CHAPTER 4.

INTERFERENCE.

1. Unless proper precautions are taken a V.H/F transmitter is likely to cause strong interference with a receiver at the same station.

2. Frequency Separation. The first method of avoiding interference is to use for the transmitters, frequencies which are well separated from those of the receivers at the same station. The receivers used on V.H/F usually have a bandwidth of about 100 kc/s. that is the receivers will respond to signals whose frequencies extend over this range. Since a transmitter at the same station will produce a field-strength in the neighbourhood far exceeding that from the distant station with which communication is desired, it is necessary to separate the frequencies by more than 100 kc/s. Even this separation will often not be enough, since a very strong signal will break through the R/F stages of the receiver, even if its frequency is well outside the range which the receiver is designed to accept. A frequency separation of 3 Mc/s is sufficient in normal conditions to prevent this, the other precautions being observed. A smaller separation may often be tolerated.

3. Frequency Progression. Even when there is good separation of frequencies, interference may occur if the frequencies are in a regular progression. For example, two transmitters on 85 Mc/s and 90 Mc/s can interfere with a receiver on 95 Mc/s. This is because the transmitter produces an appreciable amount of second harmonic. Thus the 90 Mc/s transmitter radiates at 180 Mc/s. The combination of 180 Mc/s and 85 Mc/s, if sufficiently strong, may be rectified in the R.F. circuit of the 95 Mc/s, producing the difference frequency of 95 Mc/s, which is just that of the receiver.

4. It may be possible to cut down the strength at the receiver of the 85 Mc/s and 180 Mc/s signals sufficiently to prevent this effect; but it is advisable to choose frequencies so that it does not occur at all.

5. Crystal Harmonics. Most V.H/F transmitters and receivers are crystal controlled. The frequency of the transmitter and of the local oscillator of the receiver are then harmonics of the controlling crystal frequencies. Besides these wanted harmonics, the sets generate other crystal harmonics also. If two harmonics, in a transmitter and receiver respectively, differ by the intermediate frequency of the receiver, interference may result. It is only possible to avoid this effect completely by working out a full schedule of crystal harmonic frequencies and probable causes of trouble. Sets which may interfere in this way should be separated so far as possible; if it is necessary to bring them together a look-out should be kept and filters (as described below) should be fitted when interference is found.

6. Screening. Proper fitting up of the V.H/F, equipment at a station is of the greatest value for reducing interference. It is often found that there is a great deal of interference between different links at a station when a lash-up job is made, but that there is none detectable as soon as everything is made ship-shape. The main reason for this is the screening of the sets from one another. Each set is contained in a metal case, and the V.H/F power is fed in or out through a coaxial feeder. The feeder is connected to the set by a suitable plug, the outer conductor of which makes good contact all round with the case of the set and with the outer of the feeder. As explained above, when the aerial balancing is properly done the outside of the feeder is dead. The V.H/F power can get in or out of the sets only through the aerials themselves. If the outer conductor of the feeder or of the plug is broken so as to expose the inner, radiation enters or leaves there. When a transmitter and

receiver are close together, the amount of interference from this cause is considerable.

7. Aerials. The proper placing of aerials has great effect in reducing interference. The sort of layout described in Chapter 3 para. 42 is best for this. Two directional aerials facing outwards in opposite directions feed only a minute fraction of the power from one to the other. With ARS arrays this is 50 dB down on what is fed from one to the other when they are facing towards one another. A horizontal ARS feeds even less power out at right angles to the forward direction. Hence two horizontal arrays can be fairly close together side by side, say about 30-ft apart, without much interference. The same distance should be kept between rhombics. Two vertical arrays should be separated by 75 ft. or so.

8. Choice of polarisation is also used to reduce interference. A vertical aerial picks up very little from a horizontal array, and vice versa. It is useful, therefore, where a receiving and transmitting aerial must be side by side, to arrange that one is vertical and the other horizontal. Where there is a considerable number of transmitting and receiving aerials, good results can be obtained by making all transmitting aerials of one polarisation and all receiving aerials of the other.

9. These precautions are not effective unless the aerials are properly balanced and sited. If there is an obstruction forward of a transmitting aerial power is reflected back from it and is picked up behind the aerial. Similarly, a receiving aerial picks up from an obstruction in front, power which has come from behind and been reflected back. If a horizontal aerial is not properly balanced, it radiates some power with vertical polarisation, which is picked up then by vertical aerials.

