CHAPTER 1

INTRODUCTION

1. GENERAL

Up to the present time, the major portion of naval mobile communications by radio telegraphy has employed manual methods using a morse operator. It has now been decided that H.M. ships should be provided with radio automatic equipment for the following two services:-

Shore-to-ship Area Broadcast circuits
Inter-ship and ship-shore UHF circuits

It is essential that any system of automatic telegraphy fitted in H.M. ships should be compatible with similar systems fitted in the ships of the U.S.A. or other N.A.T.O. navies, and consequently the equipment provided for the above services must fulfil the recommendations of the provisionally agreed N.A.T.O. policy on radio automatic telegraphy for maritime mobiles. Such circuits have been designated Radio Teletype or R.A.T.T. circuits to differentiate them from the fixed point-to-point services which have different characteristics and are known as Radio Teleprinter circuits.

The N.A.T.O. recommendations are:-

(a) Modulation Speed. This should be 45.5 bauds. If it is desired to extend the transmission over European Civil Networks, any required conversion of modulation speed should be done at the communication centre nearest to the mobile transmitter or receiver.

(b) Single Channel MF and HF N.A.T.O. R.A.T.T. circuits. A frequency shift method of keying (F.S.K.) should be used. At the present time a frequency shift of 850 c/s should be employed, but a reduction in shift may be necessary at a later date. The higher frequency should correspond to the inactive condition of the teleprinter (MARK) and the lower frequency should correspond to the active condition (SPACE).

(c) Single Channel LF N.A.T.O. R.A.T.T. circuits. A frequency shift method of keying should be used, with a frequency of 60-100 c/s - probably 85 c/s.

(d) Single Channel VHF/UHF N.A.T.O. R.A.T.T. circuits. An amplitude-modulated sub-carrier frequency-shift method of keying should be used. Where only two discrete steps of sub-carrier frequency shift are involved, this method is known as two-tone keying. The audio tones producing the inactive and active condition of the teleprinter should be 700 c/s and 500 c/s respectively.

These N.A.T.O. recommendations are fulfilled completely by the existing American systems of radio automatic telegraphy using teletypewriters, but not by the corresponding European systems using teleprinters. As equipment of British manufacture which is compatible with the N.A.T.O. requirements is not available at the present time, it has been necessary to provision, as an interim measure, some items of American equipment for use in association with British equipment, so that the N.A.T.O. recommendations can be implemented.

The purpose of these notes is to provide information on the radio automatic telegraphy systems which have been adopted, together with brief descriptions of the American and British equipment used in the present R.A.T.T. fitting programme, and their adaptation and interconnection to provide the services specified above.

2. GENERAL CHARACTERISTICS OF R.A.T.T. TRANSMISSIONS

Transmission is effected by means of a 5-unit code with start and stop elements. Each unit has two possible conditions, either mark or space; so that with 5 units there are 32 different combinations in the code, which is adequate for transmission of the English alphabet together with control signals for the printing machine. The start element is a space unit which precedes the 5-unit code, and the stop element is a mark signal of duration 1.42 times

greater than a mark unit, which succeeds the 5-unit code. The normal speed of transmission is such that each unit has a duration of 22 milliseconds, i.e. a modulation speed of 45.5 units/sec or bauds. The minimum duration of each character is 163 milliseconds, giving a maximum transmission speed of 368 characters or operations per minute. The code used is the International Telgraphic Code No. 2.

At the receive end of the circuit the received code signal operates a teletypewriter, which is a page-printing machine of American manufacture, being similar in principle to a teleprinter. The teletypewriter idles in the mark condition and the code-selection cycle starts on the receipt of the first space signal which must be the start element. The code selection mechanism is reset by this start signal, and is subsequently set up in accordance with the 5 code units as received, and locked by the received stop element. The receipt of a stop element after the receipt of a start element initiates the printing cycle, which is such that the selected character is printed after a delay of about 65 milliseconds, and then the printing mechanism is reset before the receipt of the next stop element. It should be noted that although the printing of one character occurs during the period of the next character, the machine prints each character when received, and the printing of one character is not dependent on the receipt of the next character, as it is with the teleprinter. The waiting condition of the teletypewriter, when a continuous mark signal is being received, is known as the inactive condition, and the condition of the teletypewriter when a space signal is received is known as the active condition.

