WIRELESS *for the* WARRIOR

Pamphlet Series

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(Incorporating Wireless Set No. X32D)

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About this pamphlet.

In this retyped but otherwise unchanged reproduction of an S.E.E. Report were the results of the first investigations at S.E.E. on the possible application of frequency modulation to British military radio communication. This unique document gives evidence that frequency modulation for British Army communication was very seriously investigated from 1941 onwards. An original of this document is held in the archive of the Royal Signals Museum, Blandford Camp, Blandford Forum, UK.

In the Appendix of this pamphlet is other relevant information such as a list of additional documents along with photographs, technical data and circuit diagram of an experimental wireless set used during the investigations.

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S.E.E. REPORT NO.798

NOT TO BE PUBLISHED

SUBJECT :- INTERIM REPORT ON THE APPLICATION OF FREQUENCY MODULATION TO SERVICE USE

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AT:- SIGNALS EXPERIMENTAL ESTABLISHMENT
WARNHAM COURT, NR. HORSHAM, SUSSEX.

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Interim report on the application of frequency modulation to service use.

Summary.

The advantages claimed in America for frequency modulation as an alternative to amplitude modulation for telephony have been critically examined. They have been found to be attainable with conventional circuits and very convincing in the field. Frequency stability requirements, though more stringent than on amplitude modulation, can be met without undue complication.

It appears that for Service use quite a low value of deviation is frequently desirable. On the 2-8 Mc/s band frequency modulation with a deviation of +- 5 kc/s has been tested against amplitude modulation with the same input power. It was found that a considerable improvement was obtained with frequency modulation, this improvement being most marked in the presence of strong impulse noise such as ignition interference.

A description is given of the work now in progress by S.E.E. and by the Trade.

1. Introduction.

The characteristic difference between F.M. and A.M. is that on F.M. application of modulation causes the frequency of the radiated wave to vary, instead of its amplitude as on A.M. This variation occurs at the modulation frequency and the extent of the variation is proportional to the depth of modulation, or the loudness of speech. Now on A.M. loudest speech corresponds to a variation in the amplitude of the emitted wave between 0 and twice its unmodulated value. On F.M. however, it is obviously impracticable to vary the frequency to such an extent and an arbitrary figure must be chosen to represent the maximum extent of the frequency swing which may occur. This figure is known as the deviation of the system and is defined as the maximum swing of frequency to either side of the carrier frequency. Typical values of deviation are from 5 to 75 kc/s. The properties of the F.M. system depend markedly on the value of deviation used and this value must therefore be chosen so as best to fit the specific requirements of the system, and the sender and receiver designed accordingly. F.M. therefore differs from A.M. in the design of the sender and the receiver and also in certain propagational features which are described below.

Up to the present, wireless telephony communication has been very largely carried out by means of A.M. Recent work in America and elsewhere has, however, shown that the different properties of F.M. make it in some ways more suited to Service use. An investigation of the applicability of F.M. to Military requirements is now in progress; some of the results already obtained are described below.

S.E.E. are investigating the properties of F.M. mainly in order to become familiar with the technique and to obtain data for future use, while the Trade have been asked to design various F.M. sets which if successful could after a little development serve as prototypes for production.

Before describing in detail the work in progress at S.E.E. and by the Trade it will be convenient to refer to the principal features of F.M.

2. Principal Features of F.M.

(1) F.M. enables an increased sender efficiency to be obtained, so that for a given radiated power both sender power consumption and size are considerably reduced while the receiver is only slightly more complicated.

The reduction in battery consumption thus afforded may be of considerable value.

The saving in size increases with the power of the sender, but is slightly off-set by the fact that one more stage is necessary in the receiver on F.M. than on A.M.

The gain in efficiency results from the fact that with F.M. and R.T. sender may be modulated at low level with subsequent power amplifiers operating at full efficiency. This is not possible with A.M. With a given output valve an increase in power output of about four to one is obtainable compared with grid modulation, with an associated gain of two to one in efficiency. Alternatively for equal sender inputs the radiated power is twice as great on F.M. as on A.M.

It should be pointed out that since C.W. is not a modulated wave no increase in sender efficiency can be obtained by the use of F.M.

(2) The F.M. receiver is less responsive to noise than the A.M. receiver, so that when a signal is being heard on A.M. above a background of noise the signal on F.M. will appear to suppress the noise, even though the signal to noise ratio at the aerial is the same on each system. Thus a signal which is just readable on A.M. becomes readily so on F.M.
This is especially noticeable when the source of noise is impulse or ignition interference. As this type of interference (generated by vehicle, atmospherics, etc.) frequently determines the useful range on A.M., greater ranges will be obtained when F.M. is used. Alternatively the problem of vehicle-interference suppression will be considerably eased.

The theoretical basis for the noise suppression of F.M. is well established. Briefly it may be stated that when two carriers or a carrier and noise are being received on an F.M. receiver the stronger signal "demodulates" or suppresses the weaker, so that the receiver tends always to respond to the stronger signal. This is discussed further in 5 (2) and 5 (3) below in relation to the capture and threshold effects.

3. Choice of Operating Frequency.

The features described above were recently confirmed in America and the suitability of F.M. mobile communication demonstrated. For the most part frequency sets on the 30-40 Mc/s waveband were used, with a radiated power of 25 Watts, and a deviation of between 15 and 20 kc/s. Before seriously proposing the possibility of F.M. for Service use in this country it was however, necessary to obtain further knowledge on the subject.

In particular it was necessary to decide in which frequency bands F.M. would give the greatest advantage. It was originally thought that in order to obtain any worthwhile advantage from F.M. it would be necessary to use an exceedingly large deviation. This would have implied that each station would occupy considerably more ether-space than on A.M., so that F.M. could only be used on high frequencies.

On the other hand, if F.M. was to be used for vehicle communication, to which it appeared most suited, propagation characteristics rendered the use of high frequencies undesirable. Also from the standpoint of a possible change over to F.M., it appeared desirable to work on the normal A.M. band of 2-8 Mc/s. This would not be possible with high deviation F.M.
Work at S.E.E. has shown that for communication purposes considerable advantage can be obtained from the use of narrowband F.M., i.e. F.M. with quite a low deviation, of the order of +- 5 kc/s. This investigation has therefore centred largely around the Army bands of 2-8 Mc/s and 20-30 Mc/s.

The main questions to be settled by the investigation were the following:

(1) Circuit design:
The method of producing and receiving F.M., their reliability and complexity. Design of auxiliary test apparatus, and ease of maintenance etc.

(2) Performance in the field:
Extent of the improvement given by F.M. in the field, the optimum deviation and usable carrier frequencies. Effects of interference noise, etc.

