Försvarets Historiska Telesamlingar
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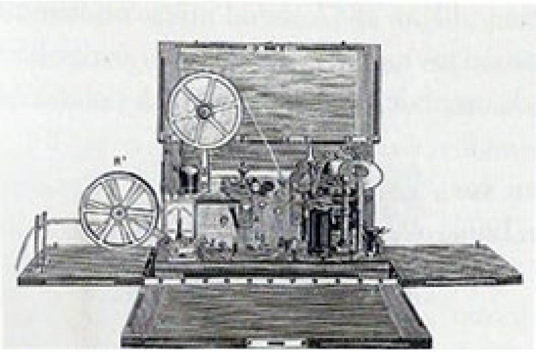
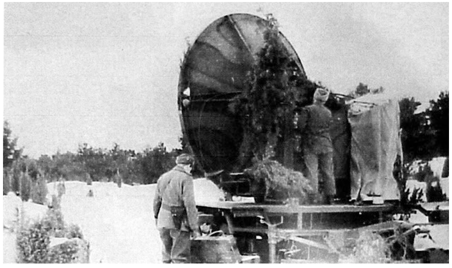
Den tekniska utvecklingen av svenska försvarets telekommunikations- och radarsystem i ett internationellt perspektiv

Göran Kihlström

F01/23



Telegraferingsapparat med transportlåda
(*Foto: TELESEUM arkiv*)



Er IIb

British Army Telephone C

Förord

FHT har under flera år i ett antal dokument beskrivit utvecklingen inom främst det svenska försvarets sambands-och ledningssystem.

I denna rapport har vi försökt att beskriva hur den tekniska utvecklingen skett i ett internationellt perspektiv inom telekommunikations- och radarområdet. Under lång tid fram till andra världskriget hade teknikutvecklingen inom telekommunikation en stor betydelse för utveckling av ledningsförmåga inom det militära området.

För att få underlag till rapporten har vi i öppna källor på internet sökt efter när de tekniska framstegen började användas inom det militära området främst i USA, England och Tyskland. En stor del av underlaget är hämtat på Militära museers hemsidor som ofta har en bra översikt av utvecklingen av tekniken och användningen inom förband. En del är hämtat från försvarsleverantörers historiska sidor. Vi har valt att behålla den engelska texten i de delar som vi funnit intressanta för framställningen.

Med det underlag vi funnit har vi jämfört hur och när användningen av den nya tekniken och de tekniska systemen skett inom det svenska försvaret. Rapporten begränsas till att omfatta utvecklingen från det att den elektriska telegrafen introducerades fram till början av 1960-talet.

Följande teknikområden har behandlats

- Elektrisk trådbunden telegrafi
- Trådbunden telefoni
- Radiotelegrafi
- Radiotelefoni
- Fjärrskrift tråd och radiobunden
- Radar
- Radiolänk

Medverkande i arbetet med rapporten har varit John Hübbert, Arne Larsson, Hans-Ove Görtz och Göran Kihlström.

Hans Bruno har redigerat dokumentet.

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Göran Kihlström

Den tekniska utvecklingen av svenska försvarets telekommunikations- och radarsystem i ett internationellt perspektiv.

Innehållsförteckning

1 Elektrisk trådbunden telegrafi

1.1 Utveckling och introduktion

The first commercial system, and the most widely used needle telegraph, was the Cooke and Wheatstone telegraph, invented in 1837. Early equipment sets used five needles to point to the letter being transmitted, but the cost of installing wires was more economically significant than the cost of training operators so a single-needle system with a code that had to be learned became the norm.

Cooke and Wheatstone's five-needle telegraph from 1837

The second category consists of armature systems in which the pulse activates a telegraph sounder which makes a click. The archetype of this category was the Morse system, invented by Samuel Morse in 1838, using a single wire. At the sending station, an operator would tap on a switch called a telegraph key, spelling out text messages in Morse code. Originally, the armature was intended to make marks on paper tape, but operators learned to interpret the clicks and it was more efficient to write down the message directly. In 1865, the Morse system became the standard for international communication with a modified code developed for German railways. However, some countries continued to use established national systems internally for some time afterwards.

Morse Telegraph

1.2 Tillämpningen av trådbunden telegrafi i militära tillämpningar

1.2.1 Krimkriget

The Crimean War was one of the first conflicts to use telegraphs and was one of the first to be documented extensively. In 1854, the government in London created a military Telegraph Detachment for the Army commanded by an officer of the Royal Engineers. It was to comprise twenty-five men from the Royal Corps of Sappers & Miners trained by the Electric Telegraph Company to construct and work the first field electric telegraph

The image below shows a sample of the Gutta-Percha cable that was used in the Crimean War of 1854 which the British fought in an alliance with the French and the Turks against the Russian Empire.

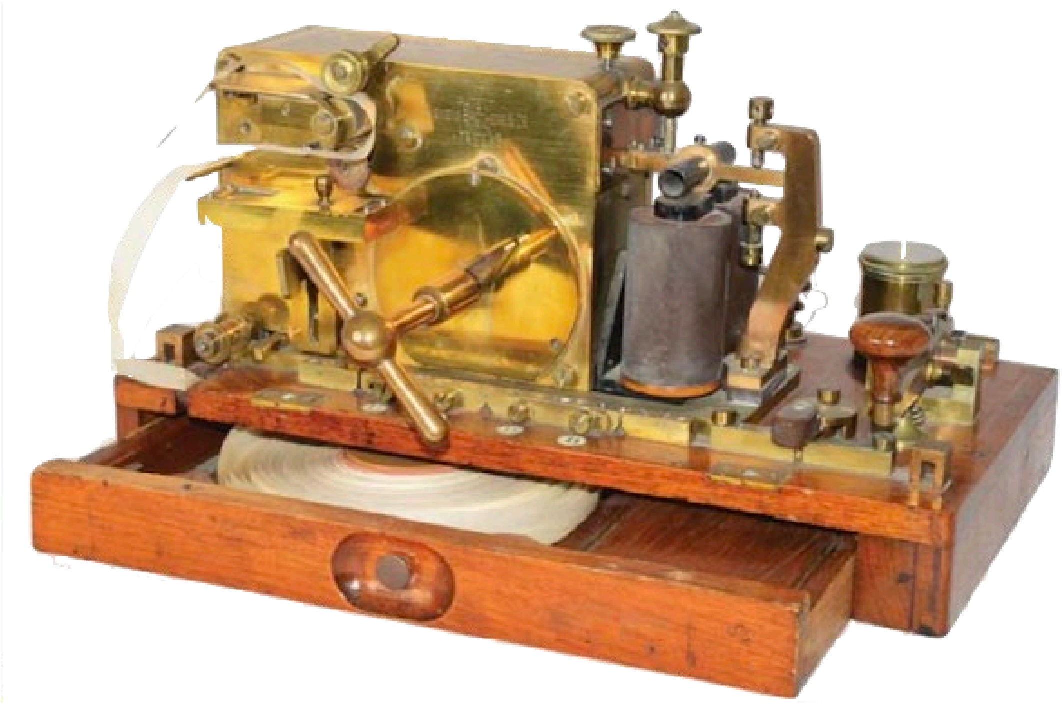
Before Cable - Lessons learned from defeat at the Battle of New Orleans
On the 8 January 1815 the British Army (led by General Edward Packenham) was defeated by the USA (led by General Andrew Jackson) at the battle of New Orleans with some 15,000 British soldiers killed or wounded. This was an especially unfortunate outcome given the Peace Treaty of Ghent - ending the war between the British and Americans - had been signed two-weeks earlier in December 1814. Sadly this news had not reached the Armies. Ironically news travelling slowly led many Americans to wrongly believe that defeating the British at the Battle of New Orleans had ended the war of 1812, but this was not actually the case.
After Cable - The Crimean War
Some 39 years later Electric Telegraph was used for the first time in the Crimean War. A 340 mile submarine cable was laid across the Black Sea from Balaclava to Varna.

Once the system was working news now travelled so fast that General Simpson, the Commander-in-Chief, received so many administrative enquiries from London he declared, "- - -the confounded telegraph has ruined everything."

1.2.2 Etablering av signalförband I England

The Telegraph Troop, founded in 1870, became the **Telegraph Battalion Royal Engineers** who then became the Royal Engineers Signals Service, which in turn became the independent Royal Corps of Signals in 1920.

In 1870, 'C' Telegraph Troop, Royal Engineers, was founded under Captain Montague Lambert. The Troop was the first formal professional body of signallers in the British Army and its duty was to provide communications for a field army by means of visual signalling, mounted orderlies and telegraph. By 1871, 'C' Troop had expanded in size from 2 officers and 133 other ranks to 5 officers and 245 other ranks. In 1879, 'C' Troop first saw action during the Anglo-Zulu War. On 1 May 1884, 'C' Troop was amalgamated with the 22nd and 34th Companies, Royal Engineers, to form the Telegraph Battalion Royal Engineers; 'C' Troop formed the 1st Division (Field Force, based at Aldershot) while the two Royal Engineers companies formed the 2nd Division (Postal and Telegraph, based in London). Signalling was the responsibility of the Telegraph Battalion until 1908, when the **Royal Engineers Signal Service** was formed. As such, it provided communications during the First World War. It was about this time that motorcycle despatch riders and wireless sets were introduced into service.



Whatstone Morse transmitter and receiver

1.2.3 American Civil War och etableringen av signalförband I USA

The **U.S. Military Telegraph Corps** was formed in 1861 following the outbreak of the American Civil War. David Strouse, Samuel M. Brown, Richard O'Brian, and David H. Bates, all from the Pennsylvania Railroad Company, were sent to Washington, D.C. to serve in the newly created office. In October of that year, Anson Stager was appointed department head. During the war, they were charged with maintaining communications between the federal government in Washington and the commanding officers of the far-flung units of the Union Army.

During the American Civil War, the telegraph proved its value as a tactical, operational, and strategic communication medium and an important contributor to Union victory. By contrast the Confederacy failed to make effective use of the South's much smaller telegraph network. Prior to the War the telegraph systems were primarily used in the commercial sector. Government buildings were not inter-connected with telegraph lines but relied on runners to carry messages back and forth. Before the war the Government saw no need to connect lines within city limits, however, they did see the use in connections between cities. Washington D.C. being the hub of government, it had the most connections, but there were only a few lines running north and south out of the city. It wasn't until the Civil War that the government saw the true potential of the telegraph system. Soon after the shelling of Fort Sumter, the South cut telegraph lines running into D.C, which put the city in a state of panic because they feared an immediate Southern invasion.

Within 6 months of the start of the war, the U.S. Military Telegraph Corps (USMT) had laid approximately 300 miles (480 km) of line. By war's end they had laid approximately 15,000 miles (24,000 km) of line, 8,000 for military and 5,000 for commercial use, and had handled approximately 6.5 million messages. The telegraph was not only important for communication within the armed forces, but also in the civilian sector, helping political leaders to maintain control over their districts.

Even before the war, the American Telegraph Company censored suspect messages informally to block aid to the secession movement. During the war, Secretary of War Simon Cameron, and later Edwin Stanton, wanted control over the telegraph lines to maintain the flow of information. Early in the war, one of Stanton's first acts as Secretary of War was to move telegraph lines from ending at McClellan's headquarters to terminating at the War Department. Stanton himself said "[telegraphy] is my right arm". Telegraphy assisted Northern victories, including the Battle of Antietam (1862), the Battle of Chickamauga (1863), and Sherman's March to the Sea (1865).

The telegraph system still had its flaws. The USMT, while the main source of telegraphers and cable, was still a civilian agency. Most operators were first hired by the telegraph companies and then contracted out to the War Department. This created tension between Generals and their operators. One source of irritation was that USMT operators did not have to follow military authority. Usually they performed without hesitation, but they were not required to, so Albert Myer created a U.S. Army Signal Corps in February 1863. As the new head of the Signal Corps, Myer tried to get all telegraph and flag signaling under his command, and therefore subject to military discipline. After creating the Signal Corps, Myer pushed to further develop new telegraph systems. While the USMT relied primarily on civilian lines and operators, the Signal Corp's new field telegraph could be deployed and dismantled faster than USMT's system.

U.S. Military Telegraph battery wagon

1.3 Utvecklingen i Sverige

1.3.1 Civil utveckling

Under 1840-talet kom rapporter från utlandet att man kunde använda elektricitet för telegrafering. Två officerare inom den optiska Telegrafinrättningen, J F von Heland och A L Fanenhjelm konstruerade ett elektriskt telegrafsystem som byggde på det befintliga optiska systemet. Detta omkonstruerades sedan till morsesystemet.

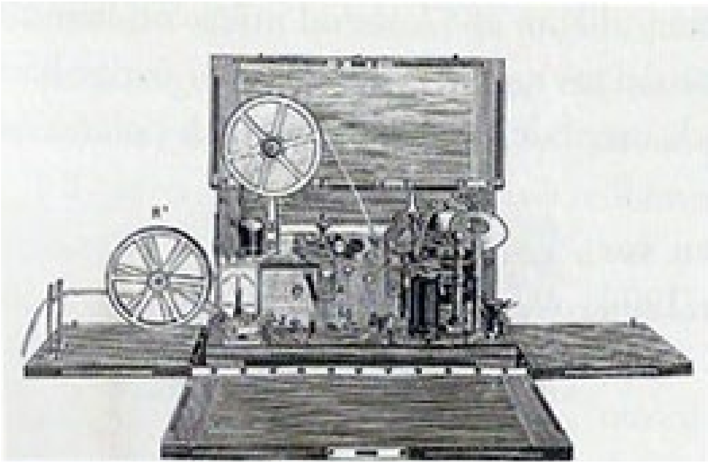
År 1852 fick general Akrell uppdraget att konstruera ett elektriskt telegrafsystem. Den första linjen byggdes mellan Stockholm och Uppsala och var färdig 1853. I mycket hög takt byggdes sedan telegraflinjer ut till alla residensstäder och med anslutning till det europeiska fastlandet och Amerika. Den då 74-åriga Akrell var chef för Kongl Elektriska Telegrafverket ända till sin död 1868 vid 83 års ålder.

1.3.2 Militär utveckling

Tio år senare började också försvaret förberedande försök med elektrisk telegrafmateriel och 1871 beslöt riksdagen om upprättandet av ett fältsignalkompani, som skulle vara underställt Fortifikationen och samlokaliserat med Pontonjärbataljonen vid Jaktvarvet på Kungsholmen. Fältsignalkompaniet var ett värvat förband, som bestod av 4 officerare, 4 underofficerare och 120 man, korpraler, spel, hantverkare och soldater samt 10 egna hästar. Vid en manöver i Uppland 1872, under ledning av den nye konungen Oscar II, deltog fältsignalkompaniet med en telegrafstation i Rosersberg och utbyggde ”hela” 5 km enkeltrådig ledning för telegrafering. Fältsignalkompaniets uppgift var ursprungligen enbart avsedd för arméledningens förbindelser.

I samband med 1892 års härordning omdöptes Fältsignalkompaniet till Fälttelegraf-kompaniet. Under 1890-talet genomfördes en omorganisation och utökning av organisationen så att varje armfördelning skulle i fält erhålla en fälttelegrafavdelning. Vid 1901 års härordning, varvid allmän värnplikt infördes och indelningsverket avskaffades, utökades fälttelegrafkompaniet till Kungl. Fälttelegrafkåren, direkt underställd Chefen för Kungl. Fortifikationen. Kåren utökades då till två fälttelegrafkompanier och en tyg- och parkavdelning. Förbandet fick beteckningen Ing 3. Förbandet började utökas 1902 med fortsatt förläggning tillsammans med Svea ingenjörkår. År 1908 flyttade kåren till Marieberg, som sedan skulle hysa signalförband till den 1 oktober 1958.

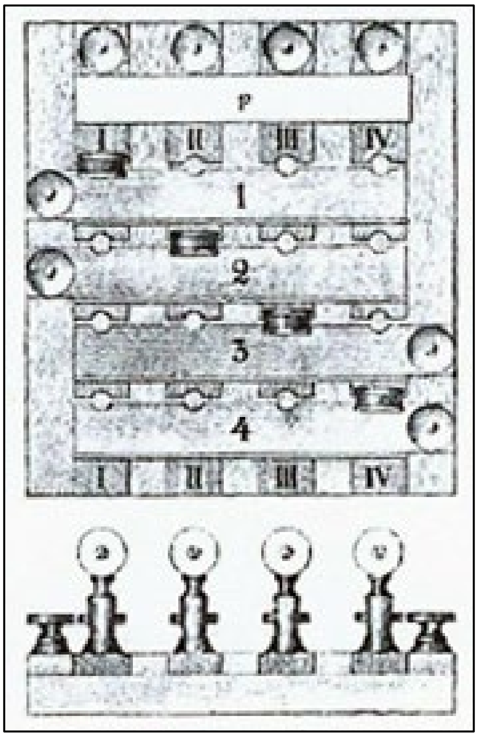
Telegrafapparat m/1871 av morsetyp med skrivapparat och telegrafnyckel - allt i trälåda med nedfällbara sidväggar. Till varje apparat hörde ett batteri om tio våtelement (vardera 1,5 volt) av leclanchétyp och inneslutet i trälåda.

Telegraferingsapparat med transportlåda (Foto: TELESEUM arkiv).

Telegrafen strömförsörjdes med Fälttelegrafbatteri m/1886 av leclanchétyp. För flera telegraflinjer vid samma plats fanns en Linjeväxel m/1887.

Swedish Field Telegraph Attributed to L.M. Ericsson, c. 1900, three-ply mahogany base with brass plates, and glass housing surrounding the key-wind spring barrel mechanism, dual coils, bell, and retractable printing reels, housed in a three-sided hinged carrying case with inset handles, ht. with reel extended 13 in.; sold with a French military field compass attributed to Houlliot.

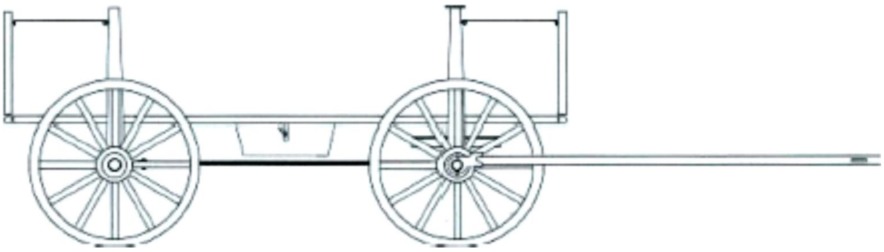


Linjeväxel m/1887 för telegrafi

Den första växeln med fyra vridbara "dockor" för främst telegrafstationer och fyra enkelledare infördes 1878, men ersattes redan 1886 med en linjeväxel med skivor, hål och proppar. Bland annan elektrisk materiel under 1800-talet märkes undersökningsbatteri med galvanometer för kontroll av ledningar och batteriprovare – en liten fickgalvanometer.

Stolpgruppen
I avdelningen ingick två stolpvagnar, vardera dragna av två hästar.
I stolpgruppen ingick en korpral som chef samt 4 man.

Stolpgruppen byggde tillsammans med trådgruppen fälttelegraflinje. Med en telegrafavdelnings materiel kunde byggas 37 km fälttelegraflinje, därav 7 km kabellinje



Stolpvagn enligt Fältsignal-Instruktion 1878
(En stolpvagn finns bevarad vid garnisonsmuseet i Enköping).

Trådgruppen
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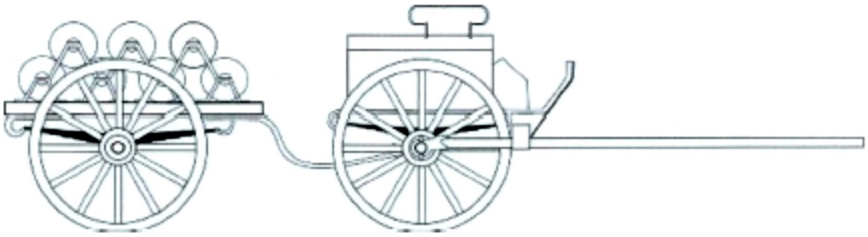


Trådvagn enligt Fälttelegraf-Instruktion 1878
(Varje trådrulle innehöll 2 000 m blanktråd, varje kabelrulle 500 a 600 m kabel).

1.3.3 Jämförelse av utvecklingen i omvärlden och i Sverige

Den trådbundna elektriska telegrafen enligt Cooke and Wheatstone intoducerades 1837.

1838 kom den tekniska lösningen som med användning av Morse kod kom att bli i sort sett internationell standard.

I militära sammanhang kom den trådbundna telegrafen att introduceras av engelsmännen under Krimkriget. 1854 bildades Military Telegraph Detachment for the Army. 25-man från the Royal Engineers utbildades av det civila Electric Telegraph Company. 1870 organiserades The Telegraph Troop, 1871 Telegraph Batalion of Royal Engineers,1904 Royal Engineers Signal Service och slutligen 1920 Royal Corps of Signals.

I USA bildades 1861 US Military Telegraph Corps, 1863 följt av US Army Signal Corps. Den trådbundna elektriska telegrafen fick sitt stora genombrott under det amerikanska inbördeskriget.

Sverige var tidigt med att bygga ett landsomfattande telegrafinät med start 1853.

Tio år senare började också försvaret förberedande försök med elektrisk telegrafmateriel och 1871 beslöt riksdagen om upprättandet av ett fältsignalkompani, som skulle vara underställt Fortifikationen och samlokaliserat med Pontonjärbataljonen vid Jaktvarvet på Kungsholmen. Fältsignalkompaniet var ett värvat förband, som bestod av 4 officerare, 4 underofficerare och 120 man, korpraler, spel, hantverkare och soldater samt 10 egna hästar. Vid en manöver i Uppland 1872, under ledning av den nye konungen Oscar II, deltog fältsignalkompaniet med en telegrafstation i Rosersberg och utbyggde ”hela” 5 km enkeltrådig ledning för telegrafering. Fältsignalkompaniets uppgift var ursprungligen enbart avsedd för arméledningens förbindelser.

Inom industrin var Ericsson tidigt framstående med tillverkning av materiel för telegrafi för både den svenska och internationella marknaden.

Sammanfattningen är att Sverige som organisatoriskt troligen sneglat på England relativt tidigt var med att introducera telegrafi inom försvaret.

I FHT dokumentation finns ytterligare information om utvecklingen i Sverige i dokumentet:
En sammanställning över Arméns telefonmateriel från 1870 till 1970-talet
(6,2 MB) *Författare: Sven Bertilsson.*

2 Trådbunden telefoni

2.1 Utveckling och introduktion

On March 7, 1876, 29-year-old Alexander Graham Bell receives a patent for his revolutionary new invention–the telephone.

The Scottish-born Bell worked in London with his father, Melville Bell, who developed Visible Speech, a written system used to teach speaking to the deaf. In the 1870s, the Bells moved to Boston, Massachusetts, where the younger Bell found work as a teacher at the Pemberton Avenue School for the Deaf. He later married one of his students, Mabel Hubbard.

While in Boston, Bell became very interested in the possibility of transmitting speech over wires. Samuel F.B. Morse's invention of the telegraph in 1843 had made nearly instantaneous communication possible between two distant points. The drawback of the telegraph, however, was that it still required hand-delivery of messages between telegraph stations and recipients, and only one message could be transmitted at a time. Bell wanted to improve on this by creating a "harmonic telegraph," a device that combined aspects of the telegraph and record player to allow individuals to speak to each other from a distance. With the help of Thomas A. Watson, a Boston machine shop employee, Bell developed a prototype. In this first telephone, sound waves caused an electric current to vary in intensity and frequency, causing a thin, soft iron plate–called the diaphragm–to vibrate. These vibrations were transferred magnetically to another wire connected to a diaphragm in another, distant instrument. When that diaphragm vibrated, the original sound would be replicated in the ear of the receiving instrument. Three days after filing the patent, the telephone carried its first intelligible message–the famous "Mr. Watson, come here, I need you"–from Bell to his assistant.

2.2 Telefonen i militära applikationer

The invention of the telephone in 1876 was not followed immediately by its adoption and adaptation for military use. This was probably due to the fact that the compelling stimulation of war was not present and to the fact that the development of long-distance telephone communication was not achieved for many years. The telephone was used by the U.S. Army in the Spanish-American War, by the British in the South African (Boer) War, and by the Japanese in the Russo-Japanese War. This military use was not extensive, and it made little material contribution to the development of voice telephony. Before the outbreak of World War I, military adaptation of the telephone did take place, but its period of growth had not yet arrived.

The **first telephone** for use in the **field** was developed in the **United States** in 1889 but it was too expensive for mass production. Subsequent developments in several countries made the **field telephone** more practicable.

The first field telephones had a wind-up generator, used to power the telephone's ringer & batteries to send the call, and call the manually operated telephone central. This technology was used from the 1910s to the 1960s. Later the ring signal has been made electronically operated by a pushbutton, or automatic as on domestic telephones. The manual systems are still widely used, and are often compatible with the older equipment.

2.2.1 UK användning av telefoni I British colonies

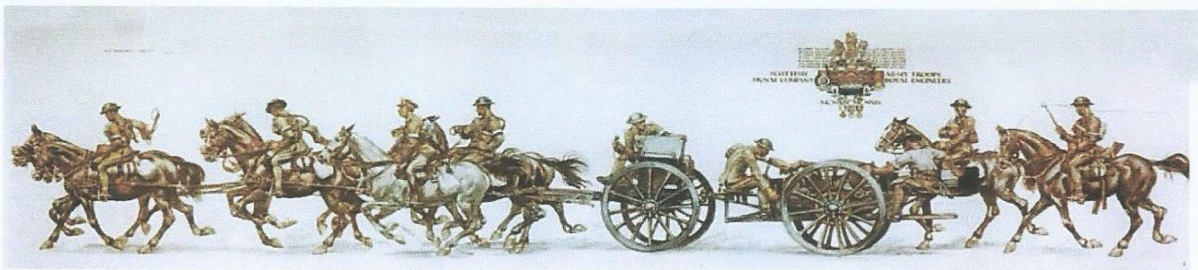
Shortly after the invention of the telephone attempts were made to adapt the technology for military use. Telephones were already being used to support military campaigns in British India and in British colonies in Africa in the late 1870s and early 1880s.

2.2.2 Utveckling av materiel för användning i fält

Field telephones operate over wire lines, sometimes commandeering civilian circuits when available, but often using wires strung in combat conditions. At least as of World War II, wire communications were the preferred method for the U.S. Army, with radio use only when needed, e.g. to communicate with mobile units, or until wires could be set up. Field phones could operate point to point or via a switchboard at a command post. A variety of wire types are used, ranging from light weight "assault wire", e.g. W-130 —8.5 kilograms per kilometre (30 pounds per mile)— with a talking range about 8.0 kilometres (5 mi), to heavier cable with multiple pairs. Equipment for laying the wire ranges from reels on backpacks to trucks equipped with plows to bury lines.

The Morse code had already speeded up communications across the globe, but during the British colonial wars, especially in Southern Africa, voice telephones started to come into use. The picture was taken of British soldiers in Southern Africa in approximately 1880. They can be seen unloading coils of barbed wire from the train, but behind the train you can see the telegraph wires that were soon to carry speech as well as messages sent in Morse code.

THE CABLE WAGON



This famous picture is of the Scottish Signal Company Royal Engineers that was based in the TA Centre in Jardine Street, Glasgow, which remains to this day the RHQ of 32nd Signal Regiment. The cable wagon that is on display in the Blandford Museum is claimed to be the only remaining cable wagon in the world and can be viewed there. This vehicle was in service from 1911 to 1937 and consisted of a team of six horses pulling the cable wagons with two outriders, who dispersed the cable away from the main track or road. The whole team, when fully manned consisted of 9 men. Although often there was an additional team leader shown in photos. The second picture is from a painting that conveys the feeling of motion that must have been present when seeing this team working on the battlefield. The majority of WW1 communications depended on laying "line" and repairing it under fire, when damaged by artillery shelling or the movement of tanks and other vehicles. The preparation for the Battle of the Somme included laying over 50,000 miles of cable. 43,000 of this total was laid above ground and 7,000 miles dug to a depth of at least 6– 7 feet. The cable wagon was replaced prior WW2. It was replaced by line laying from vehicles, cable carts or by Royals Signals soldiers on their feet dispensing from a drum of cable - Certa Cito!

Ericson from Sweden designed the telephone shown in the picture. It became known in the British Army as the Telephone C Mark 1 and came into wide-spread use during the Boer War of 1899-1902. Use was made of existing lines for voice, but these communications were then extended to the field using this telephone as well as for extending the telegraph systems. The Royal Engineer Signals had field Squadrons, whose task was to lay line in the field and extend the existing facilities of voice and telegraph that had already been created in South Africa to support mining, railways and civilian communications. In 1884, C Troop and the Postal Telegraph Companies amalgamated to form the Telegraph Battalion RE. The RE signallers became skilled in building long telegraph lines. They were aided by the new "air line "system, which consisted of a single wire carried on lightweight poles.

Instruments, such as the Wheatsone Automatic Telegraph managed to clear 6,000 words in 105 minutes. During an action at Bloemfontein, General French, who later commanded the British Expeditionary Force in 1914, controlled his artillery by telegraph. He attributed his victory in part to these good communications.

The Telephone ‘C’ Mark 1, designed by Ericsson’s of Stockholm, was the first portable military telephone. It was used in large numbers in the South African War of 1899-1902 by the Telegraph Battalion RE and became the standard field telephone of the British Army.
Telephone installation

Early telephone instruments were installed in Royal Garrison Artillery fortresses in Britain but it took some time for British officers to accept this new instrument because the early telephones were unreliable and there was no written copy of the message sent. The extensive use of telephones in the latter stages of the Boer war, however, proved their military worth. During the Boer War much use was made of the existing civilian telephones and telephone exchanges, but for field use specially designed telephones and exchanges had to be produced. The ‘C Mark 1’ was the first of a whole family of field telephones to be developed for the British Army.

2.3 Utvecklingen i Sverige

2.3.1 Civil utveckling

Telefonen uppfanns på 1870-talet och var i allmänt bruk i slutet av seklet. Sverige intog tidigt en ledande ställning inom telefonins utveckling och var länge Europas telefontätaste land. År 1892 kom L.M. Ericssons skelettapparat, även kallad *taxen* för sitt utseendes skull. Den officiella beteckningen är: Nr 375/AC 110GPO No 16. Det patent som Ericsson erhöll, avsåg idén att låta de permanentmagneter som behövdes för vevinduktorn, samtidigt utgöra apparatens ben. "Taxen" var världens första bordstelefon med handmikrotelefon, det vill säga hörtelefon och mikrofon i ett stycke. Apparaten blev en omedelbar nationell och internationell framgång för företaget och producerades i över 40 år.

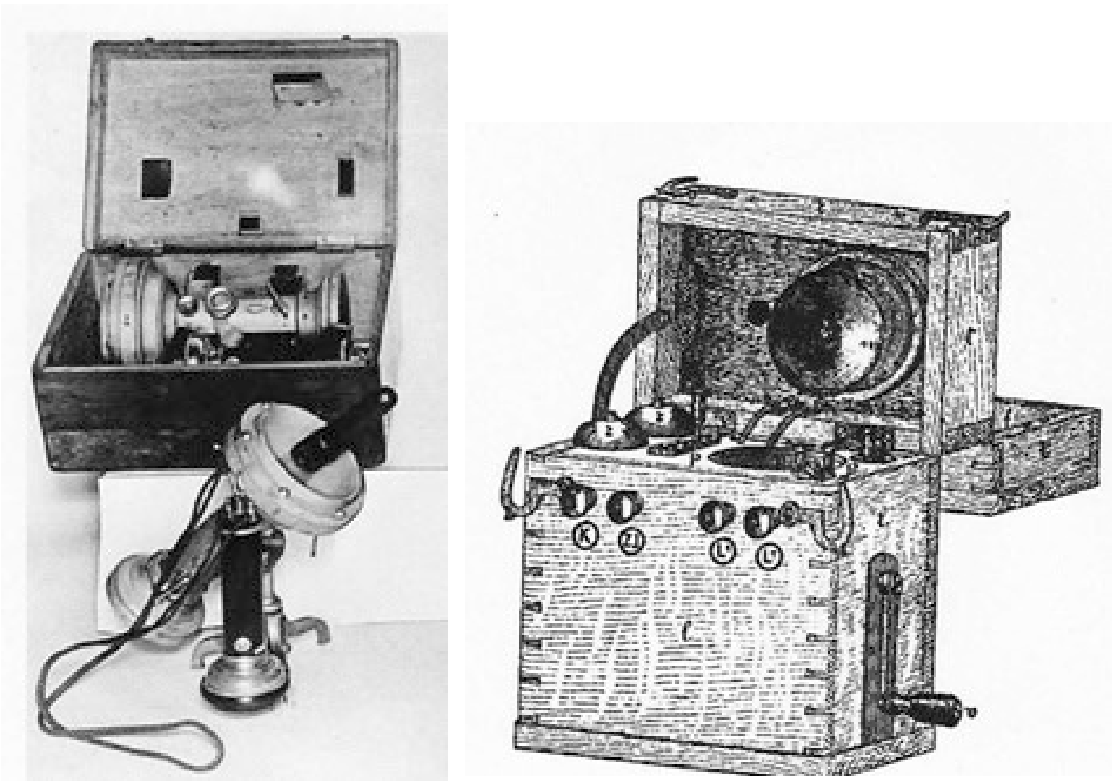
Ericssons ”taxen” från 1892

2.3.2 Telefonen inom det svenska försvaret

Fältsignalkompaniets första telefonapparat infördes i armén 1880. Det var en stor Bell telefon med särskilt bordsstativ – ja även golv- (mark-) stativ medfördes, enligt uppgift fullständigt unik i världen. Bell telefon med hästskomagnet användes för såväl tal som för att höra uti. För uppkallning fanns en signalpipa (trumpet) som placerades i telefonlockets hål. Vid anrop blåstes i denna pipa. Som hörtelefon tillkom snart en mindre Bell telefon, seriekopplad till taltelefonen och tillsammans med denna vid transport förvarad i en trälåda. År 1886 infördes en jämte pipa i läderfodral förvarad felsökningstelefon, likartad med nyssnämnda hörtelefon, men använd även som taltelefon. Dessa första telefoner synas ha använts utan batteri och hade liten räckvidd. Som komplettering till felsökningsstationen infördes en polariserad ringklocka, huvudsakligast för förbindelse med permanenta telefonnätet.

Fälttelefon m/1887
Telefonapparat m/1887. Den första verkliga telefonapparaten tillkom 1887, varvid mikrofon kom till användning, placerad i en uppfällbar del av apparatlådan, vilken i övrigt hade ett fack för hörtelefon av belltyp och inrymde signalinduktor och polariserad ringklocka.

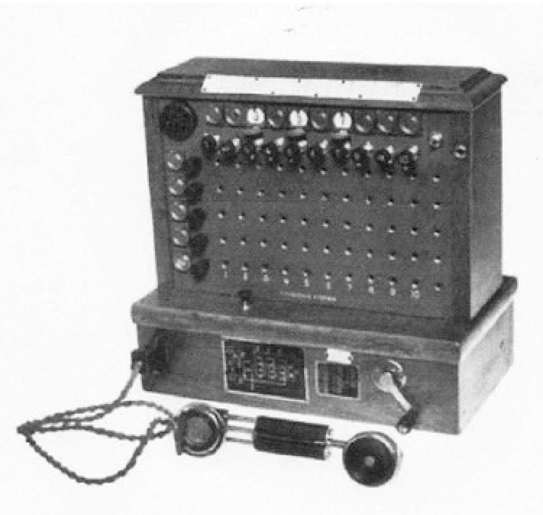
Signalinrättningens ändamål är att frambringa klocksignaler. Den består av ett avsändnings-instrument, signalinduktorn, och ett mottagningsinstrument, väckverket. Tal- och hörinrättningens ändamål är att förmedla samtal. Den utgöres av avsändningsinstrument, mikrofonen, med en ruhmkorffsrulle och ett batteri, samt ett mottagningsinstrument, handtelefonen. Med undantag av mikrofonen, som är anbragd i locket, och handtelefonen, som jämte signalinduktorns vev vid transport förvaras i lockets fack, äro dessa instrument fästade på en plint, som täcker övre öppningen av lådan.



Telefonapparat m/1887 och lådtelefon m/98

Den första kompletta lådtelefonen (m/98) fastställdes 1898. Den hade mikrofon, placerad i rörlig klyka, vilken i obelastat läge slöt batteriströmkretsen och bortkopplade ringinrättningen. Apparaten hade två inbyggda torrelement som mikrofonströmkälla. Den kompletterades senare med vibrator för ljudtelegrafering med tonfrekvent ström på linjen och blev i detta skick använd ända fram till omkring 1920.

Den första lättbetjänade telefonväxeln, växelskåp m/04, med flyttbara proppar, inbyggd signalinduktor och utförd för dubbelledningar, innebar ett stort framsteg för telefontjänsten vid arméfördelnings- och armékvarter. Först tillkom den mindre typen för 10 ledningar och senare den större för 20 ledningar.




10-linjers telefonväxel m/04. (Bild ur Svensk armémtrl under 350 år) och Telefonapp m/05

Arbetet på att förbättra telefoneringen pågick under 1900-talets första decennier, och då tillkom telefonapparat m/05, ofta benämnd lådtelefonen. Den var konstruerad av L M Ericsson i samråd med fälttelegrafofficerare och måste betraktas som en mycket lyckad stabs och expeditionsapparat. Dess yttre var lik telefonapparat m/1898, men den hade fast klyka och en tangent i mikrofonhandtaget. Apparaten försågs med vibrator (summer-) anordning främst för ljudtelegrafering, då förbindelser med telefon ej var möjlig. Telefonapparat m/05 var den förhärskande telefonapparaten vid signaltrupperna tills fälttelefon m/37 infördes.

Den första lättbetjänade telefonväxeln, växelskåp m/04, med flyttbara proppar, inbyggd signalinduktor och utförd för dubbelledningar, innebar ett stort framsteg för telefontjänsten vid arméfördelnings- och armékvarter. Först tillkom den mindre typen för 10 ledningar och senare den större för 20 ledningar.

2.4 Jämförelse av utvecklingen i omvärlden och i Sverige

Kort tid efter att Bell demonstrerat telefonen påbörjades försök för att använda telefonen i militära sammanhang. Den användes av England vid de militära kampanjerna i Indien och Afrika under senare delen av 1880 talet och tidigt 1890 tal. I USA användes den för att koppla ihop förband och staber med telefonlinjer. Den användes också för eldledning inom fast kustartilleri. Under de första åren användes kommersiellt utvecklade telefoner.

Den första fälttelefonen i USA utvecklades 1889 men kom på grund av kostnad ej att massproduceras.

Den första utvecklade fälttelefonen användes av England under det andra Boerkriget 1899 - 1902. Telefonerna som användes var konstruerade av Ericsson.

Det stora genombrottet för telefonen kom först under första världskriget.

Det svenska försvaret var mycket tidigt med att utnyttja telefonen. Fältsignalkompaniets första telefonapparat infördes i armén 1880. Det var en stor Belltelefon med särskilt bordsstativ – ja även golv- (mark-) stativ medfördes, enligt uppgift fullständigt unik i världen.

Ericsson kom tidigt att vara en ledande leverantör av fälttelefonmateriel på den internationella marknaden. Ericsson var verksamma inom militär telekommunikation på världsmarknaden ända in på början av 2000 talet.

I FHT dokumentation finns ytterligare information om utvecklingen i Sverige i dokumentet:
En sammanställning över Arméns telefonmateriel från 1870 till 1970-talet
(6,2 MB) Författare: Sven Bertilsson

3 Radiotelegrafi

3.1 Utveckling och introduktion

The 1901 edition of J. J. Fahie's A History of Wireless Telegraphy reviewed in detail the development of pre-radio wireless technologies, up through Guglielmo Marconi's groundbreaking radio work. In 1917, Donald McNicol wrote about the importance of documenting radio's "historical narrative", noting: "I believe it to be the duty of those acquainted with views and facts of its introduction to set [the most illuminating essentials] down for the inspection of the ultimate historian". McNicol's overview of The Early Days of Radio in America, from the April, 1917 issue of *The Electrical Experimenter*, covered significant events, articles, books and individuals during the period from 1896 through 1904, this time beginning with Guglielmo Marconi's demonstrations in Great Britain. (Included in this article are links to twenty-four items mentioned in the review.) In the June, 1917 *Proceedings of the Institute of Radio Engineers*, Robert H. Marriott comprehensively reviewed technical advances plus the struggles and character flaws encountered during early United States Radio Development. Five years later, with a "broadcast boom" spreading across the nation, Professor J. H. Morecroft reviewed What Everyone Should Know About Radio History, a two-part series that ran in *Radio Broadcast*, beginning with its July 1922 issue. The transformation of radio, from scientific curiosity to a practical communications technology, was due to incremental improvements in a variety of areas. H. Winfield Secor traced the history of Radio Detector Development in the January 1917 issue of *The Electrical Experimenter*, starting with the micrometer spark gap used by Heinrich Hertz, followed by various magnetic, electrolytic, and crystal detectors, and finally the very important improvements in three-electrode vacuum tubes.

One of Marconi's most important discoveries was of "groundwave" radio signals, which resulted from adding a ground connection to the transmitter and led to greatly increased transmission ranges. One reason this occurred was because "earthing" the transmitter antenna resulted in the radio signals using the ground as a waveguide, meaning the signals followed the earth's plane, and thus spread out in only two dimensions, unlike a free-space transmission like light, which dispersed in three dimensions. This in turn meant that groundwave signal strength tended to drop inversely with the distance covered, instead of the square of the distance, which was the case for free-space signals. However, it was a few years before groundwave radio signals were fully understood. At the 1904 International Electrical Congress in Saint Louis, Missouri, gifted mathematician John Stone Stone presented a paper designed to provide a rigorous mathematical foundation describing radio transmissions. However, he made one significant error, by stating that signal strength tended to fall off with the square of the distance traveled. In the discussion of the paper, Lee DeForest, who had worked extensively with commercial systems, tentatively noted that in his experience signals did not weaken that quickly, although his own lack of precise measurements still left the issue somewhat in doubt -The Theory of Wireless Telegraphy (groundwave extract).

3.2 Radiotelegrafi i militära tillämpningar

3.2.1 United States Government Activities

The U.S. Navy quickly recognized radio's potential. Following successful tests by Great Britain and Italy, the Navy Department's 1899 annual report noted that Marconi equipment would soon be evaluated, "in order to determine its usefulness under service conditions".

These tests quickly convinced the Navy of the value of radio, and three years later R. B. Bradford, Chief of the Bureau of Equipment, reported that "There is no navy, so far as the Bureau is aware, which has not given especial attention to this subject". The U.S. Navy began to equip its entire fleet with transmitters, and also set up an extensive chain of coastal stations. Radio was also employed as an aid to civilian and military navigation, beginning with time signals broadcast beginning in 1905: U.S. Navy Department Annual Report Extracts: 1899-1908. The Navy's impact on U.S. radio communications would continue to expand. In 1913, numerous shore stations started to handle commercial traffic in areas where there were no private stations, meanwhile, naval leaders lobbied for a government monopoly of radio transmitters. Finally, in April 1917, with the entrance of the U.S. into World War One, the government, led by the Navy, took over control of all radio communications for the duration of the conflict:

The Wireless Radiotelegraf at Sea

Marconi formed The Wireless Telegraph and Signal Company in 1897, having been granted British Patent number 12039 entitled ‘Improvements in Transmitting Electrical impulses and Signals, and in Apparatus therefor’, this being the first patent for a radio-wave based communication system.

In May 1897, Marconi sent the first ever wireless communication over open sea when a signal was transmitted from Flat Holm Island (in the Bristol Channel) to Lavernock Point in Penarth in the Vale of Glamorgan. The message, which had travelled 3.7 miles, simply read “Are you ready?”

In July of 1897, Marconi successfully communicated from the naval dockyard in La Spezia, Italy to the armoured cruiser San Martino which was 11 miles away at sea. The equipment consisted of a spark gap transmitter, a wire antenna and 250 watts of power provided by a battery. Whenever the key was pressed, the result was an unmusical note similar to the background atmospherics over a very broad band of frequencies. There was no way to measure wavelength and tuning was in its infancy. The frequency of transmission was therefore dependent on the size and configuration of the aerial. As a result, there was only one wireless channel as the electromagnetic energy leaving the antenna would cover an extremely wide frequency band.

The receiver consisted of a similar aerial and the use of a "coherer" which detected EM waves. A battery operated circuit then operated a telegraph "inker" which displayed the signal visually on tape. There was no means of tuning the receiver except to make the aerial the same size as that of the transmitter. It could not distinguish between atmospherics and signals and if two stations transmitted at once, the result was a jumble of unintelligible marks on the tape.
N By 1899, Marconi was able to operate radio equipment at ranges of 30 miles or more. This demonstration enabled him to raise money and the British Marconi Company was formed. Two years later, an American subsidiary was born and it dominated the British and American marketplace until the formation of the Radio Corporation of America in 1919. Many different sets were being developed for communications, however, Marconi's sets proved to be superior and were by far, the most widely fitted sets on ships. At this stage, it should be noted that the Royal Navy was already looking at three distinctly separate uses for wireless communications.

