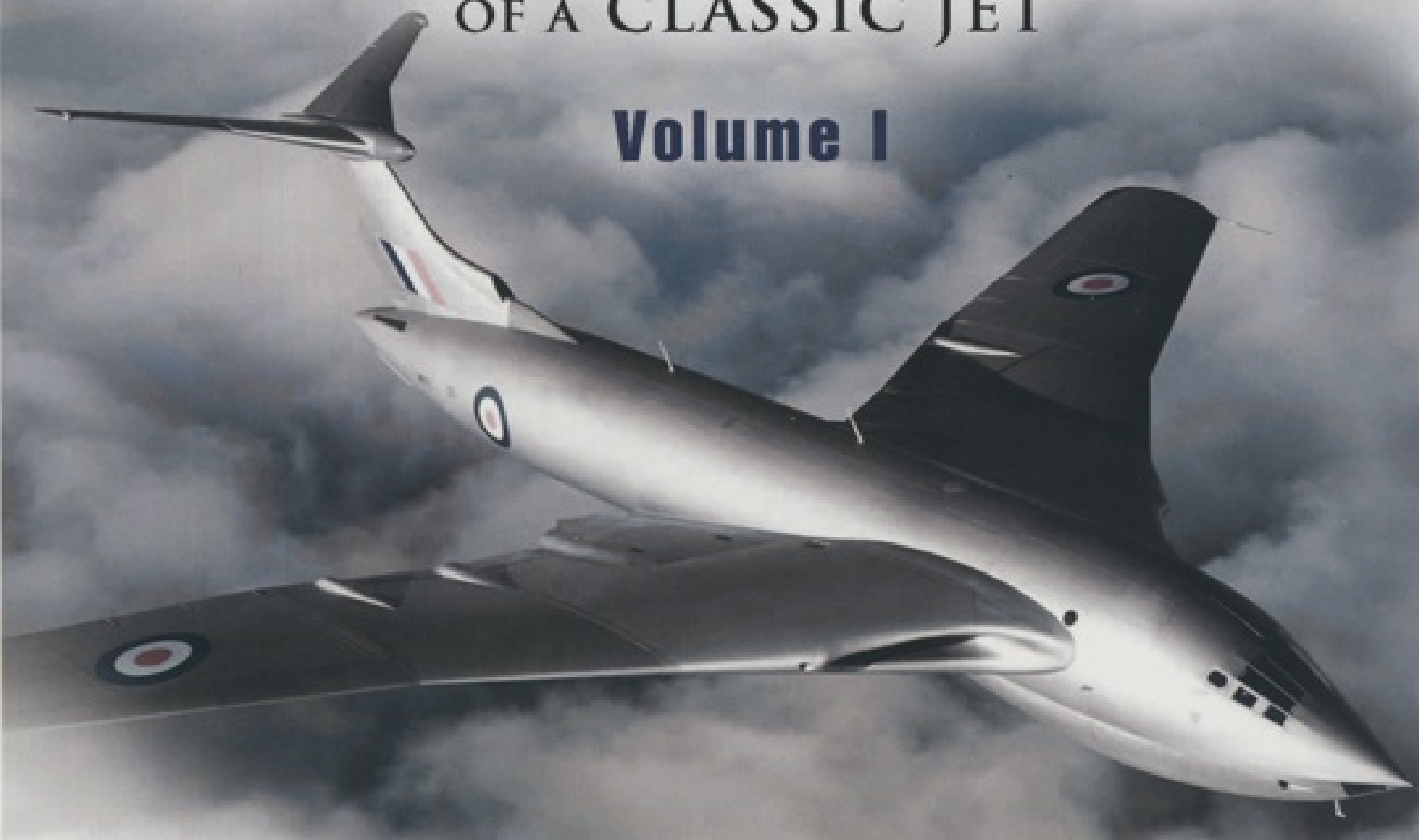
# THE HANDLEY PAGE VICTOR

## THE HISTORY & DEVELOPMENT OF A CLASSIC JET

### Volume I



### The HP80 Prototype & The Mark I

**ROGER R. BROOKS**

ARAeS

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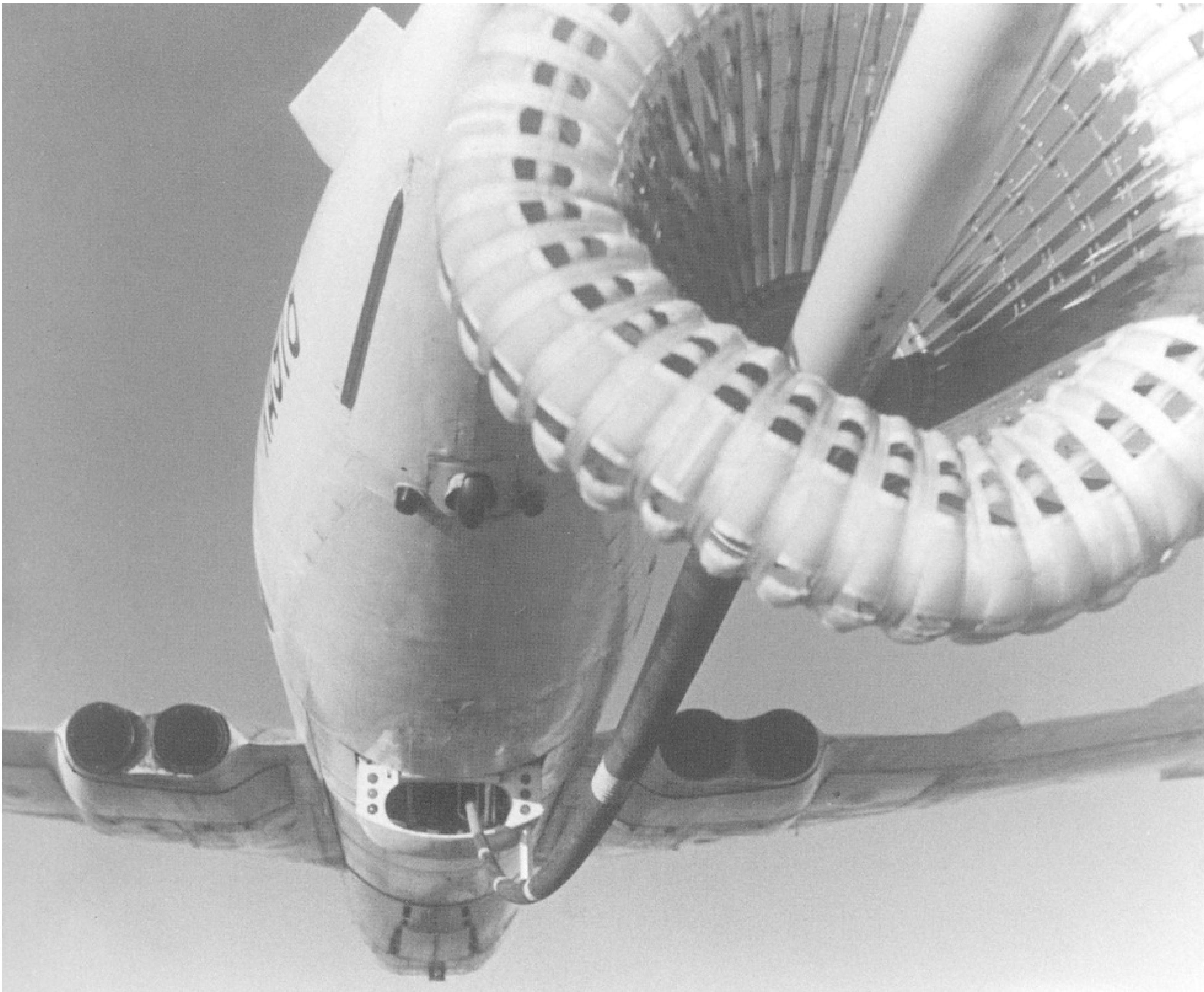
VOLUME ONE



