WIRELESS
for the
WARRIOR

Pamphlet Series
No. 10 Listening Stations (WW I-1)

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This publication traces the history and technical developments of line overhearing by induction and conduction. It describes how, during World War I, the invention of the high-vacuum valve made it possible to eavesdrop on the enemy, and to police their own communications at incredible distances by both sides. Detailed technical descriptions are given of the amplifiers and the countermeasures taken to prevent interception.

The Pamphlet Series.
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Please note that the page layout of the Pamphlet Series was set up with mirrored pages and separate cover pages, primarily intended for double-sided (colour) printing, preferably on good-quality class A paper.

For previously issued, free-to-download pamphlets, please refer to page 34.

March 2024

WftW Pamphlet No. 10 Listening Stations.

About this publication.

The core of this publication was written around 1989 but was never published in this much-extended form due to work on the 'Wireless for the Warrior' books and two moves of my home. When the manuscript was recently discovered, it was found that the Wordstar-formatted text on a diskette was no longer accessible. However, a saved printout from a matrix printer, scanned with an OCR scanner, yielded an almost faultless result. Finding reliable additional information on this topic was at times a challenge, particularly the correct and time-accurate type or name of an instrument or valve. A future publication, also focused on World War I communication, will be WftW Pamphlet 11: 'Earth Current Signalling - The History of the Power Buzzer'.

Contents Page

SUMMARY

Not only could radio signals be intercepted, but during World War I and, on a smaller scale, in World War II, both sides established listening stations to intercept enemy line communications and monitor their own. This publication will primarily highlight the technical aspects of these stations, but it will also cover other equally important topics.

Chapter 2 describes, with numerous examples, the challenges faced in early line communication interception, providing examples from that time and discussing their relevance in modern applications.

In Chapter 3, the development of listening sets is explored, with a particular focus on the advancements made by the Germans in valve amplifier technology.

Chapter 4 covers the countermeasures that were implemented, both in terms of technical advancements and tactical strategies. It concludes by highlighting the striking similarities in the developments made by the Allies and the Germans and addresses the question of why more extensive measures to avoid or minimize interception risks were not taken earlier in the war.

Detailed and illustrated examples of the primary listening sets are disclosed in Appendix 1-8. The references include a comprehensive list of literature: books, articles, manuals, reports etc.

It was the French Military Service Establishment that developed the T.M. (Télégraphie Militaire) valve, which became universal, and its manufacture was copied not only by the Allies but also by their opponents as soon as they secured specimens.

(1) INTRODUCTION

'With eager anticipation, we put on our headphones, connected the earth base, and switched on the amplifier. Suddenly, much to our delight, we heard a tenor voice singing a song on the sunny morning of May, evidently a French telephone operator.

We could clearly hear his movements, his breathing, and the chatter of others in the same room. However, it didn't last long, as suddenly, we heard high and low-pitched melodious tones, starting loudly and then slowly fading away. These were tuning fork calls (small tuning reeds mechanically connected to the microphone and used as calling devices instead of buzzers) from French telephone sets, followed by 'Alloh Compagnie, Alloh Regiment' and 'Alloh, Alloh, Cinq.' (The French reported the strength of the telephone signals in code). Replies, reports, and other calls followed, and within a few hours, we captured Division and Brigade orders to the Regiment, morning reports regarding casualties, leaves to home, and supplies of straw and rations.

We heard both strong and weak voices, some far away, while others were nearby; the voices of our own men resounded in our ears. Extended reports were sent in and received, and we wondered if the enemy would do the same and intercept with only a portion of our strength. He would experience all that we had anxiously kept in secret...' [1].

During the night of May 3rd and 4th, 1915, Otto Arendt, a 32-year-old inspector at the telegraph research establishment, installed an experimental four-valve line intercept amplifier in a forward trench near Tahure, opposite the French sector. The initial results exceeded all expectations and led to a drastic change in signal policy.

However, the tragedy was that the practice of intercepting lines had been widely known for almost four decades, yet virtually nobody recognized its potential danger. No action was taken to reduce overhearing through simple, well-known measures, nor was the phenomenon leveraged to intercept enemy communications.

(1.1) R.E. Priestley.

For more detailed information, readers are referred and encouraged to read R.E. Priestley's 'The Signal Service in the European War of 1914 to 1918, (France)' [26]. *)

In chapter VI of his book, Priestly reported: 'In the summer of 1915, the enemy suddenly appeared to be extraordinarily well informed about all that was going on behind our lines. This was manifested in many ways. Carefully planned raids and minor attacks were met by hostile fire, exactly directed and timed to the minute of the attack. Trenches where a relief was taking place were heavily shelled at the very same time as the relief, when they were naturally filled with double their complement of men. This was too often to be a mere coincidence. One day, even, a well-known Scotch battalion took over its new front to the strains of its regimental march, exceedingly well played upon a German cornet. At the time when the leakage of information appeared to be most widespread, that was about June 1915, the trouble with induction and overhearing over the jumble of lines immediately behind our front was causing serious anxiety. It was pointed out that even if overhearing could not take place without a galvanic connector, there were railways, pipelines, and water channels affording the enemy the opportunity to overhear conversations.'

The first improvised experiments on interception on the Allied side were in August 1915 when the French established a listening set and received fragments of enemy conversation.

The station had been devised by a French infantry private who had been an electrician by profession. It consisted of two insulated wires, laid out in saps and tunnels toward the German lines, and connected to a number of buried 75 mm shell cases. The 'listening set' was a pair of low resistance telephone receivers.

*) This book is now in the public domain and can be downloaded here: https://archive.org/details/signalserviceine00prie

2) OVERHEARING

Before going into some detail it is essential to outline the difference between Overhearing and Interception: Overhearing can be defined as incidental (such as unintended interference and crosstalk), while Interception (e.g. a Listening station) is deliberate.

(2.1) EARLY PROBLEMS

In the very early days of line telephony, it was discovered that overhearing occurred due to conduction or induction. This phenomenon manifested in parallel running lines, where conversations on one circuit could be heard on other circuits.

Edison's singing telephone concerts were transmitted in August 1877 by the

Western Union office in New York City. This was done for the benefit of audiences in Saratoga, Troy, and Albany, who were connected by telegraph lines. These lines were single wire, earth return systems, and, as a result, the concerts could be heard by numerous other observers connected to entirely different circuits. These broadcasts were reported as far away as Providence, Rhode Island (370 km).
Another remarkable example, though not related to telephony, occurred in 1880 when, by accident, one of the generators at the Ferranti power station in Deptford got connected to the earth. This incident temporarily disrupted the entire railway telegraph system in South London, while currents flowing through the earth were observed in telegraph instruments as far away as Leicester and Paris [11].

(2.2) CROSSTALK

With the expansion of long-distance telephony in the early days of telephony, it became necessary to mount a number of single-wire, earth-return circuits on each crossarm of a telephone pole. It was then discovered that conversations from one circuit could be overheard by other circuits, hence the term 'crosstalk'. Much effort was taken to reduce or eliminate this symptom. In a paper presented in 1878 to the Physical Society in London, W. H. Preece highlighted that induction between circuits posed a significant obstacle to the practical use of the telephone. In his paper, he provided solutions to this problem, which involved avoiding the earth return and periodically reversing the position of each wire pair in the metallic circuit with respect to the first pair [25, 65], a technique known as transposition (or 'revolving'). Field cables could be twisted for the same purpose, but single-wire/earth return remained in general use by the Army. Such technology was very well published before 1900 and must have been well known by anyone involved in communications long before the beginning of World War I.

(2.3) Early practical use

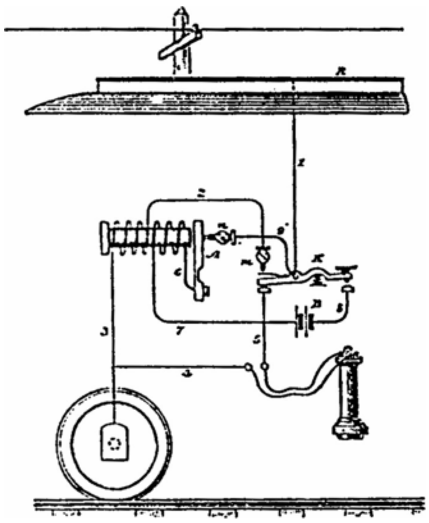
Though overhearing was considered a nuisance in line communication in the early years, it opened up a field for inventors who managed to make limited practical use of the phenomenon. Samples were earth current telegraphy, railway telegraphy and later systems based on audio and RF induction.

- Earth current telegraphy.

Communication via the earth (conduction method) was well known and used from 1846 onwards. Its practical use, however, was restricted in range and rapidly fell into disuse after the advent of radio telegraphy by the end of the century. From 1916, toward the end of static warfare, earth current communication was again successfully used by both sides [18].

- Railway telegraphy.

In 1885, Edison and Phelps developed a system (suggested in 1881 by W.W. Smith and others) that utilized existing telegraph lines running parallel to the railway track. With the assistance of induction, the inventors were able to send signals to and from moving trains simultaneously, without interfering with regular telegraph messages on the lines. This system became operational in 1886 on Staten Island, and a year later on several other lines in the USA. Although it proved to be a complete technical success, the arrangements did not garner enough use to justify their commercial success, leading to the discontinuation of the system.



A diagram illustrating the arrangements of the Edison/Phelps induction railroad telegraph is shown. When the Morse key was closed, a vibrator generated an intermittent current in the secondary circuit, running between the insulated iron-clad car roof and the earth. In the receiving position, a telephone was automatically linked between the roof and the earth. Similar apparatus was employed at stations along the line, where it was connected to the main telegraph line. [7].

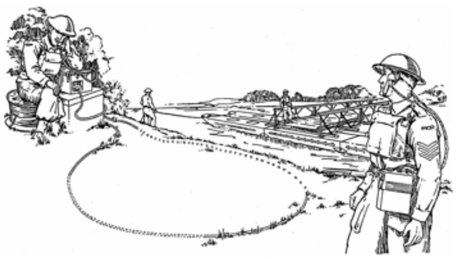
Installations working on the pure induction system, using large loops of wire with a speaking range of 1600 meters, were employed with some success in collieries [9].

(2.4) LATER APPLICATIONS.

In November 1915, a 70 km long railway line was laid from both ends, connecting Salonica to Dorain station, with a gap of 17 km in the middle. Buzzer communication was established across the gap using induction onto the existing Greek telegraph wires [33].

- Telesonic

During World War II, the Royal Engineers utilized Telesonic equipment to maintain one-way contact with dispersed working parties, especially during bridge construction. Transmission

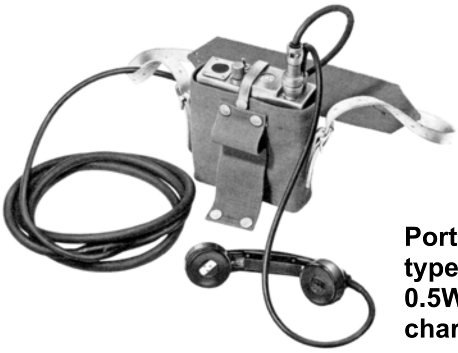


was achieved through audio frequency induction to portable receivers. Speech energy from the transmitter was transmitted via a cable loop ranging from 30 to 120 meters. Typically, six receivers were issued with one set [43, 44]. Some sources report the use of these receivers for intercepting German line communication by resistance groups.

Telesonic receiver.

- Inductorfone and Geofon

In the 1960s, AT&E developed transistorized 'Inductorfone' equipment, which found use in collieries where conventional communication methods were impractical. Inductorfone signals were induced from one circuit to another using existing metallic carriers, such as cables and pull wires. The operating frequency ranged from 95 to 155 kHz.



Portable 'Inductorphone' type TGR1. RF output 0.5W, powered by a 6V re-chargeable battery (left).

The East German 'Geofon,' manufactured by VEB Funkwerk in Dresden in the late 1950s, operated similarly to the 'Inductorphone'.

(3) INTERCEPTION

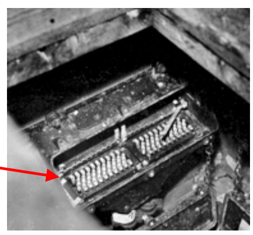
Interception (eavesdropping) of line communication was accomplished through the direct connection of the interception instrument to the line ('line-tapping') or through indirect methods, such as inductive or conductive means. The success of the second method heavily relied on the proximity of the listening set to the enemy lines. It was influenced by various other factors, including geological formations, soil conductivity, underground pipes, railway lines, streams, and wire fences. Well-insulated twisted metallic telephone circuits were resistant to interception, but they were practically impossible to maintain on the front lines. Telephone conversations over single-wire, earth return circuits could not easily be intercepted at a distance exceeding 2 km. However, for conversations induced onto other lines, longer distances were achievable. (Large numbers of disused cables were scattered around the forward area. It is recorded that, in one instance, telephone conversations intercepted by the Germans via an old line running back over 6 km were the reason for shelling expected relief troops) [17]. Buzzer and vibrator telegraphs, which operated with significantly more power, could be intercepted over distances of up to 4 km.

(3.1) LINE TAPPING

It was recorded that as early as 1862, during the American Civil War, both sides introduced line tapping.
During the American Civil War, Confederate telegraphers, attached to cavalry commands, rode at the head of every command. During raids into Union territory, they tapped every line they came across and sent out false messages and orders, thus casting suspicion upon any order that came in by the line. After finishing, all wire in sight was cut, and as much as possible was taken home.
Even a provisional 'Listening Service' was established. Much confusion was achieved by transmitting false orders and messages.

Confederate signallers, attached to cavalry commands, tapped all telegraph wires they came across.

During the South African War, the British lines were frequently tapped by the Boers. Knowing this, advantage was taken of this fact by sending false orders in clear regarding false movements of troops, later corrected by a cipher telegram.
During World War II, in South East Asia, line tapping posed a significant threat in forward areas due to the enclosed nature of the terrain and the lengthy communication lines, which made regular patrolling extremely challenging.
In 1944, it was revealed that the Germans had established clandestine connections between trunk lines without the knowledge of the French PTT. The cables were interconnected from each main cable through condensers, making it highly improbable for their existence to be uncovered through routine electrical tests [63]. These connections were only discovered many years later during repairs on a trunk cable.
Similar connections were also identified in a Dutch PTT exchange in Rotterdam, which had been made by the Germans [75].



(3.2) LINE INTERCEPTION

From World War I onwards, the focus of intelligence increasingly shifted towards intercepting both radio and line communications. The stabilization of the front line, particularly in areas where opposing armies were separated by only a few hundred meters of no man's land, created opportunities for intercepting line communications. At the beginning of World War I, all military field lines were single wire with earth return. Initially, this wasn't a significant issue. However, as static warfare began, these conditions evolved. Almost daily, complaints from telephone users who could hear each other's circuits were reported to the Signal Service [26].
Despite the widespread awareness that the use of earth return led to overhearing issues, there was initially no action taken to address this problem or to exploit the phenomenon by intentionally intercepting enemy communications.
The Germans were the first to recognize the potential and capitalized on their advantage in valve construction. The development of valve amplifiers made the well-known principles of line interception valuable for wartime purposes.
It took more than six months before a regular Allied listening service was established. During this time, the Germans reduced overhearing of their own circuits, and their signal policy called for a much more conservative use of telephones compared to the Allied side. However, the drawbacks of this policy, as experienced by the German IV Corps during the Battle of the Somme in July 1916, were reported: '... the existing telephone system proved wholly inadequate... shortages of lines had extremely adverse effects...' [57].

(3.3) 'ARENDT' STATIONS

During the winter of 1914, the Germans were concerned that secret lines might be used by the enemy to intercept communications in the occupied part of Flanders. Detachments of the German Signal Service, with the assistance of Arendt, a civilian from the German telegraph research establishment, followed the cables of civilian telephones and telegraphs. High note buzzers were connected to the lines, and search coils were used to investigate whether any lines or cables were still connected to the other side of the front line. Although the investigations were unsuccessful, they provided Arendt with the idea of using search coils for intercepting Allied telephone conversations and buzzer telegraphy. Further investigation revealed that an earth base, consisting of two well-grounded earth pins placed at least 100 meters apart, was more effective than a wire loop, but amplification of the weak signals was essential.

During the night of May 3rd and 4th, 1915, Arendt installed an experimental 4-valve line intercept amplifier connected to two earth pins in a forward trench opposite the French sector. The first intercept exceeded all expectations. In June 1915, another attempt, opposite British lines in Flanders, again resulted in the interception of much valuable information.

In 'Die F-Flagge', a German Signal Service journal, Arendt recalled in 1936: '...the stream of information was so extensive that the number of operators had to be increased... What can be said about the following telegram: A British Lt. Col. dispatched the following: 'Yesterday I marched with my men from N. to La Basse along the canal through O and P and further south via Q, R, and S, and am now in T. During this march, I lost my raincoat; please send a party to search for the coat and have it returned to me.' The telegram was signed with a complete name and regimental name and was addressed to all regiments between O and T, all in clear...' [1].

When, after five days, Arendt returned to Berlin, he left the amplifier at the front. This marked the beginning of the German Listening Service, commonly referred to as 'Arendt stations' after the originator. Precautions to prevent the men engaged in this duty from encountering other soldiers and discussing their work included additional payments and the delivery of food to them. For a brief period, they were regarded as the most exclusive branch of the service in the German army. However, when their work became known to the Allies, this treatment was discontinued, and these 'cellar detectives' were treated like the rest of their army.

In October 1915, when the first German amplifiers came off the production lines, a regular listening service was established. During specific periods arranged and set by Corps, the Germans prohibited all their telephone communication, except in urgent tactical emergencies, in order to allow their listening stations to operate without interruption from their own signals. Due to concerns about conversations being intercepted, German restrictions on the use of telephones were progressively becoming stricter, and in many sectors, significant portions of their forward telephone system were shut down.

'Moritz' stations

The 'Arendt' stations were also known as 'Moritz' stations according to articles in the German publication F-Flagge (64).

Streifzüge mit dem „Moritz".

Erlebnisse eines Abhörtrupps

von Fr. Kottmann, Hagen.

Er, der den Namen gab, hat wohl zuerst weniger daran gedacht, daß der neugetaufte Junge dem Moritz des Wilhelm Busch nachschlagen würde. Die großen Ohren hat er geerbt, hellhörig war er auch und als Lausbub von den meisten nicht gern gesehen. Der Moritz war ja auch meist auf sich angewiesen; er mußte selbst sehen, wo er etwas zu essen bekam, ein Anhängsel des jeweils in Stellung liegenden Truppenteils, der natürlich seine Leute bevorzugte. Extraportionen an Essen und Trinken oder Kontributionsgelder wurden infolgedessen leicht „vergessen".

Zudem war der Moritz auch ein unangenehmer Nachbar; er hörte alles und hatte nichts Eiligeres zu tun, als das Gehörte gleich auf dem schnellsten Wege dem A.O.K. weiterzumelden. Und was da alles herauskam! Infolgedessen regnete es bald von Dienstanweisungen über den Fernsprechverkehr. Wenn zudem einzelne Herren ihren Namen im Divisionsbefehl wiederfanden mit irgendwelchen Bemerkungen, dann war der Ärger groß!