1899: The first ship-to-shore wireless message in U.S. history is sent by Lightship No. 70 to a coastal receiving station at the Cliff House in San Francisco.

"Sherman is sighted," the message said, referring to the troopship Sherman, which was returning a San Francisco regiment from the battlefields of the Spanish-American War. It marked the first use outside England of this technology, still in its infancy.

Photo: Guglielmo Marconi reads signals on a tape recorder (left) with a 10-inch spark coil used for ship-to-shore radio tests in this 1901 photo. (Associated Press)

By 1875, the US Navy was experimenting with electricity for signaling. There was much excitement the following year when signals were read at a distance of 6 miles by means of an electromagnetic device. The flash lamp, perfected in 1878, permitted signals to be read at the unheard-of distance of nearly 17 miles! Communicators of the day hailed the event with enthusiasm. But it was the advent of "wireless" that gave Naval Communications its real impetus.

With the Nineteenth Century approaching its close, Guglielmo Marconi startled the world by his experiments with wireless. He was invited to experiment under Navy supervision. As early as 1900 the young inventor and his assistants were installing the "Marconi device" aboard several vessels. In 1901 the Navy made its first wireless installation on a battleship. A year later the first Naval wireless test stations on shore were established at Annapolis, Maryland and Washington, D. C. During 1903, five different systems of wireless were under test in the United States. By the end of that year, the Navy's tests had progressed to the extent that seven ships and five shore stations were fully equipped with wireless apparatus and operators were furnished for service use. Wireless had shed its swaddling clothes and was growing rapidly.

The Navy now demanded that the new equipment be installed on all its fighting ships. Meanwhile, developments ashore kept pace with those at sea. Six experimental stations were built. A special training school was established at the Brooklyn Navy Yard. Wireless - or radio, as it came to be called - was in the Navy to stay. From then on, advance followed advance, keeping pace with technological progress, lessons learned from operational experience, and the needs of the Navy.

Interior of US Naval Wireless Station North Head, Washington, 1907, showing wireless equipment.

3.2.2 Utvecklingen inom Royal Navy

In 1898, tests conducted at Dover with William Henry Preece, Chief Electrical Engineer of the British Post Office, using a transmitter at Fort Burgoyne sought to unravel the theoretical mysteries behind the marvel. Such work demonstrated the welcome advantage of light aerials over heavier wires and the benefits of having the aerials of transmitter and receiver arranged parallel to each other. On 7 May 1898, Commander Hornby observed Marconi successfully signal over at 10 words per minute 14.5 miles from Bournemouth to Alum Bay. Hornby observed that antennae at 30 feet height provided communication over a mile, and that range was proportional to the square of antenna height and that Marconi had conceived of the idea of different tunings to alleviate issues of a channel being monopolized by single sender.

Lieutenant Salwey reported on tests between *Europa*, *Alexandra* and *Juno* during the "Peace Manœuvres" (naval maneuvers) of 1899 in which Marconi personally adjusted the equipment and great results were obtained. The small factors that allowed for such improvements were continually revealing themselves through the person of Marconi, such as the advantage of keeping aerials as well clear as possible from ferrous structures. The process of "tuning" sets to different "notes" is also discussed. Signals were successfully conveyed over sixty miles, as long as only one ship was sending at a time.

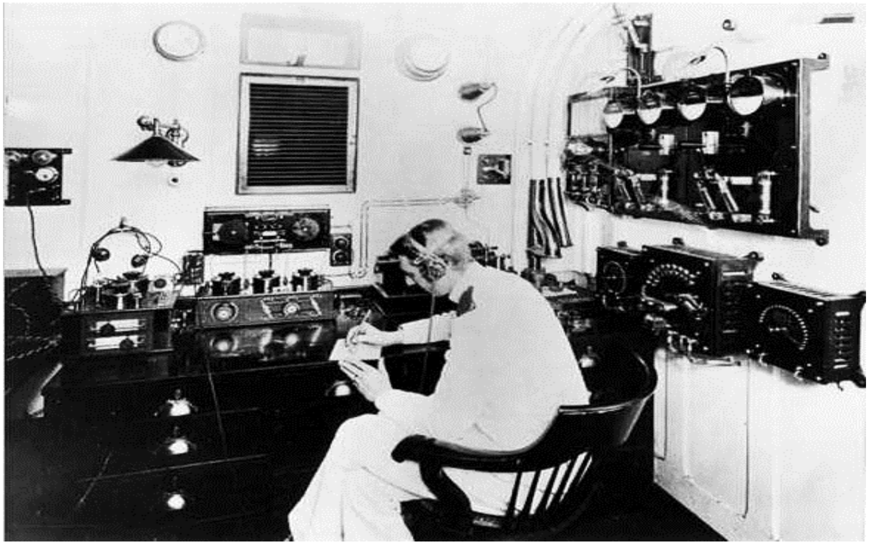
Unlike the other armed services at the start of the First World War all the main navies involved had relatively good wireless services and equipment. The Royal Navy had been installing Marconi equipment since 1899 and by 1905 they had 105 ships fully equipped. Likewise the German Navy were equipped with Siemens equipment, and the French and Russian Navies with Ducretet built systems, all of them based on Marconi's designs.
During the whole of World War One, practically every move that the British, French, or German fleets made was the result of a radio order from their respective war office. England directed the manoeuvres of her fleets from the Marconi station at Carnarvon in Wales; Germany, from Nauen, and France from Paris. Except for one hour each day, Carnarvon transmitted the orders of the British Admiralty to the various ships in a very complex secret code, which was changed daily. To further insure secrecy, the wave length was frequently and suddenly changed. The principal advantage gained in directing fleets wirelessly was that fewer ships could do the work of the many which were formerly required. Before the days of radio telegraphy, ships of a fleet clung together, and orders were either semaphored or carried from ship to ship by fast cruisers. A naval battle line, 200 or 300 miles long, was now quite feasible, while in the days before wireless telegraphy one only a fraction of that length was possible.

The military importance of radio was immediately apparent. In August 1914, the Belgians had to completely destroy a major international communications station located at Laeken, near Brussels. near Brussels, in order to keep it from falling into the hands of the advancing German army. At Laeken Robert Goldschmidt had erected one of the most powerful wireless telegraphic and telephonic stations in the world. This station was constructed so that direct wireless communication might be held between Brussels and Boma, the capital of the Congo State, a distance of about 4,000 miles. After trials extending over two years, Goldschmidt succeeded in establishing communication with Boma three or four months before the declaration of war.

The antennae were entirely destroyed with explosives, but the transmitting and receiving station were situated in a tunnel under the Vilvorde Road, between the Willebroeck Canal and the aerial site. It was only possible to carry away some of the light instruments but the remainder had to be destroyed. The most delicate parts were broken up with hammers, and to complete the destruction the station was blown up with dynamite. Finally, so that even the ruins could not be put to any possible use, the station was filled with straw and hay and set on fire. A dense smoke rose from the tunnel. It was seen rising over the canal until the evening, and the last bursts of flame were not extinguished when a detachment of the enemy's cavalry appeared on the scene.

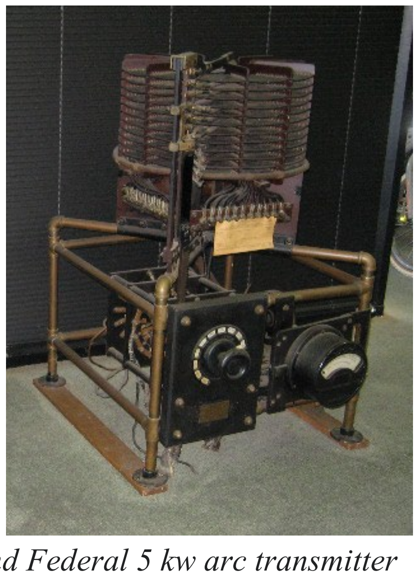
In 1914 the sea-going equipment was still simple, but the system was practical, reliable, trusted and would soon be battle tested. Most of the equipment was still based around spark transmitters and crystal sets using the Low frequency and Medium frequency bands, but the Royal Navy already had 15 years' experience and had developed tactics and operations based around it use.

The first use was to communicate from ship to ship with special emphasis on scouting and reporting on the position of the enemy. During the annual manoeuvres of 1899 and 1900, the value of wireless in this role was clearly demonstrated. As more and more equipment was installed aboard ships, the problem of mutual interference became critical as the sets lacked selectivity. The problem posed by the interception of messages by other than the intended addressee was soon recognized with the attendant requirement to use some form of secret code. These problems still exist today even with the proliferation of radio channels and the adoption of high speed fully automatic encryption systems.



RMS Olympic Radio Room, c. 1912 (MWT)

Photographs of WW1 Royal Navy Installations are difficult to find - but Marconi shipboard installations were fairly standard between RN and Civilian vessels.

Marconi Marine receiver, c. 1916 (MWT) and Federal 5 kw arc transmitter

3.2.3 Wireless Operator Training

At the outbreak of war, despite having much equipment installed, the Royal Navy was in reality desperately short of trained wireless operators. In 1914, as merchant ships reached port, the civilian Marconi wireless operators were taken off and transferred to the Royal Navy. But this, while providing experienced men for the Fleet, in turn created a critical shortage in the Merchant Navy. The deficit was made all the more acute by the need to provide a much greater number of ships with wireless apparatus, as until 1914 only ships of more than 1,600 tons carried wireless and these for the most part had only one operator who could not maintain 24-hour operation and cover.

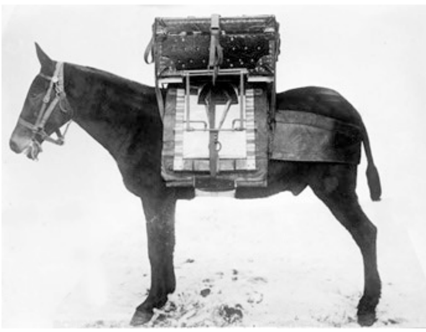
Trained wireless operators were now in great demand. For some time, Marconi's had been stimulating the interest of wireless amateurs by offering prizes for competitors in Morse code examinations and by making Morse practice sets available. The Marconi Company's head of training was seconded to the War Office to organize an army wireless school at Crystal Palace, but the company was also expected to provide all the forces and branches of supply with the operators and instructors required.

Now the Company's offices opened day and night, enrolling new recruits, instructing them on the art of wireless and examining them in Morse code. At the start of the war the Company undertook to find a further 2,000 operators to augment the 3,000 already serving on merchant ships. Purpose built classrooms at King's College and Birkbeck College were made available to ease the overload of trainees from Marconi House in London.

So great was the demand, that some of the pupils and enrolled scholars were as young as sixteen. The staff at Marconi House 'worked to the limits of their power and to the last ounce of their energy to meet the great emergency'.

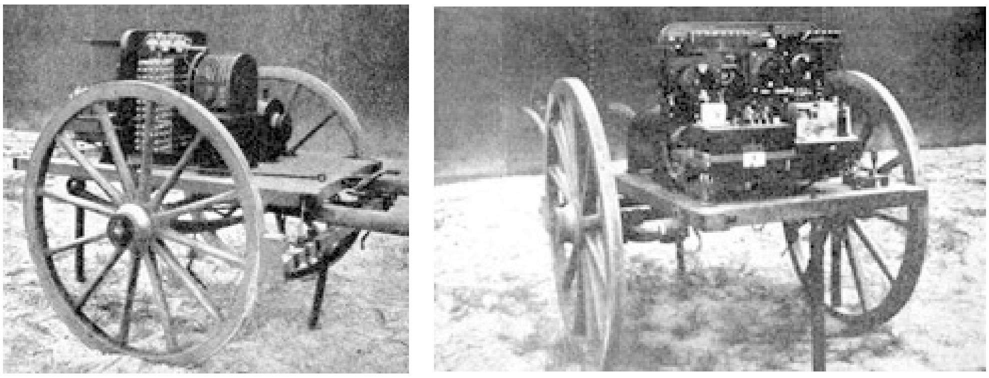
3.2.4 Early Radio Equipment, U.S. Army Signal Corps

Pack horse used by U.S. Army Signal Corps, carrying chest of instruments for local outfit for wireless telegraph. The United States Army Signal Corps develops, tests, provides, and manages communications and information systems support for the command and control of combined arms forces. It was established in 1860 and has had an important role from the American Civil War through the current day. Over its history, it had the initial responsibility for a number of functions and new technologies that are currently managed by other organizations, including military intelligence, weather forecasting, and aviation. The electric telegraph, in addition to visual signaling, became a Signal Corps responsibility in 1867. Within 12 years, the Corps had constructed, and was maintaining and operating, some 4,000 miles of telegraph lines along the country's western frontier. This photograph was taken in 1916 from the Bain News Service, one of the USA's earliest news picture libraries.

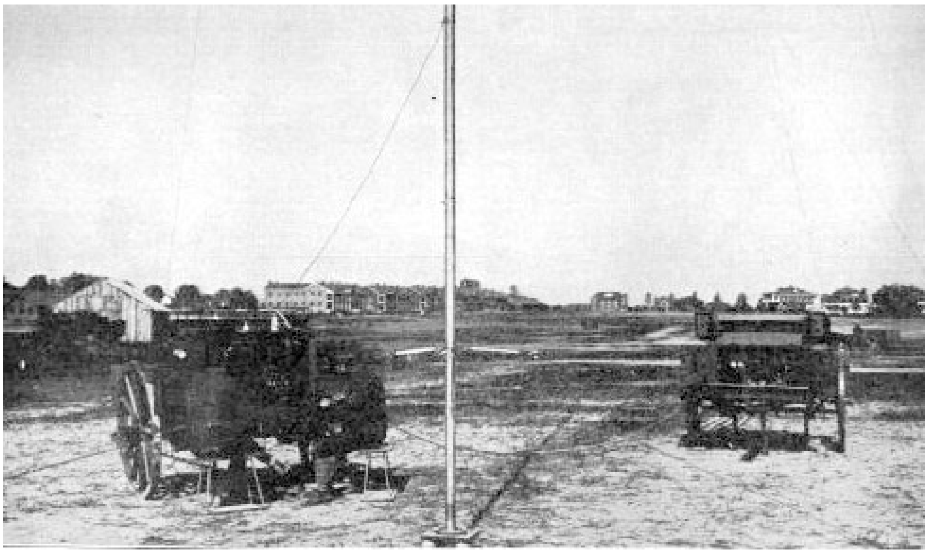


Horse in the Wagon Wireless Section

Drill Regulations for Field Companies of the Signal Corps (Provisional), 1911, (Photographs are from the 1912 edition of Alfred P. Morgan's Wireless Telegraphy and Telephony Simply Explained).



Telefunken wireless cart for military service showing transmitter (left) and receiving (right) apparatus.



Telefunken wireless wagon set in operation at Fort Leavenworth, Kansas.
The aerial is of the umbrella type supported by a steel pole on a porcelain base.

The wagon wireless section is normally composed of 18 mounted men, the wagoner and engineer, who ride on the wagon, and one wagon wireless set, drawn by 4 mules.

The mounted men are formed in column of fours, except one man who rides in rear of the wagon. At drills and ceremonies he will ride on the left of the leading team.

The chief of section is to the right of the leading four and the wagon is 2 yards in rear of the mounted men. When the section is acting alone the chief of section may go where his services are most needed.

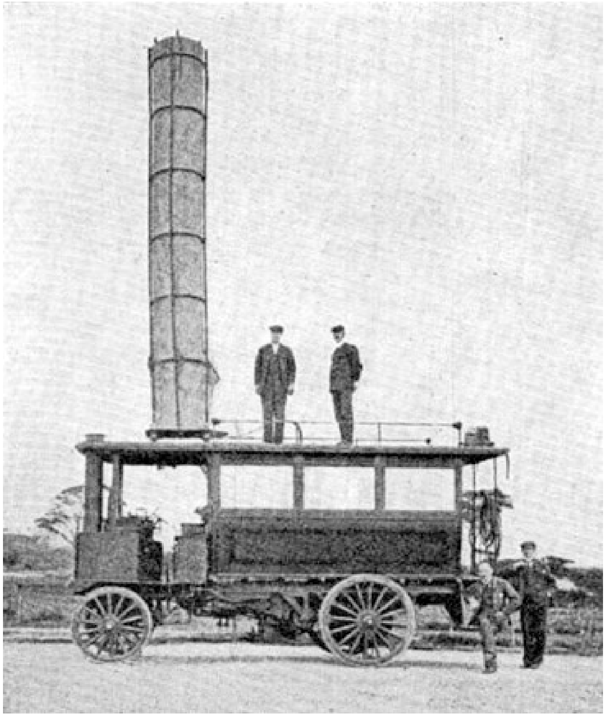
In forming fours a noncommissioned officer will be No. 1 of the leading four, and the horse holders will be No. 4 of the leading four and the third four.

The wagon wireless set consists, briefly, of a pintle-type wagon, drawn by 4 mules. The telegraph instruments are attached to the front element, and the engine and dynamo are attached to the rear element, and electrically connected with the instruments by cable. On the rear vehicle are also carried the mast, consisting of 10 sections 8 feet in length; the antenna, which has nine cords, one of which is the connecting cord; two sets of guy ropes, four to each set; and the rubber insulated wire counterpoise, consisting of eight branches.

The section is maneuvered as prescribed for the company mounted, and by similar commands.

The mounted men, except the chief of section, are numbered from 1 to 17 for the purpose of prescribing their duties in opening and closing station: Thus, Nos. 1, 2, 3, and 4 are antenna men, Nos. 5, 6, 7, and 8 are guy men, Nos. 9 and 10 (usually noncommissioned officers) direct the antenna men and guy men during the erection of the mast, Nos. 11, 12, and 13 assemble and raise the mast, Nos. 14 and 15 lay out the counterpoise and assist the engineer, and Nos. 16 and 17 are horse holders.

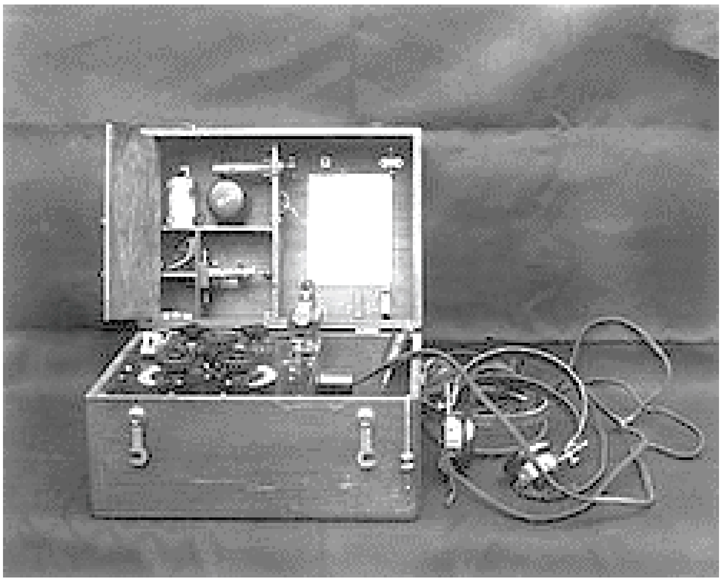
In the accompanying illustration is shown a portable outfit for wireless telegraphy, designed by Mr. Marconi and especially adapted for military requirements. It is an outgrowth of experience in the South African war and is described by an English correspondent of the Scientific American, to which journal the Western Electrician is indebted for the particulars here given. For some time past Marconi has been experimenting with cylinders to act as receivers in lieu of the high wire or antenna. These cylinders have been proved to be more efficacious for the transmission of messages over short distances, than the ordinary apparatus. When the electric currents are excited, the waves at first oscillate very rapidly and violently, but in a few moments the vibrations die down, or become damped, in much the same way as the wire of a piano decreases its vibrations after a note has been struck. It is imperative that these vibrations should be sustained as much as possible, in order to travel over a long distance, and to insure this end there must be a great capacity in the sending instruments. The effect of the cylinder is to render greater capacity than the ordinary aerial wire, and consequently to secure more sustained vibrations.



Military automobile for wireless telegraphy.

The automobile shown in the illustration is the Thorncroft steam-motor car, or lorry, which is now so much used in England for heavy road traffic. The car has a capacity for about five tons and can attain a speed of from 12 to 14 miles an hour with a full load. The rear part of the lorry is fitted up as an operating room, containing instruments and electric batteries. Upon the roof of the car the long cylinder is placed. In the picture the cylinder is shown raised ready for use, but when not required it is laid down flat upon the roof, out of the way. The cylinder is about 25 feet in height. It is constructed of metal and thoroughly insulated. The points from which the currents are transmitted into, and received from, space may be observed at the top of the cylinder, and wires connect them with the instruments below. One special recommendation of this migratory installation is that communication can be maintained while the vehicle is traveling. The maximum distance over which messages can be dispatched and received by means of this installation is 20 miles at present, which is generally sufficient for military purposes. Marconi, however, is still continuing his experiments with a view to increasing this distance. The cylinder is said to perform exactly the same functions as the aerial wire, even in connection with the tuned or synchronized messages. Although Marconi is still continuing his investigations with the cylinders, his principal experiments are still concerned with the perfection of the original system. Although Marconi has found the cylinders to be specially valuable for the transmission of messages over short distances, up to about 30 miles, it has not been found so successful in the case of long distances.

French radio equipment was more advanced than that of the U. S. Army when the United States entered World War I. The U. S. Army therefore adopted French sets early on, and developed improved sets of their own, some based on French design. Several of the French A-1 artillery receiving set were sent to the American radio laboratory in the summer of 1917 and copied with minor modifications. It was first released as the AR-4 in limited numbers for field tests, supervised by Captain Edwin Armstrong. Several changes were made based on his suggestions. The receiver was redesigned and reissued as the SCR-54 (Set, Complete, Radio). Since there was high demand, several companies produced these sets or components, including DeForest Radio Telephone and Telegraph, Liberty Electric, Wireless Specialty Apparatus, Marconi, and General Radio.



SCR-54 radio receiver.

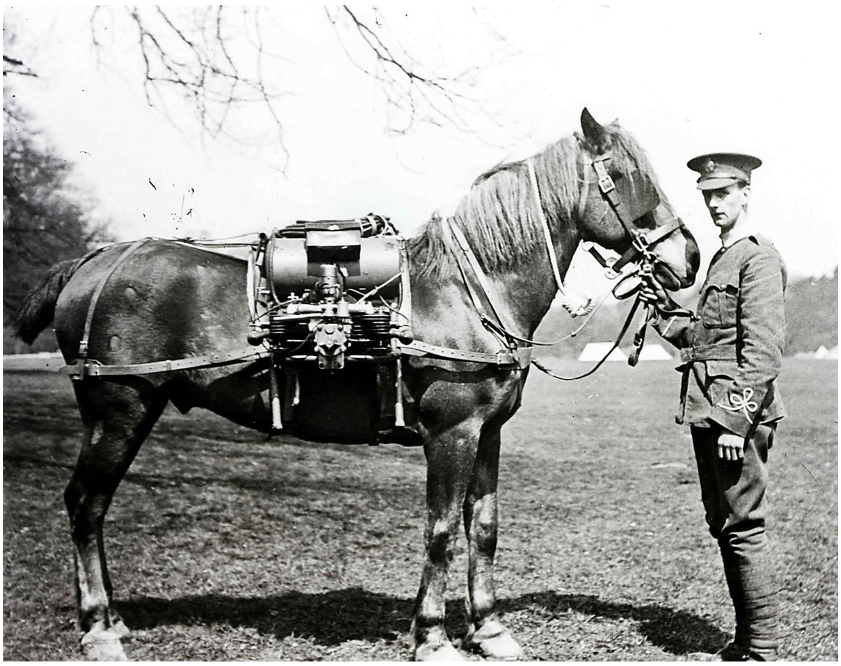
3.2.5 Early radio in Royal signal corps

Wireless

Wireless was not used as an act of war in the Boer War conflict. However, some early equipment was transported to the theatre for testing by Marconi's Wireless Telegraph Company Limited. For this reason the Boer War is often described as the first war that utilised the wireless. Perhaps it is more accurate to say it was the war that realised the potential of the wireless.

No fundamental changes in the techniques of providing signal communications took place during the war in South Africa though undoubtedly it paved the way for the subsequent improvements that were to take place.

Early equipment is on display at the Royal Signals Museum in Dorset.



Cavalry horse wearing a field radio *(BT Archives cat ref: TCB 475/YK 9)*

Major T F Purves, commissioned officer in the Royal Engineers, worked with Post Office engineers to oversee the provision of over 200 items of special telecommunications apparatus. These were adapted to fit the needs of British soldiers in the trenches and ranged from modified cavalry field radios to field communication devices for gun spotters.

Formation of the Royal Engineer Signal Service
In 1912 the Royal Engineer Signal Service was formally recognised (following a plan devised in 1908 for such a service). They provided communications during World War 1. At this time the Dispatch Rider (DR) came into prominence and wireless 'sets' were introduced into service. Wireless communications were provided in France and Flanders and also in the campaigns in Salonika, Palestine and Mesopotamia.

World War 1
At the outbreak of WW1 there were fewer than 6,000 in the Corps forerunner – the Royal Engineer Signals Service – providing mainly a telegraph service. By the end of WW1 there were some 70,000 signalers and telephone had largely replaced the telegraph as the preferred means of communication, with the wireless and dispatch riders playing ever important roles. In 1918, at the Battle of Amiens, trench warfare was largely replaced by the birth of modern warfare. During the war tanks and aeroplanes were used. Motorcycle despatch riders and pigeons were used extensively to relay messages while electricity facilitated communication in the form of telegraphs, telephones, signal lamps, and radio.

This new warfare required increasingly sophisticated communications and ever increasing numbers of soldiers specially trained in communications – thus, in 1920, the Royal Corps of Signals was formed. See Corps History.

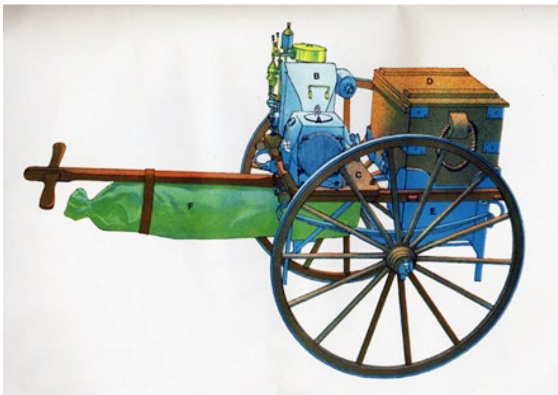
The Wireless War on Land the British Army
At the start of the war the possibilities for wireless telegraphy on the battlefield were hardly recognised by the British Army. Within the army no separate wireless dedicated organisation existed, men from various units were simply detailed to 'attend to' such wireless equipment as existed in addition to their normal duties.

Throughout most of the Great War despite huge strides in technology and equipment the primary means of army battle field communications were still visual, wire telegraph and despatch. Most despatches were either by runner or horseback. But traditional visual signalling techniques soon proved unsuitable for trench warfare as the operator had to show himself to enemy snipers, but the heliograph, flags and lamp still had an important communications role, particularly where the army was moving too quickly to establish a telephone cable network.

In 1915 signalling discs and shutters were introduced which could be operated from cover and read using a periscope. The Telegraph Troop was formed as a mounted unit and horses were used as draft animals until 1937. Dogs were trained to carry messages between trenches and horses, mules and dogs were all used during the war to lay cables. Pigeons have been used to carry messages since the Greeks. The British Army used pigeons to bring back messages from the front line for the entire war. At various periods during the war there were over 20,000 pigeons and 370 'pigeoneers' in the war zone. Very often pigeons were the sole means of communication for the British Army.

In 1912 the Royal Engineer Signal Service had been formed and made responsible for the visual, telegraph, telephone, signal despatch and later wireless communications from HQ down to Brigades and for artillery communications down to Batteries. But at the start of the war senior officers looked upon wireless as possibly a useful adjunct to visual and line signalling, but its main sphere of use was at first confined to communication between fast moving mobile cavalry and their H.Q.

It was the stalemate of trench warfare that started to drive the technology of wireless communication forward, but at the outbreak of WWI the army only had a small number of wireless sets. These were mainly spark transmitters which operated on long wave and were cumbersome, heavy and unreliable. On the day the British Expeditionary Force landed in France, its total self-propelled mobile wireless force consisted of a single lorry fitted with one Marconi wireless transmitter and receiver. By the time of the first Battle of the Marne in September 1914, the force had expanded to just ten units.



Cart "A" and "B" for British Army Portable Wireless Set c. 1911 (MWT)

By 1911 the Marconi Company had already provided the army with a battlefield wireless station by designing two small 'Portable Sets'.

They were called the 'Infantry type' and the 'Cavalry type' sets, and differed from one another only in the details of transport arrangements. The power of the sets was about 4 kW with a range guaranteed 'over ordinary country' around 40 to 50 kilometres. Three wave-lengths are used, 500, 600 and 700 metres but tuning was described as being 'rather approximate'. The transmitting gear used an ordinary petrol engine that drove an alternator direct through a flexible coupling.

The Receiving Gear was the then usual commercial Marconi receiving circuit but offered a Fleming oscillation valve detector. It was stated that designs were complete with a change-over switch-board so that a crystal detector, consisting of a brass plate in contact with a crystal of carborundum could be used as an alternative to the valve.

As the first months of War passed the British Army, like the Navy, would soon place considerable demands upon the Marconi Company in an effort to catch up. In August 1914, the Chief of the Marconi Training School at Broomfield, near Chelmsford, was seconded to the War Office and charged with the organisation of a large-scale training school at the Crystal Palace for the instruction of officers and engineers of the allied forces in the use of wireless in the field. At the same time a Field Station development section at the Marconi New Street Works was reformed as a separate department in order to meet the ever increasing needs of the armies overseas.

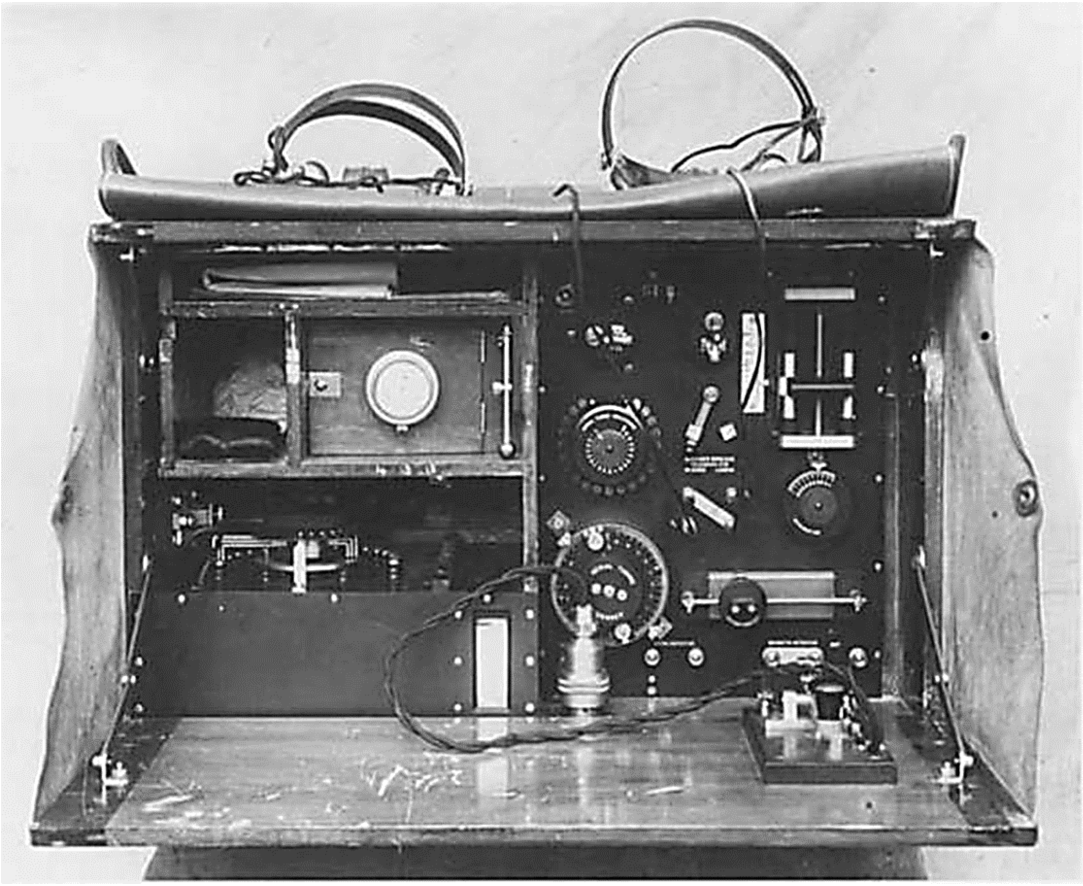
By the second year of the war wireless telegraphy in some form was in use by the practically all the world's military and naval forces. But signals officers and commanders in the field and at headquarters still rarely took into account the possibility of interception or deception. Unfortunately, the lack of really secure ciphers still made wireless transmission risky, careless or rushed operators made it dangerous. If intercepting wire cable telegraph traffic was simple, then with wireless it was almost unavoidable.

Messages were broadcast over the airwaves, and anybody could pick them up. Despite the lack of security, there was still often no alternative to wireless, since it allowed governments to communicate with warships at sea and armies on the move. By October 1915 the war of movement had ended. The advent of trench warfare brought to an end the limited role which wireless telegraphy had so far played.

Instead an urgent new requirement arose. The main Corps H.Q needed to be fully informed, on a continuous basis, about the situation on the front line. This was speedily organised by adopting a relay system consisting of a power Morse code buzzer in the front line feeding to a 50 watt mobile spark transmitting set which in turn was in contact with a 120 watt spark set further back towards base. The ultimate link was a 1.5 kW light motor set which was well within range of H.Q. Much of the output of the Marconi New Street works in Chelmsford was at this time devoted to the provision of such sets.

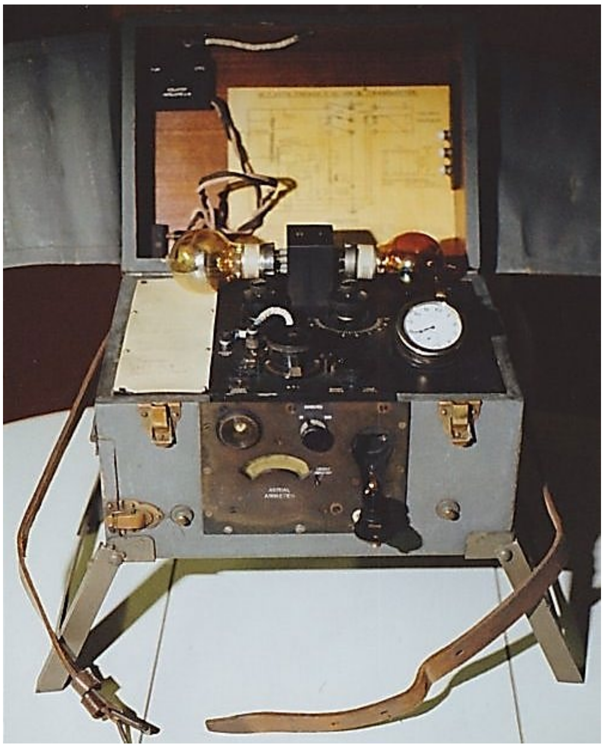
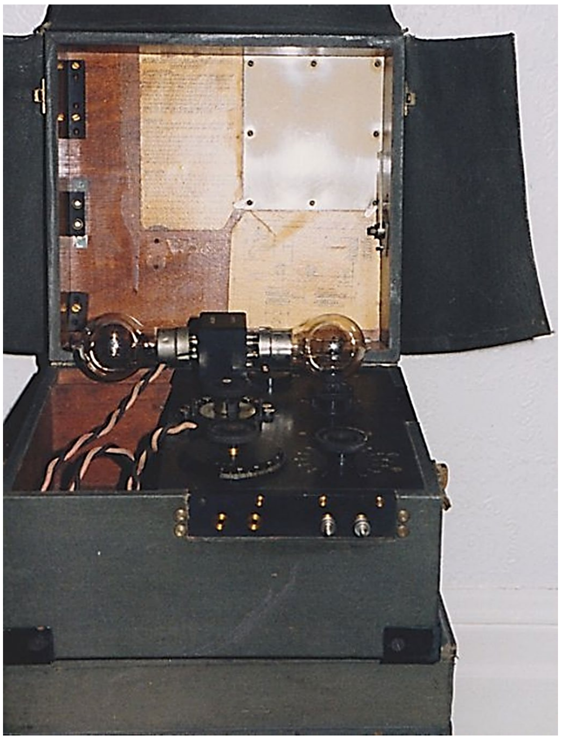
Marconi 1.5 kW Field Set (MWT)

The wagon had two compartments, one for the Wireless equipment and one for the accumulators. These accumulators were either swapped out on location and taken away to be charged at a common central charging station or a mobile Charger came around once a day to each location. During WW1 the British supplied Serbia (then an ally of the UK and France) with the same Marconi Mounted Wireless wagons.



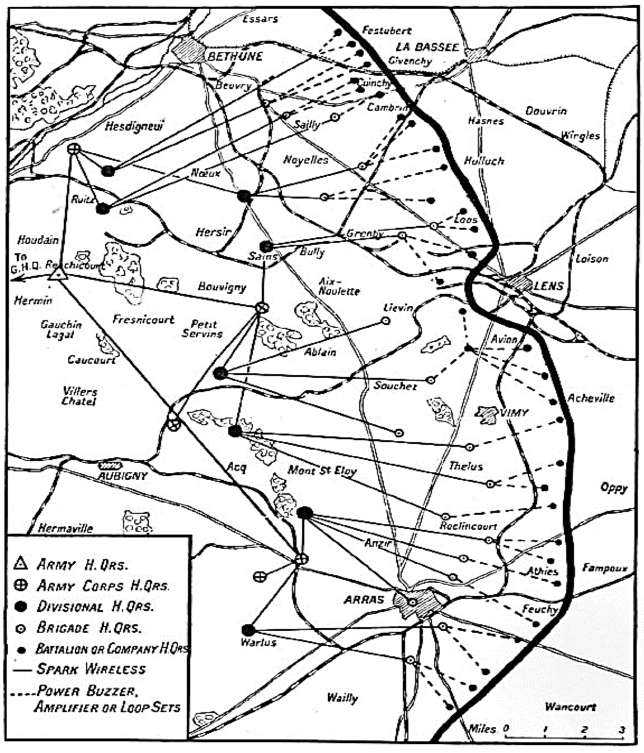
Marconi 1.5 kW Field Set (MWT).

Forward Wireless Station, The Somme, 1916 and Interior of Royal Engineers, British Army forward wireless station, MWT.

1917 W/T Trench Set Transmitter and 1917 W/T Trench Set Receiver.

By 1917 valves had been fitted to the portable ‘Continuous Wave Transmitters and Receivers’ used in the 'Forward Area' trenches. The new Trench Sets had a range of about two miles but still required a 'Volunteer' to go 'over the top' and put up a 100 foot long aerial.



The First Army Front just prior to the Great Offensive in August 1918 showing Wireless telegraphy Positions.

It is highly probable that outside of wireless intercepts, artillery spotting and D/F use that the British Army did not fully utilise the full strengths of wireless communication. But the lessons learnt allowed tactics to be continually honed and improved thus foreshadowing the all-arms strategy (the co-ordination of infantry, artillery and airpower including the use of wireless) on which success in the 100 days from August to November 1918 was based.

3.2.6 Radiotelegrafi inom flyget

The earliest communication with aircraft was by visual signalling ground to air only.

In 1910 events had occurred that were to have a profound effect on military flying and the use of artillery in World War One when Wireless communication first took to the air.

The world's first air-to-ground wireless communication from a heavier-than-air aircraft occurred on 27th August 1910. James A.D. McCurdy, a Canadian aviation pioneer, transmitted a Morse code message to Henry M. Horton, while flying over the Sheepshead Bay race track, in Brooklyn, NY.

In England, less than a month later, a pioneer British aviator called Robert Loraine (1876-1935), who was also a highly successful stage and screen actor for over 30 years, performed the same feat.

On the 27th of September 1910, leaving his role in his West End play to an understudy, Loraine was rushed by the Ministry of Defence to Larkhill, to fly a Farman biplane which was made by the British and Colonial Aeroplane Company in Bristol. A portable Marconi wireless transmitter weighing 14 lbs was attached to the passenger seat and aerial wires were stretched along the breadth and length of the biplane. The Morse key for tapping out the messages was fixed at the airman's left hand. His task as a member of the 'opposing army' in the military exercise procedure was to transmit radio messages from the air near to Stonehenge, by tapping a Morse code key with his left hand, whilst flying the controls with his right. The message simply said, 'enemy in sight' and his signals were successfully received in the 'Bristol' hangar.

Five days later Loraine was able to transmit a wireless signal in excess of one mile, leading the Bristol company to consider the use of aircraft for long-range wireless transmission. Present at the manoeuvres were Lord Roberts, Lord Kitchener and Sir John French. Also present, and particularly interested in the aerial activity was a certain Mr. Winston Churchill, the then Home Secretary.

With these early successes the Marconi Company began experimental work on ground to air and air to ground radio communication, but it quickly proved to be a difficult task.

In 1911, wireless telegraphy was put into operational use in the Italo-Turkish War.
In 1912, the Royal Flying Corps had begun experimenting with "wireless telegraphy" in aircraft. Lieutenant B.T James was a leading pioneer of wireless radio in aircraft. In the spring of 1913, James had begun to experiment with radios in a B.E.2A. James managed to successfully increase the efficiency of wireless radio before he was shot down and killed by anti-aircraft fire on July 13, 1915.

Nonetheless, wireless communication systems in aircraft remained experimental and would take years to successfully develop a practical prototype. The early radios were heavy in weight and were unreliable; additionally, ground forces rarely used radio because signals were easily intercepted and targeted by opposing forces. At the beginning of World War I, aircraft were not typically equipped with wireless equipment. Instead, soldiers used large panel cut outs to distinguish friendly forces. These cut outs could also be used as a directional device to help pilots navigate back to friendly and familiar airfields.

During the first years of the First World War the British Forces had no option but to rely on wireless communication using the crudest of equipment. The first attempts at installing aircraft wireless communication systems consisted of a large and heavy spark set with its batteries mounted in the plane and a massive crystal receiver on the ground.

It was quickly found that in an open cockpit, against the roar of engine, wind and gunfire, it was almost impossible to reliably understand Morse code sent using this equipment or any other. It also seemed to be impossible for the pilot or observer to tune his transmitter and operate a Morse key in an open cockpit, usually strapped to the top of his knee. It became clear that the ability to transmit speech was essential, not only for speed of command, but because the pilot of a single seat plane could not be expected to manoeuvre the aircraft and send Morse code at the same time.

Another problem that beset early installation of wireless in aircraft was where to put the transmitter and battery. Extra items presented a problem for an already cramped cockpit, and the observer had to perch the transmitter on his knee and keep the battery at his feet. All this equipment also left the observer and pilot virtually defenseless.

The other major handicap facing the introduction of wireless into aircraft was the very limited load capacity of the machines and the sheer weight of the wireless apparatus. The installation of wireless in aircraft now required considerable experimentation, original thought and development. The early sets weighed 75 lb (35 Kg) (some early variants 100 lb) and filled the observer’s cockpit (and sometimes most of the pilot’s), while some 250 feet of aerial wire had to be unwound by hand from a spool mounted on the fuselage alongside the observer’s position.

The Royal Flying Corps (RFC) was established in May 1912 and Major Herbert Musgrave was placed in charge of RFC's experiments. In 1896 Musgrave had applied and received a royal commission in the Royal Engineers. Three years later, Lt. Musgrave was sent to South Africa, where he remained throughout the Boer War. Musgrave witnessed the first flight across the English Channel made by Louis Bleriot on 25th July 1909 and he immediately saw the military significance of this event. Musgrave was impressed by the sight of the first aircraft to cross the English Channel and immediately and went to the War Office to explain the possible dangers this invention would pose to Britain's security.

Musgrave proposed the formation of a military aviation service to face this new threat from the sky but his ideas were rejected. Sir William Nicholson, British Chief of General Staff 1908-12, later declared that: 'aviation is a useless and expensive fad advocated by a few individuals whose ideas are unworthy of attention.

Musgrave, continued his campaign for a military aviation service and when it was decided to form the Royal Flying Corps in May 1912, he was seconded from the British Army. At the time, Musgrave was one of only eleven qualified pilots in the RFC.

He was placed in charge of the Royal Flying Corps' experimental projects, including research in ballooning, kiting, photography, meteorology and bomb-dropping. One key area of research was to determine how and if wireless telegraphy could be used by military aircraft.

The creation of a separate Headquarters Wireless Telegraphy Unit (HQ WTU) under his command on 27th September 1914 reflected the importance attached to this work. The growing pressure on wireless was officially recognised by the creation of a dedicated unit No. 9 (Wireless) Squadron, RFC, formed at St. Omer, France, on 8th December 1914, from the HQ WTU. This original unit only lasted for a brief period, its two flights being absorbed into other units early in 1915, and its headquarters disbanded.