*Victor BK1 XA 918 refuelling on trials duty with the A&AEE during 1964*. Author's collection

# THE HANDLEY PAGE VICTOR

THE HISTORY & DEVELOPMENT OF A CLASSIC JET

VOLUME ONE

THE HP 80 PROTYPE AND THE MARK 1 SERIES

**ROGER R. BROOKS**

**ARAeS**

Pen & Sword

**AVIATION**

**Dedication**

To my wife Heather, also known as 'Heater' for support and encouragement over the many years this book has been in development and compilation.

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# FOREWORD

I am honoured and delighted to have been asked to introduce this book, which is an indepth study an aircraft whose design and development, occupied on and off nearly half my working life fro 1951. I have great affection for it, not least because it brought me into close working contact with s many highly competent people, one of the foremost being the Author. In fact, I did not meet him unt long after the parent company Handley Page, went out of business, since I was an aerodynamicist b trade and (unfortunately) had little contact with the RAF people at the 'sharp end' operating an maintaining the aircraft.

Roger Brooks has some 40 years of experience of working at the 'sharp end' with the Victor an other aircraft, and has distilled some of his vast knowledge into this volume. But not only operatin aspects, as he has collected a comprehensive archive covering the Victor's design and developme story, mainly from those who were there — Godfrey Lee, effectively the 'Father of the Victor Hedley Hazelden, Chief Test Pilot on the first flight, and many others, and lucidly presents it.

That valuable contribution is enhanced by reference to many Technical Manuals, Report Specifications and Brochure, all combining to make this a most valuable contribution to our Aviatio Heritage literature.

The collection of statistical data is probably unique, and is usefully supplemented by a caref selection of illustrations.

The amount of ground covered by the Author is clear from the extensive quoted bibliography, but i fact his researches went further, and his experience as a Crew Chief for the aircraft (still continue with XL231 'Lusty Lindy' operating at Elvington) is very evident in the scope and detail in the da presented.

I feel sure this is a book which will be on most serious aviation historian's bookshelf, and wi quickly get dog-eared with use, but I hope the aircraft enthusiast will also use it — at least he wi know that this is the real, unassailable 'gen' compiled by someone who knows the aircraft inside out.

A.H. Fraser-Mitchell
Sometime Chief Aerodynamicist Handley Page Ltd
Vice President, Handley Page Association

January 2005

# INTRODUCTION AND ACKNOWLEDGMENTS

Over the past 40 years or so, many books have been written on the Handley Page Victor and the Force aircraft in general. This book is not in the same vein as those. It is written as a Data File ar subdivided into sections dealing with specific variations of this unique aircraft. It is intended as reference book and you do not have to read all of it, just the relevant items that appeal to you. Th accuracy of data in this book is backed up by the source material, which I have quoted the main iten in the bibliography. It is by no means the definitive history of this aircraft as a considerable amount very interesting data is not available for a variety of reasons by a few organisations for strang excuses.

I would like to produce a second edition within the next few years containing additional informatio on this book and the Victor in Service with the Royal Air Force from 1957–1993. Contributions for are welcomed from all readers, no matter what they contain, and should be sent to the publisher.

I would like to thank the following for their assistance and guidance over the years in the course developing the Data File.

**The following members of the Handley Page Association:**

Harry Fraser-Mitchell, Peter Cronbach, John Allam, Spud Murphy, Peter P. Baker, Jock Still, Joh Rudeforth, Alan Dowsett, John Harding, John Smith, Chris Scivyer, Brian Bowen, Mike Wilson, Harr Rayner, David Blades and Steve Mills. Finally, to all those members who I have spoken to over th past many years.

**The following past Members of Handley Page Ltd and the Handley Page Association:**

Godfrey Lee, Hedley Hazelden, Ian Bennett, Bob Williams, Gordon Roxborough, Reginald Staffor Charles Joy, R.H. Sandifer, Dr G.V. Lachmann, W.H. MacRostie, C.O. Vernon, F.R.C. Houndsfiel and John Tank. For being allowed access to the articles they wrote for the HP Bulletin nearly 50 yea ago and in particular to Ray Funnell for access to his archives.

