

# Improvements to the Communications Receiver BRT 400

by  
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*A modern Communications Receiver was described in Telecommunications, Vol. 3 No. 1 (1948). The receiver is a general purpose one covering the HF communication channels for the reception of telegraphy, telephony and high quality music. Since production commenced, work has continued with a view to improving details of performance and making the receiver conform more closely to the market requirements. This work has been largely influenced by the very diverse requirements of a large number of critical users.*

*From amongst the many users of this receiver, a few practical examples of the use to which it can be put have been selected. A large monitoring organisation is using the receivers for the reception of foreign news broadcasts, which include speech transmissions in all the broadcast bands, and a large number of CW transmissions. Allied Navy, Army and Air Forces are using them for short distance point-to-point working, the Navy for ship-to-shore communication and as shipborne receivers for world-wide communications. Several national broadcasting organisations who include the re-broadcast of programmes of other countries in their service, use the receivers generally in a form of diversity. Newspaper organisations and Post Office departments use them for both short and long distance telegraphy and telephony circuits. Many Government organisations are using the receivers for search purposes.*

*In the production of a receiver of this type, where the highest degree of performance is required, the results of a considerable amount of practical experience of the actual use of the receiver under operating conditions is required before the degree of performance is approached. It was considered, therefore, preferable to modify the original design from time to time rather than to attempt a complete re-design. This has been possible because the original conception of the receiver was sound, and although much has been found that warranted improvement, nothing that calls for a major re-design has been discovered. While it is realised that this particular receiver cannot fulfill every requirement of all Communication Receivers, it caters for so many satisfactorily that the policy of continuing with the same basic receiver, and incorporating modifications when necessary, is likely to be continued for some time. No modifications have been included which would in any way destroy the general purpose character of the receiver.*



Fig. 1.—BRT 400E Table Model Receiver.

The basic receiver now in production, known as the BRT.400D, is constructed from material and components having the Services approval, thus ensuring the highest quality in performance and construction. The use of tested materials in its construction ensures reliable operation of the receiver whether under Arctic or Tropical conditions.

Several versions of the receiver are available, the chassis and circuitry (except for the following modifications) being identical in all types. The BRT.400D and BRT.402D are the basic receivers, the former being a table model, the latter for mounting in a standard 19 inch rack. The BRT 400E and the BRT.402E are similar, but are fitted with a Crystal Calibrator. The addition of the suffix N (i.e. BRT.400DN—BRT.402EN etc.) indicates that a 9 kc/s audio rejector filter is fitted in place of the 1000 c/s audio acceptor filter.

The basic receiver is an 11 valve Superheterodyne with an integral mains-operated power supply unit using 3 valves, making a total of 14 valves in all. The normal mains supply required is 40—80 c/s. AC between 95—130V or 195—250V, but in the absence of AC mains, or for emergency purposes, the receiver may be operated by a 12 volt battery-operated power supply unit (Type BRT.401). The BRT.400E model is fitted with a 500 kc/s crystal calibrator to give calibration points at each 500 kc/s harmonic over the whole tuning range.

Provision has been made to operate two or more of the receivers for diversity reception.

The frequency ranges are as follows :—

Range 1	20	—	30	Mc/s
2	8.5		20	„
3	3.2	—	8.5	„
4	1.3	—	3.2	„
5	510	—	1300	kc/s
6	150		385	„

Bandsread is obtained by means of a 64:1 slow motion drive fitted with a flywheel. A logging scale and dial divided into 3200 divisions are provided, these give an effective scale length of  $41\frac{1}{2}$  feet per range. On the three high frequency ranges one division of the logging dial covers an average of 3.4 kc/s. The calibration is printed on six individual perspex strips, the range in use is end illuminated and thus brightly lit, the other ranges are more dimly lit from a lamp some distance behind the register, the switching of the end illumination is carried out by the range switch. This feature has been found invaluable especially when several receivers are being watched by one engineer, for the frequency to which a particular receiver is tuned is immediately obvious at the first glance.



Fig. 2.—BRT 402E Rack Mounted Model Receiver.

