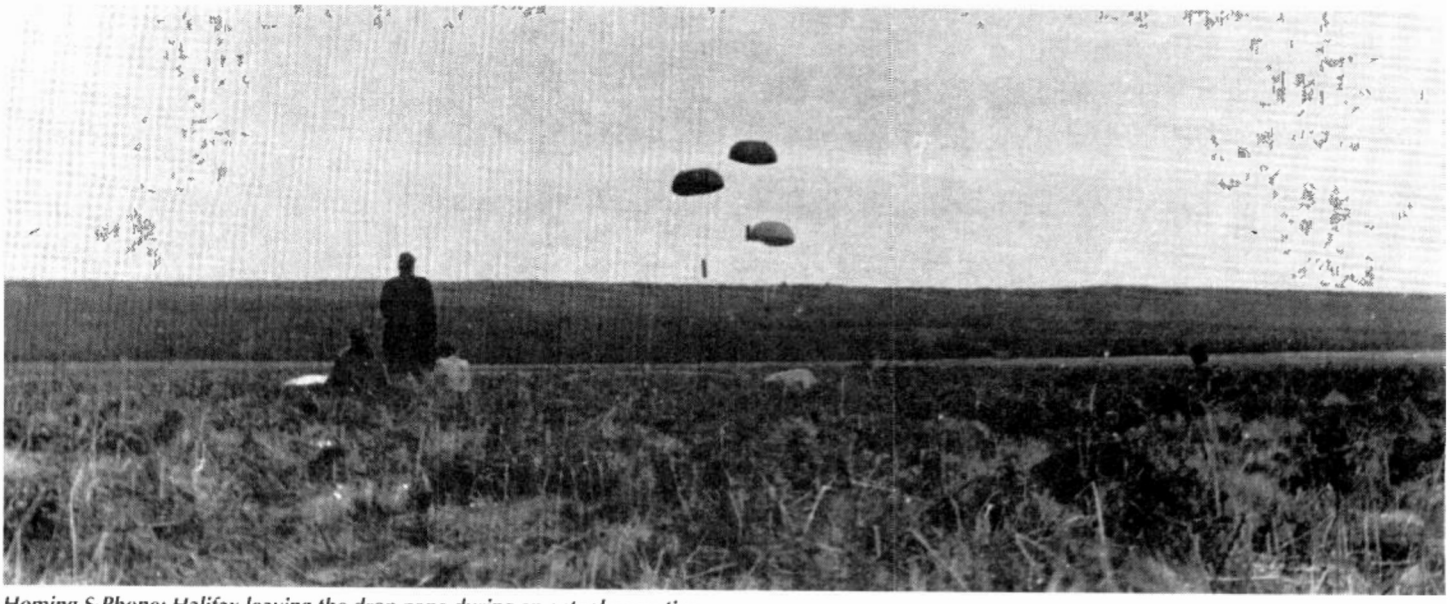


Homing S-Phone: Halifax leaving the drop zone during an actual operation.

The secret radio that kept Resistance lifelines open

Good communication and reliable parachute drops of supplies were vital for coordinating Resistance fighters in occupied Europe. Charles Bovill describes how the S-Phone met both needs – and the enemy never knew.

In a Europe occupied by the German Army, and a Britain under threat, Winston Churchill issued a directive to "Set Europe ablaze". Until the return of the Allies to Europe, that was an instruction that could only by accomplished by formation of a Resistance movement, organised by patriotic nationals – often in conjunction with agents from Britain who infiltrated occupied countries. Armaments, explosives and agents were parachuted in by the RAF, and the work of the Resistance was to harass the Occupying Forces, mainly by sabotage.

But for the work to be effective, good communications between Resistance Groups and allied agents was essential.

Low-powered HF equipment was in use – and was entirely successful. But for parachute drops, a specially designed communication system with a homing component was needed. The S-Phone, developed by Captain H Lane, was the answer.

Captain Lane, of Royal Signals, was engaged in radio work for the Inter-Service Research Bureau, later to become the Special Operations Executive (SOE). He knew that suitable equipment had to be small and very simple to operate. Reliability was an extremely high priority too, as equipment repair was practically impossible in the field.

