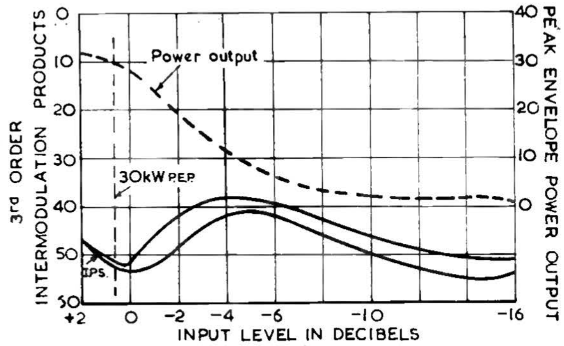


Fig. 7. Third order intermodulation products

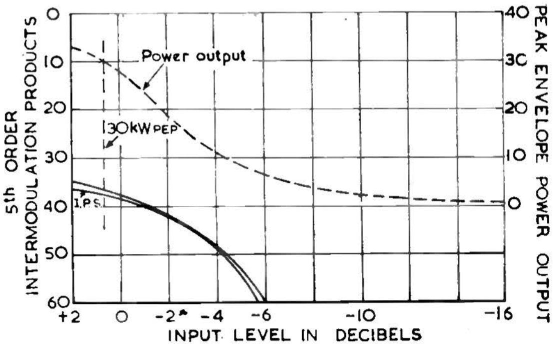


Fig. 8. Fifth order intermodulation products

power and is tunable from 4 to 27·5Mc/s and has only one tuning control for the whole stage. The stage is stable over this frequency range and no anti-squegger devices of any sort are necessary. Because of the weight of the valve used, lifting tackle, on runners, is built into this unit.

(7) Matching circuits to convert from the single sided circuit to balanced feeders are housed here. They permit tuning at 600Ω or 200Ω balanced or 75Ω unbalanced with standing wave ratios of 2/1.

(8) An access way to the back of the transmitter has been provided since it is intended that when multiple transmitters are used they will be installed butting end to end. This access way also provides symmetry of appearance.

Results

The performance of the prototype transmitter fully met the requirements specified.

Measurements of intermodulation products were taken for a large number of carrier frequencies and those for both the 3rd and the 5th order at a carrier frequency of 27·5Mc/s are given herewith (Figs. 7 and 8).

REFERENCE

BROWN, T. T. Harmonic Mixer Charts. *Electronics* (April 1951).

New Developments in H.F. Receivers

By F. W. J. Sainsbury*, Wh.Sch., A.C.G.I., D.I.C.

H.F. point-to-point communication systems vary in their requirements for a number of reasons, and at the receiving end of the system it is not practical to meet the various requirements with one type of receiver only. This article describes a range of receiving equipments recently developed with a view to meeting the various requirements both technically and economically.

THE circuits handled in most receiving stations will show a considerable variation in character, chiefly in the matter of importance, amount of traffic, degree and type of radio distortion and presence or otherwise of interfering signals. Obviously, various combinations of these characteristics can exist, but it is convenient to divide circuits into three groups:

GROUP 1

This includes heavily loaded circuits of first importance whose frequencies are not subject to change and which must be maintained for the longest possible daily periods.

GROUP 2

Under this heading fall circuits which are not required for continuous operation, or which are not subject to very severe radio conditions.

GROUP 3

This includes comparatively easy lightly loaded circuits or those where a high standard of accuracy is not essential.

To meet these varying requirements with one type of receiver would mean that if the receiver was capable of dealing with the difficult circuits then it would be more than good enough for the easy circuits. This obviously would not be an economic arrangement in spite of the standardization achieved.

A range of receivers has been developed therefore so that receiving stations may be equipped on a sound economic as well as a sound technical basis.

Group 1. Telegraph

The first of these, a double diversity telegraph receiver, is intended for Group 1 operation. The points considered as the basis of the design were:

1. SERVICE

To be capable of being connected to a pair of spaced aerials for the reception of F.S.K. and on-off signals on any three frequencies in the range 3 to 27·5Mc/s, the change from one frequency to another and general operation to be effected by the minimum number of controls. At the same time the design should provide for continuous coverage of the whole frequency range.

The output to be capable of operating a teleprinter, undulator, or tone sender.

2. PERFORMANCE

This to be the best possible so that the receiver will operate successfully for long periods with little or no

* *Marconi's Wireless Telegraph Co., Ltd.*

attention even though signal conditions are poor.

3. Operation

Without sacrifice of performance the receiver should be capable of operation by comparatively unskilled staff.

Fig. 1 shows a receiver being set up for a particular circuit by a member of the technical staff. The doors are subsequently locked and the receiver handed over to the operating staff.

The block schematic is shown in Fig. 2, and it will be seen that the receiver is a double superheterodyne with first and second intermediate frequencies of 1 600 and 100kc/s respectively. Automatic frequency control is applied to the second frequency changer and the main selectivity is provided by crystal filters at 100kc/s. For on-off signals the two paths are combined in the common load of the third detectors and taken thence to the D.C. circuits and keying frequency filters. In the case of F.S.K. signals a path selector is used, the same path selector feeds the A.G.C. circuits for both types of keying.

While the general schematic is fairly conventional the circuits and general detail are not and it is proposed to detail the more important points.

Signal Frequency

The range of 3 to 27·5Mc/s is provided by three double diversity amplifiers covering 3 to 6·5, 6·5 to 14·5 and 14·5 to 27·5Mc/s, respectively. Each amplifier has two H.F. stages and all circuits are separately tuned.

Associated with each amplifier is a crystal oscillator which covers the whole frequency range, but to provide for cases where a particular crystal may not be immediately available, a variable *LC* oscillator is fitted.