A 20 db signal to noise ratio for a band-width of 5.5 kc/s, is obtained for an input of  $7\ \mu\text{v}$  on the four high frequency ranges and for an input of  $10\ \mu\text{v}$  on the two low frequency ranges. An input of  $1\ \mu\text{v}$  will give an output of 1.5 watts at all frequencies.

Six degrees of selectivity are available, three are obtained by means of a simple crystal filter and

three by varying the coupling of the intermediate frequency transformers. The band-widths at 6 db attenuation are 0.5, 1.0, 2.0, 5.5, 9.0 and 13.0 kc/s. The intermediate frequency is 455 kc/s. A considerable amount of work has been done to improve the attenuation of the crystal filter, its frequency of maximum attenuation has been arranged to be at 1000 c/s, at this frequency  $\pm 200$  c/s it is greater than 45 db.

at the intermediate frequency has now been provided, which can be used for such purposes as the reception of frequency shift telegraphy. The level provided is 5 mV across 100 ohms.

A choice of audio filters is available according to the use to which the receiver is to be put, for C.W. a 1000 c/s acceptor filter having a bandwidth of 200 c/s at 6 db attenuation, and for speech or

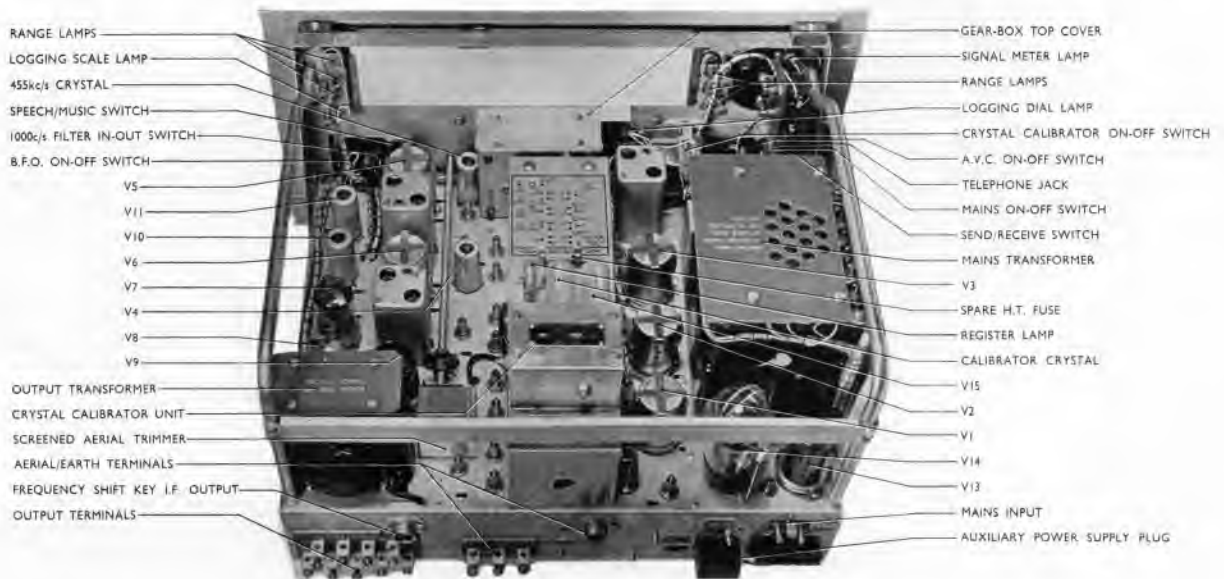


Fig. 3.—Rear view of receiver, showing major components.

The overall fidelity of the receiver has been much improved, and when measured in the broadest selectivity position working into a 600 ohm output load, is less than  $-2.0$  db at 50 c/s and less than  $-6$  db at 5,500 c/s. This facility is intended primarily for re-broadcast purposes.

In a receiver of this type good A.V.C. is essential, more especially for those forms of diversity which depend upon the A.V.C. action of the receivers. In this receiver a change in input level of 100 db results in a change of output level of less than 3 db. Zero level is  $3.0 \mu\text{V}$ .

Such an improvement in the stability of the local oscillator has been made, both to electrical variations and mechanical shock, that an output

re-broadcast purposes a 9.0 kc/s rejector filter having an attenuation greater than 30 db.