Lane's basic idea was to use a new approach to secure communications built on the line of sight performance of UHF, with operational range depending on the relative heights of the sending and receiving stations. So an aircraft flying thousands of feet above the ground station could communicate over considerable distances. The generally used formula for the horizon distance, upon which the idea was based is $D = \sqrt{(H_1 + H_2)}$ where D = distance of the horizon in miles, H_1 is the height in ft of the aircraft and H_2 is the height in ft of the ground equipment.

In a typical case the horizon distance between an aircraft flying at 3000ft and a ground station would be about 50 miles for an S-Phone at 100 feet ASL. In practice, this meant that with the low power available from the ground station the range, under favourable conditions, would be about 20 miles – an adequate range for its intended use. But as a by-product, the system was extended to intelligence work communications where it was extensively used almost as soon as the system became operational.

At short ranges, various effects severely restricted ground-to-ground communication. Over normal terrain, the range was not more than a maximum of one mile, with a power output of 200mW. Experiment indicated that the S-Phone should operate in the 400-450MHz band. But why did SOE not use the already developed VHF? The answer is that communications equipment had to be compact. It was also known that the enemy carried out extensive monitoring on the VHF band, but very little on UHF – though they did operate communication links on UHF.

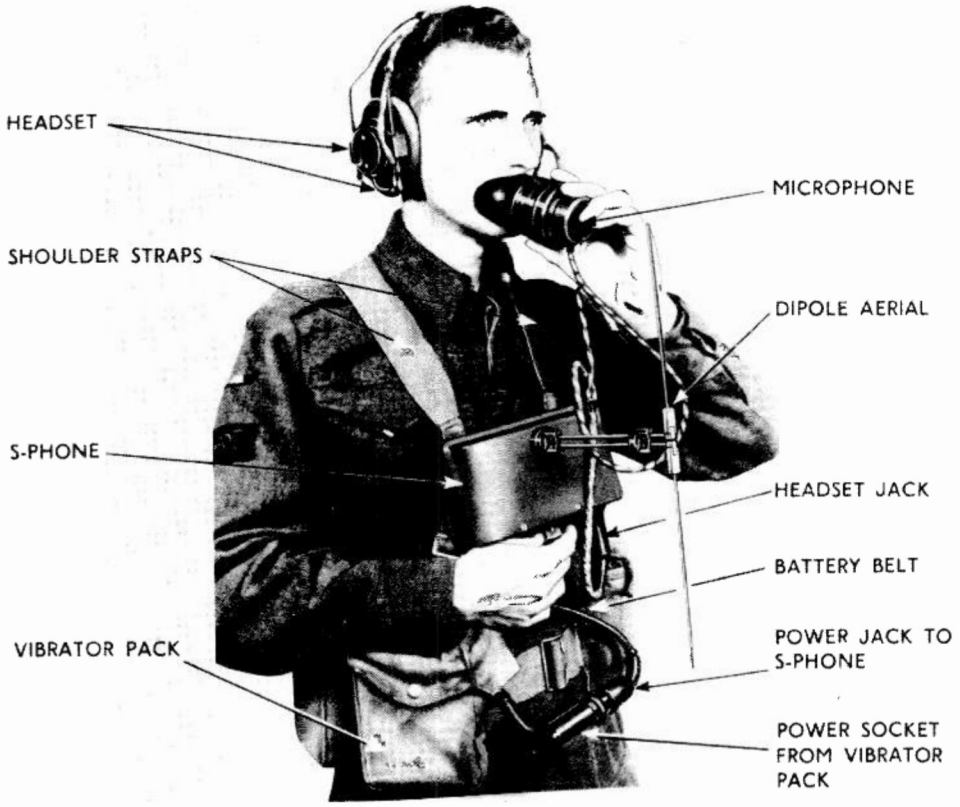
For the period in question, fifty years ago, miniaturisation was hardly an option. Only valves were available and for VHF, suitable types were rare and mostly absorbed for radar development.

Ground S-Phone

The ground S-Phone prototype hardly changed throughout the war. It consists of the transmitter-receiver unit, in a contoured metal case, a dipole antenna plugged in and a belt to which the unit was clipped and which also contained rechargeable batteries and a vibrator HT generator.