Like the British Army, the Royal Flying Corps had still entered the war with a very limited appreciation of the possible roles for wireless communication in wartime. Indeed the use of wireless telegraphy from aircraft to the ground was still widely viewed by the Army as impracticable. Consequently the first RFC units that arrived in France were equipped with only one airborne spark transmitter and one ground based receiver between them. Also, the radios in the aircraft could not receive signals, so the pilots could not be sent any instructions or questions from the ground.

No 9 Squadron, under the command of Musgrave devised a system where pilots could use wireless telegraphy to help the artillery hit specific targets. The aircraft observer carried a wireless set and a map and after identifying the position of an enemy target was able to send messages such as A5, B3, etc. to the artillery commander. Musgrave's 'Zone Call procedure.

By 1915 all the western front maps were 'squared' and a target location could be reported from the air using alphanumeric characters transmitted in Morse code. Batteries were allocated a Zone, typically a quarter of a map sheet, and it was the duty of the RFC signallers on the ground beside the battery command post to pick out calls for fire in their battery's Zone. Once ranging started the airman reported the position of the ranging round using the clock code, the battery adjusted their firing data and fired again, and the process was repeated until the pilot observed a target or close round. The battery commander then decided how much to fire at the target.

At first the results were mixed. Observing artillery fire, even from above, requires training and skill. Within artillery units ground observers received mentoring to develop their skill, this was not available to RFC aircrew. There were undoubtedly some very skilled artillery observers in the RFC, but there were many who were not and there was a tendency for 'optimism bias' and reporting rounds on target that weren't. The procedures were also time consuming.

The ground stations were generally attached to heavy artillery units, such as Royal Garrison Artillery Siege Batteries and were manned by RFC wireless operators. These wireless operators had to fend for themselves as their squadrons were situated some distance away and they were not posted to the battery they were co-located with. This led to concerns as to who had responsibility for them and in November 1916 squadron commanders had to be reminded 'that it is their duty to keep in close touch with the operators attached to their command, and to make all necessary arrangements for supplying them with blankets, clothing, pay, etc'.

Until 1917 the wireless communication was one way as no receiver was mounted in the aircraft and the ground station could not transmit to the pilot.

Crystal Receiver used in aircraft during World War One. Mounting was in a wooden box, with the unit suspended on two rubber bands. Morse code only could be received on this unit.

(Crystal set Receiver, c. 1917 (MWT) and (RFC British wireless transmitter, c. 1915 (MWT).

The Transmitter No 1 was used by the Royal Flying Corps (RFC) on the Western Front for artillery spotting duties. It was first used by the RFC during the battle of Neuve Chapelle in March 1915. It was also used by the British Army in France for artillery cooperation, and in Home Defence for spotting work. Transmitter Type No 1 was a lightweight simple spark gap transmitter assembled into a gas-tight box with its inductance calibrated in wavelengths and inductive coupling provided by a wander plug. The transmitter and Morse key were totally enclosed to prevent the spark igniting petrol vapour in the cockpit. It was usually mounted on a tray on the side of an aircraft's fuselage, and the equipment required a complete overhaul after every flight. The No 1 Transmitter operated on the 100-260 metres wavelength via a 120-foot aerial. Power was provided by a 6-volt accumulator giving a transmitted output of 30/40 watts.

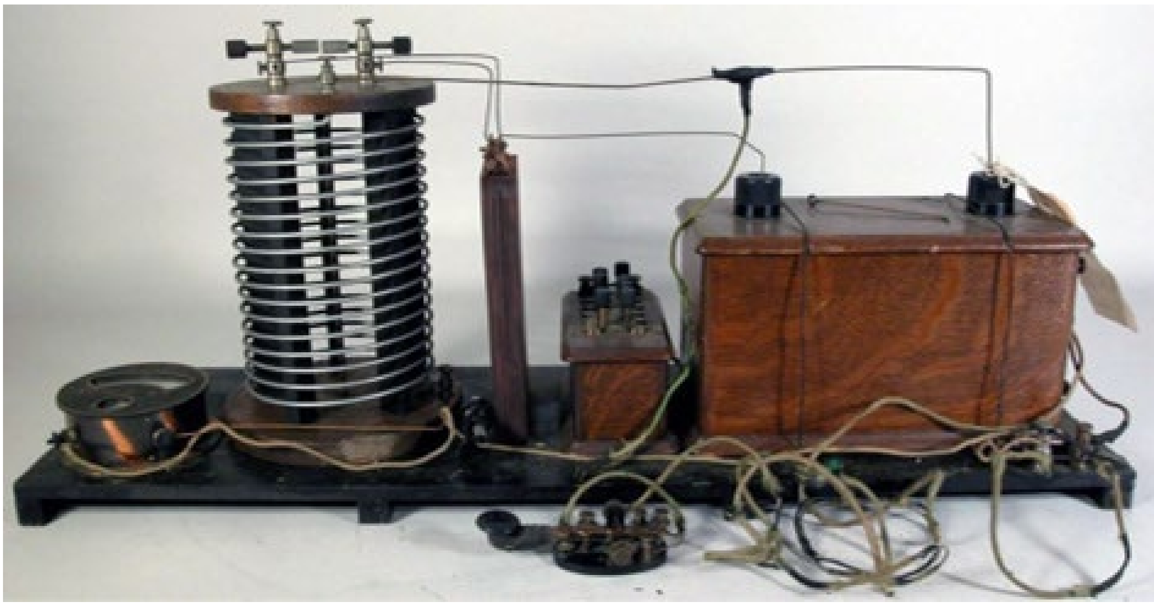
(First World War British W/T Ground Set, c. 1917, to the right)

It was based on a crystal receiver operating on the 120-700 metre waveband of the type used during 1917-1918 by the Royal Flying Corps (RFC) and the fledgling Royal Air Force (RAF). The equipment was used to communicate with night bombers and in training bomber pilots in the United Kingdom: It was also used in artillery spotting duties. The Mark III was retained in service by the RAF into the immediate post-war years.

3.2.7 Development airborne radio in US

First radio signal 1892 (distance 1320ft) sent by Sir William Preece.Then Marconi in 1895 (1 mile), 1901 (3000 miles!!!!) First ground signal received in the air (by British balloon 1905)The first radio in a German Zepplin (LZ 6 in 1909)First radio signal between aeroplane and ground in USA (1910)First British aircraft fitted with a radio 1912.By 1914 signals received over a distance of 100 miles. First British radio message between aircraft 1914 at a range of 10 miles

US First Wireless transmitter



Designed and built by Oscar C. Rosen in 1911, this wireless transmitter is the oldest known surviving example of airborne radio. It was carried aboard a Curtiss aircraft piloted by J.A.D McCurdy. The airplane could not carry the additional weight of Rosen, so the telegraph key was attached to the control wheel, and McCurdy sent the message.

H.M. Horton, a captain, and C.C. Culver, a colonel, both of the Army's newly minted Air Service. At a 1910 air meet in the Sheepshead Bay section of Brooklyn, New York, the two went up in an airplane and sent a radio signal from a transmitter credited to Horton, and the signal was received on the ground by a receiver built by Culver.

Communications through wired telegraph from balloons had already been demonstrated during the Civil War. The next evolution was to show that airplanes of the day could send, and also receive, radio telegraphic messages in flight. After first demonstrating the transmission of messages from an airplane in flight to a grandstand at a race track in New York, young lieutenants began demonstrating the military application of communications technology. In 1911, Lieutenant Benjamin D. Foulois made reconnaissance reports to Signal Corps stations along the Mexican border while in flight. Additionally, in November 1912, Lieutenants Henry H. Arnold, J.O. Mauborgne, and Follett Bradley used radio telegraphy from a Wright Model C Flyer to adjust artillery fires during an air-directed bombing demonstration.

In 1917 AT&T invented the ***first American air-to-ground radio*** transmitter. They tested this device at Langley Field in Virginia and found it was a viable technology. In May 1917, General George Squier of the U.S. Army Signal Corps contacted AT&T to develop an air-to-ground radio with a range of 2,000 yards.

One of the challenges airborne radios confronted was the need for a ground. Radio theory says that energy transmitted by an antenna completes the circuit by returning to the radio through the earth to a conductor referred to as the "ground" wire. Among the best known of the early airborne radio pioneers is an Army lieutenant named Paul W. Beck. By 1911, when Beck conducted an aerial demonstration of a keyed radio transmission with a Western

Wireless Equipment Company set, airplanes were being made of metal parts, and the mass of the parts had become the ground. Problem solved.

The antenna was a 95-foot length of wire made of fine phosphor-bronze strands and weighing just an ounce and a half. At a demonstration in January 1911 near San Francisco, Beck carried aloft a 29-pound cabinet that sat in his lap while he tapped out code with a key on its top. It was likely not the first demonstration of airborne radio, but many accounts credit Beck for the first, possibly because there's a picture of him sitting in a Wright Model B, a dapper, uniformed figure with the big box in his lap and large words on it reading: "Type A-4 Aeroplane Wireless Telegraph Set. Developed By Western Wireless Equipment Co." None of the other pioneers had their picture taken while holding a radio with a big label on it.

The accompanying account in the April 1911 *Journal of Electricity*, Power and Gas, authored by one Earl Ennis, makes the claim of first airborne radio transmission, though he is careful to limit the claim to just that: the transmission. He says that engine noise made it impossible for a radio aboard the airplane to receive the reply.

3.3 Radiotelegrafi inom det svenska försvaret

3.3.1 Armén

I anslutning till första världskriget (1914 - 1918) gjordes de första försöken med radio vid Fälttelegrafkårens radiokompani. Det var med s k gnistradio och kristallmottagare. Stationen ingick i armékårkvarter, undantagsvis i arméfördelningskvarter. De första trevande försöken med radiokommunikation i armén var tagna. Nu var det dags att införa radio även vid truppförbanden En generalplan för anskaffning av radioutrustningar för armén under åren 1927 - 1936 upprättades, vilken fastställdes av riksdagen. Enligt denna skulle en typ radiostation tillverkas för räckvidden 100 km och två stationstyper för räckvidden 50 km 100 km stationen var avsedd för armékår-, arméfördelning- och brigadkvarter, d v s stabssignal-förbanden, stationen skulle bestå av en kärradio avsedd för fördelningskvarter och artilleriet, samt en klövjad för kavalleriets spaningsförband. 50 km-stationen slutligen skulle också utföras i två versioner, en typ för telefoni/telegrafi avsedd för artilleriets eldledning och en typ enbart för telegrafi, som skulle tillföras infanteriet.

Den första utvecklingen av radiostationer i armén kan tillskrivas två personer, Arvid Öman (1896 - 1957) och Hilding Björklund (1897 - 1981). Båda började sin militära verksamhet som laboratorieingenjörer vid fälttelegrafkårens tygverkstäder i början av 1920-talet. Båda var civilingenjörer utexaminerade från Kungliga Tekniska Högskolan i Stockholm. Båda blev civilmilitära tygingenjörer (kaptens tjänsteklass) vid fälttygkåren och armédirektörer då arméingenjörkåren inrättades 1948. Arvid Öman blev armédirektör av 1. graden (överstelöjtnants tjänsteklass) och Hilding Björklund armédirektör av 2. graden (majors tjänsteklass). Han blev armédirektör av 1.graden 1950.

Arméns radiostationer vid denna tid var alla utförda för telegrafi. För artilleriets eldledning var inte telegrafi lämpligt utan man ville använda telefoni. Med utgångspunkt från den ramantenn som fanns till en av de första stationerna som utvecklats 4 vid Kungliga Fälttelegrafkårens Tygverkstäder den bärbara radiostationen (1 W Br m/28) togs en ny radiostation 5 Watts bärbar radiostation m/30 (5 W Br m/30) fram.

Vid denna tid hade mottagare av superheterodyntyp uppfunnits av E H Armstrong.

Experiment skedde vid fälttelegrafkårens verkstäder, arméförvaltningen beslutade dock att beställa utveckling vid Svenska Aktiebolaget Trådlös Telegrafi (SATT).

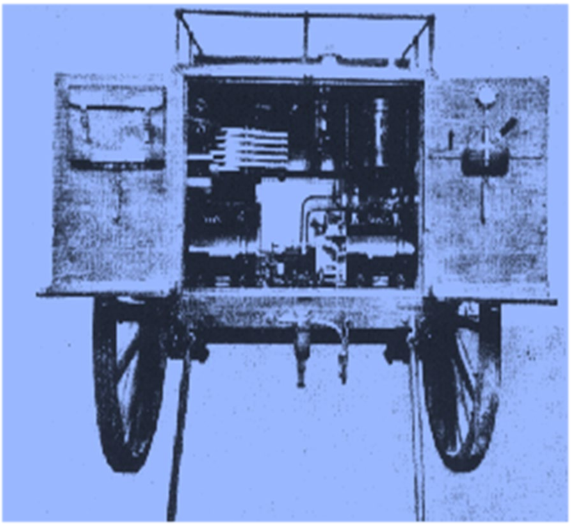
SATT fick tillgång till ramantennkonstruktionen och en beställning på prototyp. Vid leveransprov underkändes stationerna av Elektriska laboratoriet (Ellab). Efter att SATT begärt skiljenämnd som godkände stationen beslutade förvaltningen att leverans skulle ske.

Efter någon månad vid artilleriets signalskola kasserades stationerna. Arméförvaltningen beställde då stationer från fälttelegrafkårens verkstäder. SATT fick några år senare beställning på 3 watts bärbar radiostation (3 W Br m/39) en med beteckning Telefunken SE 499A. Stationen var avsedd för artilleriet med telegrafi utan ton och telefoni.

Med tiden allt bättre elektronrör möjliggjorde att en radio 10W Br m/39 utvecklades. En handgenerator konstruerades, vilken säkerställde stationens strömförsörjning Denna radio kom att tillverkas i flera versioner. Bl a så beställde Finland 200 stycken. 1939 brann alla de finska stationerna upp. För att snabbt kunna komma i gång med tillverkningen anlitades cirka 60 underleverantörer. Ett planeringskontor etablerades, som sammanställningsverkstad användes försvarets verkstäder, där man hade en personalstyrka på 400.

SiS ”Signalverkstäderna i Sundbyberg” var en efterträdare till tidigare verkstäder. När verkstaden och det elektriska laboratoriet brann 1939 var det inför hotet om ett nytt storkrig angeläget att snabbt etablera en ny verkstad. Radio 10W tillverkades i flera versioner. Två bördor, fyra bördor, buren, klövje och cykel. Radio 10W blev grunden till 25W Bl och 25W sv. Med andra rör kunde uteffekten ökas. Stationerna monterades i en metallåda med upphängningsanordning i särskilt stativ. Tillverkningen gick till som för Radio 10W d v s ett flertal industrier, med montering och slutkontroll vid SiS.

Åkande fältradiostation m/17 med gnistsändare och två kristallmottagare



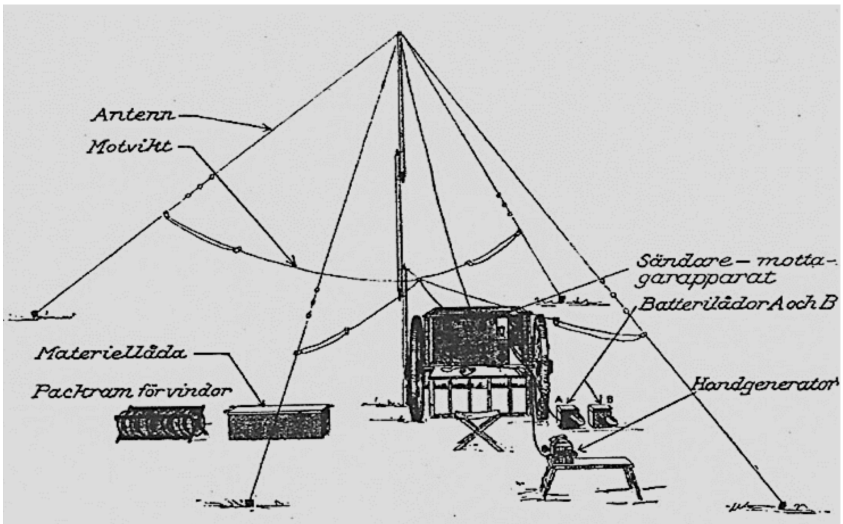
Funktion mm
Försvarsgren: Armén
Militär benämning: Åkande fältradio m/17
Operativ funktion: Samband högre förband
Tidsperiod: 1920 - 30
Tillverkare: Telefunken Tyskland
Trafiktyp: Telegrafi
Teknik sändare: Gnistsändare
Teknik mottagare: Två kristallmottagare som senare ersattes med enkla rörmottagare .
Antennbärare: 24 m teleskopmast för paraplyantenn
Övrigt: 11stycken tillverkades

Tekniska data
Radiosändare: Gnistsändare
Uteffekt: 1,5 kW
Elverk: Motorgenerator 7,5 hk
Drivmedel: Bensin
Fordon: Tre hästanspända vagnar betjänades av 19 man och 14 hästar.

En av de första stationerna som konstruerades och tillverkades i Fälttelegrafkårens verkstäder var 1 Watts bärbar radiostation m/28 (1 W Br m/28)

Tekniska data
Trafiktyp: Telegrafi utan ton (A1)
Frekvens: 3700 kHz - 6070 kHz. Med nio olika kondensatorenheter (1 - 9)
Rörbestyckning: A409 3 stycken. (Arméns typ A 1).
Vid mottagning används alla tre rören
Vid sändning används ett rör, detektorröret som sändarrör.
Strömförsörjning: Anodspännings- och glödspännings-batteri
Tillverkad av: Kungliga Fälttelegrafkårens Tygverkstäder

Kärradio 30 W Kr m/29



Funktion mm
Försvarsgren: Armén
Mil benämning: 30 W kr m/29
Förband: Fälttelegrafkåren och artilleriet
Operativ funktion: Samband
Tidsperiod: 1930 - cirka 1950.talet
Tillverkare: Fälttelegrafkårens verkstad
Trafiktyp: Telegrafi
Antenn: 3 - 4 ledningsstolpar,
2 antennlinor och 4 stagstreck
Konstruerad av: Hilding Björklund

Tekniska data
Radiosändare: KV x – xx MHz
Uteffekt: 30 W
Radiomottagare: xxxxxxxxxxxxxxx
Räckvidd: Cirka 50 km
Teknik: Sändaren 2 st B rör.
Mottagaren 4 A rör
Fordon: Hästanspänd kärra
Elförsörjning: Ett batteri för glödström till sändare och mottagare, ett batteri för anodström till mottagare. Anodström till sändare från generator. Trampdriven generator
Fordon: Hästanspänd kärra

3.3.2 Marinen

I Sverige var det liksom i övriga världen marinen som var först med radiokommunikation. Redan år1899 gjorde flottan försök med gnistapparater och ett par år senare byggdes de första fasta gniststationerna i Karlskrona, Oscar-Fredriksborg och Fårösund. 12.1.1900 föreslog chefen för minavdelningen i en V.P.M. att framställning skulle göras om upphandling av ”ett ställ apparater för signalering utan tråd enligt Marconis system” Efter ett antal sonderingar med olika leverantörer tecknade marinförvaltningen den 8.2.1901 kontrakt med AEG för leverans av fyra kompletta stationer.

Detta kontrakt blev inledningen till en 20-årig samarbetsperiod mellan marinförvaltning och AEG, som blev ensam leverantör av gnistmateriel till marinen.

De från AEG beställda stationerna levererades på försommaren 1901, och materielen installerades på pansarbåtarna Thor, Oden och Njord samt torpedkryssaren Claes Uggla.

Systematiska försök genomfördes därefter vid kusteskadern, och resultaten från dessa blev bestämmande för marinförvaltningens beslut att redan från 1902 föranstalta om anskaffning och installation i större omfattning.

Då leveranstiden var kort, kunde marinförvaltningen även meddela, att samtliga 1.klass pansarbåtar och torpedkryssare för 1902 års eskaderövningar skulle utrustas med gniststationer.

Samma år påbörjades även de första landbaserade gnistsignalstationerna vid Oscar-Fredriksborg, befästningarna i Fårösund och fortet Kungsholmen. Dessa stationer färdigställdes under 1903 och under 1904 gjordes förbindelseprov bl.a. mellan Fårösund och Oscar-Fredriksborg samt mellan Karlskrona och Tyskland.

Fram till 1907 synes marinförvaltningen varit den enda svenska myndighet, som intresserade sig för ”gnisten" och även utnyttjade densamma. Armén kunde ännu inte använda sig av denna materiel, då den var föga fältmässig, något flygvapen fanns inte och telegrafstyrelsen höll sig fortfarande till de trådbundna kommunikationerna. Införandet av gnistmaterialen medförde även behov av utbildning.

Beträffande själva signalistutbildningen kan omnämnas, att en kurs i ”gnisttelegrafering å Carlskrona beväringseskader” anbefalldes i en Generalorder redan 1902, Behovet av att avdela vissa officerare för gnisttjänsten hade ökat under årens lopp och ”gnistofficerare” förekommer första gången 1907.

Inom marinen fanns två personer som betytt mycket för radions utveckling i Sverige. Charles Leon de Champs föddes i Stockholm 1873, hela hans skolgång kom att inriktas mot Flottan, redan 1893 var han underlöjtnant vid Karlskrona örlogsstation. Sedan följde studier vid Tekniska högskolan i Stockholm med inriktning mot maskinbyggnad och mekanisk teknologi. 1899 tillträdde de Champ en tjänst vid Kungliga Marinförvaltningen.

De Champ medverkade till marinförvaltningens första kontakter med Marconi för att få köpa radiomateriel för svenska flottans räkning. Inledningsvis såg detta lovande ut men inför ett avgörande beslut drog sig Marconis bolag ur affären. Blickarna vändes då mot Berlin och AEG. De Champ var engagerad i alla faser av införandet av "gnisttelegrafin", såväl ombord på flottans fartyg som vid de första landbaserade stationerna. 1928 utnämndes han till Amiral och chef för Karlskrona örlogsstation.

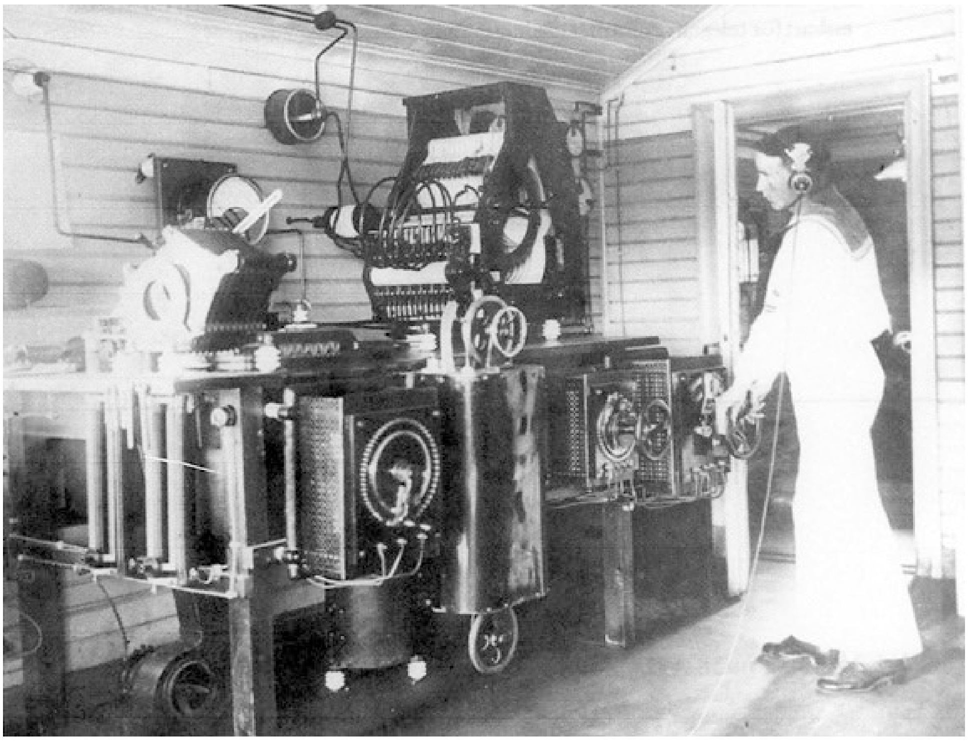
Ragnar Rendahl föddes 14 okt 1878 i Karlstad. Han studerade vid Tekniska högskolan i Stockholm men även i Berlin där han avslutade sina studier 1900. Han fick därefter anställning som laboratorieingenjör hos AEG på avdelningen för trådlös telegrafi och avancerade till chef för laboratoriet 1903. Han kvarstod i denna befattning till 1908 då han värvades över till Kungliga Marinförvaltningen i Stockholm.

Marinen var i början av 1900-talet mitt inne i utrustningen av fartyg och landstationer med radiomateriel där Rendahls stora erfarenhet kom till stor nytta. Rendahls betydelse för utvecklingen av radiotekniken inom marinen är odiskutabel. Ragnar Rendahl kom att bli en av de verkligt stora pionjärerna inom både marin och svensk radiohistoria

Marinen anskaffade successivt i takt med teknikutvecklingen ett relativt stort antal olika typer av radiostationer. Inledningsvis i allt väsentligt inom långvågs- och kortvågsbanden.

Den huvudsakliga leverantören var SRA, SRT och Philips i några fall. Ultrakortvågsmateriel (UK) började på 30-talet att anskaffas. SRA levererade 1932 en station med UK-sändare AK 2T och en mottagare MK 2B. Stationen var avsedd enbart för telegrafi 5 och arbetade inom våglängdsområdet 7 - 8 m.

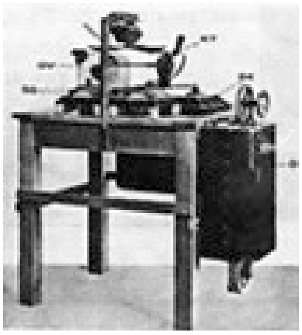
Intresset för den nya ultrakortvågsmaterielen var därmed väckt, och redan i december samma år fick SRA leverera ytterligare 8 sändare och 20 mottagare som följdes av fler beställningar.

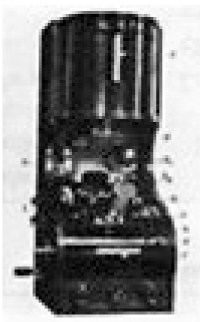


Karlskrona gniststation 1917 belägen på Lindholmen. Personen på bilden är gnistmatrosen Gunnar Ljungkrantz. (Foto från Marinmuseet)

4 kW Tonstation m/15

De första gniststationerna arbetade inom ett relativt begränsat område, våglängd omkring 600 m. Genom införande av tonsändaren märktes en verklig kvalitetshöjning. I tonsändaren kunde våglängden lätt varieras utan besvärliga omkopplingar. Genom att reglera gniststräckorna, så att överslag skedde varje halvperiod, erhölls vid mottagningen en konstant 1000 p/s signal och härav kom benämningen ”tonstation” från tyska ”Tönende Funken”.



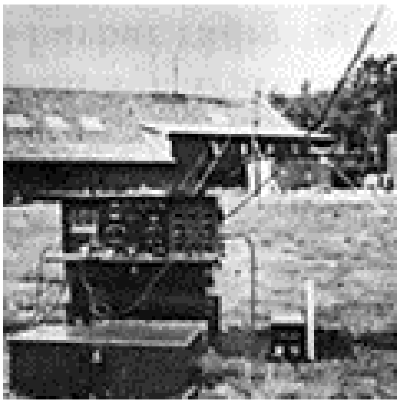


”Gnistbordet” till 4 kW Tonstation m/15 och Mottagare m/15.

Fältradiostation AFT 20/40

För att kunna modernisera radiomaterielen på Fylgia, anmodades SRA att inkomma med anbud på den första större rörsändaren AT 1000VI för 1 kW antenneffekt. Beställning utlades den 19.8.1922.

Ytterligare beställning på 8 stycken flygradiostationer AFT 20/40 utlades på SRA som därmed lade grunden för sin ställning som huvudleverantör av sändarmateriel till marinen och som fortgick till 1939/40.



Fältstation AT 20/40 version 2.

3.3.3 Flyget i Sverige

När radio för samband flyg-mark i Sverige 1916 började utprovas inom arméns- och marinens flygväsende var det gnistradio med telegrafi som gällde. Flygplanens roll vid denna tidpunkt var bland annat att rapportera iakttagelser från flygplan till marken. En mycket viktig funktion var att rapportera artilleriets träffar för att få större träffsäkerhet.

Man använde sig först av brevduvor och olika signalmedel men inget av dessa visade sig vara tillräckligt effektivt.

De svenska militärattachéerna i andra länder rapporterade att radio börjat användas. Detta fick till följd att armén, trots brinnande krig, beställde radiosändare för flygplan från AEG/Telefunken i Tyskland. Den skulle användas vid skjutövningar för artilleriet vid Skillingaryd i Småland juni 1916. Radion kunde inte levereras i tid och med kort varsel användes en flygsändare från AGA i Sverige. Proven blev en enorm framgång där löjtnant Claes von Flemming med en gnistradio installerad i en Albatross kunde telegrafera ned till marken från flygplanet.
Gnistradion fungerade genom att spänningen till en spole (induktans) bröts och slogs till och att ett gnistfält skickades ut från en på flygplanet hängande trådantenn. Genom spolens dimensionering och antennens längd kunde frekvensområdet någorlunda begränsas till långvågsbandet.

Detta var en revolution för sambandet flyg mark och som medgav tidigare oanade möjligheter. Gnistsändarnas bredbandiga utsignal var ett stort störningsproblem. Lösningen av detta har en intressant anknytning till Sverige.

Den svenske civilingenjören Ragnar Rendahl (1878 - 1929) var under några år anställd av AEG i Berlin som förste laboratorieingenjör. Han förbättrade den dåtida gnistsändaren genom att bland annat ersätta det tidigare kul-gnistgapet med en serie av mindre gnistgap i form av plana elektroder. Därmed skedde gnistöverslagen mera regelbundet och kontrollerbart och verkningsgraden höjdes.

Den nya metoden benämndes ”Tönende Löschfunken” därför att signalerna nu lät som en 1000-perioders ton till skillnad mot det råa skrovliga ljudet från sändare med kul-gnistgap. Med denna teknik reducerades störningarna avsevärt.

Ragnar Rendahl flyttade hem till Sverige och anställdes vid Kungl. Marinförvaltningen i Stockholm där han betydde mycket för utvecklingen av radio inom marinen.

Radiomottagarna på marken utgjordes av dåtidens kristallmottagare. Under 1917 kunde de från AEG i Tyskland beställda gnistradiosändarna levereras som fick benämningen Flygradio Fr m/17.

Elektronrör.
Att införa mottagare i flygplan mötte från början stora tekniska svårigheter. Tekniken kunde först endast erbjuda mottagare med detektorer av kristalltyp. De som provat på att få in en radiostation med kristalldetektor inser lätt det stora problem som fanns med att sitta i ett skakigt öppet flygplan och försöka att hitta rätt ställe med nålen mot kristallen.

Radioutvecklingen för samband, mark - flyg hade uti världen accelererats och i USA hade Lee de Forest utvecklat en förstärkare med elektronrör som innebar en revolution för trådlös kommunikation.

Nu kunde även kristalldetektorn ersättas i radiomottagarna genom att en ”förstärkarlampa” nyttjades som detektor. Nu kunde man inom arméflyget börja installera radio med mottagare i flygplanen. 1917, några år efter utvecklingen i USA, beställer arméflyget från AEG de första ljudförstärkarna med leverans och kontroll i Tyskland under 1918, alltså under pågående krig. Det var en låda som skruvades fast på framsidan på Fr m/17. Nu kunde dubbelriktat samband hållas mellan mark och flygplan.

Efterkrigsåren kännetecknades av en neddragning av försvarsanslagen och när flygvapnet bildades 1926 tillfördes flygvapnet från armén och marinen 12 stycken gniststationer m/17 och 20 stycken Fr m/20 som var rörbestyckade samt de bilburna radiostationerna Br m/23 och Br m/25. Sambandet mark-flyg skedde fortfarande med telegrafi på långvågsbandet.

Första radiosambandet Flyg-Mark 1916

Gnistsändare och kristallmottagare.

Allmänt
Försvarsgren: Arméns flygavdelning
Benämning: Radio m/16
Datum: 17 juni 1916
Antal: 1 styck
Plats: Skillingaryd
Operativ funktion: Eldledning flygplan - mark
Trafiktyp: Telegrafi
Tillverkare: Aktiebolaget Gas Ackumulator (AGA***)***
Teknik: Gnistradiosänd Flyg, kristallmott Mark
Övrigt: Försvarets första radiosamband Flyg - Mark

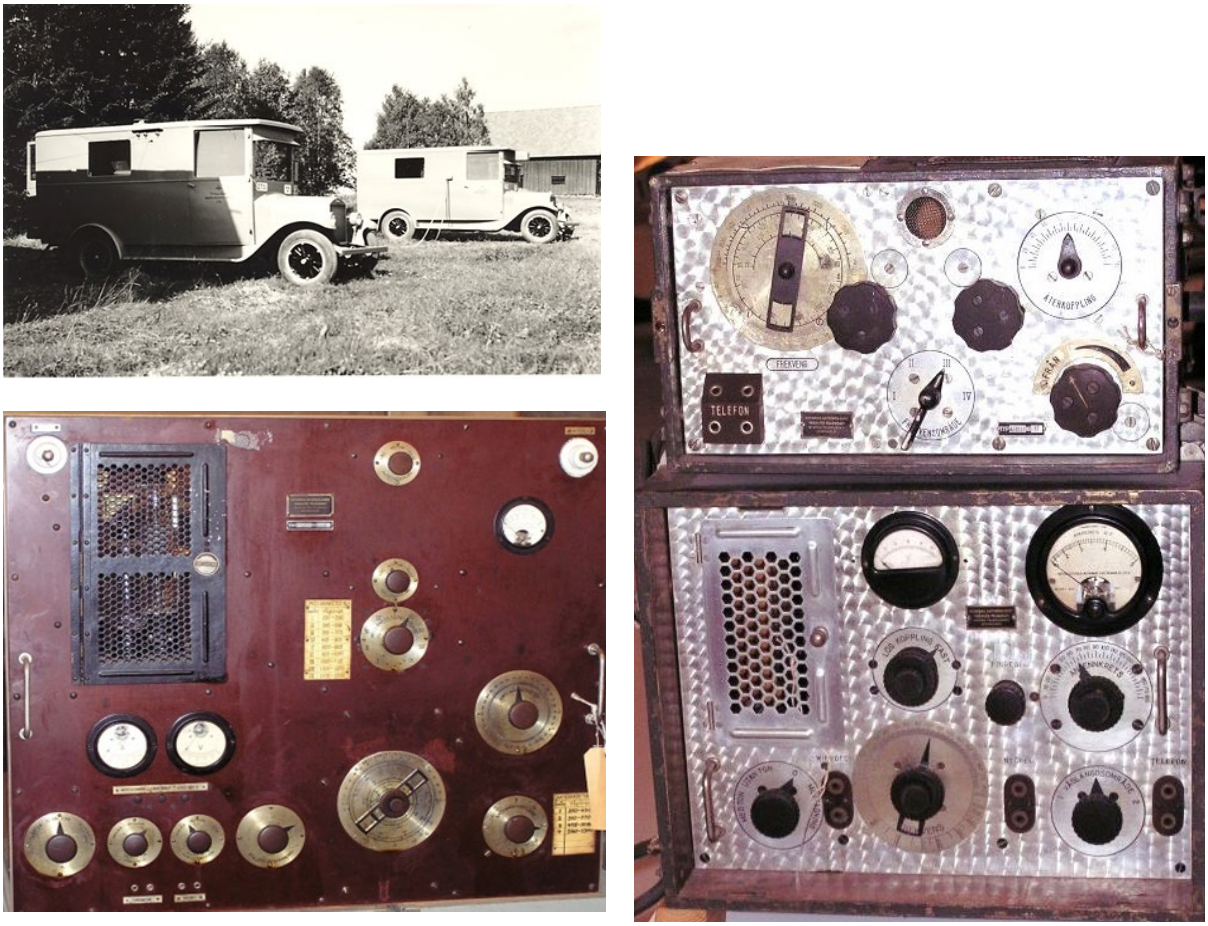
Flygplan Albatross

Tekniska data
Teknik: Radio:Gnistsändare i flygplan. Kristallmottagare mark
Flygplan: Albatross nr 6
Antenn flygplan : Koppartråd
Mottagarplats: Mindre skjul
Frekvens: Långvåg
Elförsörjning: Batteri

Radiosamband Tmr I – VII till Flygradio Fr m/27

Jaktflygplan J 3.

Jaktflygplan J 3. (Fokker C.V.D). Inköptes 1927 och var i operativ funktion till 1931 Beväpning 6,5 mm kulspruta. Fanns även i version S 6 i ett antal av 49 åren 1922 – 1946.

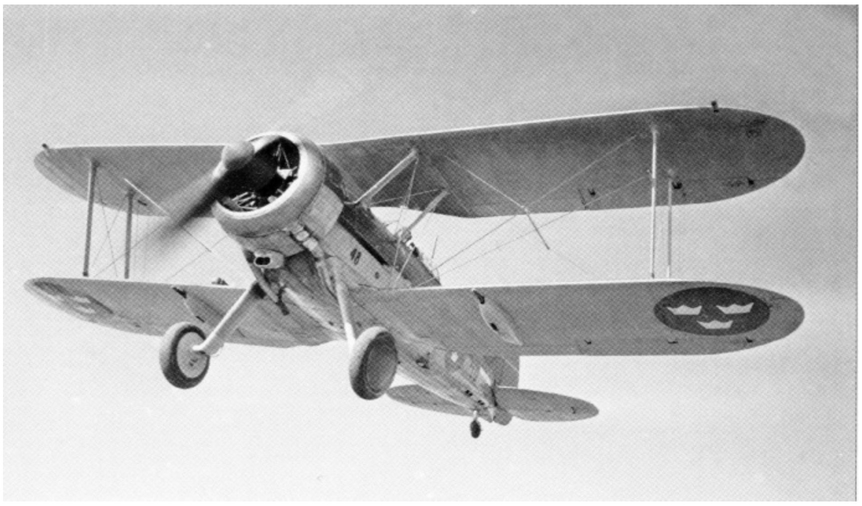


Tmr I – VII med sändare MS 20 och Flygradio FR m/27

Flygradio Fr m/27

- Levererad av SATT med enheter från AEG/telefunken
- Beställd 1927 från SATT
- 1927 - ?
- Cirkaa 15 stycken
- Installerades i Flygplan B1, J3 och J4
- Separat sändare och mottagare som medgav skilda installationsplatser i flygplanet
- Långvågssändare med elektronrör
- Modulation telegrafi utan och med ton A1 och A2
- Frekvensområde sändare 1000 - 414 kHz, mottagre 2500 - 333 kHz
- 5 W antenneffekt
- Räckvidd fpl - fpl 60 km, fpl - mark 160 km
- Strömförsörjning propellerdriven generator
- Vikt 42,9 kg
- Till F5 levererades 4 enheter som rapporterades ha många fel och som åtgärdades av flygskolans radioverkstad till en kostnad av 11,50 kr.

Radiosamband Tmr – VIII till Flygradio Fr-III



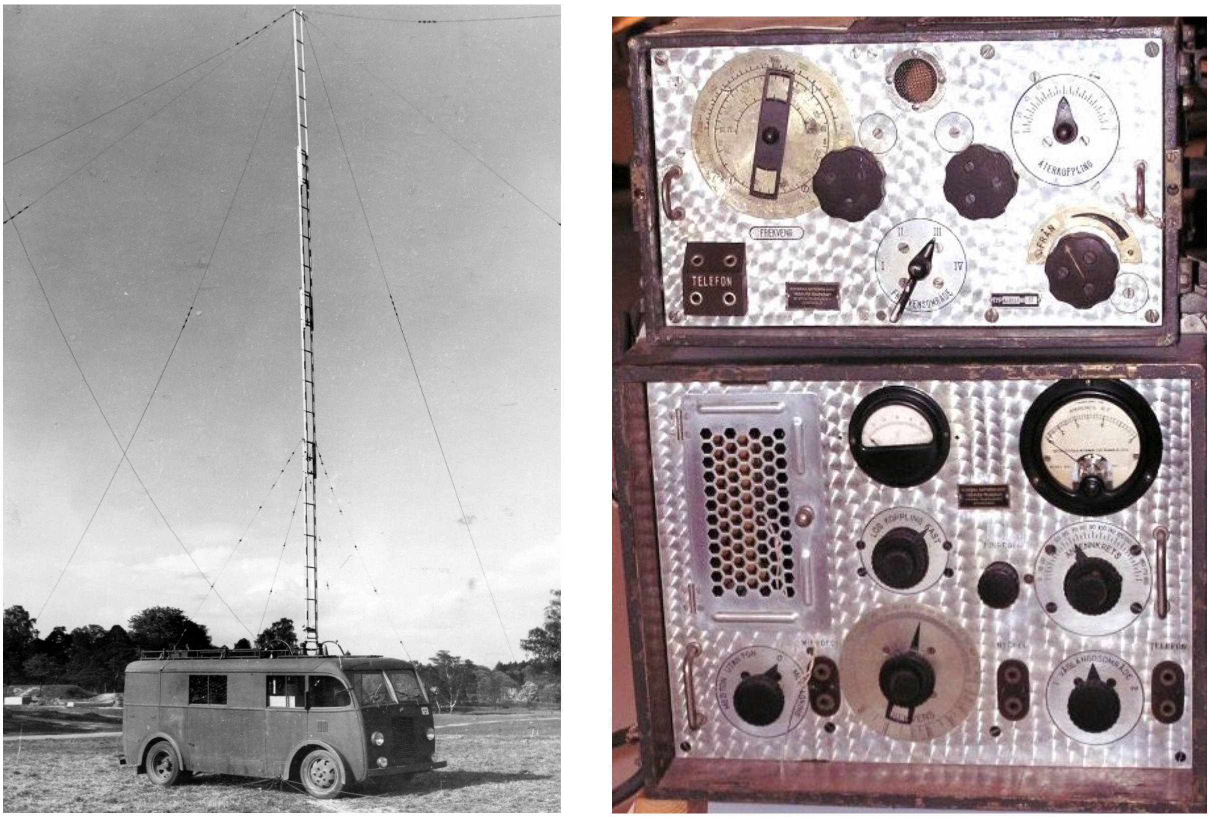
Jaktflygplan J 8 Gloster Gladiator. (Gloster Aircraft Company England).

Gloster Gladiator inköptes 1937 i ett antal av 55. Operativ drift 1937 – 1947.
Beväpning fyra 8 mm ksp m/22F. Kunde medföra fyra 12-kilos sprängbomber för lätta attackuppdrag

Flygradio Fr typ II

- Levererad av SATT
- Beställd 1937
- Operativ drift 1938 - 1952
- Antal cirka 200
- Installerades i flygplan J 8, J 9, J 11, J 20, J 22
- Sändare, mottagare och fjärrbetjäningsapparat avsedd för jaktflyg, fanns även som Mr III i 45 Ls-torn
- Kortvågsutrustning med elektronrör
- Uteffekt 12 W

- Frekvensområde 3000 - 3500 Kc/s
- Räckvidd telegrafi 100 km, telefoni 50 km.
- Strömförsörjning roterande omformare
- Trafiktyp telegrafi (A2) och telefoni (A3)
- Modulationstyp AM



Tmr I – VII med sändare MS 20 och Flygradio FR m/27

3.4 Jämförelse av utvecklingen i omvärlden och i Sverige

Liksom i övriga delar av världen var det marinen som var först med att använda radiotelegrafin. Prov och utbyggnad skedde i Sverige bara några år efter att det skett i USA och UK. Vi hade här stor hjälp av att Ragnar Rendahl arbetat vid AEG på avdelningen för trådlös telegrafi och avancerade till chef för laboratoriet 1903. Han kvarstod i denna befattning till 1908 då han värvades över till Kungliga Marinförvaltningen i Stockholm.

Inom armén startade verksamheten under krigsåren 1914 - 18. Noterbart är att vad jag kunnat se så valde Sverige att liksom US Army anskaffa den s k Åkande fältradion m/17 från Telefunken. I USA fanns den 1911 alltså några år tidigare. Troligen betydde SATT samverkan med Telefunken en del för radioutvecklingen i Sverige. Armén kom sedan att under många år i egen regi utveckla och tillverka fältradio. De svenska modellerna påminner mycket om det som utvecklades av Marconibolaget för Royal Army.

Inom flyget var vi i Sverige relativt tidigt ute med att prova och införa radiotelegrafi. Även här hade vi nytta av SATT:s knytning till Telefunken.

Noterbart är vilken stort inflytande Marconi har haft på den tidiga utvecklingen och även senare med företag etablerade i USA, England, Canada och Italien. Genom samarbetet med SRA fick Sverige tillgång till ett antal radiopatent. Sverige har fram till 2000 anskaffat en stor del elektronikprodukter från Marconibolagen.

I FHT dokumentation finns ytterligare information om utvecklingen i Sverige i dokumenten:

Arméns lätta radiostationer under 1900-talet (15 MB) (A03/09) Författare: Sven Bertilsson och Thomas Hörstedt

Arméns tunga fordonsburna radiostationer (17,6 MB) (A06/05) Författare: Sven Bertilsson.

