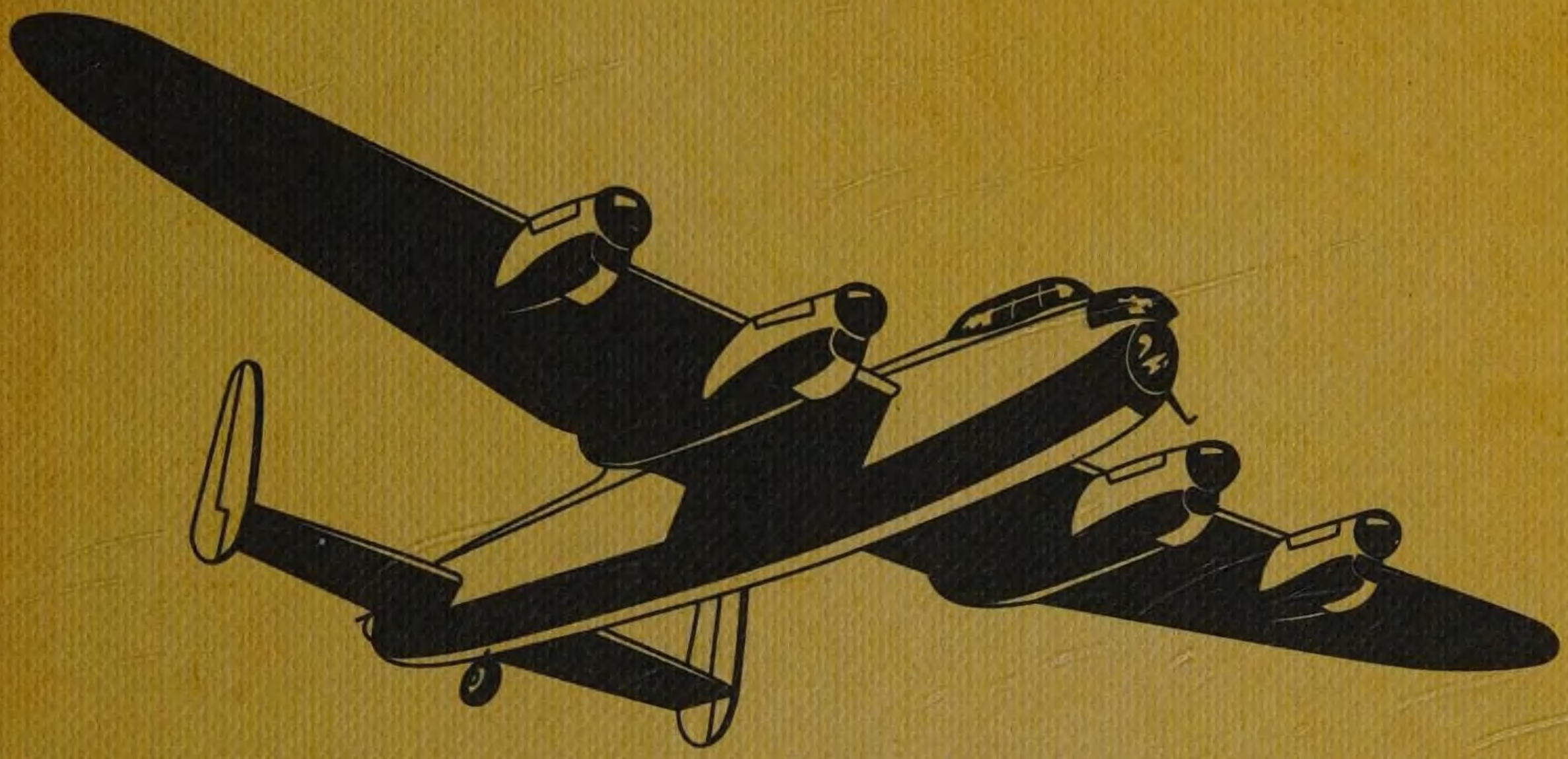
THE LANCASTER BOMBER POCKET MANUAL



1941-1945

AIR MINISTRY

THE

LANCASTER BOMBER

POCKET MANUAL

COMPILED AND INTRODUCED BY MARTIN ROBSON

OSPREY
PUBLISHING

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Introduction

'The Lancaster surpassed all other types of heavy bomber … I would say this to those who placed that shining sword in our hands – Without your genius and efforts we could not have prevailed, for I believed that the Lancaster was the greatest single factor in winning the war'.

Air Chief Marshal Sir Arthur Harris to Sir Roy Dobson,
AVRO, 6 December 1945

Like many of my generation, I first became aware of the Avro Lancaster story as a lad, lying on the floor on a lazy Sunday afternoon watching an old black-and-white film on television. That film, with its tale of British pluck, inventiveness and stirring 'Dambusters March' music was, of course, the 1955 classic portrayal of 617 Squadron's attack against the Ruhr Dams. While Richard Todd as Wing Commander Guy Gibson and Michael Redgrave as Barnes Wallis were the named stars, the real star of *The Dambusters* was, at least for me, the Lancaster bomber. Specially adapted to carry Barry Wallis's 'bouncing bomb' the 'Lanc' was (and still is) rightly famous for the 'Dambusters Raid' yet, as I have learned over the many years since watching the film for the first (of many) times, there is far more to the Lancaster story than the events of 16/17 May 1943.

In the run up to 1939 Royal Air Force procurement and doctrinal thinking had concentrated on the bomber force, with, on average, two bombers built for every fighter. Air defence of the UK was deemed a secondary role which was only addressed in 1938–9 largely due to developments in incoming aircraft detection allowed by radar which made effective interception a realistic prospect. This concentration was surely influenced by the theories of air power propagated in the inter-war years by writers such as Giulio Douhet and Billy Mitchell and encapsulated by a line in a 1932 speech by British politician Stanley Baldwin that 'the bomber will always get through' to wreak havoc and carnage upon civilian populations. The only defence, in Baldwin's opinion, was 'to kill more women and children more quickly than the enemy', but this thinking would require an effective RAF strategic bomber force. The problem was that in 1939 the RAF did not possess an effective strategic bomber force. Bomber Command was composed of 'medium' twin-engine Armstrong Whitworth Whitleys, Handley Page Hampdens and Vickers Wellingtons along with light bombers in the shape of the Bristol Blenheim (twin engine) and the

Fairey Battle (single engine). When war came in 1939 the RAF initially concentrated upon German naval targets, mine-laying and leaflet-dropping (this latter activity prompted Air Vice-Marshal Arthur Harris of No.5 Group Bomber Command to quip that all it achieved was to supply Continental Europe with five years' worth of toilet paper). Following a German 'blitz' against Rotterdam on 14 May 1940 in which nearly a thousand civilians were killed, the RAF was permitted to attack German targets in the Ruhr valley (a centre for German industry), and Bomber Command's first strategic bombing attack took place on 15/16 May.

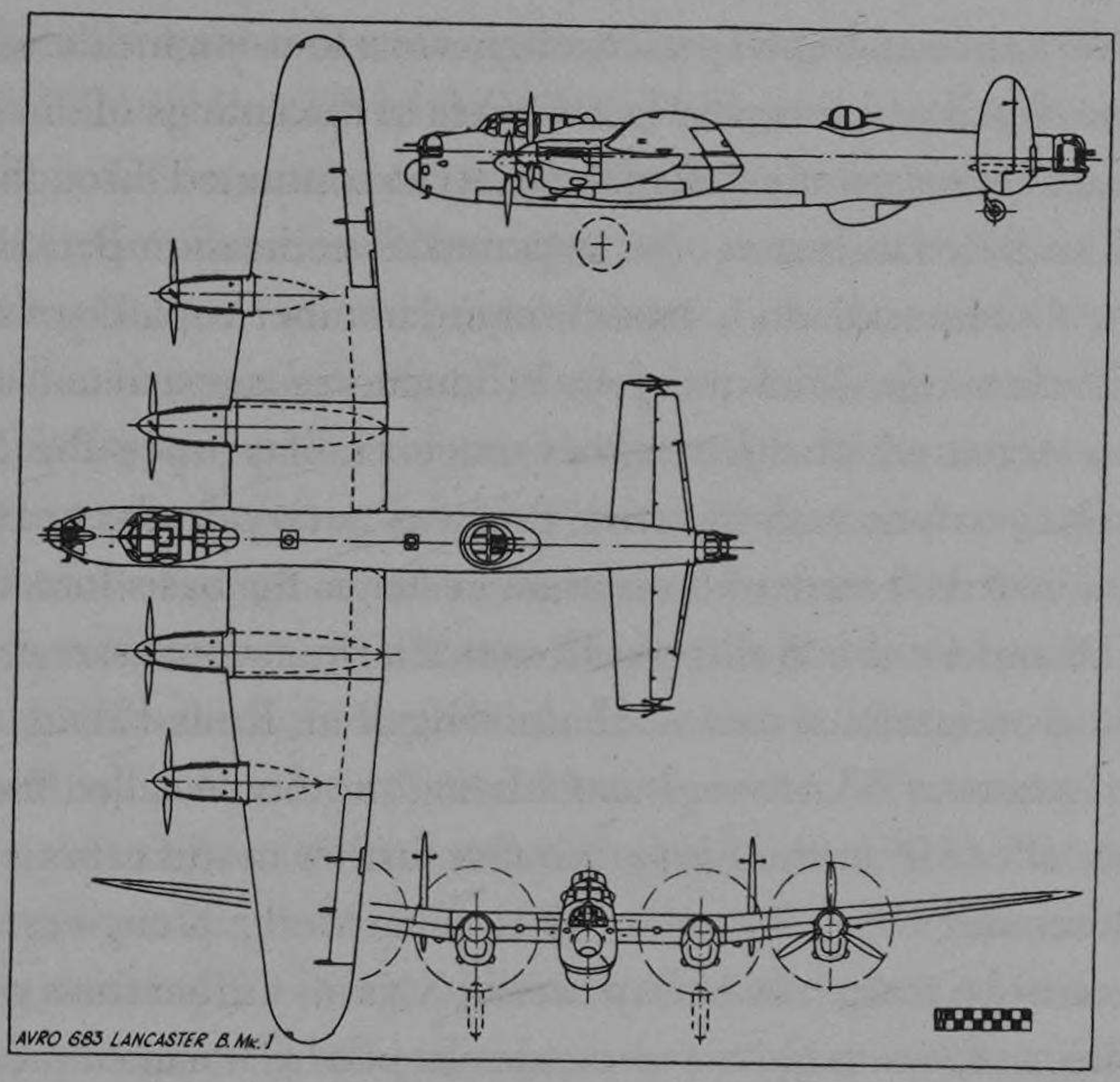
Early RAF doctrine had favoured daytime precision bombing but heavy losses and the unsuitability of the airframes forced a gradual change to night-time bombing. This change led to problems with bombing accuracy: fewer than 1 bomb in 10 fell within 5 miles of its target. Daylight operations persisted into 1941 with a new generation of bombers, in November 1940 the four-engine Handley Page Halifax entered service quickly followed in January 1941 by the four-engine Short Stirling, yet with the change to night bombing and problems with accuracy what became paramount was not precision but payload. The Wellington could only carry 4,500lb of bombs and the Whitley a more respectable 7,000lb, the new heavy four-engine bombers could deliver a payload of 13,000lb in the Halifax or 14,000lb in the Stirling. There were problems, however: the Stirling's thick wing and generally larger and heavier airframe limited the maximum payload distance to around 590 miles and also limited its maximum altitude, while the bomb-bay had internal divisions limiting the actual bomb package that could be carried and crucially ruling out the 4,000lb High Capacity bomb, known as the 'cookie', which was first used on the night of 31 March/1 April 1941. While the Stirling was withdrawn from most bombing duties in 1943, the Halifax would continue bombing targets in Germany for the duration of the war. It could not, however, bear the brunt of the strategic bombing campaign alone.

Enter the Avro Lancaster. The 'Lanc' actually had its origins in a design failure. In September 1936 the Air Ministry issued Specification P.13/36 (reproduced in Chapter I) for a twin-engine bomber. In response Avro (actually A.V. Roe) built the Manchester powered by twin Rolls-Royce Vulture engines. The airframe was solid and promised much and the Manchester entered service with 207 Squadron in November 1940, but the Vultures underperformed and by 1941 a decision had been made to equip Bomber Command solely with four-engine bombers. In fact Avro and their Chief Designer, Roy Chadwick, had in

February 1939 already turned their thoughts to a four-engine design called the Type 680. The Air Ministry were also aware of the failings of the Manchester and discussions between the Ministry and Avro continued through 1939, with Avro made aware that there would be a new Specification B.1/39 (issued in March 1939) which called for a four-engine bomber capable of delivering a 10,000lb payload . The Ministry of Air Production suggested to Avro that they switch to production of the Handley Page Halifax once the Manchester production run had been completed; this was not a popular 'way ahead' for Avro. Instead, Avro returned to the Manchester as the basis for a new design. Using 70 per cent of the components from that airframe but crucially with some significant developments, not least utilising four Rolls-Royce Merlin XX engines, by 9 January 1941 Avro had a flying prototype called the Type 683 Manchester III. This aircraft, BT308, with further modifications underwent testing at Boscombe Down in January 1941 using Merlin X engines. These were replaced in February with the desired Merlin XXs for further trials when BT308 reached a speed of 310mph. By now the design had been named the 'Lancaster'. Of the prototype Avro's Managing Director Roy Dobson is alleged to have remarked 'Oh boy, oh boy, what an aeroplane! What a piece of work'.

One of BT308's test pilots, Capt H.A. Brown, had already noticed a Lancaster key attribute: its excellent handling. This was confirmed in the official report of 3 March 1941 which stated, 'The early impressions are that the Lancaster possesses good flying qualities, and promises to give a good performance'. With a contract for 200 Lancasters signed, the aircraft went into production. R7527 was the first off the production line and made its first flight on 31 October 1941. With a few further tweaks, on 24 December three Lancasters were delivered to 44 'Rhodesia' Squadron. The Operations Record Book of that Squadron for 3/4 March 1942 reads: 'Height 600ft, time 2020, heading 272 degrees magnetic, speed 180mph. Rear gunner saw splash of four mines dropping'. This entry, describing the laying of mines off the coast of Germany ('Gardening' to use RAF parlance), might not seem particularly important, but it records the first operational mission of the Lancaster.

The Lancaster entered into service at a time when Bomber Command was facing up to a challenging situation under a new and controversial commander – Air Marshal Arthur Harris. Harris was appointed to command on 22 February 1942, eight days after the Air Ministry had sent its 'area bombing' directive to Bomber Command which focused efforts on general attacks against German cities: 'It has been decided that the primary objective of your operations should



now be focussed on the morale of the enemy civil population and in particular of the industrial workers'. The 'area bombing' directive chimed with Harris's own personal belief that the war could be won by the destruction of German cities. This policy, a response to German bombing of Allied cities, was encapsulated by his statement that Germany had 'sowed the wind, and now they are going to reap the whirlwind'. The aim of the strategic bombing offensive was 'the destruction of German cities, the killing of German workers, and the disruption of civilised life throughout Germany'. In the Halifax and the Lancaster Harris now had the airframes to implement this new policy, and although there were only four Lancasters operational on 1 March 1942 their numbers would increase rapidly, with 34 operational by 27 March and 123 by 24 July (operational duties only and not including training and conversion flights). At the height of production over 1.1 million men and women were involved in building Lancasters. A total of 7,377 were built during the Second World War at an average cost of £58,974 each (for the airframe and machinery but not fittings such as armaments, radios and such like). Lancasters flew 156,000 sorties and dropped 608,612 long tons (618,378 tonnes) of bombs; 3,349 were lost on operations (3,814 lost in total); just 34 airframes completed more than 100 successful operations; the average age of the seven members of the Lancaster aircrew was 22, of those aircrew over 21,000 were lost. Ten Lancaster aircrew won the Victoria Cross.

A loss rate approaching 50 per cent may seem at odds with the Lancaster's reputation as the most successful bomber of the Second World War. But that needs to be set against the context of the other airframes available. Harris would later write that 'The Lancaster … soon proved immensely superior to all other types in the Command'. In a report from January 1943 Harris noted the Lancaster's 'advantage which it enjoys in height and range enables it to attack with success targets which other types cannot tackle except on suicide terms'. He backed up this claim with statistical evidence: it cost the lives of 9 Lancaster airmen to deliver 100 tons of bombs on enemy targets, for the Halifax this figure was 19 and for the Wellington it was 23. In terms of lost airframes, for every Wellington lost 21.6 tons could be delivered, for the Halifax 30.1 tons and for the Lancaster 68.5 tons. In such raw, brutal terms, the Lancaster was clearly more effective in the heavy bomber role than the other airframes in Bomber Command.

To this must be added the ability to carry, again in Harris's words, 'heavier bomb loads' to those targets (upon viewing the Lancaster one surprised American exclaimed 'Goddam, it's a flying bomb bay!'). The Lancaster could not only carry an impressive payload, with a normal bomb load of up to 14,000lb, the large uninterrupted bomb bay allowed for a number of different combinations of load, as well as adaptability for some of the more specialist bombs developed during the Second World War. These combinations could be configured especially for the mission, for instance while the 4,000lb 'cookie' would demolish buildings, incendiary canisters would create conflagrations. One such combination example is a Lancaster from 467 Squadron carrying one 'cookie', three 1,000lb, twelve 250lb and six canisters of incendiaries.

Of course statistics, payloads and bombs do not tell the whole story. The Lancaster was popular with pilots who appreciated its handling. One from 75 Squadron remarked of flying a Lancaster in 1944: 'Everything about it was just right. Its muscular, swept lines were beautiful to look at. It flew with effortless grace and had a precise weighted feel. It made a pilot's job easy. You could throw it all over the skies'. Alex Henshaw was tasked with the job of production test-flying at Supermarine's factory at Castle Bromwich. Supermarine, famous for the Spitfire, had dispersed their production to the massive Castle Bromwich Aircraft Factory where the operations of that factory came under their parent company Vickers Armstrong. As part of the Air Ministry's desire to speed up Avro's production, building Lancasters was outsourced to a number of sites including Castle Bromwich. The first Lancaster built there was flown on 3

November 1943. Henshaw recalled, 'The Lancaster was a beautiful aircraft to fly, and I can think of no other large four-engined machine that gave the pilot so much satisfaction'. So much so that Henshaw is perhaps the only person on record to have officially 'rolled' a Lancaster – no mean feat considering the 102ft wingspan. Despite the losses mentioned above, Lancaster aircrew appreciated the pretty robust airframe with the ability to take punishment and return to base, and the reliability and power of the Merlin engines. Sometimes Lancasters would return on three of their four engines and sometimes on just two – and a Lancaster from 44 Squadron returning on two engines which suffered a third engine seizing up within sight of home, landed on just one engine.

Increasing the Lancasters' operational effectiveness as heavy bombers were a number of tactical and technical developments. To increase bombing accuracy, on 11 August 1942 the Pathfinder Force (PFF) was created as a specialist target-marking force to drop flares known as 'target indicators' (TIs) for following waves of bombers to home in on. Although it contained only one Lancaster squadron (and another flying a number of Lancasters trialling Oboe†) the PFF's ability to find and identify the target was enhanced by Gee radio navigation which emitted electronic pulses from transmitters in England and could be picked up by a Gee set carried on board, the TR1135. When the signal was transferred onto Gee charts the aircraft's position could be ascertained with reasonable accuracy – at least when dealing with large targets such as towns and cities. Further developments included the Oboe system, which was used by Mosquito Pathfinders, and the H_2S ground scanning radar, which was fitted to the PFF in early 1943 but was, frustratingly for Harris, only slowly deployed to the Lancaster force with the first operational use by PFF Lancasters in August 1943 before the wider 'Lanc' force was similarly equipped. Concurrent with these developments was the implementation of the Master Bomber. Usually flying a Mosquito, though Lancasters were sometimes used, the role of the Master Bomber was to coordinate target marking operations, essentially following the example set by Guy Gibson during operation CHASTISE.

Which brings us back round to that famous raid of May 1943. Harris was generally against what he called 'panacea' targets that took resources away from his main effort against German industrial targets located in urban areas. Yet he

† Radio navigation. Two transmitters in Britain emitted radio signals to be picked up by onboard equipment and re-transmitted back to the stations allowing for accurate tracking and guidance, but it could only be used by one aircraft at a time so was primarily used by the PFF who could then drop TI for the following bombers.

supported the 'Dambuster' raid because the benefits of breaching the Ruhr dams were clear – they supplied hydro-electric power and water to the heavily industrialised Ruhr valley. 617 Squadron had been formed on 21 March 1943 specially for the CHASTISE mission with the Lancaster airframes adapted to carry Barnes Wallis's 'bouncing bomb' (actually a rotating mine codenamed Upkeep). After undertaking six weeks' training the raid was launched on the night of 16/17 May, with the Möhne and Eder Dams both breached, though attacks on the Sorpe and Schwelme dams were unsuccessful. Of the 19 Lancasters in the attack, 8 were lost; 53 of the aircrew were killed and 3 captured by the Germans. On 25 May 1943, just over a week after the operation, Barnes Wallis wrote to Roy Chadwick at Avro about the 'great event', offering his 'very deep thanks for the existence of your wonderful Lancaster, for it was the only aircraft in the world capable of doing the job, and I should like to pay my tribute of congratulation and admiration to you, the designer'. Gibson was awarded the Victoria Cross and 34 other men of the squadron were decorated. Chadwick was awarded a CBE.

While the material success of the 'Dambusters' raid has been debated ever since, it proved a great propaganda coup for Britain and created a national icon in the Lancaster bomber to the point where the history of the airframe and the 'Dambusters' raid are inseparable. The raid also highlighted the versatility of the basic Lancaster design, another key factor in its overall success. Less famous but indicative of the Lancasters' versatility, were attacks on German U-boats at sea, and on their U-boat pens, as well as the many bombing missions against German industrial targets. Lancasters took part in Operation CATECHISM, the attack on the German pocket-battleship *Tirpitz* and attacked CROSSBOW targets, sites associated with the German development and deployment of the V1 and V2 weapons. As well as being the only airframe capable of carrying Upkeep the Lancaster was the only bomber that could carry other specialist bombs used in precision raids, and 617 Squadron continued in its role as a precision bombing force, dropping the 12,000lb 'Tallboy' bomb against key transport points in support of the Allied invasion of Normandy in June 1944, and later the massive 22,000lb 'Grand Slam'. A few months after Lancasters dropped incendiaries onto Dresden in the firebombing of that city on 14 February 1945 other Lancaster squadrons were flying in Operation MANNA providing humanitarian assistance by dropping food into German-occupied Holland. Their final war service was to repatriate British prisoners-of-war from Germany and troops from the Mediterranean.

The final Lancaster to leave the production line was delivered to the RAF on 2 February 1946. This was, however, not the end of the 'Lanc' story. In 1943–4 radical development of the original Lancaster design (which had in fact changed little between the Mark I and Mark III due to the soundness of the design) advanced to such an extent that the Air Ministry thought the Mark IV was not actually a Lancaster. It was renamed the Avro Lincoln Mark I and entered service in August 1945. In January 1946 there were still 1,215 Lancasters in 'stock' with another 803 in long-term storage. Lancasters continued to fulfil a military role post war, undertaking photo reconnaissance, maritime patrol and reconnaissance, search and rescue and, as the jet age developed, serving as in-flight refuelling tankers. The Lancaster bomber finally ended its active service with the RAF on 15 October 1956 but remained in service with the Royal Canadian Air Force until 1964. Lancasters had, in fact, already entered commercial service in November 1943 with the British Overseas Airways Corporation. Post-war commercial use continued in the Empire Air Navigation School or flying commercial routes, for example airframe G-AHJV was deployed by British South American Airways on its London to Bermuda route, utilising inflight refuelling to make the trip non-stop.

Today there are 17 surviving Lancasters. R5868 'S for Sugar' can be seen housed in the Bomber Hall at the RAF Museum, Hendon, London. This remarkable airframe flew 139 operational missions during the war before flying food relief and British prisoner-of-war repatriation flights at the end of the war. Only two Lancasters remain airworthy, one of these, Lancaster B I PA474 'City of Lincoln', did not see war service. Completed just after the end of the war in Europe and not required for operations against Japan once the atomic bomb had been dropped, PA474 undertook a number of duties before she was taken under the wing of the Air Historical Branch in 1964. There followed celluloid success with appearances in the movies *Operation Crossbow* and *The Guns of Navarone*. In 1973 PA474 joined the Royal Air Force's Battle of Britain Memorial Flight where the aircraft can be seen flying as 100 Squadron's Lancaster EE139 'Phantom of the Ruhr'.

CHAPTER I
Design

AIR MINISTRY SPECIFICATION NO. P. 13/36
MEDIUM BOMBER

Specification of particular requirements to accompany the Contract Agreement

This Specification is to be regarded for contract purposes as forming part of the Contract Agreement and being subject to the same conditions.

Approved by: (signed) R. H. Verney
Air Commodore, R.A.F.
Director of Technical Development
Date: 5th September, 1936

1. Responsibility for Design.

1. The Contractor shall be solely responsible for the design, construction and acceptance trials of the aeroplane to the requirements of the specification, (of which relevant Air Publications, Aircraft Design Memoranda, Standard Instruction Sheets and subsidiary specifications shall be deemed to form part) and to fulfil the requirements of the Director of Aeronautical Inspection as regards material and workmanship.

2. The Director of Technical Development (D.T.D.), his staff and the Resident Technical Officer (R.T.O.) at the Contractor's works, will be available to supply any information or advice on any matter concerning the aeroplane which the Contractor requires, but the responsibility for taking action rests with the Contractor at all times, and no excuse that any such information or advice has caused delay in the execution of the contract will be accepted.

3. The only exception to paragraphs 1 and 2 will be that the D.T.D. reserves the right to check the design of the aeroplane for strength and safety, and to call for certain static load or other tests on any part the strength of which cannot be determined satisfactorily by calculation.

4. At all times during the design, construction and test of the aeroplane the Contractor is to make accessible to the D.T.D. or his representative, drawings,

design calculations, reports of strength tests and reports of flight tests, so that any question which may affect the strength and safety of the aeroplane and the acceptance of the type record may be discussed at an early stage. The R.T.O. is also to be given notice of any strength tests made in connection with the design so that he may witness the tests.

5. The D.T.D. may, if he thinks fit, modify or waive any requirement which the tenderer considers that there may be real difficulty in meeting, or which might entail serious delay in the production of the aeroplane.

6. Prior to the delivery of the aeroplane the Contractor shall certify to the D.T.D., on the form of certificate provided that it has been built in accordance with the specification, and that the requirements of A.P. 970 (Edition, May, 1935) relevant Aircraft Design Memoranda and S.I.S. have been met, except where variations have been agreed by the Air Ministry.

II. Operational Requirements.

7. The main operational requirements are specified in Appendix "B" to this specification, which was circulated under the Director of Contracts' letter Ref. 555794/36/C.4 (c) dated 24th August, 1936.

8. The arrangements of the crew's stations shall provide the comfort necessary to enable them to perform their various duties efficiently. Each station is to be adequately warmed and ventilated by efficient methods, and sound-proofed to a low noise-level. Each station must be arranged for accelerated take off, with detachable head-rest, etc.

9. The construction of the cockpits and other parts of the fuselage and the arrangement of the equipment therein shall permit free movement in an emergency that obliges the crew to take to their parachutes. Foot and/or handholds or equivalent aids to easy and rapid egress from the aeroplane both in the emergency referred to, and in the event of it crashing or overturning on the ground, are to be provided. In addition, the cockpits, other than gun stations or turrets shall each be provided with a sliding roof or cockpit cover, to facilitate egress in the event of a forced landing on the sea.

10. A door giving direct access to the interior of the aircraft from the ground is to be provided. If the permanently unrestricted space necessary for the purpose can be made available the door should be arranged to open inwards but otherwise it is to be hinged so as to open outwards and forwards. The door is to be fitted with a positive lock and an independent safety catch and shall be non-detachable (in flight).

11. Exits through which the crew will be able to escape by parachute in an emergency shall be provided. At least one of these exits shall be in the floor of the fuselage. The exits are to be situated so as not to expose the users, after they have taken to their parachutes, to more than the minimum risk of collision with the aeroplane even though it may be falling uncontrolled. If sliding doors are fitted it is to be ensured that there will be no risk of them jamming in their guides, and whatever form of door is adopted must be closed by a safety catch.

Gun Stations.

12. The gun mountings must provide for the incorporation of a mechanically operated gun sight.

13. Each gunner's position is to incorporate harness to prevent the gunner being thrown about during manoeuvres.

W/T Operator.

14. Special attention should be given to the comfort and quietness of the W/T operator's station; he should face forward and have a window giving a view to the horizon.

Pilot's Cockpit.

15. The pilot's seat, if not in the centre of the fuselage, is to be on the port side, and is to be adjustable in flight through a 4-inch vertical range; arm-rests are to be provided. The rudder bar is to be adjustable in flight through a 3-inch longitudinal range.