These points have now been largely answered, and the conclusions with respect to circuit design and field performance are described below in 4 and 5 respectively. The present Trade position is covered by 6.

4. Circuit design.

Work on the design of F.M. Senders and receivers has shown that the circuits involved are straightforward and present no undue difficulties in alignment or in maintenance. While it is not proposed to consider in detail the circuits used, mention will be made of some of their more important features.

(1) Senders.

F.M. senders fall into two classes, namely the crystal controlled phase modulated type and the frequency modulated self-oscillator type. In comparison with the crystal controlled type, self-oscillators are inherently more liable to frequency drift but are considerably simpler and more flexible.

The modulator circuit used with self-oscillators usually consist of a "reactance valve" so connected across the oscillator tank circuit as to look like a reactance whose magnitude is varied in sympathy with the modulation applied to its grid. Such a circuit readily gives linear low-level modulation, but tends to reduce the oscillator stability. This question of stability is one of the governing features of F.M. sender design, and is being investigated in some detail.

Stabilised supplies may be used, while several circuits are available for increasing sender stability. A two valve reactance element is one method, in which the effect of variation of reactance tube parameters with supply voltages etc, is balanced out. Alternately, the sender oscillator may be locked to the receiver frequency-changer oscillator by means of a standard automatic frequency control circuit. Such a circuit is directly applicable to F.M. because the two elements necessary - the reactance tube and the discriminator are already present in the sender and the receiver respectively.

The mechanical or short-term stability of the oscillator must also be made as high as possible since any vibration etc., causes F.M. which will appear directly in the receiver. This may be achieved by rigid mounting of wiring and components, isolation of sources of mechanical vibration etc., etc.

The single-frequency sets which have been used for American Police communication by F.M. are of the crystal-controlled phase-modulated type. Phase modulation is a particular form of F.M. and may be converted into pure F.M. by means of a correcting network. A two-tube balanced modulated is commonly used which does not reduce the frequency-stability of the sets. More valves are however necessary than with the reactance-tube modulator and the size of the sets is increased accordingly. Also, the setting-up adjustments become more involved. S.E.E. have been able to perform field trials on four such sets, and their performance is described in 5 (1) below.

(2) Receivers.

The general design of F.M. receivers is now fairly standardised. It is customary to use a superheterodyne circuit in which the second detector is replaced by the combination of amplitude limiter and F.M. detector or discriminator.
Experience with receiver construction has shown that: -

a) The optimum conditions for limiting depend on the received signal strength. For Service use it is best to design for efficient limiting at quite low signal strengths. Owing to space requirements a single stage limiter is generally used.

(b) It has been found that the usual discriminator circuit described by Foster and Seeley, (P.I.R.E., March '37) is very simple, very sensitive and easy to align. Provided reasonable care is taken in the layout, excellent results may be obtained with a form of construction little more involved the standard I.F. Transformer.

(c) In F.M. receiver design the same care must be taken of stability of the oscillator as with the sender. Both the long and short-term stabilities must be made as high as possible.

(d) The use of a low pass audio filter considerably improves the signal/noise ratio of the received signal. Satisfactory results may be obtained with quite simple air-core coils.

Mention may be made here of the fact that the background noise heard on an F.M. receiver, is of higher pitch than on A.M. This is advantageous since for the same degree of noise, less loss of intelligibility is caused by the higher-pitched F.M. background.

4. Circuit design. (Cont.)

(3) Maintenance.

Although considerable auxiliary apparatus has been developed in the present work, it may be stated that for the maintenance of F.M. gear little apparatus is necessary beyond that normally used on A.M., and the alignment of the circuits is equally straightforward.

All the necessary measurements can be made on the following three instruments:

(a) Receiver alignment and sensitivity measurements appear to be very simply carried out on an A.M. signal generator, and the only use of an F.M. signal generator would appear to be to provide a dynamic test of the overall response of the receiver. For this purpose a two-valve adaptor unit consisting of a frequency changer, the local oscillator of which is frequency-modulated by a reactance valve, may be all that is necessary. The unit would be applied to frequency-modulate the output of the A.M. signal generator. Design of such a unit is in hand at S.E.E.

(b) A simple high-impedance D.C. voltmeter is also necessary for lining up the discriminator circuit. Such a unit may be quite simply constructed, and will require one valve.

(c) Radio-frequency measurements on the sender are carried out in the same manner as on A.M. Deviation may be measured by Crosby's method (R.C.A. Review April '40) but this method is not suited to production testing. An F.M. test-set consisting of a low-sensitivity receiver of wide band-width has been constructed at S.E.E. and found very useful. The sender is modulated at any frequency and tuned in on the test set. The following measurements may then be made.

(i) Deviation may be read off a calibrated scale.

(ii) Linearity of modulator, with or without pre-amplifier, may be measured as either frequency or input voltage is varied.

(iii) The modulated output may be aurally monitored.

(iv) Distortion may be determined by coupling an oscillograph or wave-analyser to the output terminals

5. Range trials.

Trials in the field have largely confirmed the result which had been claimed in America, F.M. giving increased range and considerable immunity from noise interference.

Direct comparisons of sets using various deviations between 5 and 75 kc/s and corresponding bandwidths were first made, using the 20-30 Mc/s band. It was found that the general results obtained with quite low deviations were very little worse than those obtained with large deviations. In these tests the receiver bandwidth (at 6 db down) was between 2 and 2.5 times the sender deviation, it having been established that this was the optimum ratio. A working range of 2-3 miles between stationary vehicles was obtained with an aerial power of 1 watt and a quarter-wave vertical aerial.
The success obtained with low deviations suggested immediately that F.M. might be directly applicable to the 2-8 Mc/s band. A sender and receiver have therefore been designed so as to work on this band. The sender deviation is + 5 kc/s and the receiver bandwidth 10 kc/s, which is approximately the value used for Army A.M. sets on this band. The sender input power was made equal to that of Wireless Sets No. 19 and strictly comparative tests of the F.M. sets have been made against Wireless Set No.19.

The results of these tests, which have proved extremely interesting, are described below.

(1) Ranges obtained.

(a) 2-8 Mc/s band.

Both F.M. and A.M. sets were mounted in vehicles using 8' rod aerials and the same aerial coupling system. On A.M. a limit range of 12-15 miles was obtained and on F.M., 16-20. These figures are based on a statistical examination of results taken on various frequencies and at various sites, and should be read in conjunction with (2) below. It would appear that the F.M. link is approximately 10 db stronger than the A.M. link, but this figure has not been directly measured.
The receiving vehicle was completely unsuppressed and on A.M. range of only 4-6 miles was obtained on the move while on F.M. ranges of 8-10 miles were obtained.

