

PROJECT OUTING

USAF Evaluation of the Probe and Drogue In-Flight Refueling System

By Brian Gardner

Shortly after the USAF became a separate service in September 1947, the bombardment mission was examined in the light of potential threats. But, with the exception of the Convair B-36 - then facing an uncertain future - current bombers and those under development lacked sufficient range to reach targets in the Soviet Union, then seen as a potential aggressor.

Aerial refuelling was considered the most practical method of achieving strategic capability and plans were made for developing refueling methods and modifying bombers. In March 1948, Air Materiel Command planned an aerial refueling development program, with Boeing designated supplier of refueling equipment. This aimed at achieving the "earliest possible solution to the refueling problem" and, lacking a readily-available American system, a contract was placed for the supply of British "looped hose" equipment, with Boeing installing it in B-29 and B-50A bombers.

Meanwhile, Boeing developed the "flying boom" system and the first boom contact was made between B-29s in October 1948.

The bomber escort mission was retained in Strategic Air Command for more than 10 years after the war, but the short range of early jet fighters, compared with the long range of bombers they were to escort, led to several range-extension methods being tested, including "parasite" fighters and wingtip towing. Although refueling in flight was considered there was no practical method then available for refueling single-seat fighters.

In December 1947, Maj. Gen. L.C. Craigie, Director of the Research and Development Office, Deputy Chief of Staff, Materiel, wrote to the commanding general, Air Materiel Command (AMC) requesting a study be initiated to determine the feasibility of extending escort range of F-80 and F-84 fighters by refuelling from B-29 or B-50 tankers.¹ Tankers would be sent to timed rendezvous positions along the bombers' route at distances of approximately 1,000, 1,500 and 2,000 miles from home base. Escorting fighters would refuel in flight at these points and continue with the bombers to the next rendezvous.

AMC wrote to the Republic Aviation Corp. in July 1948, advising that the USAF was "very interested in a practical solution of air-to-air refueling" and that a high priority had been assigned to the project. Various methods were being examined and Republic was asked to forward information on any studies made for refueling the F-84.²

All American Aviation also studied the problem and in October 1949 proposed three methods of refuelling fighters³: the first involved a fighter (F-80) inserting its nose into a special

tail cone in the bomber/tanker, where it would be secured and refueled; in the second scheme, the fighter would contact an open-ended nacelle trailed from the tanker, while in the third scheme, the fighter would contact an arm extended from the bomber, when it could be refueled or raised into the belly of the bomber. However, these schemes were rejected as both the boom and the probe/drogue systems were then being developed.

Frederick Steel, assignor to the Curtiss Wright Corp., filed a patent application on March 30, 1949, for a method of refueling fighter aircraft (USP#: 2582609). Featuring a trailing 'bird' (drogue) with aerodynamic surfaces for stable flight and a retractable probe in the fighter, this employed electromagnetic means for coupling. This application was made two days before the British company Flight Refuelling Limited (FRL) probe and drogue patent application was made in the United Kingdom (UK) (GB 676430) but there were significant differences between the two schemes and the Steel patent was not developed.

Although the Boeing boom system was under development, priority was given to bomber installations and the first boom tanker, the KB-29P, entered service in 1950, initially to support the SAC B-50D fleet. The first fighter to be equipped with a boom receptacle was the F-84G, which entered service in August 1951.

As FRL was involved in the B-29 refueling installation, company chairman Sir Alan Cobham visited the U.S. in October 1948 to check progress and discuss refuelling development with senior USAF officers, including Brig. Gen. D.L. Putt, Director of Research and Development at the Pentagon. General Crawford, on Putt's staff, asked for a system for refueling jet fighters and although Cobham stated this was "under development" he evaded further questions but promised a demonstration of fighter refueling to a USAF delegation due to visit England in the spring of 1949. Consequently, through the autumn and winter of 1948/1949, the FRL drawing office studied several "highly improbable" schemes involving adaptations of looped hose and crossover contacting methods, with automatic equipment in the fighter.⁴

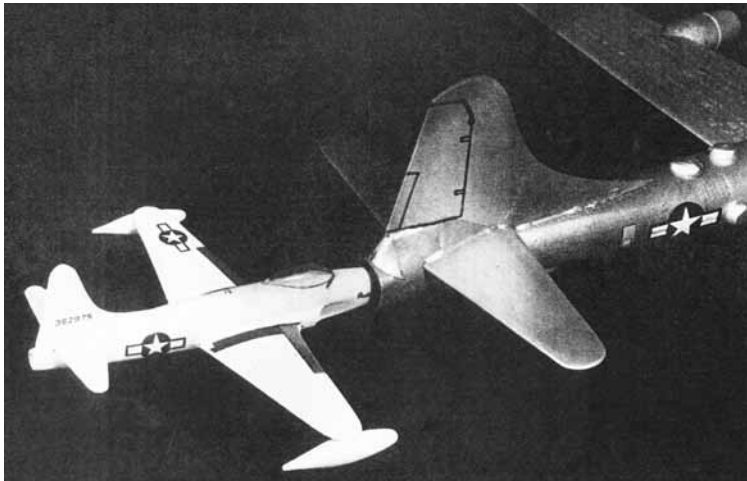
By late March 1949, the probe and drogue system had evolved and FRL submitted details to the USAF. To protect company interests, FRL filed a U.S. patent application on March 31, 1950, (USP# 2692102) describing the basic scheme and several variations.