Max and Moritz, two exasperating 'Lausbuben' were the creations of Wilhelm Busch.
His children's book: 'Eine Bubengeschichte in sieben Streichen', appeared first in print in October 1865. Busch's now classic work relates in rhyming verse with accompanying illustrations the seven mischievous pranks of two young boys and their fateful demise.
Even today, the work is well known in German-speaking countries and it holds a prominent place in the German cultural consciousness.

(A 'Lausbube' in German refers to a mischievous or naughty boy, akin to a 'rascal' or 'scamp'. It denotes playful trouble making without necessarily being negative).

Forays with 'Moritz' Experiences of an 'Abhörtruppe'. (Translation of the Fractur text above).

He, who gave the name, probably didn't initially think that the newly baptized boy would follow in the footsteps of Wilhelm Busch's Moritz. He inherited the big ears, and he was also keen-eared. As a mischievous boy, most people didn't like him. Moritz was often left to fend for himself; he had to figure out where to get something to eat. He was an appendage of the currently stationed troop unit, which naturally favoured its own people. Extra portions of food and drink or contributions were easily 'forgotten' as a result. Furthermore, Moritz was also an unpleasant neighbour; he heard everything and had nothing more urgent to do than to promptly report what he heard to the A.O.K. (Higher Army Command). And what came out of it all! Consequently, there was soon a deluge of orders about telecommunications. If, in addition, certain gentlemen found their names mentioned in the divisional order with various remarks, then the anger was great!

A German 'Arendt' station.

By the end of the war, the Germans had about 270 listening stations in use. At the entrance of an Arendt station accommodation, a printed note was attached, reading: 'No admittance, this includes officers.' This note was treated with much delight by the operators but, naturally, with disapproval by others.

After the arrival of a new regiment, the commanding officer made an inspection tour and accidentally met the chief operator of the Arendt station inspecting his earth cables.
'You are one of them?', the officer said.
'I don't understand what you mean, Herr Oberst', said the sergeant.
'I mean, do you belong to them?'
'??'
'You are one of those sneakers, spiking our cables with needles and listening to my telephone conversations'.
'Sir, we would be very pleased if we were not disturbed', replied the chief operator.
'What? My Signal Officer told me you are continuously spiking my cables. You will hear from me!' [64].

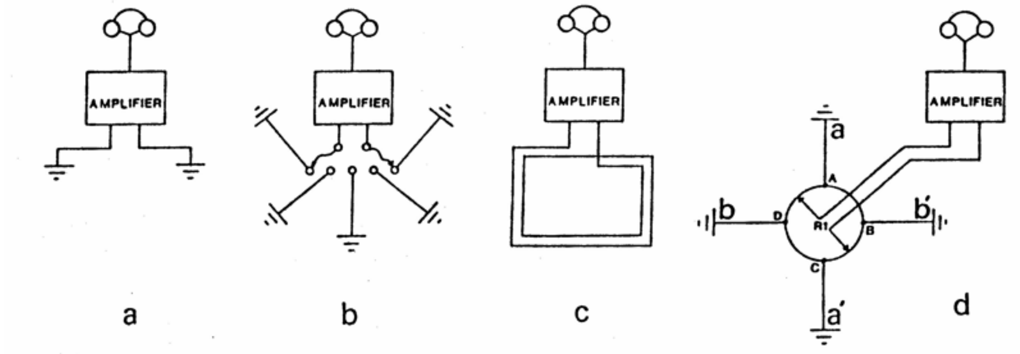
(3.4) 'it'

In August 1915, the French established an improvised listening station and received fragments of enemy conversations. French line intercept amplifiers appeared in late August 1915.
The British listening service began in January 1916, using French three-valve amplifiers borrowed from the French and installed at Vermelles, France. Three loops were installed opposite the 'Hohenzollern Redoubt' under the supervision of Lt. Col. C.J. Aston. Eight lengths of D5 cable were stapled along the trench sides, connected in series, leading to amplifiers installed in a rear dugout.
Aston later reported about his experiences: 'The stage is now set. We expect to hear German orders and reports. We hardly think of failure. Do we hear German signals? Perhaps. But we hear also our first experience of what is now known to all signal officers as the noise level. Phew! English D Mk.III buzzers *), of all pitches and notes, like a jazz orchestra gone mad. Then silence. The 8-way cable has been cut by a shell. Out goes the lineman. Now, how is this unfortunate soldier to know which of the 8 ends on one side of the break to connect to which the other ends? While he cogitates, another break!...' [2].
At that time, a significant portion of British forward communication was still in Morse. In particular, the large interception range of the high-powered vibrator and buzzer led to their abolition.*) They were gradually replaced by Fullerphones. Most of the nerve-wracking vibrator telegraphs had already been replaced with sounders at most brigade headquarters.

After some months, an organization was established, and a sufficient number of amplifiers became available. These originally came from French sources [26]. The movements and existence of the line intercept amplifiers were veiled in secrecy, and a listening set was called 'it' to accentuate this. However, some indiscreet person renamed it 'I.T.,' short for 'Intelligence Telephone' (in later years also known as 'Intercept Telephone'). The secret was then made known and broadcast! [2].
The qualifications necessary for a listening set operator included thorough familiarity with the German language and knowledge of the dialect and military expressions, but also the ability to pick out enemy signals through the jumble of other communication. (As late as the end of 1916, one of the main problems of British listening sets was the interference caused by the never-ceasing chatting on their own forward lines). At first, it was attempted to get German-speaking operators, but the quantity was limited. Then a selection was made from men who understood the German language, and they were given a course in Morse code and the use of the equipment.
Not only on the western front did the Germans establish listening stations: '… the presence of a German listening set on the Dorain (Salonica) front was a case of much annoyance. There was no doubt that it obtained much valuable information before it was possible to install a complete metallic system of circuits. Even then the leakages caused by cable rubbing on rock edges did make them by any means immune from overhearing. It took many months to impress on Staff and regimental officers the importance of this, and it was really only brought home to them when our own listening sets were installed...' [33].

*) The D Mk.III telephone and other forward telephones comprised a speech circuit and a buzzer circuit. The latter was used for calling or for working Morse telegraphy. Most buzzer telephones in the forward area were used almost exclusively for buzzing, except by the artillery. The vibrator worked on the same principle as the buzzer.

(3.5) Connecting a listening set



Typical methods of connecting up a listening set:

(a) The amplifier was connected by a pair of well-insulated wires, each not less than 200 meters in length, to a pair of ground pins. A straight line connecting these earth connections was referred to as a 'base'.

(b) In practice, however, several wires were laid out in different directions and connected to a commutator, allowing for various earth connections to be plugged in. This commonly used method was found to be best suited for intercepting conductive currents. (See page 33)

(c) Inductive currents were intercepted by connecting the amplifier to a large wire loop, preferably with several turns. These loops, generally of considerable dimensions, were laid out in trenches and, as a result, were rather vulnerable compared to the previous procedure.

(d) Direction finding by earth current. Rough bearings could theoretically be obtained by connecting the earth bases 'a,a' and 'b,b,' which were laid out at right angles, to the direction potentiometer R1.

(3.6) Uncanny power

The initial application of the listening sets was for the interception of enemy telephone, telegraph, and later in the war, earth current communication. Another significant function of the listening service was the 'policing' of own telephone lines, revealing what kind of information the enemy might obtain from their own listening sets. It was known that the Germans could intercept conversations on Allied lines. Although a perfectly balanced insulated metallic circuit could hardly be overheard, once it was broken or damaged by shelling or vehicles running over it, the possibilities of earth leakage greatly increased. In 1916, when the listening set service was established, all indiscretions were reported and action was taken against those responsible.

Of course, this policing or 'I.T. Service' was very unpopular, as Priestley explained: '… The appearance of an I.T. set was always viewed with suspicion. Definite orders backed by high authority were necessary to secure accommodation and rations for instruments and personnel. The life led by the unfortunate operators, linemen, and interpreters who manned these sets was never an enviable one. In the early days, it was made as uncomfortable as possible, both by the enemy and by our own troops....' [26].

It's worth noting that operators of German Arendt stations experienced similar challenges to the British I.T. service and were also very unpopular among their army.

During the winter of 1916, the period of their maximum efficiency, the I.T. service consisted of approximately 20 to 30 listening stations, overseen by a general headquarters officer with the title of Inspector of Listening Sets. However, the amount of sensitive information passing over the British lines decreased only very slowly. Once the arrival of an I.T. set was known, indiscretions disappeared, but they quickly recurred after their removal.

'... In September 1916, one single set heard between 30 and 40 units mentioned by name, including one Army and several Divisions. Movements of troops were referred to. Infantry operations were discussed. Whole operation orders were quoted. One unit even reported 50 casualties from own Stokes mortars, information likely to cheer the whole German Army. All this in one month, within a semicircle of 3000 meters.....'.

The I.T. sets began to take effect in the autumn of 1916, and the thoughtless use of the telephone and buzzer was significantly reduced. In March 1917, the position of Inspector of Listening Sets was discontinued, and control was transferred to Corps headquarters. The listening stations continued to be used for policing purposes until the end of static warfare. By this time, their presence was well-known throughout the British Army, and the cryptic letters 'I.T.' represented to many of its victims the outward symbol of an uncanny power... [26].

(4) COUNTERMEASURES

Effective precautions against interception included **TECHNICAL DEVICES** that were used to prevent interception:
- The use of two-wire metallic twisted lines instead of a single wire/earth return. (This reform was delayed due to a shortage of supplies. However, Army and Corps signal companies devised improvised machines for twisting cables from lorries, wheels of limbered wagons, and odds and ends. They twisted thousands of kilometres of cables before any supplies arrived from home).
- The exclusive use of the British Fullerphone and German Utel in front trench lines [76].
- In order to avoid induction to old circuits, efforts were made to clear up the mess of disused cables. Trenches leading forward were deepened to locate these cables buried in the mud. Complete isolation was established between the forward and rear telephone networks.

Screening Buzzers

Less successful was the use of powerful 'screening buzzers' (or, as we would say today, 'jamming buzzers') connected to earth bases. Their intended purpose was to drown out all signals. However, complaints were received from irate commanders who could hear nothing on their telephones except a buzz. The German Signal service received similar complaints after conducting comparable experiments. A conclusion can be drawn that their only practical use was for detecting and tracing apparent leaky lines.

Successful technical measures against line interception in World War II included, in addition to twisted two-wire lines, the use of the British Fullerphone and the German Sutel, the teleprinter, and the telewriter (Feldfernschreiber). In telephony, the scrambler or 'Privacy Equipment No 1' (This equipment essentially comprised a speech inverter).

Tactical measures that prevented the transmission of potentially dangerous messages included the following:
- The establishment of a 'danger zone' spanning 500 meters, within which the use of single wire/earth return lines was prohibited. Soon after realizing the extensive capabilities of listening sets, this zone was expanded to 1500 meters and eventually to 3000 meters.
- Orders and circulars were issued to everyone using a telephone, emphasizing the risks of eavesdropping. Disciplinary action was taken if these orders were disregarded, and restrictions on the use of the buzzer and telephone were strictly enforced [53].
- Policing stations (I.T. and Ahrendt) were established to intercept their own communications. Their primary purpose was to report any indiscretions.
- Measures were taken to prevent the enemy from reaping any advantage from intercepted messages. This involved using coded signs, names, and words, increasing the use of ciphers, and maintaining strict telephone discipline. It was strictly prohibited to transmit unit names, relief times, and unit movements, as well as details regarding the results of artillery fire and the locations of guns.

[S.S. 103.] O.B./630.

ORDERS

regarding the sending of Messages within 1,500 yards of the firing line.

1. Messages sent by buzzer on any circuit which has an "earth" within 1,500 yards of our front trenches, are liable to be overheard by the enemy.

2. As a circuit, even if metallic, may be earthed, either through damage to the conductors by shell fire or other causes, it is necessary to ensure that as far as possible messages transmitted shall not give information of value to the enemy.

3. No written message is to be sent by buzzer from or to any office in the zone 1,500 yards from the front line trenches without the sanction of an officer who must sign the message as being authorized for transmission within the dangerous zone.

4. Every station working buzzer in the dangerous zone is to be given a station call which will *not* be the recognised signal call of the unit. These calls will be allotted by Divisions.

5. Names of units are not to be "buzzed" in any messages. Only the code names of units as laid down and published by Corps and Divisions should be used.

6. The buzzer operators are to be forbidden to send any messages other than those authorized, or to converse on the circuit about any matter unconnected with the maintenance and working of the circuits.

7. The foregoing instructions are to be understood as applicable to normal conditions. In cases of emergency, discretion must be exercised as to whether the importance of getting the message through justifies the risk of its being intercepted. It may even be permissible, where a metallic circuit fails, to get transmission by earthing the circuit, but such action will greatly increase the risk of interception.

8. Speech on telephones can only be intercepted at about half the distance of buzzer signals, and the dangerous zone is that within 900 yards of the front line trenches. In or to the dangerous zone, speech between officers is to be preferred to buzzing written messages, and the precautions indicated in paras. 4 and 5 apply equally to conversations.

9. The message transmitted from a station say five miles from the front trenches to a station in the danger zone, is as likely to be intercepted as the message originating in the dangerous zone.

General Headquarters,
April, 1916.

STATIONERY SERVICES PRESS A. 4/16. S82. 5,000.

'S.S. 103': Carefully crafted orders and circulars, emphasizing the risk of eavesdropping, were produced. These were distributed to all individuals in possession of a telephone [26].

Other measures included deliberate attempts to deceive the enemy, such as calculated indiscretions and transmitting false orders and conversations through intentionally leaky lines. Remarkably, both the Germans and the Allies had to contend with nearly identical problems: many officers could not grasp that part of their troubles and a significant proportion of casualties in their units resulted from their own indiscreet use of forward telephones. It was only after disciplinary action was taken that telephones were used with a degree of caution. Even more remarkably, this occurred on both sides of the front line, with practically identical precautions being independently implemented. By 1917, the situation had significantly improved, and from then on, important communications were only occasionally intercepted [13, 22].

(5) LINE INTELLIGENCE AFTER WORLD WAR I

After World War I, the terms 'listening' sets/services/stations disappeared and were replaced by 'intercept' sets/stations/services. The Germans renamed their 'Arendt' stations/service to 'Lauschdienst.'

Between World Wars I and II, line communication security did not diminish in importance. For example, in July 1940, the Army Training Memorandum issued warnings about the danger of line interception, with special emphasis on the statement that '… the buzzer of any field telephone is the most dangerous form of telegraph instrument. Fullerphone is the only safe instrument for use in the front lines. In static warfare, all D MkV telephones were typically withdrawn and replaced by Fullerphones...' [59].

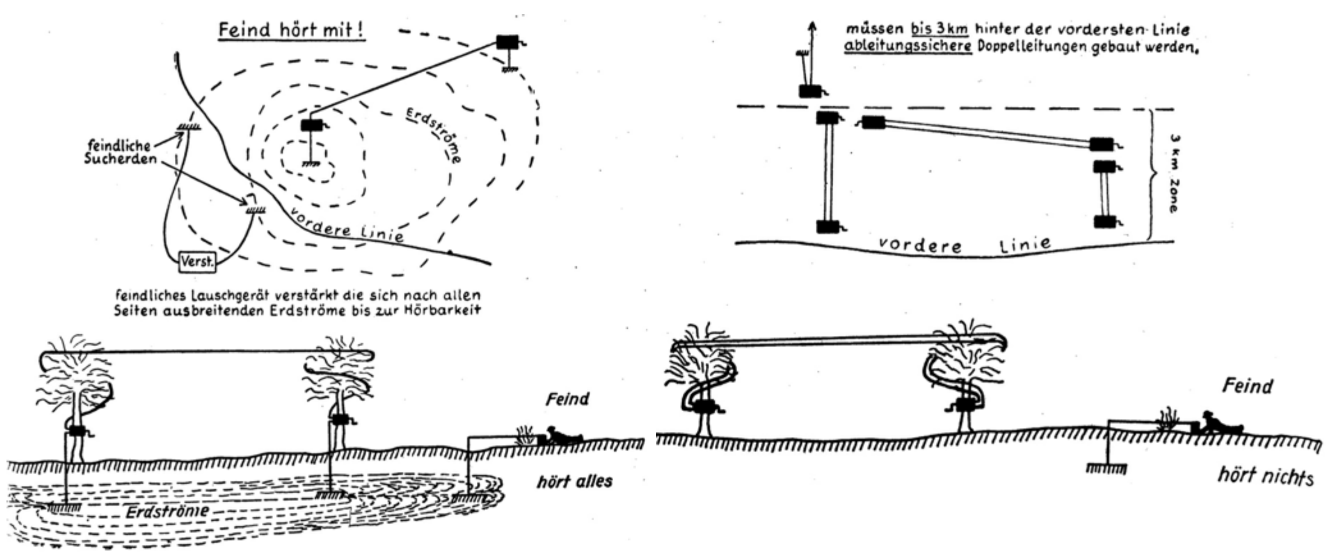
In the Russian 'Red Army Signals Journal' from October 1944, it was revealed that the Germans had been laying buried cables in front of the defensive line for the purpose of intercepting line communications. Consequently, they drew the following conclusions:

'...in the chain of communications from division to regiment, battalion, and company, the telephone lines must have a metallic circuit, and a line must not be laid closer than 500 meters to a road…'

In South East Asia, the Japanese system of line communication on permanent lines was notably primitive. Exchanges were nonexistent, and multiple subscribers shared a single route on the single-wire earth return circuits. In numerous cases, Allied forward troops intercepted these lines simply by 'teeing in' (connecting the intercept set, typically a standard field telephone, between the line and the earth). Field security interpreters occasionally reported a complete lack of security [63].

(5.1) LAUSCHDIENST

German line interception ('Lauschdienst') was chiefly practiced at the Russian front. In 1942/44, during static and semi-static warfare in various parts of Russia, much valuable information was obtained by intercepting Soviet earth return field telephone conversations [14, 15]. In many cases, Russian private telephone conversations and discussions of planned raids formed the basis for very successful countermeasures. In one case, it was even possible to interfere with the telephone net. Attempts were made by means of interpreters to persuade the Russians to surrender. Such actions were especially successful because many Russian lines consisted of single wire and earth return. In defence, the German line interception sections furnished indications that helped forewarn their division of coming Russian activities. Many German Army line and telephone companies had special six-men sections (two interpreters and four line mechanics) assigned to the interception of enemy telephone lines.



Two drawings taken from an illustrated German handbook: 'Nachrichten Fibel (Na. Fi.) Für Fernsprech und Blinktechnik' (Manual for the Communication Troops). [73].
The illustrations emphasised the dangers of single wire/earth return (left) compared with a twisted pair (right).

(6) CONCLUSIONS

At an early stage of World War I, it became evident that the use of single-wire earth return circuits resulted in overhearing issues. In 'Notes on Field Telephone Working', published in June 1915, remarks were made regarding overhearing: '… lines laid close alongside one another for any distance 'induce' the signals and ... interfere with the good working. Therefore, lines must be kept well separated....' [50]. Primitive experiments with overhearing in the French First Army area in June and July 1915 proved that speech could be overheard at a distance of 100 meters and that buzzer signals could be detected at least three times that distance.