A bas-cut has proved invaluable especially when using the selectivity of the crystal filter when receiving speech transmissions. This is provided by a speech/music switch, which gives an attenuation of 7.0 db at 400 c/s relative to 1000 c/s.

The local oscillator warming up drift is less than 5 kc/s on range 1, less than 3 kc/s on range 2, and less than 2 kc/s on the lower frequency ranges.

Radiation of the local oscillator from the aerial terminals has been very much reduced, it now has a maximum value of  $250 \mu\text{V}$ .

The input impedance is 75 ohms on all ranges, balanced or unbalanced on the four high frequency ranges, unbalanced only on the two low frequency ranges. An audio output of 2Watts at 5% distortion is available across either 15 ohms or 2.5 ohms, or 0.2Watt across 600 ohms, a telephone jack being provided. When the 600 ohm output is being used, the transmission can be monitored by either phones or loudspeaker, the insertion of the phone plug automatically switches off the speaker

Speech/Music Switch  
B.F.O. ON/OFF Switch

The valve sequence is :—

V 1	1st R.F Amplifier	W81
V.2	2nd R.F Amplifier	W81
V.3	1st Detector	X81
V.4	Local Oscillator	N77
V.5	1st IF Amplifier	W81
V.6	2nd IF Amplifier	W81

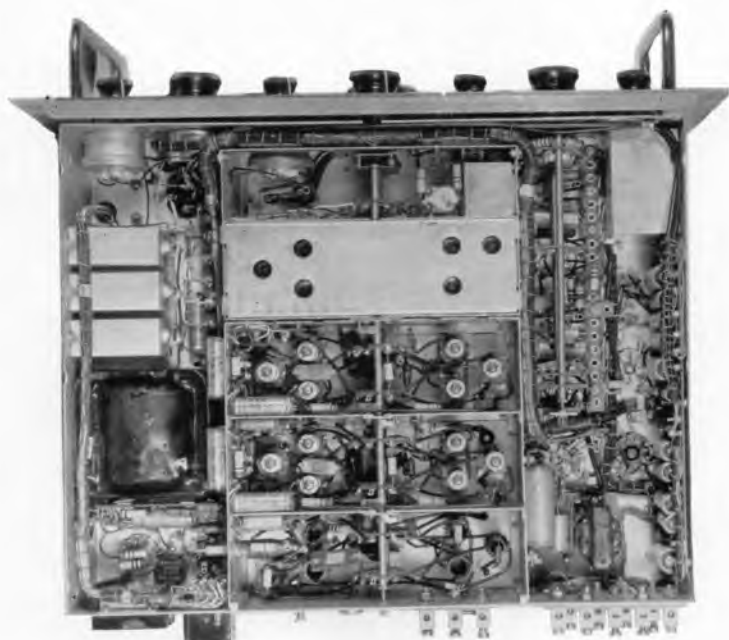


Fig. 4.—Underside of chassis showing clear layout of components.

The controls are as follows :—

Main Tuning Control and Dial Lock  
Range Change Switch  
Aerial Trimmer  
A.F Gain  
I.F Gain  
R.F Gain  
Selectivity Switch  
Crystal Phasing Control  
B.F.O. Pitch Control  
Noise Limiter Control  
Send/Receive Switch  
Mains ON/OFF Switch  
AVC ON/OFF Switch  
Calibrator ON/OFF Switch (E series only)  
Audio Filter IN/OUT Switch

V 7	2nd Detector 1st Audio Amp, IF AVC Delay	DH81
V.8	Noise Limiter R.F AVC Delay	D63
V.9	Output	KT81
V 10	A.V.C. Amplifier	Z77
V.11	Beat Frequency Oscillator	Z77
V.12	Voltage Regulator	S130P
V.13	Smoothing Valve	KT81
V.14	Rectifier	U52
V 15	Calibrator Oscillator	Z77

The power consumption is 135 watts. The weight of the receiver is approximately 80 lbs. The BRT 402 series have a panel height of 10½ inches when mounted in a rack.