**From the Royal Air Force:**

**Aircrew**

Air Vice Marshal John Herrington, Flt Lt Pancho Painting, Flt Lt Eric Anstead, Flt Lt Alan Fisher, Ai Commodore 'Spike' Milligan, Flt Lt Terry Filing, Sdn Ldr Jerry Mudford, Flt Lt Ken Norman, A Commodore David Bywater, Flt Lt Alan Gardener, Sdn Ldr C.R. 'Pop' Miles, Sdn Ldr M Reade, Win Commander Dave Griffiths, Flt Lt David Coleman, Group Captain Tony Ringer, Sdn Ldr Gordo Stringer, Flt Lt R.T. Hayward, Flt Lt John Bussey, Sdn Ldr Tim Mason, Sdn Ldr Al Stephenson, Sd Ldr Bob Tuxford, Sdn Ldr Tony Cunnane, Wing Commander Barry Neal, Flt Lt Al Skelton, Win Commander Bob Prothero, Flt Lt John Ledger. All the Victor captains and crews I flew with on th Mk 1 and Mk 2 Tanker Fleet as their Crew Chief.

**Crew Chiefs**

Bill Swann, David Haylett, John Kent, Sid Harding, Dave Parsons, Robbie Honnor and Brian Martin.

**Ground Crew**

~~Dennis Robinson, Gordon Stringer, Jim Jones, Jim Gosling, Paul Goss, Duncan Curtis, Mick Crook~~ Dave Wynn-Jones, Don Williams (Australia), Robin Cooper, Stan Jones, Pete Claydon, Tony Regan Rick Gill and Doug Gawley. Also, thanks go to all those whose names I have failed to remember.

Finally, my grateful thanks go to the following from many walks of like for their interest in th Victor and assisting in many ways:
Andre Tempest (Owner Victor XL231 'Lusty Lindy'), Martin Garland and BAE Systems Woodfor Heritage Centre, Graeme Rodgers (NZ), Garry O'Keefe, The Victor Association, Ken Ellis, Jarro Cotter and Duncan Cubbitt of *Fly Past*.

**Cover credits:**
*The Front Cover*: First Prototype of the HP 80 WB771 flown by Sdn/Ldr Hazelden On a test flight 1953. *Authors Collection via HPA*
*The Back Cover: Top Picture:* Victor B1 XA918 second production aircraft on development flying: *Authors Collection via HPA*
*Second Picture:* Victor B1 XH592 15 Squadron arriving at RAAF Richmond, Sydney NSW Australia on the 20/6/61 after a high speed run from England and on the last leg from Darwin beating the recor time by 20 minutes. Captained by Wing Commander Tony Ringer seen here descending from the aircraft, the time from England was 19hours. *Photo and data via Graeme Rodgers New Zealand*
*Third Picture:* Front Cabin of Victor B1A(K2P) XH648 *57* Squadron now with the IWM at Duxford. *Heather Brooks*
*Fourth Picture*: Victor K1A XH618 57 Squadron RAF Marham 1972. *Authors Collection*
*Bottom Picture*: HP 80 WB771 Banking to Port with Wheels down, Flap both nose and main down an airbrakes open. *Authors Collection HPA*

# ABBREVIATIONS

| | |
|---|---|
| AAPP | Airborne Auxiliary Power Plant |
| A&AEE | Aircraft and Armament Experimental Establlishment |
| AAR | Airborne Air Refuelling |
| AC | Alternating Current |
| ADF | Automatic Direction Finding |
| AEO | Air Electronics Officer (RAF Aircrew) |
| AMU | Air Mileage Unit |
| ARC 52 | UHF Radio |
| ARI | Airborne Radio Installation |
| AVCAT | Aviation Jet Fuel (used by Royal Navy on Carriers) |
| AVTUR | Aviation Jet Fuel (Jet A1) |
| AVTAG | Aviation Jet Fuel JP4 Wide Cut Gasoline type fuel |
| AwC or AWC | Awaiting Collection |
| C of G | Centre of Gravity |
| CAT 3/Cat 3 | Category 3 (Aircraft Repair Status) |
| CAU | Cold Air Unity |
| C(A) | Controller of Aircraft (Military CAA) |
| CL | Buffet Boundary Measurment |
| CRE | Central Reconnaissance Establishment |
| c/s | Call Sign |
| C/T | Continuation Training |
| CWP DC | Contractors Working Party (HP or HAS) |
| DC | Direct Current |
| DF | Direction Funding |
| DOR | Director of Operational Requirements |
| DTD | Directorate of Technical Development |
| DV | Direct Vision (small opening windows in the cabin) |
| EAS | Estimated Air Speed |
| ECM | Electronic Counter Measures |
| FEAF | Far East Air Force (RAF) |
| FI | Fatigue Index |
| FSII | Fuel System Icing Inhibitor |

| | |
|---|---|
| G4B | Aircraft Compass System Mk 1 Victor |
| GP | General Purpose |
| GPU | Ground Power Unit |
| HDU | Hose Drum Unit |
| HF | High Frequency |
| HLBSP | High Level Blue Steel Profile |
| HP | High Pressure/Handley Page |
| HZ | Hertz (frequency of electrical power) |
| IAS | Indicated Air Speed |
| IFF | Identification Friend or Foe |
| ILS | Instrument Landing System |
| IMN | Indicated Mach Number |
| IRT | Instrument Rating Test |
| JARIC | Joint Airborne Reconnaissance Intelligence Centre |
| JIB | Joint Intelligence Branch |
| JPT | Jet Pipe Temperature |
| JMC | Joint Maritime Control |
| KVA | Kilo/Volt/Amps |
| KW | Kilowatt |
| Ldg | Landing |
| LL | Low Level |
| LLBSP | Low Level Blue Steel Profile |
| LV | Low Voltage (24/28VDC) |
| M.A.P. | Ministry of Aircraft Production |
| Mcrit | Critical Mach Number |
| MF | Medium Frequency |
| MFS | Military Flight System (used in Mk 2 Victor/Vulcan) |
| Min Tech | Ministry of Technology |
| MOA | Ministry of Aviation |
| MRR | Maritime Radar Reconnaissance (H2S+ R88 Camera) |
| M.U. | Maintenance Unit (RAF) |
| MV | Medium Voltage |
| NBC | Navigation Bombing Computer |
| NBS | Navigation Bombing System (H2S+NBC) |
| N/F | Not Flown |
| NGTE | National Gas Turbine Establishment |
| NM | Nautical Miles |

