R.33 following the breakaway for which he was awarded a Bar to his AFC. 1926-27 Commanded School of Balloon Training. Qualified aeroplane pilot.

Sir John Higgins, AMSR Memo to Colmore (DAD) 28/7/1930 (Discussed in AIR5/13):

> *"R.100 Atlantic Flight - Booth has been appointed Captain. He must exercise command and be responsible for the airship. In the unlikely event … circumstances make it necessary for Maj. Scott to take command of the airship then you should formally authorise him to take over from Sqn. Ldr. Booth and report in due course that this has been done and give reasons. … You [i.e. Colmore as Director of Airship Development] will no doubt settle the route and times of departure and intended times of landing with Maj. Scott who can give the necessary instructions to the Captain of the Airship. During the flight I want Maj. Scott to watch and advise as to the general conduct of the flight and not to have any executive responsibility unless specifically authorised by you. Signed John Higgins"*

In the same file at the National Archives is this one which might be of use:
Extract from File 522050/30 - The R.100

> *"The airship R.100 is to make a voyage to Canada next month … Major G.H. Scott who had charge of R.34 when she made her voyage to America … in 1919, will be in command of R.100."*

Attached note from S.9 (The Airworthiness Department at the Air Ministry):

> *"It is stated in the above cutting from the "Times" of 12th inst., that Maj. Scott will be in command of R.100 during the forthcoming voyage to Canada. Will you please say whether this is correct, and what will be the posn., of S/Ldr Booth (or F/Lt. Irwin)? Sanction to the issue of a command allowance to these officers was obtained on the ground of the responsibility involved in the command of an airship particularly when in flight (see encs 9A and 10A). We then understood that Maj. Scott would not be in charge of the ship as in earlier flights. … Dated F.P. 14.4.30 Signed F.G.C. Young"*

Attached responses to above:

> *"18 - With ref to minutes 16 &17 both S/Ldr Booth and F/Lt. Irwin will be in charge henceforth and will carry out the duties and responsibilities as Captains of their respective ships. As far as the forthcoming Atlantic flight is concerned, S/Ldr Booth will be in command of R.100 but Maj. Scott will also be on board. It has always been the intention that Maj. Scott should accompany the ships on their preliminary long distance flights in view of his past airship experiences would prove invaluable should difficulties be encountered in event of emergency. On this occasion however he will be onboard in an advisory capacity … Signed R.N.B. Colmore, DAD RAW 2.5.1930"*

A2.3.3 Major Ernest L. Johnston OBE, AFC

Born Sunderland 1891. Tynemouth High School and Marine School, South Shields. RNR Master Mariner. Transferred to RNAS Airship section in 1916. Commander of Coastals and then CO of Luce Bay. Captain on formation of RAF, then Major. Postwar with Navigation Branch at Air Ministry then retired. RAW in 1924 then loaned to Imperial Airways to develop European routes. In 1927 he navigated S of S to India and back. Air Ministry examiner for Navigation Licenses plus Deputy Master of Guild of Air Pilots and Navigators (GAPAN). AFC and OBE.

Renowned at the time as Britain's most able air navigator. As the Air Ministry Examiner for Navigator Licences he was the natural choice to navigate both R.100 and R.101 on their long distance flights. He was also Captain designate if either Booth or Irwin should be incapacitated. He often stood watches alongside Maurice Steff with whom he had a strong friendship both on and off duty.

Speed (RAW) to Masefield 3/3/1975, (Masefield Archive, Brooklands):

> *"Johnston: A good navigator but a thug. A rough tough man, always ready to knock back a drink and the worse for it."*

His son, Johnnie Johnston later wrote 'Airship Navigator' (Johnston, 1994).

A2.3.4 Captain George F. Meager AFC

Born 1893 Newport IOW. RNAS 1915 Commanded SS and Coastals. 1917-18 to Italy, Captain of the Italian semi-rigid SR1 for its return flight to the UK for which he was decorated by the Italian Government. De-mobbed in 1919. 2nd Officer R.33 in 1925. First Officer of R.100. Later wrote *My Airship Flights* (Meager, 1970).

In a handwritten draft of *Leaves from my log book* (Meager, 1961), Meager refers to being replaced on watch in R.100 by Steff with no mention of Johnston in a supervisory position.

As for the allocation of the Captains to both ships, Meager writes:

> *"Another seemingly insignificant occurrence, the final result of which I certainly owe to the fact of still being alive, was during 1927 when I was Officer-in-charge at Pulham Air Station, I received a letter from Squadron Leader Booth saying he and I had been given the choice of which ship we should be appointed to – R-100 or R-101. I replied that I wished to be appointed to whichever ship was expected to be the first to fly. He apparently was of a like mind, and that is how we became designated for R-100 – he as Captain and I as First Officer – for at that time there appeared to be no question at all as to which ship would be completed first. As it turned out, ironically enough, R-100 was not the first to fly."*

After being told by Scott that R-100 would be ready by May 1928 he comments:

"However, we ought to have known by that time that 'airship months' bear little or no relation to ordinary months, so that it was not until the May twelvemonths that we finally reported to Howden … Such was the blind optimism of both construction staffs that as late as the first week of May 1929 the dates for inflation of the ships was 15 May for R101 and 21 May for R.100 (I except Mr Gerrish, the Shed Manager at Cardington, from hallucinations as to completion dates – he is the only man, except Booth, connected with airship construction or repair who would give a date for the completion of a job and have the job finished on or before that date)."

A2.3.5 Flying Officer Maurice H. Steff

2nd Officer R.100 and R.101.

Born 1896 Luton, Beds. Served on HMS Inflexible 1915 including Battle of Jutland. 1918 Flight Officer in Kite Balloon section RNAS, Adriatic barrage in Italy. Minesweeping in Aegean, Dardanelles and Black Sea. 1920 for 4 years School of Balloon Training in UK. 1925 Kite Balloons at RAW. Officer under Irwin in the Kite Balloon Section of the RAF at Rollestone Camp, Larkhill November 1926. Ground-assisted Meager in the Gordon Bennett Balloon Race in Detroit with Booth in 1927.

AIR 2/349 contains a comment on Steff's licence currency in April 1930:

"Flying Officer Steff would be regarded as a trainee on the Canadian flight and therefore need not have a licence at once. At some time he will have to undergo an 'A' examination."

The R.100 flight log from the Montreal flight shows that Steff was Officer of the watch on many occasions; only once having his entry countersigned by Johnston. Many of these were the night watches – Steff was on duty over the St Lawrence so, arguably, had enough recent experience to confirm his place as OOW at 0200 5th October on R.101.

Meager (1961) writes in his draft of Steff as Duty Officer on the R.100 Canadian flight thus:

"I was awakened by a violent thunderstorm; peal on peal of thunder with immediate terrific jagged lightning and hail beating on the window. I thought of Steff who was Duty Officer that night (9 Aug 1930). It must have been a pretty trying time for him but he managed very well and no damage was done to the ship though I believe one sudden change in the wind swung the ship round through 180 degrees."

This vote of confidence from Meager makes it more surprising in regard to R.101 when disaster struck. Steff was 'blamed' by some for throttling back and removing any chance of climbing away with serious damage. However, the slowing of the ship at impact would have rendered the crash survivable for those in the accommodation decks had no fire taken place so he could have been hailed a 'hero'.

A2.3.6 Noel Grabowsky (Grabby) Atherstone AFC

Born Carl Grabowsky, St Petersburg, Russia in 1894. Educated at Winchester and Charterhouse. Joined RN as Sub-Lieutenant in 1912. Airship Service in 1917 as pilot of SS Zero and North Sea blimps. First Officer R.29 under Irwin. Retired to Australia in 1920 but brought back in 1927 to RAW as 1st Officer R.101.