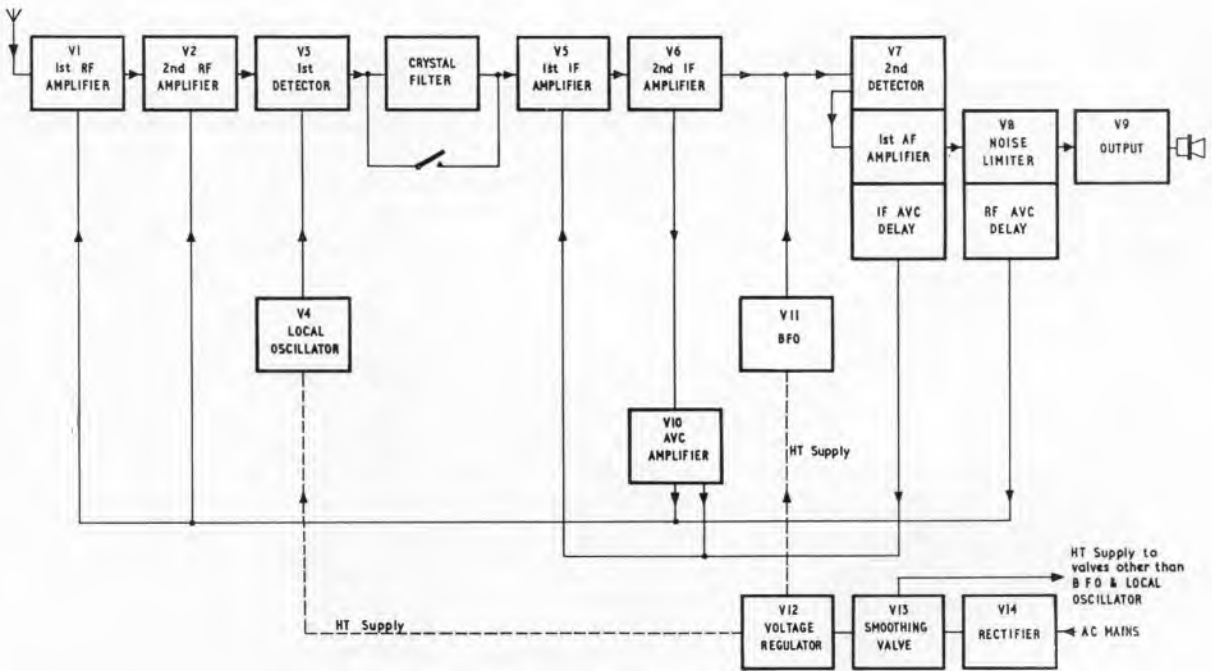


Fig. 5.—Block schematic diagram, BRT400/402.

**Technical Description.**

**R.F. Amplifier, First Detector and Local Oscillator.**

The R.F amplifier consists of two stages of amplification, followed by the 1st detector, a separate local oscillator valve is used.

Every effort has been made to keep the gain of the R.F amplifier constant over each individual range and as far as is possible, between the ranges themselves. This is necessary to keep a constant performance over the whole range of the receiver and to reduce the inaccuracies of the signal strength meter. To achieve this, mixed couplings have been used between the R.F stages, one form to control the gain at the low frequency end of a range, another to control the high frequency gain. Suitable proportioning of these two couplings makes the combined amplification of the two R.F stages compensate the change of gain of the aerial circuit over the range.

To achieve the necessary overall fidelity it has been necessary to broaden the selectivity of the R.F amplifier on the two low frequency ranges. This has been done by stagger tuning of the RF stages, the advantage of this method is that while the response is broadened at low attenuations, it is not unduly widened at greater attenuations.

An intermediate frequency filter is incorporated in the first R.F amplifier, its purpose is to prevent a signal which might be on or near the intermediate frequency breaking through the R.F amplifier. This filter is more useful on the later versions of the BRT.400 where the frequency coverage of the receiver approaches the intermediate frequency more closely both on the low and high frequency sides.

The gain of the two R.F stages is made adjustable by the manually operated gain control.

There is little doubt that if one stage of a receiver is more important than the others, it is the local oscillator. It is here and in the associated circuits that most time has been spent on improvement.