Radiouvecklingen inom den svenska armén (2 MB) Författare: Göran Kihlström (A 01/18)

Pionjärtiden Marinens Televerksamhet (3,5 MB) Författare: Gösta Brigge.

Långvågsradio och ubåtssamband (kortversion) (4,8 MB) Författare: Carl-Henrik Walde

Radioutvecklingen inom den svenska marinen (1,5 MB) Författare: Göran Kihlström (M01/18)

Första radiosambandet Flyg-Mark (3,3 MB) Författare: Arne Larsson (F02/18)

Militär flygradio 1916-1990 (8 MB) Författare: Lars V Larsson (F06/12)

Flygvapnets radiosystem, del 1, 1916-1945 (28 MB) Författare: Arne Larsson. (F13/09

Radioutvecklingen för det militära flygsambandet (1 MB) Författare: Arne Larsson

Svenska försvaret och radioindustrin Författare: Göran Kihlström (G01/18)

4 Radiotelefoni

4.1 Tidig utveckling

4.1.1 Royal Flying Corps

To speed up aircraft radio system development qualified wireless engineers were now rapidly given commissions in the RFC. The Experimental Marconi Company experimental section at Brooklands in Surrey had been formed in early 1911 and it was now hurriedly 'taken over' by the RFC in 1914 and turned into a wireless training school for pilots and engineers.

At Brooklands Captain Prince had excellent credentials for the job, having joined the Marconi Research staff in 1907, he had organised the first demonstration of telephony for Marconi in 1910, and later demonstrated telephony using valves between the Marconi New Street works and his Chelmsford house in 1914.

Under Prince’s command on 1st April 1915 No. 9 Wireless Squadron was re-formed at Brooklands. This squadron would subsequently form the basis of the Royal Flying Corps School of Wireless. Before the war an operational airborne transmitter had been designed by R.D. Bangay of the Marconi Company’s Field Station Department, but the more difficult problem of reception in the noisy cockpits of the early flying machines had not been satisfactorily solved.

The Brooklands ‘Wireless Testing Park’ was formed with the prime aim of developing practical wireless telephony (speech transmission instead of telegraphy - Morse code) for ground to air wireless communication and a team of engineers was assembled to find a solution to overcome the barrage of cockpit noise. The primary concern of these scientists was to replace the existing spark gap transmission with continuous wave sets based on the new valve technology and, in particular, the triode valve.

Major-General ‘Boom’ Trenchard, commanding the Royal Flying Corps, laid down his requirements for a system of air-to-air and air-to-ground radio telephony. A one-mile all-round range was a minimum, no adjustments to the transmitter when in operation, and only one tuning adjustment allowed on the receiver. Perfect speech quality with one hundred per cent reliability was demanded, and the maximum aerial length was 150 feet, to be replaced by a fixed aerial if possible.

Given the state of technology at the time it was a tall order, but the RFC desperately needed the wireless telephone to work in the air. Major Prince was told to do it, but no one was quite sure how.

At the outbreak of war Prince had been working on developing a continuous wave valve transmitter for airborne use. From this the idea of a telephone set was a logical step, but one which presented many obstacles before its practical realization. In the summer of 1915 success was achieved when speech from air to ground was obtained at Brooklands over a range of about twenty miles using a wavelength of 300 metres; the trailing antenna was 250 feet in length. For ground-to-air communication wireless telegraphy Morse code was still used.

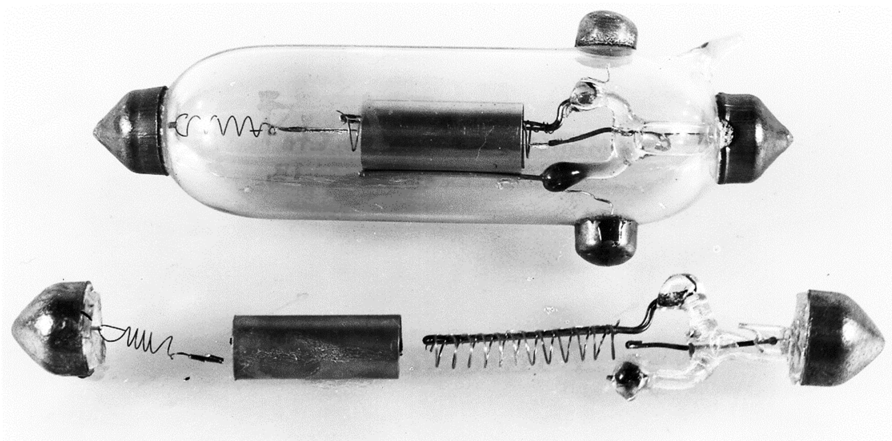
Prince and the team continued to work desperately to evolve a practical system. At Brooklands, new Wireless sets were continually being designed, tested and often immediately scrapped. Microphones were either too insensitive or too sensitive and the carbon granules inside them were subject to the heavy vibration from the aircraft's engine. Copper long-wire aerials, weighted at the far end, were often forgotten when the aircraft came in to land, and the trees around the aerodrome soon became draped with them, to the annoyance of the technicians and the men who had to climb up to collect them.

Prince decided that he now had to bring in the best men he could find, working under his control. In the early days of the war the Marconi Company was the only source. To speed the development process highly qualified and talented wireless engineers from all over the country were commissioned as officers and Prince was soon joined by Captain Whiddington, Captain J.M. Furnival, Lieutenant (later Major) R. Orme and Lt Edward Herbert Trump. Another young military engineer who joined Prince later went on to play a key role in the birth of British Broadcasting. His name was Captain Peter Pendleton Eckersley.

4.1.2 Elektronröret ger nya möjligheter

The Marconi 1913 Type C valve was a soft low vacuum triode valve, with a lime-coated platinum filament, designed by H. J Round of the Marconi Company and manufactured by Edison Swan. Early examples of these valves had to be coaxed into operation by holding a lighted match under the top glass pip to assist the valves little electric heater. Indeed surviving examples still show these burn marks. The long top pip of the valve actually contained a small piece of asbestos, which when warmed released a gas that made the valve work much better. Signal strengths could be greatly improved by stroking the valve with a match flame, but conscientious operators apparently lost all sense of pain in fingers that soon resembled well done sausages and a new wartime affliction was born – '*Burnt sausage fingers'*.........

In 1913 an American scientist, Irving Langmuir, described how to achieve a near-perfect vacuum. Coupled with this, Captain H.J. Round now used his pre-war work to produce a new generation of valves, for the receiver and the transmitter. The Brooklands engineers now had access to the new Marconi Type Q valve, developed in 1916 and its companion valve the V24, also designed by Round, probably a year later.



Marconi V24 Valves (MWT)

The technical problems that had to be overcome by the engineering team to achieve reliable speech transmission systems were immense, but the new valves showed the way ahead. But some of the problems that faced Prince at Brooklands were not technology based. He continually battled with the then existing regulations that stated that all communications work for the Royal Flying Corps had to be undertaken by the Royal Engineers. Relationships between the two organisations had already broken down as Prince had little regard for the stolid and unimaginative approach of his military rivals.

Now the problem became serious. The regular wireless technicians of the Royal Engineers had developed a great dislike for the new Marconi personnel who they considered 'hostilities only' men, essentially part time soldiers. They especially disliked their unorthodox ways of doing things. Things reached the point where Prince was more than once called in to settle ridiculous inter-unit disputes. The result was that in August 1915 most of the wireless research work was sent to an establishment at Woolwich, and the RFC wireless staff were despatched to a new site at Joyce Green.

The move was at first welcomed. Despite its pre-war success the Brooklands aerodrome was really unsuitable for training and testing as it was located in the centre of the 4,730 yard long (100 ft wide) motor racing track. On three sides there were high tension cables and to the east two 95 feet high chimneys. The small town of Byfleet lay in the south-west corner, Weybridge was to the north and it was close to the railway station and main line.

Despite this Brooklands continued as a pilot training school and by late 1917 the Brooklands School had an output of 36 fighter pilots per week, fully trained in the use of wireless telephony equipment.

Joyce Green in Kent is located between Dartford and the River Thames. This airfield had been built in 1911, again by Messrs Vickers Ltd. to test aircraft built in their Erith Works. In reality, like Brooklands, Joyce Green was also an unsuitable site for a pilot training airfield as there were numerous drainage ditches crossing the Dartford Salt Marshes. However at the outbreak of war, Joyce Green became an 'air defence' airfield to house a permanent RFC unit (No. 6 Wing). In mid April 1915, No. 39 Home Defence Squadron was formed bringing together all units and detachments detailed for anti-Zeppelin raid duties in the London area.

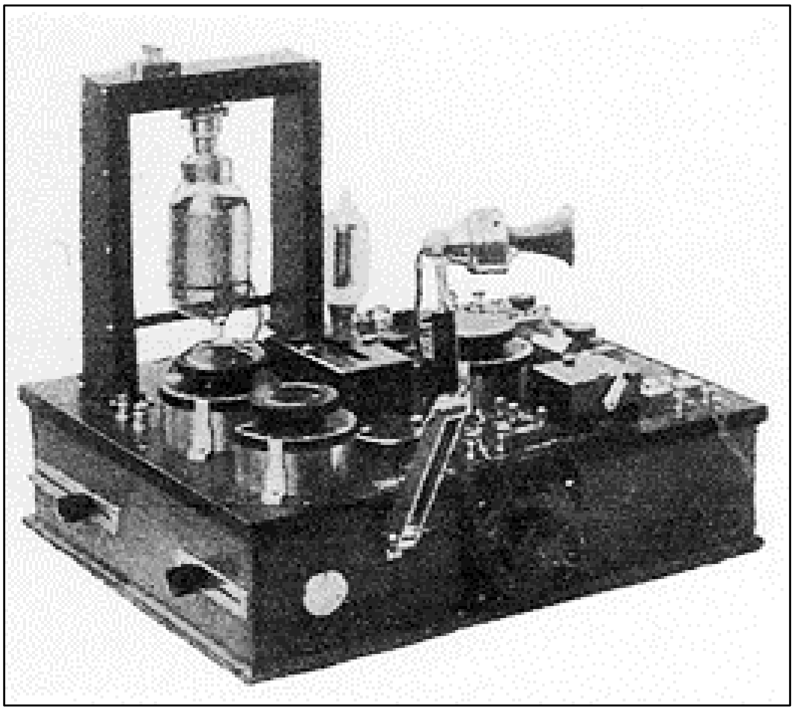
Hangars, workshops and ground staff quarters were erected at the northern edge of the landing field alongside the Long Reach Tavern. The work was completed in early 1915, and the first occupants were No. 10 Reserve Squadron with a variety of aircraft including Henry Farman's, Vickers FB5 and FB9, DH2 and FE8 machines. The role of this unit was to receive pupils from preliminary training schools for final training for their wings. Each course consisted of about 20 pupils and lasted two or three weeks. This included time spent at Lydd where aerial gunnery was practised at the range at Hythe. On gaining their wings the young pilots would get a 48 hour pass before being posted to the Front.

The Wireless Testing Park moved to this busy airfield in August 1915 on a convoy of trucks. Training, testing and wireless experiments then started immediately while around them young men practised war, throwing flour bombs as they tried to make their cumbersome Henry Farman Trainers fly.

Prince now managed to get the ear of an RFC officer who was sympathetic to new ideas, Major Hugh Dowding who, in later years as Air Chief Marshal Sir Hugh Dowding, was to use radio to devastating effect in the Battle of Britain. After listening to Prince and recognising the tremendous importance of radio telephony, he offered his whole-hearted support and asked for a demonstration as quickly as possible.

More often than not, the success of these experiments depended upon Prince's ability to borrow apparatus from non-Military sources or, as Dowding's biographer more bluntly put it; upon Prince's ability to steal the necessary items from Marconi's London office whilst Dowding distracted the store man with lurid tales about aerial fighting on the Western front!

By May 1916 306 aircraft and 542 ground stations were equipped with old fashioned spark wireless and crystal set receivers. The Marconi Company had undertaken a massive training program that was now delivering qualified operators



Marconi Short Distance Wireless Telephone Transmitter and Receiver to the left.

This set used a C valve in the receiver, connected as an RF amplifier with regenerative feedback to increase its gain and provide improved selectivity. Detection was by a carborundum crystal.

For transmission there was a single T.N. valve (seen mounted in the frame) and this was connected as an oscillator.

It is believed that Marconi used this set for CW voice trials in 1914.

It might have been possible to adapt this radio for use in benign environments in the early years of the war, but this was not to be and it was necessary to await improved, more robust valves that could be readily manufactured in large quantities. Consequently all the early radio transmitters used by the army in WW1 were spark sets and these continued to be used during the whole of the war. All the early radio receivers used crystal detectors, the two most used being the carborundum and the Perikon detectors, described later in this paper.

Although the triode valve had been invented by Lee de Forest at the end of 1906 it was not used successfully as an amplifier until 1911. The earliest recorded amplifier using the audion valve would appear to be that of Otto von Bronk, a Telefunken engineer who applied for a German patent on 2 September 1911. The circuit shown is of an RF amplifier (without grid blocking capacitor as used by de Forest in his detector and early attempts to produce an amplifier). The output from the valve is shown connected by an RF transformer to a crystal detector and telephone earpiece.

4.1.3 Sammanfattning tidig utveckling

1. Before the outbreak of WW1 in August 1914 many of the circuits to be used in later years for CW radio communications had already been invented, although most of these were still at an early stage of practical applications. These circuits include the radio wave detector, the oscillator, the heterodyne, the RF amplifier and regeneration.
2. The British Marconi Company embodied all of these in the Marconi Short Distance Wireless Telephone Transmitter and Receiver which was produced in 1914 and used on ship-to-shore trials.
3. There were few valves available in 1914 for use in radio equipment. The de Forest audion was erratic in operation, fragile and had a short filament life. The Marconi soft valves, the C and T, were produced in 1913 and used in the radio mentioned in the previous paragraph. The C was a receiver valve and the T a transmitter valve. Both of these were difficult to manufacture and not suitable use on the battlefield. Apart from this the T valve required a power of 6-volts, 4-amps for its filament which meant very frequent replacement of the storage battery. Also an HT of several hundred volts was required.
4. One important application of the Marconi C valve was in direction finding receivers and these continued to be used throughout the War until suitable hard valves became available from 1916.

4.1.4 The Superheterodyne Receiver: Better Tuning for Radio

Radio technology existed before the war, but two wartime inventors greatly improved them. In 1917 and 1918, respectively, a French officer named Lucien Lévy and an American officer named Edwin H. Armstrong independently came up with what would become known as the superheterodyne receiver—a way to tune radios and to allow them to pick up distant signals. The receiver basically superimposed one radio wave on another and greatly amplified and filtered the resulting intermediate frequency, which was then demodulated to generate an audio signal, which was in turn amplified for output to loudspeakers or earphones.
Initially, Lévy sought a way to increase the secrecy of radio transmissions. He had been working at the Eiffel Tower—which the French military began using for radio experiments when the war broke out. Lévy had the idea that a supersonic wave could be superimposed upon a radio frequency carrier wave, which would itself be modulated by an acoustic wave. He refined that idea, producing the supersonic wave in the receiver and then heterodyning the received signal against a local oscillator. He applied for a French patent on 4 August 1917.

Armstrong was made a captain in the U.S. Army Signal Corps shortly before he was sent to France in 1917 to work on Allied radio communications. By then, he was already famous in the radio world for his regenerative feedback circuit (a device that greatly amplified a signal), for which he received the first Medal of Honor from the Institute of Radio Engineers. While in Paris in early 1918, Armstrong witnessed a German bombing raid. He thought that the accuracy of the antiaircraft guns could be improved if there were a way of He thought that the accuracy of the antiaircraft guns could be improved if there were a way of detecting the extremely short electrical wavelengths emitted by the ignition systems of the aircraft engines. That led him to invent his superheterodyne receiver, for which he filed a French patent application on 30 December 1918.

After the war, Armstrong's and Lévy's competing claims on the superheterodyne receiver did not prevent it from being used widely, helping transform the radio into a hugely popular consumer product. (For more on Lévy, Armstrong, and the controversy surrounding their inventions, see Alan Douglas's "Who Invented the Superheterodyne?").

4.2 Militära applikationer

4.2.1 Radiotelephony Takes to the Skies in US

Photo: AT&T Archives and History Center Voices on High: AT&T employees (some of whom had joined the U.S. Army Signal Corps during World War I) listen in on an early trial of air-to-ground voice communication.

In April 1915 Captain J.M. Furnival was the first person to hear a voice from the ground when Major Prince said, "If you can hear me now it will be the first time speech has ever been communicated to an aero plane in flight." In June 1915 the world's first air-to-ground voice transmission took place at Brooklands (England) over about 20miles (ground-to-air was initially by morse but it is believed two-way voice communications was being achieved by July 1915). In early 1916 the Marconi Company (England) started production of air-to-ground radio transmitters/receivers which were used in the war over France.

Dots and dashes were replaced by human voice in February 1917. By the end of 1917, air-to-ground radiotelephone sets were in full production and were being placed in aircraft and ground stations alike. Communications distances were also increasing. In 1915, the range of radios was only two miles. In 1917, radiotelephone sets were reaching other aircraft at 25 miles away and ground stations at 45 miles away. As the Aviation Section of the U.S. Army Signal Corps gained more knowledge in shielding ignition systems, bonding, and metallizing their aircraft and radio sets, the clarity of voice communications improved. Long range communications began to enable long distance flying, creating new challenges for aviation pioneers to overcome.

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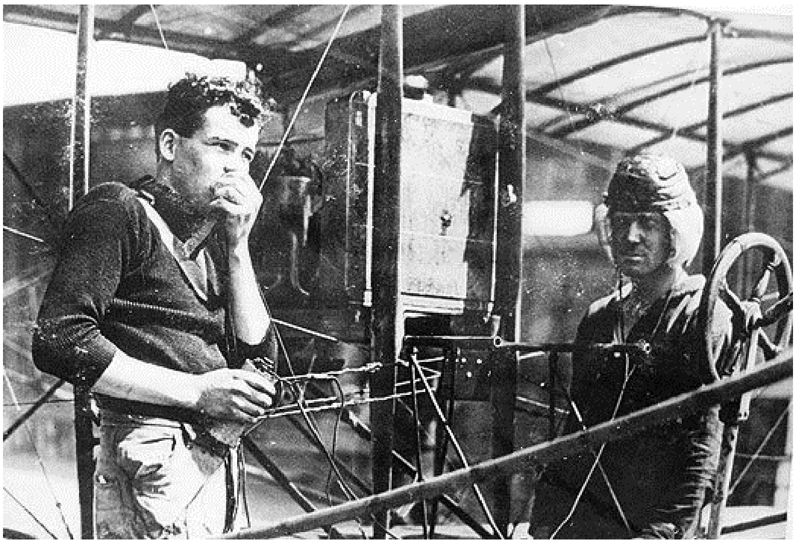


Just months after Lieutenant Paul Beck made an early airborne radio transmission, aviators test a receiving set - with the airplane's engine running - on North Island, Washington.

As early as 1910, experimenters demonstrated wireless transmissions between aircraft and the ground. These trials all involved the pilot tapping out Morse code on a transmitter held in his lap. There were a few problems, however. Engine noise tended to drown out any received messages. And pilots were usually far too busy to be operating a code key.

Clearly, voice radio would be necessary for wireless communication to become practical in the air. But voice transmissions required higher frequencies than did Morse code, and the radios and their power sources were too big and heavy to fit into the aircraft of the time.

Engineers on both sides of the conflict succeeded in making those improvements... (For more on early airborne radio, see George Larson's "Moments and Milestones: Can You Hear Me Now?")

4.2.2 Sammanfattning av introduktion inom flyget

In April 1915, Captain J.M. Furnival was the first person to hear a voice from the ground from Major Prince who said, "If you can hear me now, it will be the first-time speech has ever been communicated to an aeroplane in flight."

By June 1915, the world's first air-to-ground voice transmission took place at Brooklands, England over about 20 miles. Ground-to-air was initially by Morse code, but it is believed two-way voice communications were available and installed around this time. Marconi had established a presence at Brooklands, the home of the Royal Flying Corps Training School. However, the War Department took control of the operation in the spring of 1915 and the Marconi staff were seconded to the Royal Flying Corps.

In June 1915, the world's first air-to-ground voice transmission took place at Brooklands, England over about 20 miles. Ground-to-air was initially by Morse code, but it is believed 2-way voice communications were available and installed by July 1915.

By early 1916, the Marconi Company (England) started production of air-to-ground radio transmitters/receivers which were used in the war over France.

In 1916 the French successfully tested air-to-ground voice communication during the battle of Verdun; one year later, they demonstrated air-to-air voice communication at Villacoublay Transmitters became standard aboard German aircraft in 1916 and, by the end of that year, so were receivers.

In 1917, AT&T invented the first American air-to-ground radio transmitter. They tested this device at Langley Field in Virginia and found it was a viable technology. In May 1917, General George Squier of the U.S. Army Signal Corps contacted AT&T to develop an air-to-ground radio with a range of 2,000 yards.

By July 4 of that same year AT&T technicians achieved two-way communication between pilots and ground personnel. This allowed ground personnel to communicate directly with pilots using their voice instead of morse code. Though few of these devices saw service in the war, they proved this was a viable and valuable technology worthy of refinement and advancement therefore further models had this technology installed into Biplanes on airstrips in France 1919.

On 17 May 1918 a U.S. airplane squadron was successfully commanded by voice from the air for the first time

Marconi engineers serving in the British Royal Flying Corps developed this aerial telephony set.

By 1916 all three armed services were depending heavily upon wireless. In the great Somme offensive of June 1916 it was often the sole means of communication between aircraft, artillery and infantry. Mobile wireless stations followed the infantry and the RFC, allowing divisions to communicate with each other. The RFC also began research into how wireless telegraphy could be used to help home-defence aircraft during German bombing raids. In 1916 the RFC deployed Marconi half-kilowatt ground transmitters located on aerodromes in raid-threatened areas.

Trials started in May and pilots reported that signals were clearly heard up to ten miles but at longer distances they weakened. Further adjustments were made and by November clear signals could be heard over twenty miles. Pilots could now be informed about enemy aircraft movements and therefore had a far better chance of successfully reaching them before they dropped its bombs on Britain.

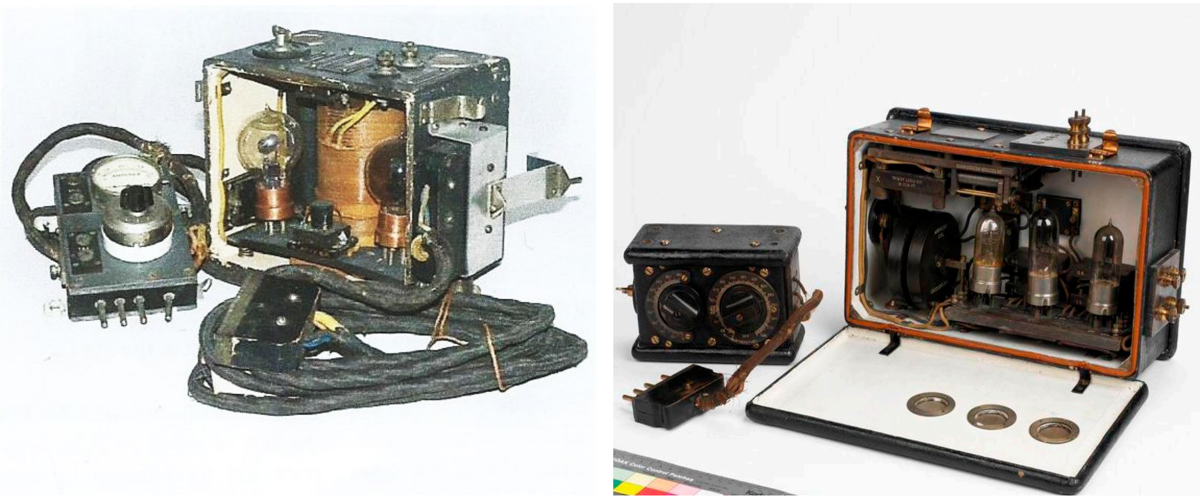
In 1916, former marine wireless officers were dropped by parachute behind German lines equipped with Marconi sets to transmit intelligence reports. In early 1916 the Marconi Company carried out the first valve transmitter tests between an aircraft and Royal Navy units at Scapa Flow. A Short seaplane carried the transmitting equipment, including a large HT battery and the light cruiser HMS Calliope was employed for the six months trial.

Later 75 Royal Navy ships were fitted with similar equipment. Seaplanes were also fitted with transmitting sets for anti-submarine use.

The new light weight of the airborne Marconi sets also allowed Belgian paratroops to be equipped by the Marconi company and dropped behind enemy lines in the first operation of this kind.

On the 23rd August a memorandum was written reviewing the principles of fighting adopted by the Flying Corps since the Battle of the Somme. The operations of this year bore out and confirmed the lessons of the past, and soon a new factor became apparent. Fighting not only extended upwards, but downwards; low-flying machines with wireless co-operated with ground troops, and attacked men, guns, trenches, transport, and hostile aerodromes. The Germans were a year behind in realising the value of wireless in the air; but once they did realise they lost no time in adopting similar methods.

The new system was introduced into the RFC ground networks which now had reliable communication with their aircraft over long distances. The new tactics which this system of squadron control made possible, came as an unpleasant surprise to the German Air Force, whose losses mounted rapidly. The Allied effort in terms of air warfare was now in top gear and they were winning.



Telephone Wireless Aircraft Mk. II and Tuner Mark III (Receiver), c. 1918.

British variable reaction valve receiver operating on the 350-450 metres and 600-800 metres waveband. The Tuner Mark III (Receiver) was carried in British reconnaissance aircraft in 1918, and used to communicated with artillery batteries

A variable reaction receiver operating on the 350-450 metres & 600-800 metres waveband. Used by the BEF for long-range artillery work, R/T and night bombing along with hostile day and night raids. Also used for spotting for garrison guns & ground inter-communications.

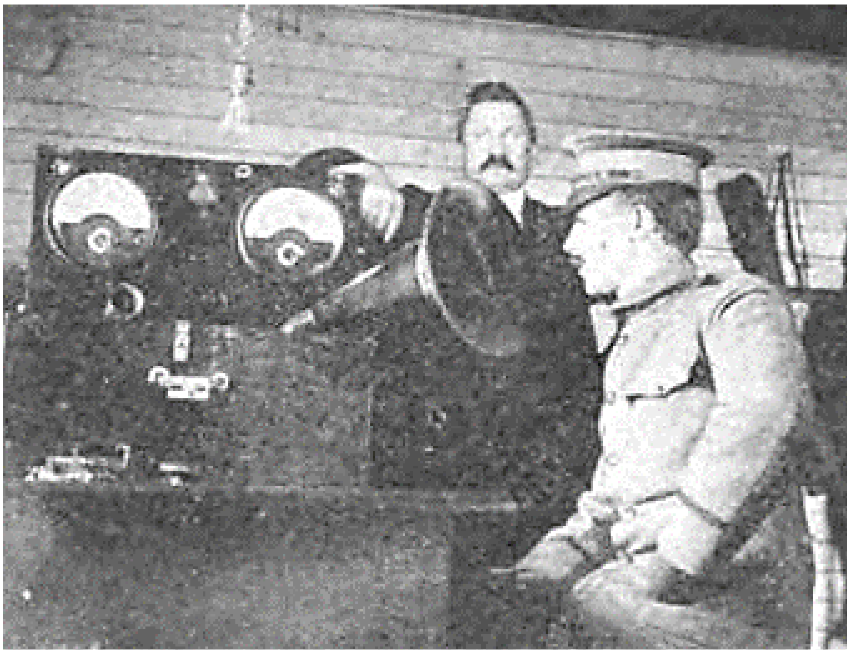
By November 1918 the RAF had some 600 aircraft fitted with the new 'Mark III choke controlled telephone sets', operating in conjunction with 1,000 ground stations and manned by over 18,000 wireless operators.

It is also tragic to remember that there was an average of 400 casualties per year among RFC wireless operators, rising to nearly 500 lives lost during the months of May to November 1918.

Unlike with the RFC there was a general lack of enthusiasm in the army for using radios, particularly during the first two years of the war. There were several reasons for this. 1. The equipment available at the time was very bulky and required several Signal Service operators to man them. 2. The radios required accumulators, which required frequent re-charging. 3. There was the genuine fear that the enemy would be able to intercept the messages. 3 This situation was to change later in the war when radio had proved to be the only reliable way to communicate when troops were on the move, making it even more imperative for Divisions to keep in touch. Also when tanks came into service in early 1916 the only way that the crew could communicate was by wireless.

4.2.3 Early radio in US Coast Artillery

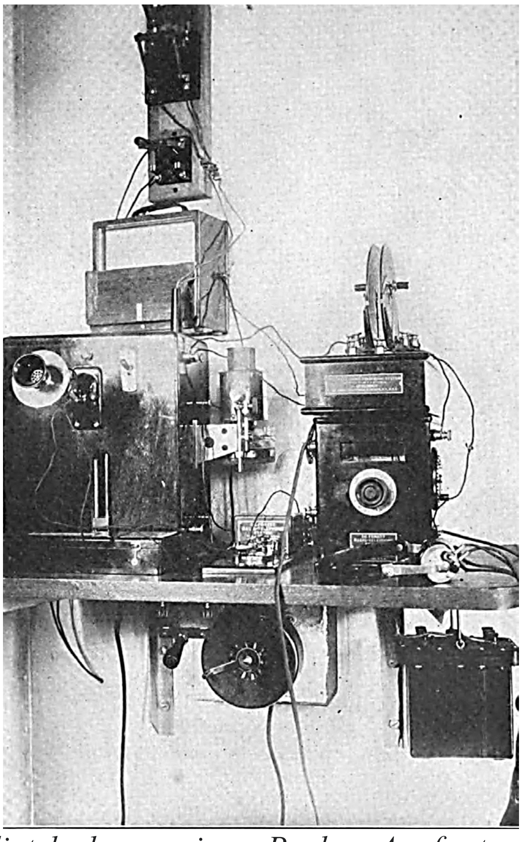
It may occur to the reader that the wireless telegraph has been in use for some time as an adjunct to military maneuvers and that the wireless telephone has no easily apparent advantages of important character over the former. Such, however, is far from being the truth. In the first place, the wireless telephone may be used under conditions which would render the wireless telegraph unavailable; it is less influenced by natural obstacles and far less subject to interference by other stations. As this is an accepted electrical fact and as its explanation would be both tedious and unavoidably technical, no attempt at such elucidation will be made here. The important point, to the lay mind, is that the wireless phone can and has been used under conditions which would render the more delicate and complex telegraph useless. There are other advantages, foremost among them the obvious facts that one may talk faster than one can telegraph and that anyone is able to communicate by telephone while it requires a skilled operator to telegraph.



Transmitting an order by wireless phone. Wooden box contains entire apparatus, making it easily available for military field work.

Wireless signal station established by milita at Presidio. Lieutenant John McHenry and Chief Operator R. G. Fontana at work.

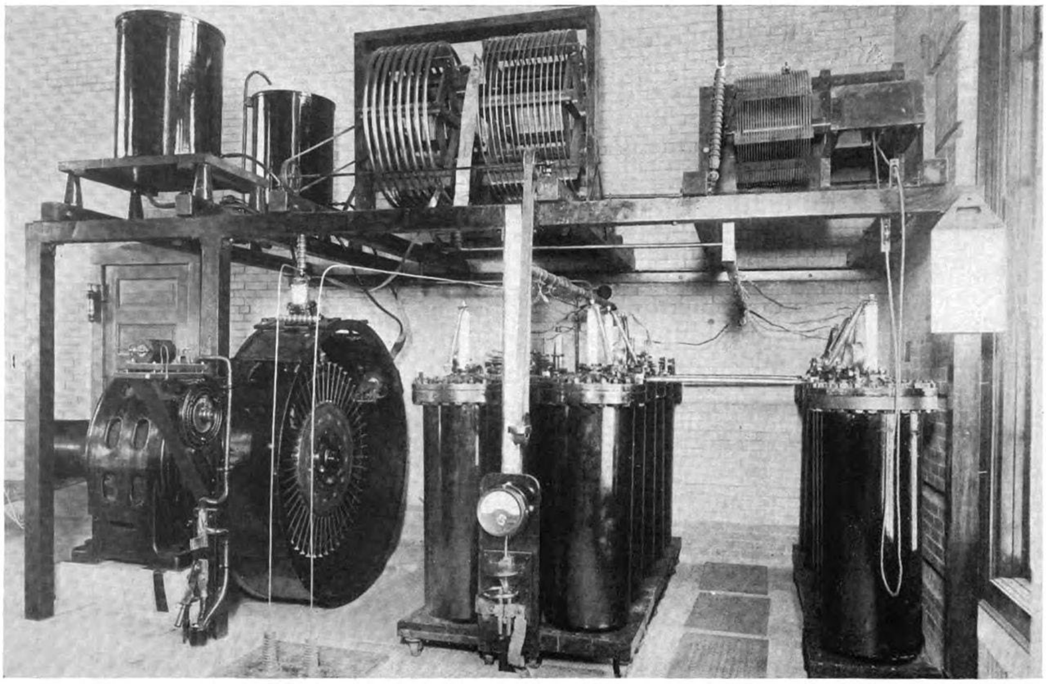
4.2.4 Early radio US Navy



A prototype US Navy radiotelephone, using a Poulsen Arc for transmission. This one was installed on the USS Connecticut, flagship of the Great White Fleet.

The problems of the spark gap meant that there was interest in other types of transmitters. The first alternative adopted wholesale by the USN and used by the British for strategic communications between ships at sea and shore stations,3 was the Poulsen arc. This used a stable resonant arc to generate a “continuous-wave” (CW) signal,4 which meant that its energy was concentrated into a much narrower bandwidth than a spark gap signal. The arc was in fact so stable that instead of turning it on and off to send signals, the frequency of the output was shifted slightly, and the special heterodyne receiver was tuned to pick up only the first frequency, making this an early form of frequency-shift keying.

However, this prevented the radio operator from listening through the signal for other ships on the net, so it was rejected by the British for fleet use. The other major radio technology was the vacuum tube, which was adopted as standard by the Germans. The triode allowed amplification of signals, and could also be used as a resonator, producing a narrow-bandwidth signal that could be turned on and off at will. The vacuum tube was ultimately the superior technology, and it would win out in the 1920s, but the superior radios that it enabled also meant that the Germans used their radios more than was probably wise.



An early USN shore-based radio transmitter

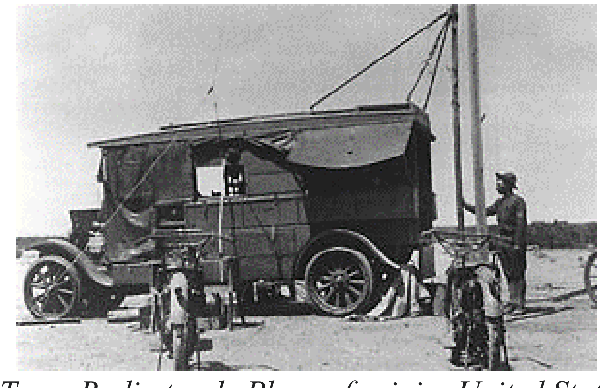
Aircraft radio was another technology that was pioneered during WWI and perfected during WWII. Initially, it was used primarily for gunfire spotting, and only worked on the sharply restricted power and weight available in an aircraft thanks to the use of an antenna trailing behind the aircraft. This had to be manually wound in and out, and if the winch jammed, landing with 50′ or more of wire hanging out wasn’t fun. Some aircraft were fitted only with transmitters, and receivers had to be shielded against interference from the aircraft’s ignition system.

AN/ARC-5

By WWII, voice radio had matured to the point that almost all aircraft, even single-seat fighters, carried one as the pilot could now serve as his own radio operator. This was necessary because of the increasing speed of aircraft, which had previously been slow enough for pilots to see most problems and react in time. Increasingly sophisticated communications protocols meant that pilots had to monitor multiple radio nets at the same time, a need supported by sets like the AN/ARC-5. A typical pilot might have to listen to traffic from the fleet's fighter directors; the general air net, only transmitted on by the leaders of groups of airplanes; the group net, which he could talk on; and the net for air-traffic control.

However, these VHF voice radios were not enough for the sort of long-distance communication required of scout aircraft, so these mostly retained HF radios with designated operators, who could transmit in Morse and hopefully fix the radio if it broke, as it often did. Improved radios and antennas meant that trailing antennas were generally not necessary, with most aircraft having a long antenna between the fuselage and the top of the tail.

4.2.5 US Army Early radio

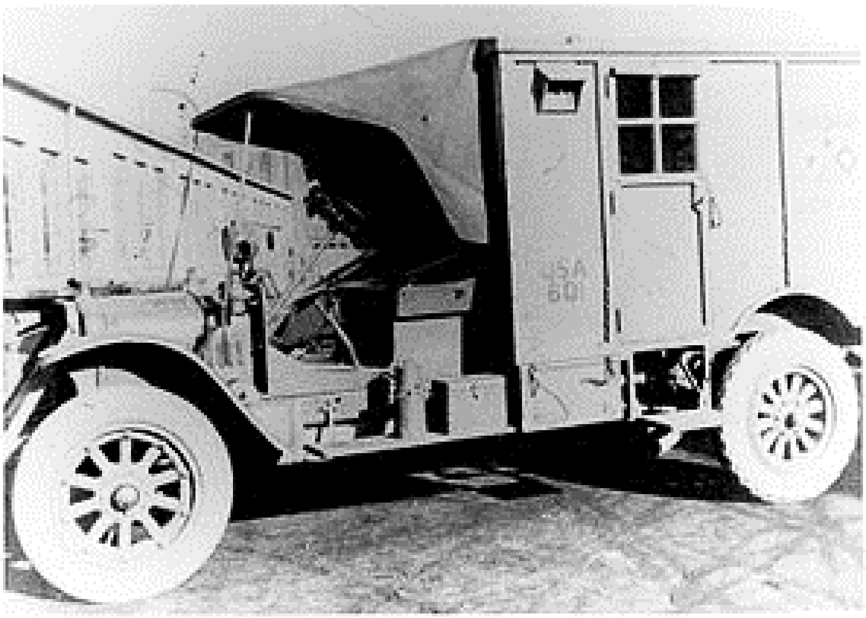


Type: Radio truck. Place of origin: United States

Service history
In service: 1914 -?
Used by: US Army
Wars: World War I

Production history
Designed: 1914 -?
Manufacturer: FWD, White Motor Company
Produced: 1914
Variants: 3

The Radio tractor was a mobile Signal Corps Radio used by the U.S. Army for ground communications before and during World War I. Prior to World War I, trucks were referred to as "tractors", and there were also telegraph tractors, and telephone tractors.



Type: Radio truck*Place of origin:* United States

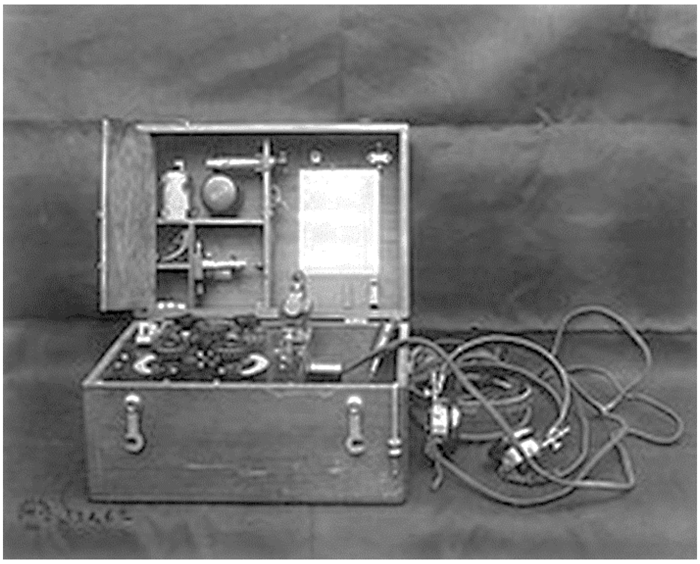
Service history
In service: 1920 -?
Used by: US Army

Wars: World War I ?

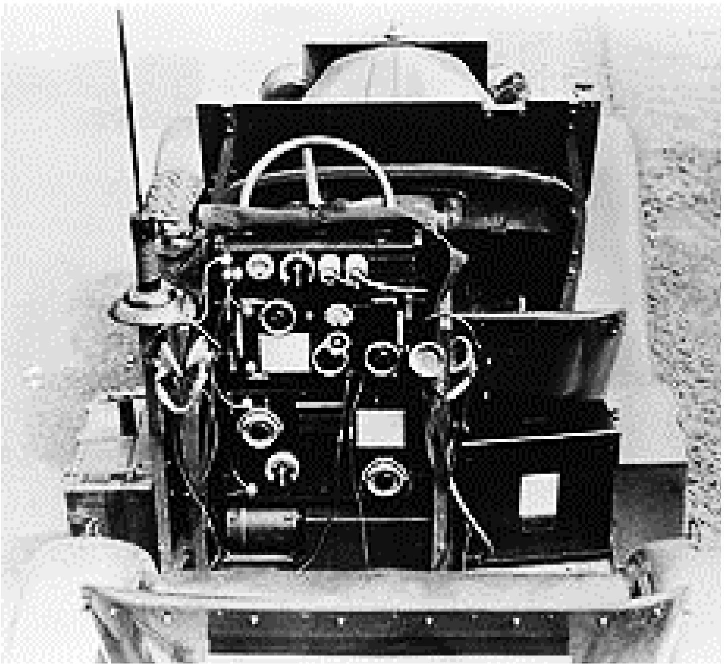
Production history
Designed: 1919
Manufacturer: White Motor Company

Variants: 1

Specifications
Mass: 1 1/2 ton
Length: 120 inches
Width: 64 inches
Height: 64 inches
Crew: 4



French radio equipment was more advanced than that of the U. S. Army when the United States entered World War I. The U. S. Army therefore adopted French sets early on, and developed improved sets of their own, some based on French design. Several of the French A-1 artillery receiving set were sent to the American radio laboratory in the summer of 1917 and copied with minor modifications.

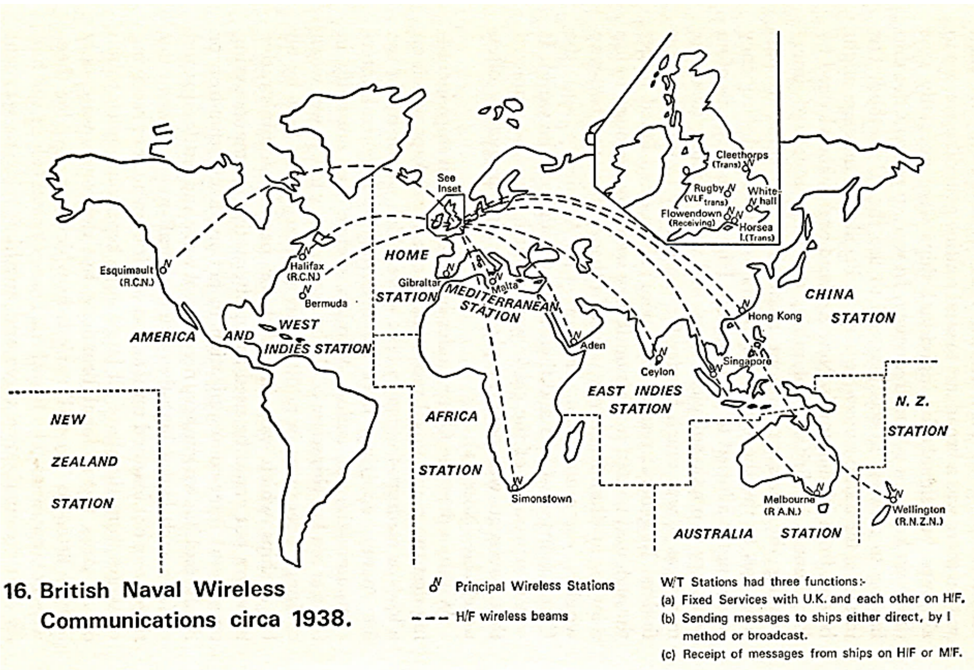


SCR-189 Installed in Pontiac Ccout Car – View from Rear of Car.

The SCR-189 was a mobile Signal Corps Radio tested by the United States Army before World War II. It was designed for armored forces, and mounted in the Six Ton Tank M1917. The original production run of these tanks included 50 "radio tanks" but the original radio components are unknown, so what or how many tanks were fitted with the SCR-189 also appears to be unknown

4.2.6 Early radio UK Navy

Marconi engineers serving in the British Royal Flying Corps developed this aerial telephony set.



