A Guide to Spitfire and Seafire R/T Installations, masts and aerials.

The Spitfire was one of the few aircraft to be in continual frontline service from before the start of World War Two. As such, it began its operational service fitted with a simple, High Frequency (HF) Radio/Transmitter (R/T), but as its operational career progressed, additional electronic equipment was required to keep up with operational needs. By the end of the war, the single HF radio had been replaced by a suite of equipment, including VHF (Very High Frequency) R/T, Identification-Friend-or Foe (IFF) and (sometimes) blind-approach landing systems, all of which needed to be fitted in essentially the same airframe.

The variety of electronic equipment also meant that Spitfires and, later in the war, Seafires, used several different configurations of aerial masts and antenna, some of which overlapped in time. This variety can still create some confusion when it comes to determining what masts and/or aerials were used, and when. Using original documents, illustrations and photos, this article provides a concise description of the various R/T installations used by the Supermarine Spitfire and Seafire, as well as putting the modifications into a chronological context.

A) HF (High Frequency) Radio and Masts.

When the Spitfire Mk. I entered service in August 1938, it was equipped as standard with the TR9B[1] single-channel Radio-Transmitter, that was designed to be used mainly in single-engine aircraft. In March 1939, Spitfire alteration I/14 was issued, stipulating that an improved, two-channel TR9D would replace the 9B on the production lines, commencing with the L1000 series[2]. The TR9D comprised a T1119 transmitter and an R1120 receiver, covering a frequency range of 4.3 to 6.6 Megahertz (MHz). One channel was used for voice transmission, while the other was originally intended to be a backup, but was later used to send a 1 kHz tone for direction finding purposes, in conjunction with 'Pip-Squeak' (for which see, under IFF equipment). Both the transmitter and receiver were housed together in a metal case: including the dry batteries and remote controller, the installation weighed 67 lbs (30.4 kg)[3].

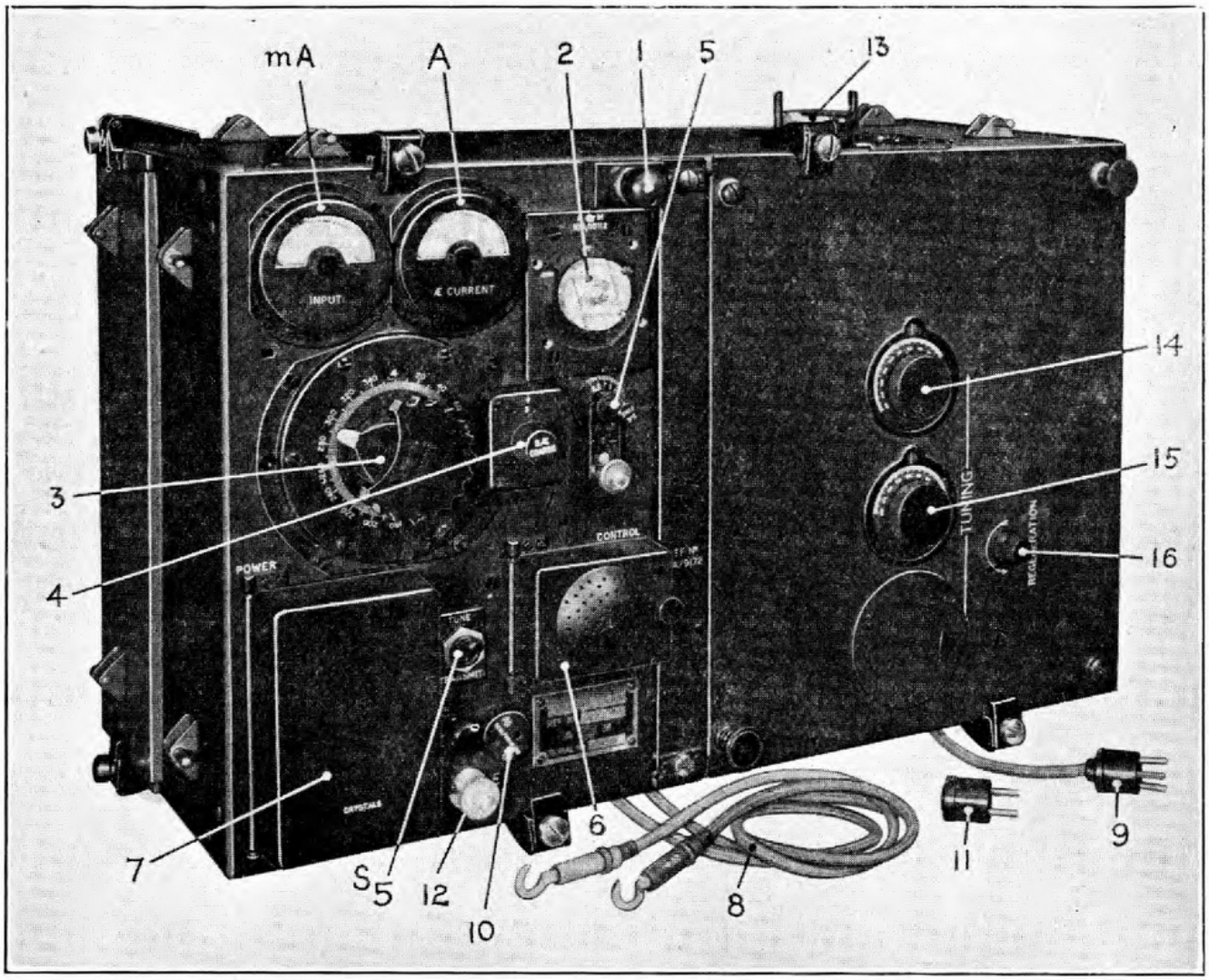


FIG. 7. Transmitter-receiver T.R.9D.

1: Uncased TR9D; to the left, is the T1119 transmitter with a millammeter (mA) and Ammeter (A), aerial terminal (1), slotted SEND-RECEIVE switch (2), and other controls and connections. The face of the R1120 Receiver shows the main tuning control (13) pre-set tuning controls (14, 15) and a regeneration control (16).[From A.P.1186; RAF Signal Manual, Transmitter– Receivers; Section 2: Chapter 4:T.R.9.D: February 1940].

The TR9D was actuated by a ‘Type C’ electro-mechanical Remote Control. In the Spitfire, this was fitted to a removable base plate and then secured to the upper, port sidewall of the cockpit, immediately aft of the instrument panel[4]. It was equipped with a send-and-receive switch (5) and a fine-tuning control (13), plus a round, electrically operated volume control knob (14) in the centre of the unit. The mechanical send-and-receive switches used flexible shafts, enclosed in a combination of rigid and flexible casings, to operate the transmitter and receiver: these were fed back from the cockpit, through to the R/T installation in the rear fuselage.