The stability of the local oscillator is dependent upon three things, its own stability, the supply voltages, and the circuit into which it is coupled.

The stability of the supply voltages has been improved in two ways, the voltage regulator has been changed from an S130 to an S130P, this eliminates the danger of the voltage regulator failing to strike and for those who require the highest order of stability a transformer which regulates the heater voltage of the local oscillator can be fitted as an integral part of the receiver. The stability of the circuit to which the oscillator is coupled (i.e. the first detector) is kept as high as possible by not applying automatic or manually operated gain control. Oscillator radiation has been very greatly reduced, that is unwanted coupling to other circuits is reduced. The effects of adjusting the aerial trimmer or R.F gain control on the local oscillator are negligible.

Improvements to the inherent stability of the local oscillator have been made, by more careful testing of components, greater attention to positioning of wiring and by mechanical improvements to the rigidity of the oscillator portion of the chassis. The circuit used is a parallel fed tuned anode, both inductance and capacity compensation are used to counteract thermal drift.

### **Intermediate Frequency Amplifier, AVC Amplifier and B.F.O.**

A crystal filter is used to provide the three narrow selectivities, and by means of the phasing control it is possible to obtain a high attenuation at a frequency which can be moved near to or away from the intermediate frequency. Thus, if whilst receiving a CW transmission another carrier appears 1 kc/s away, for example, either higher or lower in frequency than the wanted signal, by means of the phasing control it is possible to reduce the interfering signal by at least 45 db. This has been achieved by rigorous screening of the circuit, and also by ensuring that the voltages appearing in the crystal filter bridge circuit are of the same phase.

The three wider bandwidths are achieved by varying the coupling of the intermediate frequency

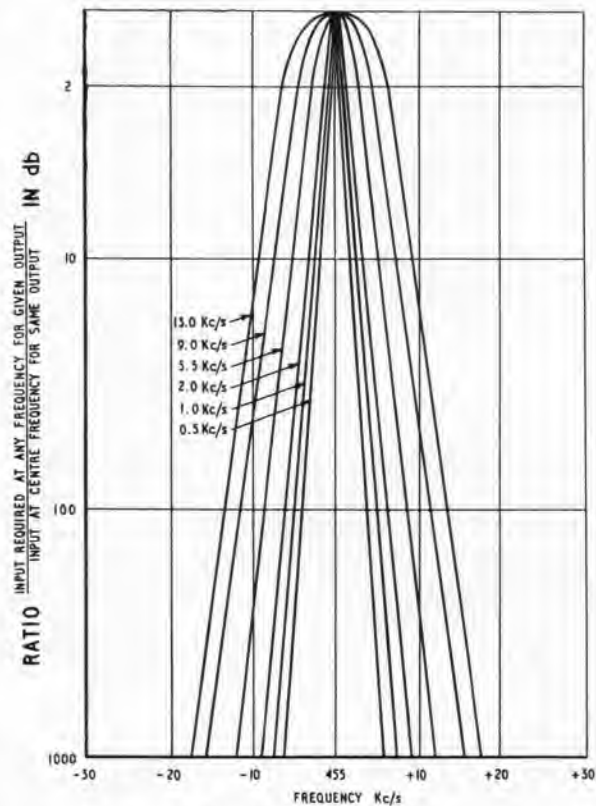


Fig. 6.—IF Response curves.

transformers. The steps by which the bandwidths are widened have been increased, firstly so that with the widest bandwidth position high quality music transmission could be received, and secondly because it was felt that the bandwidths which were used previously (5.5, 7.0, 9.0 kc/s) did not differ by a sufficient amount.

The signal strength meter is the indicator of a resistive bridge, one arm of which is the cathode resistor of the 2nd IF amplifier. A change of AVC to this valve will cause a change of current through the cathode resistor, this unbalances the bridge and actuates the meter. The controlling voltage for the bridge in earlier receivers was taken from the unstabilised H.T. supply, but it was found that when the receiver was used with the battery power supply the difference in H.T. voltage when a change from one power supply to the other was made, was sufficient to cause a difference in meter reading, hence the controlling voltage is now taken from the stabilised supply.