Finally it may be stated that in no case yet encountered has the A.M. link been more intelligible than the corresponding F.M. link.

The results of these trials are summarised in Table I.

(b) 20-30 Mc/s band.

While these tests were in progress, advantage was taken of the opportunity to test the fixed frequency American "Motorola" sets referred to in 4 (1) above. These sets work on 24 Mc/s and use a 7' rod aerial with an aerial power of about 25 watts. Ranges of up to 20 miles were obtained over the same country, the terrain being moderately flat. The deviation used is 15 kc/s and the sets exhibit remarkable immunity from ignition interference. Compared with the 2-8 Mc/s F.M. link, the Motorola link was slightly stronger. The country used for the tests was moderately flat, and over hilly country this result may be reversed on account of the high frequency of the Motorola sets.
The Motorola sets show a considerably greater degree of immunity from noise than the 2-8 Mc/s set.

It may be pointed out that the Motorola sets work into a greater wave resonant aerial and the input power to the last stage is 60 watts as compared with about 15 watts for the 2-8 Mc/s set.

An interesting feature of the Motorola receivers is the use of a 'squelch' circuit for eliminating the background noise when no carrier is being received. As the Motorola sets normally work into a loudspeaker this feature is very pleasant and was found in this case to be extremely useful. It is extremely doubtful whether 'squelch' would be desirable on sets working only into earphones. It must also be pointed out that a relatively complex circuit is used to produce the squelch action while some loss in sensitivity must occur unless some form of on/off switch or other control is provided.

(2) Threshold Effect.

It was mentioned earlier that on F.M. a strong carrier tends to suppress the background noise of the set. As the range is increased this noise suppression is maintained until the peak noise strength is equal to the carrier strength.
Beyond this point, called the improvement "threshold", the signal/noise ratio rapidly deteriorates. On A.M., this effect is absent, and as range is increased the signal grows progressively weaker until it is unreadable.

The existence of the improvement threshold produces two effects:

(a) If two A.M. sets are being worked at slightly less than limit range, signals will be readable but only with difficulty above the background noise. On F.M. under similar circumstances, noise will be largely suppressed and the signal far more readily readable.

(b) On F.M., ranges appear to be far more sharply defined than on A.M., and in some cases this may cause loss of contact, since although the operator may be at limit range he will still receive an apparently powerful signal. However the fact that the threshold always occurs beyond the A.M. working range largely compensates for this effect.

(3) Capture Effect.

This is the suppression of a weaker signal by a stronger one as mentioned in 5 (2) above. It is responsible for the fact when two signals on the same frequency differ by more than about 6 db only the stronger on is heard. The consequence of the capture effect have been most closely studied at recent U.S. Army manoeuvres where a large number of F.M. sets (including the Motorola sets referred to in 5 (1)) were used these were all set up on exactly the same frequency and their service ranges frequently overlapped.

A rigid operating system was used whereby each signal was repeated until acknowledged. As soon as the operating technique was mastered it was found that although frequent cases of capture occurred, no difficulty was caused, and the scheme was very highly commended.

It might be expected that the capture effect would render F.M. receivers more susceptible than A.M. to jamming or C.W. interference, but tests with both locally produced C.W. and fortuitous interference have shown that this is not so. See Table II.

(4) Multipath Transmission.

When the radiated signal passes from sender to receiver over two or more distinct paths (e.g. by ground-wave and by sky-wave) distortion may occur. Tests in America have shown that on F.M. this distortion is more frequent and more severe than on A.M.
Very few listening tests have however been made, although preliminary narrow-band observations have recently been carried out at S.E.E., on a frequency of 5.5 Mc/s and with a deviation of +- 5 kc/s. The range was 30 miles, and it appeared from previous tests that multipath transmission was to be expected. The distortion was not appreciable on speech, although fading did occur and with tone modulation some distortion was visible on a oscillograph.
These tests were however not extensive and it may be that under different conditions severe distortion will be obtained. According to American information phase modulation gives practically no more distortion than A.M. This is reasonable since the sideband spectrum of a phase modulated wave is not radically different from that of an A.M. wave. Further knowledge on the subject of multipath transmission is very desirable, and it is hoped to continue the tests shortly.

5. Range trials. (Cont.)

(5) M.C.W. Reception.

It has been shown that F.M. increases the useful R.T. range to the point were the signal becomes lost in noise. The M.C.W. range is therefore likely to be little greater than on R.T., although some advantage may be obtained from a tuned audio filter. Tests on M.C.W. by F.M. are now proceeding.

(6) F.M. and A.M. working

Although it was found possible to receive F.M. on A.M. receivers and sometimes vice-versa, this entails difficulties in operation and a loss in efficiency. The full advantages of F.M. will only be realised if both F.M. senders and F.M. receivers are used. Hence if a changeover to F.M. is contemplated it will be desirable to have during the change-over periods sets capable of either F.M. or A.M. working. Further information on the reception of F.M. by A.M. receivers is very desirable.

(7) Operation.

On F.M. inaccurate tuning causes distortion and reduces the signal/noise ratio if noise is present. An accurate netting system is therefore necessary. Methods of netting on F.M. differ slightly from those used on A.M., but have not yet been fully investigated.

6. The Trade Position.

The trade are designing various 5 watt, 25 watt and 350 watt sets. From two to six of each set will be built. The first two of the 5 watt sets have recently arrived at S.E.E. for test. The reminder are expected during the next six months.

(a) E.K. Cole Ltd., and Pye Radio are both independently considering the design of a set to be interchangeable with the present Wireless Set No. 19 and to provide similar facilities with alternate narrow-band F.M. and A.M. working on 2-8 Mc/s.

(b) Mullard Valve Company have already produced two sets with an aerial power of 5 watts on the 20-30 Mc/s band and a deviation of +- 40 kc/s. These sets are transceivers, the sender oscillator being controlled from the receiver oscillator by means of an A.F.C. circuit. The sets fit no immediate Military requirement but will be of considerable technical interest. Two more sets are being produced.

(c) G.E.C. Ltd., are developing two 25 watt and two 350 watt sets. This 350 watt set is primarily intended for use in A.C.V.'s for long range R.T. working. Narrow band F.M. and alternative phase modulation will be provided. Carrier exaltation circuits in the receiver may be tried with a view to combating selective fading. The frequency bands will be 20-30 Mc/s for the 25 watt and 2-12 Mc/s for the 350 watt sets.