There was little Royal Air Force interest in this scheme at the time and FRL had to use company money for initial development. However, by persistent lobbying, Cobham managed to obtain a Gloster Meteor III (EE397) for trials



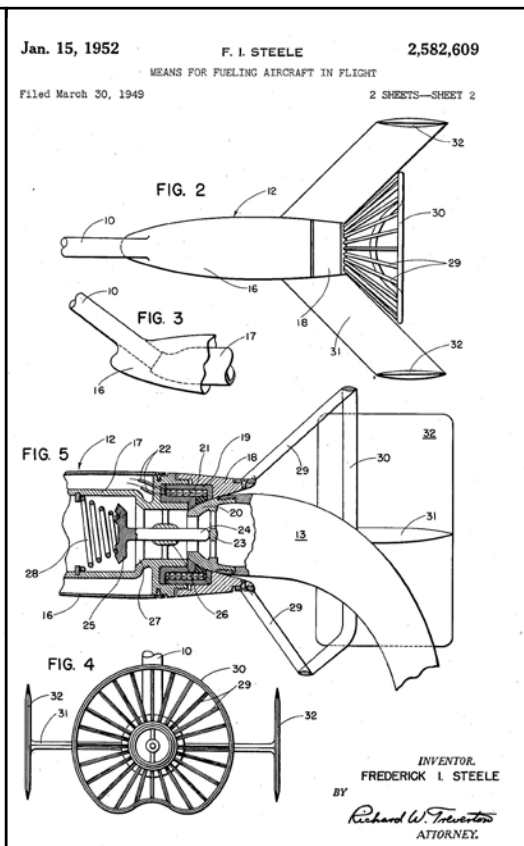
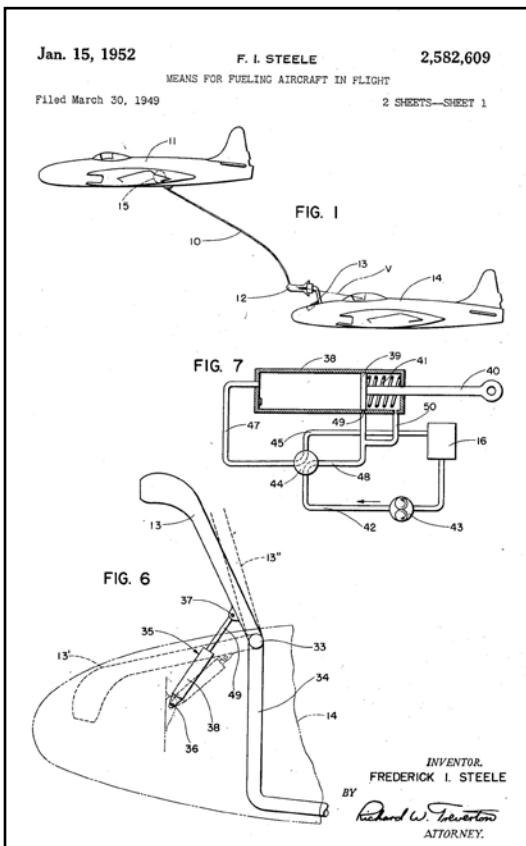
A KB-29M (upper) refuelling a B-29M with the 'looped hose' system. (USAF photo 253630 AC)

The 'looped hose' in-flight refueling system was developed by Flight Refuelling Limited and used in several British and American refuelling tests since 1939. During 1947-48, British South American Airways and British Overseas Airways Corporation used this system to evaluate the feasibility of flight-refuelled commercial services. Although it involved a complex procedure of hauling lines and required several crew members in each aircraft to operate, this system was proven and available and was chosen by the USAF as the initial method for refuelling SAC bombers, pending the introduction of a better system from Boeing.



Pneumatic tail cone with fighter engaged and refueling. (AAA Report M-139, October 1949, Fig 3)

All American Airways proposed three schemes for refuelling fighters, involving the insertion of the fighter nose into the tail of a tanker, into an open-ended nacelle towed by the tanker, or into a fairing lowered by an extended arm from the tanker. In the latter case, the fighter could be hoisted up to the belly of the tanker.



Frederick Steel, assignor to Curtiss Wright Corporation, described a method of refuelling fighter aircraft involving a trailing hose and 'bird' and a retractable probe. Engagement was by electromagnetic means. (US Patent 2582609, Sheets 1 & 2)

with a Lancaster tanker (PB972/G-33-2)⁵ and following an unsuccessful attempt on April 22, 1949, when a hydraulic line burst, the first probe and drogue contact was made on April 24.⁶

On April 27, the promised demonstration of fighter refuelling was given to USAF officers, including Lt. Gen. B.W.Chidlaw, Deputy Commanding General, Air Materiel Command, Maj. Gen. F.O. Carroll, Director, Research and Development; Maj. Gen. A.R. Crawford, Chief, Engineering Division of Air Materiel Command, and Brig. Gen. D.L. Putt, Deputy, Research and Development, HQ USAF. Other visitors included representatives from Wright Patterson and the Aircraft Projects Section. Some of the American party flew in Lancasters G-AHJU and G-AHJW to view the procedure while flying alongside the Lancaster and Meteor. Cobham explained that the present equipment was modified from the looped hose system and a temporary dry probe had been fitted to the Meteor.

Discussing potential applications, Cobham suggested that a B-29 and an American jet fighter be delivered to the FRL base at Tarrant Rushton, Dorset, where the company would test a prototype set of equipment to American specifications. Twenty complete tanker and fighter sets of equipment could then be built for export to FRL's American subsidiary Flight Refueling, Inc., in Delaware, where a working party would supervise installation in USAF aircraft. A wingtip hose unit was also being developed to enable a tanker refuel three fighters simultaneously.