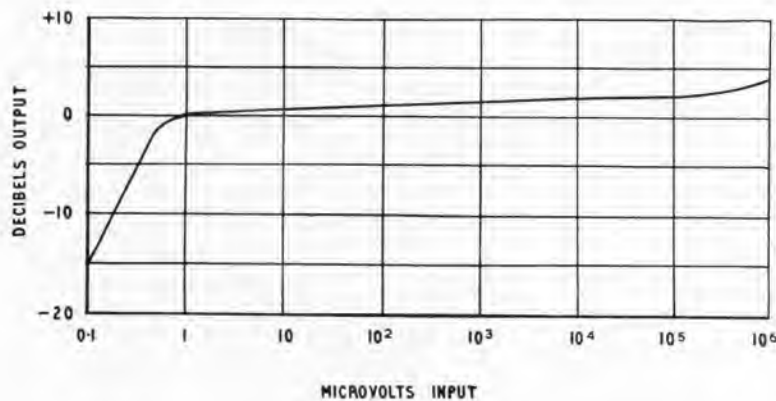


Fig. 7.—AVC characteristics taken at 10Mc/s.

The AVC is amplified with two levels of delay, one for the R.F. amplifier, and one for the IF amplifier. Detection and amplification are obtained by means of an anode bend detector, its anode load being taken to ground, its grid and cathode being at a potential negative to ground, hence a voltage of suitable polarity for AVC is developed across its anode load.

The B.F.O. (a cathode tapped Hartley oscillator) is injected directly on to the anode of the signal diode. As the AVC amplifier is supplied from the primary of the IF transformer which feeds the signal diode, by careful adjustment of the AVC delays, CW can be received with the AVC on, this is of course, an extremely valuable feature, and a necessity when using the receivers in simple diversity. By very careful screening of the B.F.O. circuit spurious responses are reduced to a minimum.

**Noise Limiter and Audio Amplifier.**

The source of the AVC voltage is the primary of the last intermediate frequency transformer. As the coupling of this transformer is varied considerably when the bandwidth is varied, the audio voltage appearing across the diode load will vary. To counteract this the audio voltage is taken from different taps on the diode load, these being switched by the selectivity switch. The audio voltage is then passed through a diode, the noise limiter control, a positive voltage is applied to the anode of this diode and is manually adjustable by the noise limiter control. The adjustment of this positive potential controls the amount of clipping

of the audio wave form. With the limiter control set at maximum, clipping will just occur when the signal is modulated 25%. With the control at minimum a signal with 100% modulation will be passed by the limiter without distortion. It was decided that it was unnecessary to provide an ON/OFF switch for the limiter. The limiter control potentiometer serves this purpose adequately, also the additional complication of making the limiter semi-automatic was not warranted as the voltage applied to the limiter is kept constant within narrow limits due to a very flat AVC characteristic.

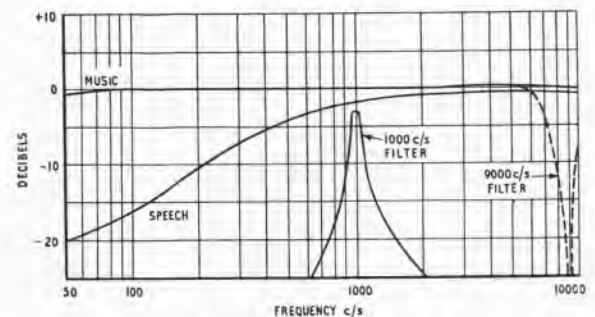


Fig. 8.—Response curves of audio stages for 600 ohms output load.