10. Filters. If it is impossible to achieve the conditions described above, or if, when they are achieved, there is still interference, filters are used to cut it out. They are plugged in between the feeder and the receiver.

11. Two types of filter are available. Rejecting filters are designed to cut out interference at one particular frequency. Filters of this type are designed by Messrs. G.E.C. to give an attenuation of 30 dB at the unwanted frequency. The insertion loss, that is, the drop in power at the wanted frequency, is 2 - 3 dB. The separation between the wanted and unwanted frequency may be no more 250 kc/s.

12. Accepting filters cut out all frequencies other than the wanted frequency. A filter of this type is designed by A.S.E. It has an insertion loss of 2-3 dB., and an attenuation of 20 dB at all frequencies separated by more than 2 Mc/s from the wanted frequency.

13. If the source of interference is known and a suitable rejector is available, this should be fitted, and tuned to cut out the interfering signal. To cut out interference from several sources at different frequencies, an acceptor is preferable, and is tuned to give best reception at the wanted frequency.

14. It is particularly important that the connection between the filter and receiver should be a screened cable matched into the set, and that the plugs at both ends should be correctly fitted. The filter cannot eliminate interference which is picked up between the set and itself.

CHAPTER 5.

TYPES OF V.H/F STATIONS.

No attempt is made in this book to describe particular Transmitters or Receivers, for which reference should be made to the relative handbooks.

2. A communication system might consist of one or more of the types of station shown in para. 3.

3. There are five different types of station in the system:-

(a) Station YY (Jeep or similar vehicle).
(b) Handcart.
(c) Central Receiving Room (C.R.R.).
(d) Transmitter Van (TxV).
(e) Station Z.

In addition, Teleprinter equipment is available for working over any link.

4. Station YY is a highly mobile station consisting of a Jeep, or similar vehicle, with trailer. Its purpose is to act as an intermediary between one station a long distance off, and another at a short distance. The best possible site is needed for the long-distance link. The jeep is used to carry the apparatus to a site which may be inaccessible to an ordinary vehicle.

5. The part of the equipment of the jeep which is concerned with V.H.F. consists of:-

(i) 1 30-watt transmitter Type 683 with moving-coil microphone.
(ii) 1 7-watt transmitter Type 681 with carbon microphone.
(iii) 2 Receiver Units, CDJ.
(iv) 1 Radio Linking Unit (R.L.U.).
(v) 2 Matching Transformer Units.
(vi) 2 field telephones.
(vii) 2 telephone head-sets, one wired with a plug to each earphone.
(viii) 1 prismatic compass.
(ix) 2 rhombic aerials type ARV with masts, guys and halyards.
(x) 2 dipole aerials with masts and guys.
(xi) 1 petrol generator.
(xii) Mains lead and telephone wire.
(xiii) Spares and tools.
Items (ix) to (xiii) are carried on the trailer.

6. The 30-watt transmitter and associated receiver are used with rhombic aerials for working with the long-distance station. The 7-watt transmitter and associated receiver are used with dipole aerials for the short link. The radio linking unit (see Chapter 8) is used to transfer to the 30-watt transmitter the signal received on the short-distance receiver, and that received on the long-distance receiver to the 7-watt transmitter. In this way the station acts as an automatic relaying station. Also the radio linking unit allows the conversation to be transferred to a field telephone which can be used for monitoring or giving instructions. The conversation can also be monitored by the telephone head sets.
The Matching Transformer Units convert the input impedances of the Transmitters to 600 ohms for matching into a line or into the R.L.U.

7. Handcart. The handcart station is a mobile unit capable only of working over short distances. It consists of two handcarts which can be carried in a van and then wheeled out to any suitable site. A handcart station may work from the neighbourhood of the CRR, to which it is connected by land line, either to the jeep or to another handcart.

8. The V.H/F equipment consists of:-

(i) One 7-watt transmitter Type 681.
(ii) One Receiver Unit CDJ (capable of being converted to Battery operation).
(iii) Two dipole aerials with masts and guys.
(iv) One Radio Linking Unit.
(v) One field telephone.
(vi) Two telephone head-sets, one wired with a plug to each earpiece.
(vii) One transformer unit in the centre compartment.
(viii) One Power Supply Unit DWC carried in separate handcart.
(ix) Telephone wire and mains lead.
(x) Spares and tools.

The functions of the main items are the same as for the jeep. The transformer unit in the centre compartment provides a microphone jack and terminals for connecting telephone wires to the input of the transmitter and output of the receiver. The microphone jack in the transmitter itself is disconnected.