By present day standards the circuit arrangement used is very simple and consists of a free-running UHF oscillator and Heising modulator for the transmitter. The oscillator valve, an *RL18* is fed into the antenna inductively and provides an output of about 200mW. The vibrator, driven by 6V from the battery belt, provides 200V for the HT of all valves in the

The lightweight self-contained SPhone enabled communication between ground and air while minimising the chance of transmissions being picked up on the ground.



transmitter and receiver sections. Batteries provide about 4h of continuous operation and a charger operating from the 110 or 220V mains was supplied.

The receiver uses a super-regenerative detector, also an *RL18*-type of valve, and audio is fed to an amplifier, using *Hivac* valves. A tuning control provides an adjustment of ±5MHz to take up transmitter and receiver frequency drift.

The detector is connected to the antenna inductively. Closeness of the transmitter circuits to the receiver input results in a side-tone signal.

The microphone is a normal RAF air crew type and gave good quality. Intelligibility was deemed essential during the experimental period as, in many cases, the ground operator and opposite number on the aircraft did not always share the same first language. Repeating signals were not desirable, because of the risk of night fighter activity.

Overall, the S-Phone, using duplex, had been conceived to resemble a normal telephone as far as possible. With correct operation on the part of the aircraft and ground operators it went near to fulfilling the task.

Crash setback

The airborne equipment presented less development difficulty in and, in the first days of trials, consisted of a transmitter of similar type to the ground model but using a superheterodyne receiver. Within a few days of the completion of the prototype, the Whitley aircraft in which it was installed crashed at Stradishall, with the loss of the crew and total destruction of the S-Phone equipment

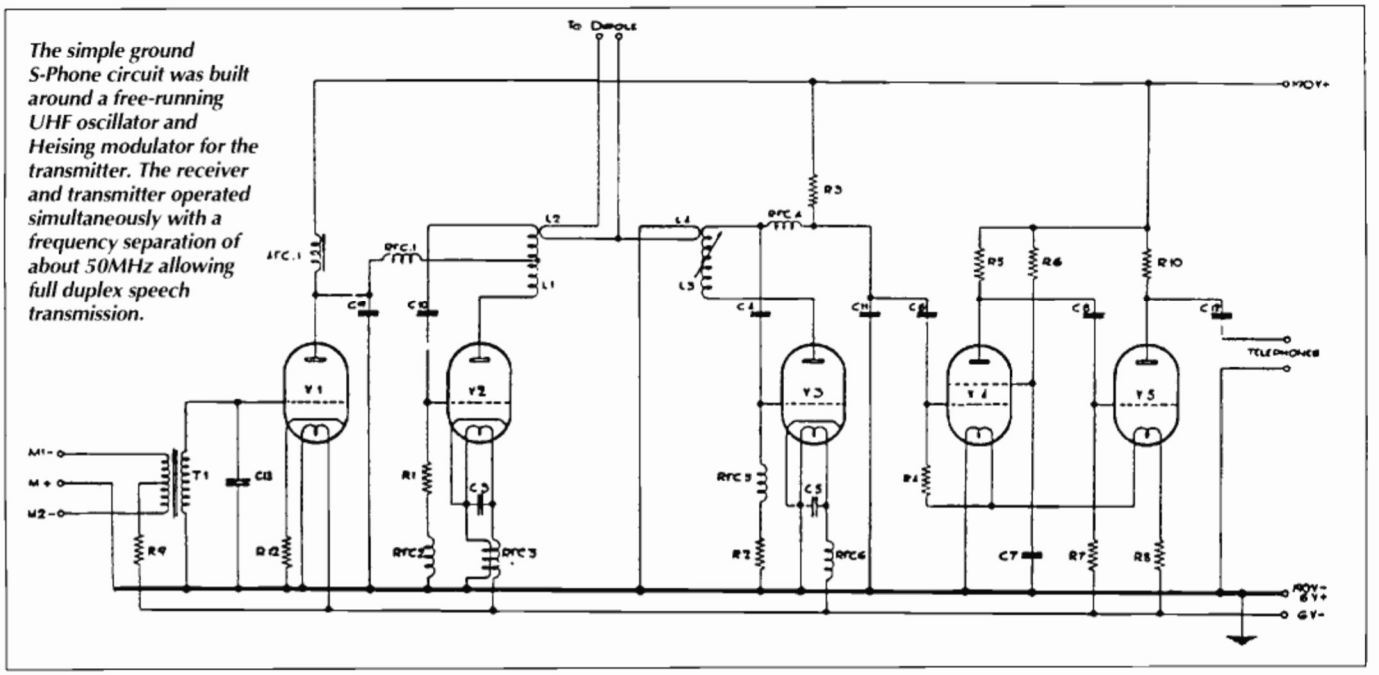
The situation was particularly serious because the S-Phone was urgently needed and the equipment destroyed had been the only one in existence. Worse, it was then discovered that no drawings of circuits had been prepared.