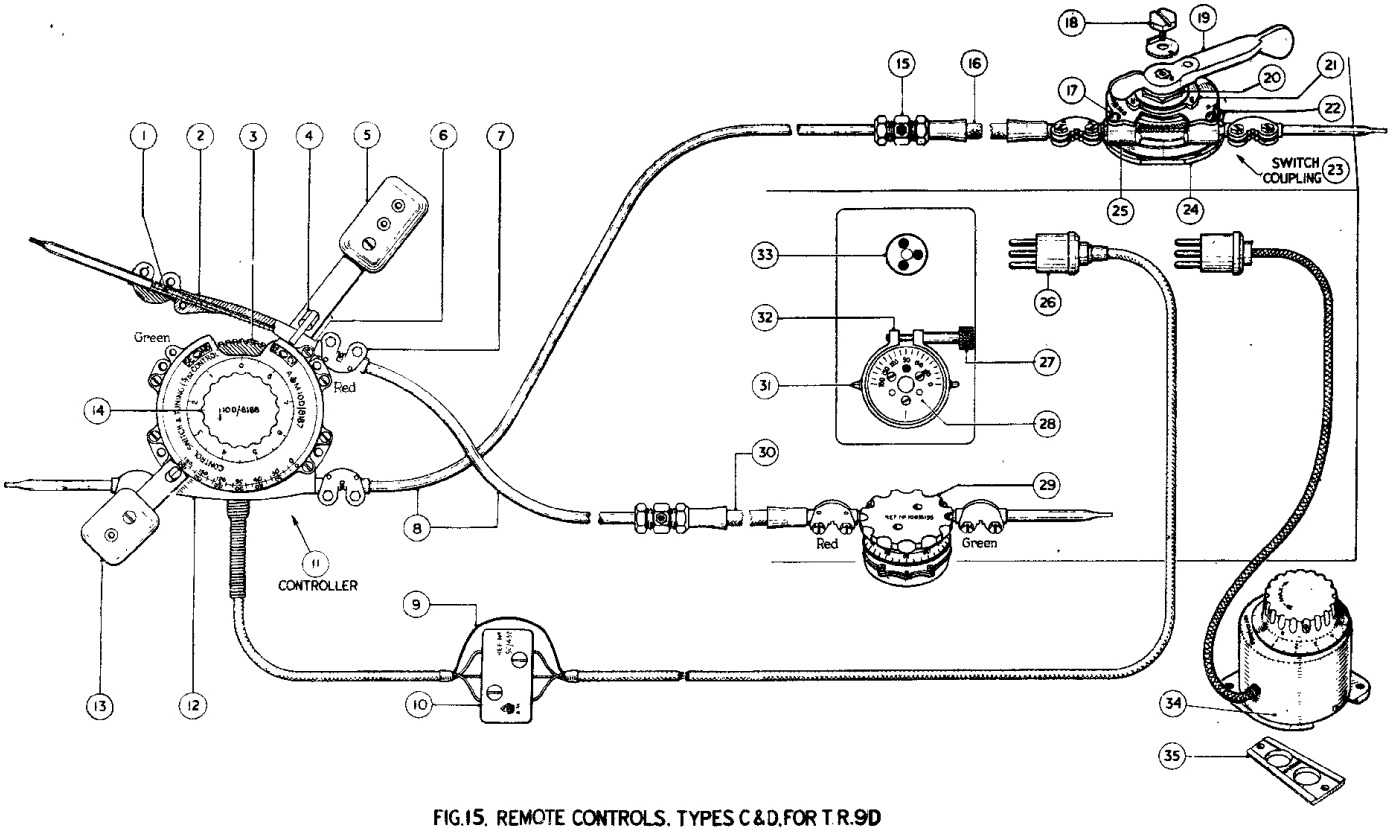
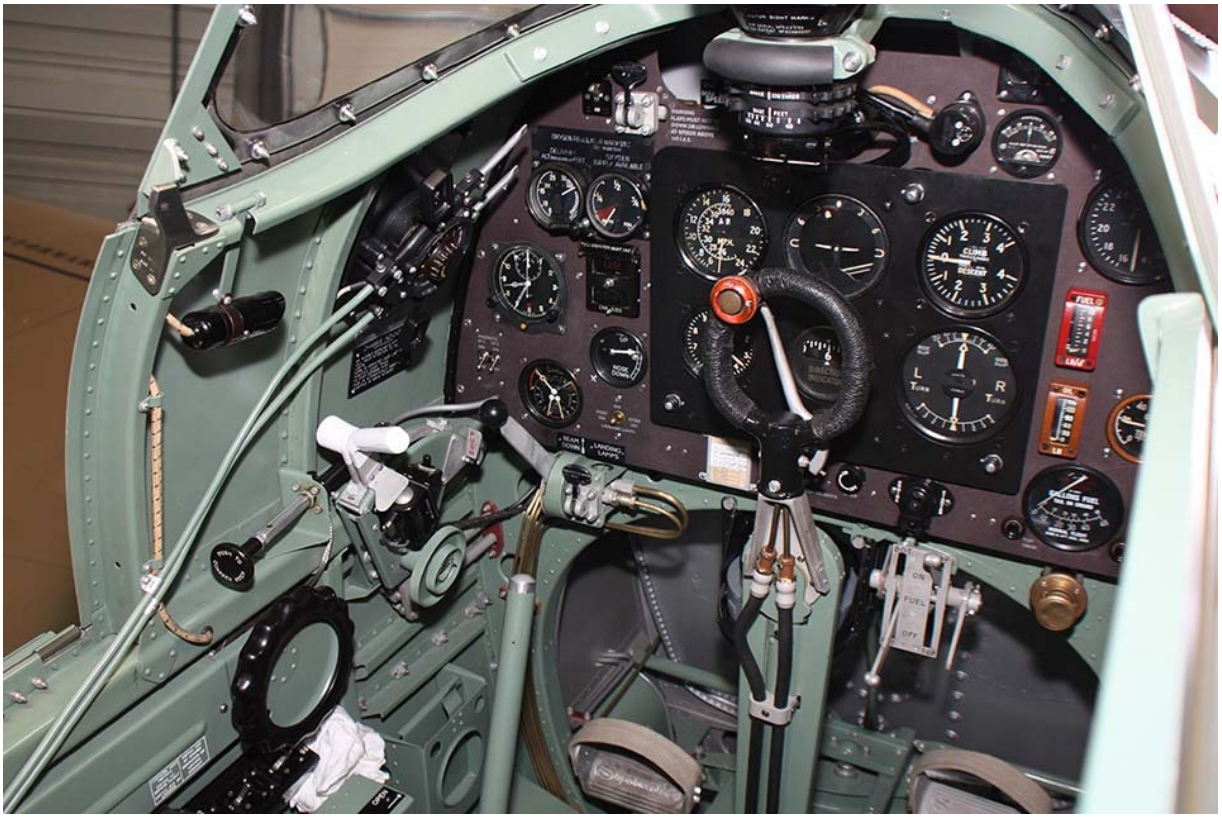