During August and September 1949, Sir Alan and a small team of FRL personnel visited America to discuss flight refueling development, obtain further orders and generate interest among military and civil authorities. On August 7 they visited Wright Patterson AFB where Cobham outlined the latest developments to General Carroll and Brig. Gen. S.R. Brentnall. After some discussion, Cobham asked about the position regarding the proposed supply of 20 sets of refueling equipment to the USAF. Carroll explained that no action could be taken on this, and many other proposals, as Congress had failed to allocate funds.

Talks were also held with Major General Crawford and Col. G.F. Smith, Chief, Aircraft Section, Engineering Division. Colonel Smith requested a cost proposal for installing equipment in two B-29 tankers, one B-29 receiver and one F-80 receiver and suggested that Cobham arrange to look over a B-29 and F-80 in England.

Cobham also visited SAC headquarters at Omaha where he described the probe and drogue system to SAC commander Gen. Curtis E. LeMay and his deputy, Maj. Gen. Thomas Power. However, the boom system was already planned for installation in B-50D and subsequent bombers and SAC was unwilling to depend "upon a system whose parts were manufactured overseas." At the Pentagon, General Putt "showed great interest" in the new system but repeated that lack of funds prevented any serious discussion of Cobham's proposals.

On September 7, a conference was held at the FRL offices at Littlehampton, England, with USAF officers to investigate how the new flight refueling system could be tested with American aircraft. An early decision was required to permit equipment standardisation as the USAF was currently backing the boom

system as this had greater potential for high rates of flow and was adaptable to both bombers and fighters. However, if FRL could persuade the USAF that their system was superior, they would adopt it.

In response to the request from Colonel Smith, and after further discussions with General Putt and representatives of the U.S. Embassy, FRL prepared a quotation for the installation of flight refueling equipment in B-29 and F-80 aircraft. Putt suggested FRL working parties travel to the U.S. to carry out the modifications at Wright Field but Cobham persuaded him that it would be easier to have the aircraft flown to Tarrant Rushton where company facilities would be available in case of installation problems.

The quotation, dated September 13, 1949, involved the following work:⁷

- Demonstration of bomber refueling between B-29s by the hose and drogue system.
- Equipping an F-80 as receiver for tests with a B-29 tanker.
- Demonstrate increased rate bomber refueling with new tanker equipment in a third B-29 and installation of special receiving equipment in a fourth B-29.
- Demonstrate multiple fighter refueling with the third B-29, with hose/drogue units installed at each wingtip and in rear fuselage. A second F-80 will be equipped as a receiver.

Meanwhile, demonstrations of the probe and drogue refueling system were given at Tarrant Rushton to representatives of manufactures, armed services, civil servants and politicians in the hope of obtaining official support for development. Among these guests was Col. David C. Schilling, USAF, who, in July 1948, had led a squadron of P-80s of the 56th Fighter Wing across the Atlantic, landing at various points for refueling.⁸ He attended a demonstration on June 21 and on June 29, flew the Meteor on a successful refueling sortie with a Lancaster tanker. Schilling was enthusiastic about the possibilities of this refueling method and on returning to his duties at the Pentagon, urged that trials be made of the British system.

On August 22, HQ SAC requested a study be made on the application of the probe and drogue system to fighter aircraft. Accordingly, a contract was placed with FRL for modification of six USAF aircraft for evaluation.

Project Letyette/Outing

Project *Letyette*, involved the modification of four B-29 and two F-84 aircraft by FRL and carried an A-1 priority. It came under the personal attention and guidance of Maj. Gen. Carl Brandt, Deputy of Air Force Requirements, Maj. Gen. D.L. Putt, Director of USAF Research and Development and G.B. Wood, assistant to Mr Symmington, Secretary of the Air Force. The project was coordinated among USAF Europe, the British Air Ministry, and the British Ministry of Supply.

With some revisions, including substitution of F-84s in place of F-80s, the FRL quotation of September 13 was accepted



Initial fighter refuelling schemes from FRL were based on the cross-over contacting method, involving the fighter trailing a weighted line to contact the tanker line. Both lines were drawn in to the tanker and the fighter line connected to the hose nozzle. It was then drawn back to the fighter and engaged in an automatic coupling. ('A Method of Increasing the Endurance of Fighter Aircraft,' FRL November 1948, Cobham Archives)



Two Avro Lancasters, used by FRL for refuelling development, supported the Outing project. Lancaster G-33-2 (ex- PB972) was fitted with the first hose/drogue unit for early trials with Meteor III EEE397 and refuelled the F-84s over Prestwick on the Fox Able 4 flight. The fuselage nose had been shortened to give a better view for the pilot when using the old looped hose system, although this was now unnecessary with the probe and drogue. Lancaster G-33-1 (ex- ND748) was used to test the ejector probe and the Mk 7 hose drum unit used in the single-point B-29 tanker. (Copyright Charles Brown Collection, RAF Museum, ref. 6328-2)



Fitted with a dummy probe attached to underwing rocket rails, the F-84E (FS-091) made eight flights and 31 contacts with the Lancaster tanker to determine optimum probe location and forming position. It is seen here with the dummy probe fitted to the right wing. (FRL photo/Cobham Archives)



The left side was favored and a fixed probe was installed at mid-point on the left wing. The F-84E is seen approaching the drogue trailed from a Lancaster tanker. (Copyright Charles Brown Collection, RAF Museum, ref. 6420-4)

and contract No AF33(038)-8997 dated December 7, 1949, was issued. This involved conversion of one KB-29M as tanker, another as receiver, together with two F-84s as receivers. A contract extension covered the conversion of one KB-29M to a three-point tanker and another as a high rate of flow receiver.

A USAF engineering officer and two U.S. civilian engineers would work with the contractor in England to give on-the-spot approval for modifications. USAF aircrews would check out contractor personnel on F-84E operation and airborne operation on the B-29, although a USAF crew would be on board the B-29 at all times.