Atherstone compiled a personal diary which survives with the Airship Heritage Trust. The daily comments from this experienced source present a compelling picture of attitudes and conditions at Cardington throughout the construction and trials programme.
Mrs Atherstone, now Eve Whaley Cohen, wrote to E.A Johnston in 1954, PGM Archive:

> *"As far as I understood at the time, there was absolutely no bitterness among the Cardington people about Burney and the R.100. Rivalry yes, and a rather envious feeling that the Howden people were free from the officialdom and frustration of being under Government control.*
>
> *There used to be good-humoured jests about Burney and Co, but certainly no hard feeling. But I do very clearly remember going to Howden with Grabby and being introduced to various 'Bods' in the airship shed (probably Norway was among them) and feeling a distinct restraint and frigidity and an unwillingness to compare notes or 'give anything away' so much so that when we left Grabby remarked that they weren't very matey."*

A2.3.7 George W. (Sky) Hunt AFC

Veteran of the R.33 breakaway, saw service on R.36. Chief Coxswain R.101.

George Hunt was, like Atherstone, extremely experienced and would have been vital to any decisions taken when disaster struck. The very fact that he left the Control Car to warn the crew confirms the Inquiry conclusion that, whatever the problem, it was felt inevitable that the stricken airship would come to ground. Disley is clear that, after calling calmly 'we're down lads' he went aft to the crew space. He had already passed through the officers cross corridor so Irwin and Johnston would have been woken if they were sleeping there. It is likely that Hunt, in addition to preparing the crew for the expected safe evacuation, would have his long term soul-mate Wally Potter in mind. There is a report that Hunt escaped the inferno but went back for Wally though no survivor or witness reports this so it cannot be denied or confirmed. Had Hunt survived he would have been vital to the Inquiry.

A2.4 Academic support staff:

A2.4.1 Professor Sir Leonard Bairstow CBE, FRS, ARCS, FRAeS.

Zaharoff Prof of Aeronautics, University of London 1920-49, Member of the Aeronautical Research Committee.

Born in 1880 in Halifax, Bairstow is best remembered for his work in aeronautics and for his method for finding the roots of polynomials. A scholarship took him to the Royal College of Science where he secured a Whitworth Scholarship which enabled him to carry out research into explosion of gases. He then went to the NPL (1909-17) where ultimately he became head of aeroplane research work. For a time his assistant there was Beatrice Cave-Browne-Cave, a pioneer in the mathematics of aeronautics. He served in the Design Department of Aeroplanes at the Air Ministry until 1920 before becoming Professor of Aerodynamics at the Imperial College. He served on the aid Committee into the R.38 disaster. Died 1963.

A2.4.2 Dr Harold Roxbee Cox, later Lord Kings Norton PhD, DIC, BSc, FEng, FiMechE

Harold Roxbee Cox, aeronautical engineer: born Birmingham 6 June 1902. He left Kings Norton Grammar School at the age of 16 and joined the Aircraft Design Department of the Austin Motor Company at Longbridge, which was, at that time, designing and building light aircraft. When Austin's aviation interests failed in 1920, Roxbee (as he was known to his friends) was transferred to the workshops to work with the apprentices, and worked towards an external University of London BSc, which he gained with first class honours. In 1922 he left Longbridge for London, where he began studying for both a PhD and a DIC (Diploma of the Imperial College) at Imperial College London in the aerodynamics and instabilities of wings. As soon as he had graduated, he joined the state-financed R.101 engineering team at the Royal Airship Works, Cardington.

Lecturer in Aircraft Structures, Imperial College, London 1932-38; Principal Scientific Officer, Aerodynamics Department, RAE 1935-36; Head of Air Defence Department 1936-38; Superintendent of Scientific Research 1939-40; Chief Technical Officer, Air Registration Board 1938-39; Deputy Director of Scientific Research, Ministry of Aircraft Production 1940- 43; Director of Special Projects, 1943-44; Chairman and Managing Director, Power Jets (Research and Development) 1944-46; Director, National Gas Turbine Establishment 1946-48 during the Whittle years; Chief Scientist, Ministry of Fuel and Power 1948-54. In 1954, Roxbee left the civil service to begin a second career in industry and over the next twenty years he served on the boards of companies as diverse as the British Printing Corporation, the engineers Ricardo, and chemicals company Hoechst UK. He also chaired the packaging company Metal Box and the paint-makers Bergers, Jenson and Nicholson, and was President of the Campden and Chorleywood Food Research Association for 33 years. In 1965 he was created Baron Kings Norton. Chancellor, Cranfield University (formerly Cranfield Institute of Technology) 1969-97. Married 1927 Marjorie Withers (died 1980; two sons), 1982 married Joan Pascoe (nee Pack). Died 21 December 1997.

In his memoir *A Wrack Behind* (1999), Lord Kings Norton describes his early contribution to the shape of R.101 in 1924. This highlights the emergence of mathematics in the new science of aerodynamics at this time:

> *"Clearly, in those early days, the design of the ship was in a very fluid state, though the basic notion of a structure with heavy transverse frames and relatively light longitudinals was in the air. One day Collins took me into a long room in which were*

men kneeling on a smooth floor bending long flexible wooden laths into curved shapes. I asked Collins what on Earth they were doing and he said that they were developing the shape of the airship. This I gathered was ship design practice, conducted in what was known as the moulding loft. I remarked that however practical this might be in ship design it was quite unnecessary for the profile of an airship. In its place I proposed that we should adopt as the profile a mathematical curve of streamline form, the ordinates of which could be calculated and used to design the ship's structure.

I provided Richmond with a number of such shapes and we selected one in which the length of the profile was five times the maximum diameter (the fineness ratio)."

A2.4.3 Major Sir Richard Vynne Southwell MA, LLD, FRS

University of Cambridge,1912 first class degree in both mathematics and mechanical science (engineering). 1914, lecturer in Mechanical Sciences. Royal Naval Air Service during World War I. Then head of the Aerodynamics and Structures Divisions at the Royal Aircraft Establishment, Farnborough. In 1920, he moved to the National Physical Laboratory. He returned to Trinity College 1925-29 as Fellow and Mathematics Lecturer. Professor of Engineering Science, Oxford, from 1929. He developed a research group, including Derman Christopherson, with whom he worked on his relaxation method. He became a member of a number of UK governmental technical committees, including the Air Ministry Airship Stressing Panel, assessing the designs of the R.100 and R.101. The relaxation method was crucial to the understanding of structural stress calculation. This was a vital element in those pre-computer days. Southwell is quoted on 19th October 1930 by Masefield in *To Ride the Storm* (Masefield, 1982), in an open letter to The Times, and in the RAeS Journal, May 1988:

"Of this I am certain; that insofar as man's thought and labour could have ensured success, the best of man's thought and labour was given without stint; that no chances were taken where certainty could be attained. The spirit in which that work was conceived and brought to completion is known to few who are alive today."

"To those who were so fortunate as to have some shares in the great adventure, one possession will still remain – the memory of a gallant company, bound together by selfless devotion to the cause they had at heart."

A2.4.4 Dr Alfred John Sutton Pippard MBE, FRS

Born 1891, Yeovil. Bristol University. Authority on the strength of structures. At the start of the First World War, Pippard joined the Admiralty Air Department where he studied aircraft stresses. After the war he joined an aeronautical engineering consultancy with many of his colleagues and was involved in accident investigation cases. He gained his Doctorate of Science from Bristol in 1920 and took up the chair in Civil Engineering at University College, Cardiff in 1922. This began a long career in academia at Cardiff, Bristol and Imperial College during which he was responsible for the analysis of the methods used in the design of the R.100 and R.101.

