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BROAD BAND-PASS CIRCUIT ARRANGEMENT

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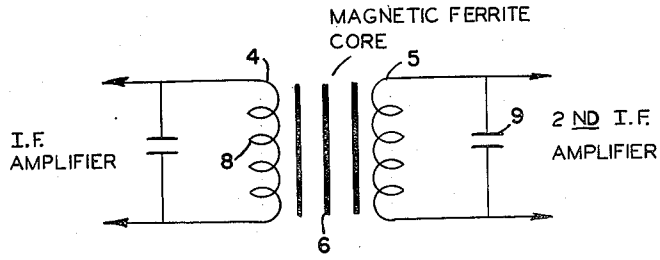


FIG. 2

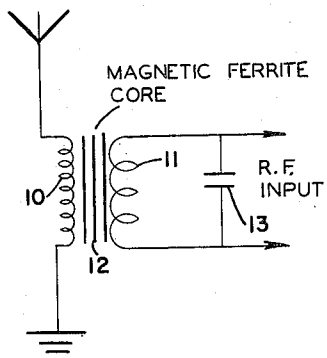


FIG. 3

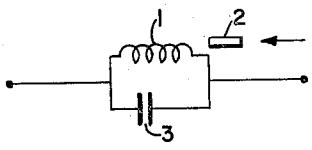


FIG. 1

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AGENT

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BROAD BAND-PASS CIRCUIT ARRANGEMENT

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2 Claims. (Cl. 178—44)

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This invention relates to circuit-arrangements for the transmission of electrical oscillations, more particularly oscillations of very high frequency allowing the passage of a broad band of frequencies. Circuit-arrangements of this kind are used, for example, in television technique, in transmitting and receiving devices in which use is made of frequency modulation, in carrier-wave telephony utilising a number of transmission channels and the like. The object of the invention is to provide a circuit-arrangement in which an advantageous transmission of a frequency band of any arbitrary width may be ensured in an extremely simple manner.

In the circuit-arrangement according to the invention use is made of a selective circuit including an inductance coil comprising a core of ferromagnetic material. Coils of this kind are known as such. The core of the ferromagnetic material, which in this case generally constitutes a closed circuit, serves to increase the inductance with the same dimensions of the coil as such. Highly advantageous results in this respect have been obtained with cores substantially consisting of ferromagnetic metal compounds and more particularly oxides exhibiting substantially no electrical conductivity, which substances when made of a determined composition exhibit high permeability with comparatively low losses even at higher frequencies. In connection therewith it is possible, by utilising coils comprising cores of such material, to obtain oscillatory circuits having a high selectivity for high frequency. However, upon increasing frequency, the losses of the coil increase and its permeability decreases, so that the use of such a coil above a determined frequency, which is dependent upon the nature of the ferromagnetic material, has been considered to be less efficient.

The invention is based on recognition of the fact that advantage may be taken of the increase in losses and the decrease in permeability in determined ranges of frequencies, if it is essential to obtain a circuit-arrangement which allows the passage of a broad band of frequencies. Hitherto for this purpose it was frequently ensured that the selective circuits exhibited increased damping by providing resistances in parallel with the resonant circuits or by combining a number of circuits by means of determined relative couplings to form a band-pass filter. With amplifiers it is also known to tune the resonant circuits serving as coupling elements between the various successive amplifying stages to slightly different frequencies.

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The present invention consists in that in a circuit-arrangement for the transmission of electrical oscillations allowing the passage of a broad band of frequencies, which comprises at least one selective circuit including an inductance coil which comprises a core of ferromagnetic material exhibiting substantially no electrical conductivity, the properties of the said material are chosen to be such in regard to the frequencies to be transmitted that the permeability exhibits a material decrease with increasing frequency with respect to the frequencies of the region to be passed.

In this case the coil is used in a range of frequencies in which the effective value of the permeability is much smaller than the maximum value considered as the optimum one in former uses the value now being, for example, from one-third to one-tenth of the last-mentioned value.

An apparent fall in the permeability of the material of the core with increasing frequency also occurs in coils comprising laminated or finely-divided iron as a result of the so-called skin effect. Such an effect is undesirable for the subject of the present patent application since it does not lead to the desired result. Consequently, the skin effect is required to play an unimportant part only.

It has been found that, more particularly with the said coils comprising cores of materials containing ferromagnetic compounds, a suitable composition of such materials permits of obtaining in the frequency range to be transmitted, a decrease in permeability with increasing frequency such that the circuit-arrangement exhibits an advantageous action as a band-pass filter.

The invention will now be explained in connection with the accompanying drawing in which:

Fig. 1 shows a single parallel resonant circuit band-pass filter;

Fig. 2 shows a coupled parallel resonant circuit band-pass filter; and

Fig. 3 shows an aerial circuit employing a band-pass filter according to the invention.