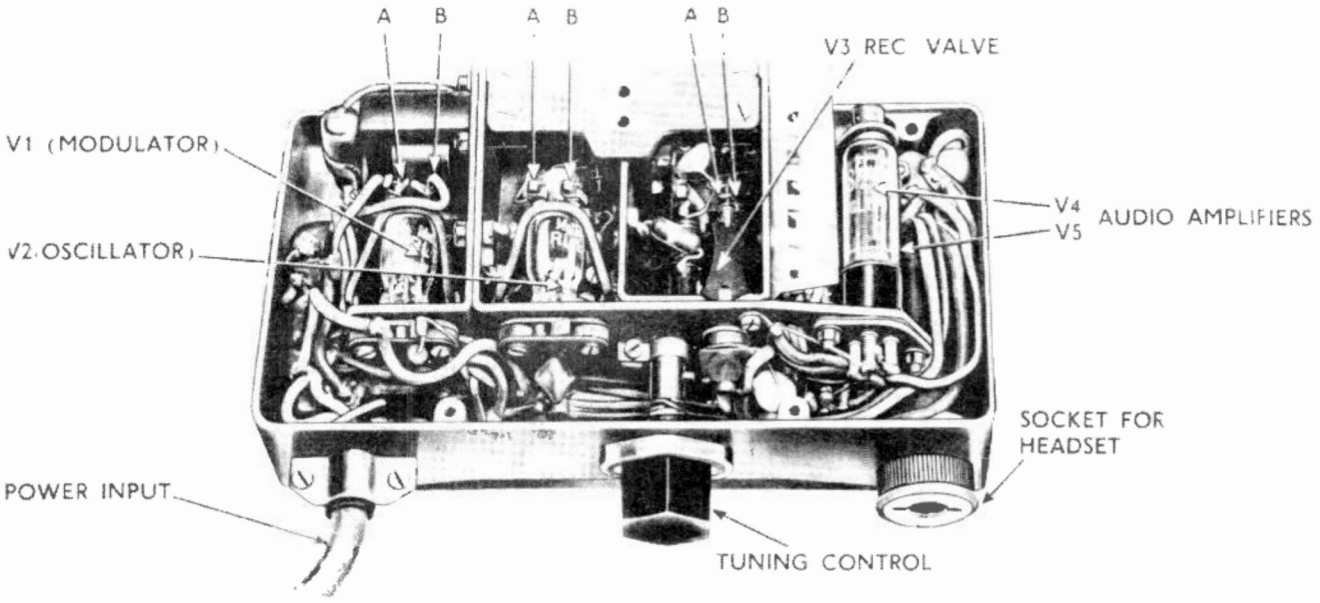
But such was the attitude and the "press on" spirit during the war that, on the evening of the crash, work was immediately put into hand and new equipment was available for airborne tests within three days.

The new airborne unit altered the receiver to a super-regenerative type using tuned lines, as did the transmitter, both with good performance – the receiver had a sensitivity of the order of 5μV for "a loud and clear signal". Transmitter power was also increased.

Because of the unusual conditions attached to parachute dropping, the speech output from the transmitter and the receiver were connected to the intercommunication circuits of the aircraft, facilitating operations and eventually saving several aircraft and crew on dangerous missions.