The frequency range of this oscillator is 2 to 4Mc/s and multiplying circuits are used to extend the range to 32Mc/s. By careful electrical and mechanical design the setting accuracy of this oscillator is correct to within 1kc/s at the fundamental frequency and the temperature coefficient is not more than 5 parts in $10^6/°C$. Humidity variations have no effect on the stability. Normally, one of each type of amplifier is fitted, and frequency selection is achieved by switching the aerial input and I.F. output. Should two of the required frequencies be in the range of one of the units then that particular unit could be

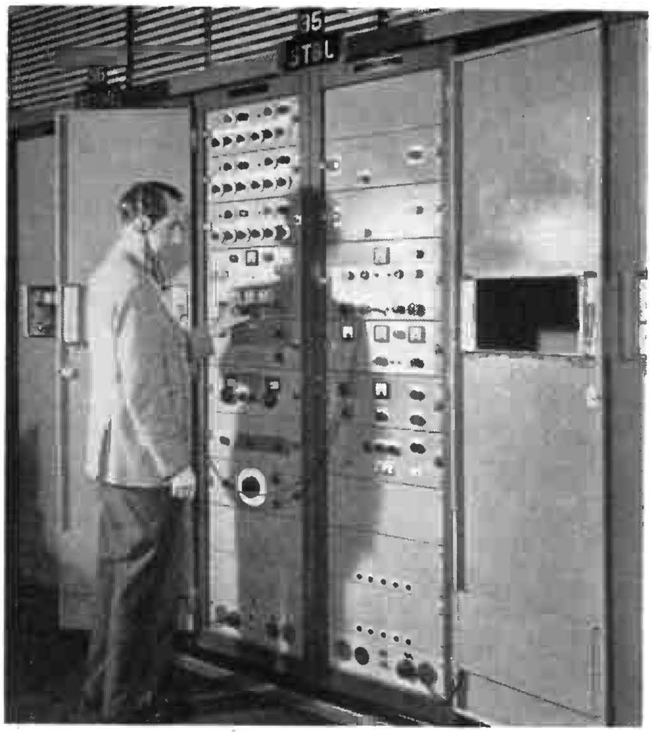


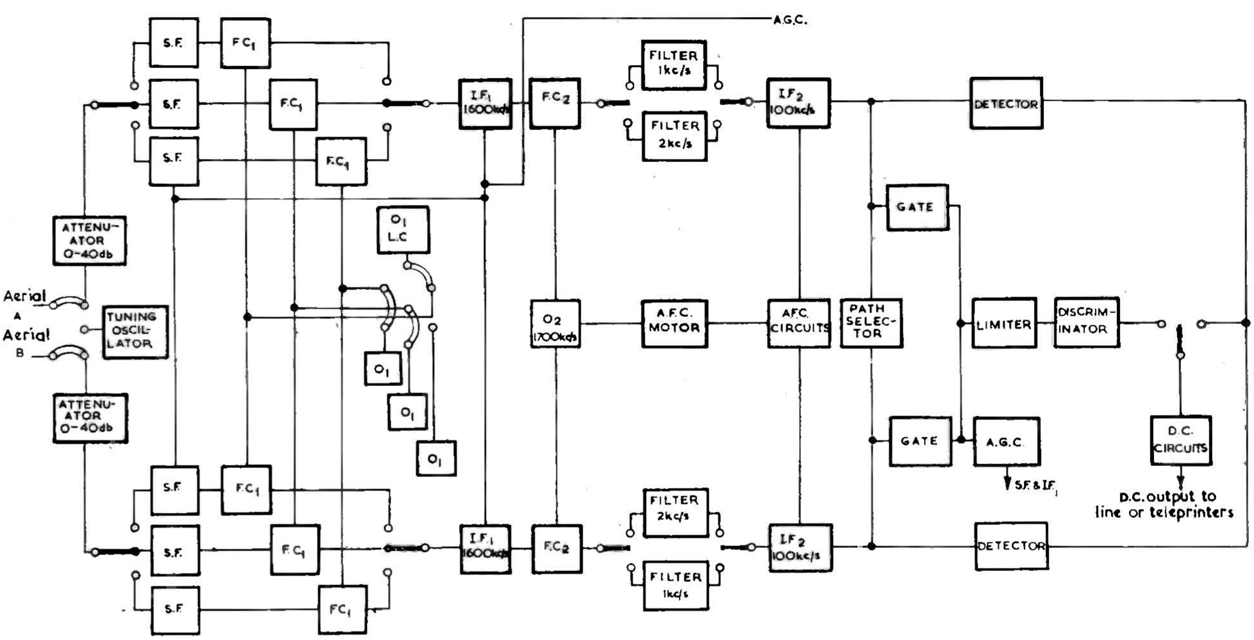
Fig. 1. Preset adjustments being made on the HR.91

duplicated at the expense of one of the other types.

Tuning of the H.F. circuits is facilitated by the provision of a tuning oscillator which can be patched into either aerial input at will.

In a receiver designed for central station working it is important that the radiation of the first frequency change oscillator is kept to an absolute minimum, otherwise spurious signals are created which may cause interference, and in certain circumstances mistune another receiver by operation of the automatic frequency control circuits.

Fig. 2. Simplified diagram of the HR.91



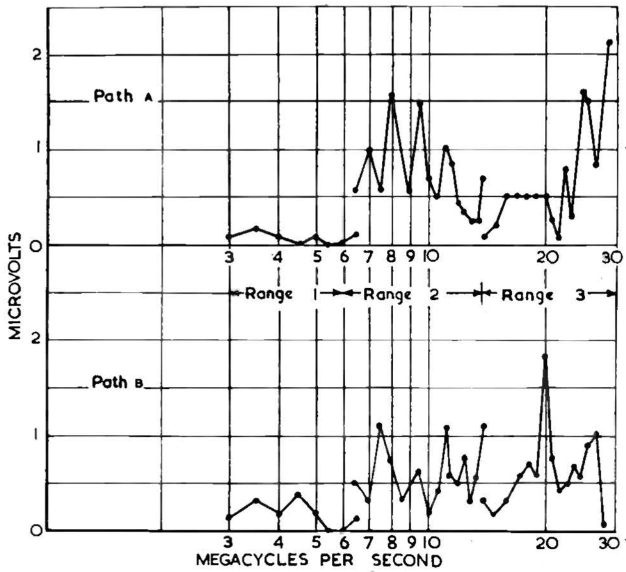


Fig. 3. Typical oscillator radiation figures (HR.91)