| | |
|---|---|
| OCU | Operational Conversion Unit |
| ODM | Operating Data Manual |
| PE | Pressure Error |
| PFCU | Powered Flying Control Unit |
| PR | Photographic Reconnaissance |
| PSI | Pounds Per Square Inch (pressure) |
| PTR 175 | UHF/VHF Radio |
| QFI | Qualified Flying Instructor |
| R.A.E. | Royal Aircraft Establishment |
| RAT | Ram Air Turbine |
| RATO | Rocket Assisted Take Off |
| RBS | Radar Bombing System |
| RCM | Radio Counter Measures |
| RE | Royal Engineers |
| RPM | Revolutions Per Minute |
| RRF | Radar Reconnaissance Flight |
| Rtn | Return/Returned |
| RWR | Radar Warning Receiver |
| SARAH | Search and Rescue Aircraft Homer |
| SARBE | Search and Rescue Beacon |
| SBAC | Society of British Aircraft Constructors |
| SOC | Struck off Charge |
| SOO | Special Order Only (modifications) |
| SSR | Secondary Surveillance Radar |
| TEZ | Total Exclusion Zone (South Atlantic) |
| Tkr | Tanker |
| T/O | Take Off |
| TRU | Transformer Rectifier Unit |
| Trg | Training |
| TTF | Tanker Training Flight |
| TX/RX | Transmitter/Receiver (Radio/Radar) |
| U/C | Undercarriage |
| UDF | Ultra High Frequency Direction Finding |
| UHF | Ultra High Frequency |
| U/S | Unserviceable |
| VHF | Very High Frequency |
| VISRBS | Visual Radar Bombing System |

| | |
|---|---|
| VMMU | Victor Major Maintenance Unit |
| ZULU | Greenwich Mean Time |

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A&AEE Boscombe Down/HP Test Pilot Reports, various
Royal Aeronautical Society Transcripts of Lecture (Victor)
*The following Air Publications were used for checking data accuracy only:*
AP 101B-1100 Victor All Marks
AP 101B-1101 Victor B Mk 1
AP 101B-1103 Victor B Mk 1A

Bomber Command/Strike Command Victor Servicing School Notes (all Marks) Release to Service Data
My extensive collection of a wide variety of books, magazines and other records and data sources collected over thirty-five years.
Interviews and discussions with Handley Page Flight Test and Ground Test Staff, Aerodynamicists, Production Engineers and many production staff. A&AEE Test Pilots and Flight Test Engineers.

# PART ONE

# The HP 80

## From its Concept to Flight

### The Requirements that lead to the HP 80 and later the Victor

*This article is based on the paper by G H Lee ARCS, BSc, DIC, FRAes*
*Deputy Chief Designer of Handley Page in 1954 and presented to the*
*Royal Aeronautical Society Handley Page Memorial Lecture on 26 May 1976.*

*'Unassailable Aerodynamical Logic' – an enduring theme for Handley Page Ltd*

As for the most of the British Aircraft History, the jet age started for Handley Page in 1945, when th war had been won and we had the chance to consider properly the implication of jet propulsion, unt then used only in the fighter installations. Two events in that year should be recorded.

1. The setting up by the Ministry of Aircraft Production of the Swept Wings Advisory Committe comprising of representatives of the official Establishments [RAE etc] and the aircra manufacturers.
2. In September–October sent a team, to Germany to find out about the German work on tailless an swept wing aircraft.

In June 1945 Sir Frederick Handley Page was confident that a replacement for the Avro Lincoln woul be needed and as the specification for the twin engine jet bomber had been issued it seemed logical Sir Frederick that the 4 engine aircraft would be next. On the 14th June 1945 he issued a private an confidential memorandum address to R.S. Stafford, Frank Ratcliffe and Godfrey Lee in this h requested an immediate investigation of two classes of bomber one of 100,000lb all up weight wi four turbojets of the size of the AJ65 (Avon) or two of twice that size the other a 60,000lb aircraft wi two AJ65 engines and he suggested that they should have wings incorporating a 40 degree sweep.

*The late Sir Frederick Handley Page.* Author's collection

The real start of the Victor design was in the course of the next few months actually undertaken September–October when a visit to the German aeronautical research establishments at Gottingha and Volkenrode with a MAP fact finding team was undertaken by Godfrey Lee as the representative o Handley Page. It was, as part of this visit that the concept of the swept wing as a means of enabling a aircraft with reasonably thick wings to fly at high subsonic speeds without drag rise first becan understood. From this there stemmed the realisation that by combining a swept wing with a jet engin one could have an efficient high subsonic speed aeroplane capable of carrying a good payload over long range. Work on this concept began at Handley Page in about November 1945

In January 1946 after work on the HP72 heavy transport had been abandoned, the designatior HP72A and HP75A were used as a cover for Godfrey Lee's investigations into the possible je propelled high-speed bomber of 90,000lb all up weight. The HP 75A with a front rider plane wa quickly ruled out in favour of the 72A with 45 degree swept wings and wing tip rudders having a sma swept tail plane and elevators to balance nose down pitching moments caused by either flap lowerin at low speed or compressibility at high speed. With no operational requirement yet promulgated b the Air Staff to guide him, Godfrey Lee put forward an inspired proposal on the 25th February 194 for a design of 2100sq ft, 122ft span, aspect ratio 7, wing loading 43lb/sq.ft to carry a 10,000lb bom at 520 knots true air speed over a still air range of 5,000 statute miles; the wing root thickness /cho ratio was to be 16%, with a 9 ft diameter body accommodating a crew of four in a pressurised no compartment. Avon (AJ65) engines were larger than the ideal size for this aircraft and Godfrey Le suggested scaling them down to 5,600lb. Two days later Reginald Stafford approved this proposal an instructed C.F. Joy the Chief Draughtsman to prepare a brochure for submission to the Princip Director of Technical Development (Stuart Scott-Hall) by the end of March 1946; this brochure was t demonstrate the projects effectiveness as a bomber. At this stage the number HP 80 was allocated an so started the HP80/Victor project way back in March 1946.

*The late Godfrey Lee, ‘Father of the Victor’.* Heather Brooks

The brochure was issued to the Director of Operational Requirements Group Captain Silyn-Rober and with his deputy Group Captain Cooper they visited HP Cricklewood on the 19th July 1946 discuss the third draft which had been issued in June 1946 of the Air Staffs requirements for a lor range bomber mainly derived from the Handley Page proposal, but containing several operation innovations. These included the visual bombing facility as a back up to the possible delay and failure of the radar bomb sight, a Flight Engineer’s station, unless the engine controls could b simplified, Electronic Counter Measures operator in a separate cabin near the tail, reached by a tunn from the main cabin and if possible a jettisonable main pressure cabin. A bomb bay load of 30,000l was to be carried with normal tanks full, but bomb bay tanks were to be allowed to achieve maximu range with a 10,000lb bomb.