9. For power supplies, mains, if available, or the battery generators can be used. The change over from one to the other can be completed in thirty minutes.

10. CRR.

The CRR acts as the local mobile headquarters station. It is connected to main headquarters by land lines or V.H/F links. Its chief purpose is to receive medium and high-frequency signals and to operate by remote keying high frequency transmitters in another van. For this purpose the station consists of two CRR's connected together by land line. These are linked by V.H/F with two transmitter vans which are also connected together by land line.

11. Of the two CRR's one contains:-

(i) One V.H/F transmitter Type 681 for R/T
(ii) One V.H/F receiver for R/T., on the same frequency as the transmitter (i).
(iii) One aerial changeover relay.
(iv) One V.H/F transmitter Type 681 for remote keying.
(v) One 3-channel V/F transmitter unit for remote keying.
(vi) Two dipole aerials with masts and guys.

The other CRR contains:-

(vii) One V.H/F transmitter Type 681 for remote keying.
(viii) One single-channel note-modulator for remote keying.
(ix) One dipole aerial with mast and guys.

12. Items (i) and (ii) are used for simplex R/T communication with the transmitter vans. The aerial changeover relay, allows a single aerial to be used for transmission and reception. The 3-channel V/F transmitter provides three keying notes which modulate the V.H/F transmitter and are used to key three of the H.F. transmitters in the Transmitter-Vans. The single channel note modulator provides the fourth channel for keying the fourth transmitter. Item (vii) has been modified by bringing out leads to provide supplies for the note-modulator.

13. Transmitter Vans.

This station consists of two vans connected by land-line. Each contains two H/F transmitters (T1190) which are keyed from the CRR's. In addition one of the two vans contains:-

(i) One V.H/F transmitter Type 681 for R/T.
(ii) One V.H/F receiver for R/T., on the same frequency as Transmitter (1).
(iii) One Aerial Changeover Relay.
(iv) One V.H/F receiver for remote keying.
(v) One 3 channel V/F receiver unit for remote keying.
(vi) Two dipole aerials with masts and guys.

The other van contains :-
(vii) One V.H/F Receiver for remote keying.
(viii) One single channel note-detector for remote keying.
(ix) One dipole aerial with masts and guys.

14. Items (i), (ii) and (iii) form the R/T simplex link to the CRRs. Items (iv) and (v) receive and separate the three notes sent from the first CRR. Two of these are used to key the two H/F transmitters in the same van, and the third is sent by land line to the other Tx Van and keys one of the H/F transmitters in that van. Items (vii) and (viii) receive the note sent by the single channel keying system in the second CRR and so key the fourth H/F transmitter.

15. If required the remote keying can be carried out over land line instead of cover V.H/F link. A switching system is provided to change over from one to the other.

16. Station Z.

This station is the opposite end of the long-distance link from Station YY. Its equipment consists of :

(i) 1 30 watt transmitter Type 683 with moving-coil microphone.
(ii) 1 Receiver Unit CDJ.
(iii) 1 Radio Linking Unit.
(iv) 2 telephone head sets, one wired with a plug to each earphone.
(v) 1 prismatic compass.
(vi) 1 rhombic aerial, type ARV, with masts, guys and halyards.
(vii) 1 petrol generator.
(viii) Mains lead and telephone wire.
(ix) Spares and tools.

The whole station is duplicated to provide alternative operation to another station similar to station YY.

17. Teleprinter Equipment.

This equipment can be used over any V.H/F link or over land line. It provides two-way speech and teleprinter operation between two stations over a single link. The equipment at each station is identical and comprises the following units :-

(i) Teleprinter Unit.
(ii) S plus D unit.
(iii) Attenuator pad.
(iv) Field telephone.
(v) Signalling unit.
(vi) Filter unit.
(vii) Hybrid unit with double-pole double-throw switch from land line to radio.
(viii) Rectifier Unit.
(ix) 4 in No. 6V Storage Batteries.

18. The transformer unit connects to the V.H/F transmitter and receiver. It is unnecessary when the equipment is used with a hand-cart or jeep station, where a radio-linking unit is provided. The switch can also be omitted in this case.

CHAPTER 6.

REMOTE KEYING OVER V.H/F LINKS.

1. V.H/F links can be used to key H/F transmitters from a remote station. The technique is essentially the same as with land lines, and either one or several channels may be run over a single link.