16. A dual control conversion set and a blind flying hood or screen are to be supplied with the aeroplane. Specifications D.T.D 1018 and 1036 should be used as a guide to requirements in this connection.

17. The pilot's seat should be easily accessible in flight so as to facilitate a change of pilots. It is of special importance that the pilot's station should be comfortable, and as quiet as possible.

Bomb Installation.

18. Specification D.T.D. 1007 should be used as a guide to the design of the bomb installation, etc. Installation dimensions for the L.C. 250 lb. bomb and for the S.C.1. type '3' bomb are shown on drawings C.D. 3658/6 and A63812 respectively [not included here]. Special consideration should be given to the accessibility of the bomb gear, and to facilities for all necessary changes in the

equipment for different bomb loads. The time required for loading bombs should be as short as possible; all necessary winch gear and equipment should be included in the design, and capable of being carried in the aeroplane as alternative load.

19. The bomb fuzing and release controls are to be electrically operated. The selector and bomb distributor gear should be under the control of the pilot only. The bomb aimer only requires a firing switch and jettison switch.

Manufacture in quantity.

20. The design, construction and materials of the aeroplane shall be such as to facilitate its manufacture in quantity. Wherever possible, standardised parts and fittings, including A.G.S. parts, which can be obtained in quantity production are to be used (see A.D.M.'s 310 and 311).

III. Design Requirements.

Mock-up.

21. The Contractor will be required to make a mock-up of the aeroplane at an early stage of the design, which shall show the disposition of all the equipment, and the view and facilities available to the pilot and the crew to enable them to carry out their duties. The mock-up conference will be convened by the Air Ministry, but its report shall only be regarded as advisory. The mock-up must be ready for preliminary inspection within four months from the date of receipt of the order.

Materials.

22. All parts of the aeroplane that contribute to its strength in flight are to be of metal.

23. With any form of fabric-covered wing or tailplane, the leading edge shall be metal-covered.

24. Wherever possible, the materials used in the construction of the aeroplane are to be in accordance with current R.B. Specifications or others approved by the D.T.D. A list of the approved specifications, showing the latest issue numbers, can be obtained from the D.T.D (R.T.P).

25. If the Contractor proposes to use any material for which an approved specification is not extant he shall: –

(i) Give the D.T.D. written notice of his intention and

(ii) Supply such information regarding, and test pieces of, the material in

question as are considered by the D.T.D. to be required in order that its properties may be fully determined.

26. All A.G.S. parts incorporated in the aeroplane are to be in accordance with the latest issues of the relevant drawings. The issue numbers of such drawings are not to be quoted on the aeroplane drawings.

27. The cockpit padding and all other upholstery are to be rendered fireproof.

28. No unapproved kind of safety glass may be used in windscreens or windows, but the possibility of using new forms of synthetic material should be considered (see para. 25).

29. The aeroplane shall be "camouflaged" in accordance with the approved scheme for landplanes.

Protections of materials.

30. Each part in the structure of the aeroplane is to be protected against corrosion or deterioration by an approved method, in which connection attention is drawn to A.D.M.'s 319, 323 and 324. The aeroplane is to be able to withstand satisfactorily the sudden changes in temperature and humidity experienced in semi-tropical climates, and it should be realised that the durability of the wind surfaces and all essential parts must be such that it can be maintained in the open for long periods. All covered components are to be effectively sealed against the entry of water, for example, rain, or liquid from the engine-cooling system. Such components must also be provided with vents to provide adequate ventilation internally.

Mechanical Tests

31. The Contractor will be required to supply and ordinarily to test specimens of such parts of the aeroplane as are required to ensure that the structural strength of the aeroplane will be satisfactory. The D.T.D. to be notified of such tests in advance. (See paragraph 3.). Such additional specimens and tests as may be required by the D.T.D. to support the assumptions made in the strength calculations are to be provided by the Contractor as an extra to contract.

32. A thin coat of oil, lanoline or vaseline may be applied to metal specimens to prevent corrosion. Varnish, enamel or similar substances may not be used for this purpose.

Engines and Engine Installation.

33. The aeroplane should be fitted with British engines which shall have passed 100 hours Service Type Test before delivery of the aeroplane, and for which fuel to Specification D.T.D.230 would be suitable. The Contractor will inform the Air Ministry of his selection directly it has been made.

34. The engine installation arrangements shall be such as will permit of the engines being changed with ease and rapidity when the aeroplane is operating "in the field". Every endeavour shall be made to design the engine mounting as a unit removable with the engine, and its equipment, together with oil cooler, oil tank, starter gear, and such like ancillaries. The number of structural attachment points of this power plant unit to the airframe must be kept to a minimum, and be designed to give minimum misalignment after wear; all such points shall be readily accessible for assembly and dismantling. It shall be possible for two men to remove and replace an engine in not more than two hours. A suitable form of hoist is to be supplied for these purposes, provided that standard tackle cannot be used.

35. To facilitate engine maintenance "in the field", particular attention is to be paid in design to the following points:–

(i) Adequate space is required between the rear of the engine and the fireproof bulkhead, to facilitate the making of joints, etc. Joints should be made in this space or at the bulkhead for all pipes and controls.

(ii) Rubber shall not be used for joints in pipes; only metal connections being permitted for this purpose.

(iii) Cowling formers should form part of the cowling, and not be attached to the engine mounting. The cowling should be in large overall units attached by quick-release straps, and not by flush fasteners.

(iv) For "in-line" engines, a liberal clearance shall be provided between the engine mounting structure and the overall width of the widest portion of the engine.

36. An approved form of rubber mounting shall be included in the engine bearers.

37. Supports and footholds are to be provided to facilitate minor repairs and adjustments to the engines and to the installations and accessories.

38. The engines, the fuel, oil and engine cooling systems and the accessories and piping therefore must be installed in the aeroplane with full regard to efficiency and fire risk, both in flight and when refuelling.

39. One standard engine instruction plate is to be fitted in a position where it will be clearly visible to the pilot.

40. The exhaust systems comprising manifolds or pipes of any description shall be made of stainless steel.

Anti-icing precautions.

41. The aeroplane shall be designed so that an approved form of de-icing equipment can be readily fitted to the mainplanes, tailplane and tail fin, though the equipment need not be fitted to the experimental aeroplane.

42. Provision shall be made in the design of the engine installations for an approved form of carburettor de-icer, though this need not be fitted to the experimental aeroplane. Alternatively, a controllable warm and cold air supply shall be fitted, with sufficient warm air supply to guard against freezing under ice-forming conditions, and a distant-reading thermometer on the pilot's instrument board to indicate air-intake temperatures.

43. If a venturi is required for the turn indicator (and any other flying instruments requiring it) it shall be incorporated within the oil or liquid cooling radiator in such a way as to ensure an adequate warm air supply, or protected against freezing by other approved means.

Airscrews.

44. Variable pitch airscrews, or some equivalent device shall be fitted, and each airscrew shall be satisfactory as regards its strength under the diving tests referred to in Aircraft Design Memorandum No.292, and shall be designed to suit the rated power and speed of the engine.

Fuel System.

45. Specification D.T.D.1001 shall be used as a guide to the design, etc. of the fuel system, except that it shall be sufficient for each engine to supply its own fuel with a single pump of approved design, with a hand or electrically operated pump for use by the pilot or other member of the crew in the event of the failure of the engine pump. No gravity system will be accepted.

46. The fuel capacity shall be adequate for the range called for in the operational requirements.

47. The design of the aeroplane shall be such as to facilitate the rapid and easy filling of the tanks and is to provide for this being done both by pumping from bulk containers and directly from tins by hand. Hand and/or footholds are to be provided for the use of a mechanic whilst attending to this operation. In no circumstances shall it be necessary for the purpose of fuelling to employ

ladders and/or other gear not forming part of the aeroplane's equipment.

48. Arrangements for fuel consumption measurements are to be made in accordance with Specification D.T.D.1004, paragraph 19.

49. The arrangement of the fire extinguishers shall be such that it will be possible to extinguish a fire inside an engine cowling from the pilot's cockpit.

Oil Systems.

50. The systems shall be designed to maintain a satisfactory circulation of the oil without exceeding a safe maximum temperature under tropical atmospheric conditions corresponding to those governing the design of the engine cooling systems, and so that there will be no stoppage of the oil supply to the engines when the aeroplane is flying in any attitude within limits corresponding to:–

(i) The greatest angle it can reach when taking-off or in climbing flight, and

(ii) Its angle when diving at the limiting speed.

51. Provision shall be made for rapidly warming the oil so as to expedite the starting of the engines in cold weather.

52. The aggregate net capacity of the tanks shall be sufficient for an endurance, calculated at the maximum rate of consumption, 25% greater than that for which fuel is provided, after reckoning the ¼ hour allowance. Some method of gauging shall be provided for the oil tanks, so that they do not need to be filled to full capacity when the aeroplane is operating at reduced ranges.

53. One distant reading oil thermometer per engine shall be fitted to indicate the temperature of the oil entering the engines. During the flying trials oil outlet thermometers shall be fitted temporarily. (See A.D.M.248).

54. Gauges to indicate the pressure of the oil in the engines are to be provided in the pilot's cockpit. If an oil cooler is fitted, provision shall be made so that a pressure gauge may be connected to it on the inlet side. (Note: the latter gauge will be fitted only during the type trials of the aircraft.)

55. Each system shall incorporate a filter, fitted either in the tank sump (as is preferable) or in the pipe from the tank to the engines. Any auxiliary tank that is not fitted with a filter shall be connected to the permanent system so that its contents are filtered before reaching the engines.

56. A relief valve or other means of preventing the generation of excessive pressure due to the high viscosity of the oil when cold is to be incorporated in oil coolers.

57. The risk of fire due to the generation of electricity by friction during re-

oiling operations is to be guarded against as prescribed in Aircraft Design Memorandum No. 262.

Engine Starting.

58. The aircraft is to be equipped with electric starting and a hand turning gear for maintenance purposes only. The electric starter shall work from a 24-volt system, and provision shall be made for a ground starting plug with a switch under the control of the pilot so that the engines can be started under cold conditions from an outside supply.

59. A means of switching off both engines simultaneously in an emergency is to be provided under the control of the pilot.

Engine Cooling.

For air-cooled engines.

60. Provision is to be made for satisfactory cooling of the engines under tropical conditions, or the cooling arrangements shall be easily adaptable to meet tropical conditions.

61. A thermo-couple thermometer for each engine shall be permanently installed on the pilot's instrument board to record the temperature of one cylinder. The engine and aircraft sections of the thermo-couple leads shall be connected by a standardized junction box mounted on the engine side of the engine bulkhead. The relevant (provisional) specification is No. P.G. 390 (latest issue).

For liquid-cooled engines.

62. Efficient cooling systems are to be installed, and shall provide sufficient cooling to fulfil standard "Tropical Summer" requirements, or shall be easily adaptable to fulfil these requirements.

63. A means (preferably automatically-controlled) of regulating the temperature of the cooling liquid is to be provided.

Undercarriage

64. A retractable undercarriage is desirable and full consideration should be given to ensuring its reliability. Attention is drawn to A.D.M.'s 321 and 322.

65. The wheel track is to be of such a width that no risk of overturning will be incurred when the aeroplane is manoeuvring on the ground. The aeroplane shall be capable of taxying satisfactorily in any direction in a wind of 20 m.p.h.

66. The wheels and tyres should be the size approved for use at the following load:

$$\frac{11 \times \text{weight of aeroplane with intermediate loading*}}{\text{number of main landing wheels.}}$$

* Load as in para 2 (ii) (b) of APPENDIX "B".
at a tyre pressure not greater than 36lb./square inch so that the aeroplane can operate without difficulty from soft aerodromes.

67. A wheel brake system shall be fitted, with hand control on the pilot's control lever and differential pedals to be operated preferably without the use of compressed air.

68. A tail wheel shall be fitted and may be made retractable. It shall be provided with an approved type of electrically conducting tyre and shall be arranged for unrestricted movement through 360° with a self-centring device to ensure return to the landing position.

Controls.

69. The design of the lateral control system is to be such that operation of the ailerons will produce the minimum of adverse yawing affect on the aeroplane. Adequate means of ensuring lateral control and stability at and below stalling speed are to be provided.

70. The tail plane shall be fixed as a rigid part of the fuselage structure, and the necessary trimming control to offset movements of the centre of gravity and centre of pressure shall be effected by movable flaps on the elevators. The range of adjustment shall be sufficient for coping with normal variations in the load carried, and the control shall be easy to operate throughout this range under all conditions of flight. The change of setting necessary on moving the engine throttle controls from the fully open to the closed position or to neutralise any shift of the centre of gravity due to the release of bombs from the aeroplane shall be a minimum; operation of wing flaps shall entail no change of setting.

71. The directional control system shall incorporate an auxiliary control which the pilot can lock at the angle required to keep the aeroplane on a straight course, should any engine fail.

72. Both ailerons should be fitted with means adjustable on the ground to provide lateral trimming.

73. The range of movement of each control organ is to be limited by stops so that in no circumstances will it jam or foul parts of the aeroplane.

74. Provision is to be made for locking the slats (if any) in the closed position and the rudder(s) (including the Servo rudder(s), if any), ailerons and elevators in their neutral (or other suitable) positions. The arrangements made for these purposes shall be such that there will be no danger of the pilot attempting to take-off with the controls (excluding slats) locked.

75. If necessary, provision is to be made for carrying standard ballast to maintain the centre of gravity in its correct position whenever the aeroplane is flown not fully loaded.

Maintenance.

76. The component parts of the aeroplane are to be suitable as regards size, etc., for conveyance by Royal Air Force M.T. vehicles. For this purpose the maximum sizes of the various components when packed must not exceed the following dimensions:–

Component.	Length.	Height.	Width.
Main portion of fuselage or centre portion of planes.	35′	9′ 6″	5′
Other sections of fuselage and sections of planes other than wing tips.	32′	9′	7′ 6″
All other components.	21′	6′ 6″	6′

77. The working drawings of component parts of the aeroplane are to accord as fully as possible with the requirements stated in Specification D.T.D.1019 so that if (in the event of the aeroplane being adopted for use in the Royal Air Force) parts are required to be manufactured in series, each member of a series will be strictly interchangeable with the original part.

78. The construction of component parts of the aeroplane is to permit of them being rapidly dismantled, and the aeroplane as a whole is to be designed so that the maintenance operations scheduled in Aircraft Design Memorandum No. 242 can be performed quickly and easily and such repair work as R.A.F. Units will be required to undertake can be done with the minimum of difficulty.

79. Ladders and/or other miscellaneous items which may be necessary in connection with routine maintenance operations are to be supplied with the aeroplane as part of its equipment.

80. The design of the aeroplane is to provide for its being jacked up or otherwise supported in a secure manner so that the undercarriage or other parts

may be removed. The arrangements made for this purpose are not to entail elaborate forms of support or to require that the aeroplane be slung. The strong points for jacks and/or trestles are to be easily accessible and clearly marked. The provision for jacking must be such that the operation of the retractable undercarriage can be rapidly checked as a routine operation.

81. The examination, adjustment and lubrication of all parts of the controls in the planes and elsewhere are to be provided for. So far as may be possible, provision is to be made for the lubrication of moving parts by grease gun, and for the exclusion of dust and water from these parts.

82. Parts that require frequent inspection or to be frequently replaced are to be easily accessible and fully visible to a mechanic working on them. Provided the type of construction permits it is desirable that direct access to all such parts in the fuselage should be ensured by incorporating a quickly detachable panel or panels (properly sealed at the edges) in the fuselage covering, and that the fuselage and bay should be quickly detachable.

83. To prevent any need arising for the frequent replacement of pin-jointed parts or for the use of over-size pins or bolts in such parts, the bearing areas for pins or bolts are to be sufficient to prevent the holes elongating under the bearing loads. In addition, in the case of moving parts, wear due to the rotation of pins or bolts is to be provided for by bushing the holes; the bushes are to be easily replaceable.

84. Holding-down rings or the equivalent are to be provided at suitable positions on the aeroplane, e.g. the underside of each bottom wing and at the aft end of the fuselage. They should be dragless when not in use.

85. The following are to be supplied in accordance with the Director of Contract's circular letters, reference 163625/32/C.4(a).

1. Descriptive Notes and Rigging Instructions.
2. Maintenance Schedule.
3. Repair Notes.

Equipment.

86. The aeroplane shall be fitted with equipment to be supplied by the contractor as given in Appendix "A" to this specification [not included here]. Details of this equipment may be amended from time to time during the currency of the contract, in which case notice of such amendments will be given by the Director of Contracts. The aeroplane in its completed state is to be equipped in accordance with the Appendix as finally amended.

87. The electrical equipment is to be installed in accordance with Specification No. G.E.164. The whole electrical system shall be 24 volts. The electrical generator(s) will be engine-driven. The instruments are to be illuminated by the R.A.E. type of reflector flood-light. Two R.A.E. type H. landing lamps are to be fitted in the port wing. Station-keeping lights are to be fitted. Two 4″ forced landing flares are to be carried, stowed in separate chutes with release under control of the pilot.

88. The aeroplane is to be bonded and screened in accordance with Specification No. G.E.125, including screened sparking plugs and any other precautions necessary for very short wave W/T radio equipment. Provision shall be made for blind landing equipment if developed in sufficient time.

89. The compressor for the automatic control apparatus will be engine-driven.

90. Such parts of the equipment of the aeroplane as permanently-fitted adjuncts of the dual control conversion set, etc., if liable (unless specially protected) to be accidentally damaged, shall be provided with detachable guards.

91. Provision for the operation of equipment such as flaps, retractable undercarriage and gun mounting shall not involve the use of non-standard or unapproved accessories to be fitted to the engine.

92. Waterproof covers are to be provided for the engines and airscrews. The design and material of the covers are to be such as will ensure the complete exclusion of water during heavy rainstorms.

93. Such instruments, plugs and leads as do not form part of the permanent equipment of the aeroplane are to have labels affixed to indicate (in the case of instruments) the positions occupied when fitted in the aeroplane, or (in the case of plugs and leads) their identities.

94. On completion of the aeroplane, the Contractor shall forward to the D.T.D. (R.D.A.4) a copy of the Appendix "A", drafted in accordance with the current master schedule, giving details (weights, lengths and quantities) of the equipment with which the aeroplane is fitted.

Handling Equipment.

95. Items of ancillary equipment which the Contractor may have to supply are as follows:–

1. Hoist for engine-changing.
2. Ladders for reaching the engines, and tanks and controls in the top plane.

3. Undercarriage jacks.
4. Wing and tail trestles.
5. Tail steering arm.
6. Bomb winch.

but the aeroplane should be designed with a view to the fullest possible use being made of standard R.A.F. equipment for those operations. Particulars of the standard equipment are obtainable from the D.T.D. (R.D.A.5) on written application being made.

96. Any special tools essential for maintenance of the aeroplane shall be provided with the aeroplane, but the introduction of non-standard articles is to be avoided where possible.

97. Any non-standard equipment necessary for the work referred to in para 95 must be delivered with the aeroplane, but its cost will not be included in the tender price.

Typical Service Load.

98. The total load to be carried by the aeroplane for the purpose of the flight trials at each condition of loading shall comprise:

(i) The military load specified hereunder, together with such removable non-standard parts as it will be necessary for the contractor to supply and fit in order that this military load may be carried.
(ii) The fuel, oil and (if necessary) cooling liquid for the specified range, plus the necessary allowances.
(iii) The "tare weight" items shown in column 10 of the Appendix "A".



A Modified Lancaster bomber on a test flight.

Military Load.

(Crew and removable standard items only)

Item.	Weight (lb.) A.*	B.*	C.*
Crew, with parachutes.	800	1200	1200
2 Browning guns with accessories (front)	41	41	41
4 " " " " (rear)	82	82	82
Ammunition, 2000 rounds (front guns)	130	130	130
" 6000 " (rear ")	390	390	390
Bombs	1000	2500	3500
Bomb-sight	14.5	14.5	14.5
Signal pistol and cartridges	6.5	6.5	6.5
Flares, 4" training (forced landing)	26	26	26
Marine Distress Signals	10.5	10.5	10.5
Power Supply for wireless	45.5	68	68
Navigational	12.5	12.5	12.5
Oxygen	116.5	262	262
Miscellaneous	3	77.5	77.5
W.T. – T.1683 R.1082 D.F. equipment. Intercommunication.	81.5	81.5	81.5
TOTAL	2759.5	4902	5902

* A = normal load.
* B = increased load.
* C = maximum load.

Structural Strength.

99. The strength of the aeroplane shall not be less than is defined by the ultimate factors stated hereunder:

At limiting weight (with load as in para. 8(ii) (c) of Appendix "B").

1. Factor with the centre of pressure in its most forward position in normal flight 5.5
2. Factor with the centre of pressure in its most backward position in horizontal normal flight 4.2

At limiting weight x 1.1

3. Factor under an up gust of 25 feet/second (indicated) when the aeroplane is flying at its normal top speed 2.0

At normal weight (with load as in para.2 (ii)(a) of Appendix "B") x 1.1

4. Factor in the "fast glide" case of A.P. No.970 (edition of May, 1935) chapter 2, para. 5 2.0
5. Factor under "up" and "down" gusts (normal to the flight path) of 25 feet/second (indicated) in a steady dive to 1.3 times the maximum horizontal speed 1.5
6. Factor when diving with flaps down along a flight path at 70° to the horizontal at the steady gliding speed appropriate to this condition:
   (1) In a steady glide 2.0
   (2) Under "Up" and "down" gusts of 25 feet per second (indicated) normal to the flight path 1.5

100. The aeroplane carrying its normal load shall be able to withstand an impact with the ground at a vertical velocity of 12 feet per second, and at this velocity the impact load on the undercarriage is not to exceed three times the weight of the aeroplane, fully loaded. The ultimate factor for the undercarriage when subject to this impact load shall not be less than 1.5 and for the remainder of the structure not less than 1.7 (this difference between factors is always to be maintained whatever modifications may eventually be made in the design of the experimental aeroplane). The ultimate factors on the limiting weight when the aeroplane is at rest on the ground shall not be less than the following:–

For the undercarriage	4.4
For the remainder of the aeroplane	5.0

The ultimate factor throughout the structure under a side load at the axle equal to the limiting weight of the aeroplane shall not be less than 1.1.

101. Should the realised factors for any part of the aeroplane prove to be less than those specified herein, a compensatory addition (equal to the estimated weight, as agreed between the D.T.D. and the Contractor of the reinforcement necessary to remedy the deficiency) will be made to the load to be carried during the type trials.

102. The torsional and flexural stiffnesses of the wings shall be satisfactory under the worst conditions likely to be encountered, and their natural frequencies of vibration shall be such that the lowest probable flutter speed will be above the maximum diving speed of the aeroplane. In calculating stiffnesses the contribution from fabric covering is to be disregarded. The Contractor shall provide facilities at his works for stiffness measurements to be made.

103. The strength of the fittings by which safety belts (and harness) are attached to the aircraft shall be in accordance with A.D.M.318.

104. The fuselage structure in the vicinity of the parts occupied by the crew is to be designed to afford the crew as much protection as possible in the event of a heavy landing or crash. Such structure shall be appreciably stronger than the adjacent parts so that these latter will absorb some of the shock by deformation before the former yields.

105. Satisfactory anchorages are to be provided for all such items of equipment as would, in the event of a heavy landing or crash, be liable to break from their positions and injure occupants of the aeroplane. The strength of the anchorages is to be at least as great as that of the structure to which they are attached under forward inertia forces acting parallel to the thrust line.

106. The ultimate factor for platforms or similar parts included in the aeroplane structure for lifting or supporting an engine, freight, personnel, etc. shall not be less than is required in the case of ancillary equipment designed for any such purpose (see A.P.970).

107. The tail wheel shall be capable of withstanding loads occasioned by sudden application of the brakes and abrupt changes in the aeroplane's direction of motion.

108. All normal requirements of Air Publication No.970 (edition of May 1935), except as modified by this specification, are to be satisfied at 1.1 times the weight corresponding to the normal load case. In estimating normal top speed the horsepower to be taken is two-thirds maximum engine power at maximum cruising r.p.m.

109. In calculating the strength of the structure under fin and rudder loads, the load specified in A.P.970, chapter III, para. 10, and chapter V, Section II, para. 2, is to be increased by trebling the ordinates of the present load distribution curve over the region from the fin leading edge to 0.3 of the fin chord aft of the leading edge.

110. The ultimate factor for control surfaces and systems under tail-to-wind loads in accordance with A.P.970 (May, 1935 edition), chapter 3, para. 24, shall be 2.

111. The requirements of Aircraft Design Memorandum No. 304 (Issue II) are to be satisfied.

112. The aircraft to be capable of being launched from a catapult at 1.1 times its limiting weight under the following conditions:–

1. The acceleration at the end of the catapult stroke to be 8½g.
2. Maximum catapult speed, 110 m.p.h.
3. Maximum side wind, 50 m.p.h. at 45° to catapult.

A factor of 2.0 is required under the above conditions.

Final examination.

113. The aeroplane is to be presented for the final inspection required by D.A.I. 14 days before the date quoted for its completion in readiness for flight tests. Seven days before the said date it is to be presented for final examination on behalf of the D.T.D. The final examination will deal with matters relating to equipment and installations, the operation of all controls and any device affecting safety of aeroplane or personnel. Items of maintenance and handling equipment to be supplied by the contractor for use with the aeroplane, are to be available at this final examination for demonstration of their use. The aeroplane is to be presented for examination equipped in accordance with the requirements of typical Service load, see paragraph 98. If so required, the contractor is to demonstrate that the alternative items of load detailed in the Appendix A can be installed in a satisfactory manner.

Weight and Centre of Gravity.

114. The Contractor shall furnish to the D.T.D. or his authorised representative (at least one week before the aircraft will be delivered to the official test station for type trials) written particulars of:–

(i) The tare weight of the aeroplane and

(ii) Its weight and the position of its centre of gravity when fully-loaded (unless it is likely that the aeroplane will be delivered for the trials in an incompletely equipped state, when the parts of which it is expected to be deficient shall be clearly designated, but their weights left out of account.)

115. The tare weight of the aeroplane is its weight when fitted with the fixed equipment detailed in column 10 of the Appendix "A", but not with any removable equipment, and with the fuel and oil tanks empty. In the case of aeroplanes with water or evaporatively-cooled engines, the weight of the cooling water is to be included in the tare weight.

116. The Contractor will be required to certify that the methods whereby the weight and centre of gravity have been determined are such that:–

(i) The stated weight is accurate to within 0.5%.

(ii) The stated C.G. co-ordinate parallel to the datum line (see Aircraft Design Memorandum. No.250) is accurate to within 1 per cent of the mean chord dimensions.

(iii) The stated C.G. co-ordinate normal to the datum line is accurate to within 5 per cent of the mean chord dimension.

117. On or before completion of the aeroplane the Contractor shall forward to the D.T.D. (R.D.A.3) an analysis of the weights of its constituent parts, etc. A form suitable for the analysis will be issued to the Contractor at or about the time when the contract is placed.

IV. Acceptance Tests.

118. Prior to the delivery of the aeroplane it shall have been certified to the D.T.D. by the Contractor that:–

(i) The aeroplane has been subjected by the Contractor's pilot to the following tests:–

1. General flying trials in accordance with Aircraft Design Memorandum No.291 at the normal, intermediate and limiting weights.
2. Diving tests in accordance with Aircraft Design Memorandum No.292 at the normal and intermediate weights.
3. Lateral stability tests in accordance with Aircraft Design Memorandum No.293 at the normal and intermediate weights.

(ii) The above-mentioned tests have shown that the aeroplane is safe to be flown by Royal Air Force Pilots.

119. The general requirements applying to the case of flight under manual control are that the aeroplane, when fully loaded, should:–

(i) Have positive stability about all axes.

(ii) Respond quickly to the controls and be fully controllable at any speed, especially near the stall when it should have no tendency to hunt;

(iii) Be easy to manoeuvre;

(iv) Not be tiring to fly;

(v) Form a steady platform for bombing and firing at any speed within its range;

(vi) Not experience excessive fluctuations in the speed for which it is

trimmed if the throttle control is moved from the correct position for that speed to any other position.

So far as may be possible without seriously reducing the aeroplane's suitability in the foregoing respects, the stability and control characteristics should also be conducive to the efficient working of automatic control apparatus. The aeroplane is to satisfy the requirements applying to manually-controlled flight as completely as possible when carrying any permissible load.

120. Effective longitudinal control is to be available at all speeds from the limiting speed to below the stalling speed.

121. Flight tests shall be made to ascertain how far the aeroplane complies with the main operational requirements at full load comprising:–

(a) Crew and all removable equipment (or ballast) including bomb load for normal range.

(b) Fuel and oil for normal range (or ballast to make up).