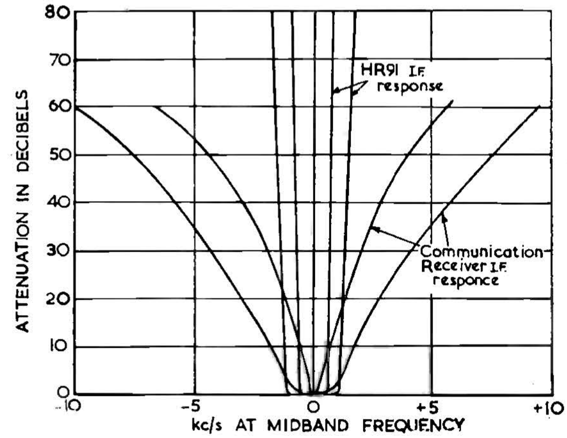


Fig. 5. Comparison of I.F. responses

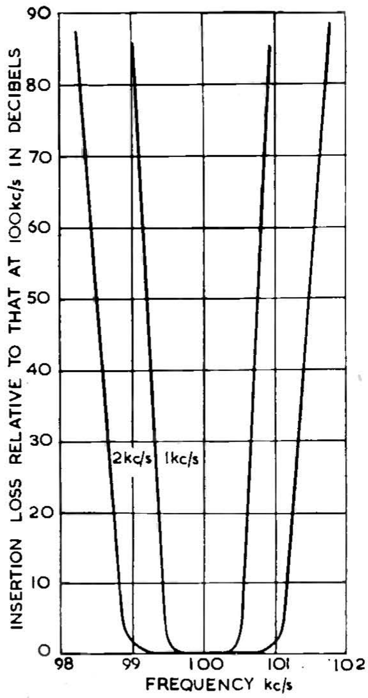


Fig. 4. Filter response (HR.91)

Special precautions have been taken to minimize this oscillator leakage by careful attention to screening and decoupling. Fig. 3 shows, for a typical receiver the amount of first oscillator voltage leaking through to the aerial terminal.

First I.F. Amplifier

The first intermediate frequency amplifier is centred at 1·6Mc/s and has a bandwidth of 8kc/s. This allows for a maximum signal spread of 2kc/s and a receiver drift of ±3kc/s.

Second Frequency Change Oscillator

The second frequency change oscillator, like the first oscillator, is designed for maximum stability and is comparatively unaffected by variations in temperature, humidity and supply voltage. Automatic frequency control is applied to this oscillator.

Second I.F. Amplifier

The second intermediate frequency amplifier is centred at 100kc/s and provides the main selectivity of the receiver. Alternative passbands of 1 and 2kc/s are provided by crystal filters whose response curves are shown in Fig. 4. The ratio of bandwidths at 80db and 3db attenuation is less than 2 to 1 and the performance is unaffected by temperature over the range 10° to 15°C.

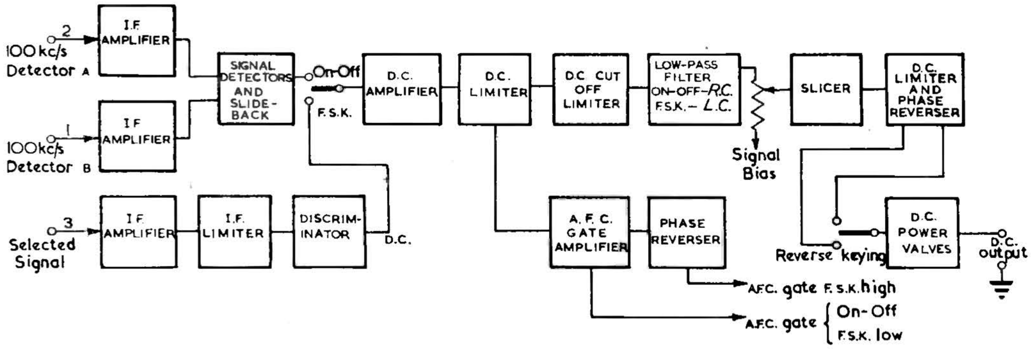
For comparison purposes the response curves of the 100kc/s filters has been redrawn in Fig. 5, together with selectivity curves of a good communications type receiver.

D.C. Circuits

For on-off keying, the output of the 2nd I.F. amplifier is taken to a diode rectifier, and combination of the two diversity signals is achieved by providing a common load for the two final rectifiers.

The D.C. amplifiers and limiters are conventional and low-pass filters serve to differentiate between keying and noise frequencies (Fig. 6).

Fig. 6. D.C. circuits of the HR.91



The overall characteristics of the receiver are such that on-off signals of sine wave formation varying in amplitude by 35db, are handled with negligible bias variation. This is shown in Fig. 7 and it is interesting to note that over the range of signal strengths shown the level at the final detectors varies from 4 to 400 volts. No automatic gain control is used for this test.

The recording threshold is the steady input necessary to change the current output from a clean space to a clean mark and is a static test. Under this condition the first limiter is not fully operative and some bias variation will be present when the signal is keyed, from the curve it will be seen that zero distortion is reached, i.e. the limiter is fully operative, when the input has been increased by approximately 5db. This gives the ratio between the static and working sensitivities for the keying formation and speed considered. If the signal is "square," i.e. is not curbed, then the static and working sensitivities should be identical. In practice, however, due to the build-up time of the I.F. filters, some curbing is introduced and the ratio is of the order of 1 or 2db.

For frequency shift keying, a path selector is used to select the strongest signal which is then fed to a limiter discriminator and then to the D.C. circuits.

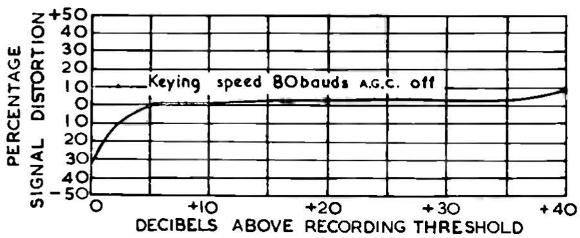


Fig. 7. Signal bias variation (HR.91)

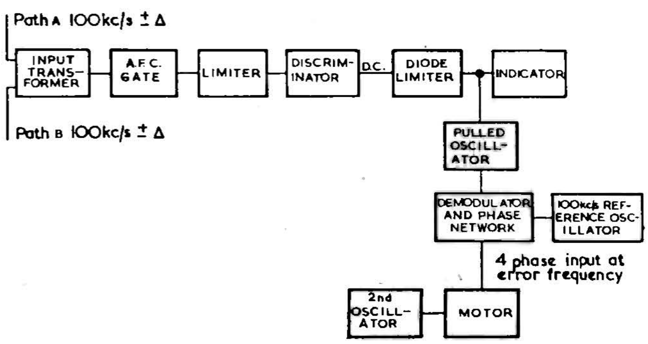


Fig. 8. Automatic frequency control (HR.91)

A.G.C.