(d) Murphy Radio are designing a 5 Watt set covering the frequency bands 2-8 Mc/s and 20-30 Mc/s with narrow-band F.M. and A.M. on all bands. This set will give similar facilities to Wireless Set No. 22 now under development and will be interchangeable with it.

(e) E.M.I. Ltd. are designing a 25 watt F.M. set to work on 20-30 Mc/s. This set is largely investigational and incorporates several experimental features. These include variable deviation, +- 5, 10 and 25 kc/s, crystal or controlled self-oscillator operation, push button tuning with six preset frequencies and adjustable squelch control (this feature silences the receiver background noise when no carrier is being received).

(f) S.T. and C. Ltd., have submitted proposals, but as requirements have changed they have been asked to consider an alternative scheme.

7. Conclusions.

An investigation of the applicability of F.M. to Army R.T. communications has led to the following conclusions:

(1) F.M. shows the following advantages:
(a) For a given power an increase of about 25% in range is obtained.
(b) F.M. offers considerable immunity from interference, especially vehicle or impulse noise. The problem of vehicle interference suppression is therefore very considerably reduced by the use of F.M.

(2) These advantages are maintained even with deviations as low as +- 5 kc/s. Thus it is possible to use practically the same channel-width on F.M. as on A.M.

(3) The circuit necessary to produce and receive F.M. offer no difficulties.

(4) Maintenance is straightforward and very little auxiliary apparatus is necessary.

(5) The advantages given by F.M. are largely restricted to R.T. Operation.

(6) The advantages have only been verified for ground-wave working. If on any set considerable sky-wave working is likely it may be desirable to design the set to work on both frequency modulation and phase modulation.

(7) For pack sets or other low-power equipment, although the saving in battery power and freedom from noise will still be obtained, the increased receiver complexity may make the overall size of the set greater than on A.M. This increase in size and weight may outweigh the advantage to be gained in battery consumption.

(8) On F.M., inaccurate tuning causes distortion. This, taken with the increased susceptibility to drift of the sender, implies that an accurate netting system is essential.

(9) While A.M. receivers will receive F.M. signals, the noise suppression effects are lost and the received signal may be distorted. It will in general not be possible to receive A.M. on an F.M. receiver. However if narrow-band F.M. is used it will be possible to provide alternative A.M. and F.M. reception with little extra complication.

(10) It thus appears that F.M. is particularly suitable as a means of providing R.T. communication between vehicles, since both the interference from the vehicle and also that from outside sources are largely suppressed.

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- Photographs and documents courtesy Royal Signals Museum, Blandford Forum, UK.
- Royal Signals Museum website: http://www.royalsignalsmuseum.co.uk
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TABLE I.

Signal strengths obtained with Wireless Set No.19 and F.M. set of equal input power under identical conditions and with no external interference.

NOTE: The R strengths given are estimated values, averaged in some cases over many observations. They illustrate the noise-suppression features of F.M. referred to in 5 (2) above.

Mileage	Frequency	Received A.M. signal	Received F.M. Signal		
			R Strength		
8 ½	5,5	Readable with slight difficulty	R6	R8-9	100% readable
11 ½	5,5	100% readable	R7	R8-9	100% readable
11 ½	3,5	100% readable	R7	R9	100% readable
13 ½	3,5	100% readable	R8	R9	100% readable
14	3,5	100% readable	R7	R9	100% readable
15	3,5	25% readable	R4	R9	100% readable
16 ¼	3,5	25% readable	R3	R7-9	100% readable
17	5,5	Unreadable	R2	R7	100% readable
18 ¼	3,5	25% readable	R2	R6	100% readable
18 ½	3,5	Unreadable	R2	R8	100% readable
19 ½	3,5	No signals	Nil	Nil	No signals
20	3,5	No signals	Nil	R1	Unreadable
20 ¼	3,5	Unreadable	R1	R5	100% readable

TABLE II.

Effect of interference on A.M. and on F.M.

NOTE: The wanted signal was transmitted either on Wireless Set No.19 or on the equivalent F.M. sender, both sets using the same input power and having been netted to the same frequency.

Mileage	Frequency	Interference	Received A.M. signal	Received F.M. Signal
8 ½	5,5	CW	Unreadable	Just readable
11 ½	3,5	CW	Readable	Readable
11 ½	5,5	CW	20% readable	100% readable
13 ½	5,5	Strong CW	No signal	Signal present but unreadable
13 ½	5,4	CW	25% readable	100% readable
14	4,5	CW	Readable with difficulty	100% readable
14	5,5	CW	Unreadable	100% readable
15 ½	4	Strong CW	Unreadable	Unreadable
16	3,5	CW	Unreadable	100% readable
16 ½	4	Strong carrier	Unreadable	Unreadable
17	6	Strong RT	No signal	No signals

APPENDIX 1

Function of the SEE/SRDE organisation till its move to Malvern.

(Partly retrieved from: *SRDE, Function and Organisation*, written in 1963.)

The Signals Research and Development Establishment (SRDE) had its origin in the Wireless Telegraphy Experimental Station, which was formed at ALDERSHOT by the Royal Engineers in 1903 following the invention of wireless telegraphy at the turn of the century. This Section, which was quite small at the time, was was transferred to WOOLWICH DOCKYARD and linked with the Inspectorate of RE Stores in the early days of the first World War and then, in 1916, became the Signals Experimental Establishment (SEE) located on WOOLWICH COMMON not far from the Royal Military Academy.
It was a War Office Establishment whose basic objectives and responsibilities were not very different from those of SRDE at the present time, except that it included sections dealing with gun sound ranging and sound location of aircraft. These sections moved away in the early 1920's to the Air Defence Experimental Establishment at BIGGIN HILL, leaving SEE to look after the needs of the newly formed Royal Corps of Signals.

Army Wireless Telegraphy had made enormous strides by the end of the 1914-1918 War, but it was handled by a relatively small number of skilled specialists numbering not more than about 2000 for the whole British Army. In contrast, the Royal Corps of Signals numbered 150,000 in the Second World War, and these were supported by a large number of REME personnel.

By the outbreak of the last war, the Establishment in common with all research and Development activities was transferred from the War Office to the Ministry of Supply and was renamed the Signals Research and Development Establishment. After a partial evacuation to HORSHAM in 1941/42 it was moved to its present location in CHRISTCHURCH in 1943. In 1959 this Establishment was transferred to the Ministry of Aviation, on the close down of the Ministry of Supply.

The principal tasks of the Establishment are research in the field of communications, and the development of ground communications requirements required by the Army and RAF. The Establishment is however also conducting research and development in certain other fields of which the most important are satellite communications, quantum electronics and visual aids.