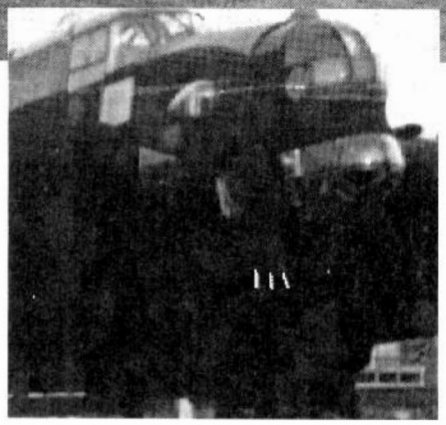
The simple ground S-Phone circuit was built around a free-running UHF oscillator and Heising modulator for the transmitter. The receiver and transmitter operated simultaneously with a frequency separation of about 50MHz allowing full duplex speech transmission.





Inside the ground S-Phone.

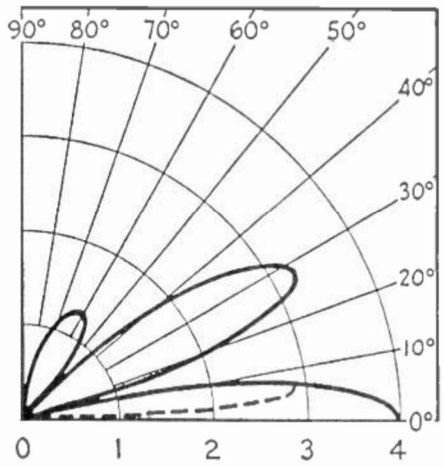
(Right). Many Halifaxes were fitted with the S-Phone. Inset shows a close up of the S-Phone antenna, poking out from under the fuselage. The three-quarter wave antenna provided a bearing facility onto a ground S-Phone set.



Antenna fine-tuning

The airborne installations – in the first instance on Whitley, Wellington and Halifax bombers, converted for dropping parachutes – hit problems with the antennas. Fitting the antennas on the lower surface of the fuselage seemed to be the most suitable solution for ground-to-air communication.

But on the first test flight, with the aircraft at a low altitude, received signals experienced severe distortion from the ground, due to the inherent radiation of a super-regenerative receiver reflected back from the ground below.



Lobes of radiation from the ground S-Phone were not as expected. The gaps were used to guide aircraft to a drop.

Further experiments showed that the difficulty could be overcome by mounting the antenna – a quarter wave type – on top of the fuselage.

The best position was not determined until several flight tests has been made, because, at some angles of flight, such as steep banking and climbing, the antenna was shielded.

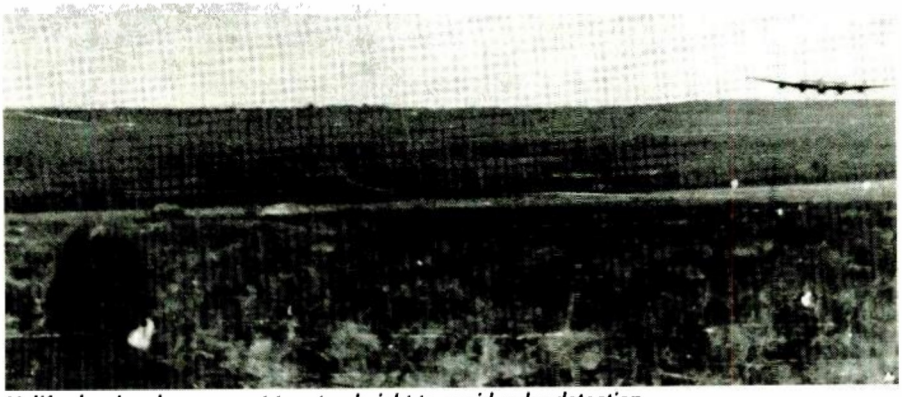
During these experiments developers noted that in some positions of the antenna, distortion of signals occurred, only to be eliminated when the aircraft was flying directly towards the ground transmitter. The effect was in fact due to reflections from the airscrews, an unsophisticated but practical homing system. It was never adopted and better solutions were to come into service later.

The combined characteristics of the ground and airborne antennas added together in quite a fortunate manner. Lobes of radiation from the ground S-Phone were not what is found in textbooks, mainly because of the position, and basic nature of the antennas. The result was several radiation lobes at low angles, causing gaps which, when flown through at relatively low altitudes, were distinctly noticeable by the drop in signal strength, followed by a clear "cone of silence" when signals were not heard.