The six aircraft involved in Project *Layette* were:

Phase One

- One KB-29M, 44-69704, modified to single-point low rate of flow (LRF) hose/drogue tanker.
- One KB-29M, 45-21781, modified to low rate of flow (LRF) probe receiver
- Two F-84Es, 49-2086 and 49-2091, modified to probe receivers as EF-84E.

Phase Two

- One KB-29M, 44-87753, modified to high rate of flow (HRF) probe receiver.
- One KB-29M, 45-21734, modified to three-point hose/drogue tanker as YKB-29T.

Several supplementary items were added to the original *Layette* contract, including:

Items 9 to 11: Atlantic trials (Fox Able 4 flight)

Item 12 to 18: Conversion of two KB-29M to Quickie tankers

Item 19: *Outing* Phase 2 spares (three-point tanker)

Items 20 to 23: Licence rights for probe and drogue system

Items 24 to 27: Supply of eight Mk 12 hose Reels

With effect from March 22, 1950, Capt. Frank W. Klibbe became USAF representative on Project *Layette* at Tarrant Rushton and from August 9, Capt. J.G. Goppert became project officer.

On May 23, the code word *Layette* was withdrawn and replaced by *Outing*.⁹

In addition to the six USAF aircraft, Meteor 4, VZ389, already with FRL under a Ministry of Supply loan agreement, was used to test equipment being developed for the USAF. The FRL Lancaster tanker, G-33-1, was also used to flight test equipment, including an ejector probe and hybrid Mk 7/11 HDU fitted in the Phase 1 B-29 tanker and was also used to refuel the F-84s.

USAF interest in the probe and drogue system was reported in the *New York Herald Tribune* on October 20, 1949, when it was revealed that experiments were being conducted "with another system" permitting three jet fighters to refuel simultaneously. "This system was developed by Sir Alan Cobham who is chief executive of a new American company, Flight Refueling, Inc., of Danbury, Connecticut."

During November and December 1949, *Aviation Week*

carried brief items to the effect that F-84 and B-29 aircraft had flown to England to test "British aerial refueling techniques" for the USAF.

Phase 1 Flight Tests

The two F-84Es were delivered to Tarrant Rushton on October 24, 1949, by Cols. Schilling and Fleming. Schilling remained for several days to familiarize himself with project activity at FRL and other crew members underwent training at Tarrant Rushton. Most F-84 flight tests were made by Schilling and FRL test pilot P.R. Hornidge.

Following flight tests with a dummy probe located, in turn, on each wing of an F-84 to determine optimum position a fixed probe was fitted at mid-span on the left wing. With probe installation and associated fuel system changes complete, contacts with the single-point tanker began on August 21, 1950, and four days later, fuel was transferred at an average rate of 190 gpm at 25,000 feet.

On this flight, Hornidge complained that the button on the control column that controlled the probe nozzle valve was "most unsatisfactory." After keeping it depressed for a short time to keep the valve open for fuel flow, the pilot's thumb began to ache and the trimmer was difficult to operate: it was necessary to change hands, entailing removing the left hand from the throttle "which is very undesirable when in close formation."

Early nozzle valves were hydraulically-actuated under pilot control and if not closed before disengaging from the drogue coupling the valve stem could be bent, preventing further operation.¹⁰

The greatest quantity of fuel transferred to an F-84 during a single contact was 740 U.S. gallons. Modifications to the fuel system enabled all tanks to be refuelled via the probe. Optimum contacting and refuelling speed at 25,000 feet was 205 mph IAS at an all up weight of 11,854 pounds. As fuel was received and the aircraft became heavier, optimum contacting speed was reduced to 190 mph IAS. Overall time for a complete refuelling operation was just under four minutes.

By February 1950, Cobham admitted that the *Layette* job was much bigger than anticipated and delays were being caused by additional work required, delivery of bought-out parts and the necessity for testing the B-29 unit on a Lancaster.

The Phase One KB-29Ms were delivered to FRL on November 1, 1949, and flight tests began with investigation of mutual forming positions and forming on a drogue trailed from a Lancaster tanker. A mock-up probe was then fitted to the LRF receiver and attempts were made to contact the drogue but with little success.

An ejector probe was designed to make contacting easier for large receivers but difficulties experienced during flight testing on a Lancaster led to the ejector probe being abandoned and a fixed probe was fitted to the B-29 receivers.

On July 10, 1950, a demonstration was put on for American VIPs, including Lt. Gen. B.W. Chidlaw, Commanding General Air Materiel Command. With the party watching from a chartered Viking airliner, Meteor VZ389 made contact with a Lancaster and with the single-point B-29.

Flight tests with both B-29s began on July 26, 1950, initially



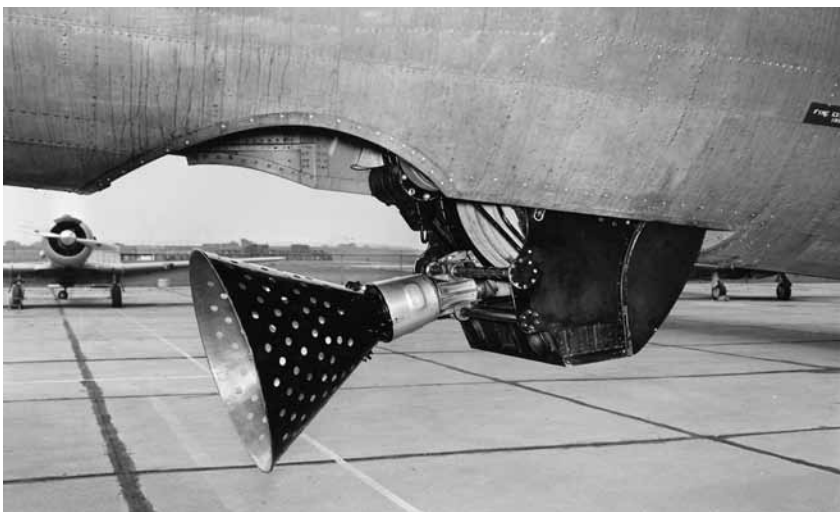
Lincoln RA657 was used in RAF evaluation trials and permission was given for it to be used in the Fox Able 4 flight to refuel the F-84s over Iceland. (Copyright Charles Brown Collection, RAF Museum, ref 6421-1)