Members of the Telecomunication Research Establishment (TRE) visited HP Cricklewood on th 2nd November 1946 to discuss radar equipment, the main feature being the H2S Mk 9 Scanner 6 long and rotating on a vertical axis within a large radome below the flight deck floor, in addition we Gee and Rebecca Mk4 for short-range navigation, IFF and ECM, the latter requiring a tail parabol scanner of 18inch diameter facing aft, the estimated total weight of the radar equipment was 1,500ll and all aerials would be suppressed. The TRE wanted the H2S scanner to be pressurised but this w virtually impossible and the idea was abandoned. It later came to the notice of C.F.Joy that the DO insisted that the crew cabin being as small as possible to reduce the vulnerability, even if it were at th ~~expense of crew comfort and that the whole pressure cabin should be jettisionable because the~~ use ejection seats at 50,000ft and 500mph was considered likely to be fatal. The whole cabin would be l down on large parachutes with the crew strapped in 25g seats falling nose first and relying on the no structure to absorb the shock of impact

Two pilots were required and it was agreed that locating the ECM operator in the tail wa impracticable because of the large size of the proposed nuclear weapon, which might be 6 ft diameter and up to 30 ft long. The Air Staff intentions were made known by Stuart Scott-Hall when l visited HP Cricklewood on the 25th November 1946; they wished to replace the AVRO Lincoln in years time by a four jet bomber capable of delivering a 10,000lb nuclear weapon at 500mph from height of 45,000ft the still air range being 3,500miles; as a later development the range would have be increased to 5,000 miles and the operational ceiling to 50,000ft these data being formal promulgated in the Air Staff Operational Requirement No. 230. Godfrey Lee estimated all up weig to be 90,000lb for 3,500 miles using a swept wing and 121,000lb for a conventional straight wing. further meeting was held with the Principal Director of Technical Development on 14th January 194 After Handley Page had submitted their proposal to meet OR230, the official view was that both th structure weights and drag estimates were optimistic, so that the design cruising speed would not l released. The DOR now wanted the cruising speed to be raised to 575mph which meant that the all u weight also would have to rise to 100,000lb in order to attain the 3,500 miles still air range 120,000lb for 4,000miles. Therefore tenders would be called for to meet the revised specificatio B35/46 which had been finalised on 1/1/47 and approved by the Director of Aircraft Research an Development on the 24/1/47 and issued with OR 230 on 24/3/47. In view of the large wind tunnel te programme involved, the prototype HP80 could not be expected to fly until 1951. Apart from th exploration of the new problems of tip stall, high lift sections, stability and various methods boundary layer control, a firm choice between tailed and tailless types still had to be made. Charl Joy proposed to begin the drawing office programme on the 1/10/47 allowing 21 months until Ju 1949 for the basic layout and 30 months to March 1950 for the completion of the powered flyi control system. All drawings for the first prototype would be completed by June 1951 and the ext drawings for the fully equipped prototype by March 1952. The target date for the first flight of th flying shell was March 1952 and for the fully equipped aircraft September 1952. It was a tremendo programme for the small design team but not impossible, so the HP80 tender was submitted.

On the 28th July 1947 Sir Fredrick Handley Page received a telephone call from Stuart Scott-Ha stating that the HP80 was to be ordered along with the AVRO 698 subject to the confirmation of th high-speed wind tunnel test results to approve the theoretical basis of the design.

## We were started on the ‘Victor’

### The Basic Design Concept

Specification B35/46 called for an aircraft capable of carrying a considerable bomb load (10,000l over a range of 1,500 miles from a base that might be anywhere in the world. The aircraft will l required to attack targets at great distance inside enemy territory. And it must be assumed that it wi be tracked by radar and other methods for a large part of its flight. It must therefore be capable avoiding destruction by making the inevitable attack from ground and air launched weapons difficult

To achieve this the aircraft must have the following:

1. A high cruising speed which should be such that the attacking fighters will have to fly at a spe at which they might become unmanoeuvrable.

2. The design must be such that the aircraft can turn rapidly and without loss of height or much lo ~~of speed when at maximum cruising height. The height being 35,000 to 50,000ft.~~

3. The carrying of adequate warning devices to detect the approach of ground launched weapons ar the proximity of approaching aircraft.

4. The carrying of defensive equipment such as jamming devices for guided missiles.

5. The size of the pressure cabin must be as small as possible.

6. Visual and electronic bomb-aiming positions are required.

7. Maximum performance is the ultimate aim and must not be sacrificed for ease of maintenance.

8. It must be possible to operate from existing Heavy Bomber airfields at the maximum loade weight which must, therefore, not exceed 100,000lb.

9. The aircraft must be suitable for large-scale production. It is stated in the Specification that th economic production of 500 aircraft at a maximum of 10 per month was proposed.

**HP 80/Victor Specification and Design Concept**

The combination of sweep and range seemed to us to lead to the need to have both high sweep ( fairly high sweep) and moderately high aspect ratio. For us combining high sweep and high aspe ratio gave rise to the tip stall problem. Therefore the Crescent wing was evolved. We came to th crescent wing by arguing that the high sweep was essential at the root for structural reasons and provide adequate stowage for engines and undercarriage. It was then argued that if we reduced th sweep over the outer parts of the wing we would reduce at the tip where it mattered, the adver effects from sweep that gave rise to tip stall. In particular it was expected that this would reduce th trouble from the outwardly drifting boundary layer over the rear of the wing, it being assumed that th boundary layer from the highly swept parts of the wing would stream off the wing before reaching th wing tip. We had to accept a weight penalty from the thin outer wing of about 22 degrees sweep ar 6% t/c at the tip but felt that since this part of the wing is the least highly loaded the extra weight w acceptable; stowage problems did not arise in the outer wing. We decided that to go from 53 degree to 22 degrees at one kink was too sudden so we put in an intermediate section at about 35 degrees.