(c) The tare weight items, as shown in Appendix "A" to this specification.

122. At least 14 days before the final examination the Contractor should supply to the Resident Technical Officer for transmission to the D.T.D. (R.D.A.4) full particulars of the fuel, oil and engine cooling systems.

123. One week before the delivery of the aeroplane the Contractor is to submit the "Type Record", i.e. a detailed description of the aeroplane, such drawings as may be required, a summary of the strength calculations, records of strength tests, and detailed weight data, to the D.T.D. or his representative for acceptance.

124. When the aeroplane is handed over for type trials, copies of the General Arrangement Drawings of the completed aeroplane shall be forwarded, with General Arrangement drawings showing the lay-out of the whole of the equipment, to the D.T.D. (R.D.A.4) in duplicate, and similarly for any subsequent aeroplane, if different from the first.

Wind Tunnel Tests.

125. If so required at any time by the D.T.D. the Contractor shall furnish the drawings and data necessary in connection with the construction of a true-to-scale model of the complete aeroplane for test in a wind tunnel.

Publication of Test Results

126. The D.T.D. reserves the right to publish data contained in reports of any wind tunnel or other tests relating to the design of the aeroplane that may be undertaken on his behalf.

AIR STAFF REQUIREMENTS FOR A TWIN-ENGINED MEDIUM BOMBER LANDPLANE. SPECIFICATION P.13/36.

Appendix B.

1. The Air Staff require a twin-engined Medium Bomber for world wide use. It should be an aircraft that can exploit the alternatives between long range and very heavy bomb load which are made possible by catapult launching in a heavily loaded condition.

During all operations it is necessary to reduce the time spent over enemy territory to a minimum, therefore the highest possible cruising speed is necessary. Load carrying capacity and range with adequate facilities for an interchange of petrol and bomb load are of primary importance and all round defence is essential. In order to ensure that the all round defence is adequate power operated gun turrets are to be located in the nose and tail. The aircraft must be suitable for operation by day and by night at home and abroad and must possess the best possible bomb aiming and navigational facilities. Since this aircraft is to be used at home and abroad it must possess good facilities for maintenance in the open.

It appears that there is a possibility of combining the Medium Bomber, the General Reconnaissance, and the General Purpose classes in one basic design which can be adapted at some stage in its construction to each specific role. The following requirements are issued with this end in view. It is not intended that the type as a whole shall be able to carry out each of the three roles enumerated above. Special consideration is to be given to the possibility of carrying two torpedoes, see paragraph 5 (d).

2. Performance.

(i) Speed:- The speed at 15,000 feet must be not less than 275 m.p.h. at two-thirds maximum engine power at maximum cruising R.P.M. at normal loading.

(ii) Range:-

(a) At normal loading:- (500 yds. take off)

The range at 15,000 feet must be not less than 1,000 miles at two-thirds maximum engine power at maximum cruising R.P.M. at normal loading (including 1,000 lb. bombs) after ¼ hr. at maximum power at sea level.

(b) Increased load:- (700 yds. take off)
The range at 15,000 feet must be not less than 2,000 miles at two-thirds maximum power at maximum cruising R.P.M. with not less than 3,000 lb. bombs after ¼ hr. at maximum power at sea level.

(c) Maximum load:- (accelerated take off)
The range at 15,000 feet must be not less than 3,000 miles at two-thirds maximum power at maximum cruising R.P.M. with not less than 4,000 lb. bombs after ¼ hr. at maximum power at sea level.
N.B. Under condition (c) above it is hoped that a range of at least 2,000 miles will be attained when carrying the maximum possible bomb load i.e. 8,000 lbs. The maximum range for this aircraft should be not less than 3,000 miles.

(iii) Service Ceiling:- The service ceiling should be not less than 28,000 feet at normal loading. The aircraft at normal loading must be capable of flying level at 10,000 feet with one engine stopped.

(iv) Take-off and Landing:- Reasonable landing and take off conditions for an average sized aerodrome are required. The following conditions are given as a guide to what is considered reasonable.
When taking off at normal loading the aircraft should clear a 50 foot obstacle in not more than 500 yards. When landing at normal loading the aircraft should come to rest in 600 yards after coming in over a 50 foot obstacle. The landing run should not exceed 250 yards.

3. Crew.

Provision is to be made for a crew of 4 as follows:-

2 pilots. One of the pilots to act as navigator bomb aimer and front gunner.
1 W/T operator.
1 Air Gunner.

Accommodation must be provided for one additional pilot, who will act as relief pilot or navigator on long flights, and for one additional observer who will act as relief W/T operator or air gunner on long flights. This provision to be regarded as alternative load.

4. Armament:-

(i) Forward:- Two guns in a power operated turret under the control of the second pilot, who must be able to fire from a seated position. Each gun

must be provided with not less than 1,000 rounds of ammunition and must cover the following areas:–

Azimuth:– Wing tip to wing tip or airscrew disc to airscrew disc and not less than 180°.

Depression:– not less than 45°

Elevation:– not less than 45°

(ii) Tail:– Four guns in a power operated turret, under the control of the air gunner who must be able to fire from a seated position. It is essential that access to the tail turret is provided from within the fuselage. Each gun must be provided with 1,000 rounds of ammunition, it is desirable that 1,500 rounds be provided if this can conveniently be arranged. The guns must cover the following areas:–

Azimuth:– not less than 180°

Depression:– not less than 45°

Elevation:– not less than 60°

A reserve of 6,000 rounds (or 4,000 rounds if 1,500 are provided for each gun at the tail position) is to be stowed in such a manner that the extra supply can quickly be fed to the guns at the tail position. The reserve ammunition to be alternative load.

Note:– Any satisfactory alternative scheme for remote control of the guns which will help towards minimising the resistance of the turrets will be considered.

5. Bombs†:–

Provision is to be made for carrying a maximum bomb load of 6,000 lb. which may be made up in any of the following forms:–

(a) 16 250-lb. G.P. or A.S. or S.A.P. or "B" or L.C. or S.C.1. apparatus (4,000 lb.)

or

(b) 16 500-lb. G.P. or A.S. or S.A.P.

or

(c) 4 2,000 lb. A.P.

or

† G.P. General Purpose; A.S. Anti-shipping; S.A.P. Semi-armour piercing; L.C. Light case; S.C. Smoke curtain; A.P. Armour piercing.

(d) It may be possible to use a limited number of this class of aircraft for torpedo dropping. When submitting designs therefore it should be stated whether it will be possible to carry internally two torpedoes – 18″ diameter 18′ 2½″ length with a special tail portion, particulars of which will be supplied – without reducing the performance or altering the main structure of the aircraft. If this is possible details are to be given in the tender designs.

Internal horizontal stowage for bombs in superimposed tiers or some equivalent arrangement will be required.

Two light series bomb carriers, capable of being reloaded in the air, are to be provided for carrying practice bombs. They are to be easily detachable so as not to interfere with the war role of the aircraft. Provision for carrying 16 practice bombs in the aircraft is to be provided.

It is realised that conversion from the universal carrier to the 2,000 lb. carrier may take some time but provision is to be made for carrying out the work as quickly as possible.

Further details of the carriage of bombs, including rate of release, have been issued and should be read in conjunction with the above.

6. View.

The best possible all round view for pilot, navigator and bomb aimer and air gunner is to be provided but this is secondary to performance. A good view backwards for the pilot or someone standing beside him is important.

A good view for formation flying is required both for formation leader and flanking aircraft as well as for landings at night.

7. Manoeuvrability:-

A high degree of manoeuvrability is not essential but the aircraft must be sufficiently manoeuvrable at high speeds for dive bombing, the provision of flaps to reduce the speed in the dive should be considered. The controls must be positive and effective in order to provide a stable bombing platform.

8. Equipment.

The following are required:–

(i) Full night flying equipment including wing landing lights and station keeping lights.

(ii) W/T, R/T, D/F and internal communication between crew stations. Provision for the installation of blind flying and blind landing equipment.

(iii) Oxygen for a crew of four for 5 hours as part of the normal load. In addition it will be necessary to make provision for oxygen for a crew of six for 10 hours. This increase is to be considered as alternative load.

(iv) Camera.

(v) Automatic controls.

(vi) Cockpit heating at all crew stations.

(vii) Provision for anti-icing equipment.

(viii) Emergency dinghy/s for crew of six with appropriate marine distress signals.

(ix) Full flotation gear (G.R. class only).

(x) Stowage for desert equipment.

(xi) Stowage for 20 flame floats and 12 aluminium dust markers as alternative load.

9. Special Features.

(i) Navigation is to be done in the vicinity of the pilot's station. Bomb aiming is to be done from the front station which is to be so arranged that the bomb aimer can work from a seated position.

(ii) Launching tubes will be required for 4″ training flares (which is also used as a forced landing flare) and 4.5″ and 5.5″ reconnaissance flares. The flares may be regarded as alternative load. Stowage must be provided for 4 training flares and 12 reconnaissance flares.

(iii) Tropical engine cooling is to be incorporated or made easily attachable.

(iv) The fuselage is to be so constructed that any member of the crew can move from his usual station to any other station.

(v) Attention must be paid in design to good ventilation of all crew stations and it is desirable that sun proof blinds are fitted above all crew stations for use in the tropics.

(vi) Provision is to be made for fitting a blind flying hood to the pilot's seat.

(vii) Suitable lugs are to be provided to which cables can be attached for moving the aircraft about by tractors when on the ground.

(viii) The design, construction and material of the aircraft is to be such as to facilitate production in quantity. Wherever possible standardised parts

and fittings, including A.G.S. parts which can be obtained in quantity production are to be used.

(ix) At least one parachute exit must be provided in the floor of the fuselage. This exit/s should also be suitable for supply dropping.

(x) In view of the fact that the aircraft may be in the air for periods of 10 to 14 hours, it is desirable that attention be paid to sound-proofing the pilot's and W/T operator's cabins.

(xi) A latrine is to be provided for use of the crew.

(xii) Consideration is to be given in design for fitting a light removable form of seating for the maximum number of personnel that can be accommodated within the fuselage when the aircraft is being used for reinforcing purposes.

(xiii) Particular attention is to be paid to providing facilities for changing engines in not less than two hours.

Load Factors. (Added by D.T.D.)

When operating at maximum load the load factors shall not fall below the following standards.

(i) C.P. forward. 5.5

(ii) C.P. back. 4.2

(iii) Factor under up and down gusts of 25 ft./second when the aeroplane is flying at its normal top speed at maximum weight x 1.1 2.0

(iv) The aeroplane when carrying its normal load shall be able to withstand an impact with the ground at a vertical velocity of 12 ft. per second, and at the velocity the impact load on the undercarriage is not to exceed three times the weight of the aircraft. The ultimate factor for the undercarriage when subject to this impact load shall not be less than 1.5, and for the remainder of the structure not less than 1.7. The ultimate factors at the limiting weight for aerodrome take-off and when the aeroplane is at rest on the ground shall not be less than the following:–

For the undercarriage 4.4

For the remainder of the structure 5.0

(v) All normal requirements of A.P.970 are to be satisfied.

CHAPTER II
Trials

REPORT NO.47
TACTICAL TRIALS – LANCASTER AIRCRAFT

Air Fighting Development Unit,
R.A.F. Station, Duxford.

Introduction

1. In accordance with arrangements with Headquarters, Bomber Command, trials of the Lancaster I commenced on 24.4.42 at Duxford with a crew from No.44 Squadron to discover the fighting capabilities of a single aircraft. A tactical circus of 3 Spitfires then visited all the Lancaster Squadrons in No.5 Group, Bomber Command, and carried out a series of affiliations both with single aircraft and with various formations. The information obtained from this work is embodied in this report

Brief Description of the Aircraft

General

2. The Lancaster I is a mid-wing monoplane powered with 4 Merlin XX engines developing 1280 h.p. each. The present gross all-up weight is 60,200 lbs., and the maximum bomb load carried at present on operations is 12,000 lbs., though there is provision for carrying 14,000 lbs. when necessary. With 12,000 lbs. of bombs the total air mileage that can be covered is 1,100–1,200 miles. The maximum air mileage available is about 2,000 miles, in which case the bomb load must be reduced to 4,000 lbs.

Crew

3. The crew consisted of seven whose duties were as follows:–

Captain & 2nd Pilot	–	At controls
Air Observer	–	Navigator and Bomb Aimer
1st W/Op. Air Gunner	–	W/T
2nd W/Op. Air Gunner	–	Front Turret
Air Gunner	–	Mid-Upper Turret
Air Gunner	–	Tail Turret.

4. It is understood, however, that the 2nd Pilot will shortly be replaced by the Pilot's Assistant who will aid the Pilot and also act as Flight Engineer and Front Gunner. An Air Bomber whose duties are map reading and bombing will be carried in place of a second Wireless Operator.

Wireless and Inter-communication

5. Standard bomber wireless installation is carried. The T.R.9 for inter-communication has proved fairly satisfactory, but a very high standard of maintenance is necessary if this is to be relied on for formation fighting control.

De-icing Equipment

6. De-icers are provided for the propellers but there is no protection for the main or tail planes other than de-icing paste.

Balloon Cutters

7. Balloon cutters are fitted along the loading edge of the mainplane.

Armament Characteristics

General

8. The Lancaster is at present armed with .303" Browning guns in three Fraser-Nash turrets. The F.N.5A in the nose and the F.N.50 in the dorsal position have two guns each, with an ammunition supply of 1,000 rounds per gun. The F.N.20 in the tail has 4 guns with servo-feed mechanism and 2,500 rounds per gun. There is also provision for an under-turret – the F.N.64, with 2 guns and a periscopic sight. This is not yet in the Service but was fitted to the aircraft while at Duxford so that trials could be carried out to discover the tactical value of the turret. A full report on this turret will be issued separately.

Front Turret

9. The F.N.5A in the nose has a good field of view and is satisfactory in all respects except that there is no foot rest for the gunner. This is extremely inconvenient when the bomb aimer is in position as the gunner is liable to tread on the bomb-aimer's head in moments of stress.

Mid-Upper Turret

10. The F.N.50 in the dorsal position is a comfortable and roomy 'turret', although the seat design is unsatisfactory. This results in the gunner having

great difficulty in entering or leaving the turret. The field of vision is very good and attacks can be seen from any angle except a very steep climbing attack from dead astern. The turret has rotation through 360 degrees and its movement when the guns are elevated about 20° is fast and smooth. Cut-outs are provided for the tail fins and a taboo cam track runs round the turret to prevent damage to the wings, propellers and the tail unit. A restrictor valve is fitted to the hydraulic system to slow down the movement of the guns when they are depressed on to the taboo cam so that a violent movement does not damage the fuselage or fairings. This restriction, however, is not at all satisfactory since the movement of the guns is slowed down so much that it is impossible to follow a fighter who breaks away at fairly close range. As this is usually the air gunner's best opportunity to shoot the fighter down, the loss of rotational speed at this critical moment is serious. While some restriction is clearly necessary it is considered that the present reduction in speed is too great for reasonable operational requirements. The fairing which has been introduced aft of the turret for streamlining purposes is also too high, as the cam track which runs over it cuts down the field of fire between the fuselage and the fins considerably.

Tail Turret

11. The F.N.20 turret in the tail is satisfactory and accurate, and fast traversing is possible. The vision is naturally somewhat restricted by the armour and gun mountings, but it is impossible to have armour and perfect vision, and a reasonable compromise has been effected. Unless the base of the turret is kept perfectly dry, oil is liable to be forced up the rear perspex by the slipstream, but a clear vision panel 6″ wide by 3″ long has much improved the position. This makes the gunner very cold under icing conditions, but the extra vision and reduction of searchlight glare more than compensate for the discomfort. One other minor criticism of this turret is that the doors are liable to burst open when taking violent evasion as the locking catch is not sufficiently positive.

Under Turret

12. The F.N.64 in the under position is smooth in operation and the view through the periscopic sight is remarkably good, although limited to 60° cone. However, the turret rotates through 180° and search can be carried out without difficulty. A cut out is provided for the tail wheel and the lower part of the fins which are just within the field of fire.

Fields of Fire

13. The fields of fire of the three main turrets are shown in Appendix 'B' with an additional diagram showing the scope of the under turret. The fire power overlaps well and the only serious criticism is the blind spot of the mid-upper directly astern.

Sights

14. The G.J.3 reflector sight is fitted in all turrets except the under turret which has a prismatic sight with 25 and 50 m.p.h. rings.

Harmonisation

15. The four guns of the rear turret are harmonised on a point at 250 yards by night and on a 7′ 6″ square by day. The upper and front guns are usually harmonised 5 feet apart at 400 yards.

Armour

16. Apart from normal turret armour for the Air Gunners, the main protection for the crew consists of an armoured door 7 mm. thick behind the wireless operator's position. The Pilot also has two plates of armour, each of 4 mm. thickness, behind his seat and a head piece of 8½ mm. Bullet proof glass 2½″ thick is provided behind the 2nd Pilot's position. The petrol and oil tanks are self-sealing but the engines have no protection.

Tactical Trials

Flying Characteristics

17. The Lancaster is reasonably manoeuvrable for a large aircraft. The controls are positive and moderately heavy under normal cruising conditions, but tend to stiffen appreciably as speed is increased over 200 m.p.h. When any evasive manoeuvres are attempted, however, there is a considerable lag in the aileron control and this is very marked when the aircraft is fully loaded. This means that considerable practice is required before violent evasion is possible at ground level. The cruising speed is approximately 185 m.p.h., I.A.S.†, with full load and about 220 m.p.h., I.A.S., when light. The maximum speed near the ground at a weight of 60,000 lbs., is approximately 220 m.p.h., I.A.S.

† Indicated Air Speed

Fields of View and Fighting Control

18. The combined all-round view from the Lancaster is good. Owing to the raised position of the cabin the pilot's general view, although slightly restricted on the starboard side, is satisfactory towards the beam and quarter, and of considerable assistance in taking evasive action. The Fighting Controller can stand just behind the 2nd Pilot but this gives a poor view downwards and even if he used the astro-hatch beside the Wireless Operator, he is still given a large blind area by the mainplane. For this reason control is mainly carried out by the mid-upper gunner who is able to see all attacks except those from beneath and directly astern. For these he relies on the rear gunner so that with practice a good commentary can easily be maintained.

19. It is considered, however, that it is a mistake for air gunners to carry out fighting control as it is extremely difficult to combine control with good shooting. If therefore a low level sortie is to be made, with the result that attacks must develop from above, the fighting control should be carried out from the astro-hatch.

Fighting Manoeuvres for Single Aircraft

20. General – The trials were carried out with the object of discovering the best method of evasion by the Lancaster against all types of attack both by single fighters or by a number of fighters simultaneously.

21. It has already been found in previous trials with heavy bombers that the only really effective evasion against the astern, quarter or beam attacks is the corkscrew, or the tight turn towards the fighter. Other forms of evasion, such as skidding, undulation and throttling back are useful but not as effective.

22. Corkscrew – This evasion consists of a steep diving turn of about 30° and 500 feet, followed by a steep climbing turn of 30° and 500 feet in the opposite direction. The manoeuvre must be as violent as possible, particularly at the top and bottom of the corkscrew, to avoid giving an easy deflection shot. It should begin when the first fighter attacking is at 600 yards and should be continued throughout the engagement unless all the fighters attacking can be clearly seen by the Controller to be out of position, when normal flight can be resumed. This evasion is tiring for the pilot and must be stopped immediately it is clear that no immediate attacks are developing. The main advantages of corkscrewing are that the bomber can make good its course, while the fighter is given difficult deflection in two dimensions in that he has to aim in front and below during the diving turn, and in front and above during the climb. Assessment of fighters

cine camera gun films proved in the case of the Lancaster, as with other 4-engine bombers, that even the most experienced fighter pilots who knew what the evasion was to be were only able to obtain moderate results. Height can be maintained without any extra throttle opening when the Lancaster is without bomb load, but when fully loaded slight opening is necessary to regain height in the climbing turn. This evasion does not affect the air gunner's shooting as much as a tight turn and did not prevent them from obtaining good cine camera gun results when they became used to the movement.

23. Tight Turn – The Lancaster is sufficiently manoeuvrable to be able to do a very tight turn and if this is timed correctly, a fighter who is making an attack at a fast overtaking speed is given difficult deflection and only a short burst of fire. Against a steep diving attack, a slightly climbing turn is advisable but against a normal astern attack, a diving turn is best as it enables the Lancaster to gain speed. Both these manoeuvres increase the fighter's deflection. The tight turn is the best evasion against a single fighter provided that it is correctly timed – at about 600 yards – and that there is no question of shortage of petrol or other fighters coming up to engage the bomber. Under the latter circumstances or if more than one fighter is attacking, the corkscrew evasion is more effective, because it enables the bomber to maintain a course and height instead of flying in circles.

24. Head-on Attacks – Head-on attacks were carried out against the Lancaster but were difficult to deliver owing to its high speed. It is often possible for the Lancaster to prevent the attack developing by edging towards the fighter when it is trying to get into position. If the attack is delivered, a diving turn at about 800 yards is effective and gives the fighter an extremely difficult deflection allowance. The mid-upper gunner, who will be facing forwards for this type of attack, is given a reasonable shot.

Fighting Manoeuvres for Formations

25. Low Level Attacks – It is considered that a formation of more than 3 Lancasters is unwieldy if adequate individual evasive action is to be taken. The 3 aircraft should be in Vic formation with Nos. 2 and 3 only slightly behind the leader and at about 1½ wing spans interval. The leader can fly at about 50 feet with Nos. 2 and 3 slightly above, to give them a small margin if the leader has to climb up suddenly to avoid ground obstacles.

26. Fighter affiliation carried out with the Squadron has proved that if a formation of Lancasters simply relied upon low flying, it will always provide an

easy target for fighters. If the formation is intercepted it should therefore climb up to about 600–700 feet. This is absolutely essential to give the bombers room to manoeuvre. It cannot be over-emphasised that flying at ground level is not in itself an adequate form of evasion when attacked.

27. In the past it has usually been considered that tight turns in formation are the best form of defence against fighters but it is almost impossible with heavy bombers to make the turns sufficiently steep to upset the fighter's aim. Turns also have another very serious defect as they have to be begun early in order to make them at all effective, and this results in the formation turning through nearly 180°. It can be seen that a series of turns results in the bombers flying in circles so that they waste petrol and are unable to maintain their track towards the target.

28. It has also been found in the majority of recent daylight operations that the German fighters are shy of the power-operated turrets and stand off at 600–400 yards using their cannon. The result is that if any close formation is adopted by the bombers they present a mass target while adding nothing to their mutual fire support, owing to the extreme difficulty of achieving a correct aim at long range with our present sights.

29. It has therefore been necessary to develop a form of evasive action which will give the bombers a chance to carry out individual evasion while maintaining their track to the target and giving each other assistance. Just before the fighters attack the Lancasters should climb up to about 600 feet and numbers 2 and 3 should come well up on the beam of the leader. When the fighters close in the leader of the Vic should undulate violently between 600 feet and ground level, while Nos. 2 and 3 carry out a modified form of corkscrew on either side of the leader beginning with a diving turn outwards of about 20° and varying their height between 600 and 100 feet. Practice is necessary to ensure that the outside aircraft are never more than 300 to 400 yards from the leader and that they do not mask his guns by sliding in behind him during their inward movement. Nos. 2 and 3 should attempt to keep as close as possible to the leader until an attack actually develops so that during their evasion they will not go too far away from him. This evasive manoeuvre enables the formation to continue upon track while it gives the fighters difficult deflection shooting. The fighters found it hard to attack the leader as he was protected by the guns of the outside aircraft, and if they followed an outside aircraft in its corkscrew, they were soon drawn under the leader's guns. A further advantage of this manoeuvre is that the slipstream of the formation is

fanned out over a large area and frequently upsets the fighter's aim, being particularly unpleasant near the ground. This evasion has been tried by nearly all the squadrons of heavy bombers and has proved very satisfactory under practice conditions.

30. R/T and Fighting Control - An advantage of the formation corkscrew movement is that fighting control by the leader is not essential. It is still necessary so that the leader can warn Nos. 2 and 3 when he wishes to change course, but with the present standard of R/T equipment and maintenance, it is not advisable to rely absolutely on T.R.9 control.

31. High Level Attacks - Little high level formation flying has yet been attempted. It is considered that the corkscrew evasion described for low level attacks will again be effective and would be useful against flak prior to the actual bombing run. It is thought, however, that fighting control from the leader would be essential, so that the formation could have time to settle down preparatory to bombing.

Night Flying

32. A short night flight was carried out with a fighter observing the exhaust flames from the Lancaster; there was no moon and 10/10ths cloud. The flames appear as a very dim glow and can be seen from about 500 yards dead astern. On closing range they appeared rather like 8 bright cigarette ends at about 150 to 200 yards. The exhausts are not visible from any position other than dead astern and at long ranges are unlikely to catch the eye of a night fighter pilot until he is looking directly at them.

Slipstream

33. The slipstream of the Lancaster is fairly strong at the same level as the aircraft back to 600 yards, but is only of real tactical value at about 400 yards where it is sufficiently vicious to upset a fighter's aim completely.

Conclusions

General

34. The Lancaster is capable of carrying a large bomb load at a good cruising speed. Its range is superior to that of other heavy bombers except the Liberator. Aileron control when fully loaded is not good, but the aircraft is still very manoeuvrable for its size. (paras. 2 & 17).

Armament

35. The armament of the Lancaster at present consisting of nose, mid-upper and tail turrets, is good. The field of fire of the upper turret towards the rear is only moderately satisfactory. (paras. 8 & 10).

36. The new under-turret – the F.N.64 – which is not yet in the Service, is of considerable value for daylight operations. A separate report will be issued shortly which will cover the possibilities of this turret for day and night use. (para. 8).

37. Adequate armour protection against 7.9 mm. machine guns is provided for the crew. (para. 16).

Tactical

38. The field of view of the crew is satisfactory and good fighting control can be carried out. (para. 18).

39. For a single aircraft the best evasion against astern, quarter or beam attacks is the corkscrew or the tight turn. (paras. 22 & 23).

40. Against head-on attacks a turn and dive is effective. (para. 24).

41. For formation flying a Vic of three is the most suitable unit. For high or low level attacks the best evasion is by individual action by each of the 3 aircraft. The leader should undulate steeply while Nos. 2 & 3 corkscrew on either side of him. This can be done without losing the value of mutual fire support. It enables the formation to maintain track towards their target while giving attacking fighters difficult deflection shooting. (paras. 25–28).

42. If intercepted during a low level operation, it is essential for a formation to climb up to about 600 feet to give themselves room for evasive action. Evasion by low flying only is not effective. (para. 29).

AFDU/3/20/2
30th May 1942.

LANCASTER I – FIELDS OF FIRE

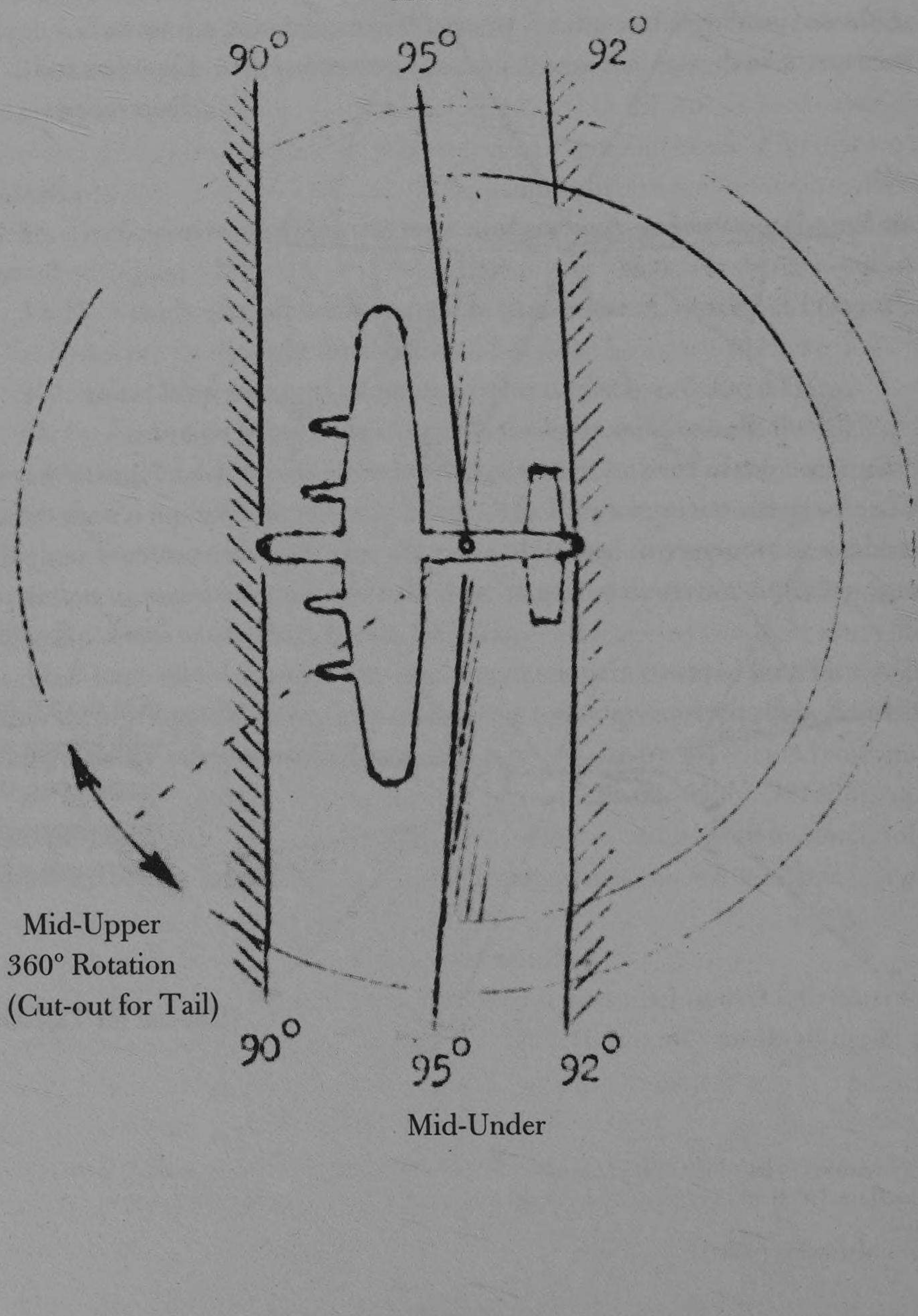
Appendix 'B'

Elevation and Depressions

(On the a/c on which trials were carried out, the max. depression astern was +10°)

(Cut-out for Tail wheel)

AZIMUTHS


Mid-Under
90°
95°
92°
Mid-Upper
360° Rotation
(Cut-out for Tail)
90°
95°
92°
Mid-Under

NIGHT COMBAT TRIALS WITH A LANCASTER

F.I.U. Report No.201.