That a circuit comprising a core of the said ferromagnetic material exhibits the desired property is accounted for by the fact that in the region in which the permeability decreases upon increasing frequency, the inductance decreases to the same extent. More particularly if use is made of a parallel resonant circuit, such a circuit accommodates itself as it were to the impressed frequency and the impedance of the circuit varies with frequency less rapidly than in

the case of a circuit comprising a coil without ferromagnetic core and with otherwise the same damping. Such a circuit arrangement is shown in Fig. 1 of the drawing in which a band-pass filter designed to have an impedance which varies with frequency in such manner that as the frequency increases the impedance of the filter increases through to a less rapid extent than if the coil had no core. In this figure, the filter consists solely of a coil **1** provided with a core **2** of mixed crystal ferrite and a capacitor **3** in parallel therewith.

The relationship between permeability and frequency in a determined region may be approximately represented by the formula

$$\text{perm.} = Cxf^{-m}$$

in which C is a constant and m a quantity which is dependent on the kind of the constitutive material of the core. According to the invention, the kind of the material with respect to the frequencies to be transmitted is preferably chosen to be such that the quantity m is comprised between 0.8 and 2 in the region to be transmitted.

It may readily be shown that, if $m=2$, the ideal position would be obtained, that is to say that, when the coil forms part of an oscillatory circuit, the circuit is in resonance for any frequency of the range under consideration. Consequently, the aim will be to approach this position.

It has been found that the materials which are known under the name "Ferroxcube" and which contain ferrite as the principal constituent exhibit highly advantageous properties for the purpose in view. This material has a general formula $MO.Fe_2O_3$, in which M designates a bivalent metal, e. g. Mn, Cu, Ni or Mg. It is essential that the material consists of homogeneous cubic crystals and in general will consist of mixed crystals of two or more ferrites.

With respect to circuit-arrangements comprising parallel resonant circuits which pass a band of frequencies widened by means of a parallel resistance, the subject of the invention affords the advantage of obtaining a much more advantageous value of the product of the bandwith and the maximum impedance of the circuit if, for example, the term bandwith is understood to mean the difference between two frequencies at which the impedance drops below a determined portion of the maximum impedance.

Variation in the composition of the material permits of varying the frequency range in which the relationship between permeability (or losses) and frequency occurs which is optimum for the invention so that band-pass filter action of the circuit-arrangement for different ranges of frequencies may be obtained by suitable choice of the material.

The present invention is applicable to amplifiers comprising parallel resonant circuits of the kind which are required to pass a frequency band of determined width, but it is also applicable to amplifiers for use at video-frequency voltages, in which oscillations of any frequency below a determined limiting frequency are required to be amplified. Furthermore it is applicable to band-pass filters comprising coupled circuits and band-pass amplifiers in which the coupling elements between the various successive stages are constituted by oscillatory circuits which are relatively detuned. Such a circuit is shown in Fig. 2 which comprises two parallel resonant circuits

each comprising a coil **4** and **5** respectively coupled together by a core consisting of a mixed crystal ferrite **6** and **7** respectively and shunted by a capacitor **8** and **9** respectively.

It has been found that particularly advantageous results may be obtained in the range of frequencies comprised between 10 and 100 megacycles/sec.

In this connection it may be mentioned that in radio-receivers comprising frame aerials it is known as such to provide the receiving frame with ferromagnetic material in order to ensure better concentration of the magnetic lines of force passing through the frame. The present invention is distinguished from this known device not only in that there is worked in a range of frequencies chosen in a particular manner with respect to the range of frequencies to be received but also in that the dimensions of the aerial of ferromagnetic material are great with respect to those of the coil. The latter may be concentrated on a comparatively small length of the rod-shaped core. The aerial is preferably positioned in the direction of the magnetic lines of force and may be active as a magnetic dipole bringing about strong concentration of the magnetic lines of force. For similar reasons as the parallel resonance coil with magnetic core as already described, such an aerial will be suitable, for uniform reception of frequencies located within a broad region. An aerial coupling circuit according to the invention is illustrated in Fig. 3 which comprises a primary winding **10** in the antenna circuit coupled to a secondary winding **11** by means of a core consisting of a mixed crystal ferrite **12**, the secondary being tuned by a condenser **13**.

What I claim is:

1. A broad band-pass circuit arrangement, particularly for passing high-frequency electrical oscillations, consisting solely of an inductance coil having a core of ferromagnetic material and a capacitor in parallel with the coil, said core material consisting essentially of a mixed crystal ferrite, said core material having a magnetic permeability $\mu=Cf^{-m}$ wherein C is a constant, f is a frequency of oscillation, and m is a number lying between 0.8 and 2.

2. A broad band-pass circuit arrangement, particularly for passing high-frequency electrical oscillations, consisting solely of an inductance coil having a core of ferromagnetic material and a capacitor in parallel therewith, said core material consisting essentially of a mixed crystal ferrite having a magnetic permeability which materially decreases with increasing frequency in the pass band.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,441,116	Mackey	May 4, 1948
2,442,310	Polydorff	May 25, 1948
2,452,529	Snoek	Oct. 26, 1948

OTHER REFERENCES

Publication: Philips Technical Review, vol. 8, No. 12, pages 353–360, Dec. 1946.