FIG.15. REMOTE CONTROLS. TYPES C&D.FOR T.R.9D

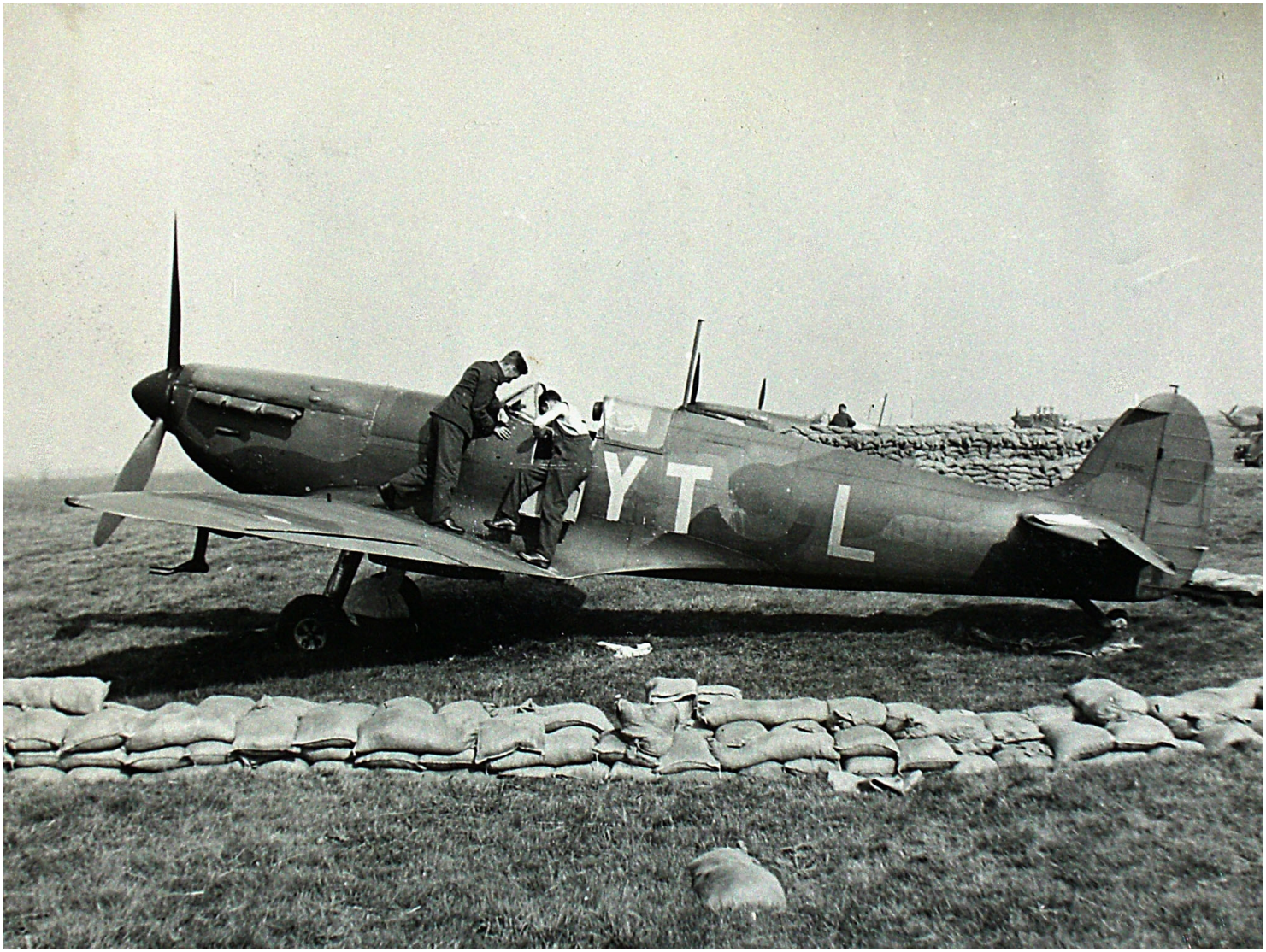
(F.1800). F. & C. LTD.

2: Type C Remote Control Unit [From A.P.1186; RAF Signal Manual, Transmitter– Receivers; Section 2: Chapter 4:T.R.9.D: February 1940].



3: Cockpit of a rebuilt Spitfire Mk. I, P9374, showing the location of the Remote Control Type C and the flexible control cables that ran back to the TR9D installation in the rear fuselage.[from https://www.facebook.com/Spitfirel/]

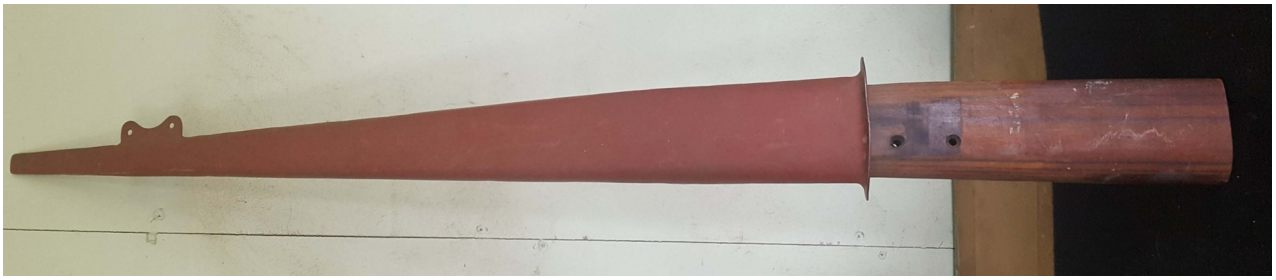
The first two production batches of 310 Spitfire Mk. Is (K9787 through to L1096) used a 28.9 inch (75.6 cm) tall, pole-type aerial mast that incorporated a ribbed, drum shaped insulator at its base. This mast was slotted through a rectangular, alloy reinforcement plate riveted to the top of the fuselage, then secured to an internal anchor. A stainless steel aerial wire ran up through the hollow mast, emerging from the top through a rubberised, weathertight seal: the other end of the wire was secured to an insulated, swivelling connector mounted on a short post that was riveted to the top of the rudder.



4: An early production Spitfire Mk. I, K9906 of 65 Squadron, with the pole mast and rudder post, with its swivelling insulator. Also note the crudely painted code letters and repainted fuselage roundel. [Photo taken by Sergeant Patrick Hayes. https://www.asisbiz.com/il2/Spitfire/RAF-65Sqn-YT.html https://aviation-safety.net/wikibase/21971]

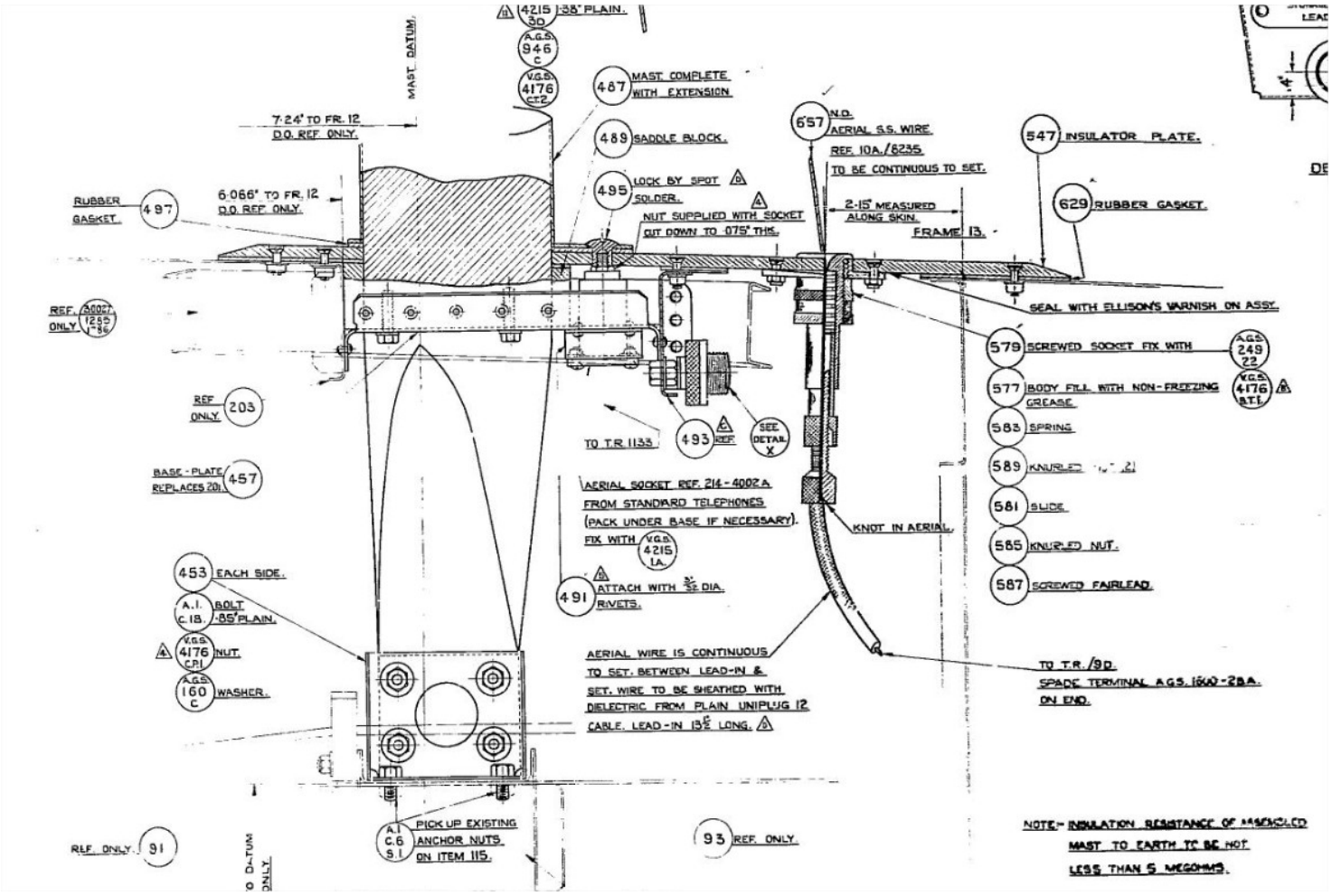
K and L series Spitfires with the pole mast continued to be on active front-line service throughout much of the Battle of Britain, although combat attrition, rebuilds and replacement by later production Spitfire Is and IIs, meant that this original mast was seldom seen on Spitfires in frontline service by late-1940.

