Design of High-Frequency Chokes

An Article to Fill a Definite Need

By "CATHODE"

THE H.F. choke is a device which offers a high impedance to radio frequency currents without introducing appreciable D.C. resistance. The explanation generally given is that the H.F. choke is essentially an inductance, and that its impedance is therefore proportional to the frequency or inversely proportional to the wave-length applied. This explanation, however, only approaches the truth in the case of a parallel feed circuit, where the self-capacity of the choke is absorbed into the tuning capacity, and the impedance or reactance presented by the choke is that of its inductance alone. The impedance presented by a typical commercial choke under these circumstances and at different frequencies is shown diagramatically in the upper curve of Fig. 1 (reproduced from "The Efficiency of Parallel Feed," "Radio Record," October 4, 1929, to which the reader is referred for a fuller explanaion on this point).

At radio frequencies the association of capacity with inductance results in resonance. When it is realised that the capacity across a choke is raised by 10 or 20 micro-microfarads immediately it is inserted in a receiver circuit there can be no longer any doubt that every H.F. choke resonates at some well-defined wave-length.

The lower curve of Fig 1 is typical of the majority of H.F. chokes on the market to-day, and clearly proves that the H.F. choke must be treated as a tuned circuit. The resonant frequency of this choke is about 2500 metres, and it will be seen that although the impedance to H.F. is very high at long wave-lengths, it falls off to 25,000 ohms at 500 metres. This falling off is serious if the choke is to be used for coupling the H.F. valves in a portable set, as in Fig. 2, but in capacity-controlled reaction circuits is fortunately not so important since the impedance of the reaction condenser also falls as the wave-length is reduced, and is able to compensate for the falling-off in H.F. current available at the plate.

From Fig 3 it is obvious that a choke is a parallel resonant circuit. In other words any H.F. current which flows is divided between the capacity branch and the inductive branch with its resistance, and the currents in the two branches may be widely different. The current is greatest in the capacity branch at wave-lengths below resonance, but above it the greater current transfers to the inductive branch. Most chokes are worked at wave-lengths below resonance, so that the self-capacity does the choking and not the high inductance marked on the carton!

In Fig 3 the anode-filament capacity **Caf** is in parallel with the choke and merely tends to raise its natural resonance, but the anode-grid capacity **Cag** serves to transfer H.F. energy back to the grid. The phase of the H.F. voltage returned to the grid in this way will depend on whether the choke is being worked on the capacitative of the inductance side of resonance. If the choke is worked below the resonant wave-length the reaction effect is negative and the valve cannot oscillate; above the resonant wave-length the reaction effect is positive, and the valve will oscillate without any coupling between the adone and grid circuits other than the valve capacity **Cag**.

Thus the choke used in drawing the lower curve of Fig. 1 would cause oscillation above a wave-length of 2500 metres, but would be satisfactory at any less wave-length. A point which is immediately apparent is that the reactance is highest at wave-lengths approaching resonance; consequently it naturally occurs to one to try the effect of reducing the inductance of the choke

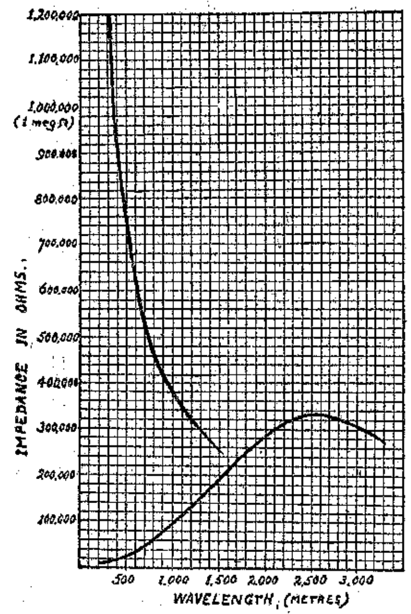


FIG. 1.

so as to work it nearer to its resonant point.

In practice there proves to be a definite advantage in so reducing the inductance, although it is always necessary to be careful not to reduce the inductance so far that resonance occurs within the broadcast band. When the choke is wired into circuit, its self-capacity is augmented by the valve capacities, and any other stray capacities, so that even though the choke itself were resonant at some point within the broadcast band, in any practical receiver the resonant point would be moved to a longer wave-length which might be outside the band, thus permitting satisfactory operation.

This point is well illustrated in Figs. 4 and 5, in which are given the resonance curves of a number of representative chokes of various inductances, firstly without any added capacity (in Fig. 4), and secondly with an added shunt capacity of 15 micro-microfarads such as would be introduced by incorporating any of the chokes in a practical receiver (Fig. 5). Note that curve 1, relating to a choke of 10 millihenries, resonates, without any shunt capacity, between 300 and 350 metres; this choke would at first sight appear likely to prove unsatisfactory, but, when an added shunt capacity of 15 mmfd. is introduced (Fig. 5), as would almost inevitably be the case in practice, the resonant point is moved to a higher wavelength which, as it happens, is outside the broadcast band.

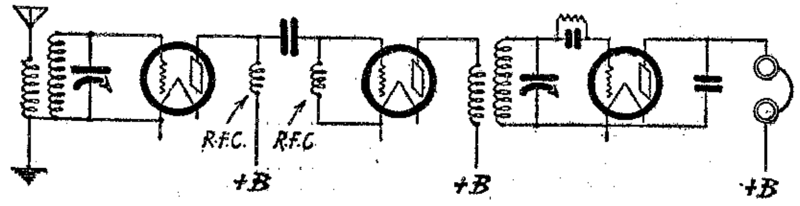
Thus this choke of 10 millihenries would almost certainly be perfectly satisfactory in practice; in fact it is the most satisfactory of the several chokes whose curves are given in Figs. 4 and 5. At the same time, an inductance of 10 millihenries does not offer much margin of safety (as regards avoiding resonance within the broadcast band) and the writer prefers to adopt an inductance of about 15 or 20 millihenries, just in case the incidental capacities should be lower than anticipated in any particular instance.

It seems appropriate, now that the theory of high-frequency choke design has been dealt with more or less completely, to summarise the principles involved and the requirements entailed thereby, subsequently giving practical designs to meet these requirements.

(1) Firstly, then, for a parallel feed choke, we require a choke having a very high inductance indeed, but fortunately self-capacity is of only minor importance, as it is absorbed into the tuning capacity.

(2) Secondly, for an untuned high-frequency coupling (Fig. 2) we require a choke having maximum reactance over the broadcast band—that is to say, we require a choke whose resonant point, when in circuit, is round about 600 to 700 metres. A choke of about 15 or 20 millihenries will best fit this requirement, especially since the less amount of wire entailed by a fairly low inductance enables us to keep the self-capacity down without taking any particular precautions.

(3) Thirdly, for use in the plate circuit of a detector valve to give reaction effects. Such a choke as is outlined in paragraph (2) above would be suitable, but the fact that inefficiency



Impedance Coupling Between Two R.F. Stages.

is of small moment in a reaction choke dispenses with the need for careful construction; the most compact design will be most satisfactory, for little room is usually available for a reaction choke.

(4) Fourthly, the experimenter who insists on using one choke for all purposes confronts us with the difficult problem of providing a choke of high inductance (to cater for parallel-feed circuits) whose reactance over the broadcast bend shall yet be high