A2.4.5 Sir Alfred Pugsley OBE, DSc, DUniv, FRS, FICE, FIStructE, FRAeS.

Born 1903. Chair of Civil Engineering at Bristol University. Driving force behind the formation of the Standing Committee on Structural Safety. Sir Alfred Pugsley's career involved work on aircraft structures and structural engineering from the 1920s onwards. Head of the Structural and Mechanical Engineering Department, RAE. Chairman of the Aeronautical Research Council 1952-57. His papers cover a wide range of topics based on structural mechanics and structural engineering including current engineering practice, structural safety and suspension bridges.

Sir Alfred Pugsley Dickinson Lecture, Newcomen Society, May 1982:

> *"Rigid airship construction brought into being the whole aluminium industry, upon which aeroplanes have since so much depended. Indeed, as I have pointed out elsewhere, in this country the construction of the R.100 and R.101 did for aluminium alloys what the construction of the Forth Railway Bridge did for steel."*

A2.4.6 Sir John Fleetwood Baker FRS, OBE

Born 1901 Cheshire. Clare College Cambridge. Technical Officer at RAW. In 1933 became Professor of Engineering at Bristol University. Scientific Adviser to the Design and Development Section of the Ministry of Home Security 1939 to 1943. In this time he created the Morrison shelter, using his plastic theory of structural analysis. From 1943 to 1968 he was Professor of Mechanical Sciences and Head of Department at Cambridge University Engineering Department. In 1963 he became Doctor of Science at the University of Edinburgh. He was made a life peer as Baron Baker of Windrush on 1 February 1977.

A2.5 Others

A2.5.1 Sir Barnes Neville Wallis (Designer R.100)

Barnes Neville Wallis was born on September 26th, 1887 in Ripley in Derbyshire. When aged two, his father's work as a doctor took him to London. Both Barnes and his eldest brother John spent many hours in a workshop in their house making whatever they could - including paper toys for their sister Annie. Wallis was educated at Christ's Hospital in Horsham, West Sussex. Here he built on his talent for Mathematics and Science and determined that he would become an engineer by the time he had finished his education. His first job was working for Thames Engineering Works - a firm that made ship engines. In 1908, he moved to the John Samuel White's shipyard on the Isle of Wight. In 1913, he joined Vickers - a company that was to become synonymous with airship and aircraft development. He tried to join the Army but failed the eyesight test. He did pass another medical in a different section of the Army by memorising the eye test chart - before the actual test! Just at this time, the Admiralty decided to reconvene Vickers' airship development team and Wallis was recalled from the Army.

In 1916, as chief airship designer at Vickers, Wallis, together with Pratt and Temple, proposed a streamlined airship based on experience gained on the Parseval. The result, R.80, promised to be Britain's most effective airship to date though hot weather and other circumstances on her first flight in 1920 caused a rapid rise due to superheating and the emergency release of gas, by both Wallis himself and Maurice Dean who were on board as observers. The event caused severe structural damage to R.80's girders and, once repaired, it was used briefly for training the Americans until being put into storage after the accident to R.38.

Although the project was driven by Burney, Wallis was very much involved in the design and development of the R.100. This included the simplification of the basic structure into a small number of scaleable components including his innovative 'spider' joint. Pugsley and Rowe produced a biography for the RSA in 1981:

> *"All the main girders of R.100 were of triangular form, with three booms joined by Warren bracing. Wallis had from the start decided to use throughout his ship the well-tried duralumin – in the design use of which he had become so accomplished and experienced – and so found himself needing tubular booms for his girders of some 4 inches in diameter. Existing methods of manufacture could not provide such large duralumin [structures] and Wallis had to invent a new method of manufacture. His tubes were constructed of 9 inch wide strips of duralumin twisted as spirals with edges overlapping enough to be riveted spiral-wise throughout the length of the tube. The special machines needed for the formation of the tube, and for its awkward riveting (involving the external closure of rivets to ensure sound joints), were a wonderful illustration of Wallis's skill as a mechanical engineer. J.D. North, the chief designer of Boulton and Paul, who constructed the corresponding girders for the R.101, using steel strip drawn into smaller close-jointed tubes, an ingenious alternative process, and was in this matter a rival, regarded Wallis as 'the best mechanical engineer' of his day"*

Wallis moved on to fixed wing aircraft at Vickers in 1928 but was 'on call' to Howden throughout 1929. Wallis continued inventing things. In May 1943 the 'Dambusters' attacked the Ruhr Dams using the bomb invented by Barnes Wallis. Wallis also designed the 'Tallboy' and 'Grand Slam' bombs and the Wellington bomber. After the war he invented a glassless mirror that did not mist up - and put forward innovative ideas for swing-wing planes. He retired aged 83 and his work for the country was recognised in 1968 when he was knighted. Barnes Wallis was also made an Honorary Fellow of the Royal Aeronautical Society. Barnes Neville Wallis died on October 30th, 1979, aged 92.

Masefield (handwritten) draft text for *To Ride the Storm* (Masefield, 1982):

> *"Wallis – brilliant and attractive as he was in so many ways, had, throughout his life – an unfortunate psychological antipathy towards any other toilers in his own field of work ... In a man of so many talents and attractions it was a sad and unhappy trait."*

Chamberlain to Topping regarding Richmond, 4/6/1983:

> *"May I add finally that when I went to interview Sir Barnes Wallis about 12 years ago, I raised these same topics with him and rather rashly, invited him to give me an opinion*

of his one-time rival. I should have known better, because it was very bitter and quite unquotable!"

Masefield correspondence with Bergel March 1983 following publication of *To Ride the Storm*:

"Barnes Wallis had a phobia about anyone who was in competition with him. This applied to everything that was done at Cardington, and later, regrettably, to his antipathy to R.J. Mitchell at Supermarines and to George Edwards at Vickers – a sad trait in an otherwise admirable character. But he could never see anything good about those who he thought were rivals and I had many long discussions with him on the subject but never shook him in the slightest."

Pugsley and Rowe summed up his character thus (*Biographical Memoirs of Fellows of the Royal Society*, vol.27 (1981), pp.603-627, Sir Alfred Pugsley and N.E.Brown, 'Barnes Neville Wallis…', p.625)

"Professionally he was a hard master, demanding above all quality of thought and execution from those who worked for him. Clearly he was convinced of his conceptual, innovative and inventive powers as an engineer; thus he might appear to be arrogant when rejecting engineering suggestions or criticizing the work of his designers. He was most certainly intolerant of any who failed to agree with and appreciate what he, Wallis, knew to be the best engineering answer and he would brook no interference with his engineering responsibilities, but he was not personally arrogant. In fact it may be truly said he had the failings of genius; he had so often been proved to be right by the results obtained from great innovations in his basic thinking and in his engineering applications. He had immense mental energy and intellectual driving force, coupled with a mastery of his subject, displayed in his written reports and the clarity of verbal expression in lecture, professional discussion, or criticism of his staff's design ideas. But he did not suffer fools gladly. Nor did he make close friendships with associates."

Lord Kings Norton recalled his dealings with Wallis in a memoir *A Wrack Behind* (1999):

"I first heard of B.N.Wallis, as he was usually known at the time, when I joined the Royal Airship Works at Cardington in 1924 to take part in the design of R.101. Wallis, who had participated in the design of several Vickers built airships, and had been wholly responsible for the design of the successful but under-employed R.80, was in charge of the design of R.100 at Howden in Yorkshire. Almost immediately I became aware of the enmity existing, if not between the two design teams, then between their leaders; Richmond, who led the Cardington team, was openly scornful of Wallis and Wallis, I subsequently learned, was equally scornful of Richmond and, I think, the rest of us. [The entire RAW design team] Not unreasonably therefore, a picture grew in my mind of an arrogant dominating Wallis with a poor opinion of the abilities of most other engineers.