S.R.D.E was moved to Malvern in 1980 and lost its identity when it was amalgamated with (RRE) Royal Radar Establishment and (SERL) Services Electronics Research Laboratories to form (RSRE) Royal Signals and Radar Establishment. In April 1991 RSRE amalgamated with other defence research establishments to form the Defence Research Agency, which in April 1995 amalgamated with more organisations to form the Defence Evaluation and Research Agency. In June 2001 this became independent of the MoD, with approximately two-thirds of it being incorporated into QinetiQ, a commercial company owned by the MoD, and the remainder into the fully government-owned laboratory DSTL

APPENDIX 2 Wireless Set No. X32D



Wireless Set No. X32D

Country of origin: England

DATA SUMMAY

Organisation: British Army.

Design/Manufacturer: SRDE/Pye Radio

Year of Introduction: 1942.

Purpose: Experimental set to obtain comparisons between AM and FM communication.

Receiver:

Circuit features: RF, mixer/LO, 2xIF, limiter IF for FM, discriminator, detector, BFO, AF.

Frequency Coverage: 2-8MHz in two ranges: 2-4MHz and 4-8MHz. CW, FM and AM voice.

Intermediate frequency: 460kHz.

Transmitter:

Circuit features: Master oscillator, FM modulator, driver, limiter, RF PA.

Frequency coverage: 2-8MHz in two ranges: 2-4MHz and 4-8MHz. CW, FM and AM voice.

RF output: 10W CW/FM.

FM maximum deviation: ±5kHz.

Aerial: Standard No. 22 Set rods and wire aerials.

Power Supply: (No. 19 Set) Power Supply Unit No. 1 Mk.III.

Weight: 16½ kg. (Set only)

Sizes (cm): Height: 20, length 43, width 30. (Set only)

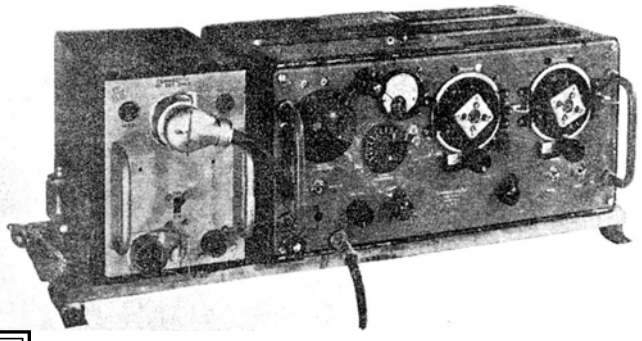
Remarks

Wireless Set No. X32D was an experimental set to obtain comparisons between AM and FM, carried out by the Signals Experimental Establishment. It was produced in a very small quantity and not intended to be issued for operational use.

The set comprised a combined transmitter/receiver and a No. 19 Set power supply unit. Based on Wireless Set No. 22, having the same dimensions and general appearance, it had standard 6.3 Volt type valves opposed to the 2 Volt valves in the original set.

The No. X32D could operate on AM, FM and CW.

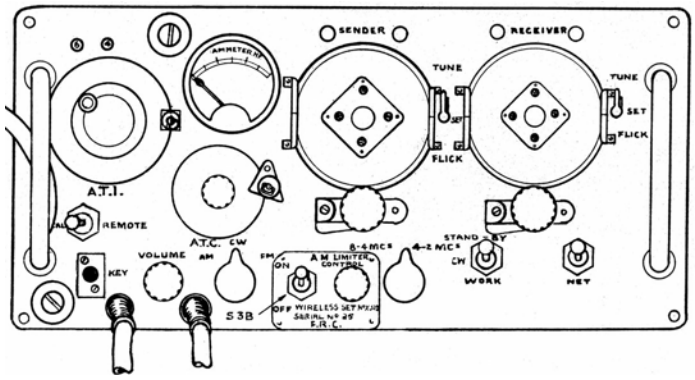
Two versions of the WS No. X32D were produced, with and without an AM noise limiter.

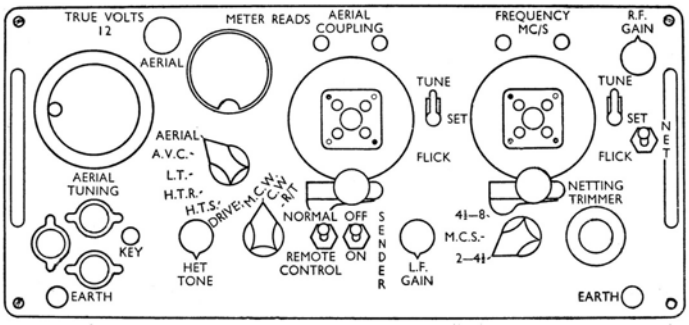


An early version of Wireless Set No. X32D without a later added AM noise limiter.

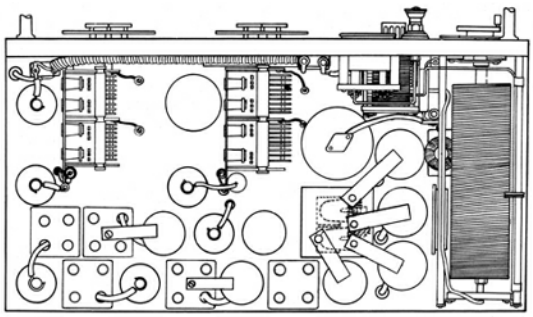
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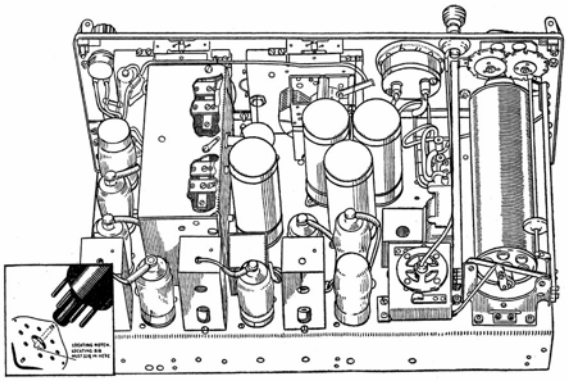
- Wireless for the Warrior, Volume 1, Wireless Sets 1 to 88, Louis Meulstee, ISBN 1898805 08 3, 1995.
- EMER's Tels F 370/1, Dec. 1944.
- SRDE Handbook No. 445, Wireless Set No. X32D, Nov. 1943.
- SRDE Handbook No. 574B, Wireless Set No. X32D, Provisional Working Instructions, May 1945.
- SRDE Handbook No. 575A, Wireless Set No. X32D, General description and maintenance, June 1945.