But well before World War I, 'Instruction in Army Telegraphy and Telephony' [49] taught that: '… vibrator circuits interfere seriously with telephone circuits, unless these are carefully constructed metallic circuits, properly revolved...' and the conclusion was drawn that '… earth returns are not suitable for telephone work … but can be used for short distances, well away from other circuits, and often so used for military work in the field where a metallic circuit would require more time and material than is available...'.

The earlier history of the telephone, going back to its inception, demonstrates a clear understanding of overhearing, or crosstalk, and the technical methods for preventing it. However, it soon became evident that the most effective countermeasures did not involve technical improvements to the lines or instruments but rather the strict enforcement of line security.

Therefore, one may wonder why it took so long before energetic measures were taken to prevent overhearing and halt indiscreet conversations. It has been documented that in 1916, a year after the establishment of the German interception service, more interceptions occurred than in 1915.

According to Priestley, the answer could be: '… Perhaps the pressure of work, caused by the unexpected increase in the demand for line communication, diverted attention temporarily from the serious risks of overhearing and interference between wires using earth returns....' [26].

An important factor was the scarcity of cable; single-wire, earth return circuits conserved cable, and almost no supplies of twisted cable were available. Another aspect was that before World War I, and indeed for quite some years afterward, the telephone was not in very widespread use. The majority of officers were non-technical, and to them, it was simply unbelievable that the enemy could easily pick up their voices over considerable distances.

Despite repeated warnings, many telephone users were careless and naive. Officers in the forward area, preoccupied with matters of life and death, often failed to recognize the danger of using plain language and neglected to follow the orders and instructions that seemed like unimportant details to them. '... One example of the trouble in overcoming the overhearing menace, even when it was fully realized, is seen in the equivocal position of the divisional signal officer… he was continually obliged to make complaints to senior officers. The latter, too often, only recognized him as a regimental officer and not a representative of the staff. Battalion commanders frequently took no notice whatever of his advice…' [26].

In March 1917, following a combined Staff and Signal conference, S.S.148 (soon followed by S.S.191), the first Staff publication entirely dedicated to intercommunication problems, was printed and definitively recognized the Signal Service as a collaborator of the General Staff.

Fascinating are the parallel developments, carried out individually and independently by both opponents during virtually the same period.

Evaluating the efficiency of listening sets versus the efforts of personnel and equipment costs was not a difficult task. British listening stations achieved significant results and, even more importantly, compelled the enemy to discontinue much of their forward telephone communication. This effect persisted after the end of 1916 when telephones were used with greater caution, and virtually no important messages were intercepted. With the second use of listening sets for monitoring (policing) their own communication, most of the careless talk eventually ceased.

(7) Posters 'Der Feind hört mit!'

'Der Feind hört mit! Vorsicht am fernsprecher'

('The enemy listen too. Take care on the phone').

The Germans distributed posters as part of tactical countermeasures to maintain secrecy, possibly indicating the effectiveness of British listening sets. By the end of World War I, when British troops captured German trenches, they discovered sealed enemy telephones. Captured orders revealed that these phones were only to be used in the most dire emergencies. The officer who broke the seal was instructed to submit a written report detailing the nature of the emergency. As far back as 3 kilometres from the front, German telephones were found to be sealed.

A selection of German posters which warned about the risks of telephone overhearing.

Russian, Israeli (on the left), Romanian, and Italian posters emphasized the risk of eavesdropping on telephone lines, all conveying a message in a similar vein:

Il nemico vi ascolta. Tacete! (The enemy is listening to you. Be silent!) Dusmanul asculta (The enemy listens.)

'Indiscretions REPERCUSSIONS' Somewhat different in style from the German WW I posters, this British WW II poster conveyed concerns about the ever-present risk of eavesdropping on telephone conversations (left).

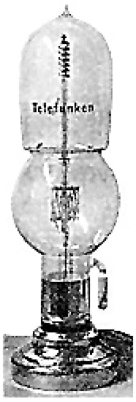
This poster, 'Telephone communication - Unsafe', was distributed in the Dutch Army in the early 1990s (right).

A postwar British poster (exact year of publication unknown (left).

Appendix 1.1: German amplifiers

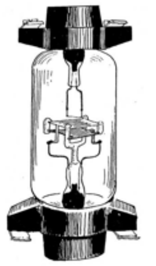
Early German valves and amplifiers.

Before 1914, Von Lieben valves, also known as LRS Relay, were employed on a modest scale in Reichspost telephone repeaters. Following the outbreak of the war, urgent military demands necessitated their use in telephone connections between battle areas and headquarters. As the LRS Relay valve proved unsatisfactory due to its temperature sensitivity and challenges in large-scale production, a decision was made to shift towards developing a high-vacuum type of valve. This decision led to the introduction of several valves, including the AEG-Telefunken Type EVN 94, one of the first introduced in mid-1914, and the electrically quite similar Type A and Mc valves developed and manufactured by Siemens & Halske. Originally designed for use in telephone repeaters, these valves were later incorporated into audio amplifiers for wireless receivers, listening stations, and earth current signalling from late 1915 onward. These valves featured a very rigid construction, resulting in minimal microphonics. However, their gain was insufficient for oscillation, and they performed poorly as detectors. After the discovery of the possibility of intercepting telephone lines through induction or conduction by Otto Ahrendt, the use of amplifiers in listening stations and, slightly later, in earth current signalling gained prominence. A small selection of early German (telephone repeater) amplifiers is showcased on this page. It was after capturing samples of the 'French' valve that the Germans reproduced valves with similar characteristics, such as the Telefunken EVE 173 [12, 28, 30].



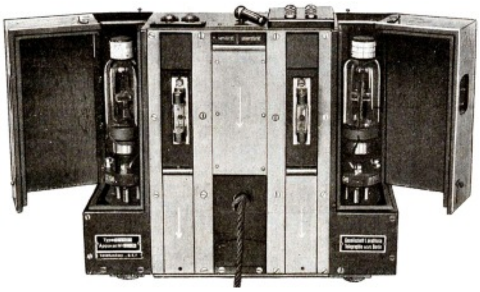
LRS Relay

Telefunken EVN 94



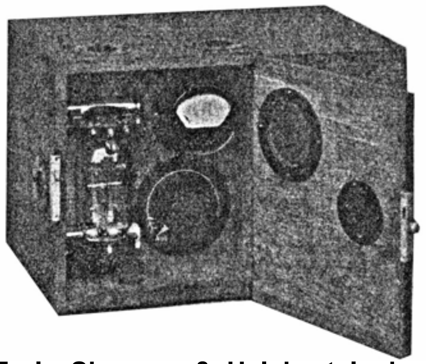
S&H Type A

Early German valves were sturdy, built with blade contacts on the base end mountings.



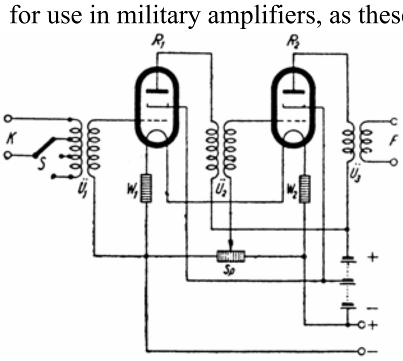
Telefunken EV 89 amplifier with two EVN 94 valves. This was an early model with barretters, hydrogen-filled glass bulbs in which an iron wire was located. These functioned as resistors with constant current characteristics, maintaining a consistent current over a specific range amid varying voltage for the fragile filaments.

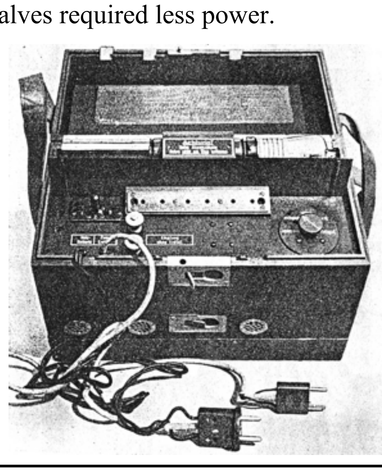
German listening station: The maker and type of both amplifiers could not be identified. Additionally, one might question whether a listening station was ever deployed in the open air.



Early Siemens & Halske telephone repeater with a single Type Mc valve.

Developed in late WW I for earth current signalling and believed to have been used for listening stations, this German amplifier featured two Siemens Scottky Type SS I space charge valves. These types of valves were designed to operate at low voltages and worked on the principle of accelerating electrons towards a weakly charged plate. This made them more efficient and ideal for use in military amplifiers, as these valves required less power.



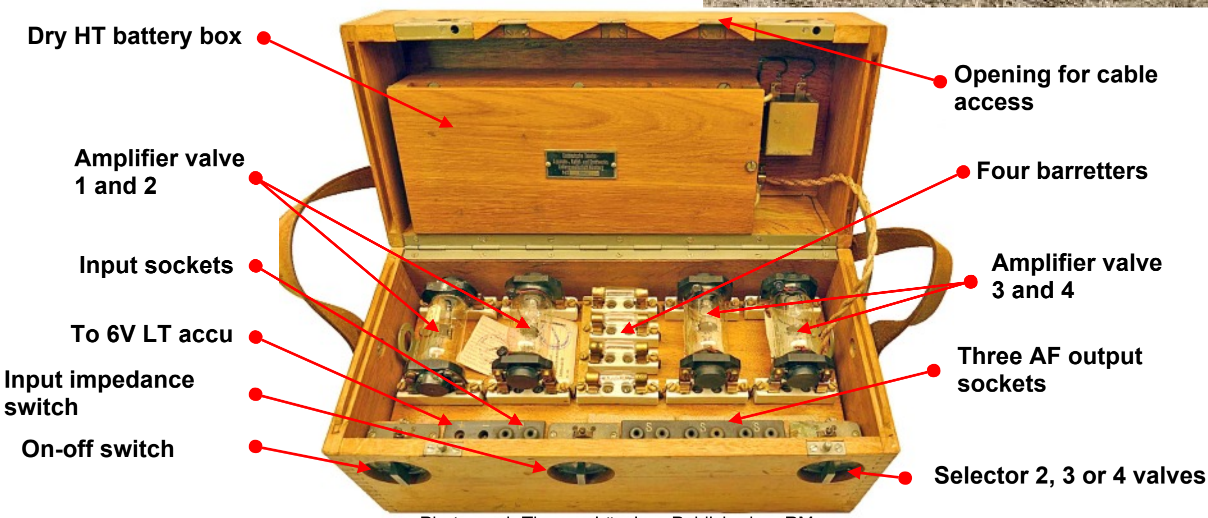


Amplifier and circuit diagram with two Siemens & Halske Type SS I space charge valves.

A later produced telephone repeater amplifier type Prls 13 with two S&H type Mc valves.

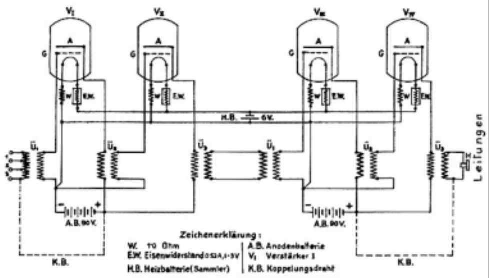
Appendix 1.2: German amplifiers

On the cut-out of a WW I German soldiers' group photograph, was shown an amplifier used for earth current signalling and as a listening set. As far as could be traced, this amplifier appeared to be a version produced by various makers, for example TKD, as shown below.
It should be noted that most of these amplifiers were also used with earth current telegraphy, called Etel, short for Erd Telegraph. English= Earth Current Telegraph; French= Télégraphie par Sol (T.P.S.).



Photograph Thomas Lüscher, Published on RM.org.

Audio amplifier made by Süddeutsche Telefon Apparate-, Kabel-, und Drahtwerke A.G. (TKD). Valve # 2, 3 and 4 were TKD type T1. Valve #1 (located at the left hand side), Siemens type A, was possibly a later replacement.



Simplified circuit diagram of the four valve TKD amplifier above, drawn without switches etc.

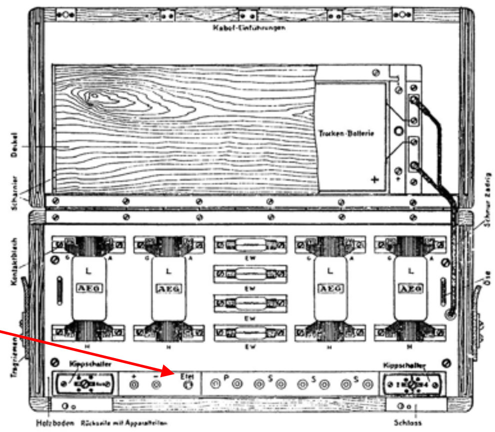
Very similar probably later version four valve amplifier type KF4, manufactured by AEG Telefunken using type K1 and K3 valves (right).

Photograph Götz Linss †, Published on

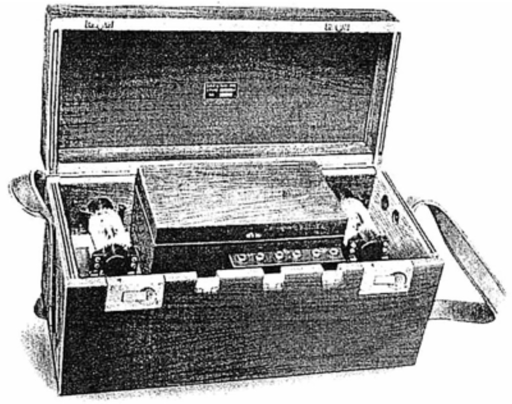
A comparable model was produced by Telefunken using later EVN171 valves to make the amplifier smaller. It had no internal HT battery and before closing the lid, the valves must be removed (above).

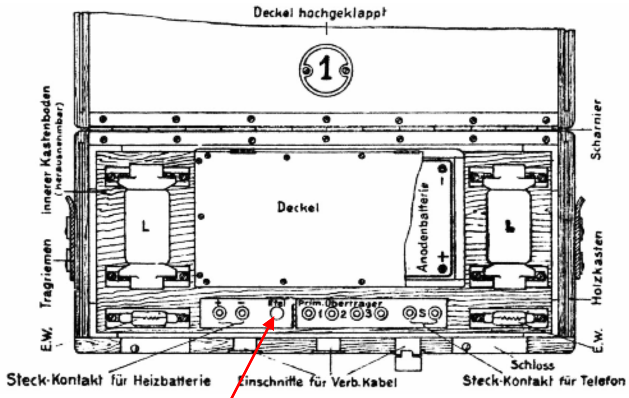
Four valve amplifier made by Radio Apparate Geselschaft mBH with four type Siemens A valves.

Drawing of a similar amplifier made by AEG Telefunken.
Note the socket for connecting an Etel, forming a complete earth current signalling station.

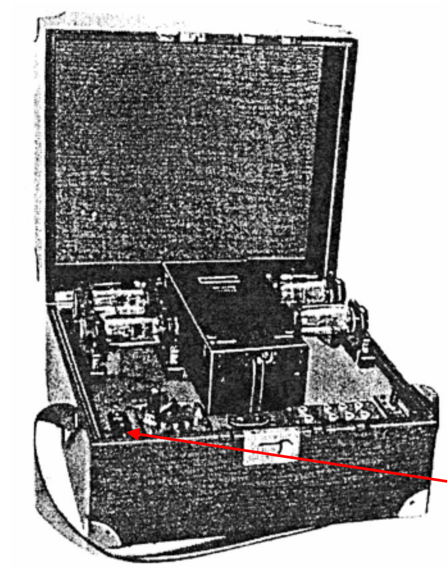


Appendix 1.3: German amplifiers

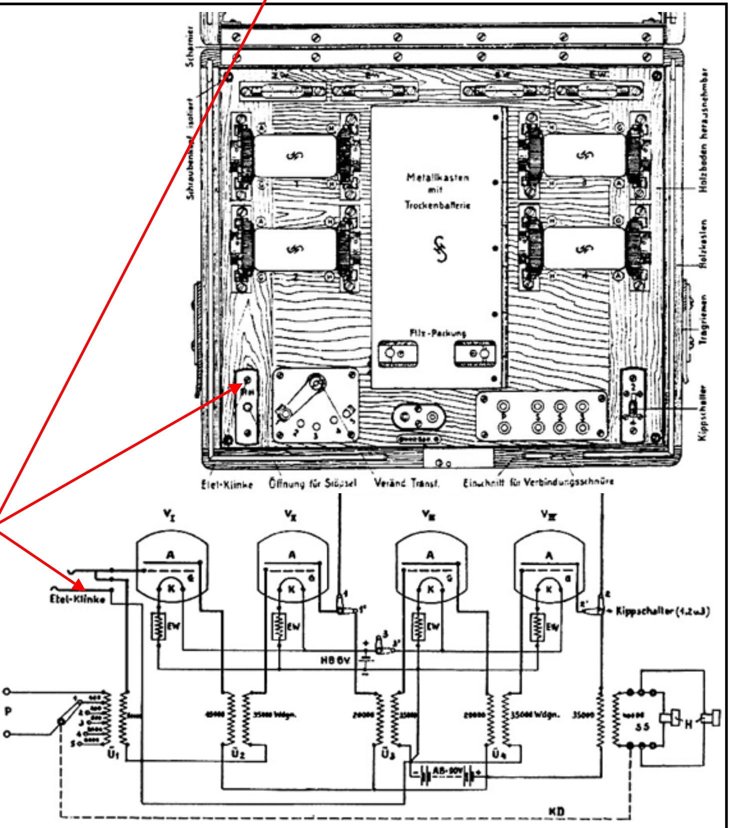




AEG Telefunken type KF2 two valve amplifier, a simplified light weight model without external switches, but still an internal HT battery and socket for connecting an 'Etel' transmitter. It used two type K3 valves.



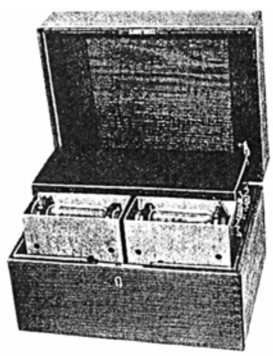
'Etel' socket.



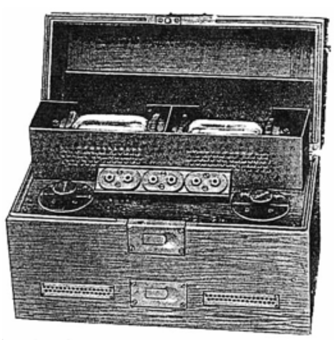
This Siemens & Halske four valve amplifier was electrically quite similar to the AEG/Telefunken and TKD amplifiers, but differed considerably in construction. It had no external switches and could be used with either two or four valves. An 'Etel' socket allowed the amplifier to be connected to an earth current transmitter and using its earth base.

Circuit diagram Siemens & Halske four valve amplifier.

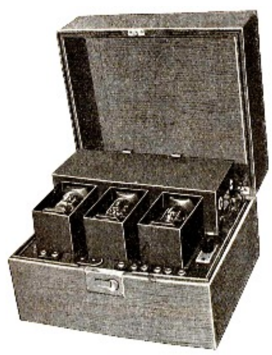
A single-valve amplifier from Siemens & Halske, featuring a type MC valve, lacked an internal HT battery and an input impedance switch. It was probably not used as a listening set



Two valve amplifier Siemens&Halske, with two dual grid (space charge) valves. Early model with internal HT battery in metal box.



