VHF INTERFERENCE PROBLEMS

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THE opening of local radio stations on the v.h.f. band and the continual plugging by the BBC of the better quality obtainable with frequency-modulation is increasing the public interest in this area of broadcast reception.

Unfortunately, the claims that reception is interference-free is far from true, and as a result users and engineers may face some tricky problems. While interference from foreign stations, the bane of medium-wave listening, is absent, there are other forms to take its place.

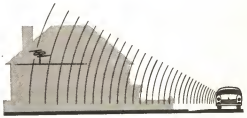
For those living on or near main roads, car ignition interference is probably the most troublesome. This is especially so if the road is on a hill, when not only is the interference generated by a car in low gear much worse, but it also takes longer to pass.

All new vehicles are now suppressed, and have been for the last few years, indeed it has been noticeable that ignition interference has been thinning out, as the older vehicles become fewer in comparison with the new ones. However, there are still sufficient passing on any main road in a given time to cause a number of serious interruptions to any particular programme.

While the irate listener may feel like taking drastic action against the offenders, the solution in this case cannot be applied to the source, and in any case would be illegal! Usually, part of the trouble lies with the aerial. The majority of chimney stacks are already so festooned with Band I and III television aerials plus probably u.h.f. as well, that there just isn't room for a Band II radio aerial. Often, in areas not too remote from the transmitter, quite good signal strength can be obtained with the internal aerial wire running around the back of the cabinet, or at least with one along the picture rail. So the idea of having anything more elaborate seems pointless and money-wasting.

However, although the signal may be strong enough to give reasonable fade-free reception, it is when a splash of interference comes along that the inadequacy becomes all too apparent. The signal-to-noise ratio is just not good enough.

If the chimney looks as though it just will not stand any more, the answer may be in the loft. A good loft aerial is much less expensive than an outdoor one as it does not have to be weather-proof, or need chimney lashings. It will give a much stronger signal, and being elevated well above the road will be out of the worse area of ignition interference. The directional properties of the aerial will also help as any radiation from directions other than the transmitter will be reduced. If the transmitter direction is away from the road, mount the aerial on that side of the loft as this will put the bulk of the house between the aerial and the road, and so afford a degree of shielding. This really should reduce ignition interference to the level of background noise, if not entirely eliminate it.



Loft aerial positioned on side of house furthest from the main road. House affords measure of screening from ignition interference.

The other form of interference can be more troublesome to deal with. There seems in most of our major cities a proliferation of private radio-telephone installations as used by police, ambulance, taxis and other services. These operate on a number of frequency bands, three of them in the v.h.f. range, 70-85MHz., 103-140MHz. and 168-175MHz. There is also one in the u.h.f. region. The broadcast v.h.f. frequencies of Radio 1, 2, 3, and the local stations lie within the range 88-96MHz. or right in between the two lowest radio-telephone bands, and so are vulnerable to interference from them.

Spurious Signals

To see how this interference can occur, we will review the ways by which spurious signals can be received with a superheterodyne receiver. First, there is breakthrough of signals at the *i.f. frequency*, which in the case of most f.m. receivers is 10·7MHz. The local oscillator has no effect on these, so they would be heard irrespective of the setting of the tuning dial, and in fact, this factor serves to identify them. There are no authorised transmissions at this frequency, so this class of interference should not be encountered unless it was due to a short-wave transmitter operating illegally.

Another form of interference is the well-known *image* or *second-channel* type. There are two frequencies that will produce a response in a superheterodyne receiver, one is the sum of the local oscillator frequency and the i.f., and the other is the difference between them. If, as is common practice, the oscillator is running higher than the programme signal, it is operating on the difference, and another signal which is the sum will produce interference.

We can use an example to illustrate: If the wanted signal is at 90MHz, the oscillator is running at $90+10\cdot7=100\cdot7$MHz. An unwanted signal will produce the i.f. frequency at the output of the mixer if it is higher than the oscillator by the frequency of the i.f., or $100\cdot7+10\cdot7=111\cdot4$MHz. As can be seen, this is within the middle band used by radio-telephone services. Second-channel interference then, arises from signals twice the frequency of the i.f. away from the wanted signal; higher if the oscillator is running high, and lower if it is low. For normal v.h.f. sets the interfering signal would be 21·4MHz higher than the broadcast frequency.

Similar, is the *i.f. harmonic interference*. This is the sum of the local oscillator and half the i.f., and also their difference. Such a signal will produce an output at the mixer anode of half the i.f. frequency, and it is the second harmonic of this which will be passed by the i.f. circuits.