The A.G.C. circuits are also fed from the selected output and the A.G.C. control voltage is variable both in amplitude and time-constant, so as to cater for the type of keying and speed of fading. For on-off keying very little A.G.C. action is used, it being found preferable to rely on the overload characteristics of the receiver. A time-constant of 100msec is a usual value. Rather more A.G.C. action may be used for F.S.K. signals.

A.F.C.

The A.F.C. system is shown in block schematic form by Fig. 8. The purpose of the gate valve is to prevent operation of the A.F.C. system by noise or interfering signals in the case of on-off keying and to select the required control signal in the case of F.S.K. signals. The control voltage is obtained either from one of the D.C. limiter stages, or from the signal discriminator. For the latter case a reversing stage is included so that the A.F.C. is controlled by either the mark or the space frequency.

The A.F.C. discriminator is centred at 100kc/s for on-off keying and is varied to suit the shift value for F.S.K.

After limiting, the discriminator output is used to pull the frequency of a crystal oscillator. This is achieved by varying the mutual conductance of a reactance valve connected to the crystal oscillator via a quarter wave network.

A four-phase output is obtained from the difference frequency between the pulled and reference oscillators and is applied to an impulse type motor which is geared to vary the frequency of the second oscillator.

The speed of the motor is a function of the error frequency so that no overshoot is present such as exists with a system using a constant speed motor which is switched on and off. The resulting tuning accuracy is better than 10c/s.

CONTROLS

Reference to Fig. 1 will show that a large number of controls of various types is fitted, but the great majority of these are set to suit the particular circuit. When used as a three frequency pre-tuned receiver, the doors are closed and the only controls then accessible are:

1. Frequency selection switch.
2. Aerial attenuator in each path.
3. Fine tuning control giving variation of ±3kc/s.
4. A.F.C. on-off switch.
5. Signal bias.
6. Monitoring switch.

In addition 2 path level meters and the current output meters are visible.

Group 1. Telephone

The corresponding Group 1 telephone receiver is the type HR.93. It follows the basic principles of the first receiver except that it is designed for non-diversity reception of independent, single, and double sideband telephony transmissions. A total of six preset frequencies is allowed for.

The main design points in a S.S.B. receiver are:

1. ACCURACY OF TUNING

This is especially important when using a local carrier when a frequency error of not more than a few cycles can be tolerated. This calls for very stable frequency change oscillators, and an automatic frequency control system which is accurate and will not mistune the receiver during periods of fading.

2. SENSITIVITY

So that full advantage may be taken of a quiet receiving site and directional aerials, the receiver sensitivity in terms of signal input for a given signal-to-noise ratio should be good. Furthermore, the signal-to-noise ratio should increase progressively as the signal strength increases, this is particularly important for rebroadcasting.

3. SELECTIVITY

The present-day close spacing of frequency allocations demands that each channel should occupy the minimum possible bandwidth. On the other hand, quality considerations demand that the channel should be as wide as possible.

It follows, therefore, that the ideal selectivity curve should be square, i.e. uniform response in the passband with extremely rapid rate of cut-off outside the passband. To minimize the possibility of interference and cross modulation effects it is important that the passband should not be wider than necessary, ideally it should be adjustable to suit the transmission.

4. OVERALL FREQUENCY RESPONSE

When two subscribers are connected via a land and radio telephone link, a great many pieces of apparatus are involved, each with its frequency response. If the overall frequency response of the link is to be reasonable, then the performance of each individual piece of apparatus must be of a high standard.

The simplified block diagram is shown in Fig. 9. It is similar to the first receiver in that the double superheterodyne principle is used with first and second intermediate frequencies of 1·6Mc/s and 100kc/s respectively. Automatic frequency control is applied to the second frequency changer and the separation of the sidebands and carrier is effected by crystal filters at 100kc/s. Both local and reconditioned carrier facilities are provided.

It will be noticed that the general schematic is not novel, the interest lies in the detail and this will now be described briefly.

Signal Frequency

This follows the pattern of the HR.91 except that the number of preset frequencies now totals six. The same types of signal frequency amplifiers, crystal oscillators and stand by variable oscillator are used.

amplifier depends on the filter bandwidth, the tendency is to make the filter as narrow as possible. The bandwidth adopted represents the limit when such points as ease of tuning and stability with temperature and other variables are considered. The gain of the amplifier is variable to suit the various degrees of carrier suppression used, and the output is limited so as to present a fixed level at the demodulator.

Sideband Filters

Alternative bandwidths of 6kc/s and 3·5kc/s are provided for each sideband, selection being by means of coaxial U-links. Typical response curves of the upper sideband filters are shown by Fig. 11 and are summarized in Table 1.

The figures given are substantially constant over the temperature range of 10 to 50°C and are independent of varia-