*The final sweep on production aircraft after further wind tunnel testing at 1/4 chord was to end u as 47.5 degrees at station 60–212 the inner wing, 40.5 degrees at station 312–330 the intermedia wing and 32 degrees at station 330–660 the outer wing.*

We first intended that the HP 80 should be to all intents and purposes, tailless, since we thought w had enough sweep to do this. We had wing-tip fins and rudders and pitch control was obtained fro symmetrical deflections of the elevon (we knew that tip stall was better with elevons up). To he balance the nose down pitching moment from the big Fowler flaps we introduced a small all movi swept tail plane mounted above the fuselage on a very short fin; this was to be moved so that th trailing edge up when the flaps were lowered.

However there were worries about the bad effect of tip fins on tip stall and some fears, not clear defined that these tip fins might lead to asymmetrical conditions with objectionable yawing momen under some unspecified conditions, possibly at high Mach number

Because of this feeling it was decided to delete the tip fins and go for a conventional fin and rudde Having got this far we also went for a ‘conventional’ tail plane and elevator. We put this on top of th fin primarily to get it out of the way of the jet efflux and also because we wanted to avoid the fairi and structural problems of a tail part way up the fin. We new at this time that this arrangement w bad from the tip stall point of view but we decided that we could fix this with nose flaps or somethi similar.

Having got a thick wing root with a maximum depth of approximately 6 ft we decided to put th engines inside the wing immediately outboard of the fuselage to save nacelle drag and to avoid ar

serious yawing moment from a cut engine, thus easing the design requirements for the fin and rudde
The ~~undercarriage retracted into the wings thanks to a 4 wheeled 8 tyred bogie outboard~~ of th
engines.

Because of the way in which the engines and the undercarriage were installed the centre wing ma structure was limited to a torque box ending at about 30% chord. At the fuselage side this torque bo had a large kink and passed across the fuselage in a span-wise direction.

There was an important aerodynamic advantage to this centre wing box structure. Because of th high sweep, the centre wing spar structure was well forward of the C of G of the aeroplane when crossed the fuselage. This meant that all the moveable military load (bombs or reconnaissance crate was aft of the rear spar and thus we could mount the wing centrally on the fuselage with conseque drag and Mcrit (Critical Mach Number) advantages; further the whole fuselage cross section w available for useful load fuel at the top and military stores below thus minimising the cross section area diameter to 10ft.

**Wing Design – High Speed**

The aim was a constant critical Mach number across the span. After an arbitrary choice of taper rat initially about 2.5 to 1 but later increased to about 4 to 1 and sweep we had at our disposal th following items by means of which we could effect the super velocities so as to get the desired critic Mach number.

1. Fairing Shape and Thickness,
2. Camber.
3. Twist

When we got our first wing designed a model was tested in the old RAE high-speed wind tunne (Which was no longer in use over 30 years ago) The results showed the drag rise coming in too ear round about Mach 0.8 I understand. There was at that time evidence that the trouble was on the out parts of the wing. It was a mixture of pressure plot data and indications of shock wave positions so w reduced the thickness of the outer wing by 2% chord throughout making the necessary changes to th shape of the intermediate wing, which remained unaltered at its inboard end. This fixed it and we we from there. At the wing root we got a favourable interference from the mid wing arrangement. On can I suppose, argue that if one looks at the wing fuselage intersection in plan there is an obviou wasting of the intersection line, remember it is a 6ft thick wing passing centrally through a 10 diameter fuselage and thus there is automatically a good root fairing. We actually thought of it rathe differently though the result is the same. What we said was that if you plotted, along the length of th fuselage, the cross-sectional area of the fuselage outside the wing you then had the distribution of th added area.

**Low Speed**

As design proceeded there was continual pressure for more wing depth at the root for stowage engines, undercarriage etc. This led, by insidious steps to the gradual increase in the root cord until th taper ratio had increased to about 4:1 and the inner kink on the trailing edge had been eliminated: th aspect ratio was now down to about 6. When we at last got a model of this into the low speed win tunnel the pitch-up at stall was terrible. We tried all sorts of leading edge devices with out muc success.

Drastic measures were called for so we decided to increase the chord of the outer wing by a 20 forward extension: this new leading edge ran inboard to intersect the leading edge of the intermedia wing much further inboard than it formally had; the outer kink was now about half-way from th fuselage side to tip instead of ⅔ as originally. This combined with a droop nose flap on the new larg ~~outer wing gave an acceptable answer then anyway. The nose flaps were, I think, hinged at~~ abo 12.5% chord from the leading edge and went down about 45 degrees. An automatic control system w designed based on the signal provided by a pressure ratio switch which made an electrical conta when the differences in the pressure coefficient between holes on the top and bottom surfaces of t wing reached a pre-set value. The nose flap was lowered by the stored energy of a hydraul accumulator and came down in a second. This quick action was necessary to beat the increase Chord Line (CL) raising was slow and the hydraulic pumps had to recharge the accumulator to fu pressure before the flaps retracted so that it might be ready for action again. This was lat demonstrated to be acceptable by flying at high Mach numbers with nose flaps down.

**Aerodynamic Controls**

We started the design in 1946 and had to design the biggest aeroplane that we had ever done, wi swept wings and a flight envelope going up to a pretty high subsonic Mach number. In thes circumstances we decided that manual controls were ìoutî so we went for duplicated power operat controls with no manual reversion. The aileron jacks were independent, i.e. not connected across t wing from port to starboard, so we put in a fixed upwardly deflected tab to cut down bo and b.; reduce b2 we also had a geared tab. Rolling power on the Victor is very high because when v changed over from elevons to ailerons and elevator we did not reduce the size of the ailerons and they are larger than normal. The rudder had a geared tab. We gave up the idea of an all movi tailplane for mainly structural reasons (the HP 88 had such an item) and went instead for a very sma fixed tail-plane just something to hold the hinge brackets with a very large elevator. The elevator ha an enormous horn balance (the outer 60% of the span I should guess) and was deliberate overbalanced for all normal flight conditions. We did this so as to reduce the hinge movement ( saving size and weight of the jack.) at maximum flight M; positive and negative movements we about equal in magnitude and it seemed to work all right. Service experienced seems to justify o decisions as the Victor has flown at Mach numbers in excess of 1.0 on a few occasions. Although t prototype did a lot of flying without auto stabilisation, we ultimately added first a yaw damper a then a Mach trimmer. These were more important on the B2 versions with the Conway and the great altitude capability.