Using our above example, the local oscillator frequency is again 100·7MHz, and the interfering frequencies will be $100\cdot7+5\cdot35=106\cdot05$MHz and $100\cdot7-5\cdot35=95\cdot35$MHz. In relation to our wanted signal of 90MHz, the frequencies are plus half and $1\frac{1}{2}$ times the i.f. Harmonics are not usually as strong as the fundamental, so interference from this cause is not so likely to give trouble unless the unwanted signal is very strong.

A further type is the *beat interference*. This occurs from a signal that is spaced from the wanted signal, either above or below, by the i.f. frequency, and is caused by the two signals beating together to form a resultant at the i.f. frequency. Actually, the interfering signal performs the same function as the local oscillator, only of course it carries its own modulation which is passed on through the i.f. stages and detector along with that of the wanted signal. If the interfering signal is strong enough, the set would continue to work with the local oscillator stopped, and this fact could be used to help identify this form of interference. Thus for a wanted signal of 90MHz, beat interference would be caused by signals at 79·3MHz and 100·7MHz.

Finally there is the interference caused by *oscillator harmonics*. All oscillators produce harmonics, and the second-harmonic of 100·7 which you remember is our local oscillator frequency for receiving a signal at 90MHz, is 201·4. Signals spaced above and below this by the i.f., i.e. $201\cdot4-10\cdot7=190\cdot7$, and $201\cdot4+10\cdot7=212\cdot1$MHz, would therefore be passed into the i.f. circuits.

These frequencies are in the commercial television band and above the highest radio-telephone range. The third-harmonic of the oscillator would bring it even higher. Frequencies so remote from the wanted ones should be greatly attenuated by the tuning in the r.f. circuits and the tuned aerial, so should not present any problems. If though it is found that commercial t.v. signals are breaking through, this is the probable cause.

Summing up then, interfering signals can be spaced from the wanted one by twice (second channel); $1\frac{1}{2}$ times (i.f. harmonic); once (beat interference); and half (i.f. harmonic) times the i.f. frequency, on the high side; and one (beat interference) times on the low side. So there are at least five possible frequencies that will interfere with each and every broadcast station. As there are four BBC programmes in most areas, this gives us some 20 possible interfering frequencies. The situation is aggravated by the fact that f.m. receivers are not sharply tuned as are a.m. sets. It is of course necessary to maintain a wide pass-band because of the nature of the f.m. signal. Broadcast deviations are up to 75kHz either side of the carrier frequency, so receiver circuits must extend well beyond these limits.

This means that interfering frequencies do not have to be spot on the values calculated, and if only near them, interference can result. With the previously noted increase in radio-telephone users, it can be seen that the possibility of interference with broadcast programmes is high, and is steadily increasing.

Radio-telephones

The question is, what can be done? Mobile units are not so much a nuisance, as they operate at low power, and usually cause interference only when they are fairly close to the receiver. The chance of a mobile operating at a frequency which could cause interference, coming sufficiently close to a working f.m. receiver tuned to a vulnerable frequency, is not very great, and the odd occasion when it may occur could hardly constitute a major nuisance.

It is the base stations that are the real menace. These are operating more or less continually, and are relatively high powered. Should one of these be within a few miles and operating on a critical frequency, then constant jamming will result.

The first step is to try to identify the offender. This is not too difficult as a number of his messages are being unwillingly intercepted. The class of business can be quickly deduced, and a local knowledge of the businesses of that type large enough to operate radio telephones, will help to narrow things down. One clue is whether the interference is present in the evenings or at week-ends. If it is, then a business that offers service outside normal hours will be the obvious culprit.

After eventually identifying the source, one can try swinging the aerial away from the direction of the transmitter while not losing too much of the broadcast signal. A local road map will help to obtain the precise directions involved. Do not swing too far away from the BBC station though, as the received signal may then be reflected and suffer phase-distortion, which is similar to ghosting on a television picture.

The next step is to find out the exact frequency of the transmitter. Once the owner has been identified, this should present no problem; if the reason for requiring the information is explained, he will no doubt be willing to co-operate. He may not know the frequency, perhaps being non-technical, but this should be shown on the transmitting licence or other paperwork connected with the system. The relationship between the frequency and that of the broadcast signal with which it is interfering can then be seen and the type of interference identified.

If it has not proved possible to discover the source of the interfering transmission, it may be possible to deduce the type of interference from the clues given above, and so arrive at the possible frequency. For example, stopping the local oscillator (without shorting-out the input signal) will determine whether the interference is due to a beat-signal. If this is found to be the case, the frequency will be spaced either above or below the wanted signal by an amount equal to the i.f. So if receiving a station on 90MHz, the interference will be either 79·3 or 100·7MHz. As the latter does not fall within the band used for radio telephones, then it is fairly certain that 79·3MHz or thereabouts is the offending frequency.