Starting in June 1939, with the third production batch of Spitfire Mk. Is (N3023 on), the pole mast was replaced by a stronger, more aerodynamic 28.8 inch (73.2cm) tall, steel mast that was screwed to a wooden core[5]: the latter was slotted through a 13.6 in (34.6) long, teardrop-shaped insulator and fixed to a rigid support frame in the fuselage. The steel section of the mast was secured to the insulator using screws through the flanged base section[6]. This mast was standardised for the overwhelming majority of factory-built Spitfires and Seafires.

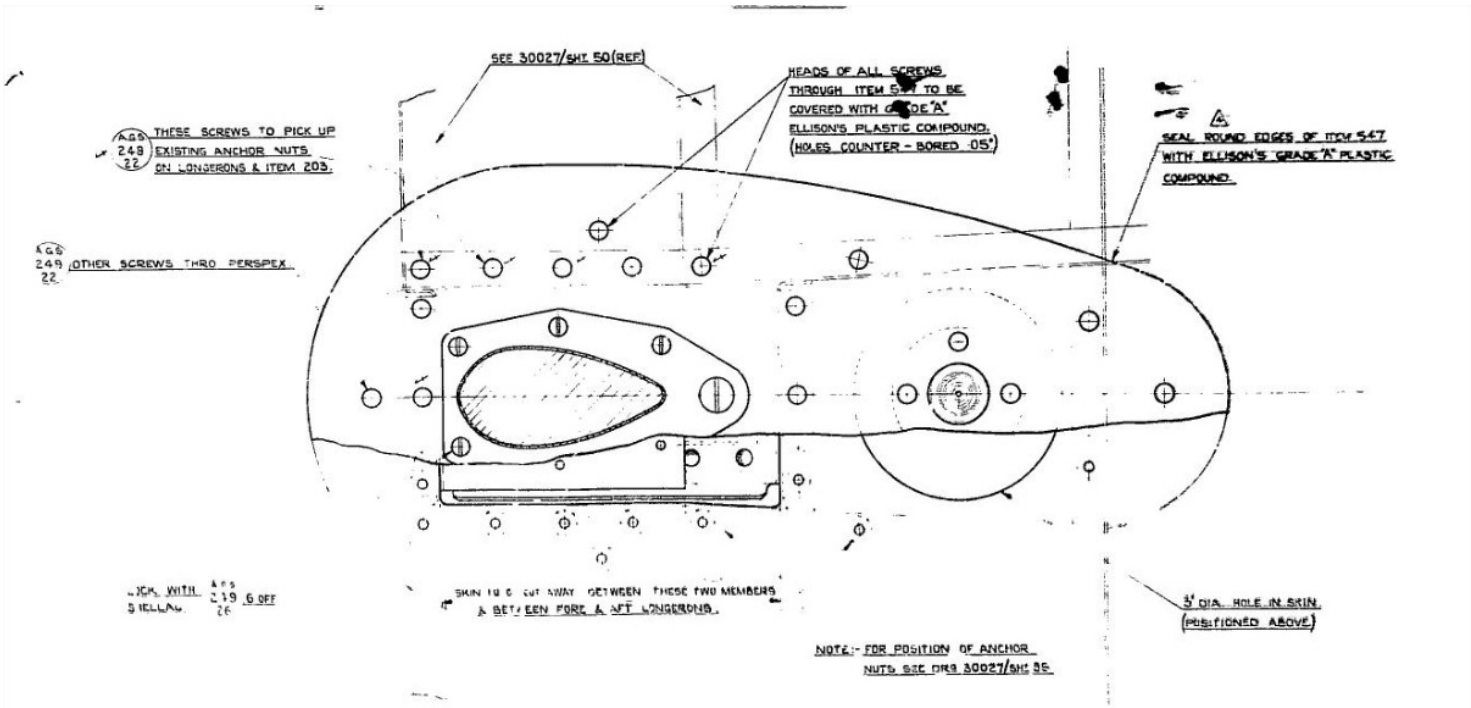


5: The standardised, steel-bodied, wooden-cored mast. The wood core was normally more tapered towards the base to fit in the fuselage anchor point (see 6). Also note the integral, scalloped attachment point for the pulley insulator: it was never deleted, even when the VHF R/Ts were installed. [From: http://spitfirespares.co.uk/radio.html]

The TR9D's stainless steel wire was first attached to the rudder's insulator, then led forward to a triangular 'pulley insulator' that was attached by split pins to the rear of the mast. From there, the wire was led down to a screened, spring-loaded tensioning socket aft of the mast and was finally attached to a 'spade' terminal on the TR9D.[7]



6: An illustration from a Spitfire Mk V manual, A.P.1656E, that shows the installation of the definitive production mast and its base insulator plate. To the right is the screened socket and connections for the TR9D's stainless steel aerial wire; centre-left was the socket for the later VHF TR1133's aerial lead, that was attached to the base of the mast using a large screw and nut directly aft of the mast. Thus, the mast itself served as the aerial.



7: Another illustration from the same manual, showing the teardrop-shaped base insulator and its attachment to the fuselage. The flange at the base of the steel mast was secured to the insulator by six screws.

8: The triangular pulley insulator for the antenna wire and 9: the insulated, swivelling connector that was fitted to the rudder post [From http://spitfirespares.co.uk/radio.html]

10: P9450 on a factory test flight in April 1940, showing the standardised mast, with the triangular wire guide at the rear and teardrop-shaped base insulator. The insulator was left unpainted and could vary in colour, from black to a dark-brick red. The lead-in for the stainless steel wire can just be seen as a white dot, aft of the mast.

B) VHF (Very High Frequency) Radio.

In 1938, the HF TR9 series was the best available R/T unit for single engine fighters, but the RAF had already recognised that it was barely adequate for modern air combat. The reception was rated by pilots as being “poor” to “awful” and was usually worse in adverse weather conditions, while the relatively short, non-resonant aerial array used by the RAF’s single engine fighters meant that it had a maximum transmission and reception range of between 30 to 35 miles air-to-ground, and five miles air-to-air.