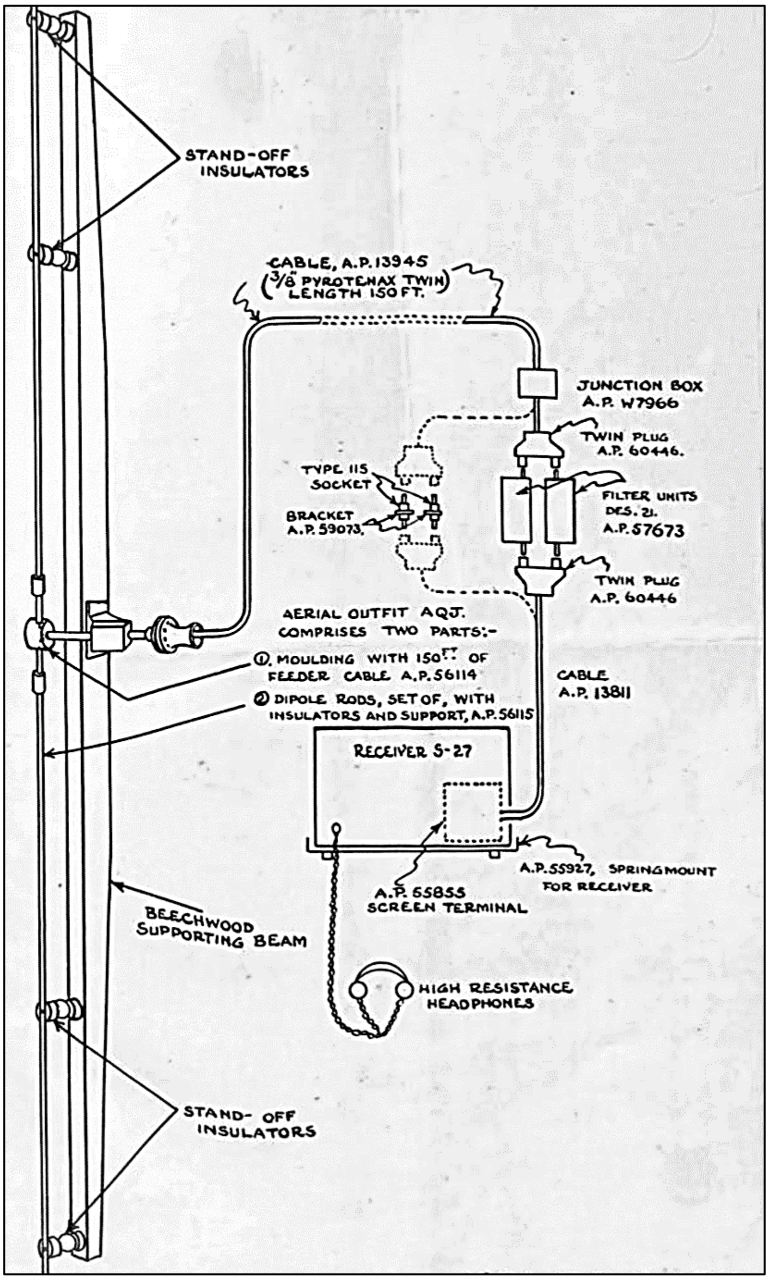
HEADACHE

Of interest, was the function known as *Headache*. This codename was applied to the shipborne sections of 'Y' intelligence who were charged with the task of intercepting and reading German low-grade radiotelephone traffic which had been steadily introduced since 1941. Generally speaking, Headache operators came from a Special Branch of the RN and were fluent in German. 'Every important warship in the D-Day armada and the bombing force was provided with a Headache Unit for the interception and interpretation of enemy air and naval R/T on VHF. Fifty warships in all were fitted with Headache units'.

This is the actual Headache Office aboard HMCS HAIDA during WWII. Pictured is the Hallicrafters S-27 receiver which was removed in 1949. (RCN photo HS 1749-59 taken in 1946).

Lawson Gregory of Woking, England relates his experiences as a Headache operator. "Having knowledge of German, I volunteered for any job where I could be of more use. When my ship, HMS Zulu was sunk during the raid on Tobruk in September 1942, I was initiated into Headache. Once I was drafted to a ship, I was accompanied with a special VHF radio set, plus aerial and of course a copy of the code used by the enemy. The presence of a Headache operator usually meant the ship would probably be very close to the Germans. On HAIDA, my action station was in a small office just below and aft of the bridge.

Communication with the bridge was through voice pipe. Even when not at action stations, I would listen in. On one occasion, enemy aircraft were giving a sighting report on HAIDA's position while she was in Plymouth! Overall, it was a fascinating job almost guaranteeing action". On HAIDA, one of the tags on a telephone junction box in the Fire Control Room makes reference to the Headache Office. HAIDA's Headache receiver was the Hallicrafters S27 whose frequency coverage was 27 Mcs to 143 Mcs. The receiver was given the Admiralty pattern designation RL85. Together with the aerial it was referred to as Outfit QD."

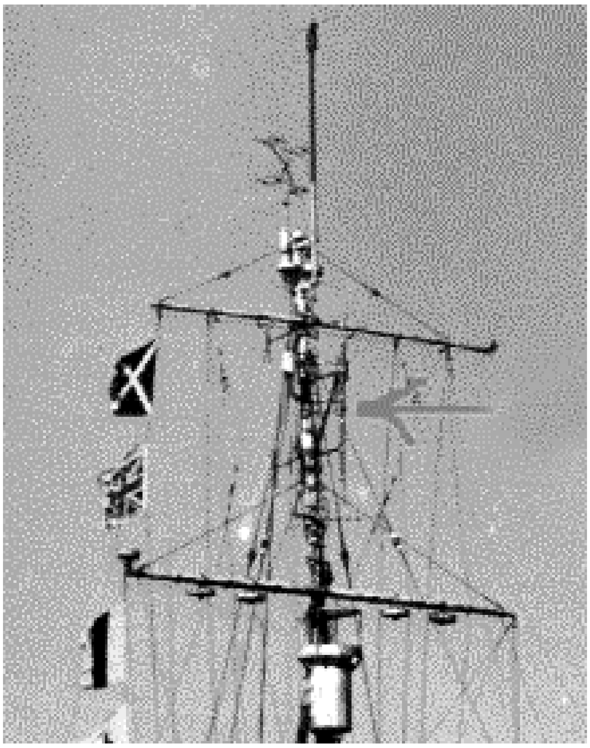


Outfit QD consisted of a VHF dipole antenna, a Hallicrafters S-27 receiver and interconnected with Pyrotenax transmission line instead of co-ax. It is presumed HAIDA was fitted in the identical manner (Image via Collingwood Heritage Collection).

The S-27 receiver covered 27.8 to 143 MHz (*Photo courtesy UK Vintage Radio web page)*

The S-27 receiver covered 27.8 to 143 MHz (*Photo courtesy UK Vintage Radio web page)*

The S-27 receiver covered 27.8 to 143 MHz (Photo courtesy UK Vintage Radio web page)


Although its a bit hard to see, this was the location of the QD antenna aboard HAIDA. (Image extracted from a photo of HAIDA entering Plymouth harbour in 1944).

4.2.7 UK Royal Signal Corps

Trench Set Radio

Radio, or as it was called prior to the 1950's 'Wireless', had started early in World War 1 for observers in aircraft, who could provide targets and intelligence for the artillery supporting fire. The introduction of wireless into trench warfare was much more piecemeal, especially with the use of voice instead of Morse Code.

WT Set Field Telephone

An early attempt was the "WT Set Field Telephone, made at the War Department factory in Teddington, had separate transmitter and receiver boxes and provided both voice and Morse Code capabilities.

The Trench Set Radio Mark 3 developed from these such early prototypes. It was designed in 1917, operated in the frequency range 150 KHz to 1.3 MHz. and remained in service until the early1920s when it had become obsolete.

The Trench Set Radio Mark 3

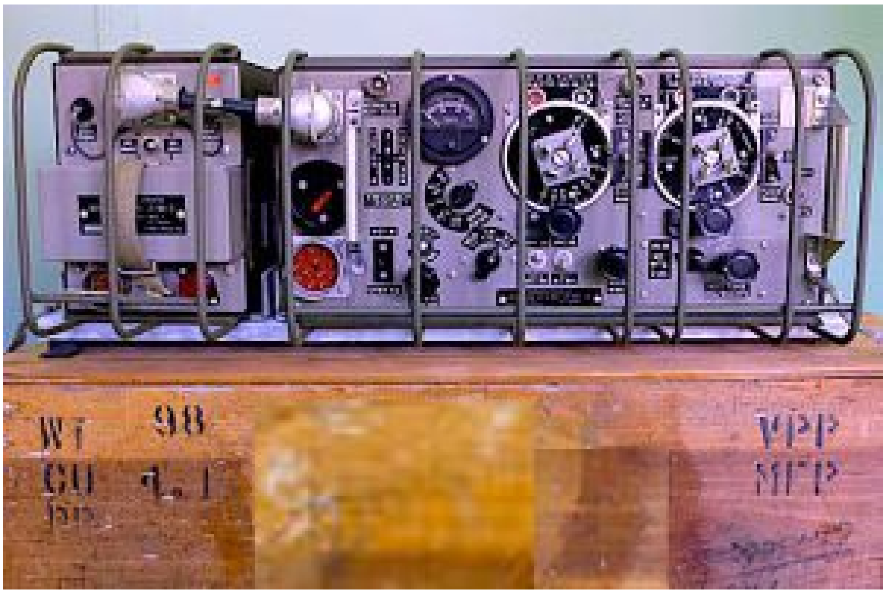
All the challenges faced by communicators during World War 2 and subsequently, such as antennas, battery size and set reliability, were present in this wireless, which even included a compass for the operator to use to orientate the antenna correctly. One of these compasses is held in the Royal Signals Museum. It was donated originally by the operator of this set during operations fighting the Germans on the Somme front. He had to destroy the set so it did not fall into enemy hands, but then used the compass to guide him back to Corps HQ.

Another major handicap with the Trench Set Radio Mark 3 was its poor power output, which frequently necessitated the use of a power amplifier, another bulky item. This meant that the overall weight was unacceptable as, by 1918, fighting had become much mobile. This situation was to prove to be the trend leading to World War 2 and beyond; Radio sets and the associated ancillaries had to become much more portable.

The No 1 Wireless Set was one of a range of wireless sets brought into service following the formation of the Corps in 1920. In 1929 a new series of Army wireless sets was formulated and in 1933 the Wireless Set No 1 was introduced into service for use by Infantry and Artillery Brigades.

Early sets were manufactured by Standard Telephones and Cables and designed to be vehicle or horse mounted to facilitate mobile communications. Limitations in the original design made the set unsuitable for large scale production so in 1935 Ferranti Ltd submitted a proposal for a redesign. The revised models were tested in 1936 but proved a failure; the primary disadvantage was the limited working range and, as considerable progress had been made with the design of the No 1 set, no further orders were placed. It is estimated that overall around 1800 No 1 sets were manufactured, the last sets delivered as late as 1938.

The No 1 Wireless Set



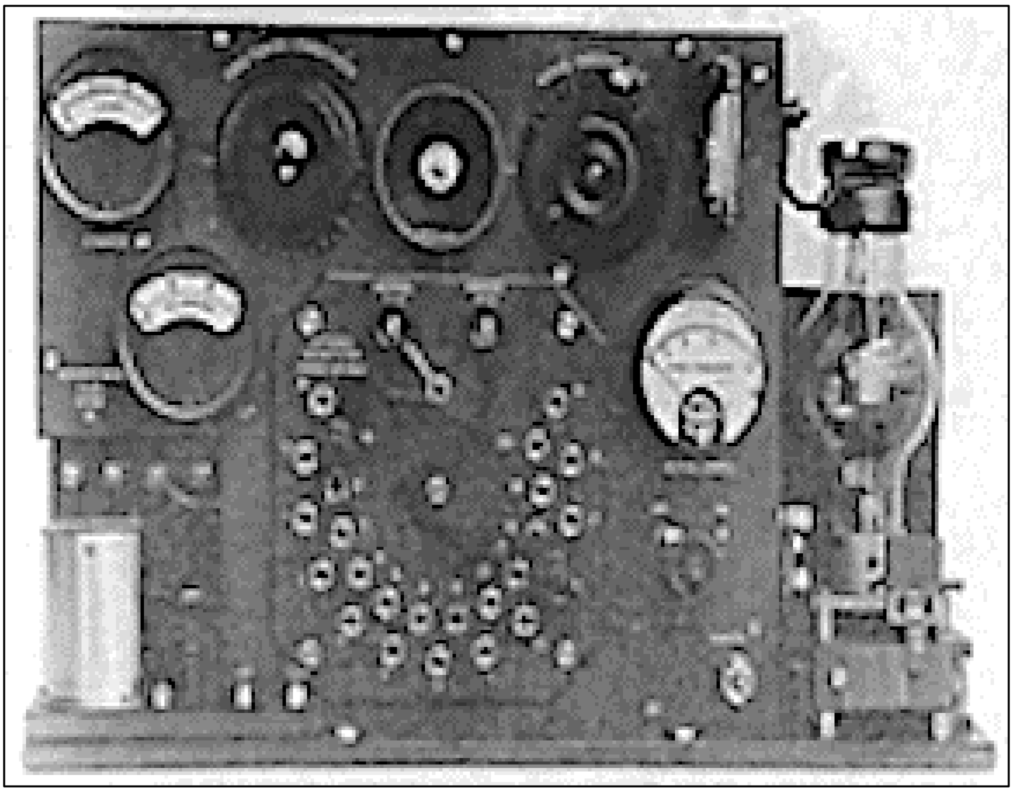
The No 19 Wireless Set

The No 19 Wireless Set was developed primarily to fulfil the communications requirements of highly mobile Armoured Fighting Vehicles in World War Two. It incorporated the B set and an early use of a VHF transceiver to provide inter-tank R/T communication.

Designed to War Office and Signal Experimental Establishment specifications and manufactured by Pye Ltd the Mark I was introduced into service in 1941 and used extensively in the North Africa campaign. Unfortunately, as a result of the intense heat leading to capacitor failure in the power supply unit many were soon put out of action. Replacement capacitors were obtained from the USA and flown direct to North Africa to allow the sets to be returned to service.

It was soon realised that the frequency coverage of the Mark I was too limited and a Mark II with a better frequency range was introduced into service in 1942. Further modifications were made to improve efficiency especially of CW and to reduce the drain on power and the Mark III set was introduced in 1943. Despite initial difficulties the No 19 Wireless Set gave good service and revolutionised armoured formation communications in World War Two. The Mark III set was particularly successful remaining in service until the late 1960's and used even later by Army Cadet Force signal units.

Wireless Set C
The C set came into service in 1926 and was still in use in India in the Waziristan Frontier War in 1937. It suffered from a great deal of interference and atmospherics even in the remote North West Frontier. Lt Col W R C Penny R SIGNALS, writing in the RSI Journal on the Waziristan Colonial War refers to the C set as follows : "Intercommunication between the two [fighting] columns was also allowed for by the C set, but local conditions defeated these sets and communications between the columns failed... At times atmospherics made work impossible, but wireless operators rapidly became familiar at dealing with messages up to 500 words, working under bad conditions for hours on end... When the C sets were defeated, then short wave sets homemade in the Corps Signals workshop played their part."



The Wireless Set C

The C set therefore heralded as the first real communications challenge in the use of radio. The alternatives, Line and Despatch Riders - mainstays of World War 1 - were no longer viable alone in future warfare. Radio was the future but, as all Royal Signals operators know, this came with its own challenges especially in the HF frequency band.

Background

The importance of Army communications, including the use of radio, was recognised in World War 1 and the formation of the new Corps of Royal Signals in 1920 was yet another sign of this new era. This period also saw commercial broadcasting becoming popular world wide. The BBC was formed in 1922 and George V broadcast his first Christmas message to the UK and the Commonwealth on 25 December 1932. Every family lived with a wireless from now on right through World War 2.

The Army planned a group of radio equipments known as the A, B and C sets, but, owing to defence cuts, only the A and C sets saw service. The frequency band of the C set was 150 - 462 KHz (receive) and 75 - 500 KHz (transmit), unfortunately this was the same band used for commercial broadcasting around the World.

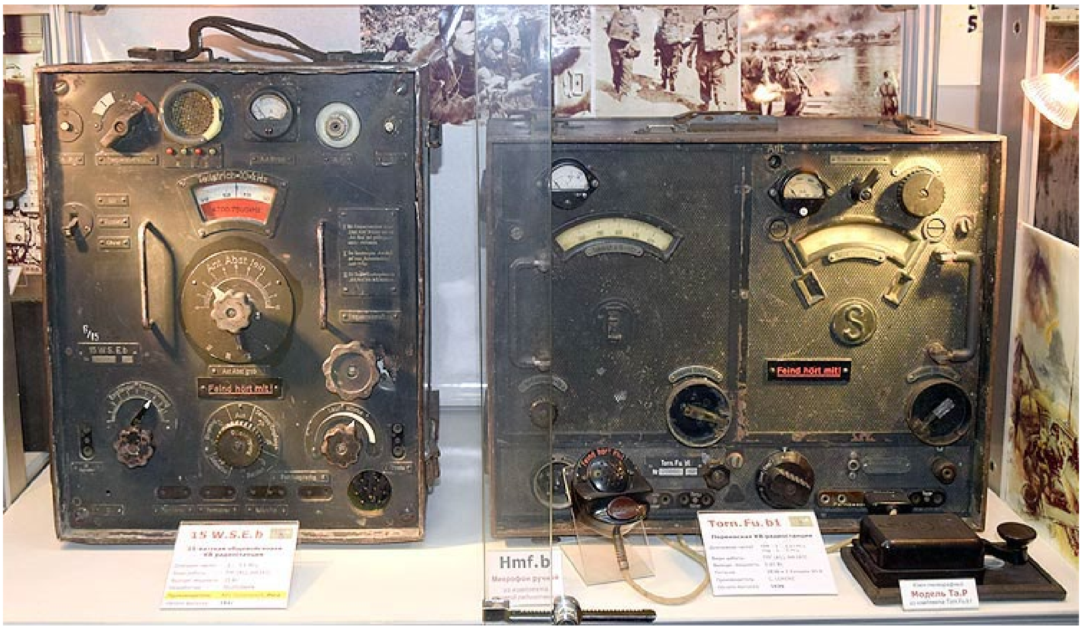
4.3 Some US WW 2 radio in a Russian museum

BC-222 *- Early US Army backpack radio, part of SCR-194,* ***T-74 / CRT-3*** *("Gibson Girl") - Life-raft transmitter, part of AN/CRT-3.*

71-TK-1 *Transmitter of tank HF radio, made in 1938,* ***US*** *General coverage receiver, made in 1937,* ***RPK-2*** *(Chaika) Airborne DF receiver made in 1941,* ***US-4S*** *HF receiver for ground transportable and fixed applications.*

WS No.48 Mk.I *- Infantry man-pack HF radio,* ***KL3*** *- Flameproof straight key for WS No.48,* ***T-17-D*** *- US Signal Corps hand microphone (Shure SW-217),* ***SV1*** *- Spare vacuum tube case for WS No.48.*

4.4 Some WW 2 German Radio in a Sovjet Museum



15 W.S.E.b *- Infantry two-man pack 15-watt HF radio,* ***Torn.Fu.b1*** *- Infantry two-man pack HF radio,* ***Dfh.f*** *- Standard infantry headset of German Wehrmacht,* ***Hmf.b*** *–Hand microphone of German backpack radios,* ***Ta.P.*** *- Straight Morse key of German backpack radios.*

4.5 USSR Radio WW 2

RSB-F *- HF transmitter, manufactured from 1940,* ***KUB-4M*** *- TRF receiver of Soviet Navy.*

5 Radiotelefoni i Sverige inom försvaret

5.1 Armén

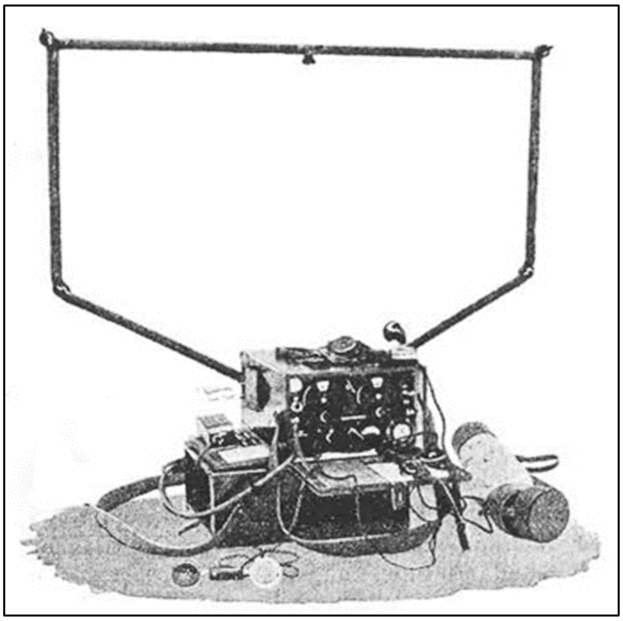
Arméns radiostationer var inledningsvis alla utförda för telegrafi. För artilleriets eldledning var inte telegrafi lämpligt utan man ville använda telefoni. Med utgångspunkt från den ramantenn som fanns till en av de första stationerna som utvecklats vid Kungliga Fälttelegrafkårens Tygverkstäder den bärbara radiostationen (1 W Br m/28) togs en ny radiostation 5 Watts bärbar radiostation m/30 (5 W Br m/30) fram.

Vid denna tid hade mottagare av superheterodyntyp uppfunnits av E H Armstrong. Experiment skedde vid fälttelegrafkårens verkstäder, arméförvaltningen beslutade dock att beställa utveckling vid SATT. SATT fick tillgång till ramantennkonstruktionen och en beställning på prototyp. Vid leveransprov underkändes stationerna av Elektriska laboratoriet (Ellab). Efter att SATT begärt skiljenämnd som godkände stationen beslutade förvaltningen att leverans skulle ske. Efter någon månad vid artilleriets signalskola kasserades stationerna. Arméförvaltningen beställde då stationer från fälttelegrafkårens verkstäder.

SATT fick några år senare beställning på 3 watts bärbar radiostation (3 W Br m/39) en med beteckning Telefunken SE 499A. Stationen var avsedd för artilleriet med telegrafi utan ton och telefoni.

Med tiden allt bättre elektronrör möjliggjorde att en radio 10W Br m/39 utvecklades. En handgenerator konstruerades, vilken säkerställde stationens strömförsörjning Denna radio kom att tillverkas i flera versioner. Bl a så beställde Finland 200 stycken. 1939 brann alla de finska stationerna upp. För att snabbt kunna komma igång med tillverkningen anlitades ca 60 underleverantörer. Ett planeringskontor etablerades, som sammanställningsverkstad användes försvarets verkstäder, där man hade en personalstyrka på 400.

5 Watts bärbar radiostation m/30 (5 W Br m/30)



5 W Br m/30 med ramantenn monterad

Radiostationen är uppdelad i fyra enheter, bestående av apparatlåda, två batterilådor, varav den ena i reserv samt en antennram i ett koger. Lådorna och kogret med antennramen kunna bäras i rem över axeln eller på mesar.

Batterilådan typ BL141 innehåller ackumulatorbatteri för rörens glödspänning samt tre seriekopplade anodbatterier på vardera 63 volt.

Ackumulatorbatteriet utgöres av två seriekopplade nifedubbelceller, typ dM18.

Antennen utgöres av en av metallrör bildad ram, antennramen, vars ändar genom hål i apparatlådan infästas i mottagare- och sändarapparaten. Antennramen är hopfällbar och skyddas vid transport av ett koger.

3 watts bärbar radiostation m/39 (3 W Br m/39)

3 W Br, drift under marsch

Tysk bärbar 1 watts KV-radiostation utförd för telegrafi utan ton och telefoni. Tillverkad av Telefunken med den civila beteckningen "Tragbare-1-Watt-KW-Station" type: SE499A. I Sverige kallades den ömsom för 1 W och 3 W. Den slutliga beteckningen blir 3 Watts bärbar radiostation m/39 (3 W Br m/39).

Stationen transporteras i två bördor:

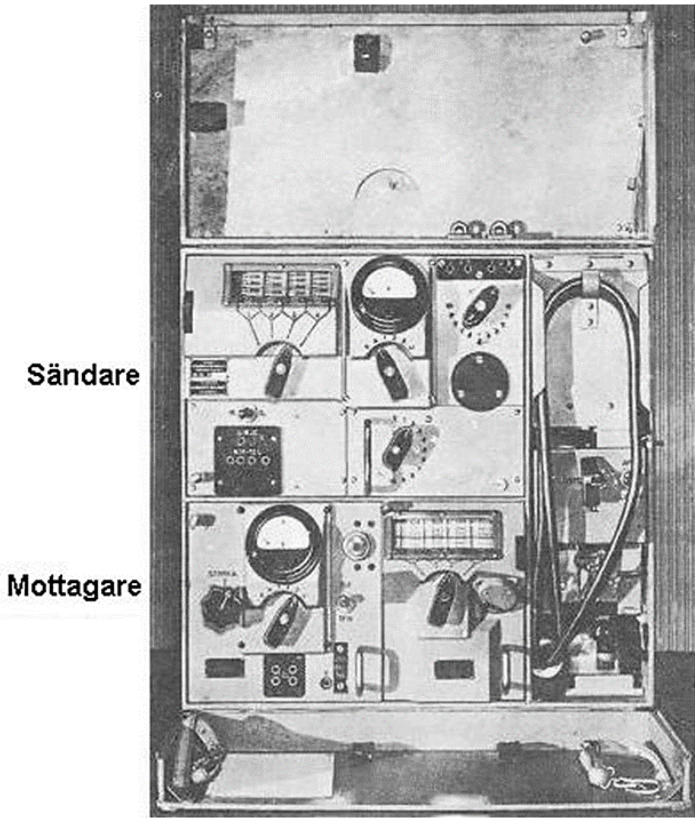
Apparatlådan innehåller sändare och mottagare.

Batterilådan innehåller batterier samt tillbehör bestående av antennutrustning, batterikabel, hörtelefon, handmikrotelefon, strupmikrofon och telegrafinyckel mm.

Batteriutrustningen utgöres av ett glödströmsbatteri bestående av två nifeackumulatorer typ D10 samt två seriekopplade anodbatterier typ A90.

Antennutrustningen utgöres av:
- En 12 m lång antennlina.
- En stavantenn som sammansättes av en fotdel 2, 3, 4 eller 5 antennstavar och ett toppstycke.

10 Watts bärbar radiostation m/39 (10 W Br m/39)



10 watts Br m/39

Svensk bärbar radiostationen som förekommer i flera olika utföranden:

10 watts bärbar radiostation (10 W Br m/39) Mtrlnr: Tc 91010
Är utförd i två bördor. Den ena bördan utgöres av apparatlådan, som innehåller sändare, mottagare och batterier. Den andra utgöres av handgenerator med packfickor.

10 watts klövjeradiostation (10 W Kl) *
Är utförd för klövjning och är uppdelad i fem enheter. Sändare, mottagare, batterilåda, materiellåda och handgenerator.

*10 watts cykelradiostation (10 W Cl) **
Är utförd för cykeltransport och är uppdelad i fyra enheter. Sändare, mottagare, batterilåda och handgenerator.

*10 watts infanteri radiostation (10 W I Br) **
Är utförd för bärning i fyra bördor på samma sätt som 10 W Cl.

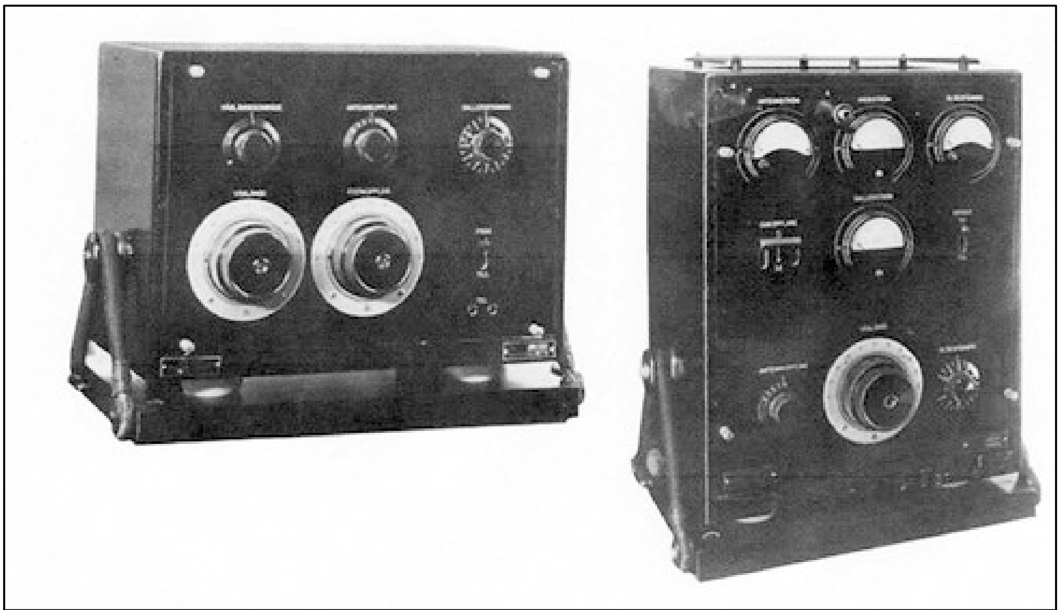
*) Dessa tre radiostationer utgick troligtvis under 1943 och ersattes av 10 W Br/4 m/39 - 43.

5.2 Marinen

Den svenska marinen var relativt tidiga med att införa UK som även efterhand kompletterades med telefonifunktion.

Från 1931 och åren framåt levererades ett relativt stort antal radiostationer för ultrakortvåg. Leverantören var Svenska Radioaktiebolaget (SRA)

Radiostationen bestod av sändare AK2T och mottagare MK2A och MK2B.



Till vänster kortvågsmottagare MK1A. UK-mottagare MK2B är till det yttre identisk med MK1A. Till höger sändare AK2T.

År 1932 levererades från Svenska Radioaktiebolaget (SRA) en radiostation med UK-sändare AK2T och UK-mottagare MK2B. Stationen var enbart avsedd för telegrafi och arbetade inom frekvensområdet 37 till 43 MHz, våglängdsområdet 7 - 8 m. Den 10 januari 1931 lades en beställning till Svenska Radioaktiebolaget på 12 st UK-stationer m/34 bestående av UK-sändare m/34 (AK2T) och UK-mottagare m/34 (MK2B) tillsammans med tre fullständiga materialbeskrivningar men exklusive antenner och faderledning till en total kostnad av 10407,50 kronor.

Samtidigt beställdes också från Svenska Radioaktiebolaget 14 telefonitillsatser typ TT-7 för UK-sändare AK2T. Stationerna var avsedda för fartyg och fler beställningar följde på något modifierad materiel. Som ersättning i händelse av haverier anskaffades reservradiostationer bl.a. ALK-25/MKL1. Prov med moderniserad UK-station M34/37 utfördes inom kustflottan. Proven gav goda resultat varför beslut fattades att äldre UK-stationer av typen m/34 skulle modifieras.

I skrivelse till CKF (Chefen för kustflottan) 11 januari 1939 ombads att flottans fartyg sände in UK-stationer för modifiering till Svenska Radioaktiebolaget. Följande fartyg planerades att erhålla modifierade UK-stationer med telefonitillsatser: Gustav V, Drottning Victoria, Gotland, Klas Horn, Klas Uggla, Stockholm, Göteborg, Dristigheten, Svea, Jacob Bagge, Snapphanen, Jägaren, Kaparen och Niord (Hårsfjärden Radio). UK-station m/34/37 med telefonitillsats planerades att installeras vid Skeppsholmen Radio i april 1939.

Beskrivningar över UK-station m/34/37 överlämnades till CÖVS (Chefen Örlogsvarvet Stockholm) och CÖVK (Chefen Örlogsvarvet Karlskrona) samt CMDS den 4 januari 1939. Det var totalt 41 beskrivningar över UK-sändare m/34/37 (AK2T/37), 41 beskrivningar över UK-mottagare m/34/37 (MK2B/37) och 41 beskrivningar över UK-vågmästare m/34/37 (VM-7CK/37) samt kalibreringskurvor m.m.

5.3 Flygvapnet

Under tidigt 20-tal började information att komma om att man bland annat i USA kunnat överföra tal till och från flygplan. Det var förknippat med stora problem, radiokanalerna var bredbandiga, informationen försvann i brus, ljudnivån i flygplanen var hög mm. Telegrafi med morsetecken var relativt säkert, treställiga bokstavskombinationer med olika betydelser var lättare att ta emot speciellt om de upprepades och radions motståndare hade tveksamt börjat acceptera radio med telegrafi.

Från 1926 hade flygvapnet börjat pröva radiotelefoni för samband med jaktflyg som var ensitsiga och därmed hade svårt att hantera telegrafimeddelanden. Manöverreglemente för flygvapnet som gavs ut 1927 behandlar bland annat ”Ordergivning i luften, med Radiotelefonering”. Försök utfördes vid F3 med Fr m/25 men utan tillfredställande resultat. Man fann att mottagaren inte var tillräckligt känslig och rapporterade att mottagning av telefoni från en 200 W markstation inte var möjligt och 1929 vidhöll Flygstyrelsen att radio endast skulle användas med radiotelegrafi.

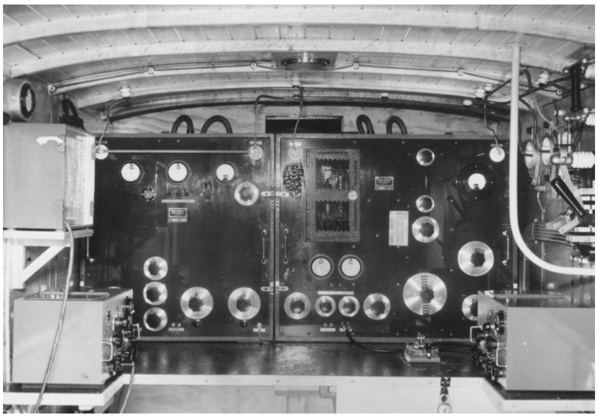
Marinen låg på en högre teknisk radionivå och Chefen för kustflottan framförde under 1930 att: ”Sommarens erfarenheter har givit ytterligare belägg på svårigheten att efter starten dirigera jaktflygplanen mot ett fientligt mål. Enda tillförlitliga sättet torde vara inmonterande av radio i jaktplanen, t.ex. kortvågstelefoni”.

Efter år av utprovningar och interna olika uppfattningar om kortvåg och telefoni angav Flygstyrelsen i ett VPM 1932 att de mobila radiostationerna skall förses med en kortvågstillsats och att kortvåg har blivit standard.

1934 blev ett märkesår för flygvapnets radiosamband då Flygstyrelsen beslöt att hålla en stor signalsamövning, som utöver flygvapnet även omfattade armén och marinen. Övningen var den första i sitt slag genom att på ett väl förberett sätt få fram hur radiosambandet fungerade inom hela Försvarsmakten samt att dra slutsatser om hur den skulle utvecklas.

I slutrapporten angavs att bristerna för radiosambandet var mycket stora och allvarliga och många förslag till åtgärder redovisades. Flera av de i rapporten redovisade förslagen till åtgärder fanns med i 1936 års försvarsbeslut och kom efter realiseringen att vara kvar till början av 1960-talet.

1936 meddelar CF1 att radiotelefoni på kortvåg visat sig vara synnerligen användbart och för de nya mark- och flygradiostationer som 1936 års försvarsbeslut gav utrymme för blev kortvåg och telefoni det dominerande sambandsmediet.



Allmänt
Försvarsgren: Arméns flygkompani, FV
Benämning: Br m/23-m/32, Tmr I - VII
Operativ funktion: Flygtrafikledning, Taktisk ledning, Väder
Tidsperiod: 1923 - 1945
Antal: 10 fordons par
Radio: sändare LV MS 20, KV SMS 20 mottagare: Typ M4A, M4k
Trafiktyp: Telegrafi, Telefoni
Tillverkare: Svenska Aktiebolaget Trådlös Telegrafi (SATT)
Teknik: Elektronrör
Fordon: Typ 1 Volvo, 4-cyl, Typ II-VI, Volvo 6-cyl

Tekniska data
Sändare LV: Räckvidd cirka 500 km, tre elektronrör,
Sändare KV: Stor räckvidd, fyra elektronrör
Tillförd effekt: LV 700 W, KV 600 W
Frekvens: LV 1200-240 kc/sek
KV 10 000-1111 kc/sek
Mottagare frekv: M4a 10 000-100 kc/sek
M4k 12 000-1000 kc/sek
Antenn: Magirusmast 17 m med antenntrådar.

Transportabel markradio Tmr I – VII. Br m/23 – m/32.

5.4 Jämförelse av utvecklingen i omvärlden och i Sverige

Radion fick under WW I sitt stora genombrott, vilket kom att innebära att stora insatser gjordes för att förbättra teknik och metoder för en fortsatt utveckling av utrustningar. Som tidigare nämnts kom Marconiföretagen att ha en stor roll för den militära radioutvecklingen. Även de tyska företagen AEG/Telefunken m fl hade stor betydelse för utvecklingen.

I Sverige fanns det AEG/Telefunken kopplade SATT, AGA, det 1919 startade SRA som senare blev delägt av Marconi. Förutom dessa arméns fälttelegrafkårens tygverkstäder som kom att stor betydelse för utvecklig och materielförsörjning av radio till armén.

I USA och UK satsades det stora resurser för att kunna införa radiotelefoni främst inom flyget och i viss mån marinen. Armén var inte så pigga på att införa radio överhuvudtaget främst beroende på risken att kunna pejlas. Inom armén var det främst artilleriet som efterfrågade radiotelefoni.

Utvecklingen i Sverige följde i stort omvärlden med några års eftersläpning. Marinen var även inom detta område tidigt framme med tidigt användande av radiotelefoni och även tidiga med att införa UK.

I Sverige dröjde det till en bit in på 30-talet innan radion var spridd inom de flesta försvarsfunktionerna. En breddspridning kom dock inte att ske förrän långt senare i samband med surplusanskaffning efter WW II.

I FHT dokumentation finns ytterligare information om utvecklingen i Sverige i dokumenten:

Arméns lätta radiostationer under 1900-talet (15 MB) (A03/09) Författare: Sven Bertilsson och Thomas Hörstedt
Arméns tunga fordonsburna radiostationer (17,6 MB)(A06/05) Författare: Sven Bertilsson.
Radioutvecklingen inom den svenska armén (2 MB) Författare: Göran Kihlström (A 01/18)

Pionjärtiden Marinens Televerksamhet (3,5 MB) Författare: Gösta Brigge.
Långvågsradio och ubåtssamband (kortversion) (4,8 MB) Författare: Carl-Henrik Walde
Radioutvecklingen inom den svenska marinen (1,5 MB) Författare: Göran Kihlström (M01/18)

Första radiosambandet Flyg-Mark (3,3 MB) Författare: Arne Larsson (F02/18)

Militär flygradio 1916-1990 (8 MB) Författare: Lars V Larsson (F06/12)

Flygvapnets radiosystem, del 1, 1916-1945 (28 MB) Författare: Arne Larsson. (F13/09

Radioutvecklingen för det militära flygsambandet (1 MB) Författare: Arne Larsson

Svenska försvaret och radioindustrin Författare: Göran Kihlström (G 01/18)

6 Fjärrskrift

6.1 Tidig utveckling

Edward E. Kleinsclunidt

Kleinschmidt began working with nascent communications technology in 1893 while still in his teens. He first patented a Morse keyboard transmitter, in 1895 (Patent No. 964,372, filed February 7, 1895; issued January 11, 1910) and later a Morse keyboard perforator. Keyboard perforators were a development from Charles Wheatstone's perforator of 1858, a hand-operated device which produced a punched paper tape for use in automatic telegraph transmitters.

Soon after, he set up the Kleinschmidt Electric Company. With George Seely, he developed signaling equipment for railways. The pair began their work in 1906, and by 1910, they were able to demonstrate a completed device. The signaling technology is still used by railways throughout North America.

In 1916 he filed a patent application for a typebar page printer. In 1919, shortly after the Morkrum company obtained their patent for a start-stop synchronizing method for code telegraph systems, which made possible the practical teleprinter, Kleinschmidt filed an application titled "Method of and Apparatus for Operating Printing Telegraphs" which included an improved start-stop method.

Instead of wasting time and money in patent disputes on the start-stop method, Kleinschmidt and the Morkrum Company decided to merge and form the Morkrum-KleinschmidtCompany in 1924. The new company combined the best features of both their machines into a new typewheel printer for which Kleinschmidt, Howard Krum, and Sterling Morton jointly obtained a patent.

In December 1928, the company name was changed to Teletype Corporation, and in 1930 Teletype Corporation was sold to the American Telephone and Telegraph Company for $30 million. In 1931, Kleinschmidt set up Kleinschmidt Laboratories, presently known as Kleinschmidt Inc, to further refine the teletypewriter and do research and development for the Teletype Corporation.

During World War II, Kleinschmidt's son Bernard learned that the US Signal Corps needed a lightweight, transportable teleprinter and in February 1944, Kleinschmidt demonstrated a working model of his lightweight teleprinter at the office of the Chief Signal Officer. The Kleinschmidt 100-words-per-minute typebar page printer became the standard for US forces in 1949.

The success of its printer, and an order for 2,000 examples caused Kleinschmidt Laboratories to purchase a 13-acre (53,000 m^2) parcel of land in Deerfield, Illinois, to house the manufacturing operations. This location and the original buildings are the current home of Kleinschmidt Inc.

Donald Murray (1865 – 1945) was an electrical engineer and the inventor of a telegraphic typewriter system using an extended Baudot code that was a direct ancestor of the teleprinter (teletype machine). He can justifiably be called the "Father of the remote Typewriter".

Murray's system became the International Telegraph Alphabet No. 2 (ITA2) or Murray Code, it was supplanted by the American Standard Code for Information Interchange (ASCII) in 1963.

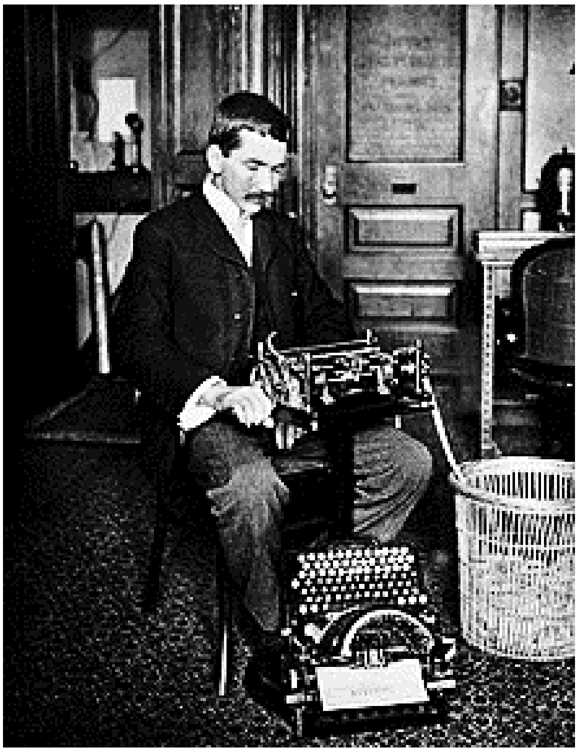
Telegraphic typewriter

It was during his time with the *Sydney Morning Herald* that Murray got the idea for the telegraphic typewriter. At the time, telegrams were transmitted by telegraphists using Morse code, then typed onto a telegram form which was then delivered by pushbike or on foot. Murray's idea was to use a typewriter to drive a device that translated each character of the text into a modified Baudot code. On the receiving end, another mechanism would print the coded characters on a paper tape, and/or make a perforated copy of the message. This system allowed the transmission of messages without need of operators trained in Morse code. At the time typists were being trained in great numbers using the QWERTY keyboard layout.

Murray went to New York City in 1899 with the idea for his invention, and sought backing while submitting a patent. The patent describes the teleprinter system. It received backing from the Postal Telegraph Cable Company, and was then manufactured. This formalized and heavily promoted the use of the QWERTY keyboard, to the detriment of other keyboard layouts.

The machines were introduced world-wide, with systems prominently at New York's Western Union and London's General Post Office.

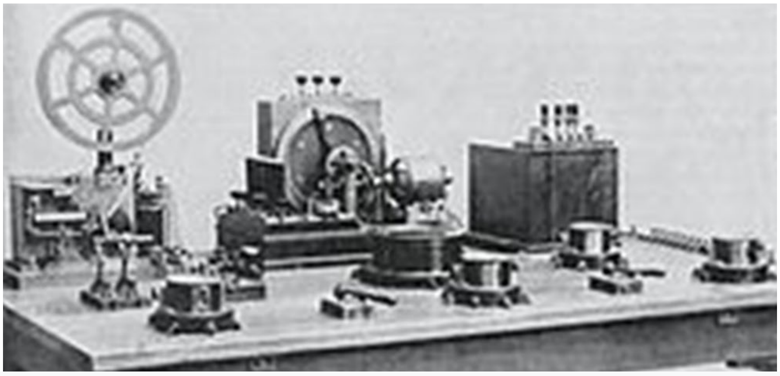
Murray soon moved to London and remained there until he sold the rights to his invention in 1925. He then retired to Monte Carlo and later Switzerland, where he studied and wrote on philosophy.