Co-axial Stubs

Having discovered the interfering frequency, the next thing is to suppress it (electrically of course). One method of doing this which is often recommended is the parallel stub of co-axial cable. Co-ax exhibits the properties of inductance and capacitance and so will form a resonant tuned circuit. With a velocity factor of unity, the length of the stub should be a quarter of the wavelength of the signal it is desired to eliminate. It should then be connected in parallel with the aerial-feeder near to the aerial socket on the receiver, the free end being left open-circuited.

In theory then, it is a straightforward matter to calculate the length and connect up. Not so in practice. First of all, the velocity factor of the co-ax is not unity, but varies from one sample to another. Typical values are 0·67 for the solid dielectric type, and 0·85 for the semi-air spaced variety. This must be multiplied by the quarter-wavelength to arrive at the actual length, so an exact calculation with any sample of co-ax is not easy.

There is a further complication; much depends on the characteristics of the aerial input circuit, whether it is inductive of capacitive. At a frequency higher than resonance, a tuned cricuit appears capacitive, whereas at a lower frequency it is inductive, the two balance out only at the resonant frequency. The receiver aerial circuits will be tuned to the wanted frequency, so at an interfering frequency, the circuit will appear either inductive or capacitive depending on whether the frequency is higher or lower than the wanted one, and the degree of inductance or capacitance will depend on the spacing of the frequencies and the Q of the circuit.

It can be seen then, that cutting a stub to the exact size is very much a matter of chance. The recommended method of tuning the stub is to cut it longer than the estimated length and cut off sections about ½ inch at a time until the minimum level of interfering signal is attained. To do this as with most tuning proçedures, it is necessary to go through the resonant point to ensure that the peak (or trough in this case) has been reached, and then tune back. Obviously it is not possible to stick back on the last few sections that have been chopped off, so the thing to do is carefully note how much has been removed since the signals started to increase, and then measure up a new stub made from the same type of co-ax.

Severe interference was being experienced on the author's own set-up which consisted of a separate f.m. tuner feeding the hi-fi system. The trouble was with the reception of Radio 3 from the Wenvoe transmitter which uses the frequency of 96·8MHz. Programmes were completely blotted out when the interference occurred, not only during the day but up to late at night and also at weekends. It was impossible to enjoy a concert, and tests with other f.m. receivers in the neighbourhood confirmed that they too likewise suffered. Their owners either put up with it, switched to a.m., or just didn't listen to Radio 3.

It was obvious from the messages received that the source was a television repair shop controlling its service vans. The fact that a number of vans were apparently in communication indicated a business of some size, and also the evening and weekend operation narrowed down the field among the local firms. A few phone calls to the short-list of suspects revealed that it was the local Rediffusion workshop. The chief engineer was co-operative and apologetic, offering to check the frequency of the transmitter and that it was duly suppressing its harmonics, but of course the frequency was assigned by the Post Office Telecommunications Department, and there was nothing he could do about that.

He was able to state the frequency which was 85·725MHz. It then became obvious that this was a case of beat interference, as the frequency is 10·7MHz away from 96·425MHz, which is just 0·375MHz off the Radio 3 centre frequency. It was an obvious boob by the Post Office in assigning so critical a frequency to a powerful base station. Admittedly, frequencies are scarce and the demand is great, but troublesome frequencies such as these could easily be assigned to mobiles.

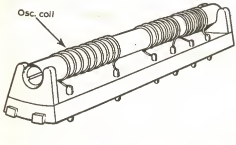
An interference form was obtained from the Post Office, and all the details as to source of interference, frequency and type were included and duly sent off. However, nothing more was ever heard, and as the interference continued it appears that nothing was done by way of re-allocating the frequency.

Series Wavetrap

It was therefore decided to tackle the problem without G.P.O. assistance. First of all, stubs were tried, but the difficulties previously described foiled success with these. Unfortunately, the Rediffusion base was in exactly the same direction from the aerial as the Wenvoe transmitter, so no rejection could be obtained by swinging the aerial. Nonetheless it was tried, and although the f.m. signal dropped, the interference decreased more so, so some improvement in signal interference ratio was obtained.

Finally the possibility of a series resonant wavetrap in the aerial feeder was considered. A coil resonating with its self-capacity and tuned with a brass slug was needed to enable a quick and convenient adjustment frequency adjustment to be made. The problem was, how to make one with any degree of accuracy that would not need lengthy experiments with the intermittent signal source similar to a stub.