Nothing could have been further from the truth. I got to know Wallis later, after the British airship programme was ended, and I discovered a quiet, courteous and extremely clever and imaginative engineer with whom it was a pleasure to talk and

even disagree. He was, of course, firm in his opinions and was not always a comfortable colleague. Still a Vickers employee after leaving Howden, he was translated to the Vickers subsidiary Supermarine at Cowes and found that he could not work with that other great man, R.J.Mitchell, designer of the Schneider racing seaplanes and the Spitfire. He was therefore moved to Weybridge to work with Rex Pierson, and with Pierson, he found he was wholly in sympathy. He told me he called Pierson 'Uncle Rex'."

If nothing else, this highlights the plight of the researcher quoting the opinion of others. Selective editing of this, a first-hand opinion from a highly respected contemporary, could create completely opposite impressions. I have tried to avoid this in my research. Other authors, particularly quoting more distant sources, often fall into this trap.

A2.5.2 Sir Dennistoun Burney

Sir Charles Dennistoun Burney, aeronautical engineer, private inventor and Conservative Party politician. Born 1888, the son of Admiral of the Fleet Sir Cecil Burney Bt., he was given a naval education, starting at HMS Britannia in 1903 and joining the battleship Exmouth as a midshipman in early 1905. In 1911, he came up with a novel seaplane design using a hydrofoil undercarriage. Further development was carried out by the Bristol and Colonial Aeroplane Company, but was not successful. On the outbreak of World War I, Burney was given command of the destroyer HMS Velox, but shortly afterwards joined the research establishment at HMS Vernon. Here he developed the paravane, an anti-mine device, for which he took out a number of patents in 1916. These were to earn him around £350,000 during the course of the war through their use by foreign merchant fleets. In 1920 Burney retired from the navy with the rank of lieutenant-commander, and was promoted on the retired list to commander. He then became a consultant with Vickers and came up with a plan for civil airship development, which evolved into the Imperial Airship Scheme and was to result in the R100 and R101 airships: Burney became managing director of the specially formed subsidiary of Vickers that built the R100 airship. In 1929, he published a book called *The World, the Air and the Future*.

Burney was Member of Parliament for Uxbridge from 1922 until he retired in 1929. In 1939, he was again joined by Nevil Shute in the development of various special weapons.

A2.5.3 Neville Shute Norway

Chief Calculator, and later Chief Engineer, for R.100; author of *Slide Rule* 1954

Born in west London, in 1899, he was educated at the Dragon School, Shrewsbury School and Balliol College, Oxford, from which he graduated in 1922 with a 3rd class degree in engineering science. Shute's father, Arthur Hamilton Norway, became head of the Post Office in Ireland before the First World War, and was based at the main post office in Dublin in 1916 at the time of the Easter Rising.

An aeronautical engineer as well as a pilot, he began his engineering career with de Havilland Aircraft Company but, dissatisfied with the lack of opportunities for advancement, he took a position in 1924 with Vickers Ltd., where he worked as Chief Calculator (stress engineer) on the R100 airship project for the Vickers subsidiary Airship Guarantee Company. In 1929 he was promoted to Deputy Chief Engineer of the R100 project under Barnes Wallis and when Wallis left the project he became the Chief Engineer.

In 1931, with the cancellation of the R100 project, Shute joined the de Havilland trained designer A. Hessell Tiltman (AGC designer post Wallis) to found the aircraft construction company Airspeed Ltd. Despite setbacks and tribulations, Airspeed Limited eventually gained significant recognition when its Envoy aircraft was chosen for the King's Flight. With the approach of war a military version of the Envoy was developed, to be called the Airspeed Oxford. The Oxford became the standard advanced multi-engined trainer for the RAF and British Commonwealth, with over 8,500 being built. For the innovation of developing a hydraulic retractable undercarriage for the Airspeed Courier, and his work on R100, Shute was made a Fellow of the Royal Aeronautical Society.

By the outbreak of World War II, Shute was already a rising novelist. Even as war seemed imminent he was working on military projects with his former Vickers boss Sir Dennistoun Burney. He joined the Royal Naval Volunteer Reserve as a sub-lieutenant and quickly ended up in what would become the Directorate of Miscellaneous Weapons Development. There he was a head of engineering, working on secret weapons, a job that appealed to the engineer in him. His celebrity as a writer caused the Ministry of Information to send him to the Normandy Landings on 6 June 1944 and later to Burma as a correspondent. He finished the war with the rank of lieutenant commander RNVR.

Moved to Australia in 1950 and died in 1960.

Masefield to fellow historian Walding 21/3/1991 regarding Masefield's visit to Norway in Australia, in 1953 (Masefield Archive, Brooklands):

> *"As I set down in To Ride the Storm, chapters three to seven of Slide Rule have, regrettably, become a source of many erroneous impressions and statements about the 1924/30 airship era in Britain. I fear that is true but I enjoyed my later contacts with [Nevil Shute] Norway and, of course, he was a master of delightful fiction – some of which crept into Slide Rule."*

Sir Peter Masefield (handwritten) draft text for *To Ride the Storm* (Masefield, 1982) [Some illegible words are marked xxxx]:

> *"Neville Shute Norway – as I knew him – was a sensitive, cultured, introspective, man – much influenced by his early life in England and Ireland before the First World War – (in which in June 1915 he lost his elder – and only – brother, Fred to whom he had always admired greatly), by his persistent stammer (which caused him to be somewhat withdrawn), by his devotion to aviation – and had difficulties in later life in handling employees who had to report to him or maintaining good relations with his colleagues.*

These facts led him to be somewhat of a 'loner' during the years when he had to work in an industrial atmosphere starting as a drawing office assistant at the de Havilland Aircraft Company in the 1920s, then at the Vickers Group at the Airship Guarantee Company, in remote Howden in Yorkshire – and then at Airspeed Ltd at York and Portsmouth between 1931 and 1938.

From all of this he retreated gratefully into detached – sxxxxxx – authorship of which he made a brilliant individual success responsible for 22 books in 34 years.

During his time at Howden he had been much influenced – not for the better – by Barnes Wallis. He inherited from him a 'chip on his shoulder' about the rival airship R.101 and the more [skilled expert] team –[caused] by the fact that when R.100 was complete he applied for a job on the projected R.102 and R.103 at Cardington he was turned down by Richmond. The part of the autobiography bxxxx Slide Rule about his five airship years is marred by xxxx.

I had met him, first, at Portsmouth at Airspeed in 1937 at a time when the under-capitalised company was struggling to survive. It was a time when he was – in his individualistic way –not getting on well with a number of his colleagues in the management. He departed to become a full-time author in 1938.

I next saw him in Whitehall during the War when I was secretary of Lord Beaverbrook's War Cabinet Committee on future xxxx transport aircraft at the Pxxx xxxx sxxxxx xxxx help on a project analysis of a possible future R.104 for Atlantic air services. Our survey of its possibilities showed that it could in no way compete with the post-war generation of multi-engine aircraft.

I met him again in Australia when I led a BEA team, flying the Vickers Viscount prototype in the London to Christchurch Air Race in October 1953 – and returned through Australia and spent a little while with Norway at his home in Melbourne.