Seen here over the south coast of England, the single-point B-29 tanker 44-69704 refuelled Schilling west of Greenland but Ritchie was unable to take on fuel because of a stuck nozzle valve. (USAF photo, 39655 AC)



The Low rate of flow (LRF) B-29 receiver (45-21781) in contact with the single-point tanker (44-69704). The greatest amount of fuel transferred during continuous transfer was 4,120 U.S. gallons at an altitude of 8,000 feet and the receiver system functioned satisfactorily at all rates of flow between 150 and 260 US gpm. (Copyright Charles Brown Collection, RAF Museum, ref 6422-3)



The KB-29 Outing single-point tanker (44-69704) was fitted with a semi-retractable FRL Mk 7 Series 1 Hose Drum Unit. A section of the fuselage floor and outer skin was removed to accommodate the unit and the surrounding structure strengthened. The HDU was semi-retractable but protruded slightly below the fuselage line. Holes were drilled in the drogue to reduce turbulence on the receiver aircraft. (FRIInc via C. Harry Smith)

with dry contacts and the first fuel transfer was achieved on August 19. Average transfer rate was 150 U.S. gpm at 25,000 feet and the maximum amount transferred in a single operation was 2,516 U.S. gallons.

Fox Able 4

After completing tests in the UK, the F-84s were planned to return to the U.S. in a 4,000-mile nonstop flight from Manston, Kent, to Mitchel AFB, New York.¹¹ Pilots would be Col. D.C. Schilling and Lt. Col. D.W. Ritchie. As this would be the fourth transatlantic flight by USAF jet fighters (the others staging via Keflavik in Iceland and Bluie West 1 in Greenland) the flight was designated Fox Able 4.

Three in-flight refuelings were planned: the first over Prestwick by FRL Lancaster G-33-2 flown by FRL Capt. T. Marks, the second over Keflavik, Iceland, by the FRL Lincoln (RA657), flown by FRL Captain Garside and the third over Goose Bay, Labrador, by the single-point B-29 tanker, 44-69704, flown by USAF Col. Bill Bacon and crew. The Air Rescue Service assigned six aircraft, equipped with droppable lifeboats, to patrol the over-water legs of the flight and additional aircraft and ships were positioned along the route for weather reporting.

Plans for a record attempt for the fastest time between London and New York were cancelled when "utmost secrecy" was imposed.

Practice contacts were made with the three tankers but the transatlantic flight was delayed by equipment unserviceabilities and poor weather.

On September 22, 1950, the two F-84s took off from Manston at 1:03 p.m. GMT and in spite of poor weather, radio and equipment problems, the aircraft refueled from the Lancaster and Lincoln tankers. However, after refuelling from the Lincoln, Ritchie observed fuel escaping from the probe, indicating the probe valve was stuck open. Consequently, Ritchie would be unable to refuel from the third tanker. After considering his fuel state, he decided to continue but his engine flamed out about 30 miles short of Goose Bay. Unable to reach the airfield, he ejected at 3,000 feet and was rescued and taken to Goose Bay by helicopter.¹²

Meanwhile, Schilling refuelled from the B-29 and continued but bad weather at Mitchel Field required a diversion to Limestone, Maine. Although 400 miles short of the planned destination, Schilling successfully achieved the first nonstop flight across the Atlantic by jet aircraft, covering a distance of 3,300 miles in 10 hours 2 minutes. In October 1951, he was presented with the Harmon International Aviation Trophy by President Truman.

Outing, Phase 2

The two B-29s for Phase 2 conversion to high rate of flow (HRF) receiver and three-point tanker were delivered to FRL on February 14 and 20, 1950, respectively. However, completion of Phase 2 was delayed by hose reel design problems, availability of suitable electric motors and fuel pumps. Meanwhile investigation was carried out on forming positions and the behaviour of hose and drogue trailed

from a B-29 wingtip.

Prior to installation of refueling equipment, flight tests were made with an F-84 investigating forming positions behind the wingtips of the LRF receiver, 45-21781. The first flight was made on November 16, 1949, and Hornidge reported that, with the probe mounted on the port wing and flying on the port side of the B-29, there was plenty of room and no problems were anticipated in refuelling from wingtip units.

Tests were made with 45-21734 temporarily fitted with a 32-inch diameter, 60-deg drogue attached to short lengths of hose and fixed to a structure that trailed the drogue 32 inches below the left wingtip. Prior to the first test on March 24, 1950, the aircraft was taxied at speeds up to 115 mph to observe drogue stability and effect on the aircraft. The drogue was quite stable and only a slight yaw was noted. After takeoff, speed was increased to 300 mph and the drogue showed no signs of instability. The aircraft was then put through a series of violent maneuvers in an attempt to produce some form of unstable motion but movement of the drogue could only be caused by operating the ailerons. The movement damped out rapidly once the ailerons were centralized.

A third flight test on May 2, 1950, was made with Hornidge flying the Meteor to evaluate the effects of turbulence at various positions and to determine optimum forming position.