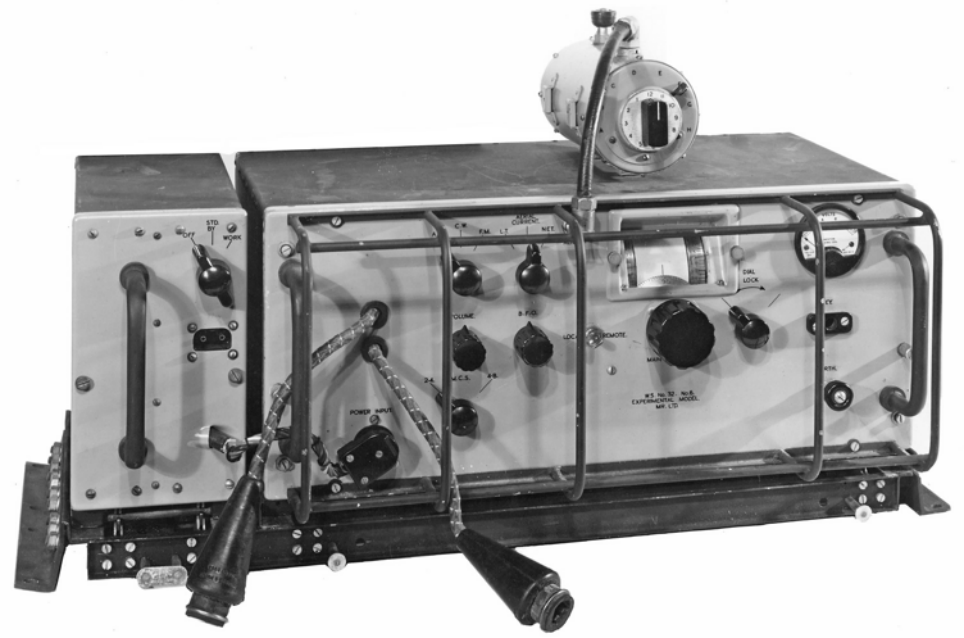


Front panel view of Wireless Set No. X32D (above) and Wireless Set No. 22 (below).
Major differences to the No. 22 Set (apart from the FM feature) were separate tuning dials of transmitter and receiver, and a third dial for the aerial coupling capacitor. The valves were all 6.3V types and the RF power amplifier an ATS25, which lead to a much higher RF output. The No. X32D Set with associated No. 19 Set Power Unit No. 1 Mk.III, had the same overall dimensions as a standard No. 19 Set.

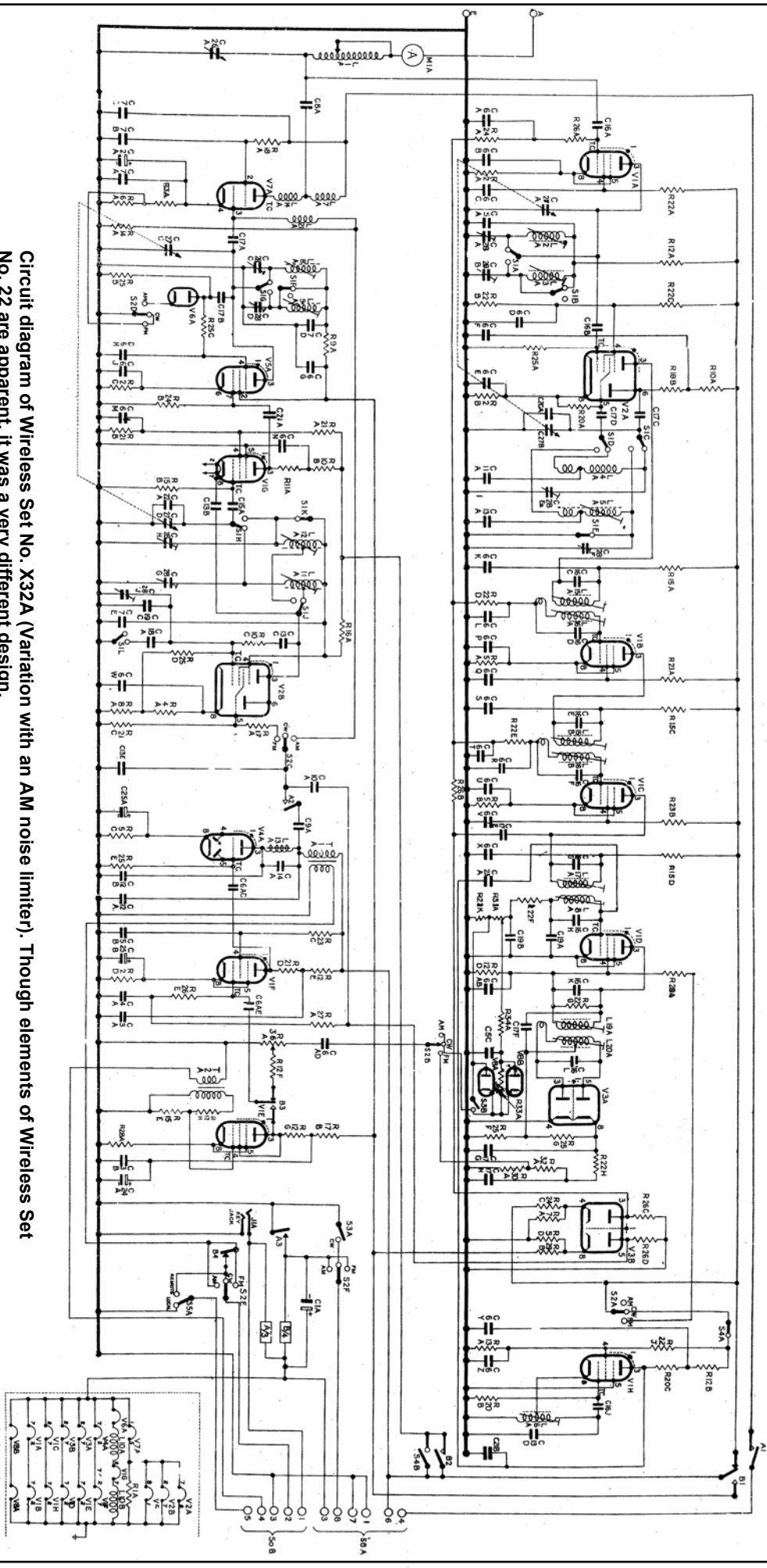




Top of chassis view Wireless Set No. 32D (left) and No. 22 (right).



Wireless Set No. 32 Experimental Model was developed by Murphy Radio. It had a number of elements of Wireless Set No. 21.
It is not known if this set was used during later investigations in the comparison of AM and FM.