Transmission of the code signal over the radio circuit is accomplished by keying the transmitter so that one frequency is radiated for the mark signal and a second frequency is radiated for the space signal. This method of modulation is known as frequency-shift keying (F.S.K.). With the HF R.A.T.T. Broadcast circuits, the frequency shift is, at the present time, 850 c/s the mark signal being 425 c/s above the assigned channel frequency, and the space signal being 425 c/s below the channel frequency. The frequency shift for the LF R.A.T.T. Broadcast circuits has not yet been decided, but it will probably be 85 c/s. With the UHF R.A.T.T. circuits a sub-carrier frequency-shift method of keying is used which is accomplished by amplitude modulation of the UHF carrier with one audio frequency for the mark signal, and a second audio frequency for the space signal. The frequencies used are 700 c/s for the mark signal and 500 c/s for the space signal. The advantages of a frequency-shift method of keying are that the power loading on the transmitter remains constant during keying so that absorbers are unnecessary, and a carrier signal is continuously available at the receiver to operate its A.G.C. circuits.

At the reception end of the circuit, the information in the code signal is extracted as a continual change of the audio tone output of the receiver, from one frequency to the other frequency. The two audio frequencies are resolved by some form of audio frequency discriminator and then converted to low frequency voltage pulses which are combined to produce the requisite current pulses to operate the teletypewriter.

3. SHORE-TO-SHIP R.A.T.T. BROADCAST SYSTEM

When receiving the R.A.T.T. Broadcasts, provision is made for the output voltages from two separate channels to be compared, and the channel which, at any instant, is contributing the greater amplitude signal is automatically switched to control the teletypewriter. This method of working is known as diversity operation and can be either space diversity, in which the same frequency transmission is received by two or more separated receiving aerials, or frequency diversity, in which the same intelligence is received on two or more separate radio frequencies. Either type of diversity can be used with the equipment provided, although it is unlikely that the required separation of aerials for space diversity, namely a distance of at least 400 feet, can be achieved in a ship. If however two separate aerials are available in the ship the HF R.A.T.T. Broadcast on one frequency can be received on both the aerials, and the diversity facility used to improve the all-round coverage obtained from only one aerial, since it is improbable that the blind arcs of both aerials will coincide. Alternatively, frequency diversity reception, using either two HF R.A.T.T. channels or one HF channel and one LF channel, can be used. The type of diversity to use will depend on the position of the ship relative to the transmitting station and the propagation conditions

prevailing at the time, so that the choice must be made by the communication department of the ship.

The ultimate aim in providing R.A.T.T. facilities for broadcasts is the replacement of the morse operator by an automatic printing machine. To allow time for familiarisation and to accumulate experience of R.A.T.T. operation the broadcasts will be made for the present both on hand-speed morse and on R.A.T.T. The equipment now being fitted does not achieve completely the requirement for unattended operation after the initial setting up, in that occasional manual adjustment of the receivers will be required to counteract the frequency drift of their local oscillators.

4. INTER-SHIP AND SHIP-SHORE UHF R.A.T.T. SYSTEM

The UHF R.A.T.T. system provides two-way simplex working between two or more stations similarly equipped. Messages can be handled only in one direction at a time (half duplex operation), but any number of stations can operate in one network on the same radio carrier frequency. Any station can function as a transmitter with the remaining stations in the network functioning as receivers, but two transmissions must not be made simultaneously; hence the operating procedure must avoid this latter condition. Facilities are provided for automatic half-duplex working, in which all equipments in the network wait in a 'standby' condition. Manipulation of the keys of any one teletypewriter automatically switches its associated equipment for transmission, and an incoming mark signal automatically switches the equipment for reception. The first requirement with each transmission is to lock the keyboards of all other teleprinters in the network by transmitting the 'BLANK' character twice. At the end of any transmission there is a delay of three seconds, to cover any pause in keyboard operation, before all equipments revert to the standby condition. In this manner each teletypewriter records the whole of the communication handled by the network. It should be noted that owing to the finite operating time of the changeover relays, the first character transmitted may be distorted, and, in order to prevent any misprinting of the teletypewriter, the first character in each transmission should be one which is not part of the message and which does not print such as LETTERS or FIGURES. Further, as explained later, it is essential to operate the UHF receiver in its noise-muted A.G.C. condition if misprinting of the teletypewriter at the end of a message is to be avoided.