There we had enjoyable discussions about the world aviation scene, our own flight from Heathrow to Christchurch NZ in a Vickers Viscount in just five stops, his own England - Australia flights in his Percival Proctor with his family – and his various writings. 'No Highway' was written in 1948 with my old friend Percy Walker of Farnborough as a somewhat over sketched central figure ["his theory"] being part of the plot of the story on his discxxxxx about the ensuing recognition of problems of metal fatigue – which, in part, became the cause of subsequent disasters to the early jet-powered D.H. Comet aircraft.

Neville Shute Norway was exxxxx a nice man, (a gentle man) who it xxx a plan to have xxx, whose introspective nature, exaggerated by his stammer, made him shy of spoken communication except with those who he knew well and liked, and undoubtedly – caused him to turn increasingly to the written word in which he was inventive, adept and articulate. Ambitious, he was frustrated by his inability to consummate early his ideas and he could be wholly articulate xxs by writing down his concept.

Cave-Browne-Cave to RAeS Historical Group, August 1962 (Cave-Browne-Cave Archive IWM):

"The public understanding of the important period of R.100 and R.101, I think, has been distorted by the widely read, but in my opinion unreliable, account written by a novelist who had been working at Howden as Chief Calculator under Mr. B.N. Wallis. He went with Commander Burney to represent the firm in R.100 during her trials and her Atlantic crossings, but that was the extent of his airship experience. Much of the information he picked up about R.101 and the Cardington staff he may have misunderstood but his treatment of it is in many cases unjust. He was eminent as the author of most attractive fiction. He included his airship story in his autobiography as interesting material for that purpose – not as authentic history."

Masefield to fellow historian Walding, 21/3/1991 regarding Masefield's visit to Norway in Australia 1953 (Masefield Archive, Brooklands):

"As he [Nevil Shute Norway] confessed to me at the time, his comments on R.101 and its team in Slide Rule were somewhat biased because, after the closure of the Vickers Airship Works at Howden, he applied for a job at Cardington and felt very put out that he was not taken on by Vincent Richmond, the Chief Designer of R.101. He wrote the comments about the team of the Royal Airship Works on the rebound from that rebuff and told me that he felt he had been unfair to some worthy characters – I must say that I agreed that he did not present a picture in a proper balance. He was at this time also influenced by Barnes Wallis who – because of the rivalry between the Howden and Cardington teams and because of his own personality – "saw no good in any competitor"."

Doug Robinson, R.100 historian and author to Masefield 11/8/1985 (Masefield Archive, Brooklands):

"It is clear that [Nevil] Shute wrote from memory and had no documents or contemporary references at hand.

I remember long ago thinking he was all wrong when he wrote that the same people who had designed the R.38 also designed the R.101. Both were RAW products, but I am sure that Campbell designed the R.38 all by himself, and certainly Richmond, Colmore and Cave-Brown-Cave had no connection with the R.38 design. Later on Shute's attitude towards the Cardington team bordered on paranoia."

Masefield correspondence with Hugh Bergel March 1983 (Masefield Archive, Brooklands): Bergel was an accomplished wartime pilot that turned to authorship in later life.

"I am afraid that Norway and Barnes Wallis did, really quite deliberately, distort the perspective on the relative work done at Cardington and Howden on R.101 and R.100 for a number of interesting psychological reasons. Norway was especially embittered by the fact that Vincent Richmond refused to give him a job at Cardington after the R.100 was finished on the grounds that he had limited funds for employment and that those already on the Cardington books were better qualified than Norway to do the job."

Pugsley to RAeS Journal 5/1988:

> *"Nevil Shute Norway complained 'bitterly that £40,000 was spent on constructing a section of the vessel, only to scrap the section as unusable' I think this must refer to what was called at Cardington 'the test section'. This was purely experimental. It was a bay of the proposed hull structure between two frames, and was used for a number of purposes – a trial assembly of the proposed frames and longitudinal girders and of the gasbag wiring; then of the behaviour of the wiring when filled with an inflated gasbag, and for structural tests on the section."*

On 25 May 1933 Norway wrote to Booth apologetically regarding criticisms 'strictures on the crew' he made in an article in Blackwood Magazine, May 1933. He admitted the article 'served to turn an honest penny'. Letter in Meager papers.
He continued:

> *"Looking back on that time, as a complete outsider I feel pretty certain that the course of things would have been different if Fellowes had not handed over to Colmore. I do not know how it occurs to you on looking back on that time now, but I should personally date the deterioration of the whole show from that time. I came to this conclusion when writing the article, and when trying to sort out what could be put in print and what could not. I shall be very interested to hear your views as personally I am very strong of the opinion now that the whole of the failure of our airship programme in this country was essentially that people of the wrong character were put in charge of it, which means that I think that the real cause of the failure of the programme was not in the technical matters but in the characters of the people behind the concern."*

A.2.5.4 Sir Peter Gordon Masefield

(Author of 'To Ride the Storm', 1982)

Peter Gordon Masefield, civil servant, administrator and aviation historian: born Trentham, Staffordshire 19 March 1914; design staff, Fairey Aviation Co 1935-37; staff, The Aeroplane 1937-43, Technical Editor 1939-43; Air Correspondent, The Sunday Times 1940-43; Editor, The Aeroplane Spotter 1941-43; Personal Adviser to the Lord Privy Seal (Lord Beaverbrook) and Secretary of War Cabinet Committee on Post-War Civil Air Transport 1943-45; British Civil Air Attaché, Washington 1945-46; Director-General of Long Term Planning and Projects, Ministry of Civil Aviation 1946-48; chief executive, British European Airways 1949-55; managing director, Bristol Aircraft 1956-60; managing director, Beagle Aircraft 1960-67, chairman 1968-70; Chairman, British Airports Authority 1965-71; Kt 1972; Chairman and Chief Executive, London Transport 1980-82; President, Brooklands Museum Trust 1993-2006, Chairman 1987-93; married 1936 Patricia Rooney (three sons, one daughter); died Laughton, East Sussex 14 February 2006.

Peter Masefield was the son of a distinguished surgeon, and a second cousin of the poet John, who had a great influence on Peter as a boy. He was sent to Westminster School, which he

forever venerated (later becoming chair of the trustees of Dr Busby's Estate), and then for further schooling in Switzerland - Chillon College, Montreux - where he became proficient in French and German. Then to Jesus College, Cambridge, where he rowed for the college, learnt to fly at Marshalls and took a good degree in Engineering.

From a very young age he had been fascinated by aircraft and took his first job, in 1935, in the design department of Fairey Aviation. But soon he wanted a wider field and a wider audience. He found this in aviation journalism, working for *The Aeroplane*, and later, in 1940, becoming aviation correspondent for *The Sunday Times* and a wartime aviation writer. Although already having a private pilot's licence, he was denied entry into the RAF and Transport Command because of poor eyesight (he always had to wear glasses). But somehow he managed to get the United States Army Air Force to accept him on bombing missions as an occasional co-pilot and air gunner, with near fatal results. He was lucky to escape with his life after his B-17 was shot up over Le Bourget and just managed to limp home to East Anglia.

He was pulled out of active service by Lord Beaverbook, then Privy Seal, who was attracted to his critical articles in The Sunday Times. In 1943 Beaverbrook made him, at the age of 29, Secretary of the Cabinet Committee considering post-war British civil aviation. With the future, after Alamein and Stalingrad, reasonably assured, it was still a momentous decision. Masefield then took part in the inter- governmental negotiations in Chicago in 1944, leading to the set-up of the International Civil Aviation Organisation (ICAO).

At the end of the Second World War Masefield was appointed the first Civil Air Attaché to the embassy in Washington. He played a significant part in the 1946 negotiations for the first post-war inter-governmental agreement on air service - the Bermuda Agreement, governing air services between the United States and the UK and its colonies and dependencies.