1. Introduction

(i) At the request of Headquarters No.5 Group, and by agreement with Headquarters, Fighter Command, F.I.U. have carried out Night Trials of the various forms of evasive action at present advocated for the Lancaster. A full investigation of the gunnery problems involved in diving turns and corkscrews has been made by the A.F.D.U. (A.F.D.U. Report No.71), and since F.I.U. has at present no facilities for cine-camera gun work at night, it was understood that no attempt could be made to supplement the A.F.D.U. findings with regard to gunnery. However, by carrying out the trials under strictly operational conditions, it was expected that the following points could be investigated:–

(a) Blind spots and efficiency of search methods.

(b) Escape from the fighter pilot's vision.

(c) The opinion of fighter pilots with regard to aiming problems.

(d) The operational significance of the Lancaster's exhausts.

(ii) Preliminary evasion trials with a Halifax equipped with Monica[†] have already been carried out by F.I.U. (F.I.U. Report No. 192), and it is important that the results of the two trials should not be confused. The problem of night evasion is complex, and it must be clearly understood that there is an essential difference in object between the Monica trials and the present series. Monica offers a method of preventing the fighter pilot from securing a visual, and may possibly enable the bomber to escape from the fighter's A.I.[‡] coverage. Monica manoeuvres in the pre-visual stage of the interception are designed to exploit the time interval which inevitably elapses before the fighter pilot receives information of the bomber's change of position. In the visual stage no such time interval exists, and such manoeuvres may well be ineffective.

2. Nature of Trials.

(i) A No.5 Group Lancaster arrived at F.I.U. on April 26th, 1943, piloted by Flight Sergeant Landon, D.F.N., V.H.F. for G.C.I. control and air-to-air

[†] Tail warning radar which alerted the crew of a night fighter approaching from the rear, but also allowed the Germans to develop a passive detector to allow their night fighters to home in on the signal.

[‡] Air Interception (radar)

communication was fitted, and two series of trials were carried out on April 27th and 28th respectively under control of Durrington G.C.I. in dark starlight conditions, at a height of 12,000 ft.

(ii) In order to test the blind spots and efficiency of search, the Lancaster carried out an irregular weave 30° either side of course, while the fighter made approaches from various positions and closed in to shooting range (200 yards). As soon as either gunner spotted the fighter, he flashed a torch from his turret, and the fighter's range was then measured by A.I.

(iii) The following forms of evasion were tested:–

(a) A diving turn with 60° bank, rate 2½, losing 1500–2000 ft. of height, with speed increasing from 175 to 250 m.p.h.

(b) A corkscrew, turning 30° in the dive, and 60° in the opposite direction during the subsequent climb. The height lost in the dive was 1000 feet and the speed range 220–160 m.p.h.

(c) A diving turn till the speed reached 220 m.p.h., followed by a sudden pull-up, with 25 degrees of flap and engines throttled well back, levelling out when the speed fell to 140 m.p.h.

(iv) In order to assess collision risks, in the initial stages of the trials the fighter pilot positioned himself 800 feet astern, and then requested specific manoeuvres by R/T. Subsequently the fighter pilot carried out practice attacks, switching on his navigation lights when he had his sights on at 60 feet range. The bomber was at liberty to carry out any of the three forms of evasion as soon as the rear gunner saw either the silhouette or the navigation lights.

(v) A Lancaster from B.D.U. arrived at F.I.U. on May 6th, 1943, piloted by Squadron Leader Daniels, D.S.O., D.F.C. This aircraft had a perspex blister fitted under the nose, the rear portion of the blister being cut away to provide a clear vision panel. By lying on his stomach and bending his head downwards into the blister, the Air Bomber was thus able to search the area below and astern. Trials were carried out on the night of May 6th, 1943, to assess the efficiency of downward search from this aircraft, and to test further evasive tactics which had been worked out since April 28th, 1943.

(vi) The trials were made with a Mosquito with Mark VIII A.I., a Beaufighter VI with Mark VIII A.I., and a Beaufighter I with Mark IV A.I. The pilots were of average flying ability, but above the average in night fighter experience, particularly with regard to this form of trial. The trial thus provides an answer only in respect of experienced crews on dark moonless nights, and the answer may prove in practice to be unduly pessimistic. However it is impossible to

make an assessment of how the strictly average crew would react; and still less is it possible for this Unit to assess the relative efficiency of the G.A.T. night fighter pilots, aircraft, and equipment.

3. Results of Trials with the No.5 Group Lancaster.

(i) Blind spots and search.

Trials on the first night were carried out over land in dark starlight with no cloud above or below. The night was very clear, and visuals of the Lancaster's silhouette were obtained from below at ranges of up to 3000 feet. In those conditions the downward visibility range is likely to be very short, and the fighter would always approach from underneath, to exploit this advantage to the full. It was found that the fighter could remain just astern of the bomber and 300–400 feet below, for an indefinite period without being seen, and that if the bomber stopped weaving, the fighter could always reach a position dead astern and obtain a non-deflection shot at 150–200 yards before being spotted. One pilot carried out seven of those attacks, being observed three times, but never until he had held the Lancaster in his sights for at least six seconds. The other pilot taking part reported that he had followed the Lancaster astern and slightly below for five minutes, taking periodic deflection shots without once being spotted. Similar results were obtained with a Mosquito on the second night, the pilot making five attacks from astern and below, and only being observed once. On ten subsequent attacks from various angles the Mosquito was spotted four times but this was mainly due to the pilot misjudging approach speed and being forced to throttle back suddenly, causing a belch of flame from the exhausts. All pilots agreed that although deflection aiming was normally difficult on dark nights, the size of the Lancaster combined with the gentleness of the weaving made aiming very much easier than usual.

(ii) Evasive action.

(a) Diving turns.

These were followed visually in most cases, but the fighter always lost ground and there was a chance that the visual would be lost if the bomber managed to get below in the early stages. It was the general opinion of pilots that shooting during this manoeuvre on a dark night would be virtually impossible.

(b) Corkscrews.

Pilots found no difficulty at all in following visually but felt that they would

not be able to shoot except during the change of direction at the bottom and top of the corkscrew.

(c) Slowing down.

This manoeuvre was not sufficiently sudden to be effective, nor was the final speed low enough to inconvenience the fighter seriously. It was always held without difficulty, even in the Mosquito, and on occasions without having to resort to lowering the undercarriage. There was a good chance that the fighter would reach a perfect shooting position during the latter stages.

(iii) The Lancaster exhaust system.

F.I.U. has already made a full investigation of visibility ranges of the Lancaster's exhausts (F.I.U. Report No.187). In the present trials the silhouette was always picked up before the exhausts, and the opinion of this Unit that the Lancaster's exhausts would not betray its position to a night fighter approaching below was thus confirmed. Provided that the fighter is astern and at more or less the same level, i.e., in a position from which it is possible to look up the shrouds, the exhausts are seen very plainly at ranges of less than 1500 feet, and undoubtedly help the fighter in the following evasion and in aiming. In more violent manoeuvres however and particularly in the diving turn, it was found that the exhausts rapidly disappeared, the angle of the Lancaster relative to the fighter having increased to a point at which the fighter pilot could no longer look up the shrouds. During the slow-down evasion observations were made to see whether the opening and closing of the throttles caused flame belch, but no excessive flame was noticed.

4. Trials with the B.D.U. Lancaster

(i) Weather conditions.

The trial was carried out at 14000 feet, and lasted from 01.30 hours until 03.30 hours. There was no moon, and in general the night was very much darker than the nights of April 27th and 28th, silhouette range being only 2000 feet as opposed to 3000 feet in the previous trials. At the beginning of the trials there was 5/10 low cloud, which however was too far below and too dark to give any assistance to observers in the bomber; this cloud dispersed after the first half hour. There was also 2/10–3/10 high cloud, at about 20000 feet, which persisted throughout the trial.

(ii) Test of Search.

The Lancaster flew straight and level, and the fighter, a Beaufighter VI, approached from below to a minimum distance of 350 feet, astern and below, finishing up dead astern at a range of 500 feet, which was the maximum range at which satisfactory aiming was possible on such a dark night. A total of 6 attacks was made, the fighter being observed once by the rear gunner when dead astern. The observer in the nose blister never saw the fighter, and it was the impression of all concerned in the trial that in such dark conditions a downward spotting was most improbable.

(iii) Evasive action.

The trials were carried out in exactly the same manner as the previous trials with the No.5 Group Lancaster, except that the fighter was at a rather closer range, owing to the darkness of the night. The rear gunner did not spot the fighter on any attack, and the Lancaster pilot acted in each case when the fighter's navigation lights were flashed. The following manoeuvres were tested:–

(a) A standard corkscrew, but using flap in the climbing turn and allowing the speed to drop off to 130 m.p.h. in the climb. It was hoped that this would either produce an overshoot, or prevent the fighter from getting his sights on at the top of the corkscrew owing to his reduced ability to turn at such a low speed. In fact the manoeuvre could be followed relatively easily, and by using flap the fighter brought his sights on at the top. In the climbing turn it would have been impossible to shoot as the bomber was above the fighter, and the fighter's nose could not be raised without the danger of a stall.

(b) An extended corkscrew, with climbs and dives sustained. The Lancaster throttled back and dived steeply for 1000 feet continuing in a steep diving turn for 30° for a further 1000 feet, the air speed reaching 270 m.p.h. It then pulled out and carried out a steep climbing turn through 60° in the opposite direction at full climbing power, allowing the air speed to drop off to 135–140 m.p.h. The climb was then sustained at this speed, and at full power until the Lancaster regained its original height, when it turned back on to its original course. It was hoped that the initial dive would put the bomber below the fighter or alternatively that if the fighter managed to stay below the bomber he would be too far below during the sustained climb to bring his sights on at such a slow climbing speed. This manoeuvre proved considerably harder to follow than the normal corkscrew and in the initial dive the fighter was forced to abandon his attack immediately and dive steeply to keep the bomber against the sky. During

the pull out and subsequent climbing turn the fighter usually ended up well below the bomber, and on one occasion the visual was lost owing to the bomber turning into a background of dark cloud. During the sustained climb at low speed the fighter found difficulty in making up the lost height difference even with the use of flap, and was not in fact able to carry out a further attack until the climb was completed. The fighter pilot found that during the climbing turn his aircraft was in a most uncomfortable attitude, and that he was only able to follow by keeping his attention entirely on the bomber, and getting his observer to pass him readings from the airspeed indicator in the rear cockpit.

(c) A dive and orbit. The Lancaster dived as steeply as possible for 1000 feet and then carried out a tight diving orbit at rate 3 through 360°, losing a further 2000 feet, with an airspeed of 270 m.p.h. As in the previous manoeuvre, the initial steep dive forced the fighter to abandon his attack and dive more steeply in order to keep his visual. During the subsequent orbit the ranges increased and the visual was lost about half way round the turn, though A.I. contact was retained without difficulty, the range being stabilised at 3500 feet. At the end of the manoeuvre the fighter was forced to search for a fresh visual and wasted several minutes in getting back into the correct position.

5. Discussion of Results.

(i) Search.

(a) It is clear from these trials that on a starlight night with no moon the Lancaster is extremely vulnerable to a fighter approaching from below. In these conditions the downward visibility range is believed to be of the order of 400 feet, and if warning of an attack is to be received it is essential that there be good facilities for downward search. In the Lancaster, during normal search weaving, with the fighter at 300 feet in an area astern and below, the search of the rear gunner, the mid-upper gunner, and the air bomber is not effective and furthermore this area is identical with the area within which the night fighter approaches with greatest ease and comfort. It follows therefore that in dark conditions the "search" weave is only of value in increasing the shooting difficulties of the unseen fighter, and in the opinion of this Unit the increase with the present weave is not very great. The difficulties increase in proportion to the strength and continuity of the weave, particularly if it involves changes of height, but the strain on the bomber pilot and the problems of navigation increase correspondingly, and it may be impossible to sustain a weave of profitable strength (rate 1½) except for short periods.

(b) The results obtained with the under-blister show that with this particular type of blister spottings cannot be expected during a normal night fighter approach on a very dark night. There is a possibility that the design of this blister and the position of the observer are unsuitable for efficient downward search. There is also the possibility that previous estimates of downward visibility on moonless nights have been optimistic. In order to clarify the situation, further search trials must be carried out with and without the under-blister in half-moon and full moon conditions. Until those trials are complete, speculation on the subject of search in bright conditions will be unprofitable.

(ii) Evasive action.

(a) In night combat the bomber pilot has the choice of attempting to escape from the fighter pilot's vision, or of manoeuvring to "shoot it out" under conditions most favourable to the bomber. If he decides to attempt an escape, he has three alternatives:–

1. To open up the actual range.
2. To reduce the fighter's visual range by getting below or against cloud.
3. To cause an overshoot.

(b) In moonless conditions the actual range tends to open up during diving orbits, and if these are carried out according to the B.D.U. formula there is a good chance of success even against experienced fighter crews. The initial straight dive is an essential preface to the manoeuvre, since it immediately prevents the fighter from continuing to shoot, and, in addition, disconcerts him by its suddenness. However, the orbit entails considerable loss of height and distance, and it is unlikely to make the fighter lose A.I. contact even with Mark IV A.I. Hence it should be regarded as an extreme remedy which will give the bomber a few minutes breathing space.

(c) The chances of getting below an experienced fighter pilot are poor, as he can always frustrate the move by diving more steeply. A dive however has great value in forcing the fighter to break off his attack, and as a preface to further evasion. It may well be successful against novices, and will certainly be successful on dark nights if the fighter tries to keep his sights on.

(d) In the extended corkscrew the range again tends to open up, but not sufficiently to produce visual escape unless advantage can be taken of cloud background. In the presence of suitable background this type of corkscrew is a sound form of evasion, since it does not entail loss of height or distance. However even if the visual is lost, A.I. contact will be retained, and hence the

respite provided should only be regarded as temporary.

(e) In the present trials the standard Corkscrew considered purely as a method of escaping from visual range was found to be ineffective, the manoeuvres being insufficiently violent or prolonged to make the fighter lose distance. This may seem to conflict with para. 38 of A.F.D.U. Report No. 71, which states that "in actual combat the night fighter rarely follows more than one dive and part of the climb"; but it should be born in mind that in actual combat the bomber is probably shooting, thus causing difficulties to the fighter which cannot be reproduced experimentally.

(f) The results obtained by slowing down were very disappointing, even against a Mosquito. During the early trials of Monica at this Unit, a Halifax managed to slow down very suddenly to less than 120 mph. by lowering wheels and flaps, and it was found that fighters in visual contact frequently overshot and were always gravely inconvenienced and unable to get their sights on the target. It has since been ascertained that bomber pilots are not prepared to lower their undercarriage as a combat manoeuvre, since in the event of the hydraulic system being damaged, it would be impossible to retract it. The Halifax results, although promising at first sight, are thus of no operational significance. Results of the present trials show that if wheels and flaps are not used, the slowing down is not sufficiently rapid, and the final speed of 135–140 mph. is too high. As a result the manoeuvre as carried out by the 5 Group Lancaster is always ineffective, and frequently dangerous, and bomber crews should therefore be discouraged from attempting to use it. The slow climb during the extended Corkscrew is also ineffective in producing an overshoot, but in this case it is difficult for the fighter to attack as long as the climb is sustained.

(iii) Escape from A.I. Coverage.

In the absence of Monica and against experienced crews, the possibility of escape from coverage of the Mark VIII type is negligible. At normal heights the chance of escape from the Mark IV type of coverage is poor, but the bomber can always evade by going down to 3,000 feet, below which height Mark IV is useless. If, as seems possible, German A.I. suffers from the same height limitation as British Mark IV, then bombers could invariably evade by going down to the lowest possible level, and in the absence of light flak areas this would be a very sound course to adopt. It must be pointed out however that no information on German A.I. is available at this Unit except that contained in normal intelligence summaries.

(iv) The Shooting Problem.

(a) Deflection shooting from a fighter at night is complicated by two factors: firstly, the increased difficulty of estimating the target's line of flight; and secondly, the tendency of the sight graticule illumination to confuse the pilot's view of the target. It is thus obvious that any manoeuvre which forces the fighter to estimate either large deflections or change of deflection is likely to give good results. In a diving turn the fighter frequently finds it impossible to get his sights on at all, and it might appear at first sight that this is the most successful combat manoeuvre. However owing to the greater size of the bomber, the fighter pilot will be able to retain a visual at ranges when the rear gunner has lost sight of the fighter, and although he will normally lose ground, he may be able to follow visually without being shot at. Thus the diving turn is not necessarily a good manoeuvre for "shooting it out", and furthermore it entails loss of height and distance.

(b) In the corkscrew the fighter pilot can follow more easily and the range is not likely to increase unless he deliberately drops back. The manoeuvre thus gives the rear gunner more opportunities for shooting. The deflection problems for the fighter are considerable, and pilots taking part in the trial felt that the only satisfactory attack would be from close range while the bomber was changing bank, a position which could only be reached in the face of continuous fire from the rear gunner. Thus if the fighter accepts combat during the corkscrew, there is a fair chance that it may be damaged, destroyed, or otherwise discouraged before it can fire effectively at the bomber. The corkscrew has the additional advantage that it entails little loss of height or distance.

(c) The extended corkscrew is harder to follow than the standard corkscrew, and the fighter's shooting problem is thus automatically greater. During the sustained climb shooting for a fixed gun fighter is virtually impossible, except after a prolonged climb at uncomfortably low speed, during which the fighter is a sitting target for the rear gunner of the bomber. The extended corkscrew thus has distinct possibilities as a combat manoeuvre, and in addition provides a chance of visual escape in suitable sky conditions. It must be pointed out however that during the sustained climb the bomber would be vulnerable to a fighter with free dorsal armament, and further that it would be more vulnerable than during the standard corkscrew.

6. Conclusions.

The problem of evasion at night is complicated by so many factors that it is impossible to find any one manoeuvre which will fit all circumstances. The

bomber pilot must decide whether to escape from view or to fight, and in general it will not be worth trying to escape from view in the following circumstances:–

(a) With more than half-moon, or with any moon above cloud or over the sea.

(b) If an initial height sacrifice of 3,000 feet is unacceptable.

In these cases it will be better to accept combat, and use a standard or extended corkscrew, at the same time edging towards any available cloud cover.

In dark conditions the chance of the rear gunner being able to see and engage the fighter during combat manoeuvres is so much reduced that it will be advisable to concentrate on visual escape, either by a dive and orbit, or, with suitable cloud conditions, an extended corkscrew. The importance of exploiting clouds and dark sky areas to the full cannot be over emphasised.

7. Recommendations.

(i) Further night combat trials should be carried out with the B.D.U. Lancaster in half-moon and full-moon conditions.

(ii) Bomber pilots should be advised not to attempt to evade by slowing down unless they can reduce speed to 120 mph.

FIU/S.504/10/AIR.
9th May, 1943.

Squadron Leader, Commanding
Fighter Interception Unit,
Royal Air Force, F O R D.

CHAPTER III
Flying

PILOT'S AND FLIGHT ENGINEER'S NOTES

MARK I – FOUR MERLIN XX, 22 OR 24 ENGINES
MARK III & X – FOUR MERLIN 28 OR 38 ENGINES

Promulgated by Order of the Air Council

PART I
DESCRIPTIVE

Introduction

1. The Lancaster I, III and X are heavy bombers, the difference between them lying mainly in the power plants; the Lancaster I is fitted with Merlin XX, 22 or 24 engines which have SU carburettors; the Lancaster III and X are fitted with Merlin 28 or 38 engines which have Bendix Stromberg pressure-injection carburettors; Hydromatic propellers are fitted to all. Lancaster X are Canadian built and differ from British Lancasters in some of the instruments and in the electrical system.

Fuel and Oil Systems

2. **Fuel tanks.** – Three self-sealing tanks are fitted in each wing, numbered 1, 2 and 3 outboard of the fuselage between the front and rear spars. On some aircraft the tanks may be marked Inner, Centre and Outer instead of Nos. 1, 2 and 3. The positions are:

No. 1 (Inner):	Between the fuselage and the inner engines
No. 2 (Centre):	Between the inner and outer engines
No. 3 (Outer):	Outboard of the outer engines.

Capacities are:

Port and starboard No. 1:		580	gallons	each
" " "	No. 2:	383	"	"
" " "	No. 3:	114	"	"
		1,077	"	" side
		or 2,154	"	in all.

Provision is made on some aircraft for carrying one or two 400-gallon tanks fitted in the bomb cells; these tanks are connected so that their contents may be transferred into either or both No. 1 wing tanks and thence to the engines. When the maximum bomb load is carried, the No. 2 tanks should be filled first, and the remainder of the fuel put in No. 1 tanks. This is on account of strength considerations of the aircraft structure.

3. **Fuel cocks.** – The pilot controls four master engine cocks (24, 30). On Lancaster I aircraft, the master engine cocks also control the slow-running cut-outs. The flight engineer controls two tank selector cocks (77) which select No. 1 or No. 2 tank on each side. (No. 3 tank replenishes No. 2, see below). A cross-feed cock (marked BALANCE COCK) connects the port and starboard supply systems, and is on the floor just forward of the front spar, with the handle visible through a hole in the spar cover.

When the 400-gallon tanks are fitted in the bomb cells they each have an ON-OFF cock situated behind the front spar in the centre of the fuselage.

4. **Vapour vent system** (Lancaster III and X aircraft only):– A vent pipe from each carburettor is connected to the No. 2 tank on the same side of the aircraft, and allows vapour and a small quantity of fuel (approx. ½ gal. per hour, per carburettor, but some later carburettors may have a second vent allowing 10 gallons per hour) to return to the tank. This carburettor is designed to work full of fuel, and it therefore requires the vent to carry away any petrol vapour and dissolved air. It also assists in re-establishing the flow of fuel to the carburettors when the pipe-lines and pump have been run dry due to a tank emptying.

5. **Electric fuel booster pumps**

(i) Originally, on Lancaster I aircraft, immersed pumps were fitted in all tanks; Mod. 594 (temporary) removed the immersed pumps from No. 1 tanks and fitted stack pipes in their places.

A later Mod. 512 put back the immersed pumps in No. 1 and No. 2 tanks and incorporated suction by-pass lines to allow fuel to be drawn from the tanks when the pumps are not in use. In aircraft incorporating Mod. 539, including all Lancaster III aircraft, a Pulsometer FB Mk. I pump is fitted in each tank and by-pass lines are incorporated at No. 1 and No. 2 tanks. On Lancaster X aircraft, Thomson pumps, similar to the Pulsometer pumps, and by-pass lines are fitted.

No. 3 tank is used to replenish No. 2 tank (*see* Figs. 5 & 6) by switching on the No. 3 tank pump. When the 400-gallon tanks are fitted in the bomb cells they each have a similar pump fitted to transfer their contents to the No. 1 tanks.

(ii) The main use of the electric fuel pumps in No. 1 and No. 2 tanks is to maintain fuel pressure at altitudes of approximately 17,000 ft. and over in temperate climates, but they are also used for raising the fuel pressure before starting and to assist in re-starting an engine during flight. If one engine fails during take-off and the electric fuel pump is not ON, air may be drawn back into the main fuel system before the master engine cock of the failed engine can be closed, thus causing the failure of the other engine on the same side; therefore at take-off the pumps in Nos. 1 and 2 tanks must be switched on; this is also a precaution against fuel failure during take-off as an immediate supply is available by changing over the tank selector cock. The pump in each tank in use should also be switched on at any time when a drop in fuel pressure is indicated or when it is necessary to run all engines from one tank by opening the cross-feed cock.

6. **Fuel contents gauges.** – On Lancasters I and III, the switch (76) on the flight engineer's panel must be set ON before the fuel contents gauges will indicate. On Lancaster X there is no fuel contents gauge switch; the gauges will indicate whenever electrical power is available.

7. **Fuel pressure indicators** – Fuel pressure warning lights (79) show when the fuel pressure at the carburettor falls below 6 lb./sq.in. on Lancaster I aircraft, and 10 lb./sq.in. on Lancaster III aircraft. They are switched off by the fuel contents gauges switch (76), and this switch must, therefore, always be on in flight. On Lancaster X, fuel pressure gauges (73) are fitted on the flight engineer's panel. They will indicate whenever battery power is available.

8. **Priming pumps.** – There is one cylinder priming pump in each inboard engine nacelle. Each pump serves one inboard and one outboard engine. On Lancasters I and III, two priming cocks are fitted in each nacelle. On Lancaster

X the priming pump handle is turned to the left to prime the left engine, to the right to prime the right engine, and to the mid-position for off.

9. **Oil tanks.** – Each engine has its own tank; capacity 37½ gallons of oil with 4½ gallons air space.

10. **Oil dilution.** – The four push-buttons (81) are on the flight engineer's panel.

Main Services

11. **Hydraulic system**

(i) Each turret is operated by an individual engine-driven pump.

Starboard outer engine:		Mid upper turret
Starboard inner	"	Front turret
Port inner	"	Mid under turret, if fitted
Port outer	"	Tail turret

(ii) Two pumps (one on each inboard engine), with a hand-pump as an alternative, charge a small accumulator and operate:

Undercarriage
Flaps
Bomb doors
Carburettor air intake shutters
Fuel jettisoning

Owing to the large capacity of the flap and undercarriage jacks, it is not normally possible to operate them by the hand-pump in the time available in an emergency.

12. **Pneumatic system**

(i) A Heywood compressor on the starboard inboard engine charges an air bottle to 300 lb./sq.in. and operates:

Wheel brakes
Radiator shutters
Supercharger rams (on Lancaster III and X and later Lancaster I aircraft)
Idle cut-off rams (on Lancaster III and X aircraft only)

A pressure-maintaining valve in the supply line from the air bottle only allows pressure to be supplied to the radiator shutters, superchargers, and idle

cut-off rams, if the pressure in the air bottle exceeds 130 lb./sq.in. (This is to ensure sufficient pressure for the brakes, which operate at 80 lb./sq.in.) It is necessary, therefore, to check on the triple pressure gauge that pressure is sufficient before S ratio is engaged or the idle cut-off controls are operated.

(ii) A vacuum pump is fitted on each inboard engine, one for operating the instruments on the instrument flying panel, and the other for operating the gyros of the Mark XIV bombsight; the change-over cock (17) is on the right of the instrument panel beside the suction gauge (23), and in the event of failure of the vacuum pump supplying the flying instruments the changeover cock can be used to connect the serviceable pump with the flying instruments and cut out the bombsight. It is not possible to operate flying instruments and bombsight on one vacuum pump.

(iii) An RAE compressor fitted on the port inboard engine operates the Mark IV automatic controls and the computer unit of the Mark XIV bombsight. For operation of the Mark XIV bombsight, the automatic control cock must be set to OUT.