These relatively short transmission ranges, meant that an extensive network of HFDF (High Frequency Direction Finding) stations needed to be built for the 'Dowding system' of fighter control. Even so, if fighter formations strayed beyond the 35 mile limit fixed by the range of the T.R.9, they could no longer be contacted by ground control, nor, more importantly, could they be vectored onto any potentially hostile aircraft that had been detected by RDF (Radar) stations. As it was, the higher speeds of the RAF's new Spitfires, Hurricanes and Defiants, compared with the biplane fighters prevalent in the mid-1930s, meant that it was more likely that fighter formations would stray beyond radio range. In addition, the poor reception (that became even worse as HF frequencies became overcrowded) compromised the speed and accuracy of communications. Thus, as described in Wood and Dempster's 'The Narrow Margin':

In January 1937 a requirement was issued for a very high frequency (V.H.F.) radio-telephony set with 100 miles range. The Royal Aircraft Establishment were entrusted with development following its (sic!) research work over the two previous years....
The Chief of Air Staff approved revised plans and orders were given for the re-equipping of four sectors each in Nos. 11 and 12 Groups. Hornchurch, North Weald and Debden were to operate both H.F. and V.H.F. simultaneously.

The whole V.H.F. programme became a race against time, which was lost. By August 1939 the first sets, designated TR 1133, were ready for delivery and in October trials began with six Spitfires of No. 66 squadron based at Duxford. The results were excellent. For the second stage of the programme it was anticipated that by May 1940 all Fighter Command aircraft would be equipped with an improved V.H.F. radio, TR 1143.[8]

The TR1133 consisted of the Transmitter Type T1136A and receiver Type T1137A, providing four pre-set frequencies of 100 to 120 MHz. These much higher frequencies increased the reception and transmission ranges to 110 miles for both air-to-ground and air-to-air, with the added benefit of affording pilots and ground controllers much clearer reception than the old TR9D. The transmitter and receiver were enclosed in a metal case: the total weight of the unit, excluding the batteries, was 46 lbs (20.9 kg)[9]. Because of its much shorter wavelength, the VHF R/T used the mast as its antenna, using a screened socket secured to the base of the steel section of the mast. The HF wire and associated fittings were deleted and the lead-in opening in the base insulator was plugged[10]. The TR9D, TR1133 and later TR1143 used the same sprung, sliding tray in the fuselage, making it much easier to swap them around, as required.

In the cockpit, the electro-mechanical Type C gave way to an 'Electric controller type 3', that allowed the pilot to select from the four pre-set channels.

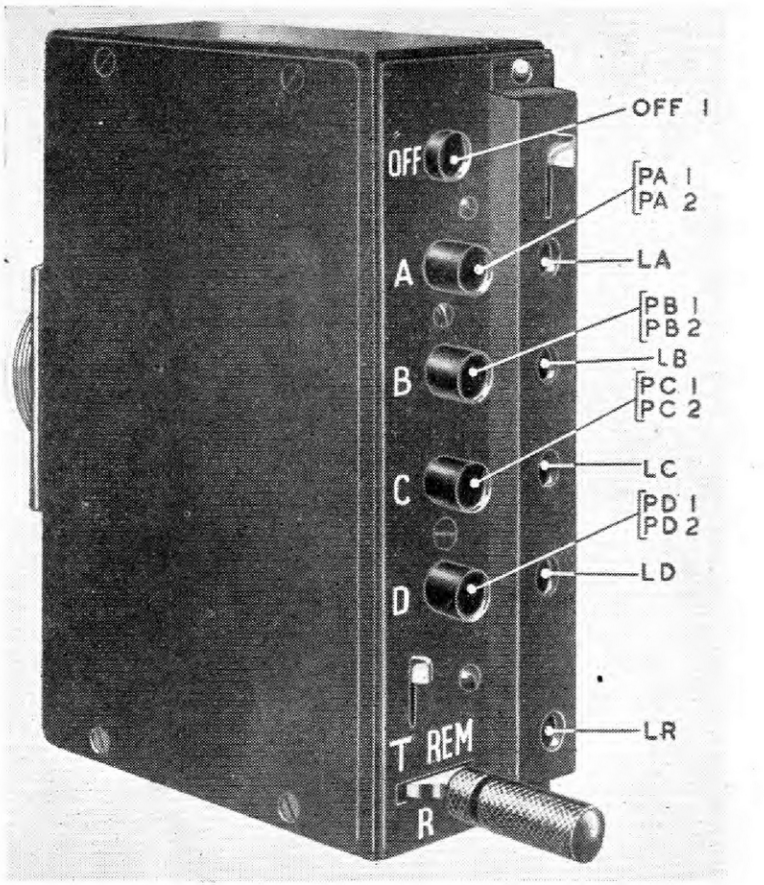


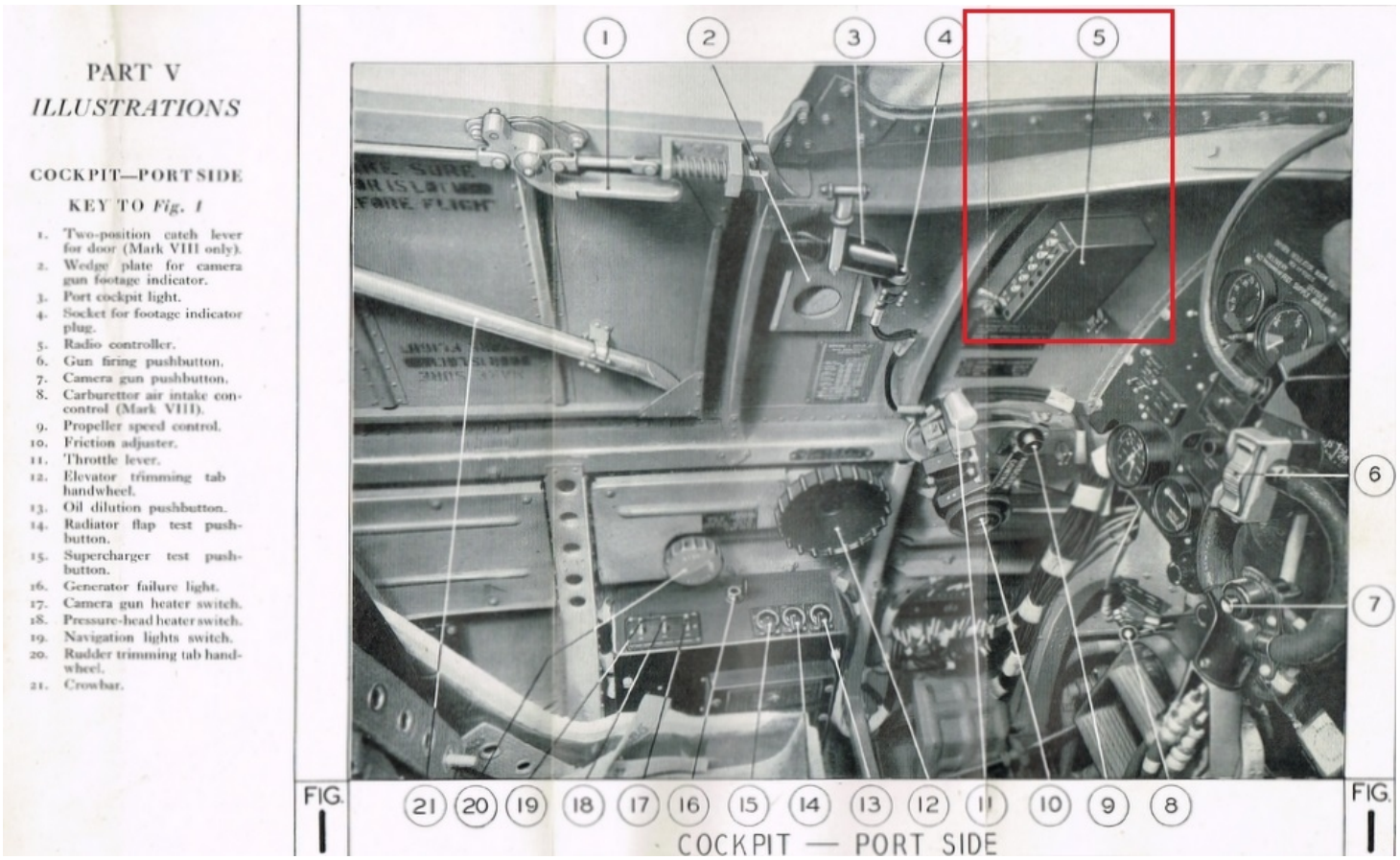
Fig. 12—Electric controller type 3.