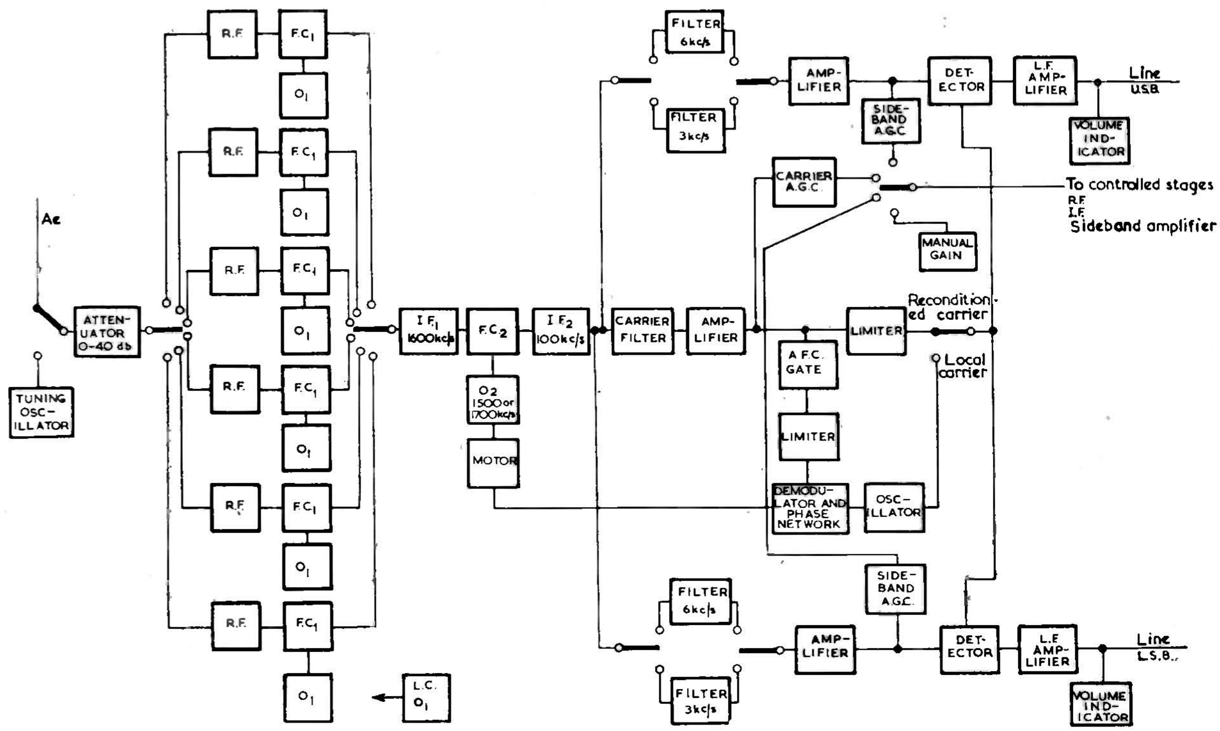


Fig. 9. Simplified diagram of HR.93

First i.f. Amplifier

The total bandwidth of the amplifier is 18kc/s, this is necessary to allow for the reception of a transmission with two 6kc/s sidebands and the possible variation of ±3kc/s introduced by the fine tuning or A.F.C. of the second oscillator.

Second Frequency Change Oscillator

By means of a switch control, this may be set either to 1·5Mc/s or 1·7Mc/s to meet the convention of sideband positioning above and below the signal frequency of 10Mc/s, A.F.C. or manual control may vary this oscillator by ±3kc/s.

Carrier Amplifier

This is centred at 100kc/s and is preceded by the carrier filter whose response is shown in Fig. 10, the filter bandwidth is 60c/s at 2db.

As the signal-to-noise ratio at the output of the carrier

tions in humidity and reasonable mechanical shock. To prove the latter point a prototype filter has been subjected successfully to the instrument vibration test specified in K.113.

Automatic Gain Control

The output of the carrier amplifier, before limiting, is used to operate the automatic gain control circuits. The valve stages controlled are the second R.F. stage, two stages in the first I.F. amplifier and one stage in the second I.F. amplifier.

During periods of selective fading it is obvious that the carrier level does not follow the fading of the sidebands, and for this reason the carrier A.G.C. is given a long time-constant. A constant volume amplifier is then necessary between the receiver output and the input to the telephone terminal.

Where the sideband signal consists of frequency modulated tones, either for facsimile or telegraphy, then sideband operated A.G.C. can be used with great advantage.

Automatic Frequency Control

The carrier amplifier output is taken via a gate valve to a limiting stage and thence to a mixer stage where it is compared with the 100kc/s standard oscillator. The output of the mixer stage, which is the difference or final error frequency, is taken to a phase-splitting network and is then used to operate a four-phase impulse type of motor which controls the second frequency change oscillator.

As this system depends upon the direct comparison of two frequencies, and the correcting system operates at a speed proportional to the difference frequency, the overall accuracy is very great and the final error is, for all practical purposes, zero.

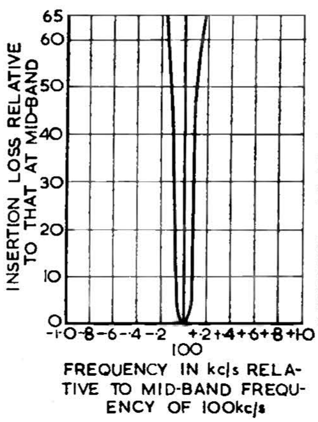


Fig. 10. Carrier filter response (HR.93)

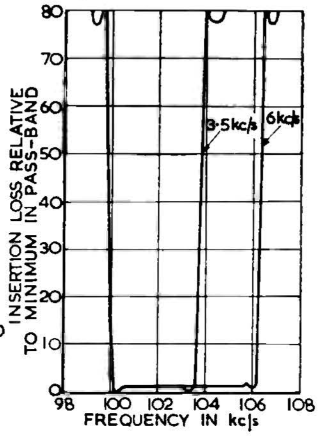


Fig. 11. Upper sideband filters (HR.93)

TABLE 1

Response of Sideband Filters

Frequency (c/s) (fc = 100 000 c/s)		Discrimination relative to mean insertion loss in passband (Decibels)
Upper sideband	Lower sideband	
$fc - 350$ and below	$fc + 350$ and below	Not less than 75
$fc - 200$	$fc + 200$	,, ,, 45
$fc - 100$	$fc + 100$	,, ,, 25
For 6kc/s bandwidth		
$fc + 100$ to	$fc - 100$ to	Not more than
$fc + 6\,000$	$fc - 6\,000$	± 1
$fc + 6\,520$ and above	$fc - 6\,520$ and below	Not less than 75
For 3·5kc/s bandwidth		
$fc + 100$ to	$fc - 100$ to	Not more than
$fc + 3\,500$	$fc - 3\,500$	± 1
$fc + 4\,020$ and above	$fc - 4\,020$ and below	Not less than 75

The purpose of the A.F.C. gate valve is to render the A.F.C. circuits inoperative by noise when the carrier fades below a certain predetermined level.

Group 2. Telegraph

A telegraph receiver designed for Group 2 working is illustrated in Fig. 12 and the block diagram is given in Fig. 13. The type title is HR.11.

It is designed like the HR.91 for double diversity reception of F.S.K. and on-off signals, but the change from one circuit to another may be effected more rapidly. The general facilities, oscillator stability and discrimination and selectivity are slightly inferior when compared with the HR.91, but improved discriminators and A.F.C. performance have been introduced so that values of shift down to 100c/s can be successfully dealt with. An overall selectivity figure of 500c/s is recommended when using the very low values of shift, and, with this arrangement, adjacent transmissions need not be spaced more than 1kc/s apart. This, of course, demands good transmitter stability and is probably achieved most easily by using frequency modulated tones spaced 1kc/s apart on one sideband of an I.S.B. transmission. For reception, the original carrier is ignored and a separate telegraph receiver used for each channel.