13. **Electrical system.** – Two 1,500-watt generators (one on each inboard engine), connected in parallel, charge the aircraft batteries (24 volt), and supply the usual lighting and other services, including

Propeller feathering pumps
Flap and undercarriage indicators
Pressure head heating
Fuel booster pumps
Radio equipment
Landing lamps
Engine starting and booster coils
Dinghy inflation
Controls for radiator shutters rams, supercharger gear change rams, and idle cut-off rams (on Lancaster III and X aircraft)
Bomb gear and bombsight
Fire-extinguishers
Fuel contents gauges
Fuel pressure warning lights or gauges
Camera
Heated clothing
DR compass

An alternator may be fitted to each outboard engine, to supply any special radio equipment.

A ground/flight switch on the starboard side of the fuselage, immediately aft of the front spar, isolates the aircraft batteries when the aircraft is parked or when using a ground starter battery.

Two generator switches are provided on the electrical control panel.

Aircraft Controls

14. **Trimming tabs.** – The elevator (62), rudder (63) and aileron (61) tab controls (on the right of the pilot's seat) all operate in the natural sense and each has an indicator.

15. **Undercarriage control.** – The undercarriage lever (64) is locked in the DOWN position by a safety bolt (65) which has to be held aside in order to raise the lever. The bolt engages automatically when the lever is set down. The undercarriage may be lowered in an emergency by compressed air (*see* Part IV, para. 56).

WARNING. – There is no automatic lock to prevent the undercarriage being raised by mistake when the aircraft is on the ground.

16. **Undercarriage indicator (39).** – On Lancasters I and III the indicators show as follows:

Undercarriage	locked down:	Two green lights
"	unlocked:	Two red lights
"	locked up:	No lights

The indicator switch (4) is interlocked so that it must be on when the port engine ignition switches are on. An auxiliary set of green lights can be brought into operation by pressing the central knob if failure of the main set is suspected. The red lamps are duplicated so that failure of one lamp does not affect the indication of undercarriage unlocked. The lights can be dimmed by turning the central knob. On Lancaster X a pictorial type of indicator is fitted. When the indicator switch is on and electrical power is available, the pictorial indicator shows the position of the undercarriage wheels and wing flaps at all times. The disappearance of small red flags shows when the wheels are locked up or down.

17. **Undercarriage warning horn.** – The horn sounds if either inboard throttle is closed when the undercarriage is not locked down. The outboard

throttles do not operate the horn. A testing pushbutton and lamp are behind the pilot's seat, on the cockpit port rail.

18. **Flaps control.** – The push-pull handle (60) should be moved to the neutral position (located by a spring-loaded catch) after each flap movement. On Lancasters I and III the flap indicator (26) is switched on by a separate switch (27). If the flaps have been selected partly down, and it is desired to lower them fully, it may be found that the flaps will not lower further for some considerable time. This is due to the pressure in the accumulator having fallen below the pressure required to operate the flaps, but not sufficiently to cause the hydraulic pumps to cut in. To overcome this, move the flaps selector to UP, and then immediately put it fully DOWN; this causes the hydraulic pumps to cut in. In an emergency the flaps may be lowered by compressed air after lowering the undercarriage (*see* Part IV, para. 57).

19. **Bomb doors.** – The control (43) has two positions only. The bomb release system is rendered operative soon after the doors begin to open and before they are fully open. The position of the doors must therefore be checked visually before releasing bombs. If the bomb doors open only part way and then stop, it is probably due to icing around the hinges and joints, which raises the hydraulic pressure sufficiently to bring the cut-out into operation, which stops any further movement of the doors. If the bomb doors selector is moved to SHUT and then immediately to OPEN, the doors will usually open further; it may be necessary to repeat this several times to get the doors fully open.

As strenuous pumping for 15 minutes is required to open the doors with engines stopped, they should be opened before stopping engines if the aircraft is to be bombed up before the next flight.

For emergency operation of bomb doors by compressed air, *see* Part IV, para. 58.

Engine Controls

20. **Throttle controls**

(i) *Merlin XX, 22, 28 and 38 engines.* – Climbing boost +9 lb./sq.in. is obtained with the throttle levers (28) at the gate. On Merlin XX installations, and originally on Merlin 22, 28 or 38 installations, going through the gate gives a boost of +12 lb./sq.in at ground level only. A later modification to Merlin 22, 28 or 38 engines gives +14 lb./sq.in. boost at ground level only with the throttle levers through the gate.

The boost control cut-out (32) gives +14 lb./sq.in. in M gear and +16 lb./sq.in. in S gear on all the above Merlins.

(ii) *Merlin 24 engines.* – Originally no boost control cut-out was fitted and no climbing gate. The fully forward position of the throttle lever gave +18 lb./sq.in. boost for take-off and combat. On these installations the automatic boost control does not allow the butterfly to open fully to maintain +9 lb./sq.in. boost up to full throttle height unless the throttle levers are progressively advanced to the fully forward position during the climb. However, a modification is now being introduced which overcomes this, and when this is incorporated a boost control cut-out is fitted which gives +18 lb./sq.in. for take-off and combat; the throttle quadrant is fitted with a gate at +9 lb./sq.in. boost, and the fully forward position gives + 14 lb./sq.in. at ground level only, for take-off at moderate loads.

(iii) On all Merlins, when climbing with a boost setting less than +9 lb./sq.in. the automatic boost control cannot open the throttle valve fully and the boost will begin to fall off before full throttle height is reached; the throttle lever should then be progressively advanced to maintain boost.

21. Mixture control

(i) *Merlin XX, 22 and 24 engines (Lancaster I).* – S.U. carburettors are fitted. The mixture strength is automatically controlled by boost pressure, and the pilot has no separate mixture control. A weak mixture is obtained below +7 lb./sq.in. boost (+4 lb./sq.in. on Merlin XX). The carburettor slow-running cut-outs are operated by closing the master engine cocks.

(ii) *Merlin 28 and 38 engines (Lancasters III and X).* – Bendix-Stromberg pressure injection carburettors are fitted. There is no pilot's mixture control, the mixture strength being regulated by the power so that a weak mixture is obtained below +7 lb./sq.in. and 2,650 r.p.m. The carburettor idle cut-outs, which are used in starting, and for stopping the engines, are operated by electro-pneumatic rams controlled by four SLOW-RUNNING CUT-OUT SWITCHES (11) on the pilot's panel just above the engine starter buttons. These switches have each two positions, the top one being the engine RUNNING position and the bottom one the IDLE CUT-OFF position. In the case of electrical or pneumatic failure the rams will return to the RUNNING position.

22. Propeller controls. – The speed control levers (29) for the Hydromatic propellers vary the governed r.p.m. from 3,000 down to 1,800. The feathering

buttons (19) are on the right of the instrument panel. For feathering and unfeathering procedure *see* Part IV, paras. 53, 54.

23. **Supercharger controls**

(i) On early Lancaster I aircraft the supercharger controls for all four engines are operated mechanically by one lever.

(ii) On later Lancaster I and on all Lancaster III and X aircraft, the superchargers are operated by electro-pneumatic rams of the single-action spring-return type. In the case of electrical or pneumatic failure the rams will return to the M ratio position. A switch, fitted to the pilot's instrument panel immediately below the engine speed indicators, controls all four engines simultaneously, and a red warning light beside it (25) indicates S ratio on the ground only (i.e. when the undercarriage is down).

24. **Radiator shutters.** – The shutters are automatically controlled when the switches forward of the flight engineer's panel are in the up position. When the switches are down, the thermostatic control is over-ridden, and the shutters are opened; this position should be used for all ground running, taxying and marshalling.

25. **Carburettor air-intake heat control.** – A single lever for the hydraulic operation of all four carburettors' hot air intakes is provided beside the pilot's seat. Hot air should not be used unless the air intakes become iced up, and as ice guards are fitted, this should rarely be necessary.

Other Controls

26. **Intercommunication.** – On Lancaster X, Bendix interphone station boxes are fitted. For inter-communication the selector switch must be set to INTER and the INCREASE OUTPUT control set full on.

PART II
HANDLING

NOTE. – All speeds quoted are for aircraft with the Pilot's A.S.I.† connected to the static vent (*see* para. 47). Speeds given in brackets are for aircraft on which the change to this connection has not been made.

† Air Speed Indicator

27. Management of fuel system

(i) *Testing electric fuel booster pumps.* – Before starting the engine each booster pump should be tested by ammeter (most aircraft have a permanent ammeter fitted on the flight engineer's panel while some early aircraft may have an ammeter test socket into which the ammeter must be plugged); to do this, the switch for each pump should in turn be set to the up (test) position, after ensuring that the idle cut-off switches are in the IDLE CUT-OFF position and air pressure is greater than 130 lb./sq.in. (on Lancaster III and X aircraft); the ammeter reading should be perfectly steady and should be between 4 and 7 amps for a Pulsometer FB Mark I pump, between 3 and 5 amps for a Thomson pump, or between 2 and 4 amps for an immersed pump. Aircraft with Pulsometer pumps may be recognised by the small blisters on the underside of the wings.

(ii) *Use of tanks:*

(a) *Starting, warm-up and take-off.* – No. 2 tanks should be used first because the carburettor vents (*see* Part I, para. 4) return to these tanks, also because the contents of No. 1 tanks only can be jettisoned.

The electric fuel booster pumps in Nos. 1 and 2 tanks must be switched on for take-off, so that if for any reason the fuel supply from No. 2 tanks should fail, fuel pressure will be available immediately on turning the tank selectors to No. 1 tanks. *See* also Part I, para. 5.

(b) *In flight.* – After climbing to 2,000 feet switch off booster pumps. Continue running on No. 2 tanks until 200 gallons remains in each, then change over to No. 1 tanks. Switch on No. 3 booster pumps to transfer their fuel to No. 2 tanks. Switch off the pumps when No. 3 tanks are empty. If overload fuel tanks are carried, continue to fly on No. 1 tanks until enough fuel has been used from them to enable the contents of the fuselage tanks to be transferred to them. Then change over to No. 2 tanks; turn on both long range fuel cocks (behind front spar) and switch on overload tank pump switches and fuel contents gauge. Transfer of fuel from long range tanks takes approximately 1 hour. Watch No. 1 fuel contents gauges and turn off each long range cock as soon as its respective No. 1 tank is filled. Turn off pumps when both No. 1 tanks are filled.

When over enemy territory, keep contents of Nos. 1 and 2 tanks approximately the same by running on each alternately for about half-an-hour.

(iii) *Use of cross-feed cock.* – The cock should be closed at all times, unless it is necessary in an emergency to feed fuel from the tanks in one wing to the

engines in the other wing. If the cross-feed cock is open for this purpose, only one tank should be turned on to feed all working engines, and the pump in this tank should be switched on.

(iv) *Changing fuel tanks on Lancaster III and X aircraft.* – If the engine cuts owing to exhaustion of fuel in one tank, back-firing may occur on turning on to another tank. For when the tank empties, the fuel pressure drops, and when the pressure falls to 4 lb./sq.in. fuel injection ceases. When the new tank is turned on, the carburettor restarts and delivers the fuel already in it, but this supply is followed by vapour from the fuel pipelines, causing weak mixture and back-firing until fuel is delivered from the new tank.

When an engine cuts due to exhaustion of one tank:

(a) Close the throttle and change over to another tank.

(b) Idle the engine till it runs smoothly and open up slowly.

(c) The use of the booster pump in the tank turned on will help to restart the engine.

28. Preliminaries

(i) *Before entering aircraft.* – Check pitot head covers removed.

Check all cowling and inspection panels, and leading edge secured. Check tyres for creep.

(ii) *On entering aircraft.* – Check security of emergency escape hatches.

Check emergency air bottle pressure (1,100–1,200 lb./sq.in.)

Check hydraulic accumulator pressure (220 lb./sq.in. minimum, under no hydraulic pressure).

Check fuel cross-feed cock OFF.

Turn ground/flight switch to FLIGHT.

Switch on undercarriage indicator and flaps indicator switches (if fitted) and check indicators.

Switch on fuel contents gauges switch (if fitted) and leave it on, and check fuel contents.

Check master engine cocks OFF.

29. Starting engines and warming up

(i) Test fuel booster pumps by ammeter (*see* para. 27).

On Lancasters III and X aircraft the fuel tank booster pump must *never* be switched on with the master engine cock open and the engine stationary, unless the slow-running cut-out switch is in the IDLE CUT-OFF (down) position and

the air supply pressure not less than 130 lb./sq.in.

(ii) Turn ground/flight switch to GROUND and plug in ground starter battery.

(iii) Set engine controls as follows:

Master engine cocks	OFF
Throttles	½ in. open
Propeller controls	Fully up
Slow-running cut-out switches	IDLE CUT-OFF
Supercharger control	M ratio (Warning light not showing)
Air intake heat control	COLD
Radiator shutters	Over-ride switches at AUTOMATIC

(iv) Have a fire-extinguisher ready in case of emergency.

(v) Turn tank selector cock to No. 2 tank (*see* para. 27 (ii)) and turn on the master engine cock of the engine to be started. On Lancasters III and X aircraft the master engine cocks of all other engines which are not running must be OFF.

(vi) Switch on the booster pump in the No. 2 tank to be used.

(vii) High-volatility fuel (stores ref. 34A/111) should be used, if outside priming connection is fitted, for priming at air temperatures below freezing. The ground crew will work the priming pump until the fuel reaches the priming nozzles; this may be judged by an increase in resistance.

(viii) Switch on the ignition and booster coil, and press the starter button. Turning periods must not exceed 20 seconds with a 30-second wait between each. The ground crew will work the priming pump as firmly as possible while the engine is being turned; it should start after the following number of strokes, if cold:

Air temp., °C.	+30	+20	+10	0	-10	-20
Normal fuel	3	4	7	12		
High-volatility fuel				4	8	18

It will probably be necessary to continue priming after the engine has fired and until it picks up on the carburettor.

(ix) *On Lancaster III and X aircraft.* – As soon as the engine fires regularly, move the slow-running cut-out control to the ENGINE RUNNING (up) position. If, however, the engine shows signs of being over-rich, return the slow-running cut-out control to the IDLE CUT-OFF (down) position, until it is running smoothly.

(x) When all the engines are running satisfactorily, switch off the booster-coil switch. The ground crew will screw down the priming pumps and turn off the priming cocks (if fitted).

(xi) Have the ground/flight switch turned to FLIGHT and the ground battery removed.

(xii) Open each engine up slowly to 1,200 r.p.m. and warm up at this speed.

(xiii) Switch DR compass ON and SETTING.

30. Testing engines and installations

While warming up:

(i) Check temperatures and pressures, and test operation of hydraulic system by lowering and raising flaps and bomb doors – but do not test bomb doors if a bomb load is on board.

(ii) Switch off electric fuel booster pump so as to test engine-driven pumps.

After warming up:

NOTE: – The following comprehensive checks should be carried out after repair, inspection other than daily, or otherwise at the pilot's discretion. Normally they may be reduced in accordance with local instructions.

(iii) Switch radiator shutters over-ride switches to OPEN.

(iv) At 1,500 r.p.m. test each magneto in turn to ensure that no magnetos are unserviceable.

(v) Open up to +4 lb./sq.in. boost and check operation of two-speed supercharger. R.p.m. should fall when S ratio is engaged, and, on aircraft with electro-pneumatically operated supercharger gear change, red warning light should come on. Return to M ratio.

(vi) At the same boost, check operation of constant-speed propeller. R.p.m. should fall to 1,800 with the control fully down.

(vii) Open throttle to the take-off position and check take-off boost and r.p.m. – *see* Part I, para. 20.

(viii) Throttle back to +9 lb./sq.in. boost; check that r.p.m. fall below 3,000 and if not throttle back until a drop is shown, to ensure that the propeller is not constant-speeding. Then test each magneto in turn. The drop should not exceed 100 r.p.m.

31. Check list before taxying

Ground/flight switch	FLIGHT

Navigation lights	On if required
Altimeter	Set
Instrument flying panel	Check vacuum on each pump – 4½ lb./sq.in.
Radiator shutter switches	OPEN
Brakes pressure	Supply 250–300 lb./sq.in.

32. Check list before take-off

Auto controls – Clutch	IN
Cock	OUT
DR compass	NORMAL
Pitot head heater switch	ON
T – Trimming tabs	Elevator slightly forward
	Rudder neutral
	Aileron neutral
P – Propeller controls	Fully up
F – Fuel	Check contents of tanks
	Master engine cocks ON
	Tank selector cocks to No. 2 tanks
	Crossfeed cock OFF
	Booster pumps in Nos. 1 and 2 tanks ON
Superchargers	MOD
Air intake	COLD
F – Radiator shutters switches	AUTOMATIC
F – Flaps	15°–20° down

33. Taking off

(i) Open the throttles to about zero boost against the brakes to see that engines are responding evenly. Throttle back, release brakes, and open throttles gently checking the tendency to swing to port by advancing port throttles slightly ahead. This will give as good a take off as taking off against the brakes, and renders it easier to correct swing.

(ii) The tail should be raised as quickly as possible after the throttles are fully open and the aircraft eased off the ground at not less than 95(90) m.p.h. I.A.S. if loaded to 50,000 lb., or 105(100) m.p.h. I.A.S. if loaded to 60,000 lb.

(iii) Safety speed is 130(125) m.p.h. I.A.S.

(iv) Raise the flaps at a safe height, not below 500 feet when heavily loaded, and return selector to neutral. Raising flaps causes a nose-down change of trim.

(v) Switch off electric fuel booster pumps of Nos. 1 and 2 tanks after initial climb, but if a warning light comes on, or fuel pressure drops below 10 lb./sq.in., switch on No. 2 pumps immediately.

34. Climbing

(i) The recommended speed for a quick climb is 160(155) m.p.h. I.A.S. The most comfortable climbing speed is about 175(170) m.p.h. I.A.S.

(ii) Switch on electric fuel pumps of tanks in use, at any signs of fuel starvation (at approximately 17,000 feet in temperate climates).

35. General flying

(i) *Stability*. – At normal loadings and speeds, stability is satisfactory.

(ii) *Controls*. – The elevators are relatively light and effective, but tend to become heavy in turns. The ailerons are light and effective, but become heavy at speeds over 260 m.p.h. I.A.S.

The rudders also become heavy at high speeds.

(iii) *Change of trim:*

Undercarriage UP.....Slightly nose up
Undercarriage DOWN.....Slightly nose down
Flaps up to 25° from fully DOWN .....Slightly nose down
Flaps up from 25° .....Strongly nose down
Flaps down to 25°.....Strongly nose up
Flaps fully DOWN from 25°.....Slightly nose up
Bomb doors open .....Slightly nose up

(iv) *Flying at low airspeeds*. – Flaps may be lowered about 15°–20°, r.p.m. set to 2,650, and the speed reduced to about 130(125) m.p.h. I.A.S.

36. Stalling

(i) Just before the stall, slight tail buffeting occurs.

(ii) There is no tendency for a wing to drop.

(iii) The stalling speeds in m.p.h. I.A.S. at 50,000 lb. are:

Undercarriage and flaps up	110 (95)
Undercarriage and flaps down	92 (83)

37. Diving

(i) The aircraft becomes increasingly nose heavy in a high-speed dive. The elevator tab control should not be used to help the entry into the dive, but it should be used to trim out the pull necessary in the later stages of the dive.

(ii) The flight engineer should be ready to assist the pilot as required.

38. Check list before landing

Auto-pilot control cock .....OUT (clutches may be left IN)
Superchargers .....M (low) ratio
Air intake .....COLD
Brake pressure.....Supply pressure 250–300 lb./sq.in.
Reduce speed to below 200 m.p.h. I.A.S. and carry out the following drill:
Flaps .....20° down on circuit
U – Undercarriage .....DOWN (check by indicator, visually, and horn)
P – Propeller.....Controls up to at least 2,850 r.p.m.
F – Flaps .....DOWN on final approach (handle neutral, (*see* para. 18)

39. Approach speeds

Recommended speeds for the approach in m.p.h. I.A.S.:

	45,000 lb.	55,000 lb.
Engine-assisted	110(100)	120(110)
Glide	120(110)	130(120)

40. Mislanding

(i) The aircraft will climb satisfactorily with the undercarriage and flaps down.

(ii) Climb at about 140(130) m.p.h. I.A.S. and, after raising the undercarriage, start raising the flaps a little at a time, retrimming as necessary.

41. Beam approach

	Indicated height: feet	I.A.S. m.p.h.	R.p.m.	Approx. boost: lb./sq.in.	Actions	Change of trim
Preliminary approach	1,500	135	2,400	-1	Set 25° flap for all manoeuvring	Nose up strongly
On QDR +30°	1,500	135	2,650	+2	Undercarriage down	Nose down slightly
At outer marker	600	130	2,650	-2 to 0 (descent at 400 ft./min.) +2 (level flight)		
At inner marker Overshoot	150 up to 300	120 130-140	2,850 2,850	0 to +2 +9	Flaps fully down Raise flaps to 25° Raise undercarriage	Nose up slightly Nose down slightly Nose up slightly

All four throttles should be used together throughout the approach.
An increase in the rate of sink has no effect on the controls.

42. After landing

(i) Before taxying, raise the flaps and open the radiator shutters.

(ii) The outer engines may be stopped and taxying done on the inners. This is preferable to stopping the inner engines, as the brakes compressor is on the starboard inner engine, and the outer engines are more liable to overheat.

(iii) Before stopping the engines, open the bomb doors for bombing up (if required).

(iv) Switch off all booster pumps before stopping engines.

(v) *Stopping engines, Merlin XX*, 22, 24. With the engines running at 800 r.p.m., turn OFF the master engine cocks and switch OFF the ignition after the engines have stopped.

(vi) *Stopping engines, Merlin* 28 *or* 38. – To stop an engine check that the air

pressure gauge reads at least 130 lb./sq.in. (*see* para 12 (i), (if not, open up starboard inner engine which drives the compressor) and move the slow-running cut-out switch to the IDLE CUT-OFF (down) position with the engine running at about 800 r.p.m. Then switch off the ignition and leave the slow-running cut-out switch in the IDLE CUT-OFF (down) position.

NOTE. – Merlin 28 and 38 engines must not be stopped by turning off the master engine cock, as this will empty the carburettor of fuel and fill it with air. This entails much trouble when starting the engine again.

When all engines have been stopped, turn off master engine cocks, check again that all booster pumps are OFF, and then return the slow-running cut-outs to the ENGINE RUNNING position.

NOTE. – If the switches are left in the IDLE CUT-OFF position, the rams will return to the ENGINE RUNNING position as soon as the master switch is turned to GROUND. Then, if any ground maintenance work is carried out which necessitates turning on and off the master switch, the rams are being continually operated.

(vii) Switch off all electrical switches and turn master electrical switch to GROUND.

(viii) *Oil dilution. – See Pilot's Notes General A.P.* 2095. The correct dilution period for this aircraft is:

Air temperatures above – 10°C	One minute
" " below – 10°C	Two minutes

PART III
OPERATING DATA

43. Engine data – Merlin XX

(i) *Fuel* – 100 octane only.

(ii) *Oil – See* A.P.1464 C.37

(iii) *Engine limitations* with 100 octane fuel:

		R.p.m.	Boost lb./sq.in.	Temp. Coolant °C	Oil °C
MAX. TAKE-OFF TO 1,000 FEET	M	3,000	+12*		
MAX. CLIMBING 1 HOUR LIMIT	M S	2,850	+9	125	90

MAX. RICH	M }				
CONTINUOUS	S }	2,650	+7	105	90
MAX. WEAK	M }				
CONTINUOUS	S }	2,650	+4	105	90
COMBAT	M	3,000	+14*	135	105
5 MINS. LIMIT	S	3,000	+16*	135	105

* *See* Part I, para 20.

OIL PRESSURE:

NORMAL 60/80 lb./sq.in.
MINIMUM 45 lb./sq.in.

MINIMUM TEMPS. FOR TAKE-OFF:

OIL 15°C
COOLANT 60°C

44. Engine data - Merlin 22, 28 or 38

(i) *Fuel* - 100 octane only.

(ii) *Oil - See* A.P.1464/C.37.

(iii) *Engine limitations* with 100 octane fuel:

		R.p.m.	Boost lb./sq.in.	Temp. °C. Coolant	Oil
MAX. TAKE-OFF					
TO 1,000 FEET	M	3,000	+14*		
MAX. CLIMBING	M }				
1 HOUR LIMIT	S }	2,850	+9	125	90
MAX. CONTINOUS	M }				
	S }	2,650	+7	105	90
COMBAT	M	3,000	+14*	135	105
5 MINS. LIMIT	S	3,000	+16*	135	105

* *See* Part. I, para 20.

OIL PRESSURE:

NORMAL 60/80 lb./sq.in.
MINIMUM 45 lb./sq.in.

MINIMUM TEMPS. FOR TAKE-OFF:

OIL 15°C.
COOLANT 60°C.

45. Engine data – Merlin 24

(i) *Fuel* – 100 octane only.

(ii) *Oil* – *See* A.P.1464/C.37.

(iii) *Engine limitations* with 100 octane fuel:

		R.p.m.	Boost lb./sq.in.	Temp. °C. Coolant	°C. Oil
MAX. TAKE-OFF TO 1,000 FEET	M	3,000	+18*		
MAX. CLIMBING 1 HOUR LIMIT	M S	2,850	+9	125	90
MAX. CONTINUOUS	M S	2,650	+7	105	90
COMBAT 5 MINS. LIMIT	M S	3,000	+18*	135	105

* +18 lb./sq.in. boost must not be used below 2,850 r.p.m.

OIL PRESSURE:

NORMAL 60/80 lb./sq.in.
MINIMUM 45 lb./sq.in.

MINIMUM TEMP. FOR TAKE-OFF:

OIL 15°C
COOLANT 60°C.

46. Flying limitations

(i) The aircraft is designed for manoeuvres appropriate to a heavy bomber and care must be taken to avoid imposing excessive loads with the elevators in recovery from dives and in turns at high speed. Spinning and aerobatics are not permitted. Violent use of the rudder at high speeds should be avoided.

(ii) *Maximum speeds in m.p.h. I.A.S.:*

Diving	360
Bomb doors open	as for diving
Undercarriage down	200
Flaps down	200

(iii) *Maximum weights:*

Take off and straight flying	65,000 lb., provided that the following mods. are incorporated: Mod. 505 or 518 " 588 or 598 " 811 or SI/RDA 660 " 1004 63,000 lb., if these mods. are not incorporated.
Landing and all forms of flying	55,000 lb.

Flying should be restricted to straight and level until weight is reduced to 63,000 lb.

(iv) *Bomb clearance angles:*

Dive	30°
Climb	20°
Bank	10° (with S.B.C.† 25°)

47. Position error corrections

All handling speeds are quoted for aircraft with the pilot's A.S.I. connected to the static vent, in the port side of the fuselage. The position error for the static vent connection is – 1 m.p.h. at all speeds from 140 m.p.h. I.A.S. upward.

The position error correction for aircraft on which the static vent connection has not been made is as follows:–

From To	120 140	140 160	160 180	180 200	200 250	} m.p.h. I.A.S.
Add	12	10	8	6	4	m.p.h.

With bomb doors open, the correction is 2 m.p.h. higher between 160 and 200 m.p.h. I.A.S.

† Small Bomb Container

48. Maximum performance

(i) *Climbing:*

160 (155) m.p.h. I.A.S. to 12,000 ft.
155 (150) m.p.h. I.A.S. from 12,000 to 18,000 ft.
150 (145) m.p.h. I.A.S. from 18,000 to 22,000 ft.
145 (140) m.p.h. I.A.S. above 22,000 ft.
Change to S ratio when boost has fallen to +6 lb./sq.in.

(ii) *Combat.* – Use S ratio if the boost obtainable in M ratio is more than 3 lb./sq.in. (4 lb./sq.in. with Merlin 24) below maximum combat boost.

49. Maximum range

(i) *Climbing.* – 160 (155) m.p.h. I.A.S. at +7 lb./sq.in. boost with Merlin 22, 24, 28, or 38, +4 lb./sq.in. with Merlin XX, and 2,650 r.p.m. Change to S ratio when maximum boost obtainable in M ratio has fallen by 3 lb./sq.in.

(ii) *Cruising* (including descent):

(a) Fly in M ratio at maximum obtainable boost not exceeding +4 lb./sq.in. with Merlin XX, +7 lb./sq.in. with Merlin 22, 24, 28 or 38, obtaining the recommended airspeed by reducing r.p.m. which may be as low as 1,800 if this will give the recommended speed. Higher speeds than those recommended may be used if obtainable in M ratio at the lowest possible r.p.m.

(b) The recommended speeds are:

Fully loaded (outward journey):

Up to 15,000 ft.,	170 (165) m.p.h. I.A.S.
At 20,000 ft. in S ratio,	160 (155) m.p.h. I.A.S.