11: The Electric controller type 3, used with the TR1133 and later TR1143. The four channels were marked A to D, next to the four push-buttons. Alongside the buttons were small lights (LA through LD) that were illuminated depending on the channel selected.

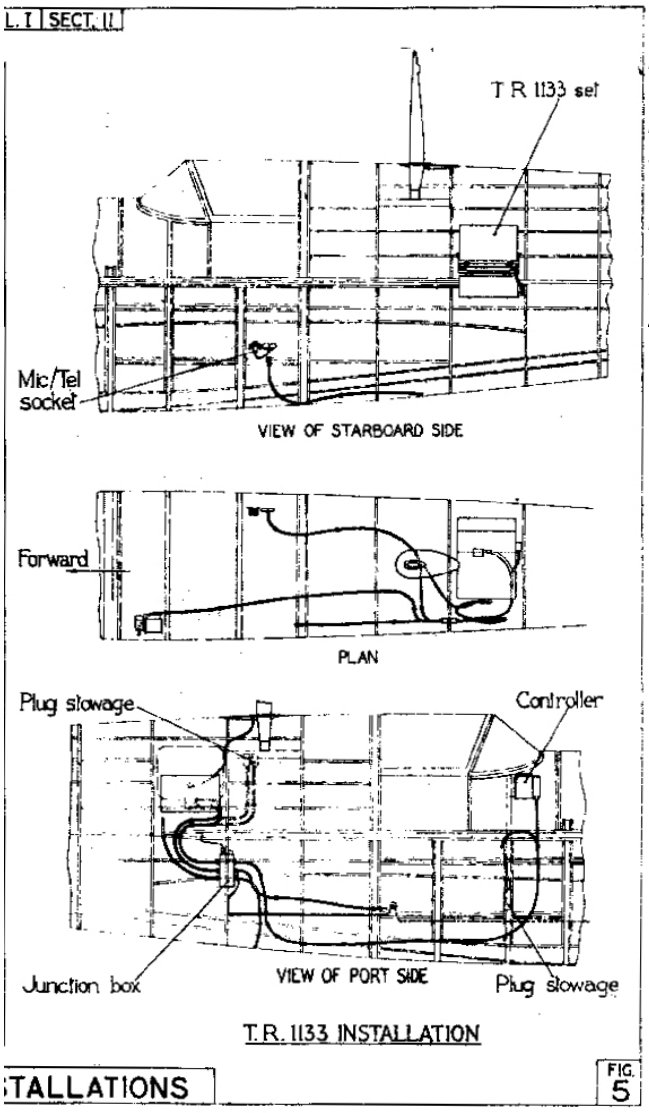
Above the lights, a small, vertical blade operated a slide that darkened the lights for night flying.

The toggle switch for Transmit, Receive and Remote (T, REM, R) was at the bottom of the unit. This was spring- loaded, so that the pilot had to hold it in position to transmit; the light marked LR stayed off when transmit was selected.

This particular unit had provision for the round, multi-socketed plug at the back, that was common to the TR1143 and its American manufactured derivative, the TR5034.
[From A.P. 2528A
Transmitter-Receiver T.R.1143A: July 1945]



12: Controller Type 3 in the cockpit: although this illustration is from the Pilot's Notes for Spitfire Mks VII and VIII, the position remained the same from the Spitfire Mk. I, through to the F/FR Mk XIV and P.R. Mk XIX. Post-war, the controller was often mounted horizontally and slightly closer to the instrument panel. [From A.P. 1565 G & H – P.N. Pilot's Notes for Spitfire F.Mk. VII – Merlin 64 or 71 Engine F.MK. VIII – Merlin 63, 66 or 70 Engine: December 1943.]



13: TR1133 installation in the Spitfire Mk. I: this was designed to be interchangeable with the TR9D, as described in the June 1940 Spitfire I pilot's and maintenance manual. The triangular pulley insulator was removed from the head of the mast, leaving the small, scalloped securing bracket at the rear.

While some Spitfire Is fitted with the T.R. 1133 retained the rudder post, on most Spitfires this too was removed.

In the cockpit, the electric Type 3 Controller did not need the flexible cables of the older electro-mechanical unit. [From A.P.1565 A Spitfire I, Volume I, Section II. June 1940]

The first successful trials of the new VHF set were undertaken by six 66 Squadron Spitfires, starting on 29 October 1939[11]: a few days later, the general introduction into operational fighters was approved. However, the TR 1133s were still being hand-built and it wasn't until January 1940 that 54 Squadron became the second unit to test the new R/T, in a batch of N31xx series Spitfire Is that were also fitted with Rotol constant-speed propellers[12] [13]. In May 1940, 41, 66 and 611 squadrons were re-equipped with VHF, along with 17, 32, 56 and 229 Hurricane squadrons. Although the superiority of the VHF R/T over the HF was proven during operational service, a steady attrition of aircraft, plus a continued shortage of TR 1133s, meant that on 1 June 1940, Air Vice-Marshal Dowding instructed the squadrons to change back to the TR9Ds.[14]

14: Two 41 Squadron Spitfire Ias, with the early TR1133 installation, RAF Catterick, late May 1940: EB-L was N3123. The triangular wire guide had been removed from the masts and the rudder post had been deleted on the Spitfire in the background.

It wasn't until 18 August 1940 that Fighter Command started large-scale conversion to the TR1133, beginning with 19, 41 and 54 Spitfire squadrons. Although slow at first, the conversion work increased in tempo, such that a memo from 29 October lists 19, 41, 54, 66, 92, 266, 602,603,609 and 611 Spitfire squadrons as being equipped with VHF: the units that had not yet been fitted with VHF were 65, 74, 152, 222, 234 and 616 squadrons, as well as 421 Flight. Two weeks later, a 13 November memo shows that the only Spitfire squadrons that had not yet fully converted to VHF were 74 and 222.[15]

At this juncture, it is worth noting that the TR9D was still being factory fitted until well into 1941, with the conversion to the TR1133 being undertaken at Maintenance Units (MUs). The HF unit was also fitted as standard to Spitfires that were exported to Portugal and Turkey. In addition, the Spitfire Vbs that were taken out of RAF service and delivered to the Soviet Union in 1942 and 1943, were re-equipped with the TR9D.