The three-point tanker was fitted with one high rate-of-flow FRL Mk 9 Hose Drum Unit aft of the rear pressure cabin and two FRL Mk 11 HDUs in wingtip nacelles, all three units being remotely controlled from operator's control panels in the waist section. Transferable fuel was carried in two bomb bay tanks and a center wing tank, interconnected to the aircraft fuel system and usable by the tanker. Alternatively, the transfer tanks could hold jet fuel and shut-off valves prevented contamination with the aircraft fuel system. The complete installation permitted the transfer of up to 4,650 gallons stored in the forward and rear bomb bay tanks.

The YKB-29T flew in April 1951 and strict security was imposed, although FRL urged this be lifted as Boeing was being given considerable publicity for the boom system.

As the two probe-equipped EF-84Es had departed in Fox Able 4 and General Putt was reluctant to commit two more F-84s, Cobham requested the loan of two probe-equipped Meteor F.8s, then being used in RAF evaluation trials,¹³ to test simultaneous refueling. Accordingly, No 245 Squadron provided pilots and aircraft and, in several flights between July 16-26, 1951, the YKB-29T demonstrated simultaneous refuelling with two Meteor F.8s and the FRL development Meteor VZ389. Pictures of the tanker refuelling three Meteors were not officially released until May 1953.

Flight trials of the B-29 HRF receiver, 44-87753, were carried out between July and September 1951 in conjunction with the three-point tanker. The greatest amount of fuel received during continuous transfers was 3,180 gallons of 100/130 octane gasoline at 9,000 feet altitude and 1,168 gallons at 25,000 feet altitude. Maximum rate of flow observed in the tanker aircraft was 450 gpm.

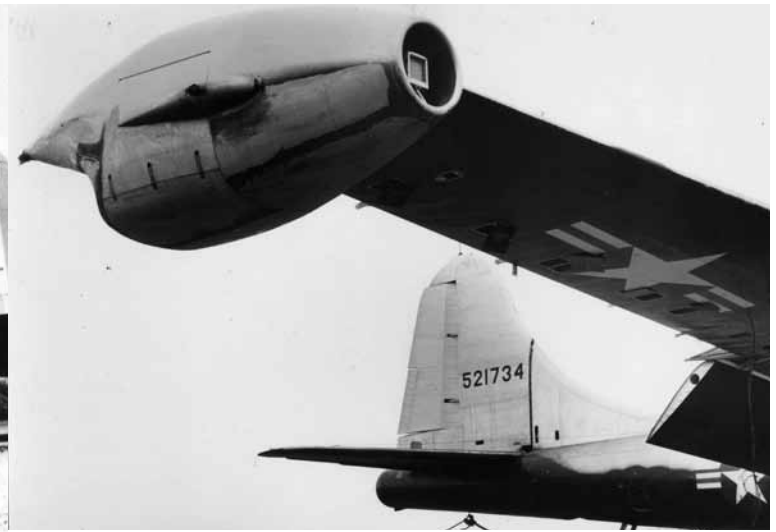
Average time taken to make contact from a distance of 50 feet behind the drogue was 17 seconds, and optimum



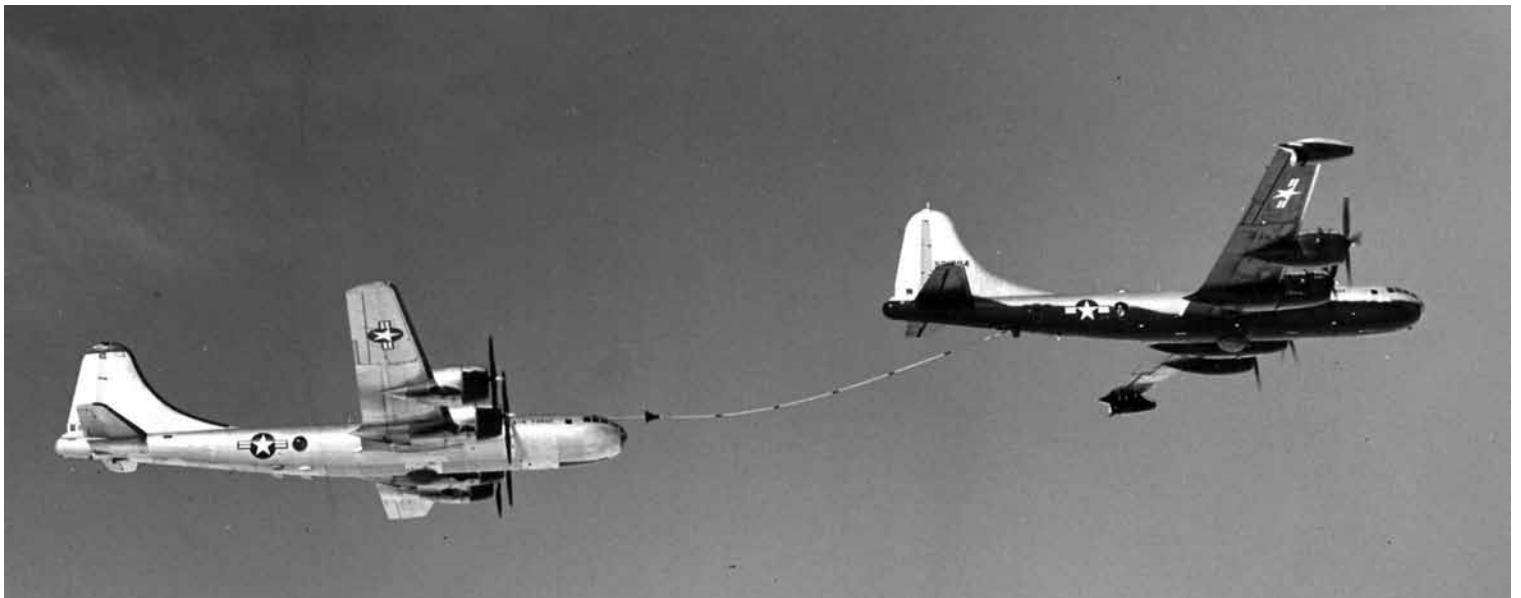
Sir Alan Cobham (left) and General Manager Hugh Johnson (right) discuss refuelling with RAF and USAF officers at Tarrant Rushton. In the background is Lancaster G-33-1 with a retractable probe, the three-point B-29 and the HRF receiver. (FRL neg. 1390(II))