The audio amplifier is in two stages. The voltage amplifier is a triode, resistance capacity coupled to the output valve. To reduce audio distortion and to maintain a level audio frequency characteristic, negative voltage feedback is applied to the output valve. The 1000 c/s audio filter is a selective negative feedback circuit, the bandwidth of this circuit is 200 c/s at 6db attenuation which is double the bandwidth of the filter fitted to early receivers. The bandwidth was widened because of

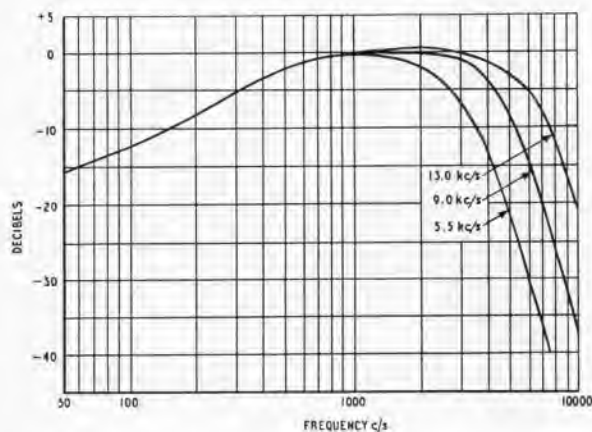


Fig. 9.—Response curves, receiver switched to "Speech" for three settings of IF bandwidth. 600 ohm output load.

the tendency of the narrower filter to "ring." For those users who are primarily interested in the reception of high quality music, a 9 kc/s rejection filter can be fitted in place of the 1000 c/s acceptor filter. This filter is a network coupling between the audio stages, the attenuation of the network at 6kc/s is negligible, and so it does not impair the fidelity when the widest bandwidth position is used, while at 9kc/s the overall attenuation of the receiver exceeds 45 db.

The output transformer caters for 2.5 ohm and 15 ohm speaker, 600 ohms line and 120 ohm phones. When phones are plugged into the receiver, the speaker output is automatically disconnected and the 600 ohm output may therefore be monitored by either speaker or phones. The output transformer, and associated wiring have been designed to conform to standard British Post Office specifications and the receiver is therefore suitable for connection to Post Office lines.

### Power Supply.

To avoid the use of electrolytic capacitors and yet obtain a very low hum level in a restricted space, valve smoothing is used in the form of a phase changing device. A portion of the ripple voltage is applied to the grid of a valve, its phase is changed by  $180^\circ$  and is fed back in phase opposition, to obtain good cancellation the gain of the valve is varied by means of an adjustable resistor in the cathode circuit.

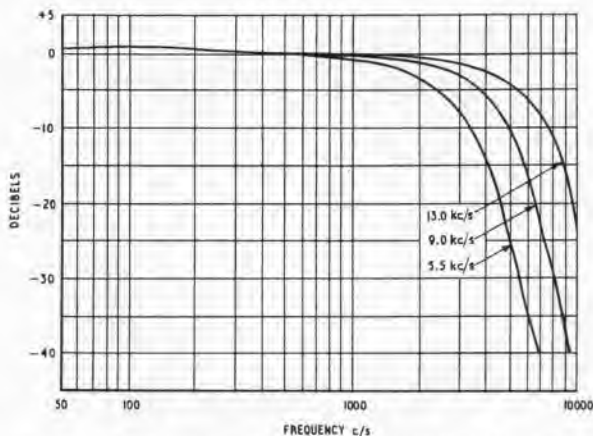


Fig. 10.—Response curves, receiver switched to "Music" for three settings of IF bandwidth. 600 ohm output load.

A neon voltage regulator is used for stabilising the oscillator H.T. voltage, and a selenium rectifier and resistance capacity filter network for providing the negative voltage for the AVC amplifier.

On the rear flange of the receiver is a plug and socket. This socket under normal conditions is a shorting device, but when the receiver is used with the battery power supply the short circuiting socket is removed and the battery power supply connected in its place.

### Crystal Calibrator.

The oscillator is of the cathode tapped Hartley type, the crystal controlling its frequency being in series with the tuned circuit. The output of the calibrator is fed on to the grid of the 2nd R.F. amplifier. The switch controlling the crystal calibrator is a "push-for-on" switch, it also switches on the B.F.O. and switches off the screen of the 1st R.F. amplifier, thus isolating the crystal calibrator from the aerial.

### Appearance.

Changes to the appearance of the receiver have been made. Two handles have been fitted, for protection of the front panel, and to make handling of the receiver easier, this applying more especially to the rack model. A dial lock has been fitted to the main tuning knob.