**Fuselage**

There is not much more to add to what has already been said in connection with the wing design. W made a very smooth pointed nose with the windscreen faired into the lines without the usual step. Th kept down the local shock waves and gave a very quiet cockpit. The bulge or chin below the no resulted from putting the radome under the bomb aimer.

**Engine Air Intake**

Right from the start we knew that swept wing leading edge intake was going to be difficult but w went ahead with it because of the very encouraging results obtained from A.VA. Gottingham wit such an arrangement. We had the wind tunnel test report by a man called Scheerer I think or else Walz.

For the Mk 1 with the Sapphire engines we just sliced off the nose section of the wing section a contrived to keep the engine air intake entirely within the original profile. The problems were to g good efficiency throughout the large range of inlet velocity/flight velocity ratios and to avoid sho waves at high Mach numbers through a fairly large range of incidence. There was the tendency und static conditions for the air to be concentrated in the outer corner of the intake; it came out as a lo thin triangle, with rounded corners, due to the high thickness taper on the inner wing. The need ~~supply two engines added more complications. We decided on a single inlet with division into the tw~~ separate trunks well back in the wing when we had got the air behaving nicely. The absence of central division on the leading edge reduced the length of the intake; if we had to push the intake f the outer engine still further outboard we would have been in real trouble with the extreme out corner, for the wing depth would have been very small indeed.

Starting with the German results and with much wind tunnel testing (many pressure plots on th lips) we got it acceptable, including the engine out cases. Later it was discovered that during the tak off run there was quite a large supersonic patch at the outer corner of the intake; the tolerant Sapphi did no more than lose a bit of thrust under those conditions.

**Dive Brakes (later called Air Brakes)**

These were formed from sections of the fuselage near the rear on each side of a roughly trapezoid plate swung forward and outwards leaving a gap between the leading edge of the air brake and th fuselage side. At full deflection it had moved out about 60 degrees. Since the above arrangeme resulted in a convex face of the air brake facing forward we put strakes on the top and bottom edge increase drag. At first the strakes were of equal depth but there was a pitching moment when th brakes were deployed; we cured this by making the top strake a lot bigger than the lower one.

These air brakes worked very well; they gave good braking without pitch or undo buffet at all Mac numbers up to the maximum. The pilots liked it so much that they used them for speed control on th final approach; they set up a reasonable thrust and adjusted the speed /angle of descent with the a brakes as one would on a glider since this was more precise than operation of the throttles.

**Structural Design**

We are committed to a thin wing (or relatively thin) and this lead to quite a high bending end load Because of high flight Mach number we imposed a quite stringent waviness criterion to avoid the ris of local areas having little shock waves.

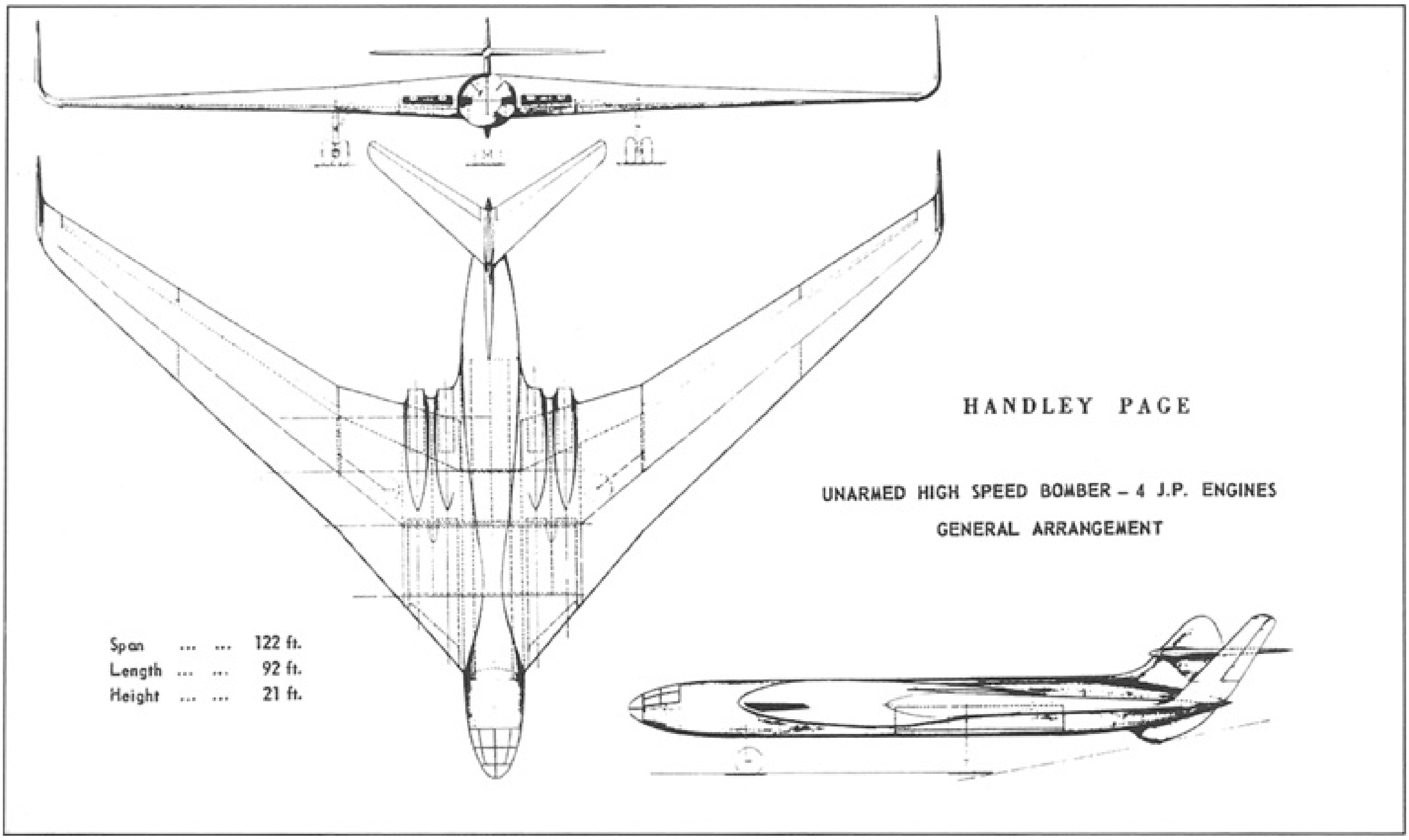
We decided quite early to use sandwich construction which, because of its bending stiffness ar strength, could carry end load (the main bending end-load) without the elastic in-flight bucklin typical of conventional skin/stringer construction and which could also take internal (fuel tank) ar external pressure loads without significant distortion. (*For a complete description of the structur design of the Victor by the then Assistant Chief Designer (Structures)* R H Sandifer)

**Flutter on the Victor**

From the start of the design we paid much attention to flutter. We were concerned firstly with th problem of estimating flutter derivatives for a swept wing where the mach number went well beyon the critical, and secondly, we had two other problems, the flutter characteristics of a crescent wing ar a T tail, both new to Handley Page.