While the TR 1133 was the first VHF set to be used by the RAF, an improved successor, the TR1143, had already started development in 1940 and was expected to be in full production by early 1941. However delays in development meant that the TR1143 would not see full scale production and installation until 1942.[16]

From 1942 until the end of World War 2, the TR1143 and 1143A were the standard R/T units for single-engine RAF fighters: it consisted of a Transmitter Type 50 and Receiver Type 71, both of which were crystal controlled. Like the TR1133, it also utilised four pre-set frequencies, operating over a frequency range of 100 to 124 MHz, with an improved reception and transmission range of up to 125 miles at 10,000 feet. The unit was enclosed in a metal case and was accessed by 4 Dzus fasteners. The total weight, without batteries, was 46 lbs. The TR1143's standard controller was still the type 3 unit, although this was later supplemented by the type 4 (see below).[17]

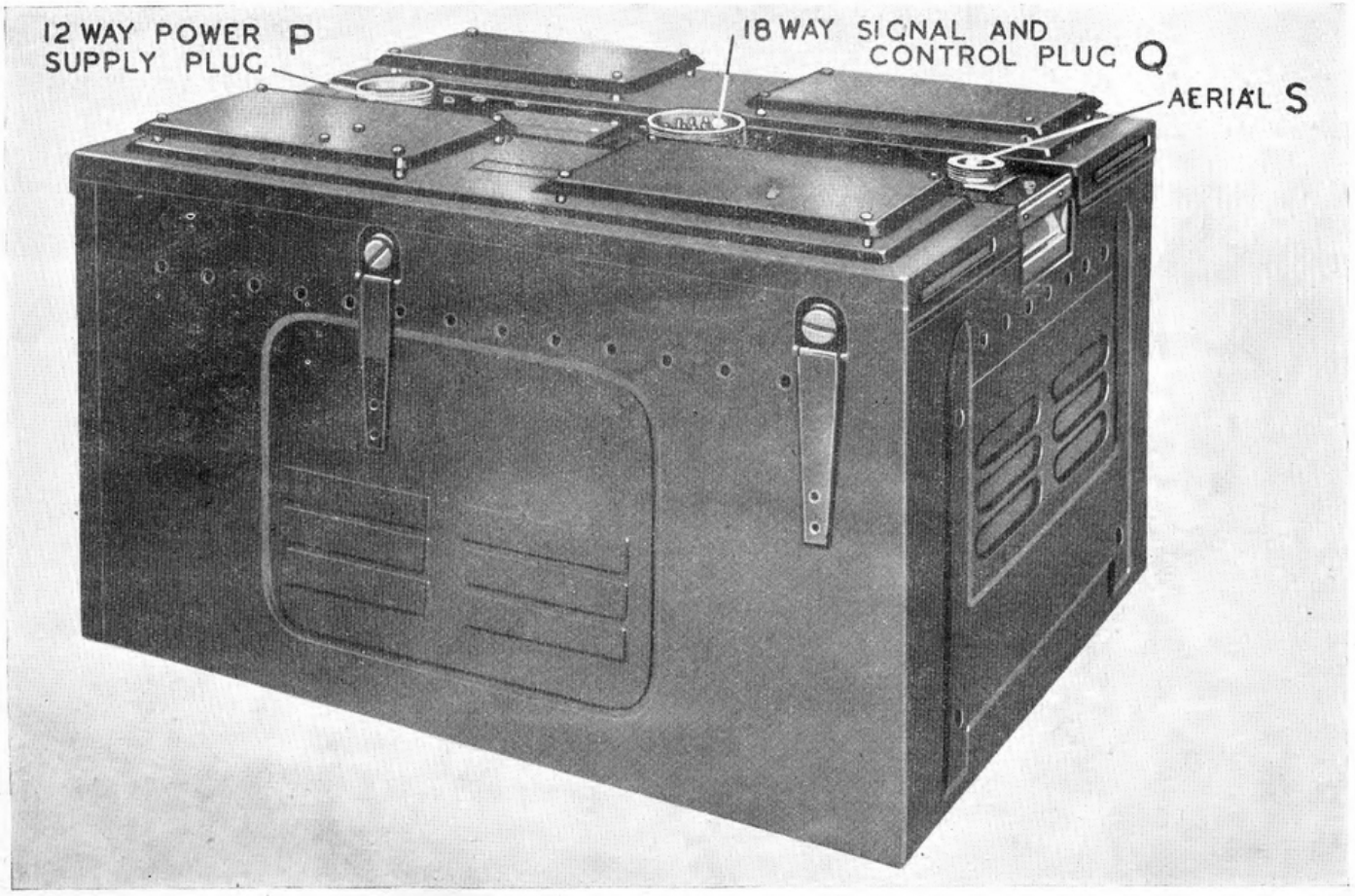


Fig. 1—TR. 1143A—general view.

15: The TR1143 R/T unit in its case: the controllers type 3 and type 4 were plugged into the unit using the 18 WAY SIGNAL AND CONTROL PLUG (Q) on top. [From A.P. 2528A Volume I Transmitter-Receiver, T.R. 1143A:]
16 (below): Schematic of typical TR1134A installation for single-seat aircraft

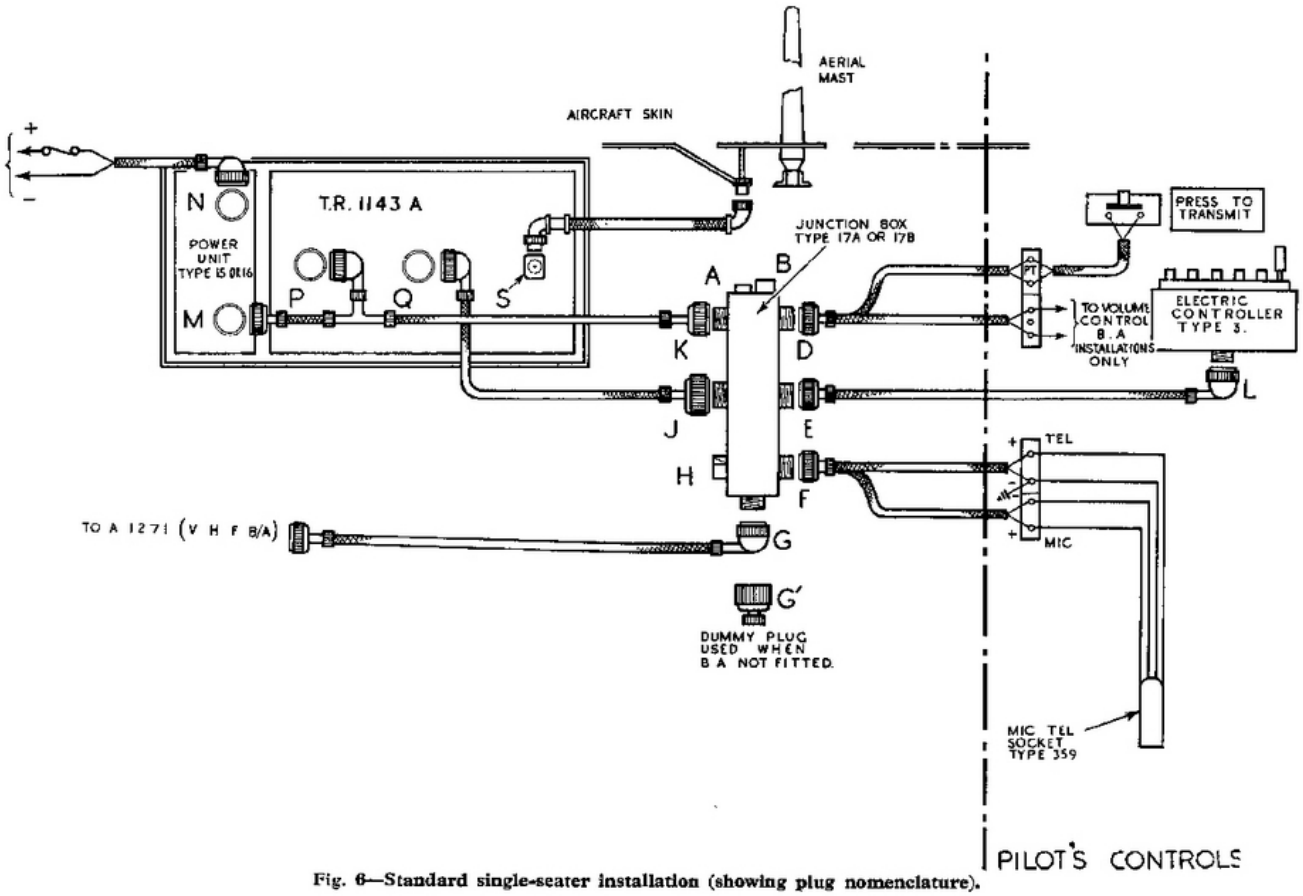


Fig. 6—Standard single-seater installation (showing plug nomenclature).