These special conditions were exploited in dropping operations. The aircraft would fly towards the DZ (drop zone) and the levels of signal strength would be noted by the pilots and the dispatcher – the crew member responsible for the release of the parachutes. Although crude by today's standards, the method was frequently used and was, in its way, successful. When the S-Phone homing system was developed and in operational use, the pilots and the dispatcher were assisted by a signal strength meter which gave accurate indications for a precise drop.

Receiver and DF units were far more advanced than the super-regenerative receiver which had been used on S-Phone operations for the previous years – the super-regenerative receiver being unsuitable for a homing system.

The transmitter remained the same, but by this time, successful UHF superheterodyne designs were available and a reliable sensitive



Halifax leaving drop zone at tree top height to avoid radar detection.

receiver was produced. In essence, the homing receiver was associated with a phase comparison unit, signals being received on three spaced dipole antennas located below the nose of the aircraft

Examination of the equipment reveals some strange techniques in implementation. But the extreme shortage of components and time available had to be taken into consideration. The main consideration was that it all worked.

Transmitting and receiving antenna

During development of the S-Phone ground equipment, one of the main difficulties was the antenna. Position of the dipole made it necessary to use vertical polarisation. Tip of the lower element was about a quarter of a wavelength from the ground, producing a slightly abnormal radiation in the vertical plane which was actually an operational advantage. In addition, the antenna – being forward of the operator – had poor back to front performance, with considerable loss of signal if the operator was not facing towards the transmitting-and-receiving aircraft.

Attempts were made to rectify this operational weakness but, short of mounting a quarter wave antenna on the operator's head, no practical solution was found and the original antenna layout was retained until the end of the war.

The weakness did lead to some operational failures. An operator knew beforehand the direction from which the aircraft should arrive at the DZ. But in many cases enemy action caused the aircraft to make a detour and probably arrive on a reciprocal bearing. In this case it would not be contacted until it was almost overhead. Usually, the operator placed stones on the ground indicating the cardinal points of N, S, E and W. While waiting for the arrival of the aircraft, the operator searching for signals by pointing the antenna in various directions. When the signals were heard, directional characteristics of the S-Phone would guide the aircraft to the DZ.

How secure were S-Phone operations?

Air-ground S-Phone operations do not seem to have been detected or seriously interfered with by the enemy – which is surprising, because Germany did have UHF systems. Clearly the aircraft transmissions would be detectable over an area of at least 400 square miles. But they were not heard, or were not felt to be of significance to the very well organised German Abwehr. Finding the ground sets, unless sought by detection units on the ground or in the air, would have involved a considerable organisation.

A reference[2] to S-Phones is made – though not by name – by the former Chief of Military Counter Espionage in Holland, Belgium and Northern France, Major H J Giskes, author of "London Calling North Pole".

Although primarily engaged in the "English Game" operation, he states that "he had heard from Berlin that progress had been made in the design of VHF sets for agents' use. It is quite possible that the enemy is using them and our normal interception service can't pick them up".

Later in his book, he reports the capture of a Dutch SOE agent with an S-Phone, although again not specified as such, who reported that the radio telephone was for communication with English ships at sea. He reports later that tests showed the equipment was capable of: "... communicating over 5km – quite a good performance at the time".