Signal Frequency

The range of 3 to 27·5Mc/s is covered by four conventional switched bands. Two stages of amplification are used and the tuning is ganged.

The first oscillator is separately controlled and for reasons of stability covers the limited frequency range of 2·7 to 5·2Mc/s, multiplying circuits being used to extend the range to match the signal frequency circuits. The maximum temperature coefficient is about 10 parts in 10^6/°C.

As an alternative to the continuously variable oscillator, crystals, up to a maximum of 6, may be plugged in and selected by switch control.

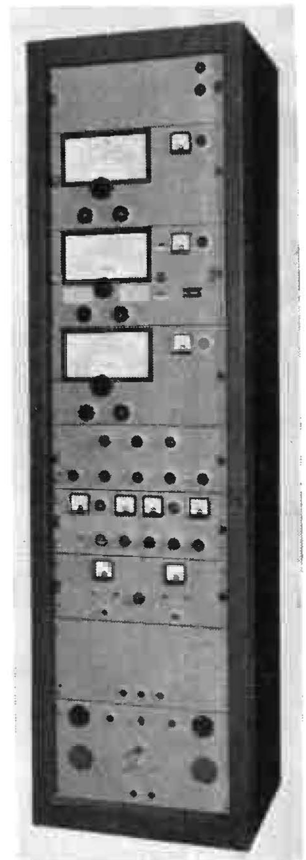


Fig. 12. The HR.11

First I.F. Amplifier

This is centred at 2·6Mc/s to give good image signal protection and has a bandwidth of approximately 10kc/s.

Second I.F. Amplifier

Two crystal filters, centred at 100kc/s, are connected in series to provide the narrow passband, one of the filters being switched out of circuit when the wide passband is required. There are two editions of the receiver, one is fitted with filters to give alternative passbands of 1kc/s and 2kc/s, and the other edition uses different filters which provides alternative passbands of 0·5kc/s and 1kc/s.

Fig. 14 shows the response curves of the three filter arrangements. Care has been taken to obtain good transient responses, especially in the case of the narrow filter.

On-off Signals

For on-off signals the output of each 2nd I.F. amplifier is taken from a power amplifier stage to a diode detector, the outputs of the two detectors are combined in a common load in the conventional manner. Two independent current outputs of 30-0-30mA are provided so that the simultaneous operation of an undulator and a teleprinter, or two teleprinters is possible.

F.S.K. Signals

For F.S.K. signals, outputs from the 2nd I.F. amplifiers prior to the power output stages are changed to 10kc/s, path selection is effected at D.C., but is controlled by the signal levels at 100kc/s. By this means greatly increased sensitivity and stability are obtained for

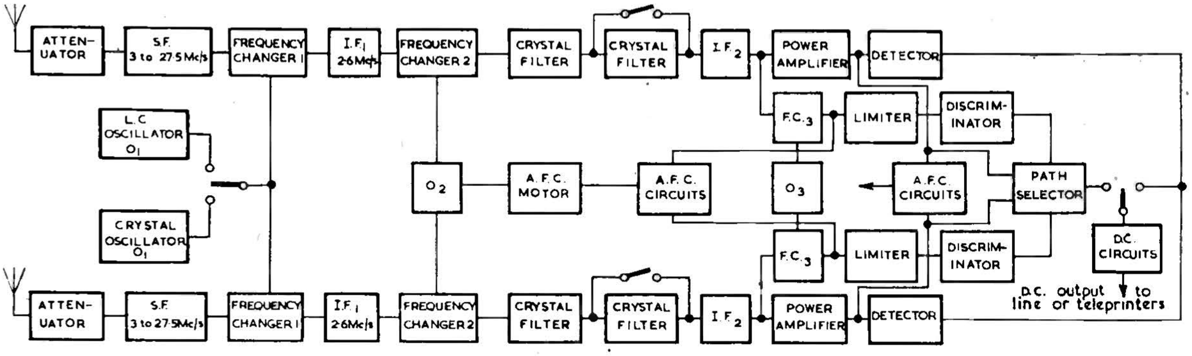


Fig. 13. Simplified diagram of HR.11

the signal and A.F.C. discriminators, and enables shift values down to 100c/s to be successfully handled.

AUTOMATIC FREQUENCY CONTROL

The block schematic of the A.F.C. system is shown in Fig. 15. An output at 10kc/s is taken to a separate limiter and discriminator, the tuning of the latter being variable in switched steps to cater for shift values of 100, 140, 200,

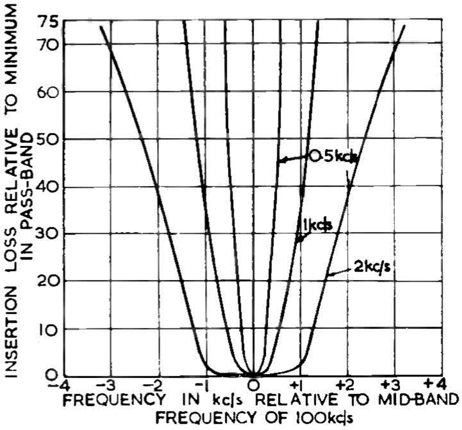


Fig. 14. Filter responses (HR.11)

280, 400, 560 and 840c/s. The use of intermediate values may give rise to a slight amount of signal bias, but this is easily corrected by adjustment of the bias control.

The D.C. output from the discriminator is fed, to a ring modulator. A tone input at 400c/s is fed simultaneously to the modulator and to one winding of a two-phase motor, the latter is mechanically coupled to a small variable capacitor forming part of the tuned circuit of the 2nd frequency change oscillator.

The tone output from the modulator, which varies in magnitude and phase according to the magnitude and polarity of the discriminator output, is taken through a gating stage to an amplifier and then to the other winding of the two-phase motor. The gating stage is keyed from the limiter in the D.C. circuits, and prevents operation of the A.F.C. system by noise or other causes during long rest periods in on-off keying.

AUTOMATIC GAIN CONTROL

The A.G.C. system is adjusted to operate for signals which are within 20db of the level necessary to cause overloading, and is not applied to the signal frequency stages until the gain of the 1st I.F. amplifier has been reduced by 20db. This latter precaution is necessary to avoid degrading the signal-to-noise ratio.