C: Enter the Americans.

With the arrival of the United States Army Air Force (USAAF) in Britain in 1942, the Allies realised that once the USAAF and RAF started operating in concert, they would need to use compatible radio equipment and frequencies. The biggest problem was that American aircraft were equipped mostly with HF R/Ts, meaning that they had trouble communicating with British aircraft and ground installations. The experimental VHF ARC-5 was still plagued with teething problems and was unlikely to be usable for some months – if at all.

The quickest solution to the problem was to build the TR1143 in the United States, using some American made components and American production techniques. This materialised as the SCR-522 'Command Equipment', that used a BC-625 transmitter and BC-624 receiver with four pre-set channels. It was able to operate within a frequency range of 100 to 150 MHz, with a reception and transmission range of 180 miles at 20,000 feet. In its case, the SCR-522 was physically identical to the TR1143, apart from the manufacturer's labels on the side, and weighed 53 lbs.[18] The type 3 controller was also 'Americanised' as the BC-602-A control box. The SCR-522 soon became standard equipment in many USAAF aircraft types, including the P-38, P-47 and P-51. As part of the bi-partisan production arrangement, large numbers of the SCR-522 and BC-602 were supplied to the British under lend-lease, as the TR5043 and Type 4 controller respectively.

1 Documentation of the 1930s and 1940s used fullstops in abbreviated titles; eg: T.R.9D. (Transmitter-Receiver 9D). For the sake of brevity, such punctuation has been omitted from this article, except where official documents are cited. Air Publications, that were printed and distributed by Britain's Air Ministry, usually used the abbreviation A.P. followed by a sequence of numbers and/or letters that referred to specific aircraft and equipment types: thus, the manuals and documents relating to the Spitfire were always prefixed A.P.1565; A.P.1565 A = Spitfire I; A.P.1565G & H = Spitfire Mk. VII & VIII.

2 The TR9Bs in K- series Spitfire Is were progressively replaced by 9Ds, most likely by Maintenance Units (MUs): the conversion was described in *A.P. 1565A-Q.4-W*, *Spitfire Modification I/14* (Mod 14), that was issued on 22 June 1940. Note that '*Spitfire Alterations*' were redesignated '*Spitfire Modifications*' (eg; Mod. 14) in late 1939.

3 A.P.1186; RAF Signal Manual, Transmitter– Receivers; Section 2: Chapter 4:T.R.9.D: February 1940

4 The Type D controller was used in aircraft where the R/T unit was located 15 feet or more from the cockpit.

5 This mast was not unique to the Spitfire, because it was also used on the Hawker Hurricane and Typhoon, the de Havilland Mosquito and the Westland Whirlwind.

6 While there can be some conjecture as to what type of material was used for the Spitfire's insulators, the most likely candidate seems to have been a moulded, resin-impregnated paper or cotton laminate manufactured by the George Ellison Switchgear Company. This product was named Tufnol® in 1944 *to "create a separate brand identity for its expanding product range....Tufnol also produced parts for the iconic Spitfire fighter aircraft"...* Source: https://tufnol.com/longevity-quality-a-history-of-tufnol/
It is also worth noting that

7 The instructions are from *A.P. 1565A, Volume I. Spitfire I Aeroplane, June 1940; Section II, sub-section 26 'Instructions for changing over from T.R 1133 to T.R.9D.'*

8 Woods, Derek and Derek Dempster, *The Narrow Margin* (London: Tri-Service Press Ltd, 1990),113.

9 R.A.A.F (ROF4) 886/2M/5/45 *Notes for Wireless Maintenance Mechanics on the Maintenance of V. H/F Equipment.*

10 *A.P.1565 A Spitfire I, Volume I, Section II:* Equipment; Wireless Installation, sections 22 to 26. *June 1940*

11 "V.H.F. R/T Tests being carried out by aircraft of the unit." 30.10.39.: "More V.H.F. Tests. Carried out by 6 Spitfire aircraft of this Unit." 66 Squadron Operational Record Book (ORB); Summary of Events, June 1916 to October 1939: 29/10/39.

12 "Wing Commander Randall arrived from Farnborough to fit T.R.1133 in Rotol Spitfires. These are being fitted to all Rotol Spitfires in the squadron." 22/1/40. 54 Squadron ORB; Summary of Events,January 1940. The Rotol propeller was a constant-speed unit that was far more efficient than the then standard de Havilland two-pitch propeller usually fitted to Spitfires by late 1939.

13 "Local flying on Rotol aircraft experience." Listed were N3110, 3122, 3104, 3097, 3103, 3111. 29/12/39. 54 Squadron ORB; Records of Events, December 1939. ""B" Flight re-equipped with Rotol Spitfires." 29/12/39 54 Squadron ORB; Summary of Events, December 1939.
N series Spitfire Mk Is listed in 54 Squadron service were N3097, 3103, 3104, 3110, 3111, 3122, 3124, 3160, 3172, 3176, 3183, 3185, 3188. It is likely that all of these were fitted with Rotol propellers.

14 A.P. 3273: The Second World War, 1939-1945: Royal Air Force Signals, Volume II. Air Ministry,

1958.

A.P. 1136: The Second World War, 1939-1945, Royal Air Force; Signals, Volume III; Aircraft Radio.

Air Ministry 1956, Chapter 23 pp 609

15 Information from http://www.airbattle.co.uk/b_research_3.html Specific sources cited: AIR 2/2946 'COMMUNICATIONS: VHF in the Royal Air Force 1938-1940' and AIR 16/185 'VHF Equipment Policy' from the National Archives, Kew.

16 As a stop-gap measure, in early 1941 all TR1133s were upgraded to the TR1133G or H by replacing the receiver type 1137A with a crystal-controlled R1225.

17 A.P. 2528A Volume I Transmitter-Receiver, T.R. 1143A: ‘Concise Details’, page 3.

18 AN-40SCR522-2 Handbook of Operating Instructions for Radio Sets SCR-522-A and SCR-542-A; General Description, section 1-1 Joint Publication United States War and Navy Departments and United Kingdom Air Ministry: 30 December 1944.

Article Part II = IFF and Beam Approach equipment...

R. 3002 IFF Mk II (Mod.224) Control unit type 17

R3067 IFF Mk III Type 90 aerial and insulater between ribs15 & 16 starboard wing: control unit types 89 & 90 [A.P.1565A/Q.9-W Spitfire F.1 – Mk III IFF Installation Spitfire Mod 801 14 January 1944]

VHF Beam Approach equipment and aerial (Mod No 472 september 1943); Amplifier stores reference 10U/549 Switchbox type B in cockpit. aerial type 62 between fuselage frames 13 & 14 [A.P.1565A Q.8-W 4 september 43