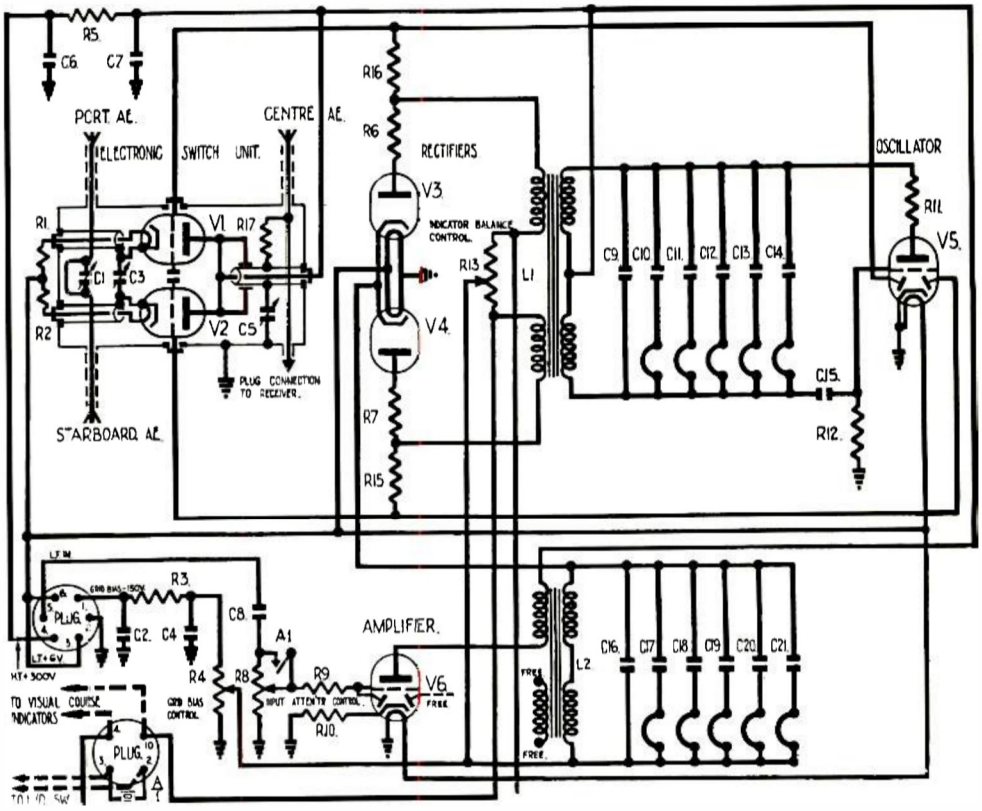
There does not seem to be a record of the capture of agents or saboteurs while using S-Phones, except in the case mentioned.

Proved by history

In these days there is a rather unfortunate tendency for authors and journalists to find fault with military operations. But the S-Phone has not yet suffered in this way and it can be concluded that the development and operations were worth the effort.

The system saved lives and was of great assistance to the valiant agents and Resistance groups in many countries.

In Holland, when the Germans had retreated to the north of the Maas river, an air-ground



Airborne S-Phone homing unit making use of phase difference between three nose-mounted aerials. In operational use pilots were aided by a signal strength meter.

Pregnant technology

Trials and operations re-commenced and included demonstrations at night. On one of these tests, to a most secret military organisation, Colonel Lord Sandhurst was critical that, when worn under an overcoat, the operator looked pregnant. The quick-witted SOE Flight Lieutenant handling the presentation, instantly replied that this was an advantage as it was a standing order that, in the presence of pregnancy, a German soldier must avert his eyes and salute.

The Auster was normally used for spotting artillery, but the SOE had them fitted with the S-Phone (in front of seat).

Intelligence gathering network was set up and operated for the period leading up to the last day of the war.

Necessary ground equipment for the activities were smuggled into enemy occupied territory by a few courageous Dutch men and women. Aircraft used were of two types: DH Mosquitoes and the smallest plane flying with the RAF – the Auster.

Normal role of the Auster was artillery spotting, but for the SOE they were fitted with the S-Phone. The aircraft only operated at short ranges and were mainly employed in "orchestrating" and organising the crossing of the Maas and other rivers, by people leaving the Arnhem battle.

The deep-penetrating intelligence-gathering Mosquitoes flew over Germany at great altitudes collecting valuable information at speeds which made them difficult for the Luftwaffe to intercept.

Airborne equipment was the normal type but the antenna arrangements were unusual. Tests showed that attenuation from the wooden fuselage was negligible at 450MHz, and for aerodynamic and concealments reasons, the antenna was placed inside the fuselage and towards the tail.

Polar diagrams of this arrangement were satisfactory and the range over which communication was possible – theoretically about 150 miles, but in practice nearer to 100 miles – adequately covered the whole area of Occupied Holland and into Germany.

10,000 in use

Estimating how many S-Phone operations were carried out in all of the theatres of war during the years of conflict is difficult, largely due to the very strict security maintained by the RAF, USAF and SOE. Keeping personal diaries was a court martial offence and few existed. Official records – and equipment – were efficiently destroyed, especially by SOE, in 1946.