Lightly loaded (homeward journey):

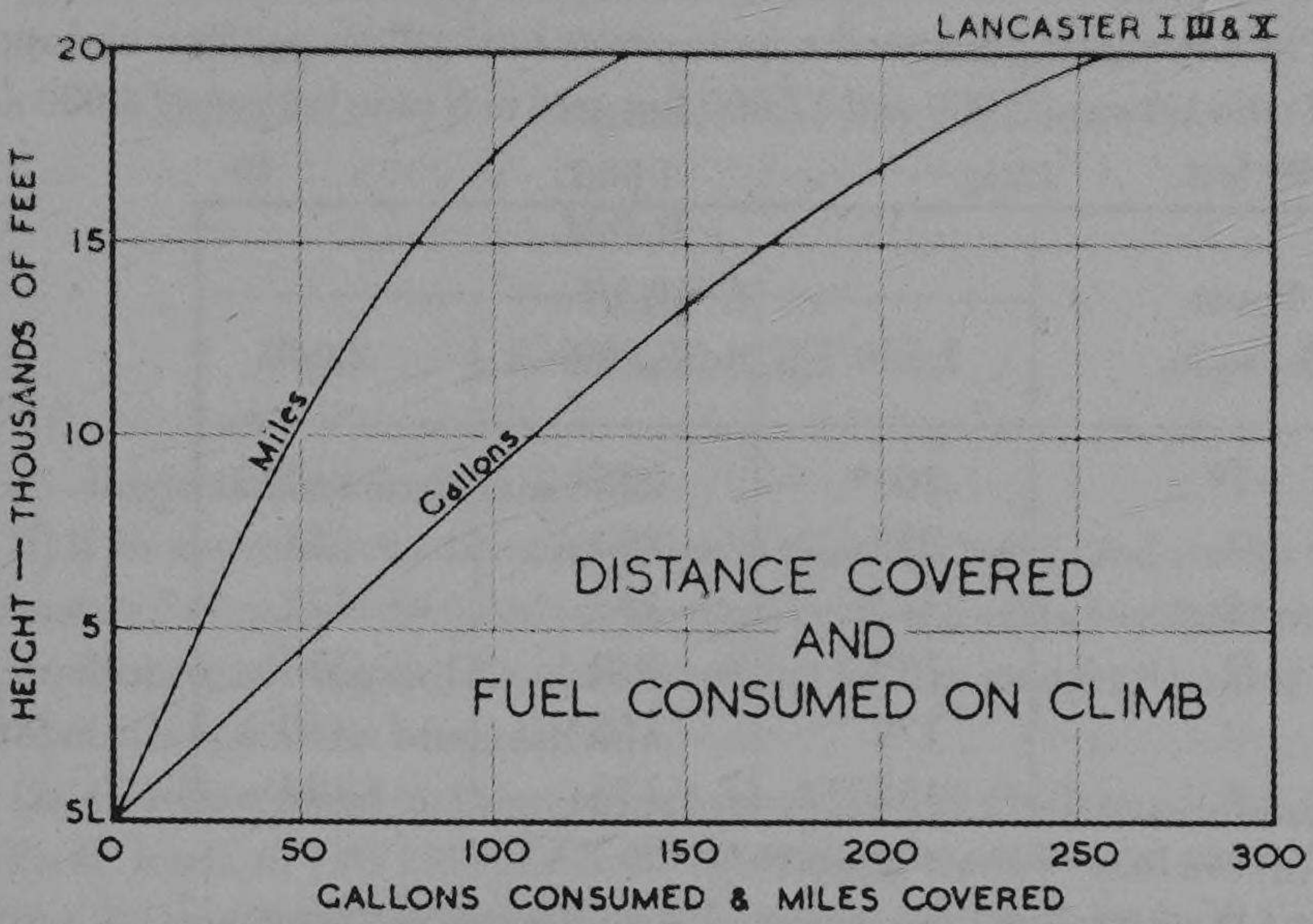
160 (155) m.p.h. I.A.S.

(c) Engage S ratio when the recommended speed cannot be maintained at 2,500 r.p.m. in M ratio.

(iii) The use of warm intakes will reduce air miles per gallon considerably. On this installation there is no need to use warm air unless intake icing is indicated by a drop of boost. *See* A.P. 2095 – Pilot's Notes General.

50. Fuel capacity and consumptions

(i) Capacity:	Two No. 1 tanks	1,160 gallons
	Two No. 2 tanks	766 gallons
	Two No. 3 tanks	228 gallons
	Total	2,154 gallons


LANCASTER I III & X
20
15
10
5
SL
HEIGHT — THOUSANDS OF FEET
Miles
Gallons
DISTANCE COVERED
AND
FUEL CONSUMED ON CLIMB
0
50
100
150
200
250
300
GALLONS CONSUMED & MILES COVERED

1·25
1·20
1·15
1·10
1·05
1·00
AIR MILES PER GALLON
Home
Out
AIR MILES PER GALLON
AT 20,000 FEET
140
150
160
170
180
190
200
M.P.H. I.A.S.

(ii) *Weak mixture consumptions, Merlin XX, 22 or 24:*

The following figures are the approximate total gallons per hour and apply in M ratio between 8,000 and 17,000 feet, and in S ratio between 14,000 and 25,000 feet.

Boost lb./sq.in.	R.P.M.		
	2,650	2,300	2,000
+7*	260*	225*	212*
+4	228	204	188
+2	212	188	172
0	192	172	150
–2	172	156	140
–4	152	136	124

* These figures do not apply to Merlin XX.

(iii) *Weak mixture consumptions Merlin 28 and 38 engines:*

The following figures are the approximate total gallons per hour for the aircraft and apply in M ratio at 5,000 ft. and S ratio at 15,000 ft. One gallon per hour should be added for every 1,000 ft. above these heights.

Boost lb./sq.in.	R.P.M.				
	2,650	2,400	2,200	2,000	1,800
+7	240	235	217	200	–
+4	216	204	196	180	–
+2	196	184	176	164	–
0	172	164	156	144	128
–2	148	140	128	124	112
–4	124	120	108	104	96

(iv) *Rich mixture consumption, Merlin XX, 22, 24:*

Boost lb./sq.in.	R.p.m.	Total gallons per hour
+14	3,000	500
+12	3,000	460
+9	2,850	380
+7*	2,650*	320*

*Merlin XX only.

(v) *Rich mixture consumptions, Merlin 28, 38:*

Boost lb./sq.in.	R.p.m.	Total gallons per hour
+9	2,850	420

PART IV
EMERGENCIES

51. Engine failure during take-off

(i) If for any reason the booster pumps in the tanks being used are not ON, the master fuel cock of the failed engine must be turned off before feathering.

(ii) If one outer engine fails, the aircraft can be kept straight provided 130 (125) m.p.h. I.A.S. has been reached.

(iii) Climbing speed on three engines should be 135 (130) m.p.h. I.A.S. at moderate loads, or 140(135) m.p.h. I.A.S. if heavily loaded.

(iv) As soon as the undercarriage is up, raise the flaps a little at a time, retrimming as necessary.

52. Engine failure in flight

(i) If an engine is stopped, air may be drawn into the fuel system through the carburettor of the failed engine. To prevent this, the master fuel cock must be turned off before feathering, unless the booster pump for the tank in use is on. If an engine seizes up, its master fuel cock should be turned off immediately to ensure that the fuel supply to the other engine on the same side is not affected.

(ii) If the failed engine cannot be made to pick up again, feather its propeller and switch off. On Lancaster III and X, set mixture control to IDLE CUT-OFF.

(iii) *Handling on three engines.* – The aircraft will maintain height at full load on any three engines at 10,000 feet, and can be trimmed to fly without foot load. Maintain at least 145 (140) m.p.h. I.A.S. The automatic pilot has sufficient power to maintain a straight course with either outboard engine out of action, but only if assisted by the rudder trimming tab.

(iv) *Landing on three engines.* – Lowering of flaps to 20° and of undercarriage may be carried out as normally on the circuit, but further lowering of the flaps should be left until final straight approach. The final approach should be made at 120–125 m.p.h. I.A.S. using as little power as possible, and rudder trim

should not be wound off until definitely committed to landing. Use all good engines to regulate approach. (*See* A.P. 2095. Part IV, Note D.)

(v) *Handling on two engines.* – It should be possible to maintain height below 10,000 feet at 140 (135) m.p.h. I.A.S. on any two engines after release of bombs and with half fuel used; but with two engines dead on one side, the foot load will be very heavy. The automatic pilot will not cope with flight with two engines dead on one side.

(vi) *Landing on two engines.* – The circuit should be made with the good engines on the inside of the turn, and undercarriage and flaps left as late as practicable. Keep extra height in hand, if possible, and lower the undercarriage later than usual, but have it locked down just before the final approach. The approach should be made at 130–135 m.p.h. I.A.S. in a glide. When certain of getting into the airfield, lower flaps for landing. Do not wind off trim until final approach can be made in a glide, as some power may be necessary in the early stages. (*See* A.P. 2095, Part IV, Notes C and D.)

(vii) Do not attempt to maintain height above 10,000 feet, either on three or two engines.

(viii) *Fuel system.* – The cross-feed cock should only be turned on when it is desired to feed fuel from port (or starboard) tanks to starboard (or port) engines. In this case all live engines should be fed from one tank and the fuel booster pump for this tank should be on. The fuel selector for the tanks on the other side of the aircraft should be off. At all other times, the cross-feed cock should be off.

53. Feathering

(i) (a) *Practice feathering.* – Check that the booster pump in the tank feeding the engine to be stopped is on. *See* para. 52 (i). Set propeller control to low r.p.m. and throttle to give a moderate cruising boost.

(b) *Emergency feathering.* – If possible, master fuel cock should be turned off immediately before feathering, but if this is not possible turn fuel cock off immediately after feathering. *See* para. 52 (i).

(ii) Hold the button in only long enough to ensure that it stays in by itself; then release it so that it can spring out when feathering is complete.

(iii) Close the throttle; on Lancaster III and X aircraft move the slow-running cut-out switch to IDLE CUT-OFF position.

(iv) Switch off only when the engine has stopped.

(v) Engine auxiliaries which will be affected by feathering:

Port outer	Alternator for special radio, rear turret hydraulic pump.
Port inner	Generator, main services hydraulic pump, mid-under turret hydraulic pump, R.A.E. compressor for Automatic Pilot Mark IV and computer unit of Mark XIV bombsight, No. 1 vacuum pump.
Starboard inner	Generator, main services hydraulic pump, front turret hydraulic pump, Heywood compressor for pneumatic system, No. 2 vacuum pump.
Starboard outer	Alternator for special radio, mid-upper turret hydraulic pump.

54. **Unfeathering**

NOTE. – It is preferable not to unfeather at speeds above normal cruising speed to avoid any risk of overspeeding.

(i) Set throttle closed or slightly open, propeller control fully down and ignition on.

(ii) Switch on the fuel booster pump of the tank in use, and turn on master engine cock.

(iii) Hold the button in and, on Lancaster III and X aircraft, as the engine starts turning set the slow-running cut-out switch to RUNNING (up) position. Continue to hold the button in until r.p.m. reach at least 1,500 and not more than 1,800.

(iv) If the propeller does not return to normal constant-speed operation, open throttle slightly.

55. **Damage by enemy action**

(i) *Fires.* – If fire occurs in bomb bay, pilot should open bomb doors, jettison bombs, and dive.

(ii) *Flight engineer's checks:*

Check fuel contents gauges. Should any abnormal consumptions be shown on the tank the aircraft is running on, or should any of the other tanks show a loss of fuel, proceed as follows:

(a) Cross-feed cock ON.

(b) Run all engines on the damaged tank, and switch on its booster pump. The fuel selector for the tanks on the other side of the aircraft should be off.

(c) When contents of damaged tank fall to 20 gallons, turn on fuel selector for the corresponding tank on the other side of the aircraft and turn OFF cross-feed valve.

(d) Watch fuel pressure warning lights or fuel pressure gauge and change over to other tank as soon as pressure drops; switch off booster pump in empty tank.

56. Undercarriage emergency operation

If the hydraulic system fails the undercarriage can be lowered by compressed air from a special bottle or bottles, irrespective of the position of the undercarriage lever.

NOTE. – The flap selector should be neutral before using the undercarriage emergency air system.

On early aircraft the control is just aft of the front spar, but on later aircraft the knob (80) for working the air system is just forward of the flight engineer's panel. The undercarriage cannot be raised again by this method. Although the undercarriage will lower by this method, irrespective of the position of the normal undercarriage selector, the latter should be left in the down position for and after landing; otherwise, any leakage of air pressure may cause the undercarriage locks to be released and the undercarriage to collapse.

57. Flaps emergency operation

After lowering the undercarriage by turning on the emergency air cock, the flaps may be lowered by operating the flaps control, which admits the air pressure to the flaps system. The flaps can be raised again, but there may not be sufficient air pressure to lower the flaps a second time; furthermore it may cause the header tank to burst. If it is absolutely necessary to raise the flaps by emergency method extreme care must be taken to raise them slowly by stages. If the flaps are lowered by the emergency method before landing, flaps must be left down after landing, owing to the likelihood of bursting the header tank.

58. Bomb doors emergency operation

On aircraft in which Mod. 757 is incorporated, the bomb doors can be operated in an emergency by compressed air from an air bottle (entirely separate from undercarriage and flaps emergency air bottle).

If, when pilot selects bomb doors open or closed, the doors fail to operate, the air bomber should withdraw the pin on the emergency air control in the nose, and hold the control down against the spring; when the doors have fully opened (or closed), the air bomber should release the control. There is sufficient pressure in the air bottle for three or four operations.

59. Bomb jettisoning

(i) Open bomb doors, and check visually that both are fully open. *See* para. 19.

(ii) Then jettison containers first by switch (15) on right of dash.

(iii) Jettison bombs by handle (16) beside container jettison switch.

(iv) Close bomb doors.

60. Fuel jettisoning

NOTE. – Contents of No. 1 tanks only can be jettisoned.

(i) Reduce speed to 150 (145) m.p.h. I.A.S. and lower flaps 15°.

(ii) Lift and turn jettison control on left of pilot's seat. Return control after jettisoning.

(iii) The jettison valve should be closed while there is still about 100 gallons remaining in each tank; if the jettison valve is left open, all the fuel will be jettisoned less approximately 70 gallons, but the last 30 gallons of jettisonable fuel runs out slowly and is inclined to get splashed over the fuselage. The jettison valve may be closed at any time during jettisoning.

Approximate weight of jettisonable fuel, leaving 100 gallons in each tank, is 6,900 lb.

61. Parachute exits

(i) Hatch in floor of nose should be used by all members of the crew if time is available; it is released by handle in centre, lifted inwards and jettisoned.

(ii) Main entrance door should be used as a parachute exit only in extreme emergency.

62. Crash exits

Three push-out panels are fitted in the roof, one above the pilot, one just forward of the rear spar, and one forward of the mid-upper turret.

63. **Dinghy and ditching**

(i) A type J dinghy stowed in the starboard wing may be released and inflated:

(a) from inside by pulling the release cord running along the fuselage roof aft of the rear spar;

(b) from outside by pulling the loop on the starboard side, rear of the tail plane leading edge.

(c) automatically by an immersion switch.

(ii) The flaps should be lowered 30° for ditching, but if the flaps will not lower by the hydraulic system, do not attempt to lower them by the compressed air system, as this will also cause the undercarriage to lower (*see* paras. 56 and 57).

64. **Engine fire-extinguishers**

Each engine is provided with a fire-extinguisher bottle which can be operated by pushbuttons on the pilot's instrument panel; the fire-extinguishers are also operated automatically by a crash switch (on the starboard side of the nose) and, when the undercarriage is down, by a gravity switch (also on the starboard side of the nose).

NOTE. – The automatic flame switches have been disconnected. Therefore in flight the operation of the engine fire-extinguisher is left entirely to the pilot's discretion.

65. **Hand fire-extinguishers**

One on port side of air bomber's compartment.

One on port side of pilot's seat.

One on starboard side aft of rear spar.

One on starboard side forward of mid-upper turret.

One at tail turret.

66. **Signal pistol.** – This is stowed on top of the front spar; the firing position is in the roof forward of the stowed position.

67. **Signal cartridge stowage.** – Starboard side of fuselage just forward of front spar.

68. **Parachutes**

One in air bomber's compartment, on aft bulkhead.
One behind pilot's seat.
One on starboard wall at rest station.
One on starboard wall forward of mid-upper turret.
One on port side, opposite entrance door.
One forward of tail turret.

69. **Static line for parachuting wounded men**

(i) If possible, fly aircraft at 130 m.p.h. I.A.S. with 15° flap.

(ii) Assist casualty to air bomber's compartment and place him feet first facing aft.

(iii) Check casualty's parachute harness, fit parachute, remove helmet.

(iv) Remove static line from stowage which is situated on starboard side of front exit. Care should be taken that the threads keeping the static line folded up are not broken. Take snap hook at end of static line and attach to parachute as follows.

(v) Pass the safety becket on the static line through the double 8 cord loop, then pass the small snap hook through the safety becket.

(vi) Snap the hook down on to the rip-cord handle. Insert safety pin to lock the shroud of the snap hook.

(vii) Stow the slack of the static line between the becket and the snap hook under the adjacent pack elastic to prevent this slack length getting caught up on anything and thus pulling the rip-cord too soon.

(viii) Open and jettison front hatch.

(ix) Slide the man through the exit feet first facing aft. Care must be taken to keep his hands to his sides. Do not hold on to the static line by hand.

70. **Emergency packs.** – On starboard side at rest station.

71. **Projectible kite container.** – Along port side at rest station.

72. **Crash axes**

One on port side of fuselage aft of main entrance door. One on starboard wall in front of rear spar.

73. **Incendiary bombs.** – Two are provided on front face of front spar for destruction of aircraft.

74. **First-aid equipment.** – Starboard side of fuselage aft of main entrance door.

PART V
SUPPLEMENTARY NOTES FOR FLIGHT ENGINEER

75. **Oil system.** – A self-sealing oil tank is fitted in each nacelle; the normal capacity is 37½ gallons with 4½ gallons air space. The normal type of oil used is DTD. 472B. A stack pipe in each tank retains 2–3 gallons for feathering the propeller. Normal high-pressure oil feeds the propeller constant speed unit.

Under cruising conditions, it is recommended that the oil temperature should not exceed 60°C., but up to 90°C. may be used without damage to the engine. The oil consumption should be between 8 and 16 pints per hour.

76. **Coolant system.** – A horseshoe type header tank, filled with 30% Glycol (D.T.D. 344A inhibited) and 70% distilled water, is mounted over the reduction gear of each engine. On the ground with engine running a small coolant discharge is normal, but not in flight.

From B block on each inboard engine coolant is led to the cabin heating radiator, through which the flow of air is regulated by controls either side of the fuselage at the wireless operator's station.

77. **Hydraulic system**

The accumulator, supplied by two pumps, has an air charging valve and a pressure gauge which should read 220 lb./sq.in. when there is no pressure in the system. Misleading pressure gauge readings will occur if the accumulator air pressure is incorrect. The gauge should read between 800–900 lb./sq.in. under working pressure, when the cut-out operates isolating the pumps and relieving them of unnecessary strain. The accumulator then provides the initial pressure to operate the various systems. When the pressure falls between 220–300 lb./sq.in. the pumps will automatically be cut in to operate the system and build up accumulator pressure again.

Hydraulic fluids. – The four fluids suitable are mineral oils. They may be mixed if additional supplies of that already in use are not available.

(i) Intava mixture 70% DTD585 + 30% DTD472.
(ii) Intava 695.
(iii) Mixture of two parts DTD44 and one part Intava 694.
(iv) DTD44.

Mixtures containing DTD44 will congeal at a higher temperature than the others. The first-mentioned mixture has the lowest congealing temperature.

Fuel jettison. – When the fuel jettison control is operated an air inlet valve is opened in the top of each No. 1 tank, and at the same time a valve is opened at the bottom of each tank, breaking a small retaining washer and releasing a spring-loaded stocking. Do not jettison below 100 gallons (*see* Part III, para. 60). The valves may be closed at any point but the stocking will not be retracted. When repacking, ensure that the stocking is dry and serviceable. Reseat the inlet and the outlet valves. Before fitting one of the spare shear washers carried in the housing, the spindle must pass centrally through the jettison valve.

78. Pneumatic system

The pressure (normally 300–320 lb./sq.in.) is controlled by a pressure regulating valve, which recommences charging when the pressure drops to 270–280 lb./sq.in. If the pressure drops to 130 lb./sq.in. or below, a pressure-maintaining valve closes, rendering the entire pneumatic system, with the exception of the brakes, out of operation. Therefore M supercharger ratio will be engaged, and the idle cut-off and radiator flaps will be inoperative. If pressure cannot be built up, to stop Merlin 28 or 38 engines, throttle down to minimum r.p.m. and close the master fuel cocks. This will drain the carburettor, which should be carefully primed to expel all the air from the fuel chambers before restarting. (*See* Para. 42 (vi).)

79. Electrical system

Four accumulators, connected in series parallel, giving a capacity of 80 ampere hours at 24 volts, are charged by two generators. Two ammeters on the main electrical control panel indicate the total generator output to services and battery charging. On the same panel a voltmeter indicates the state of the accumulators, reading 28–29 volts in flight under normal conditions and over 24 on the ground with engines stopped. On Lancasters I and III, spare fuses and a fuse location table are inside the hinged door. The main generator fuses are at the top inside the main control panel. Spare fuses are carried in the lid of the fuse box.

The switches below are for ground fault tracing and must be left on and not touched in flight.

On the front of the panel are two earth warning lights, a resin light switch (locked to prevent its movement) and the air bomber's station light switch of which the push button is for use on the ground in conjunction with the earth warning lights.

On Lancaster X, overload switches are fitted in the heavier circuits and flick off if the current becomes too great. Allow five or ten minutes for the service to cool down and turn the switch on.

80. Undercarriage failure

Should the red warning lights remain steady or the green lights not appear when the undercarriage is selected down, operate the warning light changeover switch. If this is ineffective select undercarriage up and return the selector down. If this is still ineffective check the accumulator pressure gauge reading. Should it be 300 lb./sq.in. there is probably no pressure in the system. Select the undercarriage up and down again. The pressure may drop between 200 and 300 lb./sq.in. then rise between 850 and 900 lb./sq.in. when the cut-out operates. If about 800 lb./sq.in. is indicated and the undercarriage appears to be down visually the indicator is probably faulty. If there is still some doubt use the emergency air pressure to make certain the undercarriage is down, turning the cock off when the operation is complete. This conserves the air pressure for further use; if it is necessary to use the flaps emergency system the method of operation is described in para. 57.

81. **Gauges.** – The gauges on the engineer's panel in the Lancaster X are the four point type fitting into sockets and are therefore interchangeable.

PART VI
ILLUSTRATIONS AND LOCATION OF CONTROLS NOT ILLUSTRATED

Location of Controls

Service	*Location*
Undercarriage warning horn test pushbutton	Behind pilot's seat.

Cross feed cock	On floor, just forward of the front spar.
Priming pump and cock (if fitted)	In each inboard nacelle.
Air intake heat control	Left of pilot's seat.
Radiator shutter switches	On starboard cockpit wall.
Supercharger gear change lever (on early Lancaster I)	To right of starboard master engine cocks.
Ground/flight switch.	On starboard side aft of front spar.
Cockpit heat controls	One each side of the fuselage just forward of the front spar. Two adjustable louvres in fuselage nose.
Oxygen master valve	At forward end of oxygen crate.
Camera pushbutton control	On starboard rail of cockpit.
Reconnaissance flare stowage	On either side of fuselage forward of flare chute.
Flame floats or sea markers stowage	On either side of fuselage adjacent to flare chute.

Fuses

Location	*Service*
(a) Inside junction box at forward end of bomb aimer's compartment	Bomb gear fuses.
(b) Pilot's auxiliary fuse panel	Oil and radiator thermometer fuses.
(c) Navigation panel	Radio fuses.
(d) Mid turret position	Mid-upper and underturret, call lights, and, on early aircraft beam approach fuses.
(e) Main electrical control panel	General services.

Key to Fig. 1
Instrument Panel

1. Instrument flying panel.
2. D.F. Indicator.
3. Landing light switches.
4. Undercarriage indicator switch.
5. D.R. compass repeater.
6. D.R. compass deviation card holder.
7. Ignition switches.
8. Boost gauges.
9. R.p.m. indicators.
10. Booster coil switch.
11. Slow-running cut-out switches.
12. I.F.F. detonator buttons.
13. I.F.F. switch.
14. Engine starter switches.
15. Bomb containers jettison button.
16. Bomb jettison control.
17. Vacuum change-over cock.
18. Oxygen regulator.
19. Feathering buttons.
20. Triple pressure gauge.
21. Signalling switchbox (identification lamps).
22. Fire-extinguisher pushbuttons.
23. Suction gauge.
24. Starboard master engine cocks.
25. Supercharger gear change control panel.
26. Flaps position indicator.
27. Flaps position indicator switch.
28. Throttle levers.
29. Propeller speed control levers.
30. Port master engine cocks.
31. Rudder pedal.
32. Boost control cut-out.
33. Signalling switchbox (recognition lights).
34. Identification lights colour selector switches.
35. D.R. compass switches.
36. Auto controls steering lever.
37. P.4 compass deviation card holder.
38. P.4 compass.
39. Undercarriage position indicator.
40. A.S.I. correction card hold.
41. Beam approach indicator.
42. Watch holder.

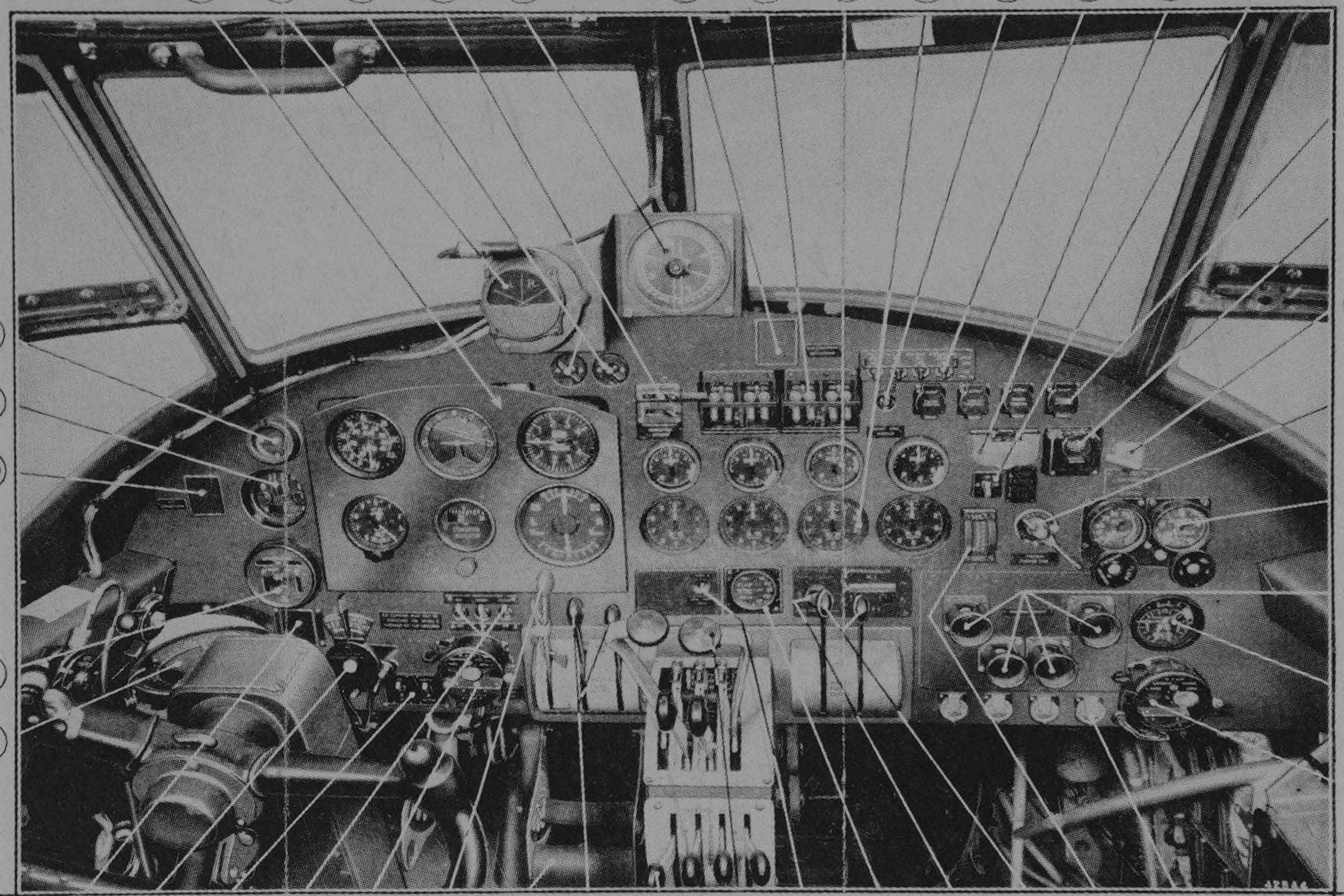


FIG 1

INSTRUMENT PANEL

FIG 1

Key to Fig. 2
Port Side of Cockpit

43. Bomb doors control.
44. Navigation lights switch.
45. D switch.
46. Auto controls main switch.
47. Pushbutton unit for T.R. 1196.
48. Seat raising lever.
49. Mixer box.
50. Beam approach control unit.
51. Oxygen connection.
52. Pilot's call light.
53. Auto controls altitude control.
54. Auto controls cock.
55. Auto controls clutch.
56. Brake lever.
57. Auto controls pressure gauge.
58. Pilot's mic/tel socket.
59. Windscreen de-icing pump.
60. Flaps selector.
61. Aileron trimming tab control.
62. Elevator trimming tab control.
63. Rudder trimming tab control.
64. Undercarriage control lever.
65. Undercarriage control safety bolt.
66. Portable oxygen stowage.
67. Harness release lever.