2. Single-Channel V/F Keying.

The apparatus for a single-channel keying system is shown in Fig.7. The key pressed at Station 1, operates the H/F transmitter at Station 2. The intermediate steps are as follows:-

3. At Station 1 there is a Note Modulator (N.M.) whose output is fed through a transformer (Tf) and blocking condenser (B.C.) into the microphone jack of the V.H/F transmitter.

4. The Note Modulator is a Voice-Frequency (V/F) oscillator, which is kept in oscillator throughout the time the circuit is running. Its output is adjusted by a resistance pad, and by the transformer, to the right level to modulate the V.H/F transmitter to a suitable depth, something not far short of 100%. The blocking condenser keeps the energising voltage in the transmitter microphone circuit out of the transformer secondary, and also out of the key, which is placed across the transformer secondary.

5. The rocker and forward contacts of the key are used. In this way, when the key is not pressed (on "space") the V.H/F transmitter is modulated by the note. When the key is pressed (on "mark") the modulation is shorted out. The resistance pad in the note modulator is so chosen that when the transformer secondary is shorted the oscillator is still working into a high-resistance load, and so it is not thrown out of oscillation. This enables a higher speed of keying to be used than would otherwise be possible.

6. At Station 2 the audio output of the V.H/F receiver, taken across the loud-speaker terminals, is fed into a Note Detector (N.D.) consisting of a rectifier circuit and a relay. This relay takes the place of the key of the H.F. transmitter. It must be capable of handling the energising voltage, and current in the primary of the relay of the H/F transmitter. If necessary a quenching device, consisting of a condenser-resistance combination is put into the circuit to help in this.

7. Since the V.H/F transmitter is modulated on space, a note will be received at the receiver during this time, and current will flow in the primary of the note-detector relay. The relay contacts must therefore be "break"-contacts, which areshorted when no current is flowing.

8. The arrangement by which a note is sent for space, and interrupted for mark, corresponds to the practice in line-telegraphy. It makes it easier to find faults, since a note can be heard if the system is working without the operator having to press the key.

9. Multichannel V/F Keying.

By using a number of V/F oscillators generating different notes, it is possible to key a number of H/F transmitters over a single V.H/F link.

10. The apparatus for a three-channel system is shown in Fig.8. At Station 1 there is, in each channel, as before, an oscillator and a resistance pad attenuator. Before being fed through the transformer to

the microphone jack of the V.H/F transmitter, the output from each oscillator passes through an appropriate filter. This prevents the oscillators for interfering with one another. It is feasible to construct reasonably compact filters which will separate frequencies about 200 c/s apart, but the notes are conveniently kept as far apart as possible.

11. The outputs from the oscillators are adjusted to be of equal voltage so that their sum total does not overmodulate the transmitter. To make this certain, each oscillator separately should modulate the transmitter about 30%.

12. At Station 2 the output from the V,H/F receiver is fed into a similar set of filters which separate out the received notes. Each note is then passed on to an amplifier and detector, and the output of the detectors again operate a set of relays which take the place of the H/F transmitter keys. The amount of amplification in each channel is made large enough to give positive operation of the relay, and not so large as to allow it to be operated instead by noise, interference or signals in the other channels.

13. Teleprinter S plus D Equipment

The lay-out of this equipment is shown in Fig.9. The teleprinter part of the equipment consists of the Teleprinter (T.P.) proper, the S plus D unit, and the Attenuator Unit (A.U.). The teleprinter is the mechanical system which controls the electrical signals produced in the S plus D unit for transmission, and is controlled by those received by the S plus D unit for reception. The speech part of the system consists of the Field Telephone (F.T.) and the Signalling Unit (S.U.). The two parts, speech and teleprinter, are separated and combined through the Filter Unit. The Hybrid Unit converts the two-wire output of the Filter Unit to the input of the V.H/F transmitter and the output of the V.H/F receiver.

14. The S plus D unit contains generators and detectors for two notes of 1680 c/s and 1860 c/s. In any given station one of these notes is used for transmission and one for reception and the other way round at the other station. The note used for transmission is radiated on space. Each key on the teleprinter interrupts the note in a characteristic way for a definite period of time.

15. In order to prevent interference between the teleprinter and speech sides of the communication all the frequencies from 1500 c/s to 2000 c/s are cut out of the speech by the filter unit, and this band alone is permitted by the filter unit to reach the S plus D unit for reception. The purpose of the attenuator unit in the teleprinter side is to adjust the relative level of the note signals and the speech for transmission over the two wire line or over radio.