Two valve amplifier made by Siemens & Halske, with two dual grid (space charge) valves. This was a later model.



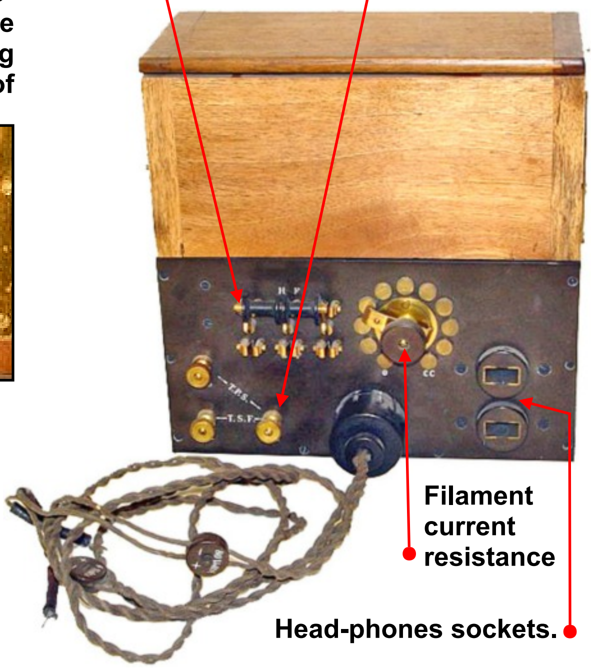
Three valve amplifier Siemens&Halske with possibly three type TKD T1 valves. It had an internal HT battery.

Appendix 2.1: French amplifiers

Amplificateur 3ter

Inset of an enlarged detail showing part of two white rubber bands that supported a mounting plate for the valves, reducing the microphonic effect of the valves.

French 'Amplificateur 3ter' with the hinged top and front door open, revealing the three TM valves.



'Amplificateur 3ter' with both hinged access doors closed. Please note the special power cable and plug connecting the LT and HT power sources (above).

The Amplificateur 3ter can be considered the model predominantly used in the French army during World War I as a listing amplifier. (The name '3ter' can be translated into English as 3 Mk.III). It also found extensive use in earth current signalling reception and served as a detector and audio amplifier for wireless receivers or tuners. It was equipped with three TM (Telegraphie Militaire) valves, powered by an external 45V HT dry battery and a 4V accumulator for the filaments, connected by a 4-point cable. Two rubber bands attached to both side panels supported a floating paxolin plate that held the three TM valves. This design was incorporated because the TM valves were notoriously microphonic (see inset above). Two electrically identical versions were observed: one fitted in a wooden box with hinged top and front access doors for field use, and a desk model without valve protection for use in, for example, an office or a sheltered location.

There were two pairs of input terminals: High impedance terminals L1 and L2 were marked T.S.F. (Telegraphie Sans Fil = wireless telegraphy) for connecting the detected AF output from a receiver, with the system switch set to B.F. (Basse Fréquence = Audio Frequency). In the case of a tuner or receiver without a detector, this switch should have been set to H.F. (Haute Fréquence = High frequency).

The low impedance terminals L3 and L2, marked T.P.S. (Telegraphie Par Sol = Earth Current Telegraph) with the system switch set to BF, were intended for earth current signalling reception or as a listening set, connected to an earth base. This earth base usually had an impedance of 100-500 ohms, depending largely on the length and nature of the soil and sub-strata. On a loop, as was sometimes used with listening sets, the impedance was even lower.

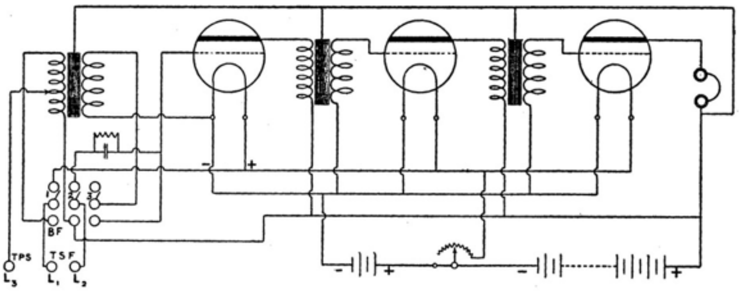
The text on the plate attached to the inside of the top access door translates into English: *When used with a galena detector, connected to terminals L1 and L2, determine the connections that provided the best amplification and prevented whistling. The galena should be located on the side of L1.*

When the American Expeditionary Force (A.E.F.) arrived in France, they initially used French communication equipment, including 3ter amplifiers, until USA-produced SCR-72 equipment became available. Please refer to Appendix 5.1 and 5.2 for information on the American BC-17 and BC-44 amplifiers.

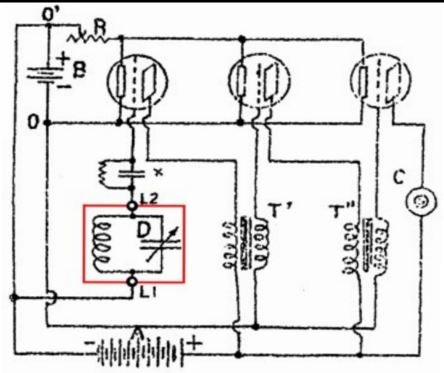
'Amplificateur 3ter' desk model.

Top view of desk model 3ter amplifier.

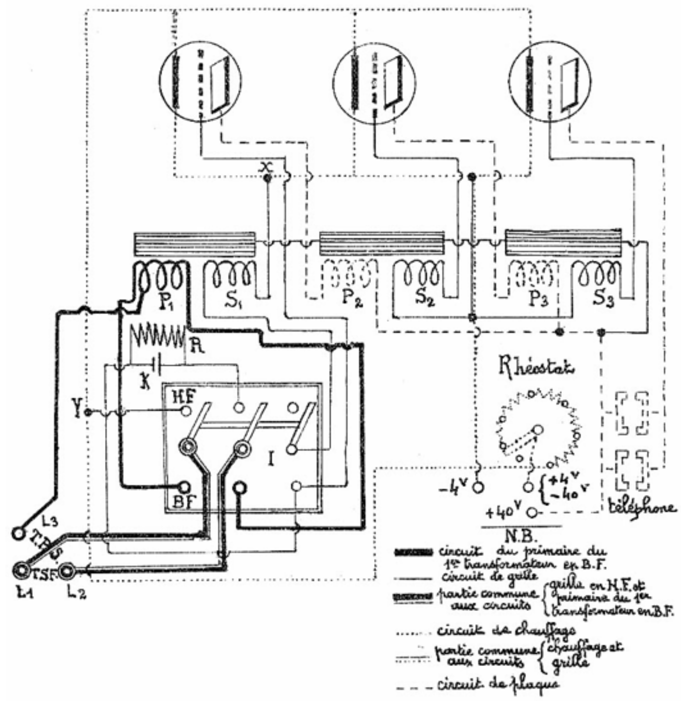
Appendix 2.2: French amplifiers



Circuit diagram of the French 'Amplificateur 3ter'.

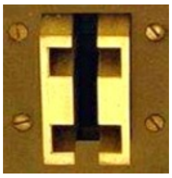


A simplified 3-ter circuit diagram was drawn in the situation where it was connected to a receiver or tuner without a detector to terminals L1 and L2, with the system switch in the HF position.



This more practical circuit diagram of the 'Amplificateur 3ter came from the user instruction book.

Nearly all French military wireless receivers and amplifiers of the WW I era were fitted with a rather unique and innovative headphone plug and socket, which replaced the awkward screw terminals. Several versions of these sockets were observed.



Cut-out from a group photo with a 3ter amplifier connected to a wireless receiver (left).

Similar French amplifiers.

Shown below are two models of similar French amplifiers used for overhearing, earth current signaling, and as detectors/audio amplifiers for wireless receivers. Both Model A 2ter and Model A 4 had similar functionality.

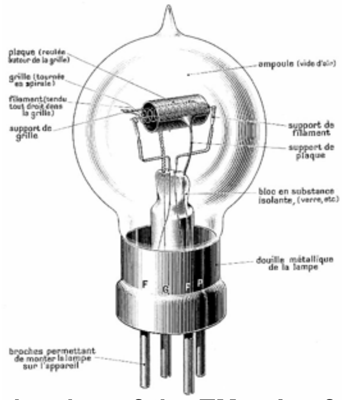
Amplificateur Model A 2ter was the predecessor of Model 3 and 3ter (with the hinged top access door closed).

Model 2ter (left) had three TM valves, with each valve having a separate filament current resistance. Headphones could be connected to either stage of amplification. It is believed that the 4-position switch at the bottom left switched the input impedance.

The later-issued Model A 4 (right) used four TM valves and was principally similar to the 3ter. Several improvements were made in the circuit, such as connecting the headphones to the secondary of the AF output transformer.

The Amplificateur Model A 4 was principally similar to the 3ter but had minor improvements.

Appendix 3: The French 'TM' valve



A drawing of the TM valve from the patent that was taken by Peri and Biguet.

Close-up internal view of the French TM valve.

Photograph of a TM valve, which was produced by multiple manufacturers.

Development of the French valve TM ('Télégraphie Militaire').

Paul Pichon, a former French army deserter from 1900, worked in Germany as a French professor and tutor for Count von Arco's children, who was a founder of the Telefunken Company. Telefunken hired him as a technical representative, and by 1912, he had become the chief of the patent service. In 1914, on the day when Germany declared war on France, Pichon, who had been in the United States, arrived in England and sought advice from Godfrey Isaacs, the managing director of Marconi's Wireless Telegraph Company. Despite being a Frenchman, Isaacs advised Pichon to return to France, where he was promptly arrested for desertion upon arrival. He claimed to have brought valuable information for Commandant Ferrié, whom he knew as a representative of Telefunken. The authorities contacted Ferrié, who ordered Pichon to bring his equipment and documents. Pichon demonstrated a three-electrode valve, explaining its benefits. Ferrié enlisted Pichon, sent the valve to Lyon physicists for analysis, and arranged mass production at E.C.&A. Grammont, known for their trademark 'Fotos'.

As expected, the initial configuration proved to be unreliable and unstable. Through trial and error, Abraham and Peri managed to devise a simpler and more cost-effective setup. Their fourth prototype, which featured a vertically oriented electrode assembly, was selected for mass production. However, it failed the field service test, resulting in many tubes being damaged during transportation. Ferrié instructed Peri to address this issue, and within two days, Peri and Jacques Biguet introduced a modified design. This new configuration featured a horizontally positioned electrode assembly and introduced the innovative four-pin Type A socket. In November 1915, the revamped triode went into production and came to be known as the TM, named after the French service that pioneered its development.

High demand led to a shortage of valves at Grammont, which prompted the involvement of the Compagnie Générale des Lampes in Ivry. They manufactured valves labeled TM 'Métal', while Grammont continued with TM 'Fotos'. These valves featured minor structural variations.

There is little doubt that the TM valve was a breakthrough in valve technology and was the base of further development.

Production of the of the French TM valve in England.

The British Thomson-Houston Co. (B.T.H.) studied the French TM-type valve, which led to the creation of the R-type valve in 1916, subsequently adopted by other British manufacturers. This valve had several versions, with early models being exact copies of the French TM tube but still exhibiting microphonics. Later versions featured a grid with a stiff wire suspension, which reduced microphonic noise when used in AF amplifiers. The base and outer shell closely resembled the French TM tube, with variations in materials and pin inserts. The R valve found widespread use in numerous applications. Other valves based on the French TM, with the same bulb, were developed and produced in England for the Army and RAF, including the A, B, and B2 transmitter valves. The 'R horned' valves were constructed with the anode and grid leads passing through the sides of the bulb, reducing the grid-filament capacity by 50% *[36]*.

The French horned valve (left) was also manufactured in England, shown right which was probably an early production version.

'Grande et Petite Histoire de la Lampe TM'.

A comprehensive historical study concerning the TM valve was published under the above title by Robert Champeix in the 'La Liaison Des Transmission' magazine, issue number 126, in November-December 1980 as a special 48-page booklet within the magazine. This document, written in the French language, was made available online for free download in digitised form.

- https://archive.org/details/GrandeEtPetiteHistoireDeLaLampeTm

Appendix 4.1: British amplifiers

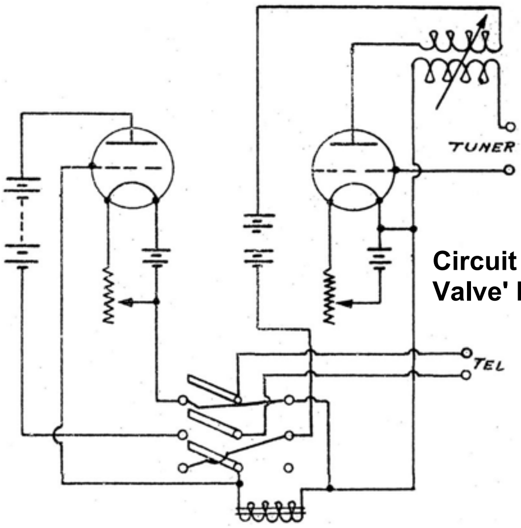
Although they were never used or even suitable for overhearing purposes, there was consideration of including amplifiers for use as detectors and AF amplifiers in wireless receivers or tuners without a detector. These were the 'Amplifier Valve' Mk.I to Mk.III** and Amplifier 'A' Mk.IV. The Amplifiers 'C' Mk.I to 'C' Mk.III were primarily developed for overhearing, serving as audio amplifiers for receivers and for earth current signalling. In early 1918, the Amplifier 'C' Mk.IV was issued, which was a general-purpose AF amplifier with the additional possibility of being used as a detector/amplifier, combining the functions of the 'A' Mk.IV and 'C' Mk.III. These amplifiers used French TM or British R valves. Almost all British amplifiers were designed by the Signals Experimental Establishment and manufactured by War Office factories. Other amplifiers included:

- Four-valve 'Amplifier Detector LF,' which was resistance-coupled, quite an unusual approach for those days, of which only 20 were produced.
- 'Amplifier Line Leak' (see page 22) was a two R or TM valve amplifier, designed for direct tapping on lines.

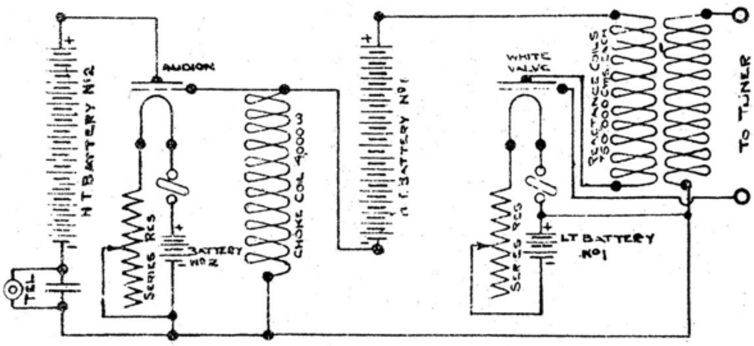
'Amplifier Valve' Mk.I to Mk.III**.

The 'Amplifier Valve' Mk.I to Mk.III were used on a very small scale in late 1915. These amplifiers were exclusively utilized with wireless tuners, serving as regenerative detectors and AF amplifiers, particularly with Tuner Short Wave Mk.1 to Mk.III, and possibly Tuner Long Wave. Three models are documented: Mk.I and Mk.II were equipped with a single White valve each, while Mk.III featured both a White valve and a DeForest audion. Mk.III had two electrically identical variations, with the later Mk.III** lacking a switch to disconnect the audion valve. With the introduction of the TM and R valves, it was eventually replaced by the Amplifier 'A' Mk.IV and later the Amplifier 'C' Mk.IV.

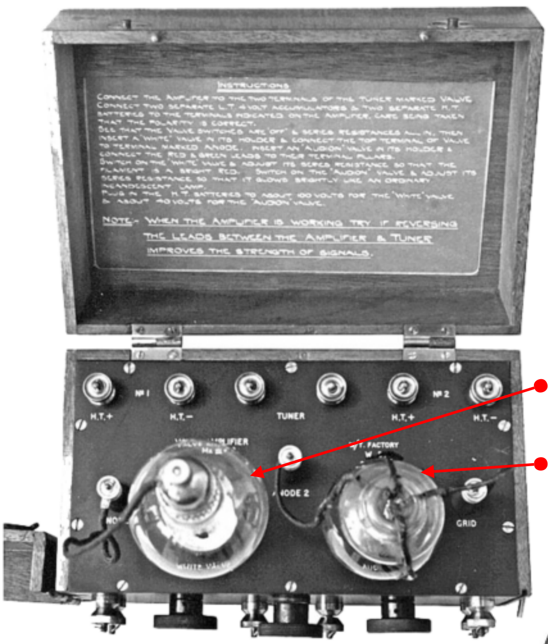
The 'Amplifier Valve' Mk.III* had a switch for selecting between one or two valves (right).



Circuit diagram 'Amplifier Valve' Mk.III*



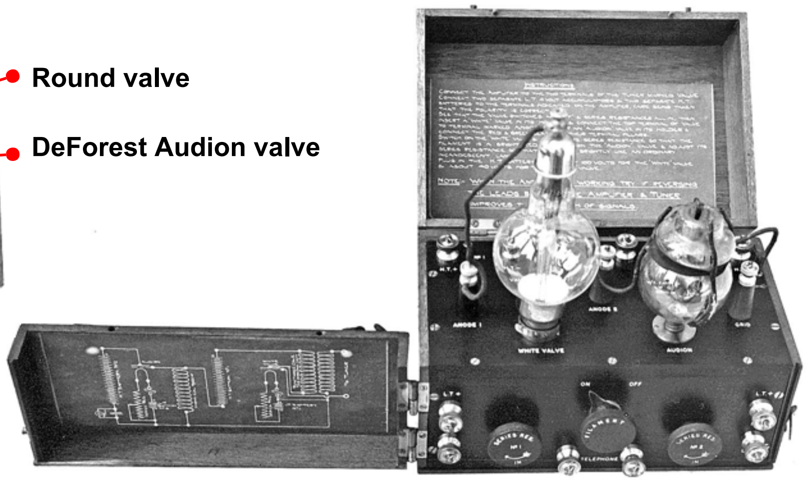
Circuit diagram 'Amplifier Valve' Mk.III**



Round valve

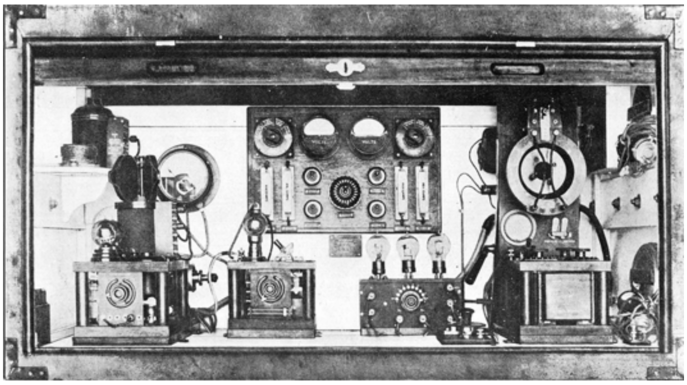
DeForest Audion valve

The 'Amplifier Valve' Mk.III was built to be more compact and electrically almost identical to the Mk.III* (shown above and to the right).**

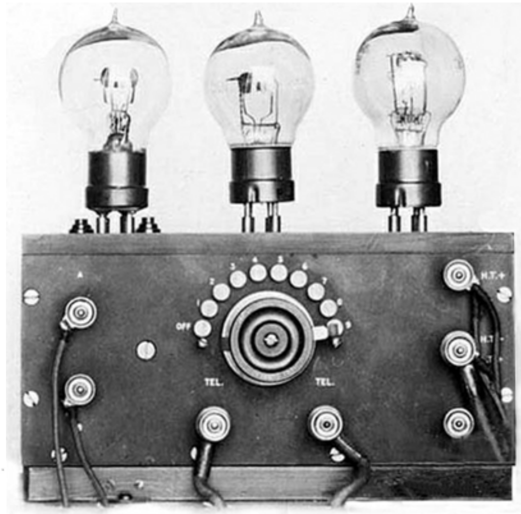


Appendix 4.2: British amplifiers

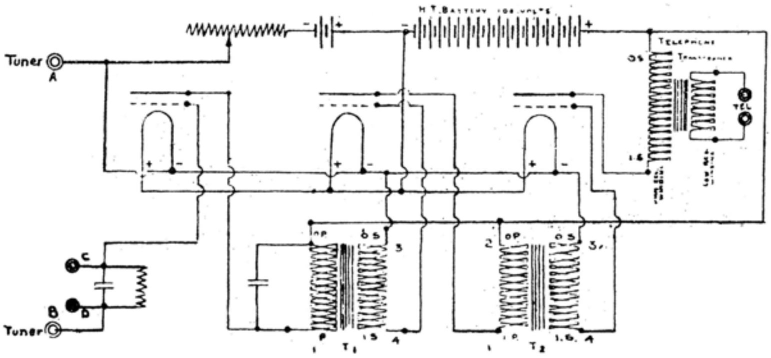
Amplifier 'A' Mk.IV.