To evaluate the behaviour of a drogue trailed from the wingtip of a B-29, a short length of hose with drogue was fitted to the LRF receiver 45-21781 for flight tests. (FRL neg 950)



FRL Mk 11 hose drum units were installed in wingtip nacelles on the three-point YKB-29T tanker. Transfer fuel is housed in bomb bay tanks and shut off valves separated the aerial refuelling system from the airplane system to prevent contamination of the B-29's avgas fuel by jet fuel if used for the refueling operation.. (FRL neg 1327)



The B-29 HRF receiver in contact with the YKB-29T tanker. Optimum contacting and forming speed was determined at 205 mph IAS (at an all up weight of 95,000 lbs) but as fuel was received and the aircraft became heavier, there was more forming latitude at 190 mph (corresponding with an all up weight of approximately 116,500 lbs). These speeds being determined at altitudes of 25,000 to 27,000 feet. (Copyright Charles Brown Collection, RAF Museum, ref 6446-13)

contacting and forming speed was found to be 210 mph IAS. At 25,000 feet it became increasingly difficult to maintain formation with the tanker as fuel was received, even with maximum engine power and a reduction in speed to 190 mph. When the CG of the transfer aircraft approached the rear limit, contact was involuntary broken and could not be re-established.

During the testing of a sieved drogue, intended to reduce turbulence, the hose started leaking as the aircraft was drawing back from the refueling position. Shortly afterwards the hose broke, leaving about 38 feet of hose and drogue attached to the receiver. The hose drifted back and about half got wedged between the base of the probe and the aircraft nose, the other half trailed straight down the center of the fuselage. Fortunately, it did not whip about or get near the propellers and Major Lester landed without difficulty.

Flight tests in the U.S.

Both EF-84Es and the single-point tanker departed in the Fox Able 4 flight and the B-29 LRF receiver returned in September 1950. Evaluation of the Phase 1 *Outing* aircraft was completed at the Wright Air Development Center at Dayton by March 1951 and the aircraft then underwent operational suitability testing with Air Proving Ground Command at Eglin Field.

The two Phase 2 aircraft (three-point tanker and HRF receiver) returned to the U.S. in September 1951 and following tests at Eglin Field, the B-29 HRF receiver was used to test high flow rate units.

Major Schleck flew the probe-equipped F-84E and made a number of successful contacts with the tanker although he had not previously seen the probe and drogue system, he made five perfect contacts straight off, then several with the tanker banking, climbing, diving and changing course and he tried all the extreme positions while in contact. He later said the system looks "pretty good."

By mid-March 1951, Phase 1 evaluation at Dayton was completed satisfactorily and further trials were planned.

Financial Considerations

Because of the A-1 priority and urgency of the requirement, FRL had been unable to examine the F-84 and B-29 in detail. Consequently, the conversion was considerably more involved than had been anticipated, particularly the F-84 installation, involving manifolding to all tanks. Although a 100% contingency had been included in the quotation, the company overspent by a considerable amount.

In an attempt to resolve the problem, FRL management met with Brig. Gen. Phillips Smith at Wright Patterson in October 1951 to discuss costs involved in contract 8997. It was suggested the Air Force purchase the manufacturing rights of FRL equipment for a price that would cover losses on the contract. Accordingly, a license was purchased for \$800,000 and item 20 of Supplemental Agreement No 10 to contract 8997, dated November 16, 1951, stated the contractor (FRL) agreed to grant the U.S. government "an irrevocable, non-exclusive non-transferable and royalty-free license to reproduce for and have reproduced by others for the U.S. Government, the probe

and drogue in-flight refueling system..."

Consequently, FRL lost exclusive rights to the probe and drogue system and their competitive advantage. Subsequent development in the U.S., initially by the Power Plant Laboratory, involved subcontracting components and several contractors produced designs to American standards, resulting in a potential loss of interoperability between U.S. and British aircraft.¹⁴

Subsequent Use

As a replacement for the EF-84E lost on the Fox Able 4 flight, Republic Aviation modified another F-84E, 49-2052, to a similar standard, with probe mounted mid-span on the left wing. In conjunction with the surviving EF-84E and a T-33A equipped with probed tip tanks (representing an F-80) simultaneous refueling was demonstrated with the three-point tanker.

The *Outing* F-84 probe installation enabled all tanks to be refueled in flight but modification was too complex and expensive for wider use and probed tip tanks were developed. However, only the tip tanks could be refueled in flight and to maintain lateral balance, three contacts were required to fill both tanks. Large numbers of probed tip tanks were produced and equipped F/RF-80 and F-84 fighters in the *Hightide* Wing-scale refuelling test in Korea.