A single switch provides simultaneous variation of the A.G.C. intensity and time-constant so as to cater for various types of keying and degrees of fading.

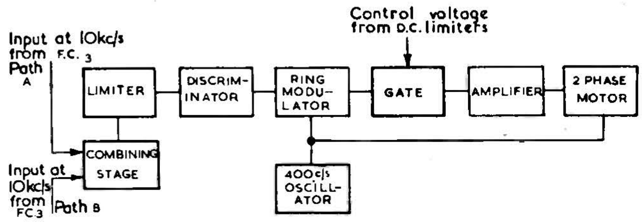


Fig. 15. Automatic frequency control (HR.11)

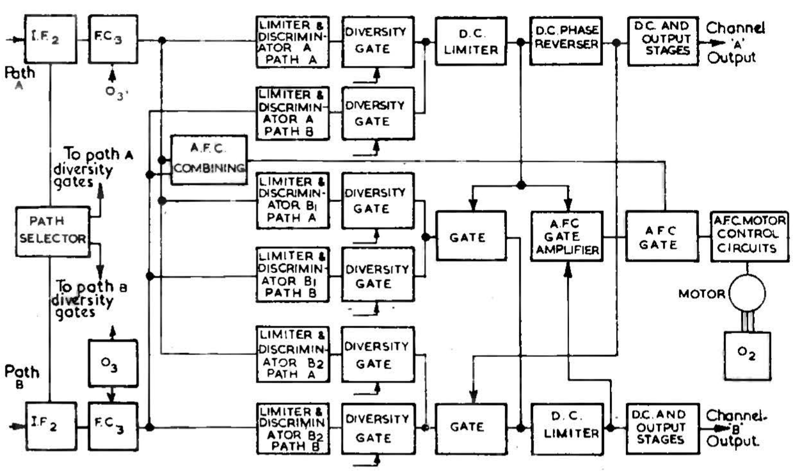
By adding an extra unit, the HR.11 receiver may be adapted for the reception of two channel frequency shift or Diplex signals. The block schematic is then as shown in Fig. 16.

Group 2. Telephone

The companion to the HR.11 for telephony working is is shown in block schematic form by Fig. 17. The type title is HR.21. The circuit arrangement is similar to the HR.93 except in the following respects:

1. The H.F. circuits are ganged for tuning purposes and conventional range switching is used.
2. The frequency stability of the 1st oscillator is slightly inferior, it varies between five and ten parts in 10^6/°C

Fig. 16. Inclusion of diplex on the HR.11



over the frequency range. The setting accuracy too, is inferior.

3. There is no tuning oscillator since tuning of the ganged R.F. circuits is comparatively easy.
4. The first I.F. amplifier is centred at 2·6Mc/s so as to maintain a good image signal protection in spite of any small ganging inaccuracies which might exist.
5. Provision is made for one bandwidth only, 6kc/s being adopted as the standard for both upper and lower sidebands, 3·5kc/s filters may be fitted instead if required. The performance of the filters is identical with those fitted to the HR.93.
6. Sideband A.G.C. is not provided.

From the foregoing it will be appreciated that the changes are largely in the nature of facilities and that the overall performance is only slightly inferior to that of the HR.93, the receiver is thus eminently suitable for all but the most difficult telephony transmissions.

Group 3. Telegraph

A telegraph equipment to deal with the easy circuits classified as Group 3 need only be comparatively simple in character, and relatively cheap to manufacture. There is, sometimes, a tendency to condemn such an equipment when it fails on the more difficult circuits, but a little thought will show that this criticism is unfair.

A simple form of double diversity recording unit is shown in schematic form in Fig. 18 and illustrated in Fig. 19. The type title is HU.12. It is intended for operation with two communication type receivers and its performance, as may be expected depends to a large extent on the frequency stability and selectivity of the particular