Murray with Telegraphic Typewriter before 1901


Hughes telegraph

Hughes telegraph, an early (1855) teleprinter built by Siemens and Halske. The centrifugal governor to achieve synchronicity with the other end can be seen

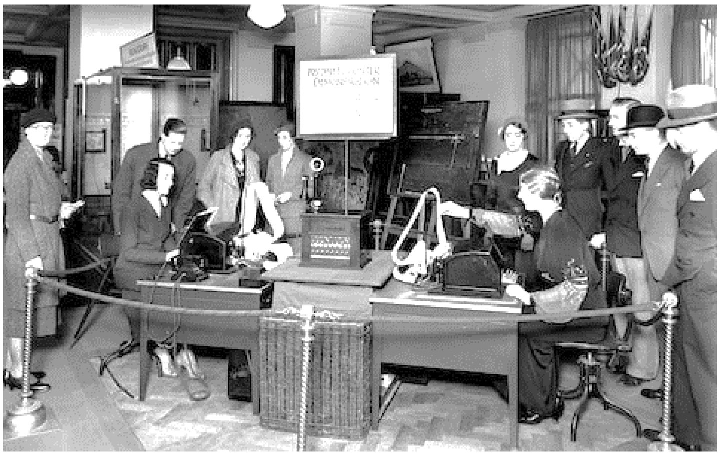

Type pressure quick telegraph from Siemens & Halske. Punch strip reader and transmitting apparatus, 1905.

The story began in 1902 when a young electrical engineer named Frank Pearne arrived in Chicago with a letter of introduction to Joy Morton, head of the Morton Salt interests. Pearne, who had been experimenting with a printing telegraph system, wanted financial help so he could keep working. Morton talked it over with his friend Charles L. Krum, a distinguished mechanical engineer and vice president of the Western Cold Storage Company, operated by Joy Morton's brother, Mark. The verdict for Pearne was favorable, and a laboratory was set up for hire in the attic of the cold storage company.

After about a year of unsuccessful experiments Pearne lost interest and decided to go into the teaching field. Krum continued the work and by 1906 had developed a promising model. In that year his son, Howard, a newly graduated electrical engineer, plunged into the work alongside his father. Experiment succeeded experiment, with many moments of doubt. But, overall, progress was encouraging, and finally the Morkrum Company -named for Morton and Krum, and later to be re-named Teletype Corporation-was incorporated on October 5, 1907, with a capital of $150,000. THE FIRST TEST. By 1908 a working model was made which looked good enough to test on an actual telegraph line. The printing portion was a modified Oliver typewriter, mounted on a desk with the necessary relays, contacts, magnets, and interconnecting wires. Joy Morton, who was a director of the Chicago and Alton Railroad, arranged for a trial on the railroad's wires between Chicago and Bloomington, a span of about 150 miles.

The test of the experimental printer was highly promising and Charles and Howard Krum went back to work, making more models and improving them, seeking to develop a small neat, direct keyboard typewheel printer. This was a period of basic invention and experimentation with printing telegraph. Western handling part of its traffic with the Barclay system; the Hughes and Baudot systems were being used abroad, and there were many others. Each system had advantages, disadvantages, imperfections. In general. they were apt to be extremely delicate, overly complicated, and too expensive in manufacturing cost and maintenance to be practical.

The most serious problem was maintaining synchronism between the sending machine and the remote printer. If the distant unit was “off;” it would receive the signals in improper sequence and print gibberish. For reliable transmission, the sending and receiving units had to be “in step” with each other-and the synchronism had to be maintained throughout transmission. It remained for this problem to be solved before the printing telegraph concept could take giant steps in the communication world. Among Howard Krum's many contributions to printing.



Taping off: a demonstration of Teleprinters at Selfridges in late 1932.

Siemens t37h (1933) without cover.

Fax
Fax (short for **facsimile**), sometimes called **telecopying** or **telefax** (the latter short for **telefacsimile**), is the telephonic transmission of scanned printed material (both text and images), normally to a telephone number connected to a printer or other output device. The original document is scanned with a **fax machine** (or a **telecopier**), which processes the contents (text or images) as a single fixed graphic image, converting it into a bitmap, and then transmitting it through the telephone system in the form of audio-frequency tones. The receiving fax machine interprets the tones and reconstructs the image, printing a paper copy. Early systems used direct conversions of image darkness to audio tone in a continuous or analog manner. Since the 1980s, most machines modulate the transmitted audio frequencies using a digital representation of the page which is compressed to quickly transmit areas which are all-white or all-black.

Fax machine from 1990, using thermal printing which required special, relatively expensive thermal paper.

6.2 utgått

6.3 Militära tillämpningar

6.3.1 USA

6.3.1.1 Radioteletype US Navy

Radioteletype (RTTY) is a telecommunications system consisting originally of two or more electromechanical teleprinters in different locations connected by radio rather than a wired link. These machines were superseded by personal computers (PCs) running software to emulate teleprinters. Radioteletype evolved from earlier landline teleprinter operations that began in the mid-1800s. The US Navy Department successfully tested printing telegraphy between an airplane and ground radio station in 1922.

Later that year, the Radio Corporation of America successfully tested printing telegraphy via their Chatham, Massachusetts, radio station to the R.M.S. Majestic. Commercial RTTY systems were in active service between San Francisco and Honolulu as early as April 1932 and between San Francisco and New York City by 1934. The US military used radioteletype in the 1930s and expanded this usage during World War II. From the 1980s, teleprinters were replaced by computers running teleprinter emulation software.

The term radioteletype is used to describe both the original radioteletype system, sometimes described as "Baudot", as well as the entire family of systems connecting two or more teleprinters or PCs using software to emulate teleprinters, over radio, regardless of alphabet, link system or modulation.

In some applications, notably military and government, radioteletype is known by the acronym RATT (Radio Automatic Teletype).

TEMPEST (Telecommunications Electronics Materials Protected from Emanating Spurious Transmissions) is a U.S. National Security Agency specification and a NATO certification referring to spying on information systems through leaking emanations, including unintentional radio or electrical signals, sounds, and vibrations. TEMPEST covers both methods to spy upon others and how to shield equipment against such spying. The protection efforts are also known as emission security (EMSEC), which is a subset of communications security (COMSEC).

The NSA methods for spying on computer emissions are classified, but some of the protection standards have been released by either the NSA or the Department of Defense. Protecting equipment from spying is done with distance, shielding, filtering, and masking. The TEMPEST standards mandate elements such as equipment distance from walls, amount of shielding in buildings and equipment, and distance separating wires carrying classified vs. unclassified materials, filters on cables, and even distance and shielding between wires or equipment and building pipes. Noise can also protect information by masking the actual data.

While much of TEMPEST is about leaking electromagnetic emanations, it also encompasses sounds and mechanical vibrations. For example, it is possible to log a user's keystrokes using the motion sensor inside smartphones. Compromising emissions are defined as unintentional intelligence-bearing signals which, if intercepted and analyzed (side-channel attack), may disclose the information transmitted, received, handled, or otherwise processed by any information-processing equipment.

Bell 131B2 mixer, used to XOR teleprinter signals with one-time tapes, was the first device from which classified plain text was extracted using radiated signals.

During World War II, Bell Telephone supplied the U.S. military with the 131-B2 mixer device that encrypted teleprinter signals by XOR'ing them with key material from one-time tapes (the SIGTOT system) or, earlier, a rotor-based key generator called SIGCUM. It used electromechanical relays in its operation. Later Bell informed the Signal Corps that they were able to detect electromagnetic spikes at a distance from the mixer and recover the plain text. Meeting skepticism over whether the phenomenon they discovered in the laboratory could really be dangerous, they demonstrated their ability to recover plain text from a Signal Corps' crypto center on Varick Street in Lower Manhattan. Now alarmed, the Signal Corps asked Bell to investigate further. Bell identified three problem areas: radiated signals, signals conducted on wires extending from the facility, and magnetic fields. As possible solutions, they suggested shielding, filtering and masking.

A long process of evaluating systems and developing possible solutions followed. Other compromising effects were discovered, such as fluctuations in the power line as rotors stepped. The question of exploiting the noise of electromechanical encryption systems had been raised in the late 1940s, but was re-evaluated now as a possible threat. Acoustical emanations could reveal plain text, but only if the pick-up device was close to the source. Nevertheless, even mediocre microphones would do. Soundproofing the room made the problem worse by removing reflections and providing a cleaner signal to the recorder.

In 1956, the Naval Research Laboratory developed a better mixer that operated at much lower voltages and currents and therefore radiated far less. It was incorporated in newer NSA encryption systems. However, many users needed the higher signal levels to drive teleprinters at greater distances or where multiple teleprinters were connected, so the newer encryption devices included the option to switch the signal back up to the higher strength. NSA began developing techniques and specifications for isolating sensitive-communications pathways through filtering, shielding, grounding, and physical separation: of those lines that carried sensitive plain text – from those intended to carry only non-sensitive data, the latter often extending outside of the secure environment.

The USN began to make use of radioteletype, a system that transmits messages that have been pre-recorded onto paper tape and prints them out on the other end, in 1944. This reduced the need for skilled operators and increased transmission speed substantially.

A radioman operating a teletype
These systems not only improved security, they also pointed the way for the future of naval communications.

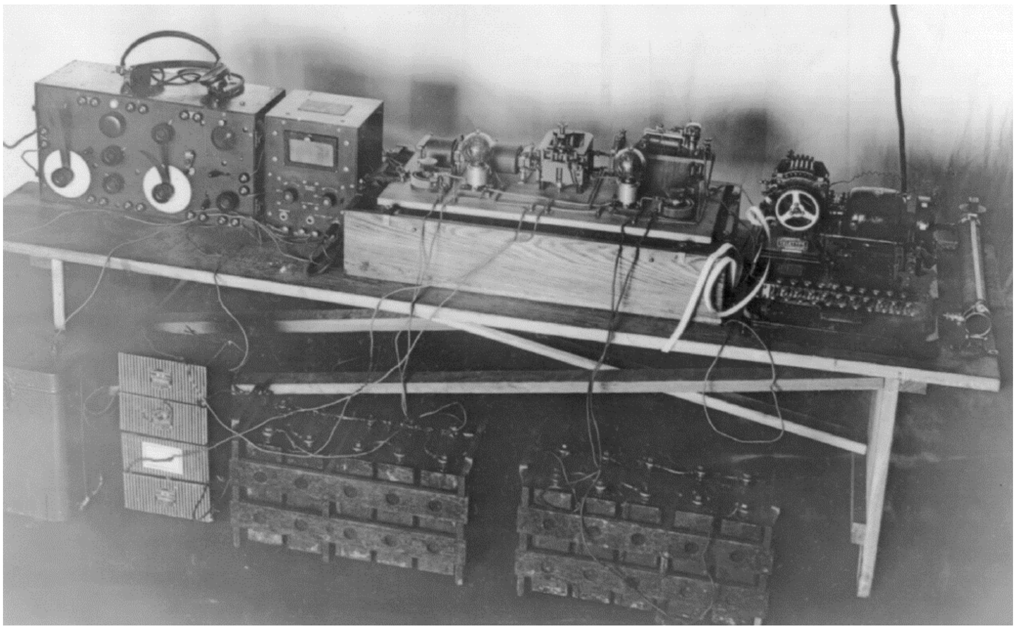
Torn Tape Equipment aboard USS Midway

19ASR. It could run at 60 or 75 words per minute by changing gears. The dial was a keystroke counter when punching a paper tape. You could only have so many characters on a line, then you had to have carriage return and line feed, before starting a new line.

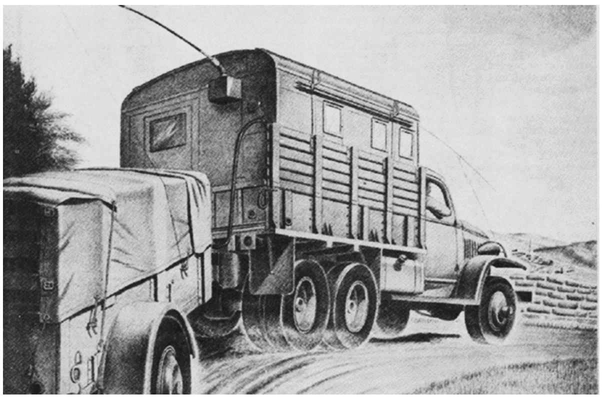
Radioteletype really got going during World War II. All the services used it. The US Navy called it RATT (RAdioTeleType) and the Army Signal Corps called it SCRT, short for Single-Channel Radio Teletype.

6.3.1.2 US Army

The US Army Signal Corp's teletype typewriter was the US major method of military communication during WW2 and was the US equivalent to the famous German enigma machine. While the enigma actually calculated the encoding and the decoding of military messages as they were typed, US coding was performed manually prior to being typed and then again manually decoded after being received on the other end. After several generations of communication technology obsolescence, most WW2 vintage teletype typewriters ended in the scrap heap. Because of their souvenir value and collectible status, more enigma machines probably survived to today than did teletype typewriters. Does that mean that a WW2 vintage teletype typewriter is rarer today than is a enigma machine?



Teletype radio plane set, used by the Navy Dept. för receiving typewritten radio messages from Naval Air planes. Created/Published 1922 Aug. 30. Format Headings. Photographic prints 1920 – 1930.



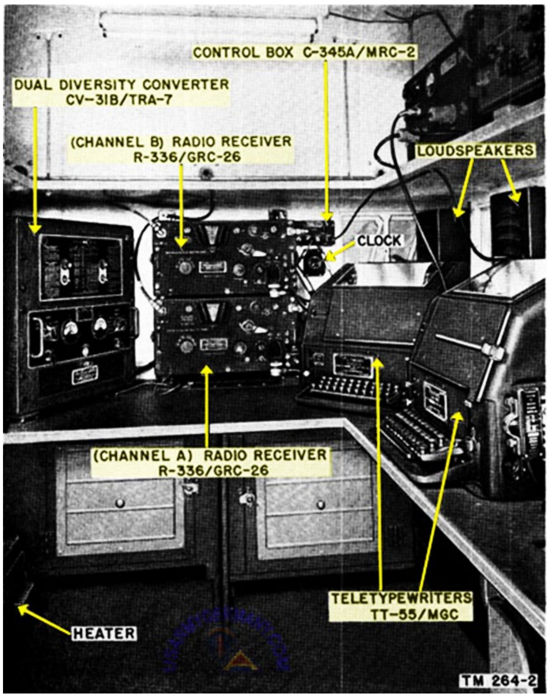
The AN/GRC-26 Series
The first high power mobile radio systems were the SCR-299, and later the SCR-399, during WWII. It was from these that the first AN/GRC-26 evolved in approximately 1950. The early sets were installed in GMC CCKW 2-1/2 ton trucks and eventually were mounted in many different 2-1/2 ton series of trucks. My unit had the 26A version mounted in M-211 and M-135 GMC trucks in 1969. We will list the components found in each version, in the sections below.

The 26 series consists of a transportable assembly of equipment providing facilities for transmission and reception of radio teletype signals on an frequency shift basis over a frequency range of 2 to 18 Mhz. Maximum power output is approximately 400 watts. Facilities are provided for operation of full duplex, half duplex or one way reversible circuits. CW and AM may be used alone or simultaneously with teletype operation. Shelter S-55/GRC, containing all the communication equipment is normally transported by a 2-1/2 ton cargo truck. Power unit PE-95(*), installed in a 1 ton trailer, is towed by the cargo truck. The complete radio set may also be transported in a C-82 aircraft.

CW and voice can be used in motion or at a halt. For teletype communication it is recommended that the vehicle be brought to a halt.

For mobile, one-way reversible operation, three whip antennas are used; two for receiving and one for transmitting. Mobil at halt operation normally utilizes whip antennas. If time permits, however, a doublet transmitting antenna should be erected to improve transmitted signal strength. For semi-fixed installations, doublet antennas are used for both transmitting and receiving with two receiving antennas for dual space diversity reception.

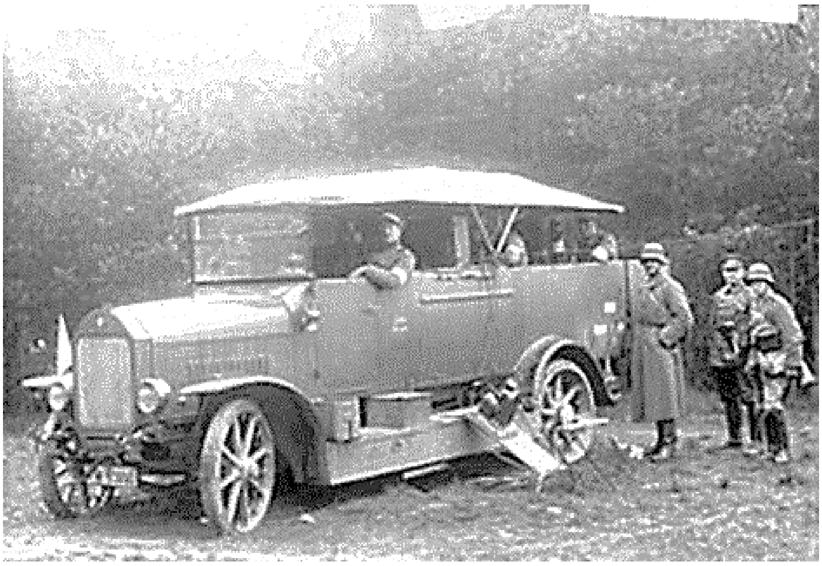
The internal equipment consists of Joint Army/Navy receivers, transmitter, teletype equipment and radio teletype components. These have been modified for this application. Components of the radio teletype equipment are in special, compact, shock mounted cabinets to allow them to be located in a limited amount of space. All operating components are located on tables and shelves in the shelter.



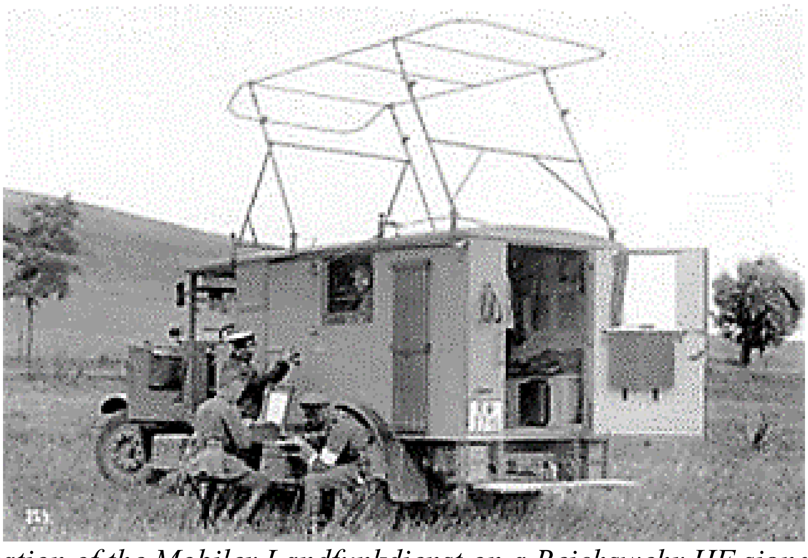
6.3.2 Reichswehr Germany

In addition to radio and telephone communications, the newly developed teleprinters, carrier pigeons and heliographs were used for messaging. During the First World War, radio telegraphy took on increasing importance. For example, in 1915 teleprinters were first used by the air force, for artillery observation. In 1916, the first signalmen equipped with mobile radios were operating on the front line.

In the Reichswehr from 1921 each division had a communications unit with two companies. As well as radio and telephone communications, signal pigeons were also used for the transmission of information. From 1930, Enigma cypher machines were used for the first time to automatically encrypt secret information.



Mercedes signals vehicle of the Reichswehr in 1925.

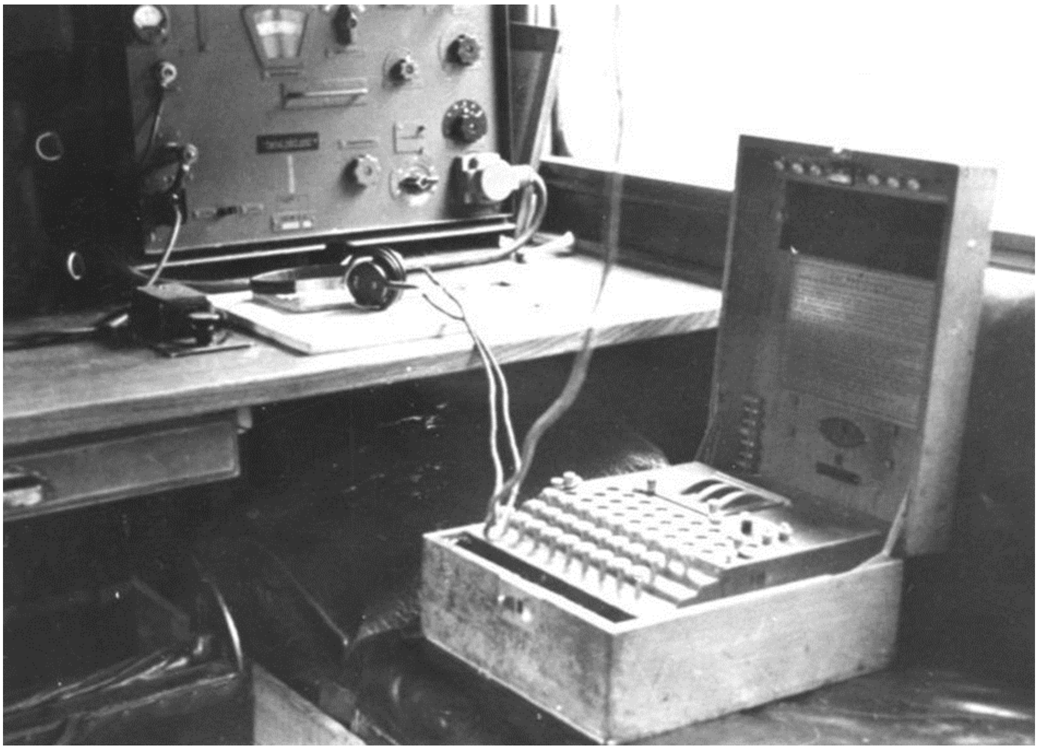


Mobile radio station of the Mobiler Landfunkdienst on a Reichswehr HF signals wagon (HF-Funkenwagen) in 1928.

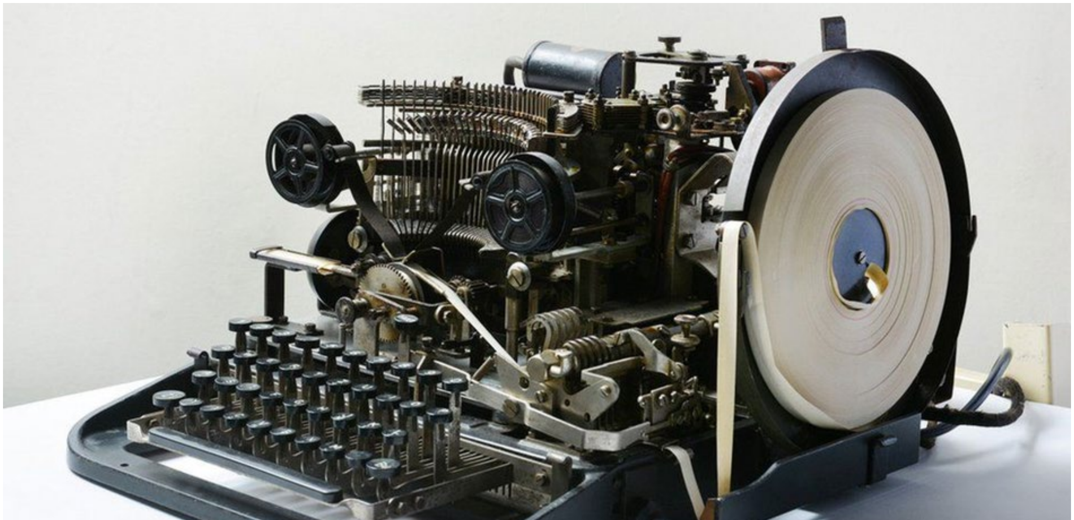
The **Hellschreiber, Feldhellschreiber or Typenbildfeldfernschreiber** (also **Hell-Schreiber** named after its inventor Rudolf Hell) is a facsimile-based teleprinter invented by Rudolf Hell. Compared to contemporary teleprinters that were based on typewriter systems and were mechanically complex and expensive, the Hellschreiber was much simpler and more robust, with far fewer moving parts. [It has the added advantage of being capable of providing intelligible communication even over very poor quality radio or cable links, where voice or other teledata would be unintelligible.

The device was first developed in the late 1920s, and saw use starting in the 1930s, chiefly being used for land-line press services. During WW2 it was sometimes used by the German military in conjunction with the Enigma encryption system. In the post-war era, it became increasingly common among newswire services, and was used in this role well into the 1980s. In modern times Hellschreiber is used as a communication mode by amateur radio operators using computers and sound cards; the resulting mode is referred to as **Hellschreiber, Feld-Hell**, or simply **Hell**.

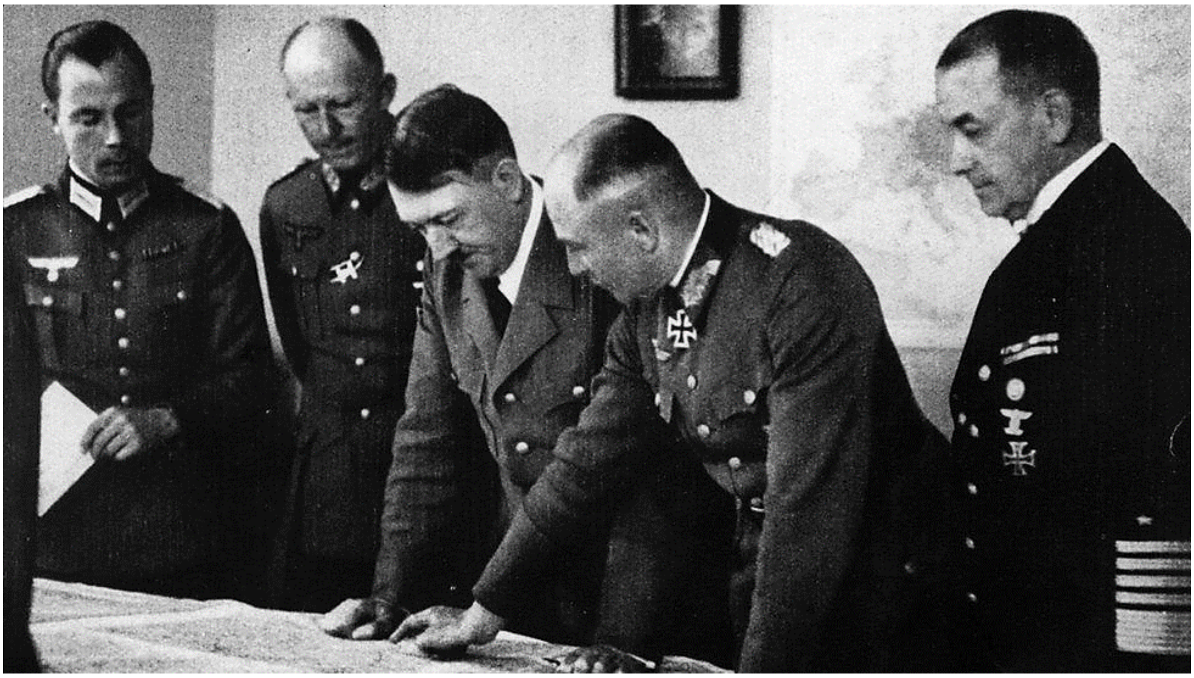
The machine is housed in a panzerholz transport case and consists of a keyboard, scanning drum, printer, motor and an amplifier. The amplifier is fixed in the top right corner, but the keyboard can be pulled forward for easier operation Fieldhellschreibers were usually painted grey and came in various shades, depending on the army department (e.g. Luftwaffe) or the year in which they were built. The image on the right shows a typical Feldhellschreiber in a rather uncommon green colour, that was built for the Czech Army in 1936.



Enigma cypher machine of the 7th Panzer Division, Eastern Front, 1941.



The teleprinter for the Lorenz cipher machine, which Hitler used to message his top generals.



During the war, the Lorenz teleprinter was used to swap personal messages from Hitler to the generals

The teleprinter, which resembles a typewriter, would have been used to enter plain messages in German. These were then encrypted by a linked cipher machine, using 12 individual wheels with multiple settings on each, to make up the code.

Andy Clark, chairman of the trustees at The National Museum of Computing, said the Lorenz was stationed in secure locations as "it was far bigger than the famous portable Enigma machine".

"Everybody knows about Enigma, but the Lorenz machine was used for strategic communications," said Clark.

"It is so much more complicated than the Enigma machine and, after the war, machines of the same style remained in use."
The museum has just received one on loan from Norway's Armed Forces.

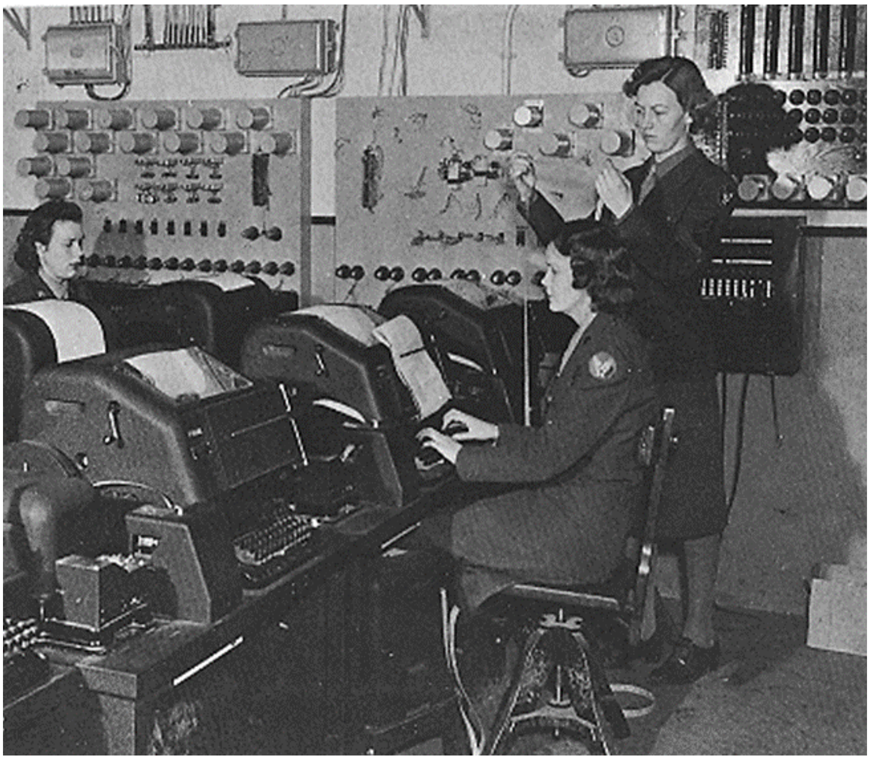
The Siemens & Halske T52, also known as the Geheimschreiber ("secret teleprinter"), or Schlüsselfernschreibmaschine (SFM), was a World War II German cipher machine and teleprinter produced by the electrical engineering firm Siemens & Halske. The instrument and its traffic were codenamed Sturgeon by British cryptanalysts.

While the Enigma machine was generally used by field units, the T52 was an online machine used by Luftwaffe and German Navy units, which could support the heavy machine, teletypewriter and attendant fixed circuits. It fulfilled a similar role to the Lorenz cipher machines in the German Army.

The British cryptanalysts of Bletchley Park codenamed the German teleprinter ciphers Fish, with individual cipher-systems being given further codenames: just as the T52 was called *Sturgeon*, the Lorenz machine was codenamed *Tunny*.

6.3.3 UK

6.3.3.1 Royal Air Force



WACs assigned to the Eighth Air Force in England operate teletype machines. (DOD photograph)

6.3.3.2 Royal Navy

Purpose

Radio teletype (RATT) equipment in HM Ships is used in conjunction with wireless equipment to enable messages to be transmitted and received by automatic printing machines.

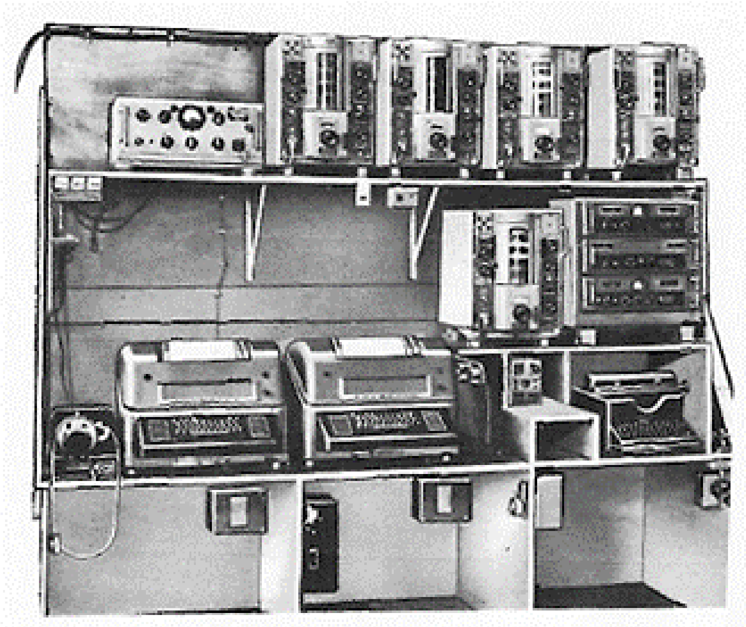
Brief description

a) Broadcast RATT Reception

The audio output of a B40D reciever, or of two B40D, or one B40D and one B41, receivers is fed to the converter-comparator. The latter automatically selects the output which, at any instant, is contributing the greater amplitude, and converts it into current pulses for operating the teletypewriter in accordance with a definite code.

b) UHF RATT Transmitting and Reception

When transmitting, operation of the teletypewriter keyboard causes pulses of current peculiar to each character to be fed to the Radio Teletype Terminal Set AN/SGC-1A where they are converted into “mark” and “space” tones. These toners are fed into the microphone circuit of the transmitter.



Typical UHF and broadcast RATT bays

When receiving, the two-tone output from the receiver is converted into current pulses in the terminal set. These are used for operating the teletypewriter, causing it to print in accordance with the code received.

6.4 Utvecklingen i Sverige

6.4.1 Civila applikationer

I Sverige öppnades den första fjärrskriftförbindelsen år 1928 mellan Radiocentralen i Göteborg och Stockholms centraltelegrafstation. Den första uthyrda fasta fjärrskriftförbindelsen tillkom år 1929 mellan Riksbanken och Stockholms telegrafstation och samma år etablerades en fast privat förbindelse mellan Stockholm och Finspång för Finspongs Metallverk. Den första förbindelsen för TT kom år 1930 mellan Stockholm och Göteborg. Det var Tidningarnas Telegrambyrå och Sveriges Metrologiska och Hydrologiska Anstalt (SMHA), som var först med större egna nät. Svenska krigsmakten tillhörde också pionjärerna då SMHA/MV år 1938 begärde att få anordna ett fjärrskriftnät för den militära väderlekstjänsten och då krigsutbrottet år 1939 blev en starkt pådrivande faktor.

6.4.2 Fjärrskrift inom försvaret

6.4.2.1 Allmänt

En central fråga som många har ställt sig är varför just fjärrskrift ansågs som ett lämplig sambandsmedel för militära organ och myndigheter världen över. Fördelarna med fjärrskrift framför telefon- och bildöverföring har bl. a visat sig vara följande:

- Skriftlig information är väl anpassad för militära order och rapportsystem.
- Fjärrskriftinformationen kan med enkla metoder krypteras.
- Behovet av transmissionsresurser för fjärrskrift kräver endast en bandbredd av 120 Hz. Upp till tjugofyra kanaler kan alltså inrymmas på en normal telefonikanal.
- Kort tid för driftsättning vid mobilisering.

Fjärrskriftsamband på tråd bedömdes som det säkraste sättet att översända information mellan militära enheter. Sambandet kunde inte avlyssnas av främmande makt, vilket var ganska enkelt vid radioöverföring. Även väderinformation ansågs vara så viktigt, att främmande makter inte skulle ges möjlighet att enkelt avlyssna väderprognoser för svenskt luftrum. Väderinformationen skulle därför sändas på tråd.

Fjärrskriftens utveckling inom det svenska försvaret finns beskrivit i följande dokument:
Fjärrskriftsystem och dess centraler 1938 - 1997 (38 MB)
Författare: Hans Bruno, Hans-Ove Görtz. (F02/16)

Rapporten är en omarbetad och fördjupad beskrivning över dåvarande FHT rapport Fjärrskriftsystem som Arne Svensson arbetade fram inom FHT till 2003. Fördjupningen omfattar bl a tydligare bakgrund till den allmänna utvecklingen, utveckling av fjärrskriftcentraler samt tekniskt underlag från dåvarande Kungliga Telestyrelsen.

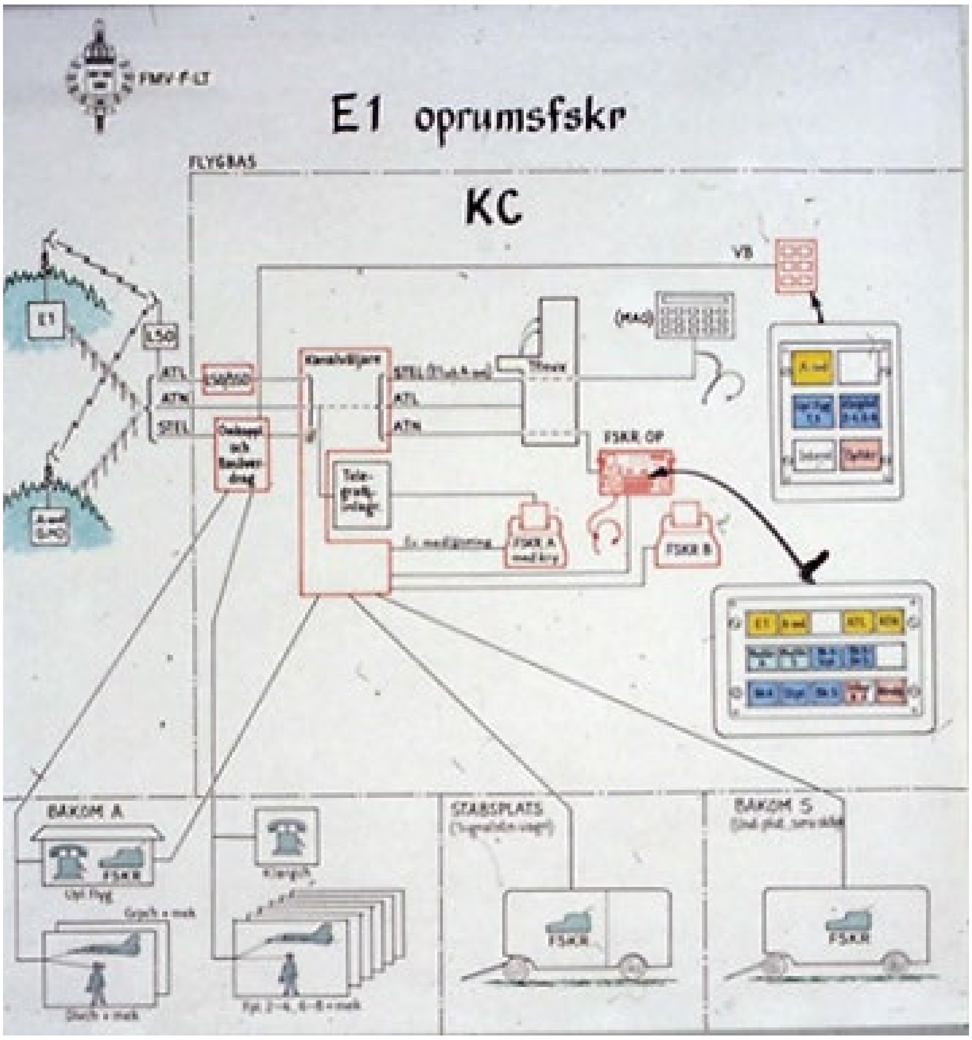
Utvecklingen av fjärrskriftsambandet inom flygvapnet har överste C-G Simmons beskrivit i sin bok, "Utvecklingshistoria om Sambandsfunktioner inom flygvapnet". Vissa textdelar av boken har använts i denna rapport för att ge en bredare överblick.

I denna rapport beskrivs inte MFC-systemet och MILTEX abonnentsystem närmre – för djupare studier hänvisar vi till Harald Andréassons FHT rapport F06/08 Meddelandeförmedlingscentral (MFC) samt Bernt Söreskogs FHT rapport F05/10 MILTEX abonnentsystem.

I följande avsnitt beskrives utöver det som behandlats i ovanstående FHT dokument några ytterligare exempel på användningen av fjärrskrift inom försvaret.

6.4.2.2 Oprumsfjärrskrift

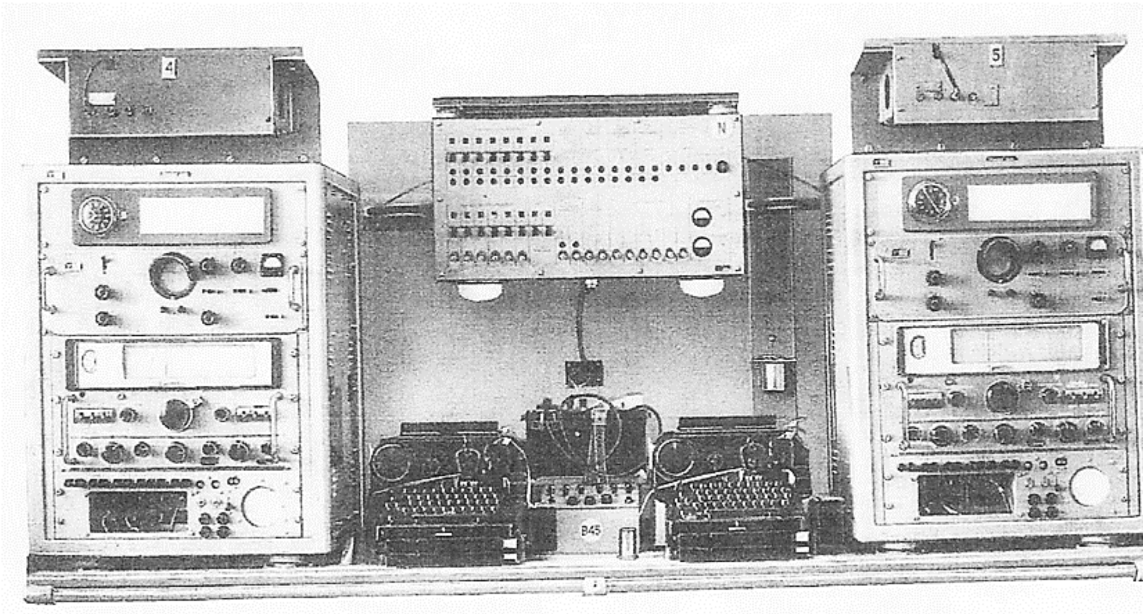
För att kunna överföra sekretessklassad textinformation påbörjades under 70-talet en omfattande utbyggnad av oprumsfjärrskrift inom det operativa ledningssystemet och ett antal övriga verksamheter. Här exemplifierat av Op-rumsfskr för E1.



6.4.2.3 Fjärrskrift inom arméförbanden

Trådfjärrskrift infördes i anläggningarna för fo- och milostaber som var anslutna till försvarets fasta fjärrskriftnät i samband med utbyggnaden av detta.

Radiofjärrskrift i de tyngre radiostationerna infördes först när Radioterrängbil 936 med Radiostation 620 (Ra 620) togs i drift på 1960 talet. Detta gällde även för fo- och milostaber där Ra 620 installerades för Stab-Stab radionätet.

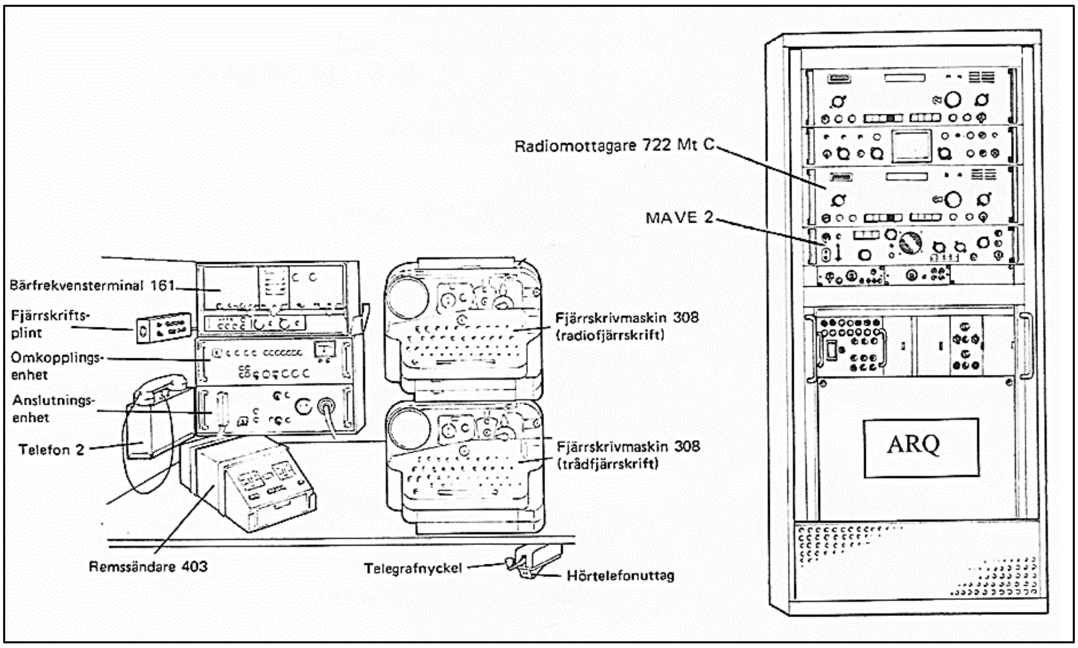


Mottagarplatser och fjärrskriftsutrustningar på höger sida i stationsrummet.