Circuit diagram of Wireless Set No. X32A (Variation with an AM noise limiter). Though elements of Wireless Set No. 22 are apparent, it was a very different design.
SO A was the 12-pt connector to the Power Supply Unit No. 1 Mk.III; SO B were the two drop leads for connecting standard No. 19/22 Microphone and Receivers, Headgear Assembly, No. 1.

WIRELESS SET NO. 32D

DATA SUMMARY

PURPOSE

This set has been produced for experimental purposes, to obtain comparisons between A.M. and F.M. communication. It is not available for issue for operational purposes.

DESCRIPTION

The normal receiver stages used are: R.F., mixer, I.F., detector, A.F. and beat oscillator, and output. For F.M. reception the detector becomes a limiter for the I.F. signals feeding a Forster-Seeley type discriminator. The sender employs a master oscillator, power amplifier, two microphone amplifier stages and modulator. For F.M. a control valve is added. The set is housed in a steel case and employs a Wireless Set No. 19 Power supply unit No. 1, Mk. III. There is no send/receive switch, the change-over being made by the microphone pressel switch or morse key.

PHYSICAL DATA

Weight: 76 lb. (sender/receiver, P.S.U. mounted on chassis)
Length: 27 in.
Width: 12 in.
Height: 9½ in.

AERIAL SYSTEM

(*a*) 12 ft. rod aerial for mobile use.
(*b*) Up to 34 ft. rod aerial for ground use.
(*c*) 140 ft. wire aerial for ground use.

FREQUENCY

Coverage: 8-2Mc/s in two bands:—8-4Mc/s, 4-2Mc/s.
Internal: 460Mc/s.

PERFORMANCE

Sender output: 10W (approx.) on C.W. or F.M. R./T.
Receiver sensitivity: (A.M.) 6-7μV for 10mW output and signal noise ratio 20db.
(F.M.) 2-3μV for 20db. quieting.
Receiver selectivity: 60db. attenuation ± 16kc/s.

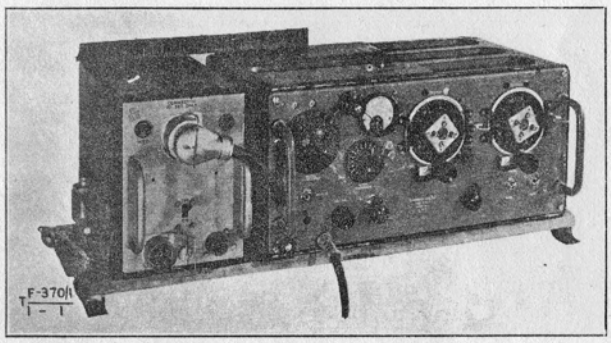


Fig. 1—General view of equipment

Distribution—Special

POWER REQUIREMENTS AND CONSUMPTION

Power supply: 12V accumulator.
Power consumption from 12V accumulator: Standby, 2.0A L.T., Receive, 3.5A L.T., send, 5.5A L.T.

ADDITIONAL FACILITIES

Remote control operation can be carried out by means of Remote control units F, Nos. 1 and 2. Similarly the set may be connected to an exchange and used on R/T from subscribers' telephones.

VALVES

Circuit reference	*Type*	*Receiver*		*Sender*	
		A.M.	*F.M.*	*A.M.*	*F.M.*
V1A	ARP34	Radio freq.	Radio freq.	—	—
V2A	ARTH2	Mixer	Mixer	—	—
V1B	ARP34	1st I.F.	1st I.F.	—	—
V1C	ARP34	2nd I.F.	2nd I.F.	—	—
V3B	ARDD5	A.V.C.	A.V.C.	A.M.C.	A.M.C.
V1H	ARP34	Beat oscillator	—	—	—
V1D	ARP34	Detector	I.F. limiter	—	—
V3A	ARDD5	—	Discriminator	—	—
V1F	ARP34	1st A.F.	1st A.F.	2nd A.F.	2nd A.F.
V4A	AR21	Output	Output	Grid modulator	3rd A.F.
V1E	ARP34	—	—	1st A.F.	1st A.F.
V2B	ARTH2	—	—	—	Control
V1G	ARP34	—	—	Master oscillator	Master oscillator
V5A	ARP35	—	—	Buffer	Buffer
V6A	ARD2	—	—	Drive limiter	—
V7A	ATS25	—	—	P.A.	P.A.

END

Epilogue.

History has shown that (VHF) FM is superior for short range Army communication, which was stated in Chapter 7 of this S.E.E. Report. At the time of compiling this Pamphlet no other reports and minutes of War Office meetings on the use of FM during WW2 could be traced or were available.

Signal Communications, a book in one of a series of volumes, compiled by authority of the Army Council to preserve the experience gained during the Second World War stated:

'Frequency Modulation'
The United States Army had pinned its faith largely on telephones, but as a result of the British Army's experience wireless was developed rapidly, using a new technique, known as 'frequency modulation', for some of the sets used in forward units. In the ordinary type of R/T set, the voice modulated transmitted signal, operating on one frequency, but with a frequency modulated set a narrow band was used instead of a single frequency and modulation was obtained by actually changing the frequency. This had the effect of reducing a great deal of the background noise, which was such an irritating feature of wireless communication, and bringing up the wanted signal much more clearly. Technically the system offered very considerable advantages but there were two main difficulties which prevented it from being introduced into the British Army on any considerable scale while the War was actually in progress:-

a) the increased number of frequencies required
b) the impossibility of changing over any large number of sets at one time. A set designed for amplitude modulation could not work to one designed for frequency modulation and the available manufacturing capacity was not sufficient to permit of a wholesale and instantaneous change.