Returning to London from Washington, Masefield was appointed to the newly created Ministry of Civil Aviation as Director of Long-Term Planning and Projects (a post specifically devised for him at Under-Secretary level aged 32). Masefield was rescued from the Ministry of Civil Aviation by an old friend, Sholto Douglas, by now Lord Douglas of Kirtleside, Marshal of the RAF and chairman of British European Airways. Much to the dismay of many senior executives, Douglas made Masefield chief executive, where he served for five successful and expanding years.

But Masefield was always on the move and went off in 1956 to become managing director of the Bristol Aircraft Co, whose main production at that time was the Britannia. The Britannia did not sell well and Masefield moved on, with the help of Pressed Steel, to the newly formed British Executive and General Aviation (Beagle) for the manufacture of light aircraft.

It was while there that he was invited in 1965 by the then Labour government to become Chairman of the newly created nationalised British Airports Authority. His period of office - until 1971 - saw great expansion and rising profits. His appointment at BAA was not renewed after his five-year term, but he was in great demand: a member of the board of British Caledonian Airways from 1975, and on the board of London Transport from 1973 to

1982. He was a director of Worldwide Estates and the Nationwide Building Society, Chairman of the Board of Trustees of the Imperial War Museum, Chairman of the Royal Aero Club, governor of Ashridge College and a member of the Cambridge University Appointments Board; and he always maintained his interests in the Royal Aeronautical Society and the Chartered Institute of Transport. He was knighted in 1972.

In his later years, Masefield described himself as an aviation historian. He wrote the definitive story of the tragic loss of the R.101 airship, *To Ride the Storm* (1982), and his own autobiography, *Flight Path* (2002), is fascinating. He also wrote good, well-researched obituaries for The Times and The Independent and numerous articles on aviation, transport, management and the First World War (a particular interest).

Draft text (handwritten) prior to the entries on page 196 of *To Ride the Storm*:

"The loss of R.101 had its parallels, before and after, in the disasters to the Shenandoah, the Akron and the Macon in the United States. In the conditions prevailing on the night of the 4/5th October R.100 would probably not have survived (given the condition of its outer cover).

Ill-judged and misleading accusations of political pressures, of incompetence and of an un-airworthy ship, which were subsequently levelled at R.101 and those concerned with it were, to a major extent, promoted partly by a refusal to admit that airships were not bad weather craft and partly with a hostility towards R.101 and the Royal Airship Works on the part of people who had an axe to grind and ought to have known better. Among them, sad to relate, were Barnes Wallis and Neville Shute Norway, both of the Airship Guarantee Company to which Thomson, Colmore and Richmond had, on their side, shown only goodwill. Wallis – brilliant and attractive as he was in so many ways, had, throughout his life – an unfortunate psychological antipathy towards any other toilers in his own field of work –[illegible] his hostility towards Richmond and the Royal Airship Works at Cardington just as he, later, developed a further hostility towards Rex Pierson and George Edwards at Vickers Aviation, towards Reginald Mitchell at Supermarines and towards the staff at the Air Ministry during the war. In a man of so many talents and attractions it was a sad and unhappy trait.

History has been further distorted by Neville Shute Norway's book 'Slide Rule' – so widely quoted but giving a largely fictional and wholly inaccurate account of the work, achievements of the Cardington team.

This regrettable situation arose because, having quarrelled with Wallis at Howden - (Wallis referred to Norway as a man about whom he 'had reservations on his ability, his intelligence and his integrity') - Norway as a member of the R.100 team applied for a job at Cardington and was turned down by Richmond as not being up to his required standard. Even at that date, as 'Neville Shute' Norway was devoting a fair part of his time to the writing of novels – at which he excelled – and he was already far from being a dedicated aeronautical engineer.

Having been rebuffed by Richmond, Norway (as he confessed to me afterwards) decided to 'take it out of him' in 'Slide Rule' – action which he subsequently regretted.

It had, however, the effect of building up a long-[conxxxxedillegible] misunderstanding of the true historical facts and atmosphere of the lighter-than-air service."

Masefield (handwritten) draft text for *To Ride the Storm* (Masefield Archive, Brooklands):

"Close analysis, from an objective aviation viewpoint (with some knowledge of the people concerned) leads to a clear pattern emerging of two airships which were, both, very much experimental prototypes; neither of them meeting in full the design specifications optimistically laid down in 1924. Both were, however, capable of further development and improvement, given sufficient time and money."

A2.5.5 Group Captain Ernest Alfred 'Johnnie' Johnston

Author of *Airship Navigator*,1994

Born 1918. Educated at Bedford School. Johnston lost his father four days before his 12th birthday in 1930, when the R 101 crashed at Beauvais in France. Between terms young Johnston was looked after at Bedford by Jess Scott, the widow of Major Scott, captain and pilot of the R 101. In 1936 he passed into the RAF College, Cranwell, as a flight cadet. Visiting an out-of-bounds pub with a fellow cadet after seeing a film at Nottingham, Johnston got drunk. He was reported and rusticated for a term. The widow of Lt-Col Vincent Richmond, chief designer of the R 101, invited Johnston to stay, and another friend of his father's arranged for him to do a navigation and engineering course at Southampton University.

After returning to Cranwell he completed his cadetship, was commissioned as a pilot officer and in August 1939 joined a Saro London flying boat squadron based in Scotland and the Shetlands. Intent upon improving his knowledge of his father's speciality, he volunteered to take the RAF's Long Navigation Course. After graduating as a specialist navigator Johnston was posted as a navigation instructor at No 2 School of General Reconnaissance.

In 1944 Johnston returned home and served as flight commander in a Liberator squadron on shipping and anti-submarine patrols. As the war ended, his deep knowledge of navigation placed him in a prime position to help to shape the service's future in his speciality. Following a spell as chief navigation staff officer at Transport Command, Johnston was appointed chief navigation officer of the Central Photographic Establishment, as the photographic-reconnaissance group had become. Johnston also kept up his own flying skills, which in 1953 were stretched - particularly by the Canberra - while he was posted as commander of the Armament and Experimental Unit at Martlesham Heath, Suffolk.

In 1956 Johnston attended Staff College and the next year received command of No 1 Air Navigation School at Topcliffe in the rank of group captain. Here he trained the new category of radio navigator for the Javelin all-weather fighter force. Late in 1959 he attended a course at the U S Air Force War College, Maxwell Field, Alabama, in preparation for joining the British Joint Services Mission at Washington. From his office in the Pentagon he noted: "I soon discovered it was a great grey prison in which I was segregated from the people I was accredited to by a wall of indifference." In 1962 Johnston was relieved to return home to help plan the new civil-military National Air Traffic Control Service.

In 1965 he moved to command Military Air Traffic Operations, Southern Region. In October 1968, on his last day of service, Johnston attended the passing out parade of No 1 Air Navigation School at Stradishall, Suffolk and presented the annual Johnston Memorial Cup, which he had initiated to commemorate his father. Afterwards, the course graduates presented him with a station tie, bowler hat and umbrella, placed him at a desk on a lorry and delivered him into civilian life.

Johnston devoted much of his retirement to the cause of airships past and present. He published *To Organise The Air (The Evolution of Civil Aviation and the role of Sir Frederick Tymms, The Flying Civil Servant); Airship Navigator*, a biography of his father, and *In My Element*, an autobiography. He was a founder and vice-president of the Airship Heritage Trust.

Johnnie Johnston was appointed OBE in 1965. He died in 2002.