Mottagarplatserna är i stort sett samma som i Ra 620. I det mellersta bordet har tillkommit Bf-terminal och apparatstativ.

I början av 1970-talet hade Ra 620-systemet blivit omodernt. Systemet hade inte den frekvensnoggrannhet som krävdes för godtagbara fjärrskriftsförbindelser. För de fasta anläggningarna (hkv och milo) hade CTR 1000 och ARQ anskaffats. Det var då lämpligt att de nya radiobussarna hade samma utrustning som anläggningarna. Den nya radiostationen fick helt logiskt benämningen Ra 630 och tillfördes högkvartersförband, milosambandsbataljoner och fördelningsstabsbataljoner.

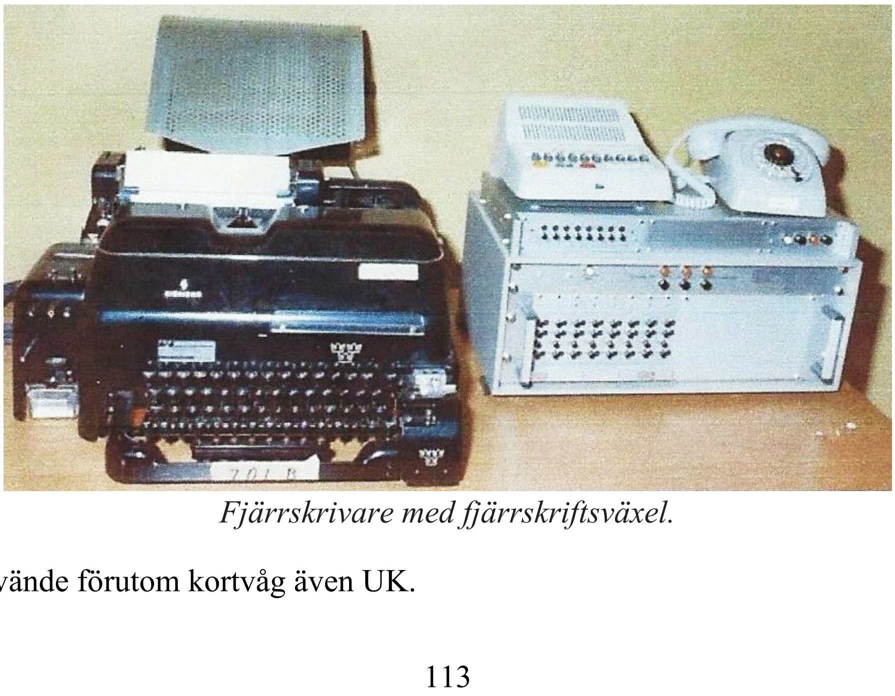
Ra 630 är konstruerad för att i första hand ge en säker fjärrskriftförbindelse. Dess funktion är följande. Från remssändaren matas fjärrskrifttecken genom anslutningsenheten till ett minne i ARQ utrustningens sändardel. ARQ betyder Automatic ReQuest, alltså automatisk omfrågning. I ARQ-utrustningen omvandlas tecknen enligt en speciell ARQ-kod, innan de matas till KV sändaren. Denna kod gör att motstationens ARQ kan avgöra om de mottagna signalerna har blivit förvrängda av störningar. Är så fallet, sänder motstationen en omfrågningssignal (RQsignal) på annan frekvens i returkanalen. När den egna ARQ har identifierat RQ-signalen, bryts genast remssändningen och ARQ minne repeterar de tre senast sända tecknen. När motstationens ARQ slutligen erhållit korrekta tecken omvandlas dessa åter enligt ARQ-koden till fjärrskriftstecken och repetionstillståndet upphör.



Fjärrskriftplatsen enheter och till höger F1-platsens enheter

6.4.2.4 Marinen

Marinen utvecklade för sina sambandscentraler en Fjärrskriftväxel 101. Fjärrskriftsväxel 101 Fjärrskriftsväxel 101 MT M3917-101001 användes i sambandscentraler med många fjärrskriftsförbindelser och hög fjärrskriftstrafik som berör olika verksamhetsområden av operativ och administrativ karaktär. Växelns uppgift är att fördela inkommande fjärrskriftstrafik till ledig fjärrskrivare i aktuellt trafikrum (Fjsk-, Kry- och Op-rum). Uppkoppling av utgående trafik sker med linjetagare, en vid varje fjärrskrivmaskin. Växeln kan också förmedla och gruppsända fjärrskriftmeddelanden, med en speciell samtrafikenhet. Växelns centralutrustning utgörs av ett 19 tums standardstativ med moduluppbyggda hyllor för kretskort. Införandet av växeln innebar att antalet fjärrskriftsmaskiner i sambandscentralerna väsentligt kunde minskas.



Fjärrskrivare med fjärrskriftsväxel.

Marinen använde förutom kortvåg även UK.

6.4.3 Telex

Landets första telexstation var en provisorisk manuell station som öppnade den 16 augusti 1945 i Stockholm. Till stationen anslöts nyhetsbyråerna Associated Press och United Press.

1946 togs tre automatiska telexstationer av märke Siemens i bruk. Dessa var placerade i Stockholm, Göteborg och Malmö och totalt var åtta abonnenter anslutna. Antalet abonnenter växte fort och kulminerade 1986 med 19 660 abonnenter.

Redan från början utgjorde en stor andel av telextrafiken internationella skrivningar. Dessa förmedlades i början manuellt, men trafiken växte snabbt och det blev nödvändigt att automatisera även denna trafik. 1956 infördes automatisk trafik mot Danmark, och 1964/65 utväxlades 92% av utlandstrafiken helt automatiskt.

Försvaret var en av användarna av det civila Telexnätet.

6.5 Kommentarer

Fjärrskrift kom att under WW II få en mycket framträdande roll för ledningen av stridskrafterna. Sverige utvecklade med start i slutet på 30-talet en utbyggnad av fjärrskriftnät inom försvaret. Fjärrskriftmaterielen levererades i stor utsträckning från utlandet, Siemens (Tyskland), Philips (Holland).

Fjärrskriften kom att under många år vara den helt dominerande textkommunikationen för stora delar av försvaret. Inledningsvis skedde kryptering av textmeddelandena innan de sändes med fjärrskrift (kryptering off-line). Ett omfattande arbete gjordes för att effektivisera hanteringen i de sambandscentraler som skötte hanteringen av textmeddelandena.

Efterhand utvecklades kryptomaskiner som anslöts mellan fjärrskriftmaskinen och transmissionskanalen (online-kryptering). Detta underlättade hanteringen så att ett snabbare flöde av informationen kunde ske. Denna metod användes speciellt i Oprums-fjärrskriften. Införandet av MILTEX på 80-talet innebar en stor förbättring av effektivisering av textkommunikationen.

För radiokommunikationen kom dock telegrafin att vara rådande under lång tid.

Radiofjärrskriftnätet inom Stab-Stab radionätet fick först med införandet av Ra 630 och ARQ en väl fungerande funktion.

Inom det luftoperativa radionätet utnyttjades högre effekt och riktade antenner för att uppnå önskad säker funktion.

7 Radar

7.1 Tidig utveckling

7.1.1 First military radars in Britannia

British physicist James Clerk Maxwell developed equations governing the behavior of electromagnetic waves in 1864. Inherent in Maxwell's equations are the laws of radio-wave reflection, and these principles were first demonstrated in 1886 in experiments by the German physicist Heinrich Hertz. Some years later a German engineer Chistian Huelsmeyer proposed the use of radio echoes in a detecting device designed to avoid collisions in marine navigation. The first successful radio range-finding experiment occurred in 1924, when the British physicist Sir Edward Victor Appleton used radio echoes to determine the height of the ionosphere, an ionized layer of the upper atmosphere that reflects longer radio waves.

The first practical radar system was produced in 1935 by the British physicist Sir Robert Watson-Watt, and by 1939 England had established a chain of radar stations along its south and east coasts to detect aggressors in the air or on the sea.

In 1935 Watson-Watt wrote a paper entitled "The Detection of Aircraft by Radio Methods". This was presented to Henry Tizard, the chairman of the Committee for the Scientific Survey of Air Defence. Tizard was impressed with the idea and on 26th February 1935, Watson-Watt demonstrated his ideas at Daventry. His idea was based on the bouncing of a radio wave against an object and measuring its travel to provide targeting information. It was called radar (radio detection and ranging). As a result, he was appointed head of the Bawdsey Research Station in Felixstowe.

By the outbreak of the Second World War in September 1939, Watson-Watt had designed and installed a chain of radar stations along the East and South coast of England. In the same year two British scientists were responsible for the most important advance made in the technology of radar during World War II. The physicist Henry Boot and biophysicist John T. Randall invented an electron tube called the resonant-cavity magnetron. This type of tube is capable of generating high-frequency radio pulses with large amounts of power, thus permitting the development of microwave radar, which operates in the very short wavelength band of less than 1cm, using lasers. Microwave radar, also called LIDAR (light detection and ranging) is used in the present day for communications and to measure atmospheric pollution. During the Battle of Britain these stations were able to detect enemy aircraft at any time of day and in any weather conditions.

Radar was also used by ships and aircraft during the war. Germany was using radar by 1940 but Japan never used it effectively. The United States had a good radar system and it was able to predict the attack on Pearl Harbor an hour before it happened.

Britain tended to have the best radar system during the early stages of the war and in 1940 the invention of the Magnetron cavity resonator enabled more centimetric waves to be transmitted. It also enabled more compact high-frequency sets to be used by aircraft in the Royal Air Force.

7.1.2 Utvecklingen i US

During the 1930s, efforts to use radio echoes for aircraft detection were initiated independently and almost simultaneously in eight countries that were concerned with the prevailing military situation and that already had practical experience with radio technology. The United States, Great Britain, Germany, France, the Soviet Union, Italy, the Netherlands, and Japan all began experimenting with radar within about two years of one another and embarked, with varying degrees of motivation and success, on its development for military purposes. Several of these countries had some form of operational radar equipment in military service at the start of World War II.

The first observation of the radar effect at the U.S. Naval Research Laboratory (NRL) in Washington, D.C., was made in 1922. NRL researchers positioned a radio transmitter on one shore of the Potomac River and a receiver on the other. A ship sailing on the river unexpectedly caused fluctuations in the intensity of the received signals when it passed between the transmitter and receiver. (Today such a configuration would be called bistatic radar.) In spite of the promising results of this experiment, U.S. Navy officials were unwilling to sponsor further work.

The principle of radar was “rediscovered” at NRL in 1930 when L.A. Hyland observed that an aircraft flying through the beam of a transmitting antenna caused a fluctuation in the received signal. Although Hyland and his associates at NRL were enthusiastic about the prospect of detecting targets by radio means and were eager to pursue its development in earnest, little interest was shown by higher authorities in the navy. Not until it was learned how to use a single antenna for both transmitting and receiving (now termed monostatic radar) was the value of radar for detecting and tracking aircraft and ships fully recognized. Such a system was demonstrated at sea on the battleship USS *New York* in early 1939.

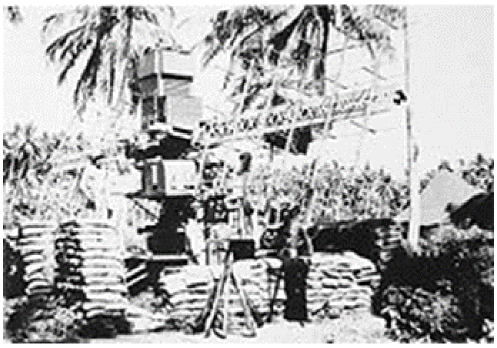
A pioneer in radar, Colonel William Blair, director of the Signal Corps laboratories at Fort Monmouth, patented the first Army radar demonstrated in May 1937.

The first radars developed by the U.S. Army were the SCR-268 (at a frequency of 205 MHz) for controlling antiaircraft gunfire and the SCR-270 (at a frequency of 100 MHz) for detecting aircraft.

Both of these radars were available at the start of World War II, as was the navy’s CXAM shipboard surveillance radar (at a frequency of 200 MHz).

It was an SCR-270, one of six available in Hawaii at the time, that detected the approach of Japanese warplanes toward Pearl Harbor, near Honolulu, on December 7, 1941, however the significance of the radar observations was not appreciated until bombs began to fall.

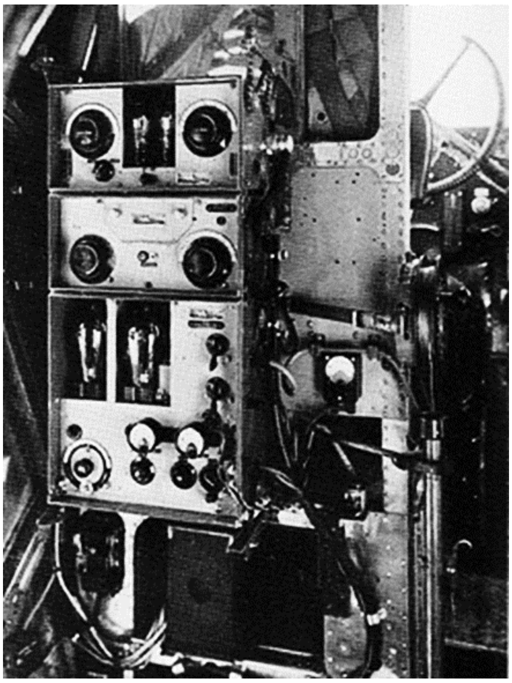
Even before the United States entered World War II, mass production of two radar sets, the SCR-268 and the SCR-270, had begun. Along with the Signal Corps' tactical FM radio, also developed in the 1930s, radar was the most important communications development of World War II.



SCR-268 radar deployed on Guadalcanal in August 1942

Country of origin	United States
Introduced	1940
Type	2D air-search
Frequency	205 MHz
Pulsewidth	7 to 15 microseconds
Range	22.7 miles (36.5 km)
Power	50 kW peak

The term "RADAR" was coined by the Navy in 1940 and agreed to by the Army in 1941. The first Signal Corps Field Manual on Aircraft Warning Service defined RADAR as "a term used to designate radio sets SCR (Signal Corps Radio)-268 and SCR-270 and similar equipment". The SCR-268 and 270 were not radios at all, but were designated as such to keep their actual function secret. Although important offensive applications have since been developed, radar emerged historically from the defensive need to counter the possibility of massive aerial bombardment.



7.1.3 RDF

In addition to the supply of ground-to-air communications equipment, between 1940 and 1941, the Company became involved in the fitting of Range and Direction-Finding systems (RDF) for early warning against air attack on larger surface ships.

Modified air-to-surface metric equipment was also developed and subsequently fitted to smaller vessels. A ‘crash programme’ was also introduced to develop even smaller sets with the extra capability of detecting surfaced submarines.

Meanwhile, two Marconi Senior Engineers (N.E. Davis and O.E. Keall) were seconded to the Admiralty to devise countermeasures against the German radar installations sited along the coast of Northern France.

By 1942 and following earlier work and improvements to the newly designed magnetron, the Chelmsford factory produced amplifier units for a new naval radar, as well as a new centimetric air-to-surface vessel (ASV) radar for the RAF. Magnetron production later moved to a new building at Waterhouse Lane thus increasing the delivery rate to several hundred per month.

For D-Day, Marconi designed, developed and manufactured an airborne system (code named Bagful) to intercept and record the frequency and approximate positions of enemy radar stations. This provided a dossier which proved vital for the planning of the whole Operation, prior to the invasion. On 6th June, Marconi technology provided a multiplicity of jamming stations in an operation code named ‘Carpet Paralyses’, disabling the German radar networks. Marconi Marine also provided servicing and support for the radio communications, echo sounding and radar equipment

7.1.4 British Chain Home

Britain commenced radar research for aircraft detection in 1935. The British government encouraged engineers to proceed rapidly because it was quite concerned about the growing possibility of war. By September 1938 the first British radar system, the Chain Home, had gone into 24-hour operation, and it remained operational throughout the war.

The Chain Home radars allowed Britain to deploy successfully its limited air defenses against the heavy German air attacks conducted during the early part of the war. They operated at about 30 MHz—in what is called the shortwave, or HF, band—which is actually quite a low frequency for radar. It might not have been the optimum solution, but the inventor of British radar, Sir Robert Watson-Watt, believed that something that worked and was available was better than an ideal solution that was only a promise or might arrive too late.

A Chain Home transmitter antenna, part of one of the first comprehensive radar systems.

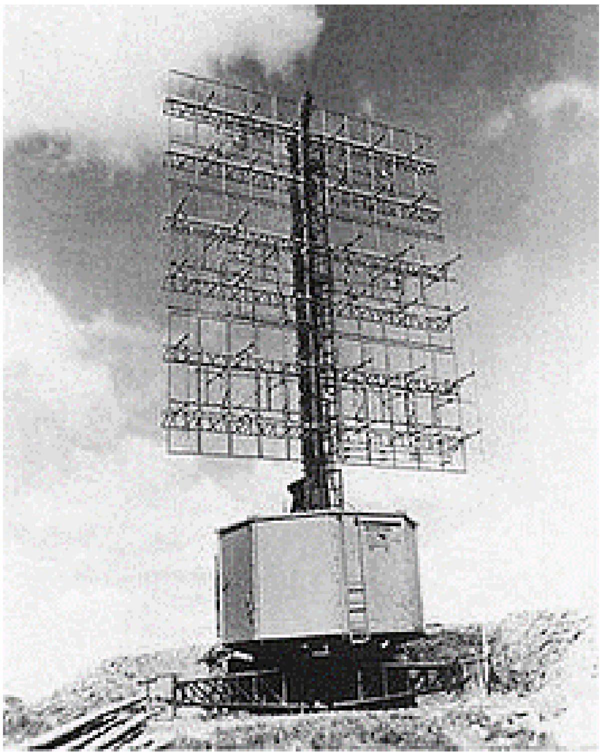
Chain Home coverage

7.1.5 Sovjet Union

The Soviet Union also started working on radar during the 1930s. At the time of the German attack on their country in June 1941, the Soviets had developed several different types of radars and had in production an aircraft-detection radar that operated at 75 MHz (in the very-high-frequency [VHF] band). Their development and manufacture of radar equipment was disrupted by the German invasion, and the work had to be relocated.

7.1.6 Germany

At the beginning of World War II, Germany had progressed farther in the development of radar than any other country. The Germans employed radar on the ground and in the air for defense against Allied bombers. Radar was installed on a German pocket battleship as early as 1936. Radar development was halted by the Germans in late 1940 because they believed the war was almost over. The United States and Britain, however, accelerated their efforts. By the time the Germans realized their mistake, it was too late to catch up.



The German Freya worked at higher frequencies and was thus smaller than its Chain Home counterpart.

Except for some German radars that operated at 375 and 560 MHz, all of the successful radar systems developed prior to the start of World War II were in the VHF band, below about 200 MHz. The use of VHF posed several problems. First, VHF beamwidths are broad. (Narrow beamwidths yield greater accuracy, better resolution, and the exclusion of unwanted echoes from the ground or other clutter.) Second, the VHF portion of the electromagnetic spectrum does not permit the wide bandwidths required for the short pulses that allow for greater accuracy in range determination. Third, VHF is subject to atmospheric noise, which limits receiver sensitivity. In spite of these drawbacks, VHF represented the frontier of radio technology in the 1930s, and radar development at this frequency range constituted a genuine pioneering accomplishment. It was well understood by the early developers of radar that operation at even higher frequencies was desirable, particularly since narrow beamwidths could be achieved without excessively large antennas.

7.2 Advances during World War II

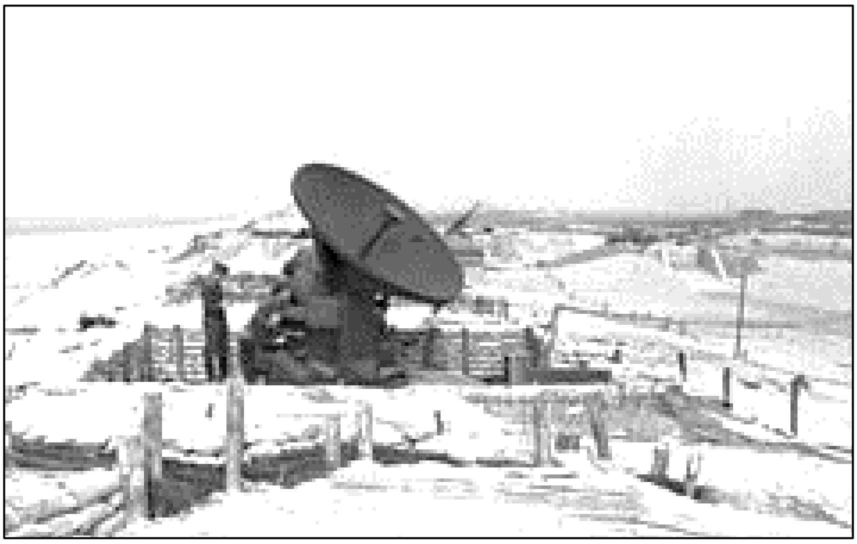
The opening of higher frequencies (those of the microwave region) to radar, with its attendant advantages, came about in late 1939 when the cavity magnetron oscillator was invented by British physicists at the University of Birmingham. In 1940 the British generously disclosed to the United States the concept of the magnetron, which then became the basis for work undertaken by the newly formed Massachusetts Institute of Technology (MIT) Radiation Laboratory at Cambridge. It was the magnetron that made microwave radar a reality in World War II.

The successful development of innovative and important microwave radars at the MIT Radiation Laboratory has been attributed to the urgency for meeting new military capabilities as well as to the enlightened and effective management of the laboratory and the recruitment of talented, dedicated scientists. More than 100 different radar systems were developed as a result of the laboratory's program during the five years of its existence (1940 - 45).

One of the most notable microwave radars developed by the MIT Radiation Laboratory was the SCR-584, a widely used gunfire-control system. It employed conical scan tracking—in which a single offset (squinted) radar beam is continuously rotated about the radar antenna's central axis—and, with its four-degree beamwidth, it had sufficient angular accuracy to place antiaircraft guns on target without the need for searchlights or optics, as was required for older radars with wider beamwidths (such as the SCR-268). The SCR-584 operated in the frequency range from 2.7 to 2.9 GHz (known as the S band) and had a parabolic reflector antenna with a diameter of nearly 6.6 feet (2 metres). It was first used in combat early in 1944 on the Anzio beachhead in Italy. Its introduction was timely, since the Germans by that time had learned how to jam its predecessor, the SCR-268. The introduction of the SCR-584 microwave radar caught the Germans unprepared.

7.3 Würzburg radar

The low-UHF band Würzburg radar was the primary ground-based gun laying radar for the Wehrmacht's Luftwaffe and Heer during World War II. Initial development took place before the war and the apparatus entered service in 1940. Eventually, over 4,000 Würzburgs of various models were produced. It took its name from the city of Würzburg



7.4 Postwar progress

After the war, progress in radar technology slowed considerably. The last half of the 1940s was devoted principally to developments initiated during the war. Two of these were the monopulse tracking radar and the moving-target indication (MTI) radar (discussed in the section Doppler frequency and target velocity). It required many more years of development to bring these two radar techniques to full capability.

New and better radar systems emerged during the 1950s. One of these was a highly accurate monopulse tracking radar designated the AN/FPS-16, which was capable of an angular accuracy of about 0.1 milliradian (roughly 0.006 degree). There also appeared large, high-powered radars designed to operate at 220 MHz (VHF) and 450 MHz (UHF). These systems, equipped with large mechanically rotating antennas (more than 120 feet [37 metres] in horizontal dimension), could reliably detect aircraft at very long ranges.

Another notable development was the klystron amplifier, which provided a source of stable high power for very-long-range radars. Synthetic aperture radar first appeared in the early 1950s, but it took almost 30 more years to reach a high state of development, with the introduction of digital processing and other advances. The airborne pulse Doppler radar also was introduced in the late 1950s in the Bomarc air-to-air missile.

The decade of the 1950s also saw the publication of important theoretical concepts that helped put radar design on a more quantitative basis. These included the statistical theory of detection of signals in noise; the so-called matched filter theory, which showed how to configure a radar receiver to maximize detection of weak signals; the Woodward ambiguity diagram, which made clear the trade-offs in waveform design for good range and radial velocity measurement and resolution; and the basic methods for Doppler filtering in MTI radars, which later became important when digital technology allowed the theoretical concepts to become a practical reality.

The Doppler frequency shift and its utility for radar were known before World War II, but it took years of development to achieve the technology necessary for wide-scale adoption. Serious application of the Doppler principle to radar began in the 1950s, and today the principle has become vital in the operation of many radar systems. As previously explained, the Doppler frequency shift of the reflected signal results from the relative motion between the target and the radar. Use of the Doppler frequency is indispensable in continuous wave, MTI, and pulse Doppler radars, which must detect moving targets in the presence of large clutter echoes. The Doppler frequency shift is the basis for police radar guns. SAR and ISAR imaging radars make use of Doppler frequency to generate high-resolution images of terrain and targets. The Doppler frequency shift also has been used in Doppler-navigation radar to measure the velocity of the aircraft carrying the radar system. The extraction of the Doppler shift in weather radars, moreover, allows the identification of severe storms and dangerous wind shear not possible by other techniques.

The first large electronically steered phased-array radars were put into operation in the 1960s. Airborne MTI radar for aircraft detection was developed for the U.S. Navy's Grumman E-2 airborne-early-warning (AEW) aircraft at this time. Many of the attributes of HF over-the-horizon radar were demonstrated during the 1960s, as were the first radars designed for detecting ballistic missiles and satellites.

7.5 Utvecklingen i Sverige

7.5.1 Svensk försöksverksamhet

Den svenska radarforskningen kom inte i gång förrän i slutet av 1930-talet. En av de första, eller kanske den allra förste, som över huvud taget sysslade med vad vi idag kallar radar var civilingenjör Torsten Elmqvist, SATT (Svenska Aktiebolaget Trådlös Telegrafi).

1939 började Elmqvist experimentera med ultrakorta riktade vågor med sikte på att konstruera en apparat för lokalisering och avståndsmätning till fasta och rörliga mål. Så småningom började liknande verksamhet komma i gång på flera håll.

AB Svenska Elektronrör började bedriva forskning inom samma område på uppdrag av arméförvaltningens tygdepartement, och inom marinförvaltningens torpedavdelning experimenterades det med reflekterade radiovågor i samband med konstruktion av spärranordning för vissa vattenleder. Den splittrade försöksverksamheten var både oekonomisk och opraktisk.

I en skrivelse till försvarsministern i dec. 1941 hemställer chefen för försvarsstabens luftbevakningsavdelning, övlt Bengtsson, att all forskning och försöksverksamhet inom ekoradioområdet skall samordnas inom det nyinrättade SUN (Statens Uppfinnarnämnd).

Dåvarande försvarsminister, P E Sköld, uppdrager åt SUN att undersöka möjligheten för samordnad forskning inom SUN:s regi. Vid nyåret 1942 åtar sig SUN uppdraget. Under ett inledningsskede på sex månader beräknade SUN att sådana erfarenheter kunnat uppnås att det blir möjligt att bedöma om den samlade forskningsverksamheten skulle kunna fortsätta.

Forskningsverksamheten startade upp redan i januari 1942 under ledning av myntdirektör A Grabe. (Ekoradiostation ERIIIB FHT dokument 1992-03-25 F02/04)

En mycket erfaren radioexpert, civilingenjör Hugo Larsson, anställd vid telegrafverket, lånades ut till SUN för att leda utvecklingen av den första ekoradion. I arbetsgruppen ingick också civilingenjörerna Torsten Elmqvist och Ove Norell samt ytterligare några radioingenjörer och radiotekniker. Fr o m okt. -42 ställdes också flygingenjör Martin Fehrm till SUN:s förfogande. Larsson och Fehrm blev de två bärande namnen inom ekoradioforskningen.

Larsson ledde utvecklingen av ekoradion enligt interferensprincipen och Fehrm ekoradion enligt pulsprincipen. I juni 1942 träffades ett avtal mellan SUN, AB Bofors, Telefon AB LM Ericsson och SAAB (Svenska Aeroplan AB) om gemensam forskning inom ekoradioområdet.

Ett råd bildades bestående av representanter från varje intressent att följa arbetet och fördela forskningsuppgifterna samt att hålla kontakt med regeringen och försvarets myndigheter.

Försöksverksamheten bedrevs i lokaler tillhörande arméförvaltningens laboratorium i Frösunda, i en barack tillhörande FOA3 vid Bromma flygplats samt i myntverkets källare.

Redan i april 1942 kunde Hugo Larsson visa upp en laboratoriemässig men fungerande ekoradio och den 3 juli anordnades ett demonstrationsprov på Bromma inför bl a försvarsministern och överbefälhavaren.

Senare på sommaren provades stationen även mot sjömål från pansarskeppet "Drottning Victoria".

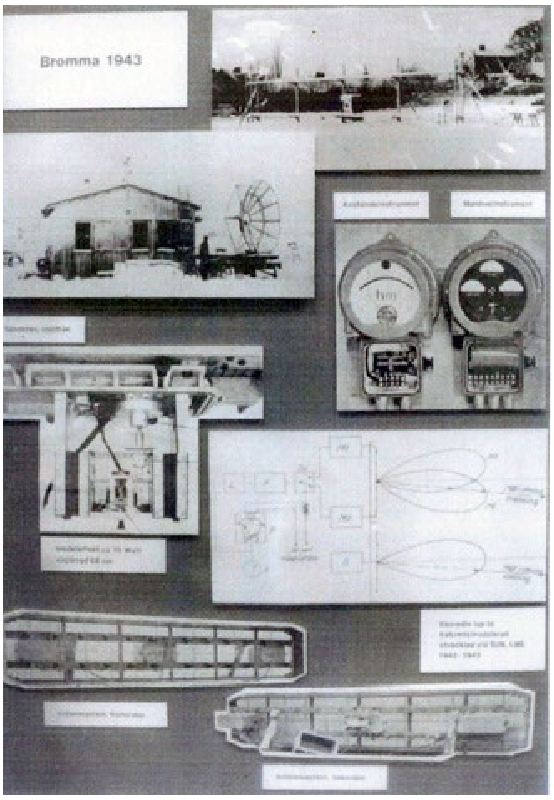
De olika utvecklingsprojekten inom SUN, som ledde fram till de första ekoradiostationerna fick projektbeteckningarna ER (Ekoradio). ERI och ERII blev således beteckningarna på de två projekt enligt interferensprincipen som ledde fram till ekoradiostationer för fartygsartilleri respektive luftvärn.

ERIII blev beteckningen på det projekt som ledde fram till ekoradion för flygspaning enligt pulsprincipen.

Sverige var under krigsåren i stort sett isolerat och avstängt från den utveckling inom elektronikområdet, som ägde rum i de krigförande länderna. Det kunnande och de impulser man kunde få utifrån var knapphändiga. Det rådde dessutom brist på komponenter eftersom svensk radioindustri var baserade på importerade komponenter.

Ett av de dominerande problemen man hade att brottas med var utan tvivel elektronrören till sändarna. Man saknade rör som kunde alstra tillräckligt höga effekter för ultrakorta vågor och som dessutom hade någorlunda livslängd.

Den första prototypen på en ekoradio byggde man i lokalerna på myntverket.
Man valde samma våglängd som i ett av flygvapnet inköpt instrument (altimeter) dvs 65cm.
Som sändarrör användes ett Telefunkenrör typ LS 30 som gav 10 - 12 W uteffekt.
Svängningskretsen var utformad som ett parallelledningssystem (Lechersystem).
Frekvensmodulationen erhölls genom en cylindrisk vridkondensator, driven av en synkronmotor.



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ERIII blev beteckningen på det projekt som ledde fram till ekoradion för flygspaning, enligt pulsprincipen.

7.5.2 ER I

För de fortsatta försöken och demonstrationerna behövdes fler ekoradio-stationer och man beslöt tillverka en mindre provserie. Dessa skulle fördelas på pansarskepp, jagare och för placering på land.

För att finansiera detta lade Marinförvaltningen ut en beställning till SUN, som skulle leda tillverkningen. LM Ericsson engagerades i denna serietillverkning framförallt med utrustning för frekvensmoduleringen av mottagaren med frekvensmetern/avståndsindikatorn. Inom LM Ericsson leddes detta arbete av Thorsten Lange. Sändaren tillverkades av SUN:s ekoradiogrupp i myntverkets verkstad. Bofors medverkade vid antenntillverkningen.

Innan provserien var färdig, fick man för ytterligare prov, montera en experimentutrustning på pansarskeppet ”Drottning Victoria”, i samband med en varvsgenomgång vid årsskiftet 1942/43.

Ekoradion med antenn placerades på den vridbara stridsmärsen ca 30 meter över vattenytan. Med denna utrustning fortsatte utvärderingen och de uppmätta räckvidderna mot olika fartygsmål ökade från ca 4 km till 8 km. Man provade även med framgång artilleriskjutning i mörker på måldata från ekoradion.

En stor demonstration den 26 januari 1943, i närvaro av försvarsministern, ÖB och alla försvarsgrenscheferna, lär ha gått till hävderna, framför allt pga. ett fruktansvärt oväder med minst halv storm och snödrev, som gjorde den optiska sikten obefintlig. Detta förstärkte kontrasten mellan de konventionella optiska mätutrustningarna och den väderoberoende ekoradion.

Allteftersom stationerna i den ”fabrikstillverkade” provserien blev klara under våren 1943 placerades de för fortsatta prov och därefter operativ drift på fartyg och kustartillerianläggningar.

Förutom fortsatta prov och utvärderingar förbättrade man systemen ytterligare.
I mars 1943 beställde Marinförvaltningen minst 15 ytterligare ekoradio-stationer av den nu utvecklade typen. Leverans påbörjades i augusti 1943 och stationerna avsågs för pansarskeppen, jagare och kustartilleriets fasta anläggningar.

Dessa frekvensmodulerade ekoradiostationer fick beteckningen ”Ekoradio typ I” eller ERIa för fartygsbruk och ERIb för kustartilleriet. Kustartilleriantennen hade måtten 7,5x2m och var monterade på ett vridbord så att den alternativt kunde roteras eller manuellt riktas för noggrann målinmätning.

På pansarskeppen bestod sändarantennen av 4 dipolrader, med 8 dipoler i varje rad. Mottagarantennen bestod av 2 rader med 8 dipoler. Antennerna var monterade över varandra, med den totala dimensionen 2,82x2,17m.

Jagarnas sändar- och mottagarantenner bestod båda av 2 rader med 6 dipoler. De placerades efter varandra med totala dimensionen 0,75x4,2m.

Ingen av dessa ER I stationer finns tråkigt nog inte bevarade till eftervärlden.

7.5.3 ER III

Den första ekoradion för luftbevakning, ERIII, blev inte klar förrän våren 1944. Stationen ställdes först upp på Mälsten utanför Nynäshamn för utprovning men flyttades senare till Nåttarö. Stationen var försedd med en stor otymplig antenn med en 6 m hög och 15 m bred antennreflektor på vilken ett stort antal antennelement var placerade.
Antennen var monterad på ett vridbart, hjulförsett underrede, som kunde vridas inom en viss sektor på en ringformad räls. Antennen kunde ställas in i önskad bäring inom sektorn med hjälp av en elmotor.

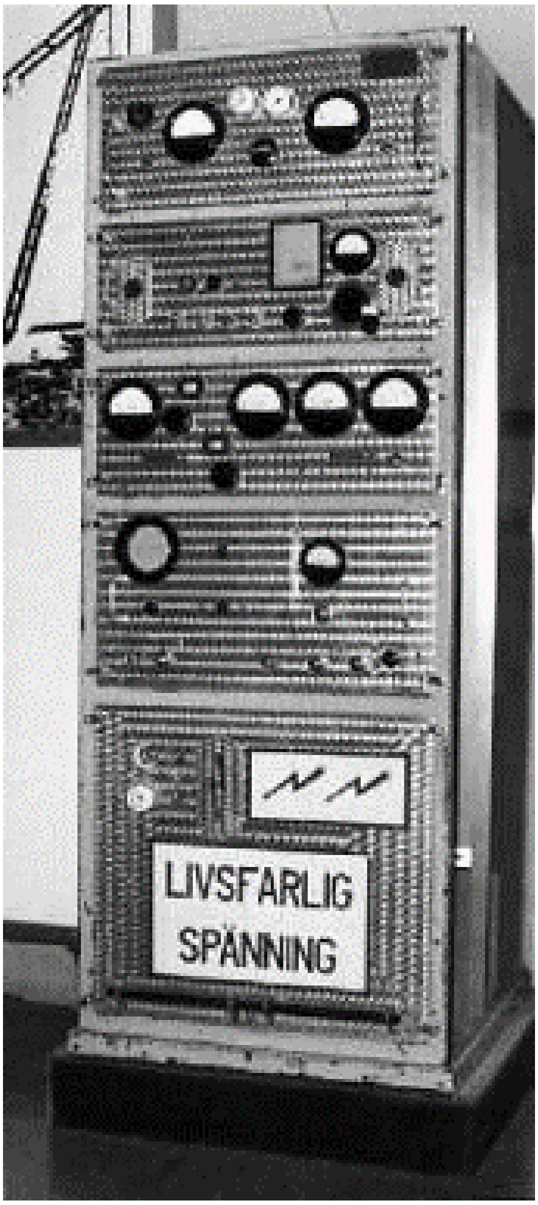
Sändare och mottagare var sammanbyggda i ett gemensamt apparatstativ som tillsammans med kringutrustning och avståndsindikator var placerad i en intilliggande byggnad. Sändaren hade en pulseffekt på ca 10 kW med en våglängd på ca 1,5 m. Stationens enda presentationsutrustning utgjordes av ett vanligt standardoscilloskop (A-skop) för avståndsmätning.

Antennen gav en mycket bred antennlob som resulterade i relativt dålig bäringsnoggrannhet och upplösningsförmåga. Stationen nådde räckvidder mot flygplan på 120 - 150 km.

Stationens tillförlitlighet lär enligt uppgift ha varit otillfredsställande. Den 14 juni 1944 ålades flygvapenchefen av överbefälhavaren ansvaret för uppbyggnaden av en ekoradioorganisation.

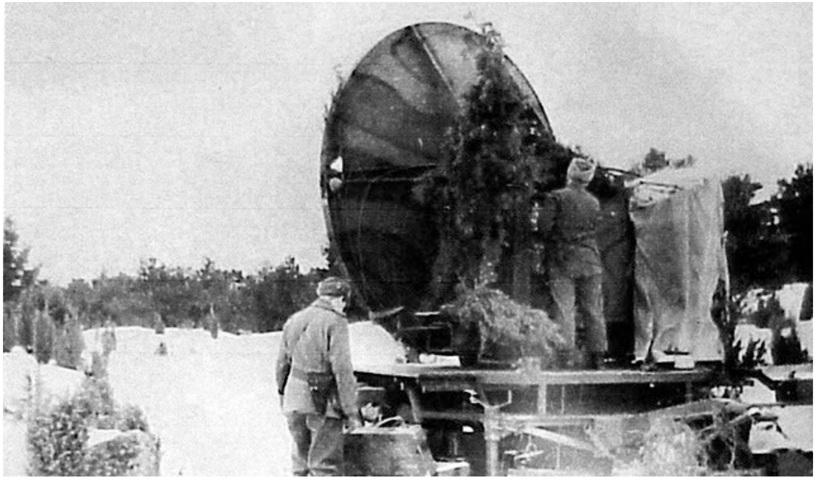
Sex á sju spanings stationer, typ ERIII, skulle beställas och så snart som möjligt upprättas inom kustområdet Gävle - Bråviken.

Stationerna var avsedda att ingå i flygvapnets organisation men avsågs till en början användas i marin spaningstjänst. I organisationen ingick även upprättandet av en ekoradiocentral som skulle placeras i flygvapnets ämbetslokal.



Apparatstativ innehållande sändare och mottagare till ekoradiostationen ERIII.

7.5.4 Er IIb



Er IIb

Eldledningsradarstation Würzburg.
Er IIb- inköptes från Tyskland 1944. Er IIb var del svenska luftvärnets första radarstation. men var redan 1950 ersatt med PE 07.

Er IIb hade en valbar räckviddsinställning på antingen 18 km eller 45 km. Våglängden var ca 50 cm och pulseffekten 8 kW. Sändarröret, dvs den komponent som alstrade radarstrålningen, var en triod. I efterföljande radarstationer var sändarrören med få undantag magnetroner ända tills moderna radarstationer, PS 70, infördes omkring 1978.

7.5.5 Ändrade förutsättningar

Sommaren 1944 inträffade händelser som resulterade i att utvecklingsarbetet inom SUN fick läggas om. Plötsligt kunde det militära behovet av radarmateriel täckas genom import från både Tyskland och England.

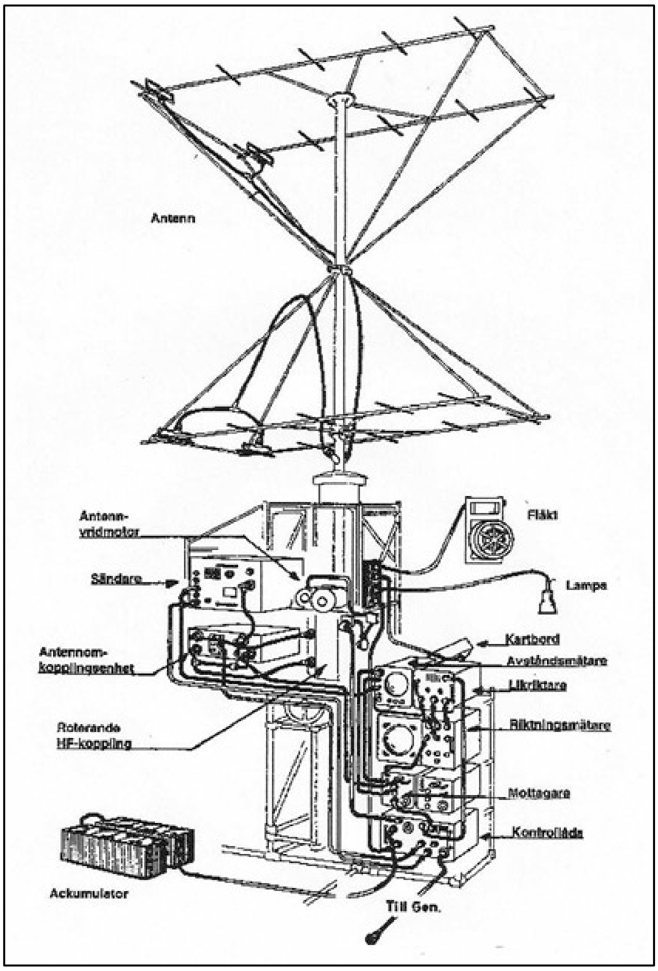
För arméns räkning lyckades man från Tyskland inköpa ett antal eldledningsradar av typ "Würzburg", av vilka de första stationerna levererades redan i augusti 1944.

Stationerna fick den svenska beteckningen Er IIb eftersom Er II var beteckningen på det projekt inom SUN som ledde fram till ekoradion för luftvärnet.

I en skrivelse av den 20 juni 1944 erbjöd sig det brittiska flygministeriet att till svenska flygvapnet leverera 50 ekoradiostationer AMES typ 6 Mk III, (Air Ministry Experimental Station) avsedd för luftbevakningsändamål.

Flygministeriet erbjöd sig samtidigt att omgående sända över 5 kompletta stationer för utvärdering. Stationerna levererades i juli 1944.

Stationen kom i Sverige att benämnas Er III b.



Ekoradiostation TmerIIIB (ERIIIB)

7.5.6 Sammanfattning av ekoradioläget 1945

Vid krigsslutet hade alla tre försvarsgrenarna egna operativa ekoradiosystem. Armen hade den från Tyskland inköpta ER IIB Würzburg för eldledning av luftvärnsartilleriet. Marinen hade den av SUN utvecklade och LM Ericsson tillverkade ER Ia för flottan och ER Ib för kustartilleriet. Flygvapnet hade den från England inköpta ER IIIB.

SUN-projektet ER III och SAAB - Bofors ekoradioprojekt nådde aldrig operativ status. Detta torde dock inte ha påverkat den främsta betydelsen som hela ekoradioforskningen och utvecklingen fick genom att den genererade ett stort antal personer med grundläggande och djup kunskap om denna nya teknik, både teoretiskt och praktiskt.

Detta innebar att man direkt kunde bygga upp effektivt fungerande ekoradiogrupper inom förvaltningarna och FOA. Därigenom kunde man snabbt tillgodogöra sig flodvågen av ny radarkunskap och information som efter kriget vällde in över oss från de allierade segrarmakterna, främst England och USA.