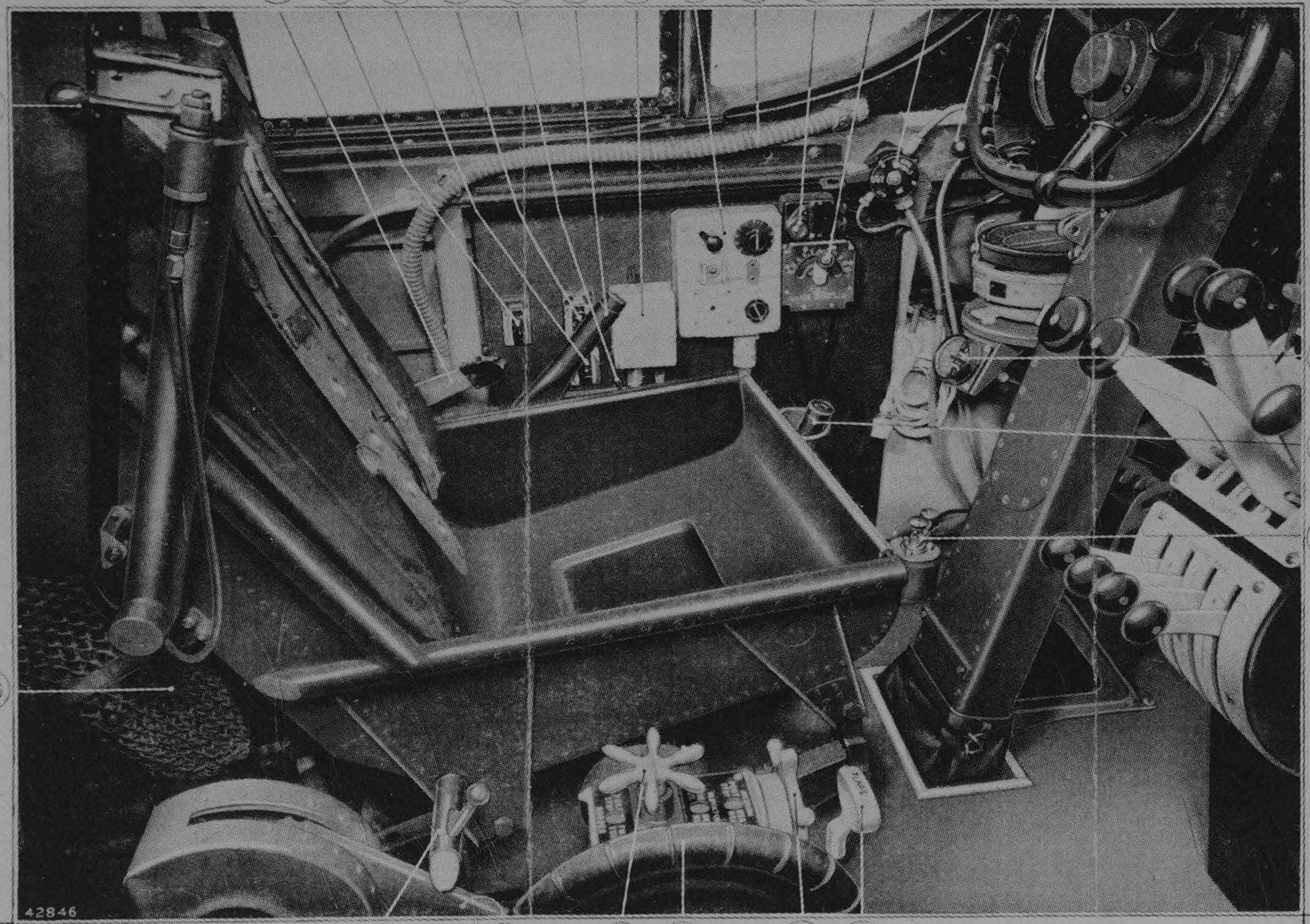


FIG 2 PORT SIDE OF COCKPIT FIG 2

Key to Fig. 3
Flight Engineer's Panel
Lancasters I & III

68. Ammeter
69. Oil pressure gauges.
70. Pressure-head heater switch.
71. Oil temperature gauges.
72. Coolant temperature gauges.
74. Fuel contents gauges.
75. Inspection lamp socket.
76. Fuel contents gauge switch.
77. Fuel tanks selector cocks.
78. Electric fuel booster pump switches.
79. Fuel pressure warning lights.
80. Emergency air control.
81. Oil dilution buttons.

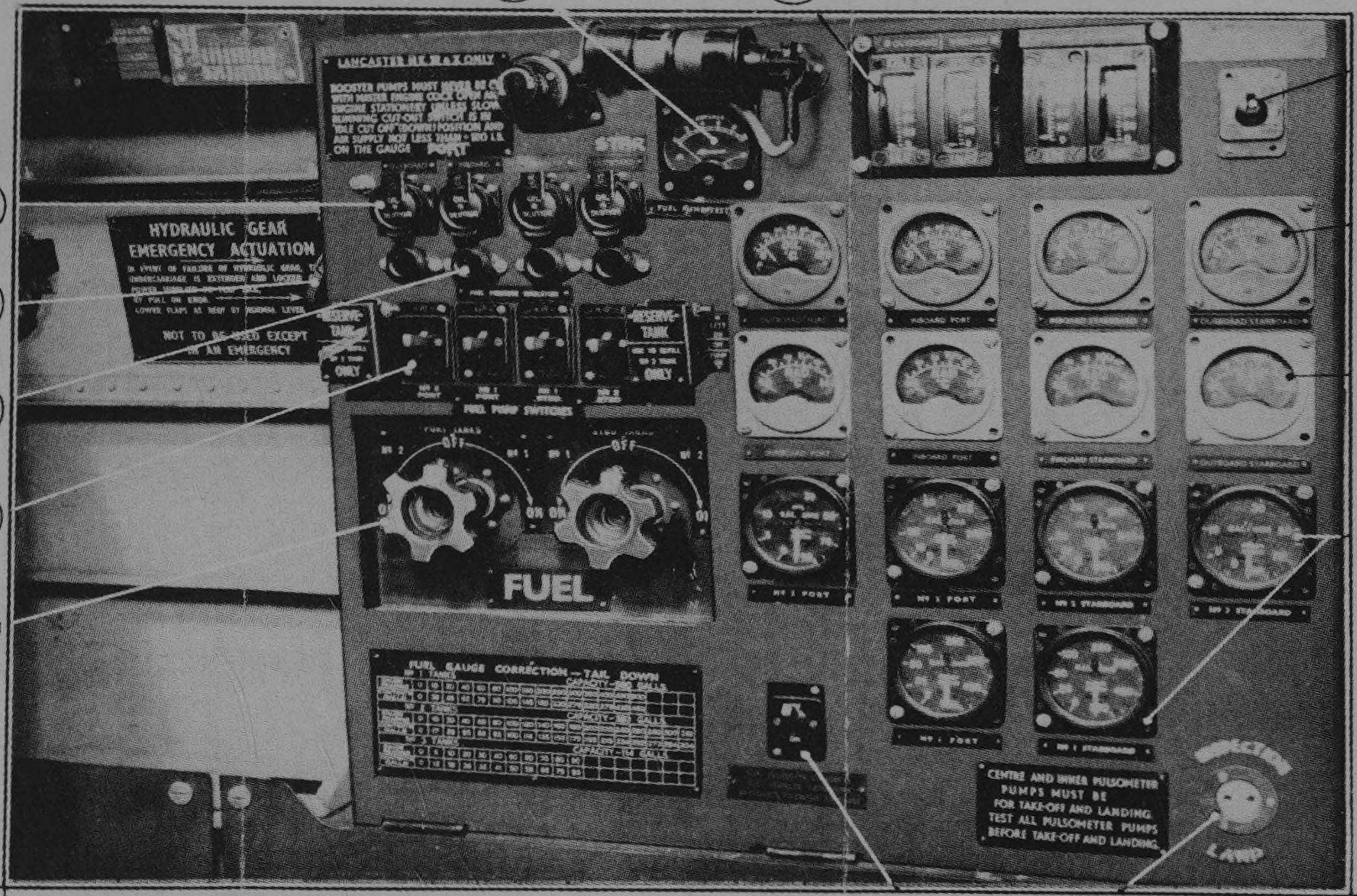


FIG 3 — FLIGHT ENGINEER'S PANEL, LANCASTERS I AND III — FIG 3

Key to Fig. 4
Flight Engineer's Panel
Lancaster X

68. Ammeter.
69. Oil pressure gauges.
71. Oil temperature gauges.
72. Coolant temperature gauges.
73. Fuel pressure gauges.
74. Fuel contents gauges.
75. Inspection lamp socket.
77. Fuel tanks selector cocks.
78. Electric fuel booster pump switches.
80. Emergency air control.
81. Oil dilution buttons.

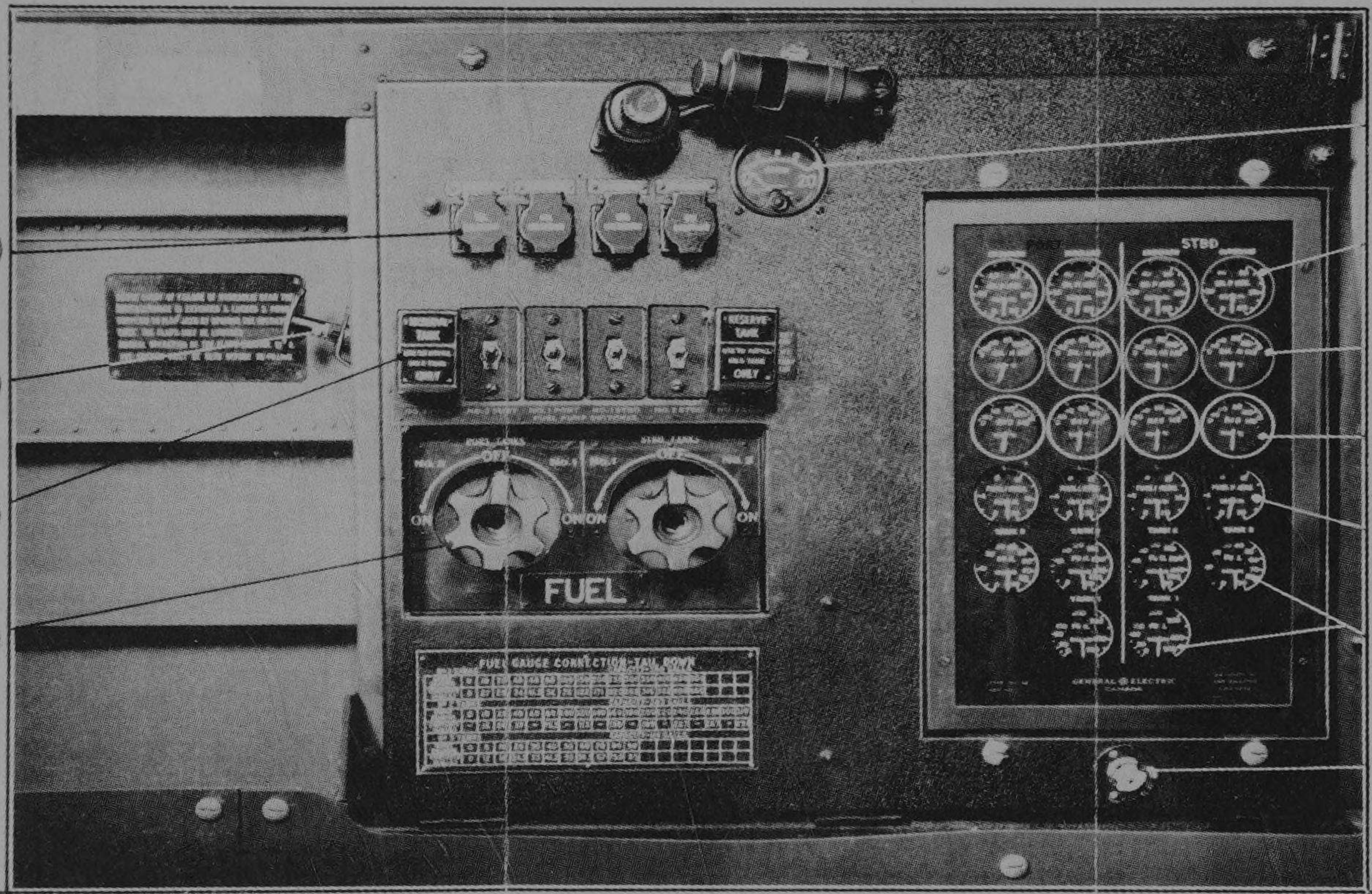
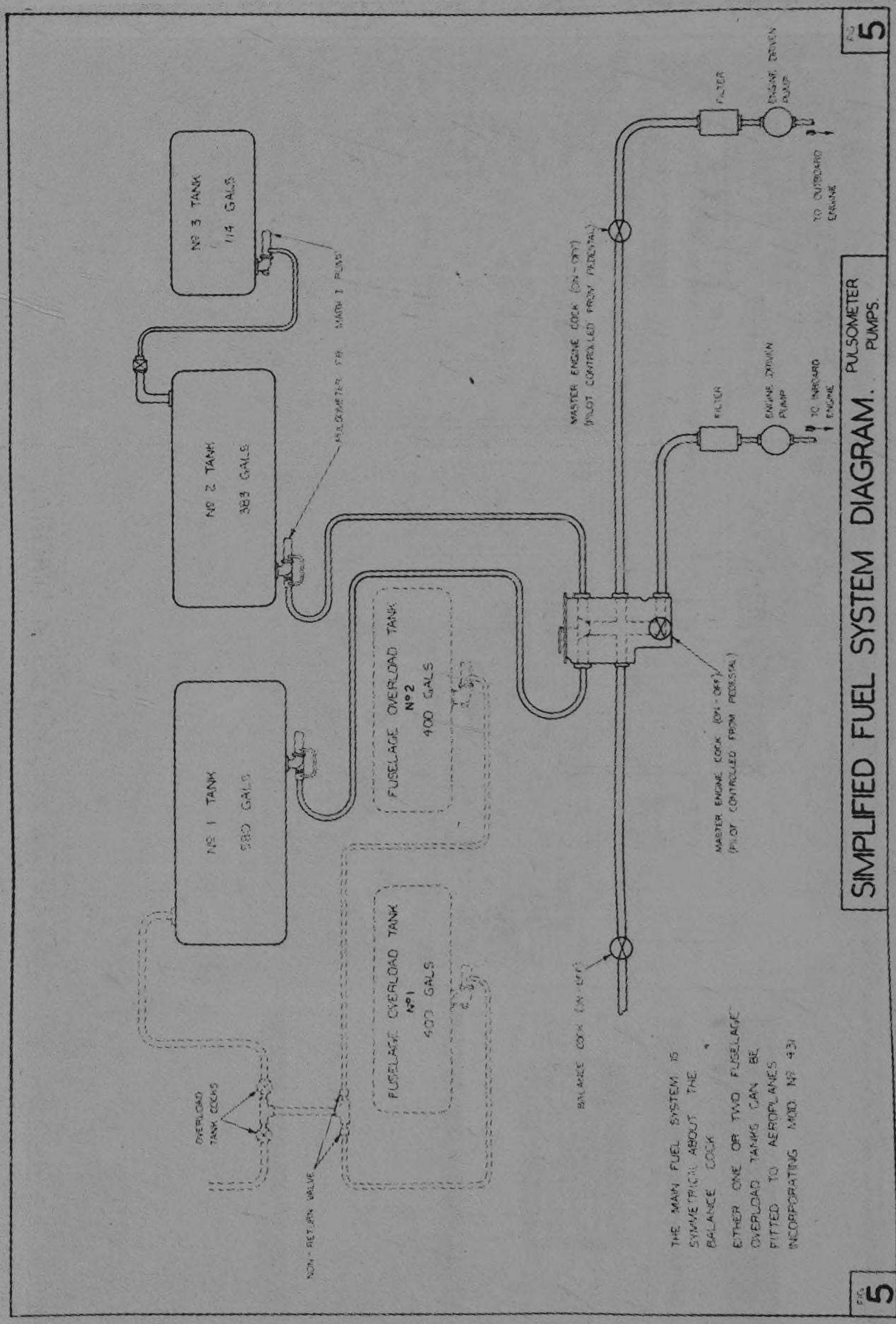
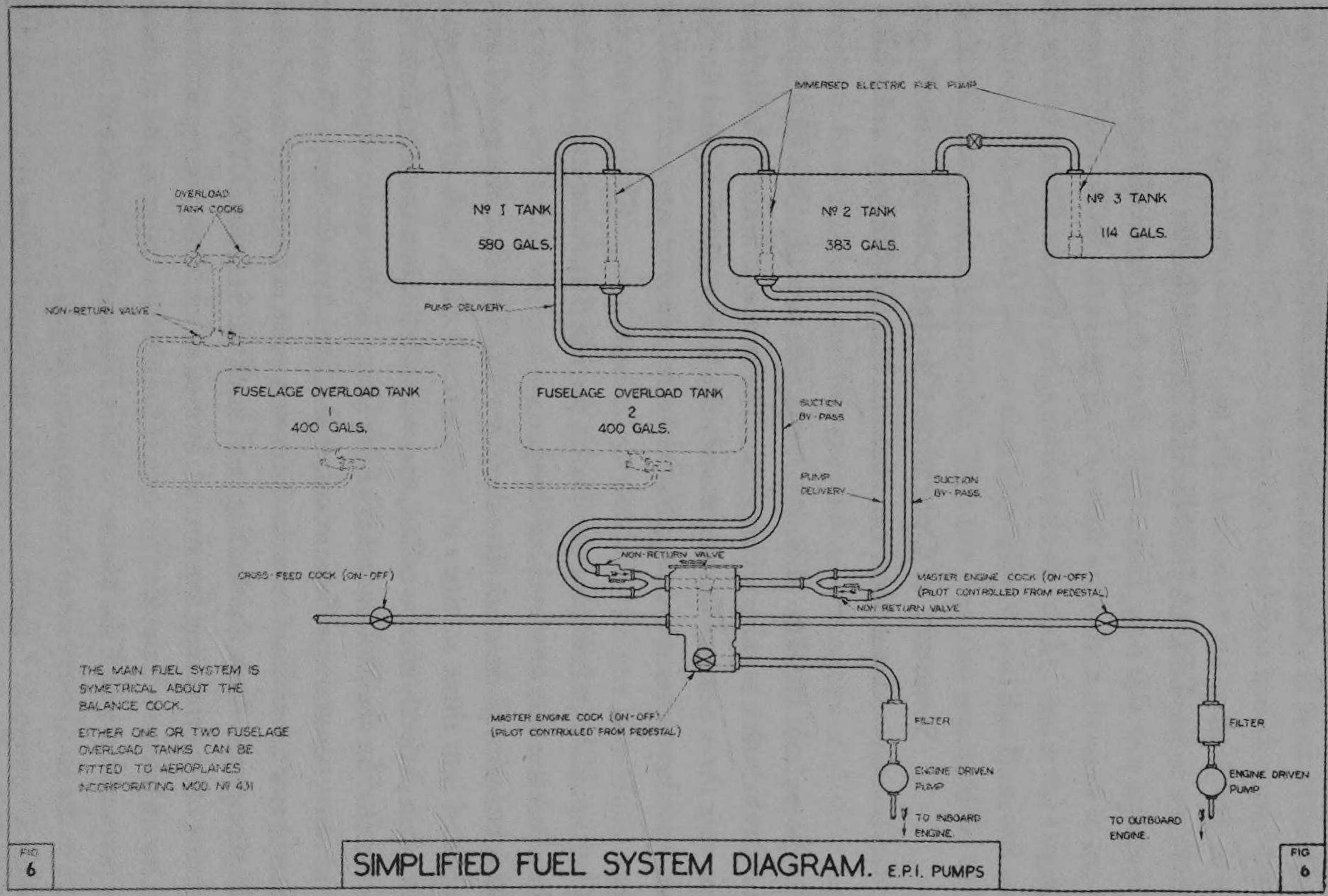


FIG 4 FLIGHT ENGINEER'S PANEL, LANCASTER X FIG 4


FIG 5
SIMPLIFIED FUEL SYSTEM DIAGRAM. PULSOMETER PUMPS.
No 3 TANK
114 GALS
No 2 TANK
383 GALS
No 1 TANK
580 GALS
FUSELAGE OVERLOAD TANK No 2 400 GALS
FUSELAGE OVERLOAD TANK No 1 400 GALS
MASTER ENGINE COCK (ON-OFF) (PILOT CONTROLLED FROM PEDESTAL)
FILTER
ENGINE DRIVEN PUMP
TO ENGINE
BALANCE COCK (ON-OFF)
OVERLOAD TANK COCKS
NON-RETURN VALVE
THE MAIN FUEL SYSTEM IS
SYMMETRICAL ABOUT THE
BALANCE COCK
EITHER ONE OR TWO FUSELAGE
OVERLOAD TANKS CAN BE
FITTED TO AEROPLANES
INCORPORATING MKD No 431



THE MAIN FUEL SYSTEM IS SYMETRICAL ABOUT THE BALANCE COCK.

EITHER ONE OR TWO FUSELAGE OVERLOAD TANKS CAN BE FITTED TO AEROPLANES INCORPORATING MOD. Nº 431

FIG. 6

SIMPLIFIED FUEL SYSTEM DIAGRAM. E.P.I. PUMPS

FIG 6

CHAPTER IV
Operation Chastise

OPERATIONS RECORD BOOK

Detail of work carried out
By No. 617 Squadron
For the Month of May 1943

Summary of Operation Carried Out By Squadron on 16/17th May 1943.

On the night of 16/17th. May, 1943, nineteen aircraft of No. 617 Squadron took off to breach a number of important Dams in and around the Ruhr area. There were three primary targets, namely the Mohne, the Eder and the Sorpe Dams, and three alternative targets, the Lister, the Ennerpe and the Diemel Dams.

The Squadron trained for six weeks, paying particular attention to map reading and accurate low level bombing.

The attack was divided into three waves. The first wave of 9 aircraft subdivided into three sections of three aircraft each, took off at 10 minute intervals, in perfectly clear weather, and with a full moon to assist them. They were detailed for the Mohne and the Eder Dams, in that order of priority. The second wave, consisting of five aircraft, took off to attack the Sorpe Dam, taking a different route, but timed to cross the enemy coast at the same time as, though at different points from, the leading section of the first wave. The third wave, consisting of the remaining five aircraft, formed an air bomb reserve and took off three hours later, each detailed for one of the alternate targets, and all detailed to be prepared to attack the Mohne or Eder Dams in the absence of any direct orders in the air to carry on to the alternative targets.

Wing Commander Gibson, en route to the target leading the first section of the first wave, met about twelve searchlights, and some concentrated light flak at the lakes 10 miles N.E. of Haltern, which was reported to Group by W/T, and passed by Group to all the other aircraft. On arrival at a point 10 miles from the Mohne Dam, the formation went over to R/T control, and each individual attack

was controlled by W/Cdr. Gibson. There were between seven and ten light flak guns around the target, believed to be mainly 20 mm. One or two were located on the Dam itself, and there were two positions on the N bank of the Lake on each side of the Dam. W/Cdr. Gibson attacked first and dropped his load accurately. Four other aircraft then attacked under his control, one of which was seen to be hit by light flak during its run up, and overshot with its load. The Dam was seen to breach on the fifth attack, and this was reported to 5 Group by W/T. The remaining four aircraft were then diverted to the Eder Dam, one of these however had been shot down on the way to the target, and only three attacked. One load was seen to overshoot, and this Dam was seen to breach, after two successful attacks. This fact was also reported by W/T to Group Headquarters.

Of the five aircraft detailed to attack the Sorpe Dam, two returned early, one is known to have attacked, and two are missing without trace. A sixth aircraft from the mobile reserve was also detailed by W/T to attack the target, and did so successfully. The two aircraft attacking both reported that the crest of the Dam was seen to crumble for some considerable distance.

Two of the remaining four aircraft of the mobile reserve were detailed to attack the Sorpe Dam, one attacked successfully and one is missing, and it is believed did not attack. The fourth aircraft was detailed by W/T to attack the Lister Dam, and acknowledged the order. There is no further trace of him, and it is not known if he attacked it. The fifth aircraft successfully attacked the Dam at Enneppe.

The most important consequence of this operation is that the Ruhr industries will be deprived of a great deal of their industrial water for the coming summer. The immediate of the floods from the two Dams breached was to cause devastation and disruption throughout the valley of the Ruhr as far as Duisburg, and serious flooding below the Eder Dam at Kassel, and other places down the Weser Valley.

Date	Aircraft Type & Number	Crew	Duty
1943 May 16/17	Lancaster III ED. 932G.	W/Cdr. G.P. Gibson Sgt. Pulford J. P/O. R.T. Taerum F/Lt. R.E.G. Hutchison P/O. F. H. Spafford F/Sgt. G.A. Deering F/Lt. R.D. Trevor Roper	Captain. F/Eng. Nav. W/Optr. A/B. F/Gunner. R/Gunner.
	ED. 925G.	F/Lt. J.V. Hopgood. Sgt. Brennan C. F/O. K. Earnshaw. Sgt. Minchin J. F/Sgt. Fraser J.W. P/O. G.H. Gregory. P/O. A.F. Burcher.	As shown above.
	ED. 909G.	F/Lt. H.B. Martin. P/O. I. Whittaker. F/Lt. J.F. Leggo. F/O. L. Chambers. F/Lt. R.C. Hay. P/O. B.T. Foxlee. F/Sgt. Simpson T.D.	As shown above.
	ED. 877G.	S/Ldr. H.M. Young. Sgt. Horsfall D. Sgt. Roberts C.W. Sgt. Nichols L. F/O. V.S. MacCausland. Sgt. Yeo A.G. Sgt. Ibbotson L.	As shown
	ED. 906G.	F/Lt. D.J.H. Maltby Sgt. Hatton J. Sgt. Nicholson V.	As shown above.

Time Up	Time Down	Details of Sortie or Flight	References
2139	0415	Mohne Dam. 1 Mine, 60ft. 0028hrs. Identified the target and carried out first attack on the Mohne Dam. Came under light flak from guns around the target, but dropped his mine accurately and then directed the remainder of the attack by R/T. He also flew alongside one a/c as it attacked, machine gunning the defences to allow it to attack undisturbed. He then carried on to the Eder Dam and indicated the target to searching a/c and stayed to assess the results.	G.
2139	–	Mohne Dam. 1 Mine, Was about to be hit by flak on the run-up and to have engine on fire. He overshot with his mine, which struck the parapet, and then flew on for a few minutes before crashing in flames. It is believed that he may have climbed sufficiently for some members of his crew to escape by parachute.	M.
2139	0319	Mohne Dam. 1 Mine. 60ft., 0038 hrs. Mine burst about 20 yds. short. Starboard outer fuel tank and ailerons damaged by cannon fire, aircraft landed safely at base.	P.
2147	–	Mohne Dam. 1 Mine. Missing. Was seen to make an accurate attack with his mine and then accompanied W/Cdr. Gibson to the Eder Dam, and back to the Mohne, when the attack was finished. He was not heard on R/T. after this, and is believed to have flown over Hamm on the return journey and been shot down there.	A
2147	0311	Mohne Dam. 1 Mine. 60ft. 0139 hrs. Made a direct hit with his mine, and the Dam was seen to breach.	J.