Johnston took issue with a number of the points raised by Masefield in *To Ride the Storm* but, given Masefield's commitment to 'correspondence' with all parties, discussed these issues at length before finally agreeing with the sequence of events as described by the Bristol University computer analysis. Johnston had paid close attention to the crash site, the deposition of the bodies and the 'crumpling' of the structure. It is obvious from the evidence on site that the record of the disposition of the bodies was unreliable at best. Given his orphaned upbringing by the Cardington support group, primarily by Scott's and Richmond's widows, it is understandable that he stood back from some of the personal issues that intrigued Masefield but his investigations have certainly enriched our study and the correspondence definitely helped in challenging Masefield's more independent account.

He disputes the watch officer situation that should not have left Steff in command; it is not clear what his sources were for this disquiet but he quotes Atherstone as sharing command on an earlier flight. He re-states our understanding that Steff was not a qualified airship pilot but accepts he was a watch-keeping officer. Elsewhere we have quoted written records of Steff keeping night watches on R.100. Johnston also adds notes that his father was available for watch-keeping duties but 'as required' rather than rostered. The Navigator was also responsible for the radio room so had plenty to keep him occupied.

He later summarizes his thoughts after reading 'Slide Rule' in 11/1954, Masefield Archive:

> *"My father is twice mentioned in complimentary terms. Booth and Meager come out of it well; Scott is directly and strongly criticised for recklessly bad airmanship. Lord Thomson gets a terrible pasting, well deserved. Looking back with the knowledge of aviation that I now have [Commander of Martlesham Heath], I am astonished by the foolhardiness of a flying programme which involved the Canadian and Indian flights at so early a stage of the development trials of the two ships."*

Appendix 3 Project Champions

Masefield in RAeS Aeronautical Journal May 1988:

> *"Among the members of the team who, fortunately, were not lost in the accident to R.101, were a remarkable number of engineers and scientists whose distinguished technical and personal qualities are now a matter of history. To mention only four among many: they have included Sir Alfred Pugsley, FRS, himself; a Technical Officer at Cardington from 1926 to 1931, later Head of Structural and Mechanical Engineering Department at the Royal Aircraft Establishment, Chairman of the Aeronautical Research Council (1952-57) and, among other attainments, currently Emeritus Pro Vice-Chancellor of Bristol University. With him at Cardington was Sir John Baker who, in a remarkable career, was one-time Head of the University of Cambridge Engineering Department and, in 1977, was created Lord Baker of Windrush. Alongside, also, was Dr. Harold Roxbee-Cox, now Lord Kings Norton, who has had a no less distinguished career. He was (with Frank Whittle) a pioneer of jet propulsion, Director of the National Gas Turbine Establishment and, among many other major tasks, is currently Chancellor of Cranfield Institute of Technology. And then there was, also, John D. North, a pioneer of British aviation and, in due course, Chairman and Managing Director of Boulton & Paul Limited. He was an originator of British metal aircraft construction and contributed substantially to R101's advanced structure, as well as to a number of significant British aircraft of his day."*

Appendix 4 Layout of crew accommodation

George Hunt's calm call of 'We're Down Lads' is the crucial evidence that nothing further could be done to prevent the grounding. The lower deck layout was misunderstood until recently. Now it all seems to fit.

Hunt's route and purpose is confused by Masefield's published diagram of the crew deck layout in *To Ride the Storm* p.387 (Masefield, 1982). Research at the National Archives (AIR5/912) has found two survivor sketches that conflict with this layout but make far more sense. Inspection of the many design drawings (PRO) confirm that only the port corridor ran right through the accommodation. The starboard side only had narrow planking linking the galley with the crew rest area.

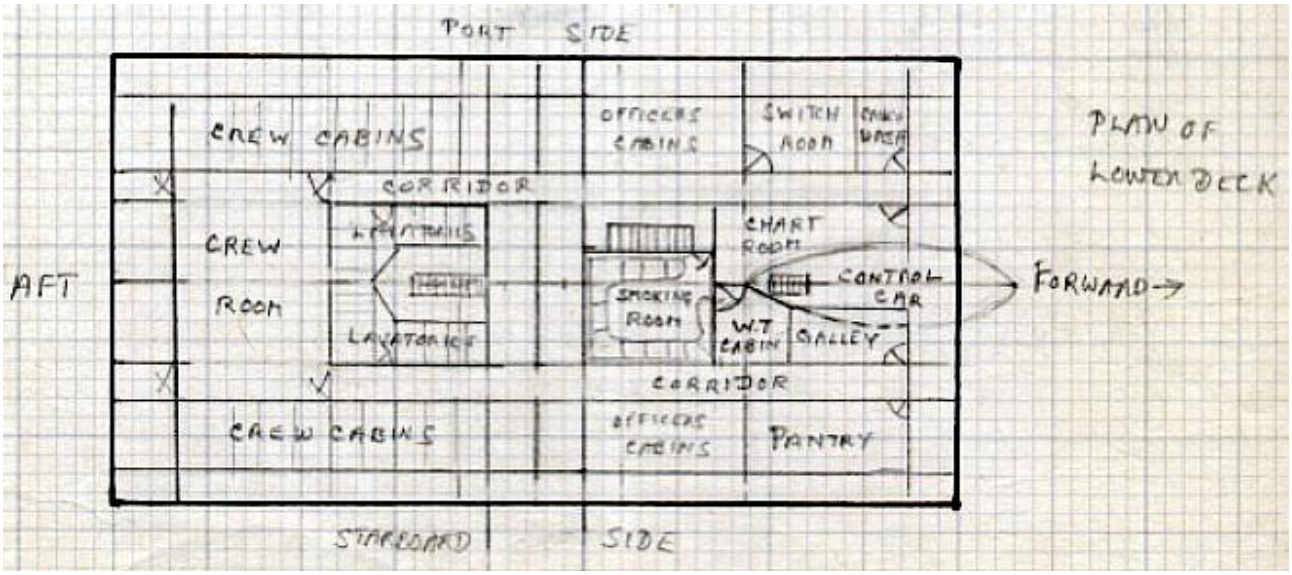

Figure A4.1 Sketch layout of the lower deck (crew) accommodation by Sir Peter Masefield as it appears in *'To Ride the Storm'* (Masefield, 1982). Another sketch layout had been drawn by Davis in the *Illustrated London News* before the first flight (ILN March 12 and October 9 1929).

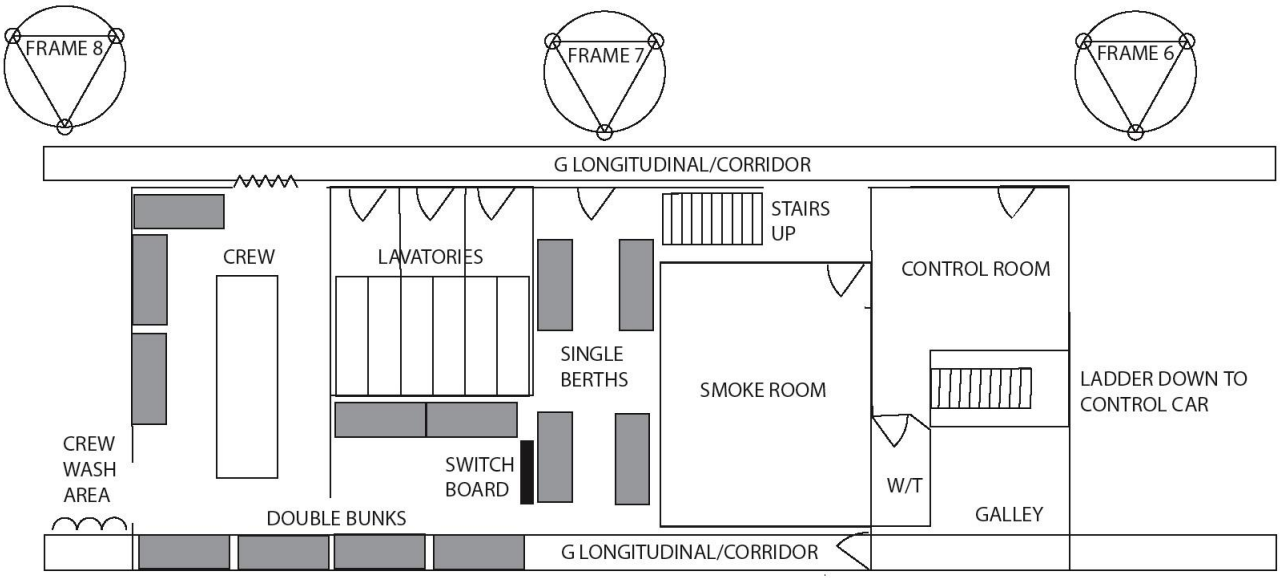

Figure A4.2 Layout of the crew accommodation deck in October 1930 by Peter Davison based on the R.101 drawing set at the National Archives and various photos of the interior.