Tanker support for *Hightide* was provided initially by the single-point *Outing* tanker, 44-69704, from June 1951 and the first of eight KB-29M *Quickie* tankers followed in September. Modified by FRL, *Quickie* tankers were equipped with an interim hose/drogue system

The FRL hose drum units were subsequently removed from the YKB-29T and used in other projects. The Mk 9 HDU was installed in the B-36 convertible tanker-bomber (TANBO) 51-5706 in 1952 before being replaced by a FR Inc¹⁵ Mk 14 unit. The two Mk 11 HDUs were installed in bomb-bay installations in two B-29s to determine feasibility of this location and to evaluate trailing characteristics of hose and drogue. One of the Mk 11 HDUs was later fitted in the cargo compartment of a C-119F (51-7968) for evaluation.

The YKB-29T was modified by Hayes Aircraft Corp., with three FR Inc A-12B hose drum units replacing the original equipment. In addition, changes were made to the electrical system, the auxiliary power unit was relocated to the tail compartment and new electronic equipment and lighting systems were installed. The modified YKB-29T was also deployed to the Far East Air Force to support *Hightide* operations.

First operational use of aerial refuelling was made on July 6, 1951, when the single-point *Outing* tanker refuelled three RF-80s and in September, an F-80C remained airborne for 14 hours 15 minutes with eight refuelling top-ups from a *Quickie* tanker.

U.S. development of the probe and drogue refuelling system continued, although opinions varied within the USAF over which system was best suited for various roles. Several types of fighter, bomber and transport aircraft were modified to evaluate the probe/drogue system and comparative evaluations were carried out with aircraft equipped for boom refuelling. ➔



Simultaneous three-point refuelling demonstrated by the YKB-29T with two Meteor F.8s from 245 Squadron RAF and the FRL Meteor IV VZ389. (Copyright Charles Brown Collection, RAF Museum, ref. 6446-7)



During tests in the U.S., the YKB-29T demonstrated simultaneous refuelling with two probed F-84Es and a T-33A with probed tip tanks (representing an F-80). This tanker was subsequently modified by Hayes Aircraft Corp. to have U.S.-built A-12B refuelling units in place of the original British equipment. (USAF Museum photo)

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About the Author



Brian Gardner joined the Royal Air Force as an aircraft apprentice in 1955 and subsequently worked on Beverley, Hastings and Britannia transports. He then trained as a flight engineer and spent ten years on the Hercules, including a tour in Singapore.

Leaving the RAF in 1978, he continued his flight engineer career with Transmeridian on the CL44 (briefly), then with British Caledonian Airways on the 707, DC-10 and 747. He continued with British Airways when BCal was taken over and retired in 1993.

In 1977, he received a financial grant from the Royal Air Force Hawker Siddeley 50th Anniversary Award Fund for a three-week visit to the USA to carry out research on the development of refuelling in flight. Visits were made to the Albert F Simpson Historical Research Center, Maxwell AFB; National Air & Space Museum; National Archives and USAF Museum.

During retirement he has continued researching and writing and has had several articles and a monograph published. This is his first article for the *AAHS Journal*.

Endnotes

- 1 SAC In Flight Refueling Program, Case History, Supporting Documents. Maj. Gen. L.C.Cragie, Director of Research and Development Office, Deputy Chief of Staff, Materiel to Commanding General AMC, December 16, 1947. (AFSHRC)
- 2 'Flight Refueling for Fighter Aircraft', AMC to Republic Aviation Corporation, July 28, 1948
- 3 All American Airways Inc. Report No M-139, dated October 26, 1949, In-Flight Refueling of Fighter Aircraft
- 4 Cobham Manuscript, Cobham Archives

- 5 This Lancaster was originally modified in 1944 for the *Tiger Force* refuelling project and was retained by FRL for flight refuelling development.
- 6 In his handwritten memoirs, Sir Alan Cobham gives the date of the first probe and drogue contact as 6 April. However, other company papers, flight authorizations and reports indicate this event took place on April 24.
- 7 Cobham Archives file, *Tonge, Mr C Memos 1949-1959* (Quotation: Probe and Drogue flight refueling installation, dated 13/9/49)
- 8 This was the first West-East crossing by jet fighters (Fox Able One). The first East-West trans-Atlantic flight by jet fighters was made in July 1948 by six Vampires of No 54 Squadron RAF, staging via Stornaway, Iceland and Greenland.
- 9 Details of the Outing conversions and flight tests have been obtained from the following FRL files: Laying Outing, Flying Programme Reports; Outing, Phase 2 Flying Programme Reports; Quickie Conversions 1952; Flight Test Reports; Extracts from Tarrant Rushton Air Traffic Log (letter from G.J.Cruikshank, 28/5/85); Report on the use of Meteor Mk 4 Aircraft VZ389 (FRL publication FR 5/52, June 1952); Fox Able Four Flight, Tanker Captains' Reports; Authorisations, 1949-51.
- 10 Later nozzles and couplings had valves that opened/closed automatically on contact/disengagement.
- 11 'Fox Able 4', Brian Gardner, *The Aviation Historian*, April 2016.
- 12 'Fortune Favored the Bold', Major Kelly F. Cook, *The Airpower Historian*, Vol. IX, No. 2, April 1962 (There are differences in the various accounts of this event).
- 13 'Fighter Command Evaluation Trials', Brian Gardner, *Air Britain Aeromilitaria*, autumn 2014.
- 14 FRL Mk 6 nozzle/couplings were initially fitted to RAF tankers and receivers but were not compatible with U.S. designs. Compatibility was achieved when FRL produced the Mk 8 nozzle and coupling, compatible with U.S. MA-2 equipment. The first USAF/RAF refueling exercise was carried out during 1960-61 in Project Floodtide.
- 15 In 1948, FRL set up an American subsidiary company 'Flight Refueling Incorporated' (FRInc) at Danbury Conn to produce refuelling equipment. Their first product was the A-12 hose drum unit, adapted from the British Mk 12 unit and manufactured to American standards.