Date	Aircraft Type & Number	Crew	Duty
1943 May 16/17		Sgt. Stone A.J.	
		P/O. J. Fort.	
		Sgt. Hill E.	
		Sgt. Simond D.	
	Lancaster III ED. 929G.	F/Lt. D.J. Shannon.	Captain
		Sgt. Henderson R.	F/Eng.
		F/O. F.R. Walker.	Nav.
		F/O. B. Goodale.	W/Optr.
		F/Sgt. Sumpter L. J.	A/B.
		Sgt. Jagger B.	F/Gunner
		F/O. J. Buckley.	R/Gunner
	ED. 937G.	S/Ldr. H.E. Maudslay.	As shown above.
		Sgt. Marriott J.	
		F/O. R.A Urquhart.	
		Sgt. Cottam A.	
		P/O. M.J.D. Fuller.	
		F/O. W.J. Tytherleigh.	
		Sgt. N.C. Burrows.	
	ED. 864G.	F/Lt. W. Astell.	As shown above.
		Sgt. Kinnear J.	
		P/O. F.A. Wile.	
		Sgt. Garshowitz A.	
		F/O. D. Hopkinson.	
		Sgt. Garbas F.	
		Sgt. Bolitho R.	
	ED. 912G.	F/O. L.G. Knight.	As shown above.
		Sgt. Grayston R.	
		F/O. H.S. Hobday.	
		F/Sgt. Kellow R.G.	
		F/O. E.C. Johnson.	
		Sgt. Sutherland R.	
		Sgt. O'Brien.	

Time Up	Time Down	Details of Sortie or Flight	References
2147	0406	Eder Dam. 1 Mine 60 ft. 0139 hrs. Diverted from the Mohne to the Eder Dam, attacked first and registered a direct hit, but no result was seen.	L.
2159	–	Mohn Dam. 1 Mine. This aircraft is believed to have been damaged on the way to the target, as something that could not be identified was seen by the light of the moon to be hanging underneath it. The mine overshot and stuck to the parapet, detonating instantaneously. The pilot was spoken to afterwards by R/T. and was heard to reply once, when he sounded very weak.	Z.
2159	–	Mohne Dam. 1 Mine. When leading his formation on the way to the target, appeared to become uncertain of his whereabouts, and on reaching a canal crossing, actually at the correct place, turned S. down the canal, as though to search for pinpoint. He fell about ½ mile behind his accompanying aircraft, doing this, and got slightly off track.He is believed to have been shot down by light flak shortly afterwards.	B.
2159	0420	Eder Dam. 1 Mine. Was the third aircraft to attack the Eder Dam. He made two runs and released his mine on the second one, making a direct hit and breaching the dam.	N.

Date	Aircraft Type & Number	Crew	Duty
1943 May 16/17	Lancaster III ED. 921G.	F/Lt. J.L. Munro Sgt. Appleby F. F/O. F.G. Rumbles Sgt. Pigeon P.E. Sgt. Clay J.H. Sgt. Howarth W. F/Sgt. Weeks H.	Captain. F/Eng. Nav. W/Optr. A/B. F/Gunner. R/Gunner.
	ED 923G.	F/Lt. J.C. McCarthy Sgt. Radcliffe J. F/Sgt. McLean D.A. Sgt. Eaton R. Sgt. Johnson G.L. Sgt. Batson R. P/O. D. Rodger	As shown above.
	ED. 936G.	P/O. G. Rice. Sgt. Smith H. F/O. R. MacFarlane. Sgt. Gowrie C.B. F/Sgt. Thrasher W. Sgt. Maynard T. Sgt. Burns S.	As shown above.
	ED. 934G.	Sgt. Byers V.W. Sgt. Taylor A. F/O. J.H. Warner. Sgt. Wilkinson R. Sgt. Whittaker A. Sgt. Jarvie R. Sgt. McDowell H.	As shown above.
	ED. 927G.	F/Lt. R.N.G. Barlow. Sgt. Whillis S.L. F/O. P.S. Burgess. F/O. C.R. Williams. Sgt. A Gillespie. P/O. H.S. Glinz. Sgt. Liddell D.	As shown above.

Time Up	Time Down	Details of Sortie or Flight	References
2129	0036	Sorpe Dam. 1 Mine. Aircraft was hit by light flak at Vlieland on the way to the target, which put the intercom. out of action and forced the aircraft to return with his load to base.	W.
2201	0323	Sorpe Dam. 1 Mine. 30ft. 0046 hrs. Had trouble with his compass and took off 20 mins late. Flew his route in reverse direction as a consequence. Had difficulty finding the lake, due to mist, and on locating it, found the run along the Dam was made very difficult by the presence of a small hill at either end. The mine was dropped and seen to explodein contact with the Dam. Part of the crest of the Dam was seen to crumble.	T.
2131	0047	Sorpe Dam. 1 Mine. Aircraft struck the sea in the Zuyder Zee E. of Texel and lost its mine, which is believed to have exploded.	H.
2130	–	Sorpe Dam. 1 Mine. Missing without trace.	K.
2128	–	Sorpe Dam. 1 Mine. Missing without trace.	E.

Date	Aircraft Type & Number	Crew	Duty
1943 May 16/17	Lancaster III ED. 910G.	P/O W.H.T. Ottley Sgt. Marsden R. F/O. J.K. Barrett Sgt. Guterman J. F/Sgt. Johnston L. Sgt. Tees R. Sgt. Strange H.	Captain F/Eng. Nav. W/Optr. A/B. F/G. R/G.
	ED. 865G.	P/Q L.J. Burpee Sgt. Pegler, G. Sgt. Jaye T. P/O. L.G. Weller. Sgt. Arthur R. Sgt. Long N. F/Sgt. Brady J.G.	As shown above.
	ED. 886G.	F/Sgt. Townsend W.C. Sgt. Powell D.J. P/O. C.L. Howard. F/Sgt. Chalmers G. Sgt. Franklin C.E. Sgt. Webb D.E. Sgt. Wilkinson J.	As shown above.
	ED. 918G.	F/Sgt. Brown K.W. Sgt. Feneron H.B. Sgt. Heal D.P. Sgt. Hewstone H.J. Sgt. Oancia S. Sgt. Allatson D. F/Sgt. MacDonald G.	As shown above.
	ED. 924G.	F/Sgt. Anderson C.T. Sgt. Paterson D. Sgt. Nugent L. Sgt. Bickle D. Sgt. Green S. Sgt. Ewan A. Sgt. Buck R.	As shown above.

Time Up	Time Down	Details of Sortie or Flight	References
0009	–	Lister Dam. 1 Mine. Missing, acknowledged his diversion to the Lister Dam, no further trace.	C.
0011	–	Sorpe Dam. 1 Mine. Missing without trace.	S
0014	0615	Enneppe Dam. 1 Mine. 60ft. 0337 hrs. Mist on the reservoir caused this aircraft to make 3 runs at the target. Mine dropped accurately on third attempt and seen to explode. Returned over Holland in broad daylight.	O
0012	0533	Sorpe Dam. 1 Mine. 60 ft. 0314 hrs. Shot up a train on the way to the target, on arrival at the target, was hampered by mist, so dropped some incendiaries in some trees, and used the resulting fire as a landmark whilst waiting for the mist to clear. Dropped mine accurately and saw it explode.	F
0015	0530	Sorpe Dam. 1 Mine. Was unable to reach target, due to mist in valleys, mine returned to base. **Guy Gibson** **Wing Commander,** **Commanding, 617 Squadron, R.A.F.**	Y

FLYING LOG BOOK, APRIL–MAY 1943
WING COMMANDER GUY GIBSON

Year 1943 Month	Date	Aircraft Type	No.	Pilot, or 1st Pilot	2nd Pilot Pupil, or Passenger	Duty (Including Results and Remarks)
April	1	Lancaster	B	Self	Crew	Local.
						Crew.
						P/O Taerum.
						P/O Spafford
						F/Lt Trevor Roper
						F/Lt Hutchison
						P/O Deering
						Sgt Pulford
"	4	"	B	"	"	To Lake nr Sheffield.
"	5	"	D	"	"	Scottish x country. Lakes.
"	9	"	D	"	"	Base – Derwent Reservoir
"	11	Maggie	–	"		Uppingham Res. – Base.
				Self	F/Lt Hay.	Local Manston.
						Crashed in field. OK.
"	15	Oxford	–	Self	Two crew	Base – Reading. Fairoaks – Base.
"	15	Mosquito	4098	S/LLongbottom (Shorty)	Self	Fairoaks – Weybridge
"	16	Lancaster	Y	Self	Crew	Cornish x country at low level with dummy attacks on lakes.
"	20	Lancaster	J	Self	Fay & Crew	Night x country to many reservoirs with dummy attacks.
April	21	Lancaster	D	Self	Crew	Local. Test of synthetic night flying equipment.
"	25	"	D	"	"	Long low level x country. with synthetic N/F gear dummy attack on Welsh dams.
"	27	"	"	"	"	Base – Manston – Base.

Year 1943 Month	Date	Aircraft Type	No.	Pilot, or 1st Pilot	2nd Pilot Pupil, or Passenger	Duty (Including Results and Remarks)
May	1	"	H	" S/L Young	"	To Manston – Base.
"	2	"	B	"	"	Low level recco.
"	3	"	B	"	"	Low level bombing. Special attack. 10 bombs.
"	4	"	B	"	"	Manston – low level base.
"	5	"	D	"	(Dinghy)	Base – Grantham – Base.
"	5	"	G	"	"	Special night attack.
"	6	"	G	"	"	Spotlight flying at 60ft at night.
"	7	Lancaster	V	Self	Usual crew	To Manston – Base.
"	8	Oxford	U	Self	S/L Smith	To Hendon.
"	"	Vega	?	Self	F/Lt Cox	Hendon – Manston.
"	"	Oxford	U	S/L Smith	Self	Manston – Base.
"	11	Lancaster	G	Self	Usual crew	Low level. Upkeep dropped at 60 ft. Good run of 600 yrds.
"	14	"	G	Self	" "	Bombing low level and V.H.F. test.
"	14	"	P	" G/C Whitworth	" D.S.O. D.F.C.	Full dress rehearsal on Uppingham Lake and Colchester Res. Completely successful.
"	16	Lancaster	G	Self	Sgt Pulford P/O Deering F/Lt Trevor Roper F/Lt Hutchison P/O Spafford P/O Taerum	Led attack on Mohne and Eder Dams. Successful.

Grand Total
1924 Hrs 20 Mins†

† Individual flight times have been omitted.

CHAPTER V
Targets

INTERIM REPORT ON H_2S NOSE INSTALLATION IN LANCASTER AIRCRAFT

Royal Aircraft Establishment,
Radio Department,
Farnborough.
28 Nov 1943

1. Introduction

A request was received for a Lancaster aircraft to be installed with H_2S Equipment with the scanner moved to a position immediately under the nose instead of the normal position amidships under the fuselage. The object of moving the scanner is to avoid interference with the forward aspect of the radiation by the introduction of over-size bomb doors to accommodate an 8000 lbs. bomb load.

Lancaster aircraft ED.371/G was allocated for this purpose. A new nose unit has been built, the scanner has been moved to its nose position and the installation of H_2S has been completed. Several flight tests have been carried out, the results of which are summarised below.

It is important to point out that this aircraft has not yet been equipped with the over-size bomb doors and that the new nose structure is of wood. The results of the flight tests so far carried out cannot, therefore, be conclusive and are not indicative of the results which may be obtained in a production aircraft having the over-size bomb doors and a metal nose structure.

2. Installation of Equipment

The standard H_2S equipment has been installed, but the movement of the scanner necessitated the movement of the T^2R Unit to a position immediately adjacent to it in the nose of the aircraft. This was necessary to avoid long leads between the T^2R Unit and the scanner.

Apart from these two features the layout is identical to the normal Lancaster installation.

3. Photographs of P.P.I.† Presentation

During several flight tests, photographs were taken of the P.P.I. tube showing different targets at various ranges, a special attachment being used for this purpose. Photographs of the gap and backward presentation were also taken and these are shown on the attached photographs [not included here]. For reasons of security, no annotation is shown on the photographs, the references being as follows:–

Fig. 1. Birmingham 9 miles ahead; Coventry to the left.
Fig. 2. Birmingham dead ahead, 20 miles, Coventry left 13 miles.
Fig. 3. Leicester 6 miles (10 mile range).
Fig. 4. Leicester 6½ miles (10 mile range).
Fig. 5. Leicester 4¾ miles (10 mile range).
Fig. 6. Showing gap behind and in front of A/C.

4. Summary of Flight Tests

4.1. The first flight test was carried out on the 24th October in the immediate vicinity of the Bristol Channel. Maximum range appeared to be good, towns showing up at 30 miles, but a gap, extending from 0–7½ miles, was observed in a dead ahead position. Returns were observed in a reciprocal heading (i.e. behind aircraft) between 0–4 miles. Further flights were carried out on the same day over Leicester, Northampton, Reading, and Oxford and on each occasion the target disappeared at a range of 7½ miles.

Both these flights were carried out at 20,000 feet.

4.2. Owing to the wooden structure of the nose it was decided to fit copper sheeting on the floor immediately above the scanner in an effort to simulate conditions obtaining with a standard metal nose.

On a subsequent flight the gap was still visible at the same range and no improvement was observed.

4.3. The standard 7° wedge was replaced by a 12° wedge, but when this was fitted in position, it was discovered that the corners of the scanner fouled the perspex cupola. In order to overcome this difficulty, the corners of the scanner were cut off, and this resulted in a decrease in the gap width of approximately ½ mile.

4.4. It was then decided to fit a copper tilting plate, 17 cms. wide, immediately under the existing tilting plate, the angle of tilt of the former being about 15° greater than that of the existing plate. During the flight test which

† Plan Position Indicator

followed this modification, there was evidence of excessive tilting as the ground return appeared as a thick ring 1 cm. wide in the centre of the tube. The width of the gap was approximately the same as before and the maximum range had been reduced from 30 miles to 20 miles.

The size of the copper tilting plate was then reduced from 17 cms. to 10 cms. and a further flight carried out over Leicester at 20,000 feet. The gap was still visible between 4–7½ miles and the ground return was very pronounced at 0–4 miles. The maximum range, however, had been increased to 25 miles.

4.5. A new scanner was fitted in the aircraft and this unit had the original 7° wedge but the original tilting plate had been elevated by approximately 1½ cms.

A flight was then carried out over Leicester and Birmingham at 20,000 feet and the gap was observed between 0–4½ miles. The echoes on the reciprocal heading were observed between 4–5 miles.

4.6. A final flight test was carried out in the vicinity of the Bristol Channel area for the purpose of testing the back radiation. This test showed that at an angle of 70° to the reciprocal heading the range was 13 miles while at an angle of 10° the range was 6 miles.

5. Conclusions

In all flights, with various adjustments of the scanner, there was a gap in the forward coverage. In the best case this extended from 4 to 7½ miles, from 20,000 feet. It appears unlikely that this gap can be completely filled by further adjustment of the type of scanner used.

The backward range was not better than 4 miles from 20,000 feet. The forward range was good.

6. Further developments

Concrete proposals have been made for a production installation of H_2S in a Lancaster nose. The proposed installation will have 8,000 lbs bomb doors, and a deeper nose, and the backward performance will be better than the existing experimental aircraft. As it is impossible to predict the performance of the proposed installation, it is hoped to carry out the following programme:–

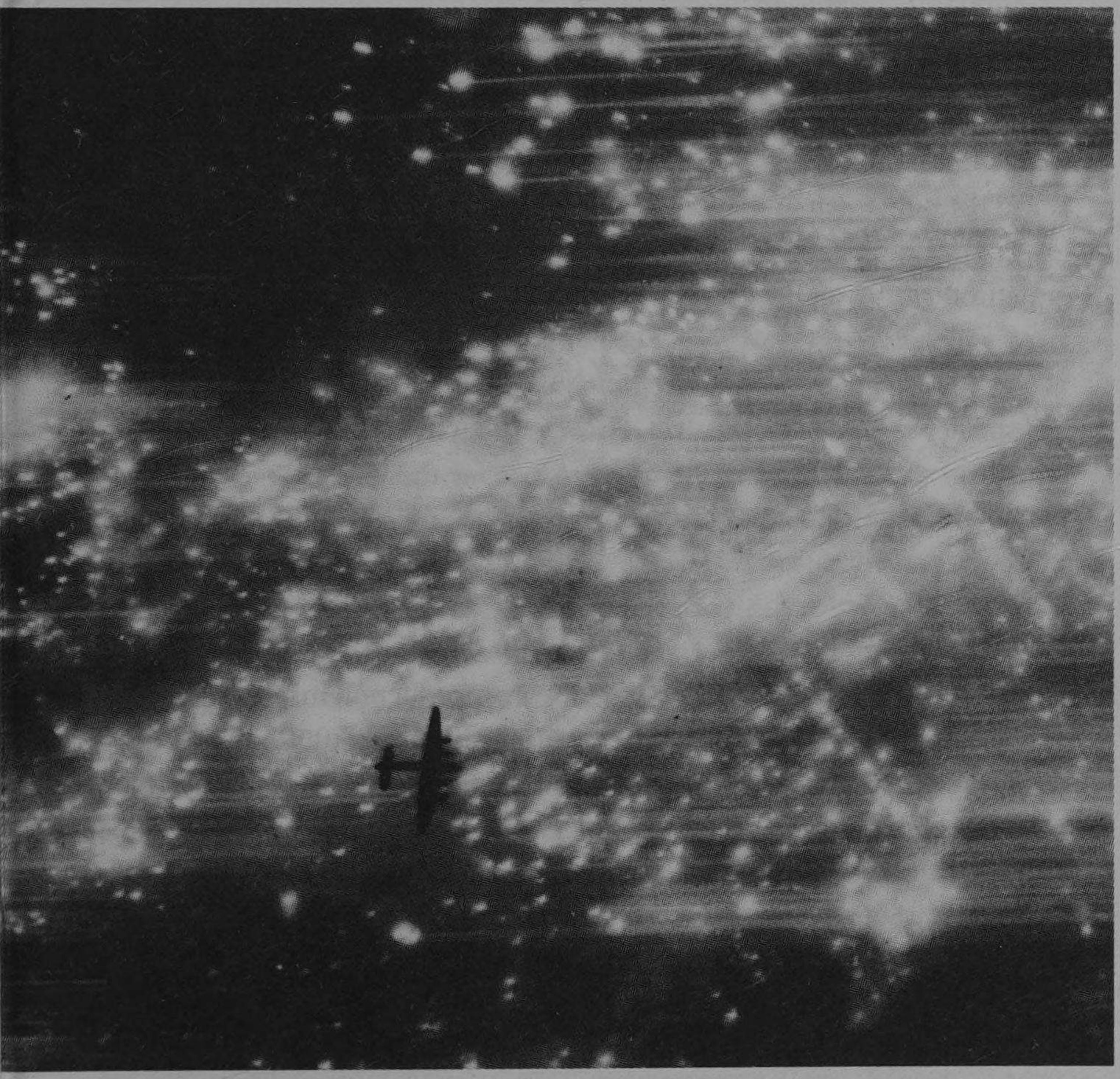
1. Modify the experimental aircraft to take a "barrel type" scanner. This occupies slightly more volume than the existing scanner but should not suffer from serious gaps in its forward coverage.
2. Modify the bulkheads, bomb doors and cupola of the experimental aircraft to simulate the proposed production aircraft in order to obtain an

estimate of the backward performance.

A final report will be issued when this experimental work is concluded.

7. Circulation

1. D.C.D. (Air Commodore Leedham)
2. D.C.D/R.D.C. 10 (Mr. Jales)
3. H.Q.B.C. (G/C Donaldson)
4. H.Q.F.C. (W/C Adams)
5. T.R.E. (Prof. Dee)
6. D. of Radar (G/C Pretty)
7. D.D/R.D.Q. (G/C Rutherford)



A Lancaster bomber over Hamburg during a bombing raid, October 1943.

SPECIAL TARGETS – NO. 617 SQUADRON

From:– Headquarters, No. 54 Base. TOP SECRET
To:– Headquarters, No. 5 Group.
Date:– 17th February, 1945.
Ref:– 54B/TS.3256/Air.

1. I have been considering methods of exploiting more fully the valuable experience and potential offensive power of No. 617 Squadron and would like to make the following suggestions. At present the Squadron is often detailed for some target of high priority at the moment and has to stand by for days waiting for the right weather at that particular spot. If they could be given a selection of targets covering the whole of the enemy territory they could drop a very much greater tonnage of bombs because it is usually possible to find the weather suitable somewhere even at this time of the year. They would of course concentrate on the top priority targets whenever the weather was suitable at those places.

2. Nothing is more detrimental to morale and efficiency than to have a squadron sitting on the ground for days on end particularly when the weather here is such as to preclude practice bombing. I suggest the squadron should be allowed to go and do its practice bombing over Germany especially on some of the smaller targets in Southern Germany. This would be good training for the squadron and would keep them in practice for the more important targets. It would also provide an excellent education in the primary effects of bombing for post war consideration by a large section of the enemy population who have probably seen little of the raids on the larger targets. Suitable targets must be available in a large number of small German towns, even if only communication targets, and a few 12,000 lb. H.C. bombs could do a lot of damage and achieve a lot of useful education during these closing stages of the War.

3. In addition there are a number of special factories and other targets which could easily be tackled by 617 Squadron and I attach a list giving certain suggestions. That at RHEINFELDEN (GF.2358) seems particularly attractive and would obviously need to be done in daylight by a squadron specialising in precision bombing, because of its proximity to the Swiss border.

4. Other possible targets are the enemy naval units which are being pushed westwards by the Russian advance. Successful attacks on these although possibly not of top priority in this European War would help drive home the

lesson of the Tirpitz both in Germany and this country and would be useful experience for the Japanese War.

5. Some of the targets suggested should be attacked by day, others by night but in general it is probably better to concentrate on the daylight targets because a flare force would usually be needed for the night attacks and it may not be possible to spare this from the Main Force operations.

6. To sum up, this letter is a plea for extending the scope of operations by No. 617 Squadron during the closing stages of this War provided the bomber policy will allow attacks to be made on the types of targets I have suggested.

[Signed} H.V. Satterly, Air Commodore,
Commanding, No. 54 Base.

[The notes in *italics* in the following section relate to pencil annotations made on the original documents.]

Germany

HILDESHEIM Turbine and compressor castings for jet power units CZ 2913

1 Time – Night
2 N/A
3 Bombs 12000lb blast bombs.
4 Forces 20 A/C of 617 Squadron.
5 Controller 617 Mosquito.
6 Marking.
A. Illumination 12 A/C
B. Low level Mosquito Marking.
OK – on "Jet" priority list No. 1.

MESCHEDE Compressor castings for jet power units. GZ 2788

1 Time – Day or night.
2 Fighter cover. If by day – 5 Squadrons of Mustangs.
3 Bombs 12000lb blast bombs.
4 Forces to be employed 10A/C of 617.
OK – on "Jet" priority list No. 4.

WERNIGERODE Light metal castings for jet A/C GY 4698

1 Time – Night
2 N/A

3 Bombs 12000lb blast bombs
4 Forces 10A/C of 617 Squadron.
5 Controller 617 Mosquito.
6 Marking.
A. Illumination 10 A/C
B. Low level Mosquito Marking.
OK – on "Jet" priority list No. 5.

NIEDERSACHS – WERFEN Underground A/C Factory GU 5062

1 Time – Night
2 N/A
3 Bombs
A. Blast bombs on Labour Camp and Plaster Works.
B. Tallboys on Tunnel Entrances.
4 Forces
A. 5 A/C on Labour Camp & Plaster Works.
B. 15 A/C on Tunnel Entrances.
5 Controller 617 Mosquito
6 Marking
A. Illumination 12 A/C
B. Low level Mosquito Marking.
OK – on "Jet" priority list No. 6.

SOLINGEN Castings for jet A/C power units. GL 2629

1 Time – Night
2 N/A
3 Bombs 12000lb blast bombs.
4 Forces 20 A/C of 617 Squadron.
5 –
6 Illumination 12 A/C
OK – on "Jet" priority list No. 14.

RHEINFELDEN GF 2358

1 Time – Daylight – Due to proximity to Swiss Border.
2 Fighter Cover – One Squadron.
3 Bombs. Tallboys fused .025
4 Forces

A. 20 Lancasters of 617 Squadron.
B. 1 Mosquito of 617
5 Controller Mosquito of 617 Squadron.
NOTE - Careful Consideration must be given to routeing as the final bombing run must be considered of Paramount importance.
Used to be important as a producer of fuel for V.1. Attacked successfully by Americans. Little current importance. Probably unlikely to be cleared owing to proximity to Swiss frontier.

WETZLAR Optical Glass Factories – GA 2537
1 Time – Daylight. Target too small for night work.
2 Fight cover. 5 Squadrons of Mustangs.
3 Bombs Tallboys fused .025
4 Forces employed 8 aircraft of 617.
Shares work with Jena. Destruction of both would produce a long term effect.

WETZLAR Steelworks. GF 2248
1 and 2 In conjunction with GA.2537
4 12 aircraft of 617
3 6 Tallboys fused .025 plus 6 x 12,000 blast.
No shortage of steel plant.

ARNSBURG GH.504
1 Time – Daylight.
2 Fighter cover 5 squadrons of Mustangs.
3 Bombs 10 Tallboys fused 11 sec. on A.P.1.
10 × 12,000 Blast Bombs on A.P.2.
4 Forces A.P.1. 10 A/C of 617 – Viaduct and Tunnel Entrance
A.P.2. 10 A/C of 617 – Railway Workshops.
OK – on transportation list – since destruction of Altenbeken priority No. 2.

ASCHAFFENBURG GO.1452: GN. 5881: GN. 5064: GN 5880
1 Time – Daylight
2 Fighter Cover. 5 Squadrons of Mustangs.
3 Bombs
A. 1 × 12000 blast bombs – Lancasters.

B. 2 × 500 fused 11 secs – Mosquito.

4 Forces

A. 20 Lancasters of 617

B. 1 Mosquito of 617

5 Targets

A. G.1452 to be destroyed by dry cannon fire and bombing from Mosquito.

B. GN.5881 4 Lancasters.

C. GN 5064 4 Lancasters.

D. GN 5880 12 Lancasters.

GN 5064 (Tanks) Clearance might be obtained. GN 1452 of no importance. GN 5880, 5881 not at the moment important. They depend upon the war equipment they contain from time to time.

PIRMASENS GC 5654

1 Time – Daylight.

2 Fighter cover 2 Squadrons.

3 Bombs 12,000 blast bombs.

4 Forces employed – 20 A/C of 617 with each A/C on specially allocated A/P.

5 Controller in Mosquito.

Of no importance.

PIRMASENS GC 5654

1 Time – Night – Moonlight or Dark

2 Fighter Cover Nil.

3 Bombs 12,000lb blast bombs.

4 Forces employed 20 Lancasters and 1 Mosquito of 617

5 Controller 617 Mosquito

6 Marking

A. Illumination. 12 A/C with one green proximity T.I.

B. Low level marking by 617 Mosquito.

Of no importance.

BERCHTESGATEN GN.3770

1 Time – Daylight Route south of Switzerland out in Daylight, return in dark.

2 Fighter Cover Nil.

3 Bombs Tallboy 11 secs. delay.

4 Forces Maximum effort. 617 Squadron.
Not important until ordered as political target.

Norway

LOKKEN SN.47

1 Time – Daylight
2 Fighter Cover Nil
3 Bombs 12,000 blast bombs.
4 Forces employed 10 Lancasters of 617
None of any importance.

KNABEN SN 50

1 Time – Daylight
2 Fighter Cover 1 Squadron
3 Bombs Tallboys fused. .025
4 Forces employed 5 A/C of 617 Squadron.
See Fawesett's letter 24990/I/Int dated 19/2.

RAUFOSS SN 82

1 Time – Daylight
2 Fighter Cover 1 Mustang Squadron
3 Bombs Tallboys fused .025
4 Forces employed 5 Lancasters of 617 Squadron.

MEROYA SN.136

1 Time – Daylight
2 Fighter Cover 1 Squadron
3 Bombs 12,000 lb blast bombs.
4 Forces employed 10 Lancasters of 617 Squadron.

EYDEHAVN SN 72

1 Time – Daylight
2 Fighter Cover 1 Squadron
3 Bombs 12,000lb blast bombs.
4 Forces employed 10 Lancasters of 617 Squadron.

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ROY DOBSON, MANAGING DIRECTOR, AVRO

On the night of 16/17 May 1943, the Avro Lancaster achieved iconic status in Operation Chastise, the attack by 617 Squadron on the dams of the Ruhr valley – more popularly remembered as the 'Dambusters Raid'. At the heart of this Pocket Manual are extracts from the Operations Record Book of 617 Squadron and the Flying Log Book of Wing Commander Guy Gibson providing first-hand details of that historic event. But the Lancaster did not achieve its reputation as the most successful bomber of the Second World War from that operation alone. This was testament to both the reliability of the airframe and the bravery and skills of the cre elied on their training and experience, supplemented b s reports and manuals that were produced during t ears. This fascinating book brings together a selection tic period documents, from the Air Ministry Specifica 936 that triggered the design, through Night Combat Pilot's and Flight Engineer's Notes, to those cover ical developments in bombing accuracy and strategic t Compiled and contextualised by historian Martin they present a vivid picture of the development and ca ory of this famous aircraft.

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