We tackled the problems on a broad front, calculation, wind tunnel test, ground resonance test ar finally flight test; mixed up with this there was also a dropped model or two to try and get high l conditions. The calculations owed much to help received from the Flutter Section of the SM Department of the RAE and the use of the RAE analogue flutter computer. The wind tunnel tests we similar to those carried out by the Boeing Aircraft Company, since we had seen their model buildin technique on a visit to Seattle in 1949. The Boeing models consisted of a light-alloy skeleton provide the elastic properties, the aerodynamic shape being formed by numerous balsa wood boxe the gaps between them being sealed by very thin rubber membranes while the mass distribution w brought up to that required by the addition of weights within the contour. Handley Page adopted th

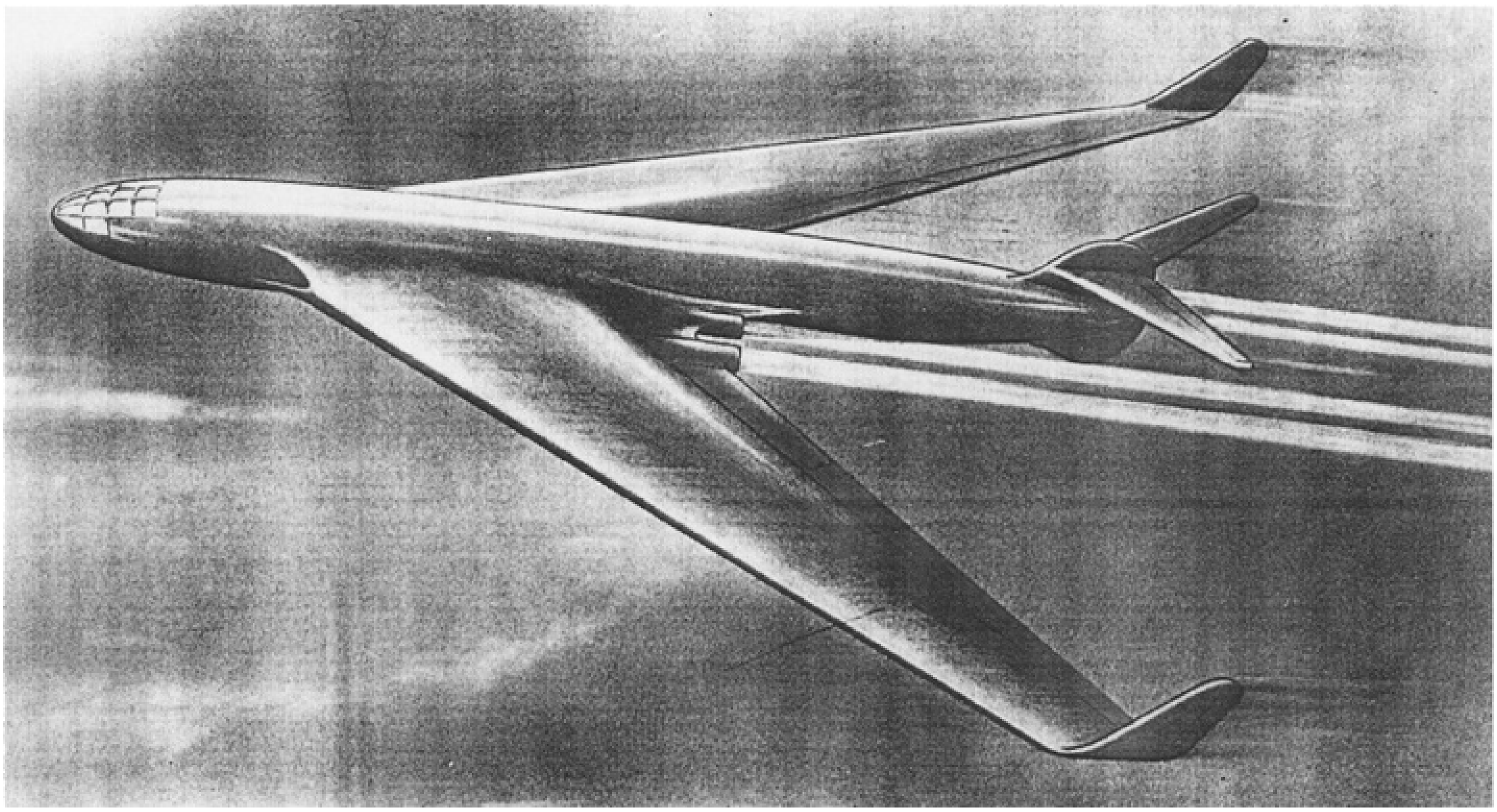
technique for the low speed wind tunnel models. As far as the wing was concerned we were entire
succ~~essful. On the tail unit, however, despite all that we did, there was a flutter incident wit~~h fat
results to the crew. The accident happened during a low altitude high speed run at Cranfield for th
purpose of calibrating the static pressure orifice; tail unit flutter occurred and this component brol
away.




*Unarmed High Speed Bomber*

To begin with this accident was very puzzling because we had assessed (or checked) the flutt
speed by three independent means and each time the result showed that the flight programme could l
safely undertaken. These three checks were:

1 An assessment of the flutter speed based on low-speed wind tunnel tests.
2 The calculation of the flutter speed using ground resonance tests results.
3 We did rudder jerks up to speeds slightly higher than that attained when flutter occurred.



*Unarmed High Speed Bomber in Flight, Model 1.*

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