Amplifier 'A' Mk.IV, part of a W/T Set Field 120W CW Mk.I.



Amplifier 'A' Mk.IV replaced the 'Amplifier Valve' series of detector/AF amplifiers using three type R valves (above).

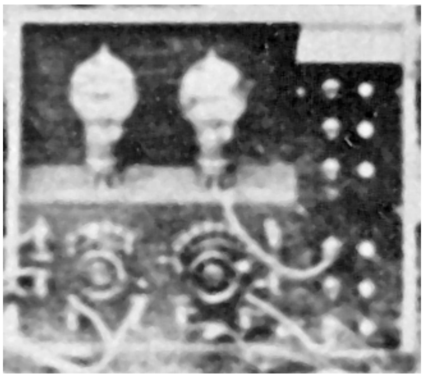


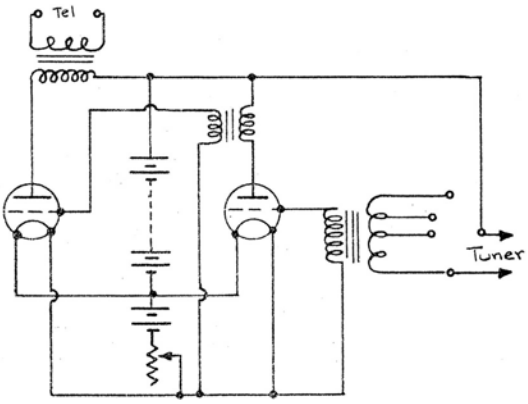
Circuit diagram Amplifier 'A' Mk.IV

Amplifiers 'C' Mk.I & Mk.II.

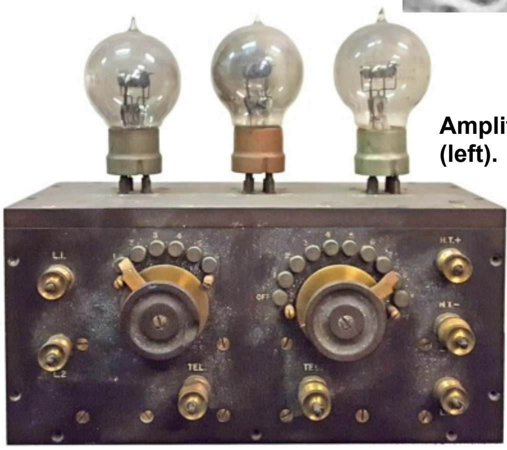
Amplifier 'C' Mk. I was the first British audio amplifier designed for overhearing line communication. Introduced in 1916, it used two French TM valves or British equivalent type R (In one reference type A valve is also noted). Amplifier 'C' Mk.II was similar but used three valves. The 'C' range of amplifiers were also used as AF amplifiers for wireless receivers and as part of earth current signalling stations also known as T.P.S. (Telegraphy Par Sol) as this system was initially devised by the French army and particularly used for communication in mobile warfare. The main visual difference from an 'A' amplifier was a switch on the front panel with impedance taps.

Detail photo of an Amplifier 'C' Mk.I (right). Note the HT batteries and a separate LT accumulator. (A French TM or R valve draw a LT current of 0.67A at 4V).

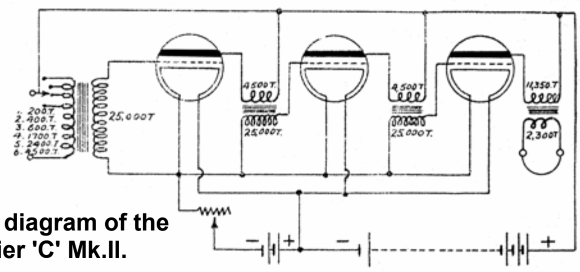




Circuit diagram of the Amplifier 'C' Mk.I.



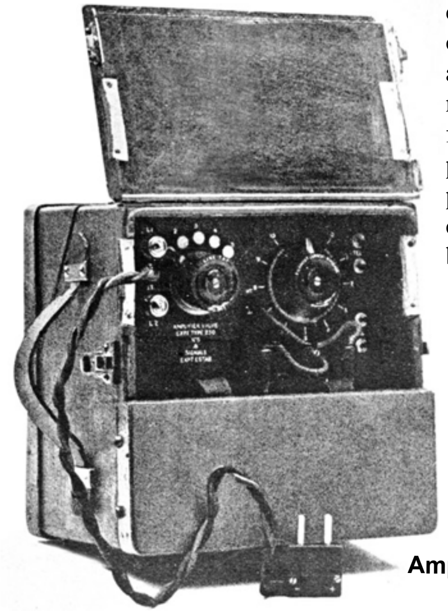
Amplifier 'C' Mk.II (left).



Circuit diagram of the Amplifier 'C' Mk.II.

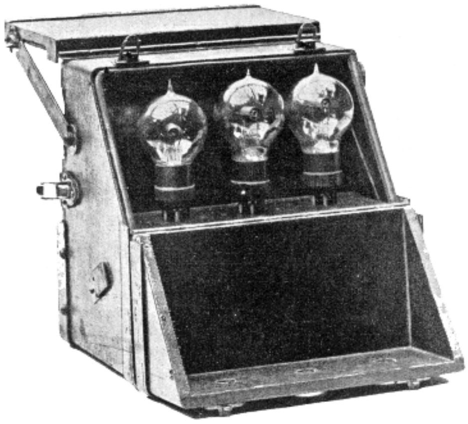
Appendix 4.3: British amplifiers

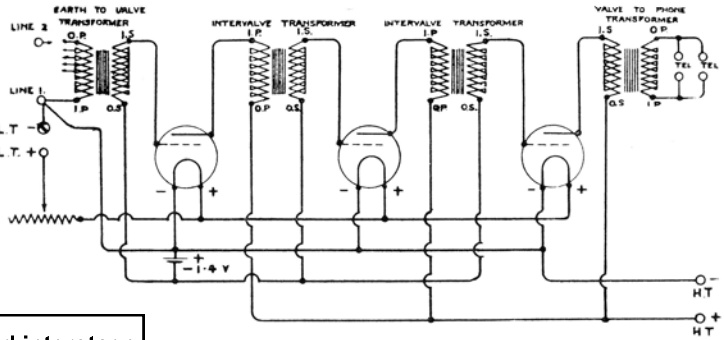
Amplifiers 'C' Mk.III & Mk.IV.



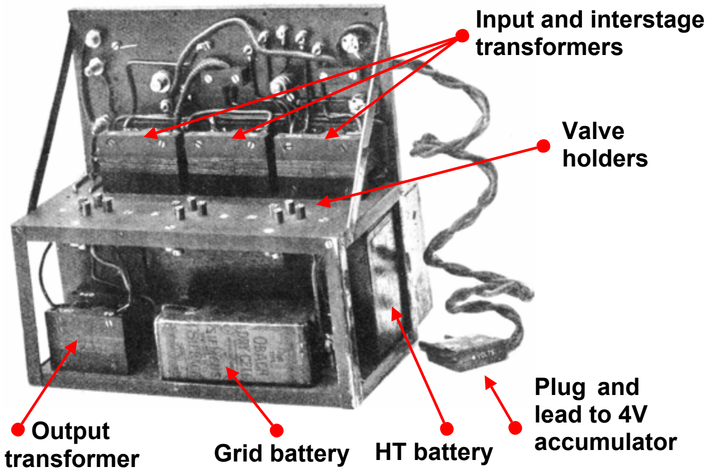
Amplifie 'C' Mk.III.

Amplifiers 'C' Mk.III and 'C' Mk.IV were quite similar, except that the 'C' Mk.IV combined the functions of Amplifiers 'A' and 'C.' They represented an improvement over Amplifiers 'C' Mk.I and II, featuring an application of negative grid potential and being housed in a waterproof case made of thin wood with a canvas cover. The HT batteries and grid battery were fitted inside this case.





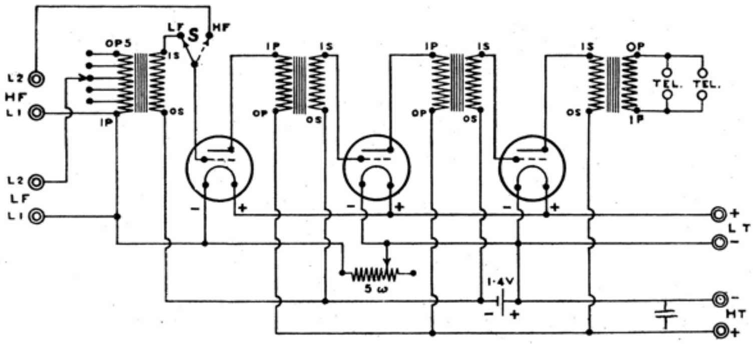
Circuit diagram Amplifier 'C' Mk.III (above).



An internal view of an Amplifier 'C' Mk.III (and a very similar Amplifier 'C' Mk.IV) removed from its case, without valves, revealing the main components.

Amplifier 'C' Mk.IV (right).

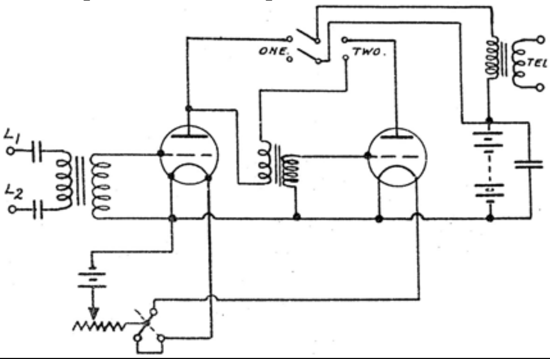
Besides their use as AF amplifiers for overhearing or earth current signalling, the 'C' Mk.IV and 'C' Mk.IV* could also serve as detectors in a receiver or tuner when switched to HF. It's worth noting that a small negative potential was applied to the valves' grids, drawn from a 1½ V dry cell, which reduced the HT current without affecting efficiency.



Circuit diagram Amplifier 'C' Mk.IV.

Amplifier Line Leak.

The 'Amplifier Line Leak' was a two-valve amplifier, potentially designed for direct line tapping to facilitate overhearing and inspection of faulty lines. It was possible to use one or two valves by connecting the output transformer to the anode of either the first or the second valve. Unfortunately, there are no available illustrations, and it is not believed that this amplifier saw widespread use.



Appendix 5.1: USA amplifiers

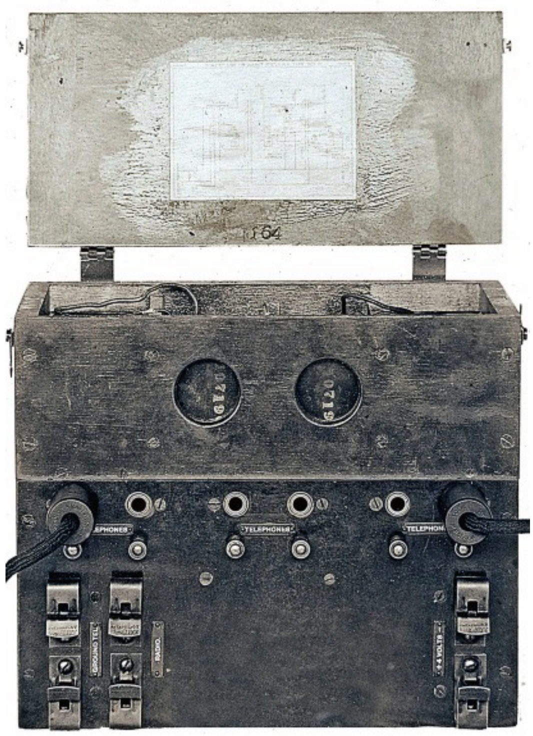
Type VT 1 valve.

The American Expeditionary Force (A.E.F.) in France initially utilized French amplifiers, notably the type 3-ter, among others. These amplifiers served the purposes of overhearing their own and enemy telephone conversations, monitoring enemy earth current telegraphy (often referred to as T.P.S., French 'Telegraphie par Sol'), and amplifying audio signals from a wireless receiver. In 1918, the A.E.F. introduced amplifiers developed and produced in the USA: the type SCR-72 and the type SCR-72-B. The design of the type SCR-72-A, which shared electrical similarities with the type SCR-72-B, was abandoned and replaced with the waterproof and lighter type SCR-72-B. All these amplifiers featured Type VT 1 valves.

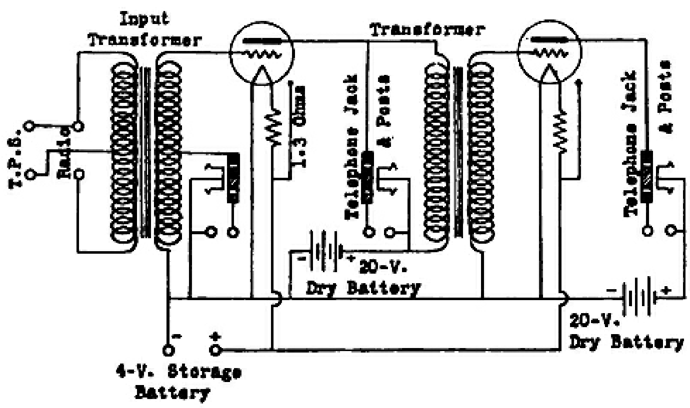
SCR-72.

The SCR-72 was a portable amplifier primarily employed for receiving earth current signals and also played a role in wireless stations. Development began at Western Electric Co in mid-1917 after a 3-valve French 3ter amplifier became available, indicating the general requirements. The American amplifier featured 2 valves and provided roughly the same amplification as the French amplifier. The detector feature found on the French 3ter was removed. In October 1917, samples were sent to France, and reports from the American Expeditionary Force indicated that they were quieter but also provided less amplification than the French amplifier using the best type of French TM valves. The set was redesigned, and reports in 1918 indicated that the production version's performance was either equal to or even superior to the French 3ter when handling low-level signals.

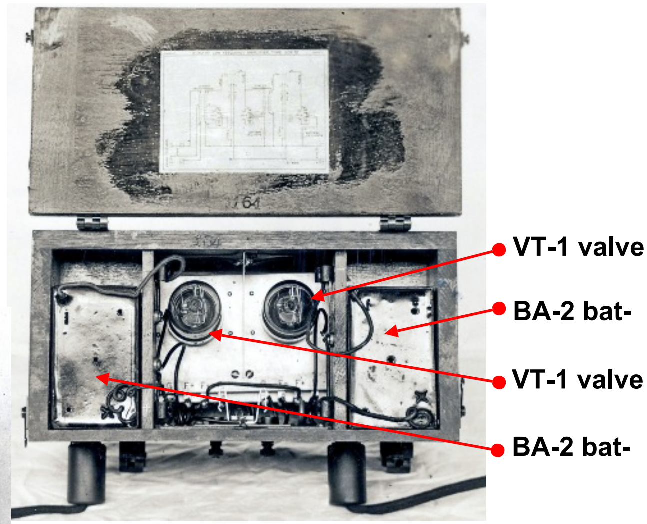
The SCR-72 consisted of a separate amplifier unit, known as type BC-17, which was housed in a wooden case of type CS-2. It was powered by two BA-2, 22½V HT batteries carried inside the amplifier, and received 4V LT from an external accumulator. The input transformer had two taps: a low-impedance option for earth current telegraphy and overhearing, while a second high-impedance tap was used for connecting a wireless receiver. The amplifier featured two type VT-1 valves that were transformer-coupled [46].



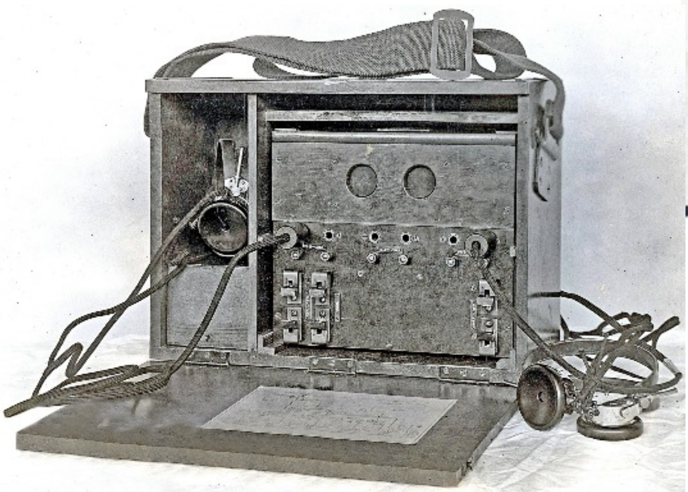
BC-17 amplifier, part of a SCR-72.



Circuit diagram of a BC-17 amplifier.



Top view of a BC-17 amplifier with the hinged lid opened, showing the VT-1 valves and two BA-2 HT batteries.

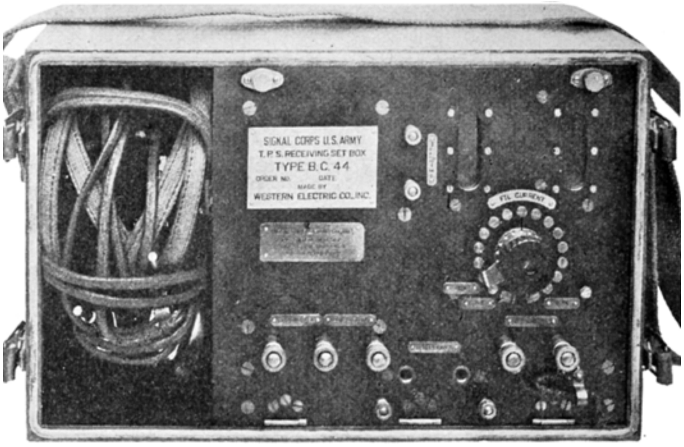


The BC-17 amplifier, fitted in case CS-2, formed the main part of SCR-72 (left). Note the two round windows on top of the front panel, which allowed the observation of the glow of the valves when in operation.