From the small amount of information available, mainly from the memories of persons actually involved, the number is of the order of 10,000 in Europe and Asia.

The aircraft equipped were Wellingtons, Halifaxes, Whitleys, Hudsons, C47, Fortresses, Liberators, Mosquitoes, Stirlings and Austers. Sorties were made very frequently so the 10,000 estimate seems reasonable.

Operations were, in the main, successful and were, from the beginning of 1944, assisted by the Eureka-Rebecca 200MHz guidance system which provided a homing and distance facility.

The marine activity using S-Phones was considerable in all theatres of war and assisted in many clandestine landings of agents from small boats and submarines. The only comparable system to the S-Phone was the American Joan Eleanor, first used in late 1943. An operation with this system is described in detail by V J Layton in an article "Above Intercept" which appeared in "73 for Radio Amateurs" during October 1985. ■

S-Phone in action

One spectacular operation using the S-Phone was when an enemy headquarters was – to use the present day term – bugged.

Ground equipment was infiltrated into the building and a remote microphone installed in an office where discussions of interest to the Allies were to take place.

For the remainder of the war, an aircraft carrying out routine flights was able to cover conversations through the S-Phone link.

In Denmark, valuable use was made of the S-Phone in establishing a link between Helsingfors and a listening post on the adjacent coast of Sweden.

The Resistance realised that an ancient high tower near Helsingfors could provide an S-Phone transmitter and receiver site for direct communication with Sweden. To meet the requirement special mains-operated equipment was designed and air dropped complete with all associated accessories. After installation on the tower, it was put into operation and regular communication was carried out until the cessation of hostilities. The tower's already-existing telephone-system was connected to the S-Phone enabling information to be passed at will and without interception. After the war, the general excitement and relief of peace resulted in the installation being completely forgotten and it was not until some years after that an ex-SOE radio engineer, who had designed the equipment, discussed the system with an ex-Danish Resistance operator. The tower was later visited and the S-Phone was found to be in perfect working order. Now the equipment is still serving a useful purpose – in a museum in Copenhagen.

Considerable use was made of S-Phones for secret landings from small boats on enemy coasts. For several years the "Shetland Express" transferred agents to and from Norway with the aid of the system. Similarly, a service was in operation between Devon and the north coast of France. In this instance, not only were the ships kept in contact with each other, but also with the aircraft which maintained a watch over them. The antennas on the ships were concealed at the top of the masts and the S-Phone equipment in the bilges. The S-Phone range over the sea from the 25ft masts was well within the horizon distance, owing to the favourable over-sea path.

Tangible proof of drop accuracy

S-Phone homing and "blind" dropping was demonstrated in the winter of 1943 before a distinguished assembly of officers. The night chosen was considered to have the worst weather that even an English winter could produce, with zero visibility, driving rain and low cloud.

The airborne operator, having complete belief in the system's ability to act as a beacon for the drop, warned observers not to remain closer to the S-Phone than 200 yards. In the event, the bad weather prompted the observers to stay in their cars – which were very close to the S-Phone. The S-phone was simply switched on, without the operator so that the drop could be automatic, and the homing run started some 30 miles from the DZ. Entering the cone of silence, the dispatcher released six containers, and this was followed by a cessation of signals.

The outcome was that the containers, having landed within a few yards of the S-Phone, had inflicted alarm and expensive damage on the distinguished gathering sheltering in their cars.

Accuracy of the homing system was also demonstrated to the US Air Force with a DC3 aircraft of the 60th Group Troop Carriers. The aircraft carried out an initial drop followed at half-hour intervals by further drops. At the end of the exercise, the parachutes from each drop were lying together in an impressive heap.

Further reading

1. "Clandestine Armament" (Also entitled in USA "Secret Warfare"), by Col P Lorain, published by Orbis Publishing, London.
2. "London Calling North Pole", by Major Giskes, published by W. Kimber, 40 Wilton Place, London.

As F/Lt. Bovill, Charles Bovill designed and tested the first widely used airborne homing S-Phone set. He remained intimately involved with clandestine radio operations throughout the war. Charles Bovill is still active as a counter surveillance consultant.