Looking around the workshop for some ready-made component which might fill the bill, attention turned to some old coil biscuits from scrapped television tuners. A channel 2 oscillator biscuit was found among them. The BBC station on channel 2 operates at 48·25MHz (sound). The sound i.f. for the set concerned, and which is now common for most modern t.v. receivers, is 38·15MHz. This means that the frequency of the oscillator coil was 86·4MHz. As the Rediffusion frequency was 85·725MHz., this was near enough to be within the tuning range of the coil.



Appearance of typical coil biscuit. Oscillator coil is usually the largest and contains a tuning slug.

Accordingly it was connected in series with the aerial feeder, and the interference was completely eliminated, without the need even to tune the coil.

Most t.v. workshops have old tuners knocking around, so a call at the local radio dealers could well produce a coil suitable for the purpose, should similar interference be experienced. The chart shows the frequencies of the main BBC band I television channels, and assuming a 38·15MHz sound i.f., the actual tuning range of an oscillator-coil biscuit. It will be noted that channels 3 and 4 coils will tune to frequencies within the v.h.f. radio band, so will be no use as wavetraps for radiotelephone frequencies as these are all outside this band. Channel 5 is just at the start of the medium radiotelephone band, and could easily tune to some of its lower frequencies.

TELEVISION CHANNEL	SOUND FREQUENCY	OSCILLATOR COIL FREQUENCY
1	41·5MHz	79·65MHz
2	48·25MHz	86·40MHz
3	53·25MHz	91·40MHz
4	58·25MHz	96·4MHz
5	63·25MHz	101·4MHz

Remember, too, that the range of the coil can be extended by the fitting of a different type of tuning slug. A brass slug will decrease the inductance, hence increase the frequency, while an iron-dust slug will increase inductance and decrease the frequency. If the range is still outside the interfering frequency, a couple of turns taken off the coil will push it higher, or a small capacitor of a few pF. will bring it lower, if wired in parallel. The biscuit may have two or three coils on the same former, the oscillator is the one nearest the open end and which has the tuning slug. The other coils are coupling coils and should be ignored. ■

Direct Conversion Receiver *continued from page 300*

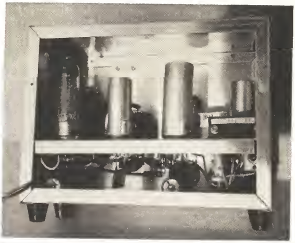
for h.t. positive, black for chassis and some other colour for the 6·3V heater supply.

ALIGNMENT

Set TC2 and TC3 about half closed and tune in any signal, with VC3 nearly open, and adjust TC2 and VC1/2 for best volume. Find a signal with VC3 nearly fully closed and peak VC1/2 for best results, then rotate the core of L1 for maximum volume.

If necessary, the core of L3 is rotated to obtain suitable band coverage with VC3. The coverage of VC3 can be checked by placing the aerial lead of a calibrated receiver near L3 and listening for the carrier produced by V3.

At all times the r.f. gain control VC1/2 is adjusted as needed for best reception even though VR1 may have to be turned back with strong signals. The cores of LI and L2 are adjusted around 3·5MHz and the trimmers TC2 and TC3 are set near 3·8MHz. TC2 may also need re-adjustment after changing the aerial. These circuits are merely peaked up for best volume and are not too critical. The extent of rotation of this control needed to tune from 3·8-3·5MHz can be increased by screwing down TC2 and TC3 and unscrewing the cores of L1 and L2 to compensate.



Rear view of the finished receiver.

Power Supply. Any supply giving about the outputs mentioned should be satisfactory. If a power pack has to be made, one with full-wave rectification is most suitable. This may employ a 250/0/250V 60mA, 6·3V (1·5A or 2A) transformer, with smoothing by means of two 16μF 350V capacitors and a 60mA choke.

Speaker and Phones. A reasonably large 2/3 ohm speaker is most suitable with a cabinet or baffle.

When phones are plugged in, the mis-match can generally be disregarded. Inexpensive surplus 600 ohm phones will be found to work well. It would be possible to use an external matching transformer for high impedance phones or to feed them through reliable isolating capacitors from V4 anode.

Aerials. Numerous transmissions were received with a short indoor aerial but changing to an outdoor wire tuned as for transmission purposes naturally gave a great increase in range and volume. In practice, any end-connected wire can be taken to A1 or A2 while the A2 connection is most suitable for short aerials. ■