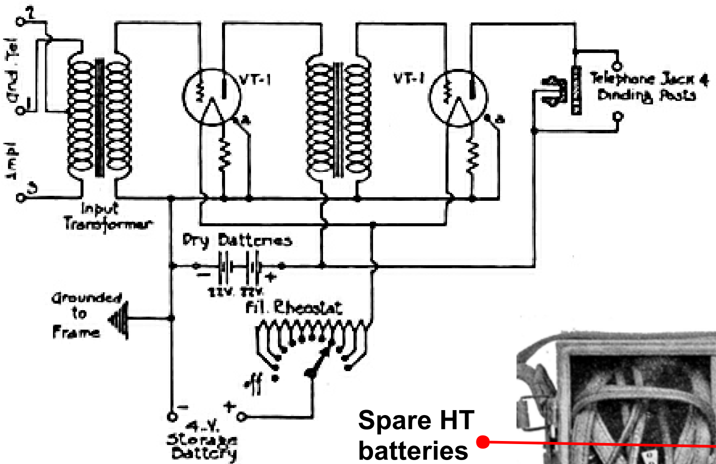
Appendix 5.2: USA amplifiers

SCR-72-B.

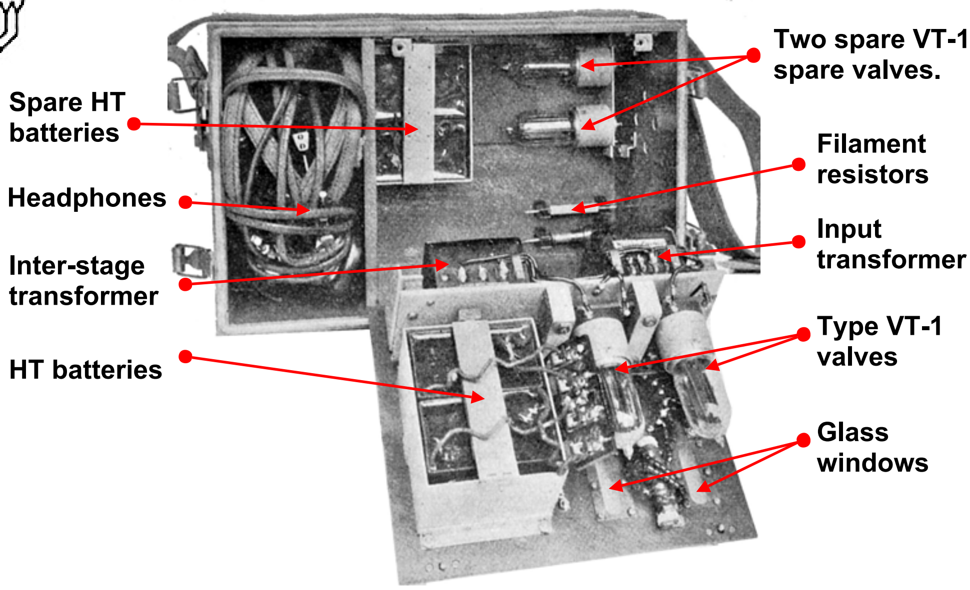
Because the SCR-72 was neither waterproof nor compact and lightweight, a redesign was initiated, resulting in the creation of the SCR-72A. However, this new version still proved to be too heavy, which led to another round of redesigns while maintaining the SCR-72A amplifier circuit Type BC-44. The SCR-72B, considerably lighter, underwent field trials in France in September 1918. Following the successful trials, authorisation for production was granted.
The set consisted of the Amplifier Type BC-44 (known as the T.P.S. Receiving Set Box), which housed two Type P-11 headphones, four Type BA-2 batteries (including two spares), and four Type VT-1 valves (two spares). A complete SCR-72B included a BC-44, three BB-14, 4V-100Ah batteries, stakes, wire on a reel, tools, and other accessories.



The BC-44 was a self-contained amplifier in a waterproof case with a cover that closed on rubber gaskets. Two headphones were carried inside a compartment of the case. Glass windows on the front panel allowed the observation of the glow of the valves when in operation. The front panel was hinged on the bottom side and could be lifted down, allowing access for changing valves or the dry HT batteries. Although primarily developed for earth current signalling, two different inputs were provided: low impedance for earth current and overhearing, and high impedance input for connecting a wireless receiver [46].



The circuit diagram of the BC-44 amplifier differed considerably from that of the early BC-17 amplifier. The two 22.5V dry HT batteries were connected in series to form a 45V battery. A variable resistor was used to adjust the filament voltage.



The BC-44 amplifier with the front panel opened, revealing the main components.

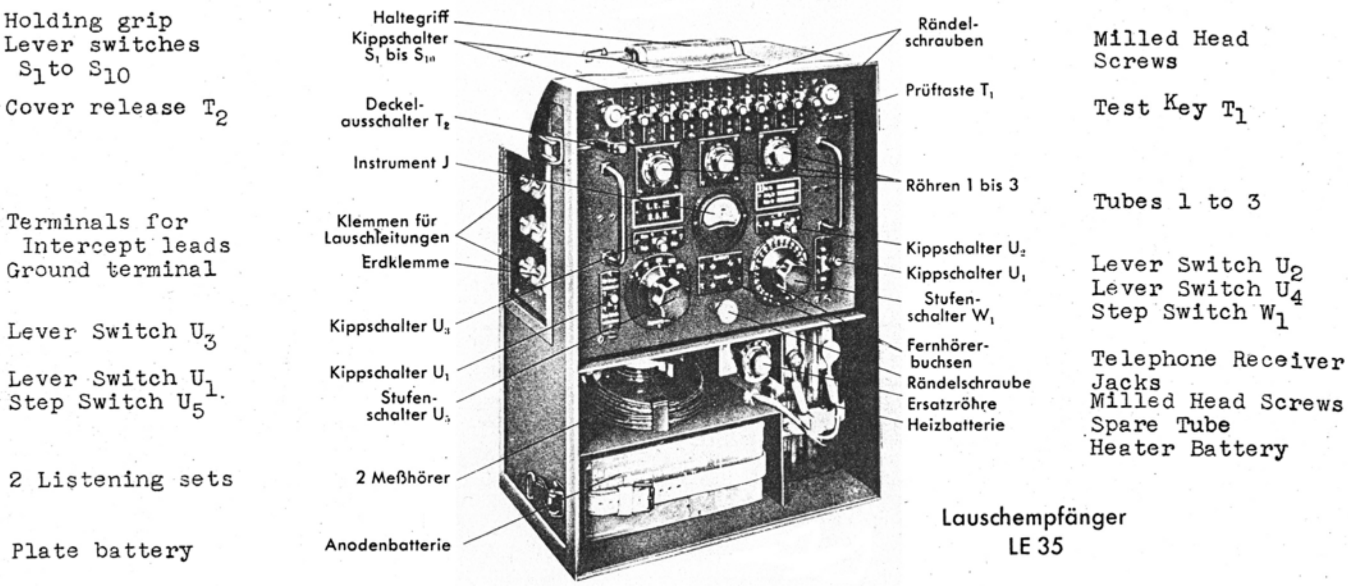
SCR-76 and SCR-76A.

The SCR-76 and its lightweight version, SCR-76A, combined an earth current signalling power buzzer (SCR-71) and an amplifier (SCR-72) for two-way earth current signalling operation. Although it incorporated an AF amplifier, it was not suitable for use in overhearing purposes. Its functionality will be covered in WftW Pamphlet 11.

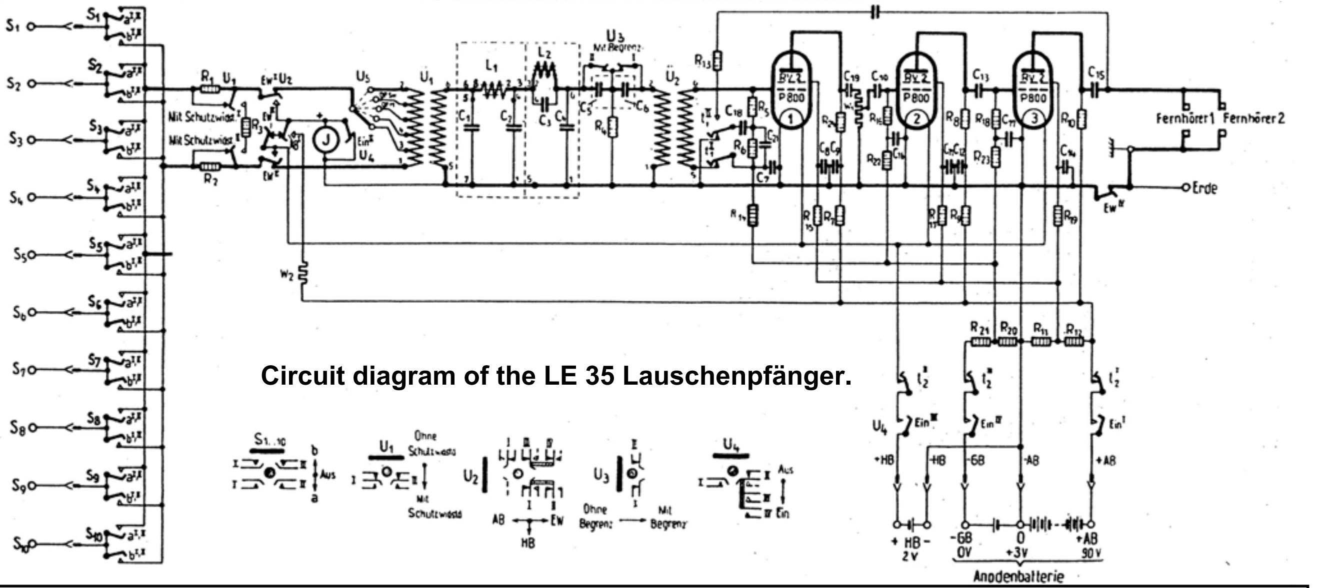
Appendix 6.1: German amplifiers of WW II

Lauschempfänger LE 35.

During World War II, the Germans used several models of line interception equipment. Around 1938, they fielded the LE 35 (Lauschempfänger Model 35). It was originally designed for receiving power buzzers or other earth current communications, and it was exclusively used for telephone line interception. It could pick up earth currents between an earth base or perform induction tapping using a wire loop. The gain of this 3-valve amplifier was nearly 75 dB, with a low-pass filter incorporated into the input circuit. Note that this amplifier incorporated a commutator with 10 lever switches.



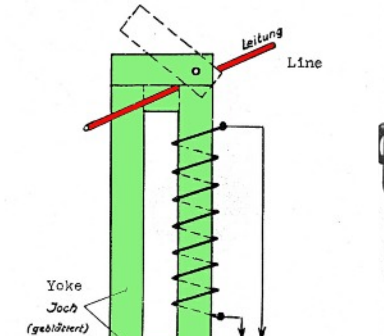
Lauschempfänger
LE 35



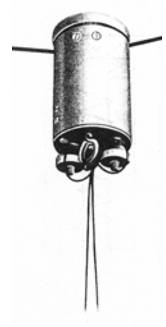
Circuit diagram of the LE 35 Lauschenpfänger.

Lauschzange LZ 35.

This German line intercept transformer, known as 'Lauschzange 35,' functioned similarly to the British 'Transformer I.T.' (see page 28) based on the principle of a current transformer. These transformers were employed when there was a need to tap lines without alerting the users. The weight of this unit was considerable at 500 g.



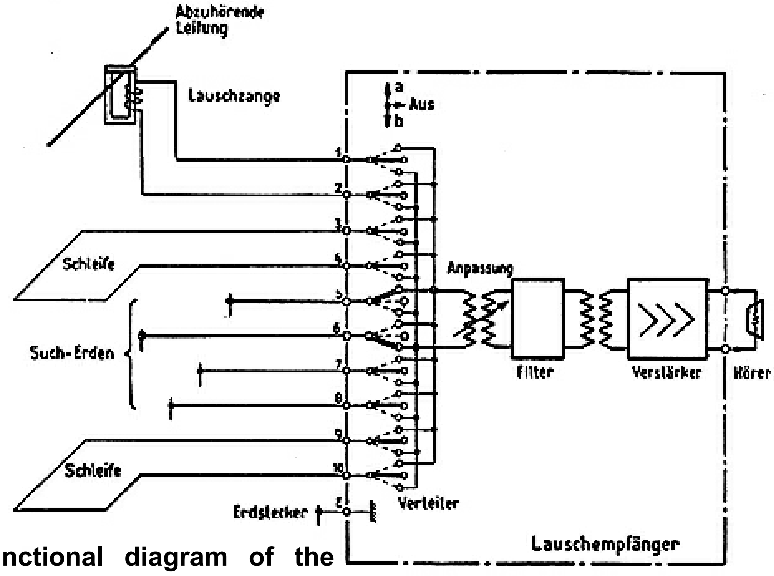
Functional drawing of the Lauschzange LZ 35.



Using a Drahtgabel ('Wire fork') normaly used to raise a field wire during construction, a Lauschzange was attached to an overhead line.

Appendix 6.2: German amplifiers of WW II

Lauschempfänger LE 40.



Functional diagram of the LE35 and LE40 line intercept amplifiers illustrating their connections to various applications by means of the 'Verteiler' (Commutator lever switches).

The Lauschempfänger Model 40 (Line Intercept Amplifier LE 40) was evidently a redesigned version of the previous LE 35. An important feature of this amplifier was the inclusion of an additional low-pass filter to attenuate the harmonics of 50 Hz power circuits, along with a band-pass filter. Both the LE 35 and LE 40 had the provision for intercepting several lines, enabling the monitoring of any required line. The use of a Lauschzange LZ 35 allowed the interception of a line without establishing a direct connection or laying a loop. The complete weight of an LE 40 was 36½ kg.

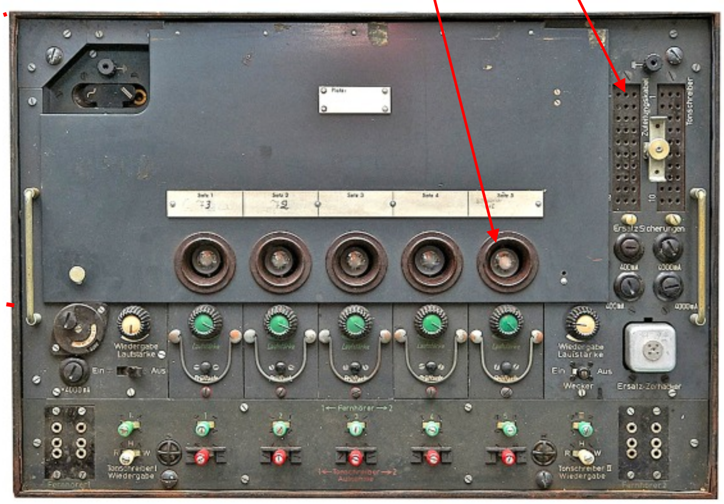
Early version LE 40 (1940).

Verstärker 41.

The Verstärker 41 (Amplifier 41) was an audio amplifier used for simultaneously overhearing up to five telephone lines and recording the intercepted audio. It is not believed that this amplifier was developed to eavesdrop on enemy lines but was primarily used to monitor the telephone lines of civilians and high-ranking German officers. Only a small quantity of the Amplifier 41 was produced, and just a few examples have survived. The amplifier could be powered by AC mains or 12V DC.

The telephone lines were connected via the multi-way socket at the top right to five removable interface modules. The controls were normally covered, apart from the magic eye valves.

The control panel of the Verstärker 41, as seen here with its protective cover plate detached, allowed access to individual controls for the volume and brightness of the magic eye on each of the 5 lines. It also provided access to the type EBF11 metal-cased valves. At the top left of the panel, there was an AC/OFF/DC changeover switch with input sockets, and on the panel below, there was a 12V vibrator and rectifier valve.

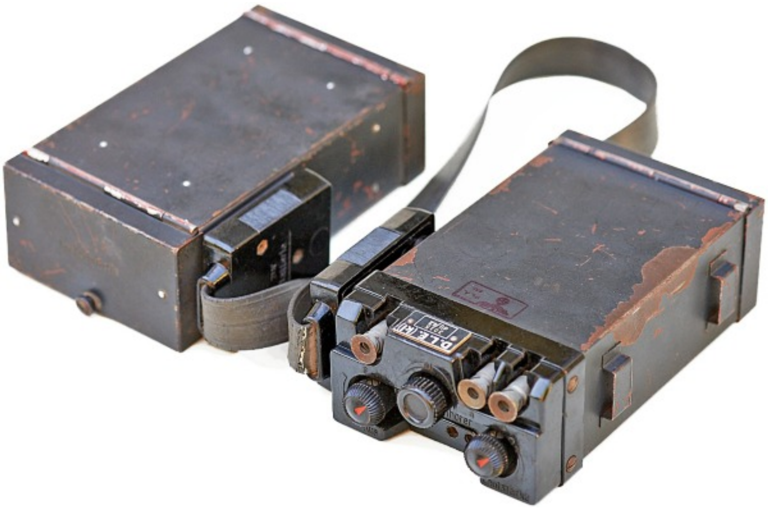


Front panel view of Verstärker 41.

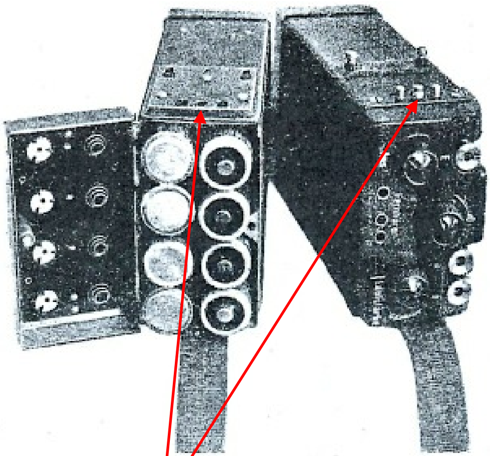
Appendix 6.3: German amplifiers of WW II

Kleine Drahtlauschempfänger DLE (kl).

The portable German line intercept amplifier set model DLE (kl), Drahtlauschempfänger (Klein) (Small Line Interception Receiver), well-suited for field use, became available in 1941. This instrument was primarily used on the Russian front. It was remarkably small and could be used with a wire loop, earth base, or connected to a special transformer ('Lauschzange 35') constructed to be clipped over a line. Direct tapping of a line, without causing connection clicks, was possible due to the set's special features. It was designed with only two space-charge valves, had a gain of 74 dB, and operated using standard 3V commercial dry cells: 8 parallel connected for the filaments and 8 in series for HT, working on quite low anode voltages.
A special potentiometer, combined with the on-off switch, was used to introduce very high impedance, thus causing no click when the set was directly connected to a line. It could be clipped to the soldier's belt together with its battery box or carried inconspicuously, with both units connected by a special cable [47].