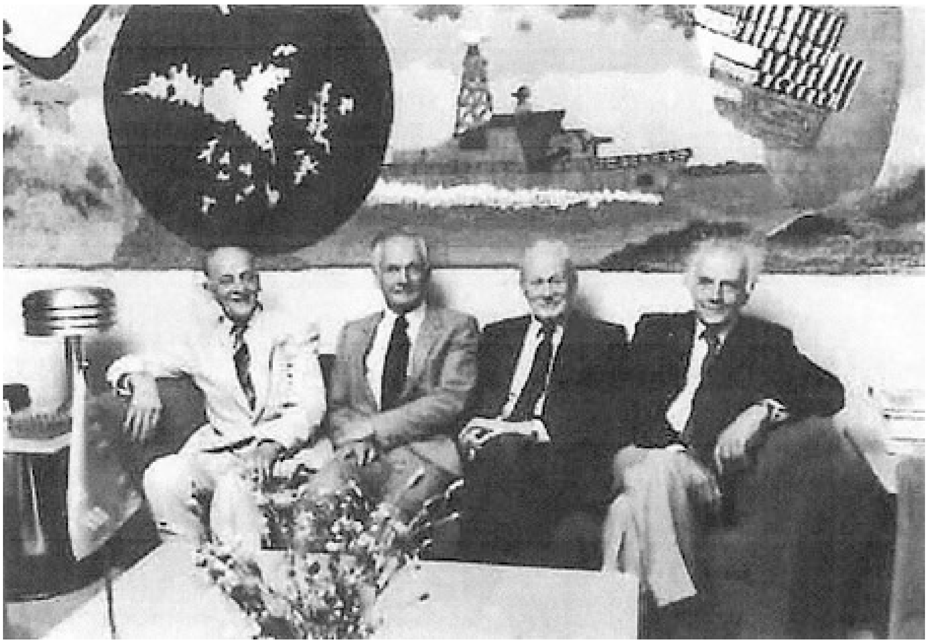
Av länderna utanför de direkta segrarmakterna torde vi därför ha varit de allra första som kunde omsätta denna nya radarkunskap i operativt fungerande system med en för tiden mycket hög modernitet.

Den fortsatta utvecklingen i Sverige skedde med stor framgång främst för luftvärnet inom armén och marinen samt nosradar inom flygvapnet.

7.5.7 Ekorrarna

En annan följd av vår kunskap på detta område var den radarindustri som tidigt började byggas upp på den grund som skapats under krigsårens ekoradioutveckling. Den har så småningom blivit en av de ledande på området.

I bilden nedan visas några av pionjärerna från SUN:s ekoradioutveckling. Den är tagen 1985 då "ekorrarna" som de själva kallade sig samlats på LM Ericsson Radar i Mölndal för att prata om gamla minnen.



Fyra ekoradiopionjärer samlade på Ericsson Radar AB i Mölndal 1985. Från vänster ser vi Thorsten Lange som byggde upp Ericssons radarverksamhet och blev förste platschef i Mölndal, Ove Norell, generaldirektör för Statens Provningsanstalt, Hugo Larsson och Martin Fehrm som efter varandra blev generaldirektörer för FOA. (Foto: Kent Eliassson, Ericsson Radar personaltidning MERA-nyheter, okt.1985)

Underlaget till avsnittet om Utvecklingen i Sverige är till stora delar hämtade från följande FHT dokument:

Radarutveckling inom armén
(1,2 MB) Författare: Kjell-Erik Lindgren.
Förstudie angående den historiska radarutvecklingen inom Flygvapnet
(F11/04) (2 MB) Författare: Karl Gardh.
Svensk ekoradioutveckling under krigsåren 1939-1945
(F03/10) (10 MB) Författare: Sven Hasselrot.

8 Radiolänk

8.1 Tidig utveckling

The history of radio relay communication began in 1898 from the publication by Johann Mattausch in Austrian journal, Zeitschrift für Electrotechnik. But his proposal was primitive and not suitable for practical use. The first experiments with radio repeater stations to relay radio signals were done in 1899 by Emile Guarini-Foresio. However the low frequency and medium frequency radio waves used during the first 40 years of radio proved to be able to travel long distances by ground wave and skywave propagation. The need for radio relay did not really begin until the 1940s exploitation of microwaves, which traveled by line of sight and so were limited to a propagation distance of about 40 miles (64 km) by the visual horizon.

In 1931 an Anglo-French consortium headed by Andre C. Clavier demonstrated an experimental microwave relay link across the English Channel using 10-foot (3 m) dishes. Telephony, telegraph, and facsimile data was transmitted over the bidirectional 1.7 GHz beams 40 miles (64 km) between Dover, UK, and Calais, France. The radiated power, produced by a miniature Barkhausen-Kurz tube located at the dish's focus, was one-half watt. A 1933 military microwave link between airports at St. Inglevert, France, and Lympne, UK, a distance of 56 km (35 miles), was followed in 1935 by a 300 MHz telecommunication link, the first commercial microwave relay system.

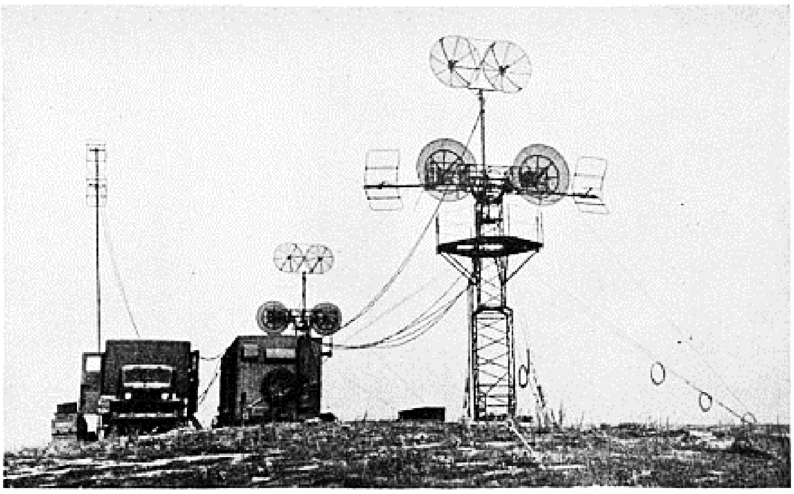
The development of radar during World War II provided much of the microwave technology which made practical microwave communication links possible, particularly the klystron oscillator and techniques of designing parabolic antennas. Though not commonly known, the US military used both portable and fixed-station microwave communications in the European Theater during World War II.

After the war, telephone companies used this technology to build large microwave radio relay networks to carry long distance telephone calls. During the 1950s a unit of the US telephone carrier, AT&T Long Lines, built a transcontinental system of microwave relay links across the US that grew to carry the majority of US long distance telephone traffic, as well as television network signals. The main motivation in 1946 to use microwave radio instead of cable was that a large capacity could be installed quickly and at less cost. It was expected at that time that the annual operating costs for microwave radio would be greater than for cable.

There were two main reasons that a large capacity had to be introduced suddenly: Pent up demand for long distance telephone service, because of the hiatus during the war years, and the new medium of television, which needed more bandwidth than radio. The prototype was called TDX and was tested with a connection between New York City and Murray Hill, the location of Bell Laboratories in 1946. The TDX system was set up between New York and Boston in 1947. The TDX was upgraded to the TD2 system, which used [the Morton tube, 416B and later 416C, manufactured by Western Electric] in the transmitters, and then later to TD3 that used solid state electronics.

8.2 Militära tillämpningar

8.2.1 USA



US Army Signal Corps portable microwave relay station, 1945. Microwave relay systems were first developed in World War II for secure military communication.

A US Army Signal Corps transportable microwave relay station from 1945 using AN/TRC-1, 5, 6, and 8 systems. Each pair of identical antennas is used for a link with another station up to 40 miles away, which can carry multiple telephone calls. Two antennas are required for bidirectional communication: one for transmitting and one for receiving. Microwave technology advanced during World War 2 due to the development of radar, and toward the end of the war the US Army began using microwave communication systems in the European theater. These military systems were some of the first practical microwave relay systems and presaged development of the great transcontinental commercial microwave relay networks in the 1950s. The systems shown here were:

AN/TRC-1, 70-100 MHz FM system carries 4 telephone circuits
AN/TRC-5, 230-250 MHz FM system carries 4 phone circuits
AN/TRC-6, 4.3-4.9 GHz TDM system carries 8 phone circuits
AN/TRC-8, 1.3-1.45 GHz TDM system carries 8 phone circuits

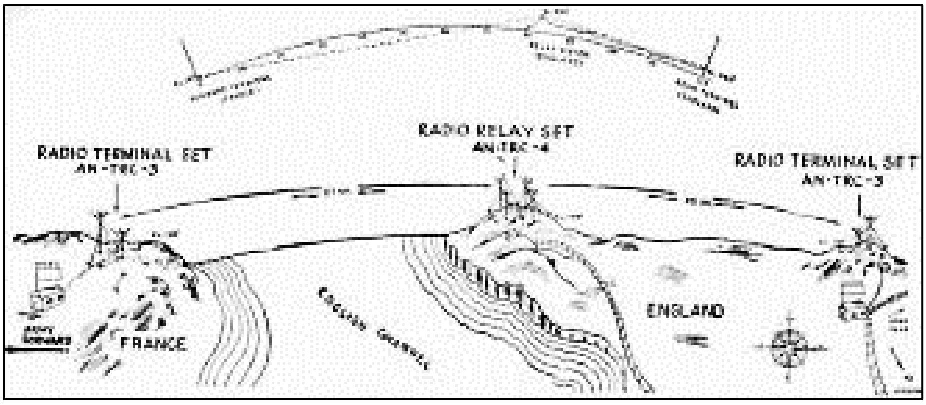


Figure shows a simplified functional diagram of a complete multichannel VHF radio relay communication system. The telephone and telegraph terminal equipment CF-1 and CF-2 is common to both the radio system and the "spiral-four" wire system. The radio terminal set is connected to its associated telephone terminal by "spiral-four" cable up to approximately 15 miles in length, one pair of the cable being used for transmitting and the other pair for receiving. The radio relay sets comprising in effect two radio terminal sets connected back-to-back are substituted for the telephone repeaters of a wire system. Duplex operation is achieved by the use of separate receiving and transmitting frequencies at each radio set.

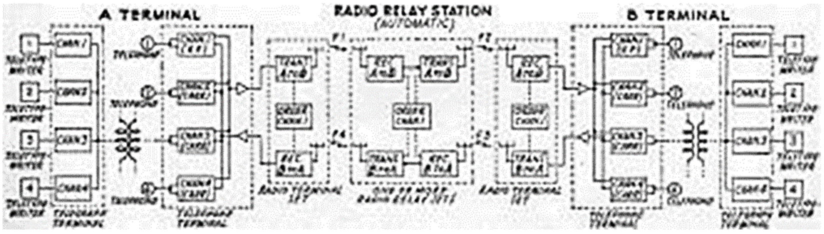


Fig 1. A typical army network, in which wire lines, carrier channels and VHF radio circuits are combined in a large multi-channel system.

Four telephone channels, each approximately 2800 cycles wide, within an audio frequency band of 200 to 12,000 cycles are obtained from the Telephone Terminal CF-1. Channel 1, operating at voice frequencies, is normally used as an order channel for intercommunication between terminals and relay sets for supervision and line-up purposes within the system. Each radio set is equipped with filters to confine the order channel to the band 200 to 3000 cycles and prevent mutual interference with the carrier frequency channels. Ringing over the individual telephone channels is accomplished from field telephones or switchboards by the use of voice frequency ringers which provide a 1000-cycle tone modulated by the 20-cycle telephone ringer.

Tone teletype channels may be provided over anyone telephone channel by the connection of the Telegraph Terminal CF-2 thereto. Additional teletype channels may be applied in like manner to other telephone channels. Facsimile service may be obtained by the use of Facsimile Equipment RC-120 on anyone or more of the telephone channels.

The principal characteristics of the radio receiver and transmitter are: (1) a horizontal three-element antenna array comprising a driven dipole fed by a 50-ohm flexible solid dielectric coaxial transmission line and parasitically excited reflector and director dipoles, all adjustable in length to the operating frequency and supported on a mast head by a 40-foot sectional steel tube mast; (2) a 2500-watt, 115-volt, 60-cycle, gasoline engine driven generator.

A 250-watt radio frequency amplifier is available as auxiliary equipment for use with the 50-watt radio transmitter to increase signal strength over unusually long or noisy transmission paths, where high power is advantageous.

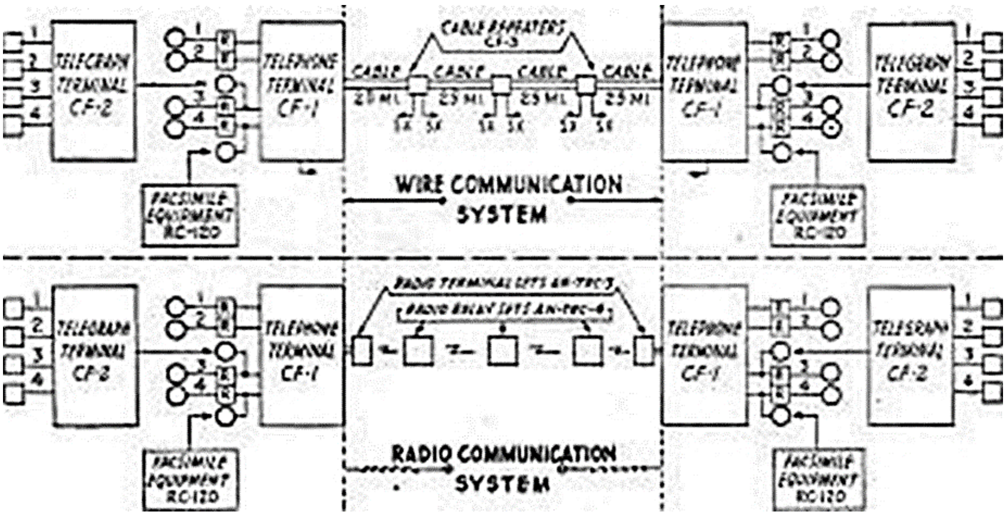


Fig2. Comparison, wire and VHF communication facilities, U.S. Army multi-channel systems.

On the second day after the initial landing on the Normandy coast, the cross-channel circuit illustrated above began operation, providing initially facsimile transmission of air reconnaissance information on military objectives from a Tactical Air Command Headquarters to the invasion forces. Shortly thereafter full multichannel telephone and teletype facilities were provided from Central Headquarters in England to the field commanders of the First U. S. Army in France. Following these outstanding uses, other armies, as they became operational on the continent, extended similar multi-channel radio facilities to their Corps, from their Corps to Divisions and between Corps within each army. The Air Forces likewise linked their base command establishments by means of similar radio circuits providing the establishment of equivalent wire circuits.

As the Armed Forces progressed across France additional radio relay facilities were established for both tactical requirements in the forward areas, and for administrative purposes in the rear Communication Zone. With the installation of additional cross-channel facilities, and of wire lines and other radio circuits on the continent, the radio relay systems became part of a completely integrated and comprehensive network of telephone, teletype and telegraph circuits covering an area in Europe equivalent in size to that from New York to Chicago and from Detroit to Atlanta. Through this integration, the radio systems became vital links in the network in providing primary circuits under enemy fire which took prohibitive toll of lives and material during attempted wire installations, or over terrain impassable to wire lines and also emergency circuits in the event of traffic overloads or failures of other facilities.

In citing the importance of this equipment as an emergency facility during a failure of the main cable system across France as a result of combat operations, the Chief Signal Officer, Major General W. Rumbough, European Theater of Operations, stated, "In spite of this very serious cable interruption, and I do not think any single trouble could have been worse, we handled 2709 messages -, that is nearly 2 messages per minute throughout the 24 hours."
The logistical advantages accruing from the use of radio relay communication system over the "spiral-four" cable system, as illustrated in Fig. 2, have been the principal factors through which this type of equipment has achieved its favorable reception and praise in relieving transportation. installation and maintenance problems. Greatly expanded commercial use of the principles for post-war applications are indicated.

Radio relay, born of the necessity for mobility, became the outstanding communication development of World War II. Sets employing frequency modulation and carrier techniques were developed and used, as were also radio relay sets that used radar pulse transmission and reception techniques and multiplex time-division methods for obtaining many voice channels from one radio carrier. Radio relay telephone and teletypewriter circuits spanned the English Channel for the Normandy landing and later furnished important communication service for General George S. Patton, after his breakout from the Normandy beachhead.

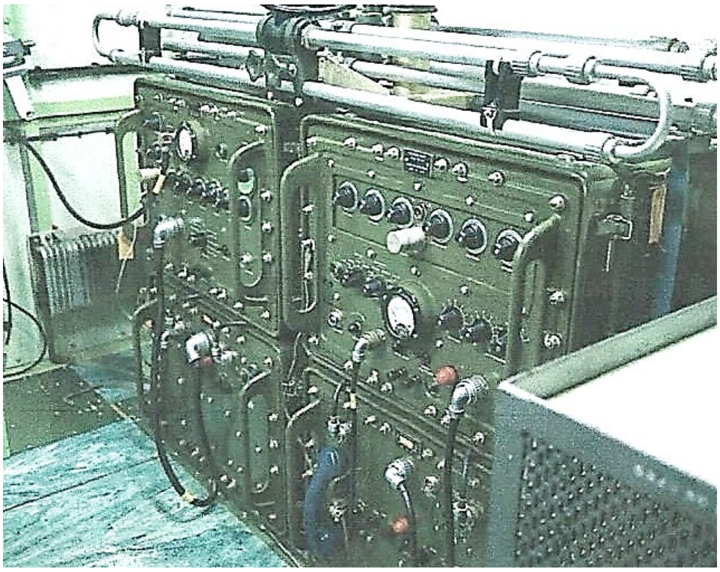
8.2.2 UK

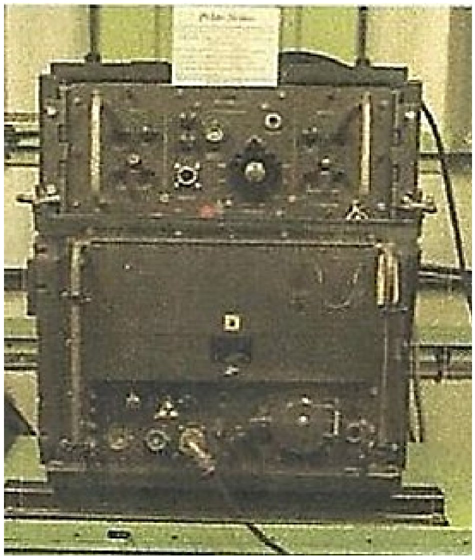
WW2 UHF Multi-channel set

The Wireless Set Number 10 provided 8 duplex speech channels using multiplexers and pulse code modulation (PCM) which was very advanced in 1944. The antenna was a UHF parabolic reflector emitting a narrow beam of approximately 5 degrees. It was first used some weeks after D Day for a link between The Isle of Wight to Cherbourg in France. However, as many Royal Signallers, who have had to struggle with Path Profile Analysis, this link was at the limit of the set's Fresnel Zone – Communications therefore were only intermittent. Later it was used in a tactical role to support HQ 21 Army Group. Its success was initially limited owing to the lack of working sets and a lack of 60 Feet masts – a familiar problem to all Royal Signals. However, soon the Signals Detachments managed to establish reliable radio relay chains across Europe even to Montgomery's final headquarters on Luneburg Heath in Northern Germany.


Establishing a radio relay link from Murud, Sararoak.

41/R222 RADIO RELAY EQUIPMENT





During WW2 the partial replacement of telephone lines by point-to-point radio relay had been achieved using the SHF No10 set, which continued in service until the 1950s.

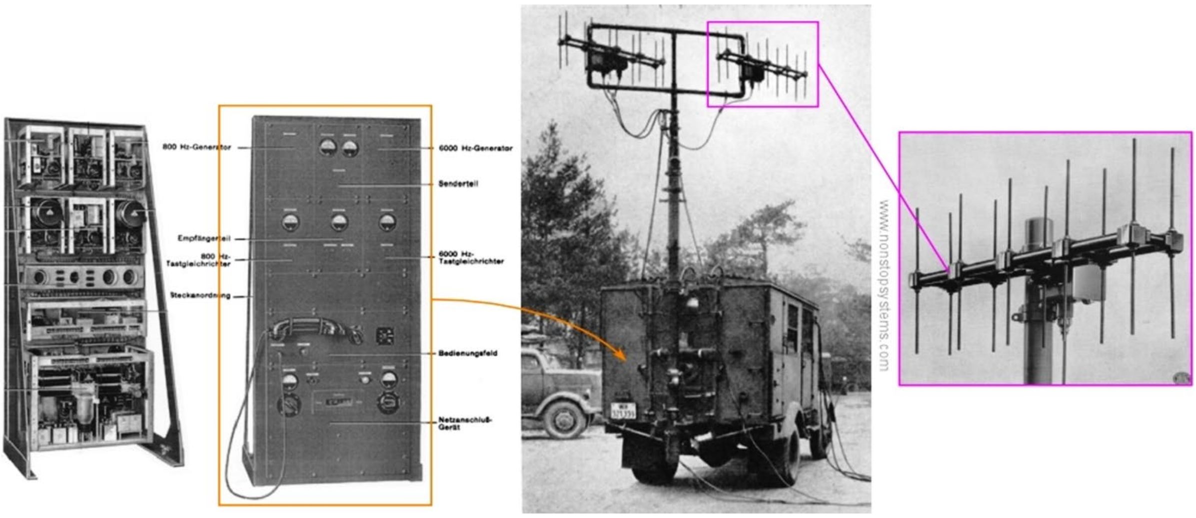
Experience in Borneo and Aden was that VHF was the way ahead for voice communications, including for radio relay equipment. You might think that the first picture was of a radio relay link using a C41 Yagi antenna, but in fact this was a C42 rebroadcast station manned by Gurkha Signals in Sarawak. This was connected to a command net, so traffic was strictly limited on this net - one speaker at a time. Enter the C41/R222 shown below: This set was a wideband FM duplex multichannel in frequency range of 50 – 100 Mhz. At first it required the insertion of several crystals, but later it was used with a frequency synthesizer that was developed for the BRUIN Radio Relay set C50/R236. More important for traffic capacity the detachment included the Carrier Set Telegraph (CST)1+4 Number 3 (above right). This gave 4 voice channels. This could be increased using the CST 12. It was first used for trunk communications between Headquarters in Germany. Owing to funding restrictions it was decided that any new trunk system would have to be introduced piecemeal. Trials were conducted in 2 Div HQ & Sig Regiment in Germany using this set with the first field automatic exchange dialing system with improved multiplexers. However, the set had several major problems. The antennas had a separate transmit and receive directional Yagi number 2, which were mounted on two masts 36/48ft steel lightweight, which took some time to erect. Secondly, in BAOR it was transported in a 1 Ton Austin K9 truck towing a generator trailer. This was unreliable and under-powered. Thirdly, the frequency range was too restricted and was used for analogue TV at that time. The first part of BRUIN that came in was the new Radio Relay sets to replace the C41, but it continued in service in 11 Signal Bde and 16 Signal Regiment for some time for the Rear Area communications in Germany.

8.2.3 Reichwehr Germany


Dezimetergerät DMG 4a K

Ln 20063

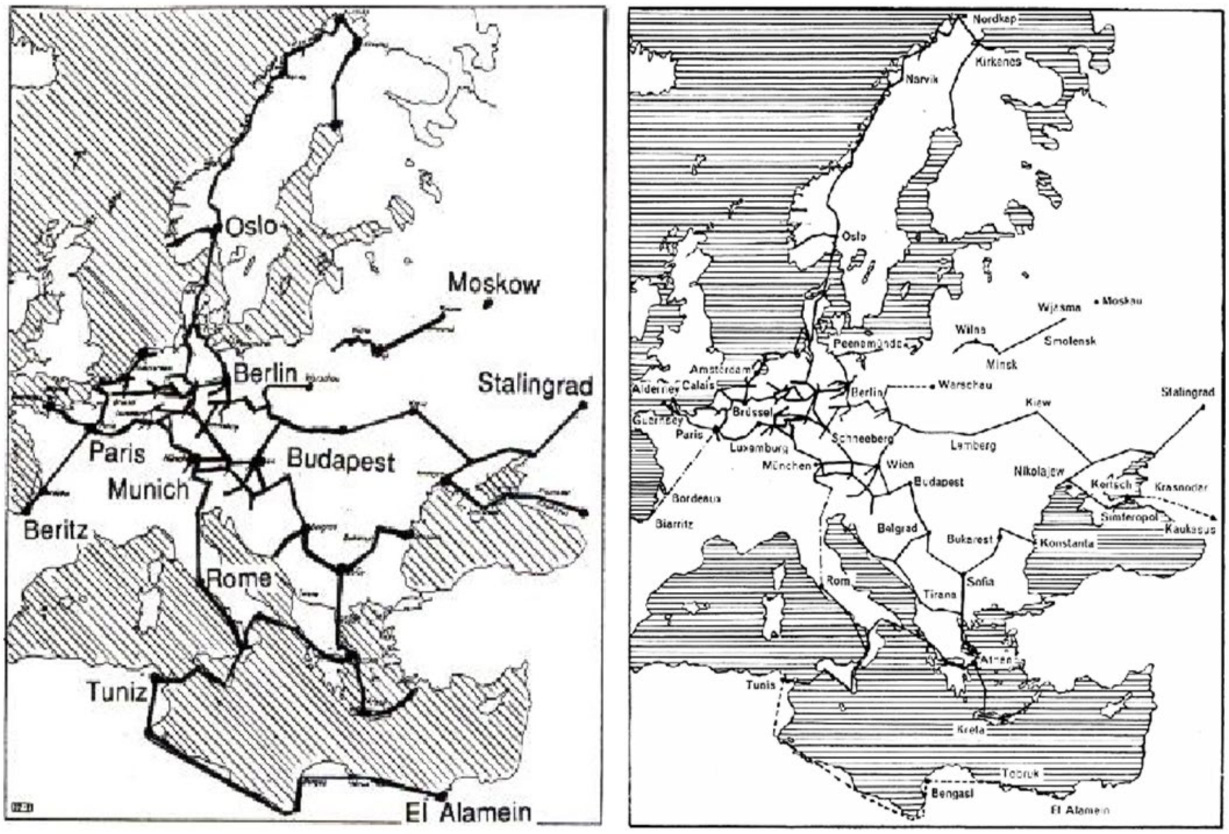
(früher: Richtverbindungsgerät K)



Radio truck with 2 sets of FuG04 / DMG 3K transmit & receive antennas and a control rack.

The documentation of subsequent DMG models such as *DMG 7 K/aK* do not explicitly mention Hellschreiber operation. However, any communications channel suitable for voice/telephony, is more than suitable for Hellschreiber.

The maps below show the network of the *Luftwaffe* UHF directional communication links. Understandably, the network branches out from Berlin, with - at some point in time - an "orphan" sub-net towards Moscow.



Network of Luftwaffe "Michael" UHF directional radio relays (late 1942?)

There are sources that state that the UHF relay network with various models of "Michael" equipment, had a total combined length of 50 thousand or even 70 thousand km (about 30 and 44 thousand miles, respectively). The 70 thousand km total length may be a 1950s estimate from *Telefunken*, based on adding up all network "legs" that were ever built up, but were never all active at the same time. Note that the network "nodes" typically moved with the fronts as the war evolved. The 50 thousand km estimate is from a later date. It *may* reflect the maximum total network size that was active at any given time. Unfortunately, no records are known to exist that can be used to reconstruct and validate these estimates.

There are also statements and claims about the longest single end-to-end network path having a length of 5 or 7 thousand km. Based on the signal-to-noise performance of the UHF relays, such distances could only be covered with a combination of UHF relays and cables (or cable-only). Actual range of the relays was not explicitly specified. It was recommended not to exceed a total length of 300 km (= five "hops" of 60 km each). Each UHF relay company ("Richtverbindungs-Kompanie") of the *Wehmacht* signal corps comprised twelve "Trupps". Each "Trupp" had one UHF transmitter and one receiver (plus mast with antennas) and could form one end-station or one relay station. Hence, at company level, a stretch of about 400 km could be covered.

Note that in the *Luftwaffe* as much as 80% of communication was via radio relays, whereas in the *Heer* (army), about 80% was via wired lines.

8.2.4 Radiolänk vid Luftbron till Berlin

Radiostation Berlin-Frohnau

Remarkable were the microwave relay links to West Berlin during the Cold War, which had to be built and operated due to the large distance between West Germany and Berlin at the edge of the technical feasibility.

In addition to the telephone network, also microwave relay links for the distribution of TV and radio broadcasts. This included connections from the studios to the broadcasting systems distributed across the country, as well as between the radio stations, for example for program exchange.

Military microwave relay systems continued to be used into the 1960s, when many of these systems were supplanted with tropospheric scatter or communication satellite systems. When the NATO military arm was formed, much of this existing equipment was transferred to communications groups. The typical communications systems used by NATO during that time period consisted of the technologies which had been developed for use by the telephone carrier entities in host countries. One example from the USA is the RCA CW-20A 1–2 GHz microwave relay system which utilized flexible UHF cable rather than the rigid waveguide required by higher frequency systems, making it ideal for tactical applications. The typical microwave relay installation or portable van had two radio systems (plus backup) connecting two line of sight sites. These radios would often carry 24 telephone channels frequency division multiplexed on the microwave carrier (i.e. Lenkurt 33C FDM). Any channel could be designated to carry up to 18 teletype communications instead. Similar systems from Germany and other member nations were also in use.

8.3 Utvecklingen i Sverige

Försvarets intresse för Radiolänk startade inom armén i slutet av andra världskriget. Ett länkstråk byggdes med importerad utrustning i mellersta Sverige.

Efter några år påbörjades prov med radiolänk för den optiska luftbevakningen. Efter proven beställdes 1948 Radiolänk RL-01 av KATF (Kungliga Armé Tyg Förvaltningen).

I samband med att den optiska luftbevakningen överfördes till Flygvapnet överlämnades ansvaret för fortsatt handläggning till KFF (Kungliga Flyg Förvaltningen).

Genom riksdagsbeslut 1948 om en uppbyggnad av ett modernt luftbevakningssystem framgår det året också som födelseår för utformningen av flygvapnets moderna telekommunikations-struktur.

1950 tillsattes en utredning med uppgift att utarbeta förslag till hur man bäst skulle åstadkomma skadetåliga telekommunikationer för luftbevakning och stridsledning.

Utredningen föreslog att ett landsomfattande nät baserat på radiolänk skulle byggas.

Valet av radiolänk som transmissionsmedel var främst betingat av kraven på ekonomi och skadetålighet. I utredningen skisserades grunderna för nätstruktur, transmission och förmedling.

Efter ytterligare studier, försök, utredningar mm togs under 1954 beslut om utbyggnad av ett nät enligt föreslagna linjer och under CFV ansvar. Kostnaderna skulle fördelas mellan ÖB (operativ ledning), FV och SJ enligt utredningens förslag.

Radiolänkutvecklingen i Armén som började 1946, men som av brist på reella resurser inte kom att förverkligas förrän omkring 1950.

1947 utfördes vissa försök med att nyttja en vanlig UK-radiostation, ra 400, som radiolänk-station. Den tillsammans med den, under tidigt 1940-tal framtagna svenska bärfrekvens-terminalen 211 (.enkan.), skulle ge fler förbindelser. Försöken utföll dock inte så bra. Försöken genomfördes i Uppland med personal ur Signalregementet.

1951 kunde inköpas några provexemplar från GEC i England och detta blev senare RL 320.

En utförlig dokumentation om utvecklingen finns i dokumentet:
Radiolänk i Armén (15 MB) Författare: Anders Gustafsson. (A06/04)

Inom FHT har utarbetats ett dokument som beskriver den tidiga utvecklingen och användningen av Radiolänk inom det svenska försvaret.

Fasta och rörliga Radiolänksystem och Flygvapnets Fasta Radiolänksystem (FFRL) skapas – ursprung och tidig utveckling (22 MB) Författare -Hans-Ove Görtz, John Hübbert, Göran Kihlström och Arne Larsson (F03/21), 2021-01-14.

Telegrafverkets intresse för radiolänk kom först på 50-talet i samband med utbyggnaden av TV-nätet.

9 Sammanfattning

9.1 Allmänt

Det svenska försvaret har genomgående sedan den trådbundna telegrafin infördes i ett internationellt perspektiv varit relativt tidiga med att utnyttja den tekniska utvecklingen inom det som nu kallas elektronikområdet.

I takt med teknikutvecklingen etablerades speciella förband som betjänade och använde den succesivt introducerade tekniken. Det första specialförbandet som sattes upp efter att riksdagen 1871 beslöt om upprättandet var ett fältsignalkompani, som skulle vara underställt Fortifikationen och samlokaliserat med Pontonjärbataljonen vid Jaktvarvet på Kungsholmen. Fältsignalkompaniet var ett värvat förband, som bestod av 4 officerare, 4 underofficerare och 120 man, korpraler, spel, hantverkare och soldater samt 10 egna hästar. Vid en manöver i Uppland 1872, under ledning av den nye konungen Oscar II, deltog fältsignalkompaniet med en telegrafstation i Rosersberg och utbyggde ”hela” 5 km enkeltrådig ledning för telegrafering. Fältsignalkompaniets uppgift var ursprungligen enbart avsedd för arméledningens förbindelser.

Ett annat exempel är Införandet av radiotelegrafi med ”gnistmateriel” inom marinen vilket medförde behov av utbildning. Beträffande själva signalistutbildningen kan omnämnas, att en kurs i ”gnisttelegrafering å Carlskrona beväringseskader” anbefalldes i en Generalorder redan 1902, Behovet av att avdela vissa officerare för gnisttjänsten hade ökat under årens lopp och ”gnistofficerare” förekommer första gången 1907.

Inom alla försvarsgrenar startades även utbildning av tygteknisk personal med ”elektronikinriktning”. Motsvarande utbildning för värnpliktig personal kom att ha stor betydelse för att sprida kunskap och kompetens som efterfrågades av den svenska industrin.

9.2 Trådbunden telegrafiutveckling i svenska försvaret

År 1852 fick general Akrell uppdraget att konstruera ett elektriskt telegrafsystem. Den första linjen byggdes mellan Stockholm och Uppsala och var färdig 1853. I mycket hög takt byggdes sedan telegraflinjer ut till alla residensstäder och med anslutning till det europeiska fastlandet och Amerika. Den då 74-åriga Akrell var chef för Kongl Elektriska Telegrafverket ända till sin död 1868 vid 83 års ålder.

Tio år senare började också försvaret förberedande försök med elektrisk telegrafmateriel och 1871 beslöt som tidigare omnämnts riksdagen om upprättandet av ett fältsignalkompani.

I samband med 1892 års härordning omdöptes Fältsignalkompaniet till Fälttelegraf-kompaniet. Under 1890-talet genomfördes en omorganisation och utökning av organisationen så att varje arméfördelning skulle i fält erhålla en fälttelegrafavdelning. Vid 1901 års härordning, varvid allmän värnplikt infördes och indelningsverket avskaffades, utökades fälttelegrafkompaniet till Kungl. Fälttelegrafkåren, direkt underställd Chefen för Kungl. Fortifikationen. Kåren utökades då till två fälttelegrafkompanier och en tyg- och parkavdelning. Förbandet fick beteckningen Ing 3. Förbandet började utökas 1902 med fortsatt förläggning tillsammans med Svea ingenjörkår. År 1908 flyttade kåren till Marieberg, som sedan skulle hysa signalförband till den 1 oktober 1958.

9.3 Telefonins utveckling i svenska försvaret

Kort tid efter att Bell demonstrerat telefonen påbörjades försök för att använda telefonen i militära sammanhang. Den användes av England vid de militära kampanjerna i Indien och Afrika under senare delen av 1880 talet och tidigt 1890 tal. I USA användes den för att koppla ihop förband och staber med telefonlinjer. Den användes också för eldledning inom fast kustartilleri. Under de första åren användes kommersiellt utvecklade telefoner.
Den första fälttelefonen i USA utvecklades 1889 men kom på grund av kostnad ej att massproduceras.

Den första utvecklade fälttelefonen användes av England under det andra Boerkriget 1899 - 1902. Telefonerna som användes var konstruerade av Ericsson.

Det stora genombrottet för telefonen kom först under första världskriget.

Det svenska försvaret var mycket tidigt med att utnyttja telefonen. Fältsignalkompaniets första telefonapparat infördes i armén 1880. Det var en stor Bell telefon med särskilt bordsstativ – ja även golv- (mark-) stativ medfördes, enligt uppgift fullständigt unik i världen.

Ericsson kom tidigt att vara en ledande leverantör av fälttelefonmateriel på den internationella marknaden. Ericsson var verksamma inom militär telekommunikation på världsmarknaden ända in på början av 2000 talet.

9.4 Radiotelegrafiutvecklingen i svenska försvaret

Liksom i övriga delar av världen var det marinen som var först med att använda radiotelegrafin. Prov och utbyggnad skedde i Sverige bara några år efter att det skett i USA och UK. Vi hade här stor hjälp av att Ragnar Rendahl arbetat vid AEG på avdelningen för trådlös telegrafi och avancerade till chef för laboratoriet 1903. Han kvarstod i denna befattning till 1908 då han värvades över till Kungliga Marinförvaltningen i Stockholm.

Inom armén startade verksamheten under krigsåren 1914 - 18. Noterbart är att vad jag kunnat se så valde Sverige att liksom US Army anskaffa den s k Åkande fältradion m/17 från Telefunken. I USA fanns den 1911 alltså några år tidigare. Troligen betydde SATT samverkan med Telefunken en del för radioutvecklingen i Sverige. Armén kom sedan att under många år i egen regi utveckla och tillverka fältradio. De svenska modellerna påminner mycket om det som utvecklades av Marconibolaget för Royal Army.

Inom flyget var vi i Sverige relativt tidigt ute med att prova och införa radiotelegrafi. Även här hade vi nytta av SATT:s knytning till Telefunken.

Noterbart är vilken stort inflytande Marconi har haft på den tidiga utvecklingen och även senare med företag etablerade i USA, England, Canada och Italien. Genom samarbetet med SRA fick Sverige tillgång till ett antal radiopatent. Sverige har fram till 2000 anskaffat en stor del elektronikprodukter från Marconibolagen.

9.5 Radiotelefoniutvecklingen i svenska försvaret

Radiotelefonin fick under WW I sitt stora genombrott, vilket kom att innebära att stora insatser gjordes för att förbättra teknik och metoder för en fortsatt utveckling av utrustningar. Som tidigare nämnts kom Marconiföretagen att ha en stor roll för den militära radioutvecklingen. Även de tyska företagen AEG/Telefunken m fl hade stor betydelse för utvecklingen.

I USA och UK satsades det stora resurser för att kunna införa radiotelefoni främst inom flyget och i viss mån marinen. Armén var inte så pigga på att införa radio överhuvudtaget främst beroende på risken att kunna pejlas. Inom armén var det främst artilleriet som efterfrågade radiotelefoni.

Utvecklingen i Sverige följde i stort omvärlden med några års eftersläpning. Marinen var även inom detta område tidigt framme med tidigt användande av radiotelefoni och även tidiga med att införa UK.

I Sverige fanns det AEG/Telefunken kopplade SATT, AGA, och det 1919 startade SRA som senare blev delägt av Marconi. Förutom dessa arméns fälttelegrafkårens tygverkstäder som kom att stor betydelse för utvecklig och materielförsörjning av radio till armén.
I Sverige dröjde det till en bit in på 30-talet innan radiotelefoni var spridd inom de flesta försvarsfunktionerna. En breddspridning kom dock inte att ske förrän långt senare i samband med surplusanskaffning efter WW II.

9.6 Fjärrskriftutvecklingen i svenska försvaret

Fjärrskrift kom att under WW II få en mycket framträdande roll för ledningen av stridskrafterna. Sverige utvecklade med start i slutet på 30-talet en utbyggnad av fjärrskriftnät inom försvaret. Fjärrskriftmaterielen levererades i stor utsträckning från utlandet, Siemens (Tyskland), Philips (Holland).

Fjärrskriften kom att under många år vara den helt dominerande textkommunikationen för stora delar av försvaret. Inledningsvis skedde kryptering av textmeddelandena innan de sändes med fjärrskrift (kryptering off-line). Ett omfattande arbete gjordes för att effektivisera hanteringen i de sambandscentraler som skötte hanteringen av textmeddelandena.

Efterhand utvecklades kryptomaskiner som anslöts mellan fjärrskriftmaskinen och transmissionskanalen (online-kryptering). Detta underlättade hanteringen så att ett snabbare flöde av informationen kunde ske. Denna metod användes speciellt i Oprums-fjärrskriften. Införandet av MILTEX på 80-talet innebar en stor förbättring av effektivisering av textkommunikationen.

För radiokommunikationen kom dock telegrafin att vara rådande under lång tid.

Radiofjärrskriftnätet inom Stab-Stab radionätet fick först med införandet av Ra 630 och ARQ en väl fungerande funktion.

9.7 Radarutvecklingen i svenska försvaret

Den svenska radarforskningen kom inte i gång förrän i slutet av 1930-talet. En av de första, eller kanske den allra förste, som över huvud taget sysslade med vad vi idag kallar radar var civilingenjör Torsten Elmqvist, SATT (Svenska Aktiebolaget Trådlös Telegrafi).

1939 började Elmqvist experimentera med ultrakorta riktade vågor med sikte på att konstruera en apparat för lokalisering och avståndsmätning till fasta och rörliga mål. Så småningom började liknande verksamhet komma i gång på flera håll.

AB Svenska Elektronrör började bedriva forskning inom samma område på uppdrag av arméförvaltningens tygdepartement, och inom marinförvaltningens torpedavdelning experimenterades det med reflekterade radiovågor i samband med konstruktion av spärranordning för vissa vattenleder. Den splittrade försöksverksamheten var både oekonomisk och opraktisk.

I en skrivelse till försvarsministern i dec. 1941 hemställer chefen för försvarsstabens luftbevakningsavdelning, övlt Bengtsson, att all forskning och försöksverksamhet inom ekoradioområdet skall samordnas inom det nyinrättade SUN (Statens Uppfinnarnämnd).

Dåvarande försvarsminister, P E Sköld, uppdrager åt SUN att undersöka möjligheten för samordnad forskning inom SUN:s regi. Vid nyåret 1942 åtar sig SUN uppdraget. Under ett inledningsskede på sex månader beräknade SUN att sådana erfarenheter kunnat uppnås att det blir möjligt att bedöma om den samlade forskningsverksamheten skulle kunna fortsätta.

Ett råd bildades bestående av representanter från varje intressent att följa arbetet och fördela forskningsuppgifterna samt att hålla kontakt med regeringen och försvarets myndigheter.

Försöksverksamheten bedrevs i lokaler tillhörande arméförvaltningens laboratorium i Frösunda, i en barack tillhörande FOA3 vid Bromma flygplats samt i myntverkets källare.

När försöksverksamheten avslutades kom den kompetens som byggts upp att verka inom FOA och industrin. Verksamheten inom SUN hade lagt grunden för en mycket framgångsrik radarindustri inom landet.

I slutet av WW 11 lyckades Sverige importera radarstationer från Tyskland. Efter kriget genomfördes en omfattande import från England.

9.8 Radiolänkutvecklingen i svenska försvaret

Försvarets intresse för Radiolänk startade inom armén i slutet av andra världskriget. Ett länkstråk byggdes med importerad utrustning i mellersta Sverige.

Efter några år påbörjades prov med radiolänk för den optiska luftbevakningen. Efter proven beställdes 1948 Radiolänk RL-01 av KATF (Kungliga Armé Tyg Förvaltningen).

I samband med att den optiska luftbevakningen överfördes till Flygvapnet överlämnades ansvaret för fortsatt handläggning till KFF (Kungliga Flyg Förvaltningen).

Genom riksdagsbeslut 1948 om en uppbyggnad av ett modernt luftbevakningssystem framgår det året också som födelseår för utformningen av flygvapnets moderna telekommunikations-struktur.

1950 tillsattes en utredning med uppgift att utarbeta förslag till hur man bäst skulle åstadkomma skadetåliga telekommunikationer för luftbevakning och stridsledning.

Utredningen föreslog att ett landsomfattande nät baserat på radiolänk skulle byggas.

Valet av radiolänk som transmissionsmedel var främst betingat av kraven på ekonomi och skadetålighet. I utredningen skisserades grunderna för nätstruktur, transmission och förmedling.

Efter ytterligare studier, försök, utredningar mm togs under 1954 beslut om utbyggnad av ett nät enligt föreslagna linjer och under CFV ansvar. Kostnaderna skulle fördelas mellan ÖB (operativ ledning), FV och SJ enligt utredningens förslag.

Radiolänkutvecklingen i Armén som började 1946, men som av brist på reella resurser inte kom att förverkligas förrän omkring 1950.

Telegrafverkets intresse för radiolänk kom först på 50-talet i samband med utbyggnaden av TV-nätet.

10 Referenser, underlag

På följande web-sidor finns intressant historisk information om utvecklingen inom området.

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