In *Wireless for the Warrior,* Volume 2, WS 88, page 5, we can read:

In 1944 much congestion of frequencies in the 2-10MHz band was experienced, especially in NW Europe where troop density was such that '..it is rarely possible to find interference-free channels for sets in the 18 and 38 class and almost impossible for the host of 19 and 22 Sets…' (D Signals Liaison Notes, No. 19, Jan. 1945). Looking at the success of the USA Signal Corps VHF FM sets types SCR-508, SCR-509 and SCR-300, it became clear that the employment of VHF FM would provide the answer to this problem.
Future General Staff policy decided to introduce VHF FM and specifications were drawn up for designs of several models including a replacement for Company/Platoon Wireless Set No. 38. The new set, on which development had already been commenced, was designated Wireless Set No. X88. Two models were initially developed: No. X88A and No. X88B. The latter was supported by the War Office as it was felt that: '…the electrical performance of the X88A might be too inconsistent for field use and … the set is not capable of working to Wireless Set No. 31 (D Signals Liaison Notes, No. 25, July 1945)

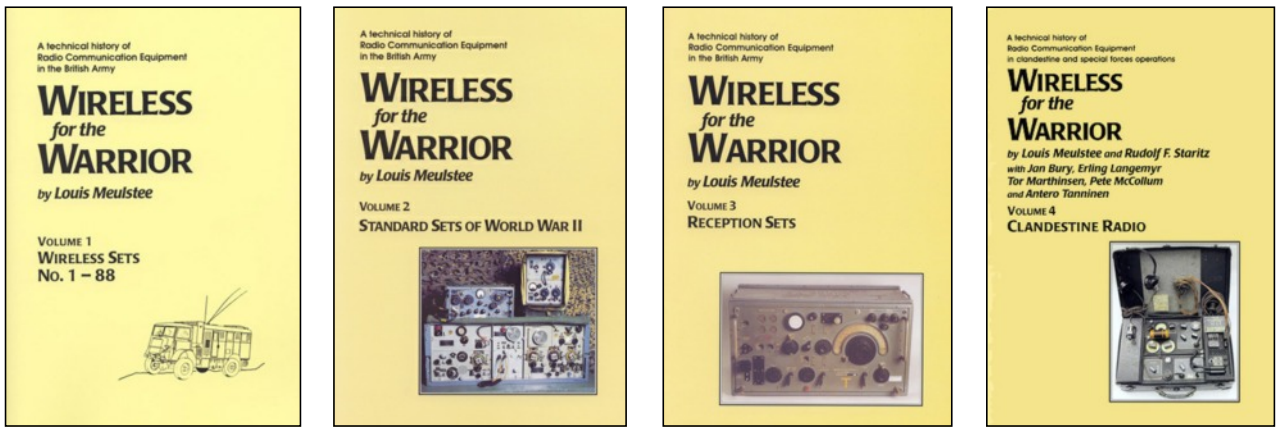
In the same Volume 2 of *Wireless for the Warrior*, in the Historical Development chapter of Wireless Set No. 31, it was reported that: '…in late 1944, in consideration of … the outstanding success of the USA SCR-300-A at Battalion / Company level communication … it is proposed to manufacture a set in this country as nearly as possible identical with the SCR-300-A…'. (D Signals Liaison Notes). In April 1946 the nomenclature of this set was decided, being known as Wireless Set No. 31 and it was thought of as the ultimate replacement of Wireless Sets Nos. 18, 68 and 46.

Earlier designed HF sets with FM capabilities were Reception Set R209 (1943 development had started) and Wireless Set No. 42 (start of development 1943/44) but eventually abandoned in 1946.

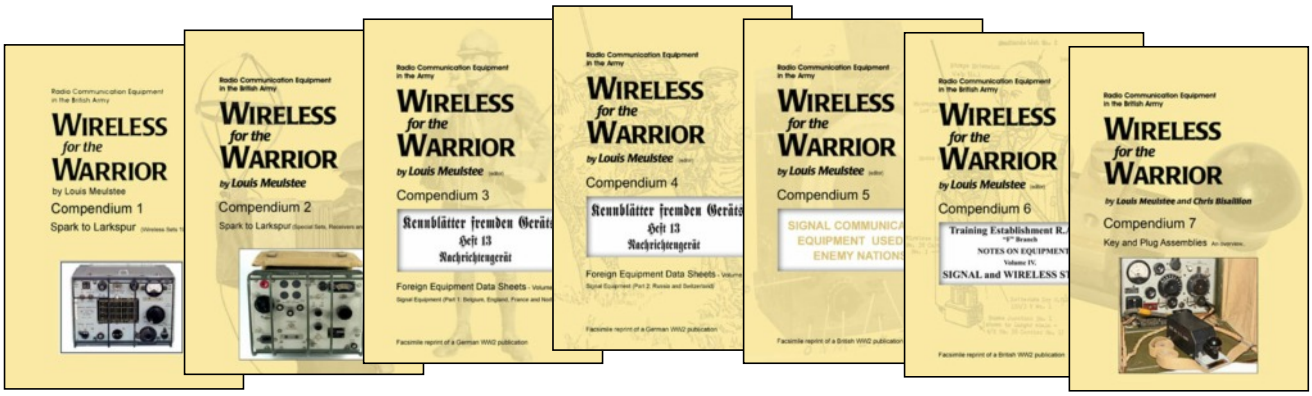
Notes.

About the Wireless for the Warrior books.

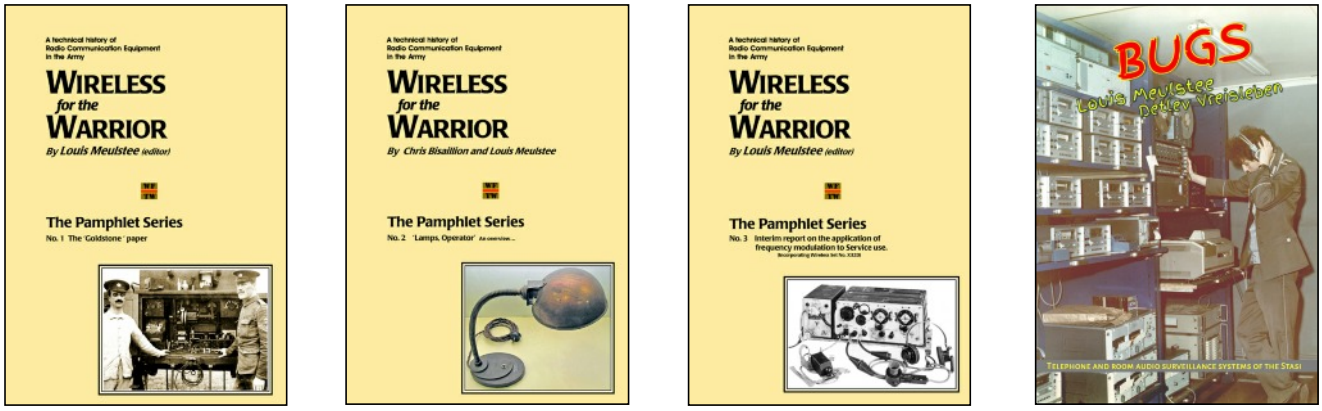
The Wireless for the Warrior range of books (comprising the **Volume** and **Compendium** series) are intended as a source of reference to the history and development of radio communication equipment used by the British Army from the very early days of wireless up to the 1960s. Line equipment and military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



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



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



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WftW **'BUGS'** is the newest book describing the technical history of telephone and room surveillance systems of the Stasi.