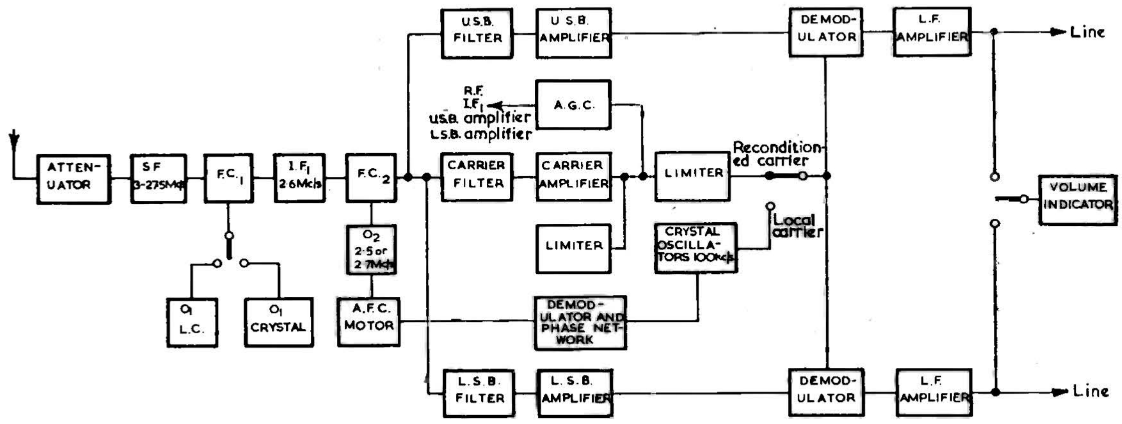


Fig. 17. Simplified diagram of the HR.21

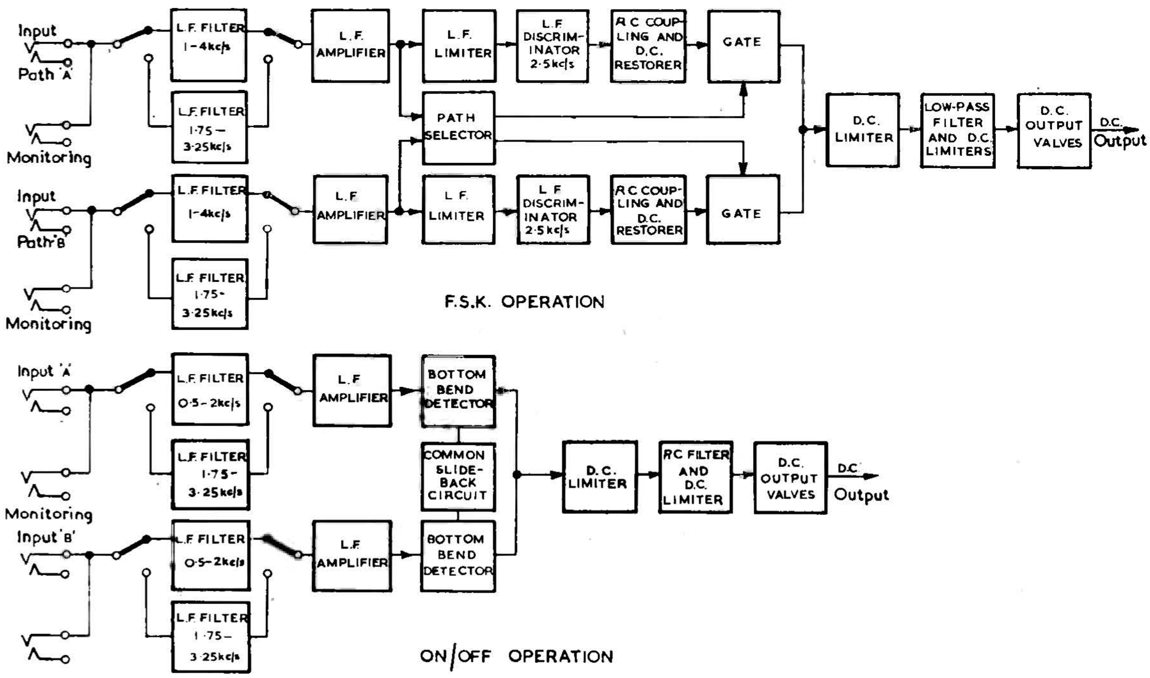


Fig. 18. The HU.12

Fig. 19. The HU.12

receivers used. No modifications are necessary to the receivers.

F.S.K. OPERATION

The B.F.O. of each receiver should be offset from the mid-frequency of the I.F. amplifier by 2·5kc/s and the L.F. gain controls set so that the receiver output level as determined by the A.G.C. system is about +5dbm. The minimum input level to record is about − 25dbm so that the equipment will handle quick fades of the order of 30db.

To minimize the effect of receiver drift a wideband discriminator is used, the output being capacitively coupled and clamped by a D.C. restoration circuit. As a result, the signal may drift ±800c/s before retuning is necessary, but a preliminary warning is given by a simple flashing neon light system.

Combination of the two received paths is effected at D.C. and is controlled by a selector operated by the signal levels before limiting.

The equipment will handle frequency shift values between 400 and 1 000c/s the maximum keying speed is 120 bauds, but the keying filters may be switched to give optimum noise protection at normal teleprinter speed.

ON-OFF OPERATION

It will be seen that the circuit adopted is conventional, diversity combination of the signals is achieved by the use of a common load for the two bottom bend detectors.

The receiver output may be centred at 1 000c/s in the usual way or may be adjusted to 2 500c/s to facilitate change-over from on-off to F.S.K. reception.

Group 3. Telephone

A Group 3 telephony receiver is illustrated in Fig. 20 and shown in block diagram form in Fig. 21.

It will be noticed that the circuit follows a conventional S.S.B. practice, but the mechanical size is that of a normal

Fig. 20. The HR.22

communication type receiver. This has been achieved by relaxing the performance somewhat in the following respects:

1. The signal frequency and variable oscillator circuits are ganged.
2. Provision is made for the reception of one sideband only; this, however, may be switch selected.
3. The skirts of the response curve of the sideband filter are not so steep as for the HR.93 and HR.21.
4. The overall frequency response is not so good.
5. The first oscillator stability is of the order of 30 parts in $10^6/°C$.

BRIEF CIRCUIT DESCRIPTION

The signal frequency range of 2 to 30Mc/s is covered in four switched bands and two stages of radio frequency amplification are provided. The first frequency change oscillator may be either variable or controlled by any one of six crystals.

The first I.F. amplifier is centred at 1·6Mc/s and the second at 100kc/s, the second frequency change oscillator

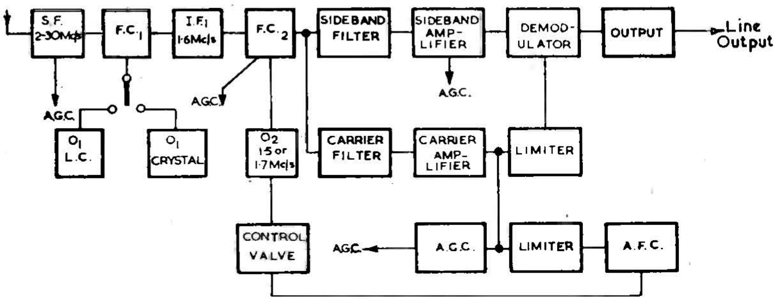


Fig 21. The HR.22

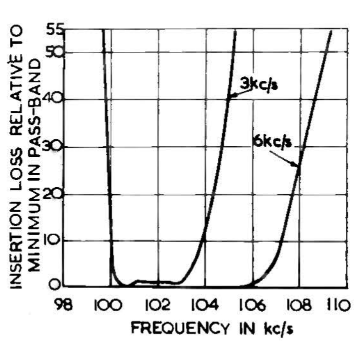


Fig. 22. Sideband filter (HR.22)

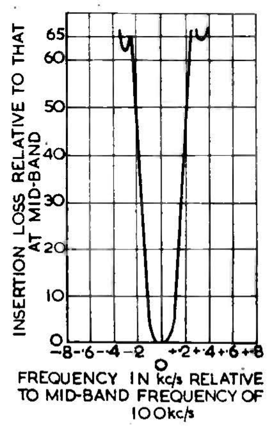


Fig. 23. Carrier filter (HR.22)

may be set either to 1·5 or 1·7Mc/s according to which sideband is required.

The remainder of the circuit is obvious from the diagram, responses of the sideband and carrier filters are given by Figs. 22 and 23 respectively. Provision is made for reconditioned carrier only, and as this does not call for such accurate tuning as in the case of local carrier operation, the carrier filter is relatively wide.

Automatic frequency control is applied to the second frequency changer through a reactance valve, which in turn is fed from a crystal discriminator. Frequency drifts up to ±3kc/s are corrected to within 10c/s by this system.