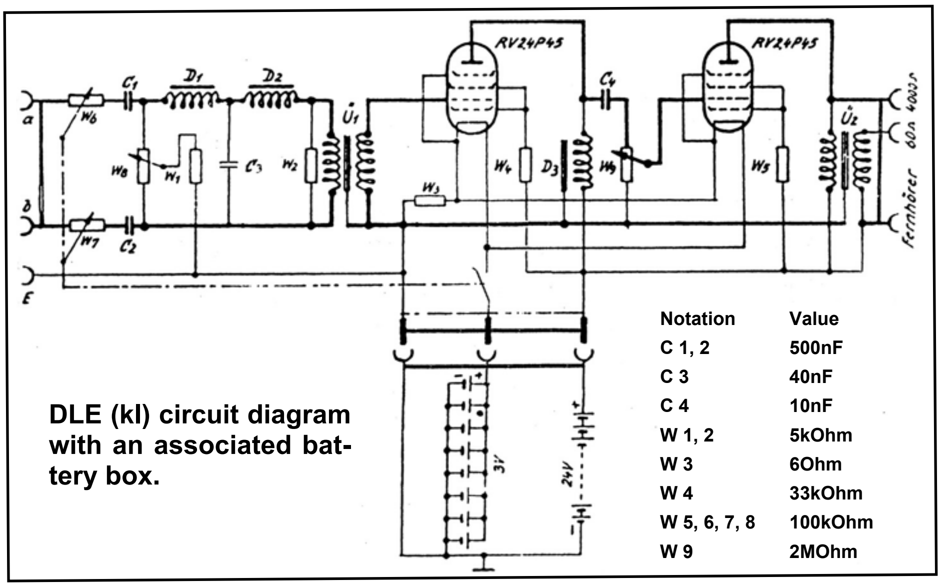


The German miniature line intercept amplifier DLE (kl) (on the right) was accompanied by its associated battery box (on the left), and in this scenario, both units were connected together by a special flat cable.



The DLE (kl.) amplifier (on the right) and the opened battery box (on the left). Note the three contact pins on the amplifier and the sockets on the battery box; these were used when both units were connected together.

The DLE (kl.) amplifier detached from its cover, as seen from the bottom, revealing the two RV 2.4 P 45 valves in their holders.



Notation	Value
C 1, 2	500nF
C 3	40nF
C 4	10nF
W 1, 2	5kOhm
W 3	6Ohm
W 4	33kOhm
W 5, 6, 7, 8	100kOhm
W 9	2MOhm

DLE (kl) circuit diagram with an associated battery box.

The DLE (kl.) with the battery box and spare parts was packed for transport in a leather bag.

Appendix 7.1: British amplifiers after WW I

Preliminary work and developments in 1938.

In 1938, two commercial amplifiers were obtained from Messrs. W. Brian Savage Ltd for trials involving line interception. These amplifiers had a gain of approximately 75 dB between 600 and 2500 Hz, with an output impedance of 120Ω. The amplifier used three Osram type Z 63 valves, consuming 900 mA at 6V for the filament and 7 mA at 180V for HT. The dimensions were 21x14x11 cm. The input impedance, originally 100kΩ, was later reduced to a nominal 450Ω using a step-up transformer. Initial trials at Aldershot, using cables laid in the Basingstoke Canal, proved unsuccessful due to the high level of noise picked up from local power stations. This noise was higher than that picked up from the line.

A quieter location near Knockholt Pond was selected, where two types of pickups were employed: an earth base and a loop. It was observed that, in terms of noise reduction, the loop performed about 30 dB better than the earth base. However, the earth base was approximately 15 dB more effective in picking up the desired signals.

After a provisional band pass filter was created, despite its poor quality, it demonstrated that a high-quality filter could enable the full use of the Savage amplifier's gain. Throughout these experiments, a significant pickup from passing motor vehicles was noted, likely due to static discharge from the tires. This observation was supported by the audible passage of a bicycle running beside the loop. Furthermore, the introduction of a filter in either the loop or earth base completely eliminated all radio interference.

The results of the experiments justified further extended field trials, with the condition that minor technical modifications, including the addition of a band-pass filter, be implemented, and improvements made to enhance the construction's suitability for field use. It is believed that these trials ultimately led to the development of Amplifier I.T. No. 1 [37].

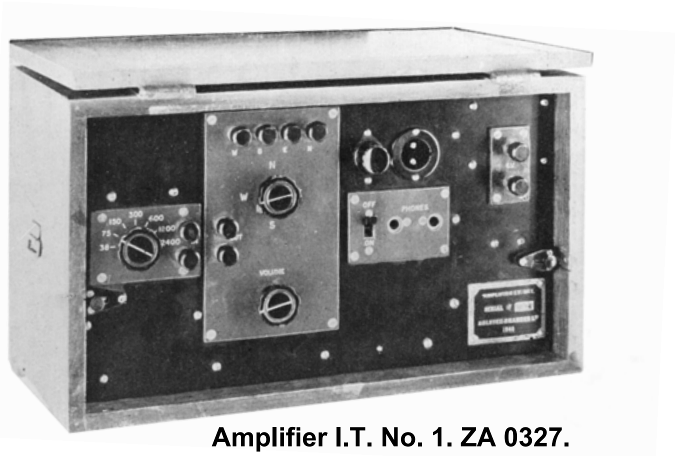
Amplifier I.T. No. 1.

Amplifier I.T No. 1 was a two-stage, high-gain audio amplifier manufactured by Kolster Brandes around 1939/1940. It was designed primarily for intercepting or 'eavesdropping' and was used by British security sections during World War II for line monitoring on telephone circuits without the necessity of electrical contact with them [62]. It could also be used as a microphone amplifier or for any other purpose where a high-gain amplifier capable of an output of 1mW into a load of 150Ω might be required.

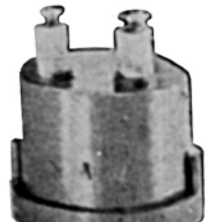
The gain of the amplifier was 90 dB between 400 and 3000 Hz; beyond these limits, the gain fell rapidly. The input of the amplifier could be matched to impedances ranging from 38 to 2400Ω.

The amplifier was configured for connection to a single earth base, a loop base, a directional earth base, or using a Transformer I.T. clipped over one of the wires of a telephone circuit. The circuit consisted of two choke-coupled indirectly heated valves. A very thorough screening of the amplifier and wiring was conducted, which was essential for correct operation. The 6V LT was derived from two internal 3V batteries, with provisions made for both internal and external use. The external HT supply comprised a carrying case with four 60V dry refill units connected in series. In emergencies, when no 6V batteries were available, the LT circuit could be rewired for 2V operation using a 2V accumulator.

Reference [38, 39].

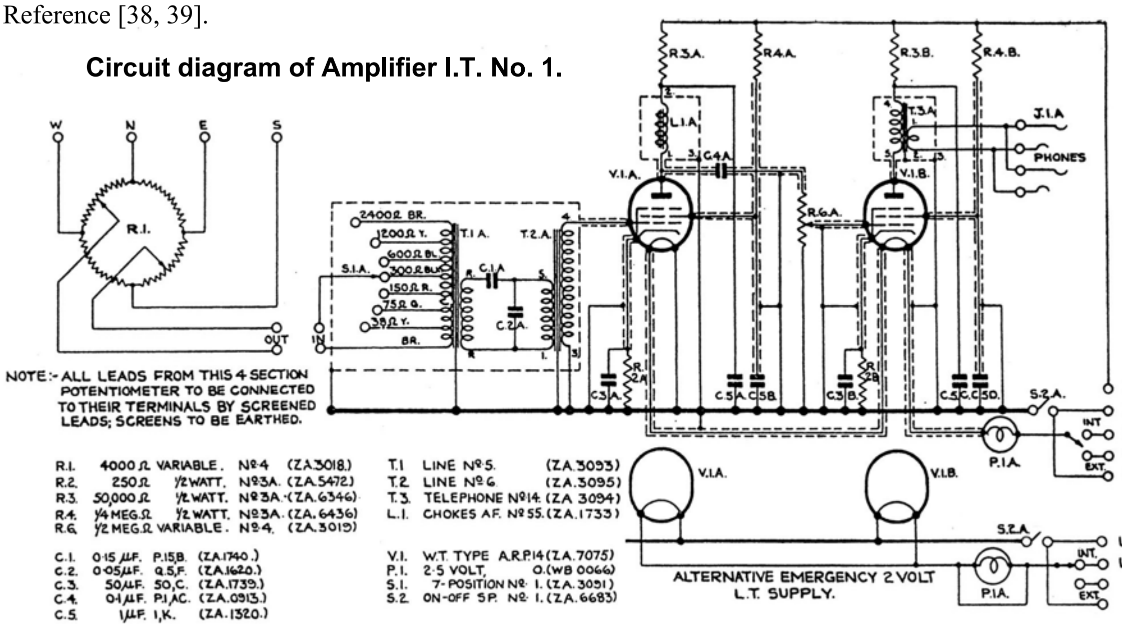


Amplifier I.T. No. 1. ZA 0327.

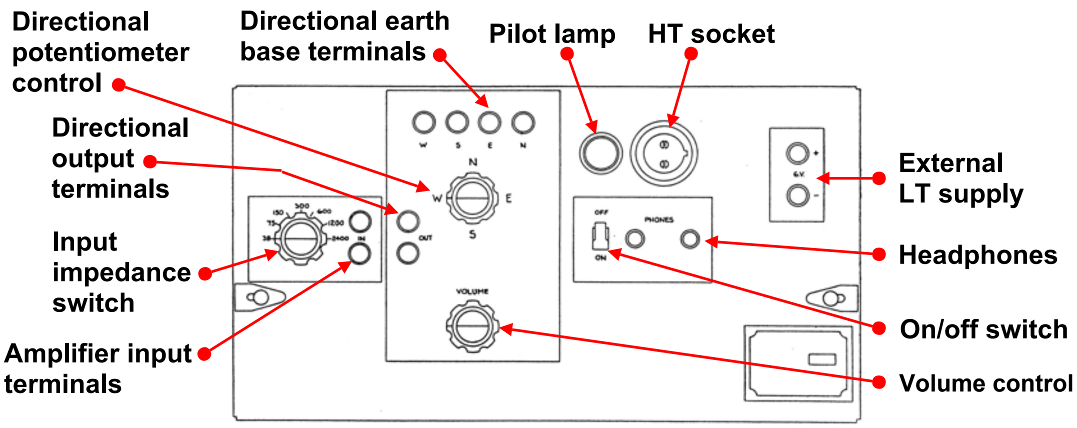


Transformer I.T.

Circuit diagram of Amplifier I.T. No. 1.



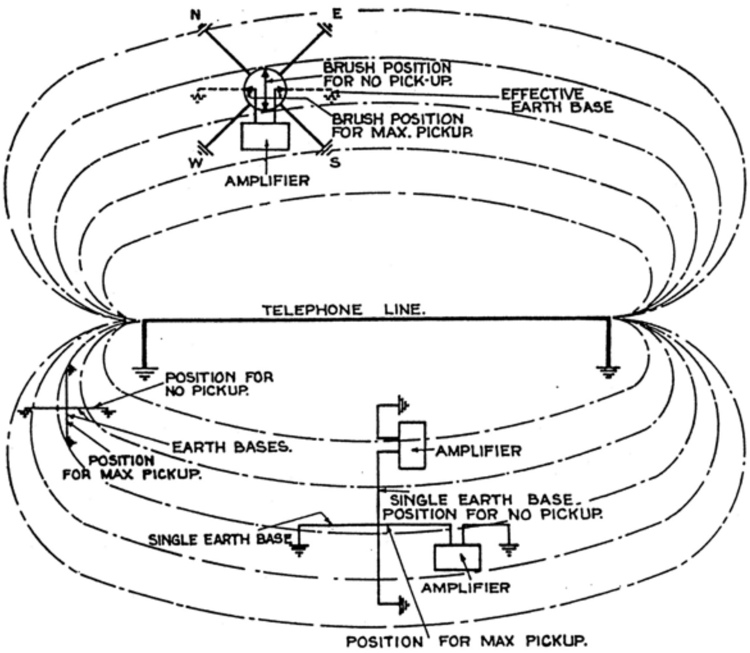
Appendix 7.2 : British amplifiers after WW I



Functions of controls on front panel Amplifier I.T. No. 1.

The path of earth currents.

The drawing (right) illustrated the path of earth currents or equipotential lines created by a single wire with an earth return telephone circuit, along with the positions of earth bases for maximum and no pickup. It is important to note that the earth base or effective earth base for maximum pickup must always form a chord of an equipotential line.



The directional type of pickup device, in conjunction with the amplifier, permitted the determination of the direction of signals being intercepted. If interference was present, the signal strength-to-interference ratio could be adjusted easily, without the necessity of orienting the base, which might be required with a single earth base.

Miniature line intercept amplifier (1942).

During November 1942, at S.R.D.E., work was carried out to investigate the suitability and performance of a miniature line intercept amplifier submitted by S.R.9. The amplifier was a very small and compact instrument designed for overhearing traffic over lines without breaking into the circuits, accomplished by using a special transformer constructed to be clipped over a line. It was designed for extreme portability, allowing inconspicuous carrying in a few large pockets, although this was achieved partly at the expense of robustness. The complete equipment consisted of an amplifier with a built-in 45-volt dry battery and a separate 2-volt LT 20Ah non-spillable accumulator, providing a continuous listening time of approximately 80 hours before recharging. The accumulator had a light, flat construction, approximately the same size and shape as the amplifier (16x11x3 cm). These components were interconnected by a 3-ft lead. The high-impedance headphone had a 6-ft lead with a Post Office-type plug for connecting to the amplifier.

The line intercept transformer was cylindrical, with a diameter of 2 cm and a length of 5 cm. It was connected by a screened 5-ft lead with a Post Office-type plug attached.

The amplifier, which was built into a flat metal case, had three resistance /capacitance coupled Hivac miniature valves. An on-off switch was provided to disconnect the battery supplies.

In the conclusions, it was reported that the line intercept transformer required redevelopment, which would result in an increase of about 25dB.

No further information on this amplifier could be found, neither about the name of the originator of this project, S.R.9, nor about the designer/constructor, which might have been the Post Office workshop. It is not believed that this amplifier ever came into production. [40].

One may speculate that if the intercept amplifier was intended for resistance groups or agents listening to enemy line communication, as an alternative, a Telesonic receiver might have been issued (see page 5).

Appendix 7.3 Forward area Listening Device

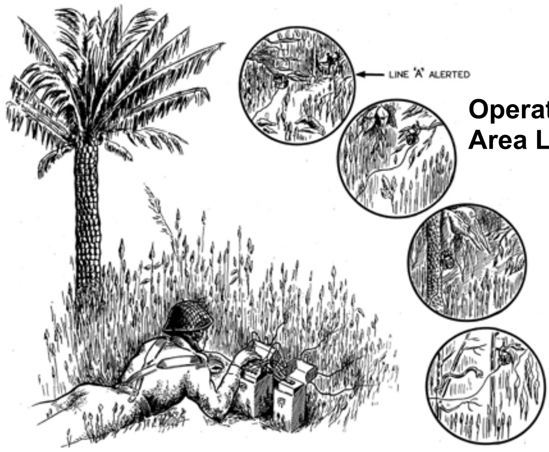
Although not directly related to the main topic it was still considered worthwhile to include in this Pamphlet. The forward area Listening Device was a miniature, lightweight audio amplifier designed to assist in detecting the approach of the enemy through remote microphones. It underwent troop trials around 1953. The amplifier featured four inputs connected by D10 field cable to four inconspicuously installed microphones in forward positions, spanning up to half a mile from the Listening Device. Sounds produced by speech, movements, vehicle engines, etc., were captured by the microphones and transmitted to the amplifier. Using selective switching, the operator could determine the origin of the sound from one of the four positions.

The operator could listen to all four circuits simultaneously or select/reject any single circuit through suitable switching. The listening device and battery, fully tropicalised, could be carried in two webbing pouches similar to normal Bren gun ammunition pouches, while the four microphones and headphones were carried in a Satchel Signal. The microphones were positioned near roads, tracks, etc., or at any points where it was thought the enemy might be expected to pass.

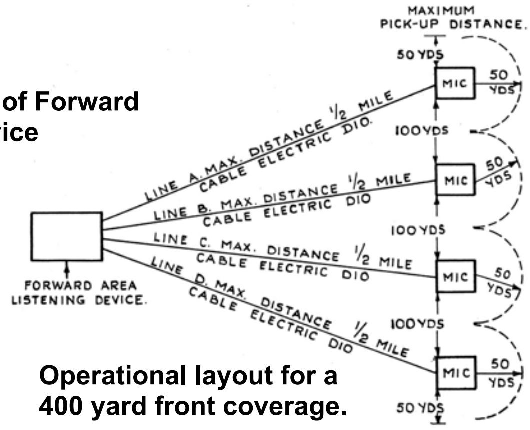
The useful range of a microphone was about a 50-yard radius for loud speech, with proportionately greater distances for motor vehicle engines, etc.

The frequency response of the audio amplifier was approximately flat over the range of 300Hz to 10kHz, and the gain of the amplifier within this range was 70dB. Since the cut-off frequency of the microphone and headphones combined was lower than the upper frequency response of the amplifier, the effective response fell off above 3kHz.

The two-valve amplifier was powered by a standard battery, HT/LT Dry 90 volt/1.5 volt No. 2 (e.g., also used with Wireless Set No. 88). The expected life of a battery under continuous use was approximately 10 days. There are no indications that the Listening Device was ever produced [41].

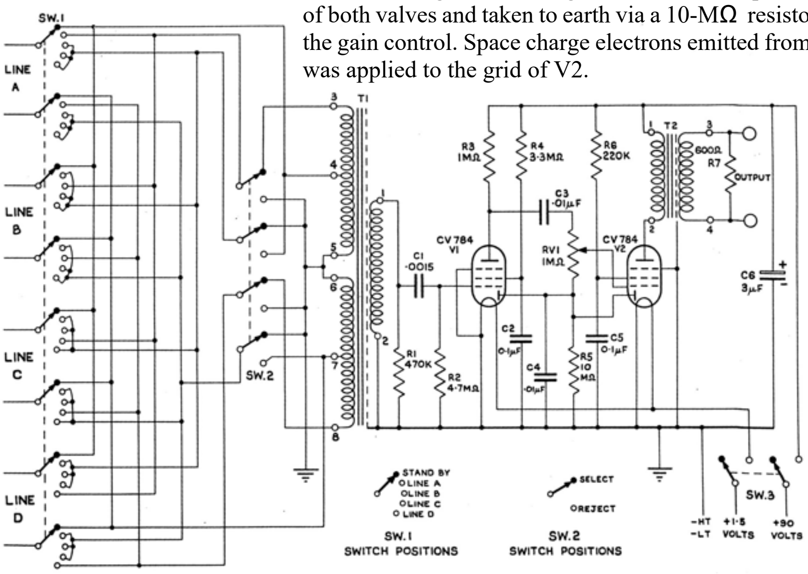


Operational use of of Forward Area Listening Device

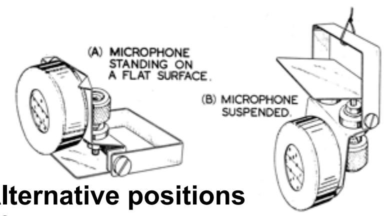


Operational layout for a 400 yard front coverage.