Commentators have suggested that Hunt was either going to wake the passengers or investigate aft damage to the elevator winding cable. Identifying his route suggests that only the crew were his target as he passed by the stairs on the port side. If the soft landing had been successful the crew would have assisted the passengers or Hunt might merely have been heading for his 'best friend' Coxwain Wally Potter to ensure his safe escape, Potter was one of the survivors of R.38.

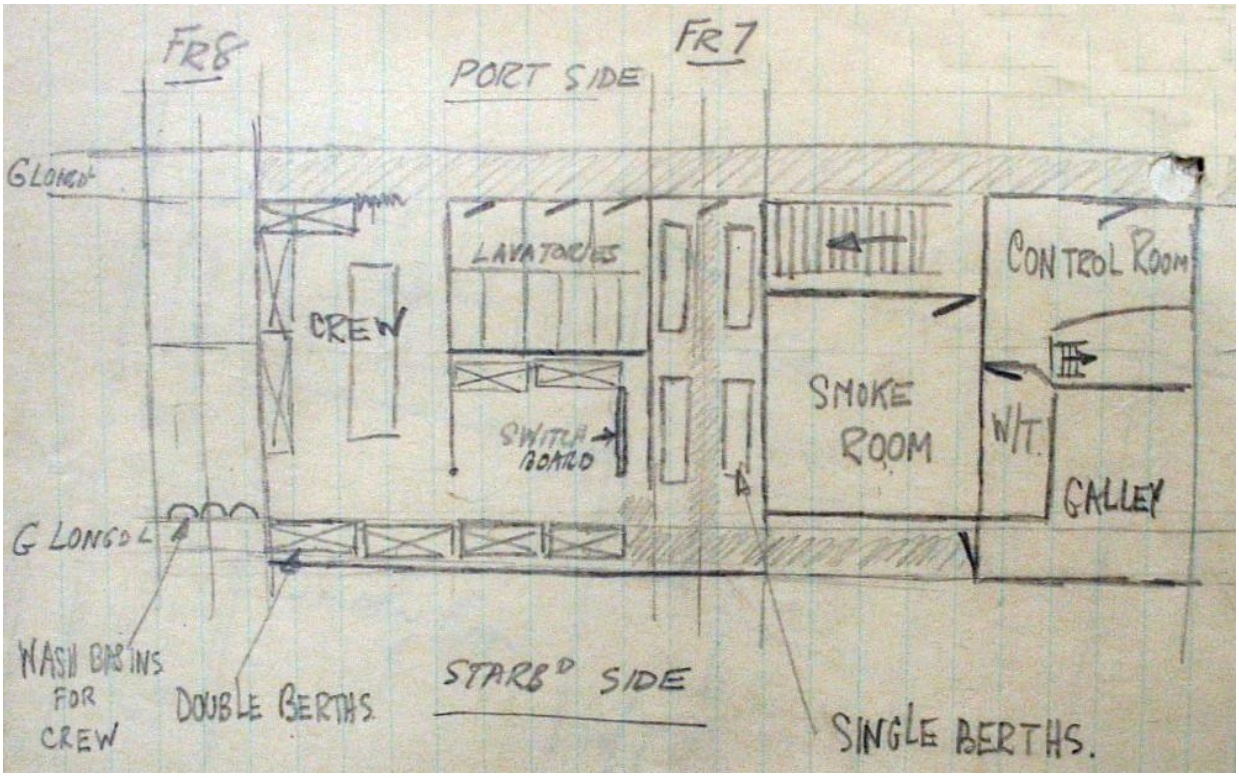

Figure A4.3 Sketch layout of the crew accommodation deck, based on reports by survivors and submitted to the Inquiry (AIR5/912)

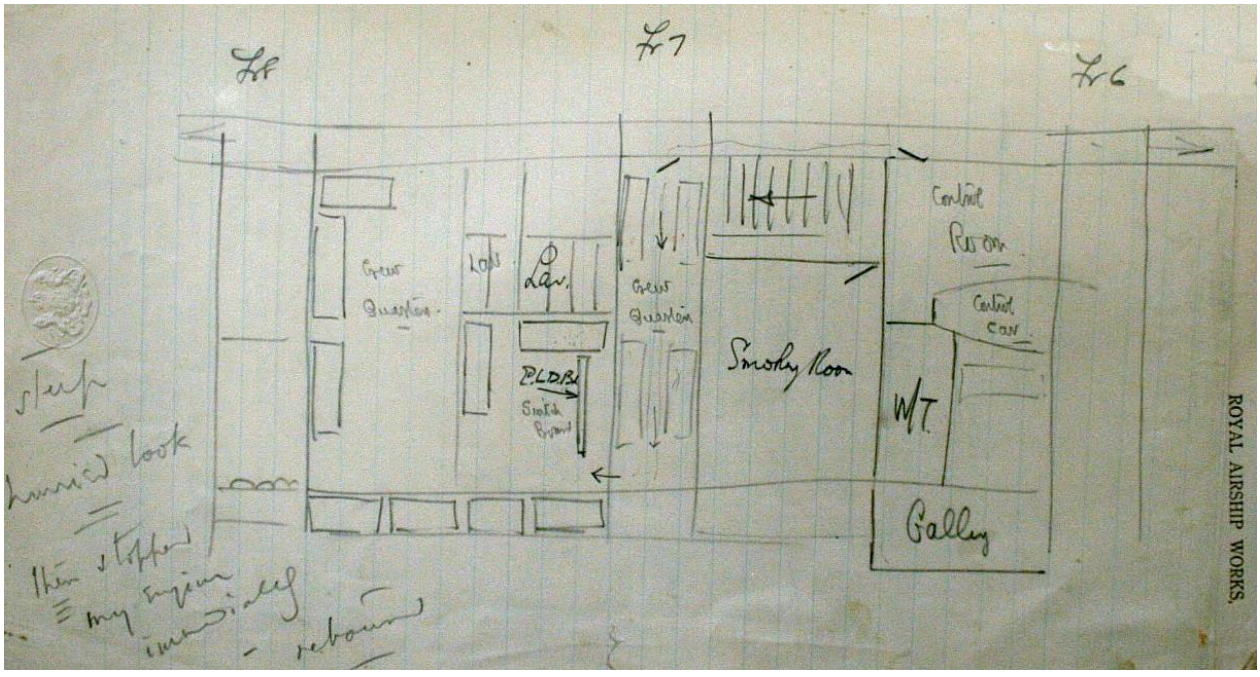

Figure A4.4 Probable route by Hunt through the crew accommodation area, probably by survivor Disley (AIR5/912)