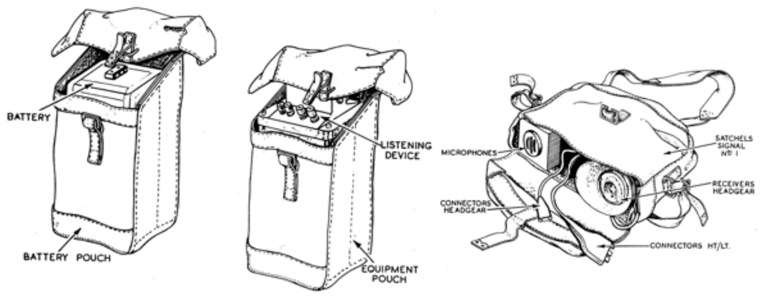
It is interesting to note that grid bias for the amplifier was obtained by strapping together the diode sections of both valves and taken to earth via a 10-MΩ resistor, with the unearthed end connected to the grid through the gain control. Space charge electrons emitted from the filaments caused a small negative potential, which was applied to the grid of V2.



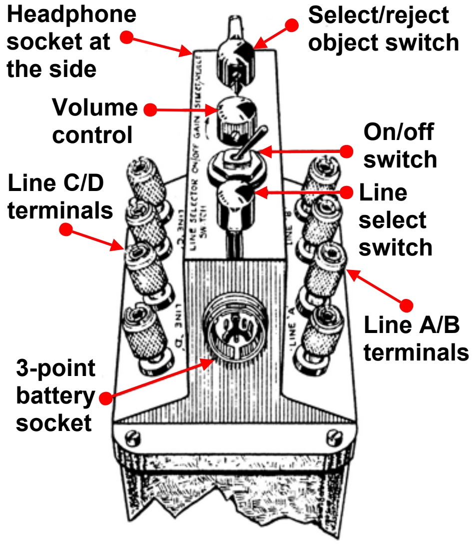
Circuit diagram of Forward Area Listening Device.



Alternative positions of mounting the microphone.



Stowage of equipment when carried as a manpack.



Functions of controls listening device.

Appendix 8

COMMUTATOR FOR USE WITH "IT."

(i.) The commutator is designed to allow any one of three loops, or any combination of eight earths being switched on to the instrument and to test any of the above combinations.

Connections.

(ii.) The attached diagram shows the terminals and switch points with back connections in red. Terminals 1 to 8 are connected to earths. Terminals A, B and C to one end of three loops, the free ends being taken to A′, B′ and C′. W is reserved for an aerial. T is taken to a local earth, situated as near the instrument as possible.

The terminals marked "to galvo" are connected through a suitable battery to the Detector P.O. pattern No. 1 or other galvonometer.

Terminals marked L1 and L2 are connected to L1 and L2 of the instrument.

When the amplifier is in use the throw-over switch is in the down position. It will then be seen that if the switches are on similar letters, both ends of a loop are connected through to the instrument. In the same way, if one switch is on a number and the other on another number, two earths will be connected to the instrument. If both switches are on a similar number, the instrument will be short circuited and no signals can be received.

Testing.

(iii.) ALL TESTS ARE TO BE ENTERED IN THE TEST DIARY, and the state of the weather recorded. When testing, the throw-over switch is in the top position.

(iv.) To test a loop for continuity.—The switches are brought on to the desired letter and the galvo reading noted; the needle should go well over and remain perfectly steady. If the needle is not steady, it shows the loop is broken and has an intermittent contact. If there is no deflection, the loop is entirely cut.

(v.) To test a loop for leakage to earth.—Set the left-hand switch to the loop letter and the right-hand switch to T. If the insulation is perfect, there will be no deflection of the needle. In very wet weather the insulation is liable to become slightly defective, and a small deflection of the needle will be observed. If this becomes worse, all joints should be examined for leakage.

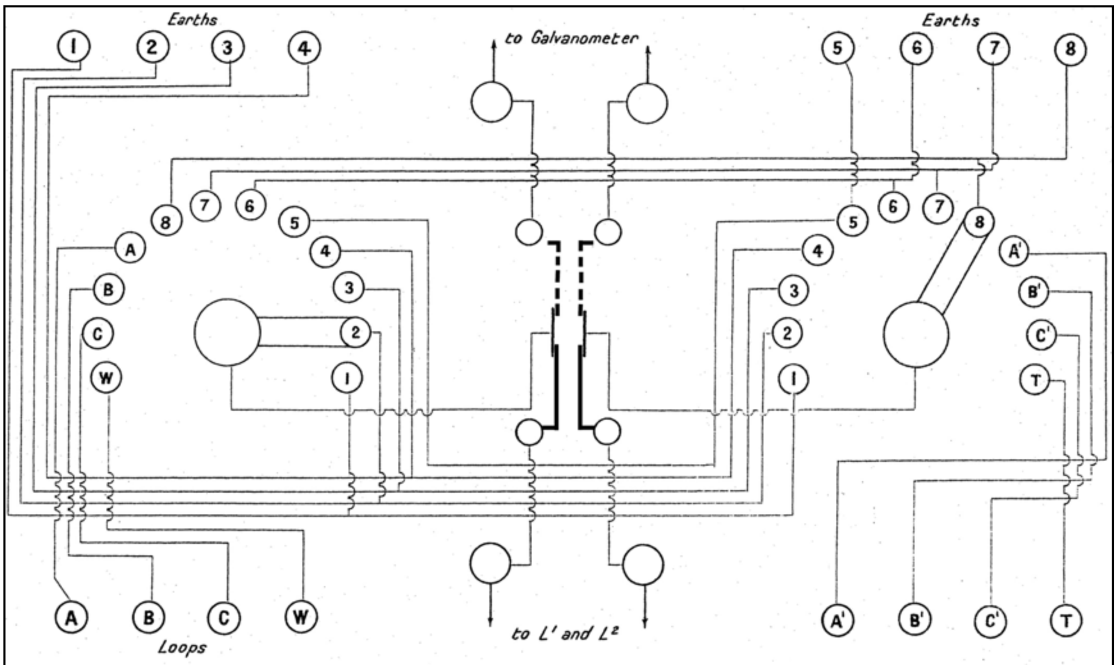
(vi.) To test an earth.—Put the right-hand switch to T and the left-hand switch to the earth to be tested. Note in the Test Diary the galvo reading obtained. If the deflection obtained is only very slight, the line should be examined. Tests should always be compared with previous readings, as it is only by comparisons that deductions can be made. EARTHS AND LOOPS ARE TO BE TESTED EVERY HOUR.

Manipulation.

(vii.) Put the throw-over switch in the down position and search for signals.—On loops, by changing both switches over to similar letters; on earths, by setting one switch to any number and manipulating the other over the range of numbers. Repeat, changing the position of the stationary switch each time.

Wireless.

(viii.) To receive wireless signals, switches should be put to W and T.



D.A.S. WIRELESS CIRCULAR No 6.

1st Printing Coy R.E. G.H.Q. (3242)

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- Library Technical University, Delft, Holland.
- Library PTT Bidata, the Hague, Holland, (Closed after privatisation of PTT).
- Library PTT Museum, The Hague, Holland, (Closed after privatisation of PTT, now 'Beeld en geluid').
- www.radiomuseum.org, particularly on confirming data on German WW I valves.
- Much of the core information and illustrations in this pamphlet were retrieved from the Royal Signals Museum, with kind permission and assistance of current and past Directors and Staff of the Royal Signals Museum, Blandford Forum, U.K.

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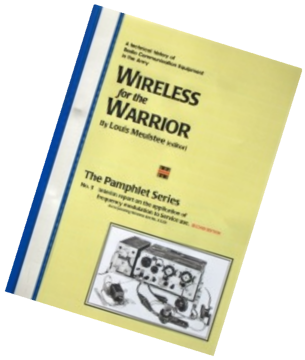

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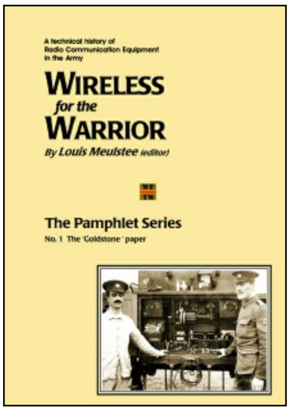
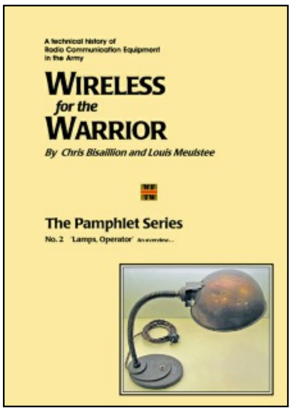
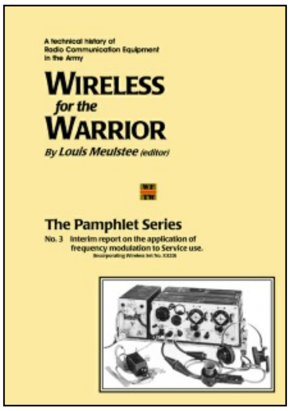
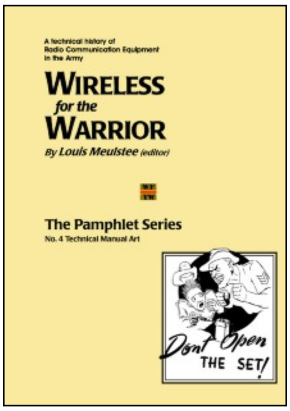
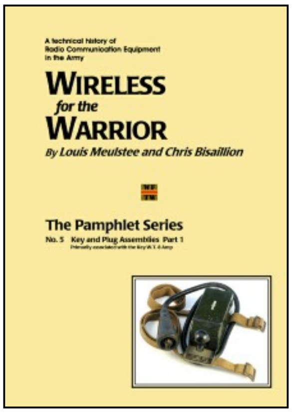
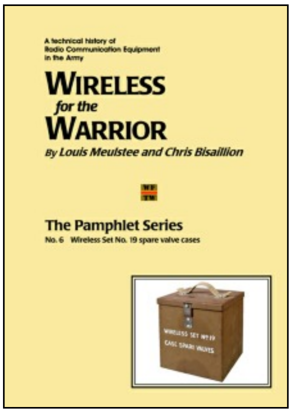


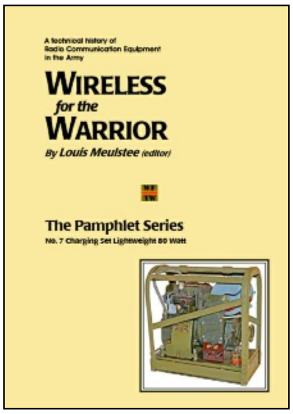


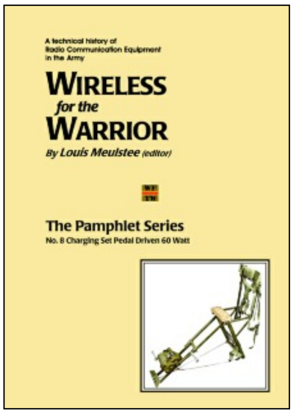


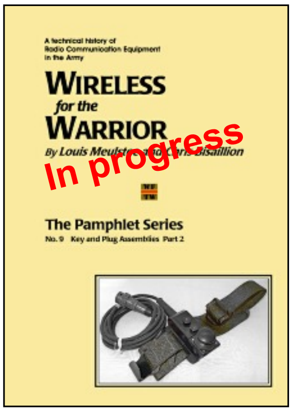


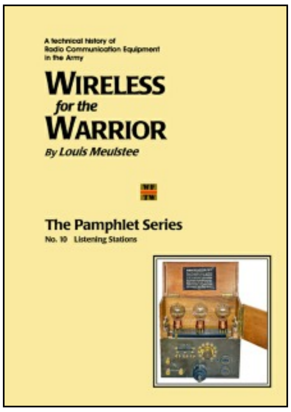


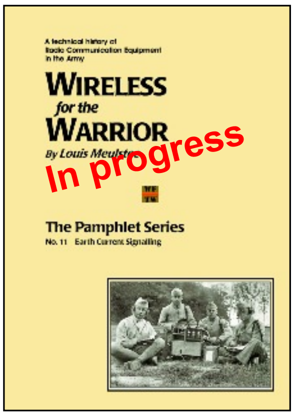


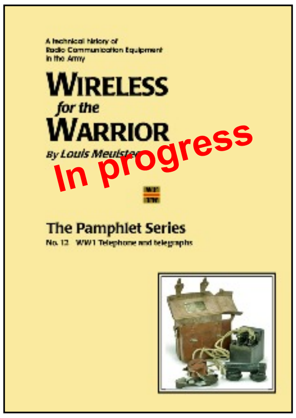










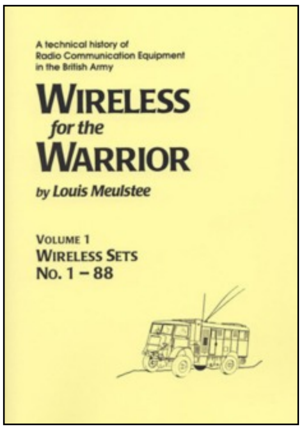


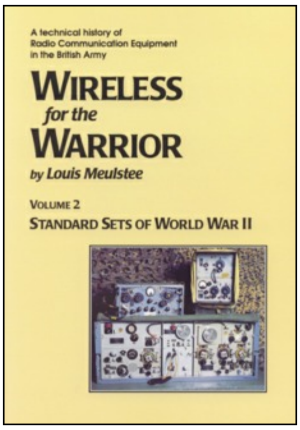
The **WftW Pamphlet** series is an addition to the Wireless for the Warrior range, created to accommodate a future range of reprints of articles and reports of historical importance, hitherto not published documents, and technical reports on British Army signalling. This free to download and print ready series in A4 format replaced the now discontinued 'Overview' booklets. WftW Pamphlet No. 5 replaced the earlier Compendium 7 A5 format free download and is now only available in A5 printed form and free A4 format download.

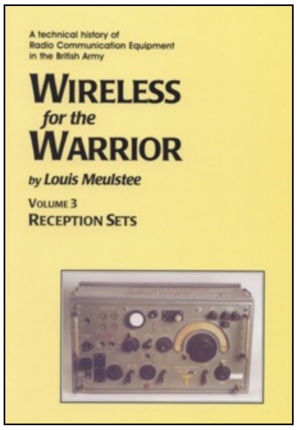
In answer to requests, WftW Pamphlet No. 4 (Technical Manual Art) is also available via 'print on demand' Lulu inc. See https://www.lulu.com/spotlight/wftw

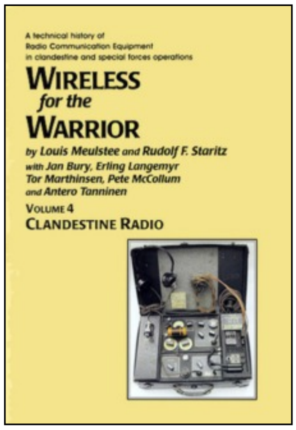
About the Wireless for the Warrior books

The Wireless for the Warrior range of books (comprising the **Volume, Compendium, Supplement** and **Pamphlet** series) are intended as a source of reference to the history and development of radio communication equipment used by the British Army from the very early days of wireless up to the 1960's. Line equipment and military radio communication equipment from other countries is also covered in the recently published Compendiums. For detailed information, review pages and order information visit www.wftw.nl

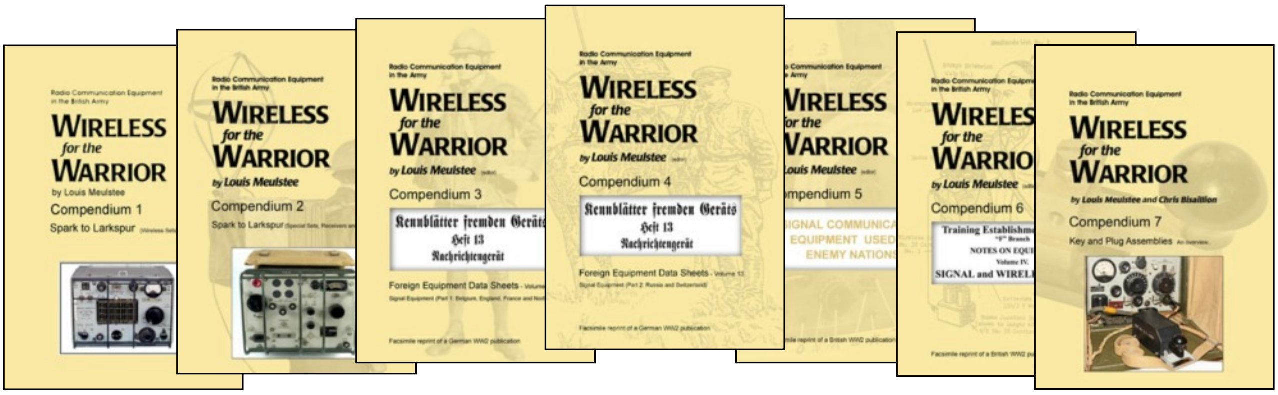




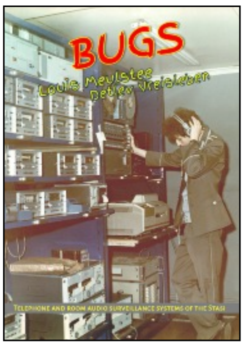




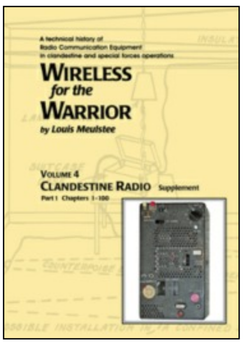
The books in the WftW **Volume** series are very detailed and include circuit diagrams, technical specifications and alignment data in addition to technical development history, complete station lists and vehicle fitting instructions. Generally no operational histories are given as these have been published extensively in numerous other books.

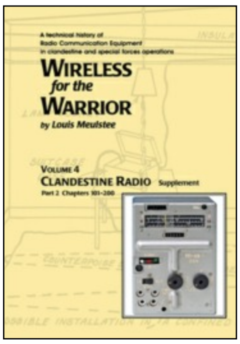


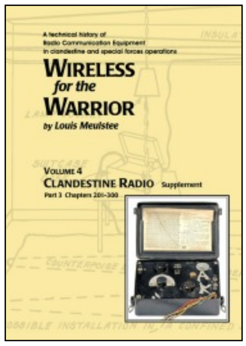
The WftW **Compendium** series is a new addition to the Wireless for the Warrior range, currently comprising 7 books. The new series is principally intended as a practical guide and reference source to vintage military signal communication equipment. The books are particularly valuable to anyone with an interest, professionally or otherwise, in this subject, requiring an elementary but complete quick reference and recognition handbook. Containing condensed data summaries, liberally illustrated with photos and drawings, explanatory captions and short description of the main ancillaries, its pocket size format and laminated soft cover makes it an ideal reference and reliable companion for events such as auctions and radio rallies, or just for browsing at leisure.



WftW **'BUGS'** is a recent book describing the technical history of telephone and room surveillance systems of the Stasi. It was written in cooperation with Detlev Vreisleben.







The WftW **'Supplement'** series are full colour reprints of previously published WftW Vol. 4 Supplement 'Chapters'.