June 15, 1937. J. P. MINTON ET AL 2,084,160

FILTER SYSTEM FOR LOUDSPEAKERS

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Fig. 1

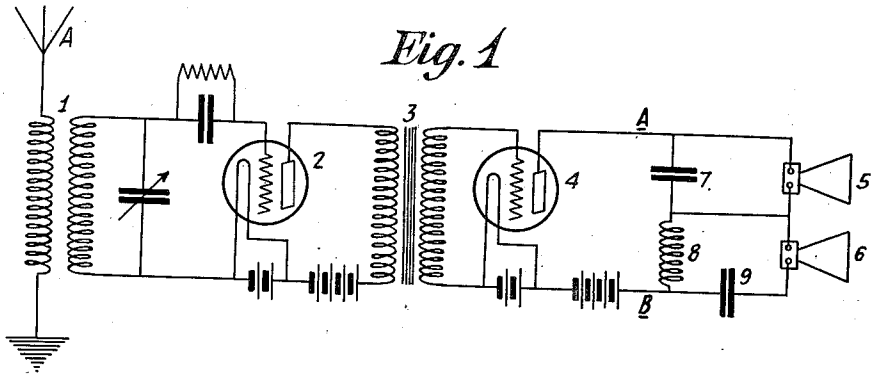
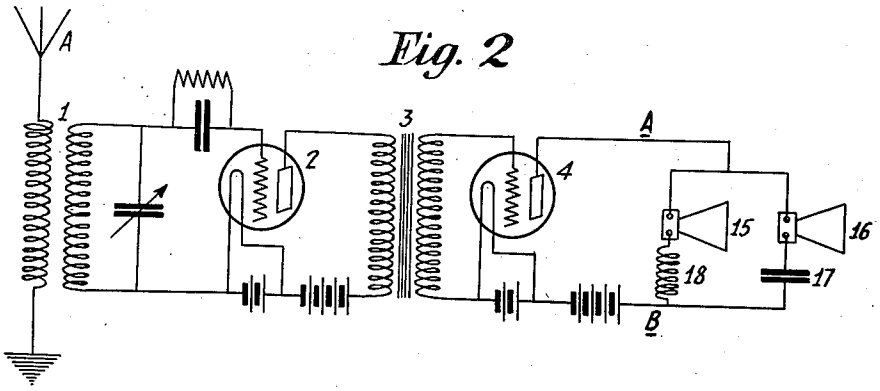


Fig. 2



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Fig. 3

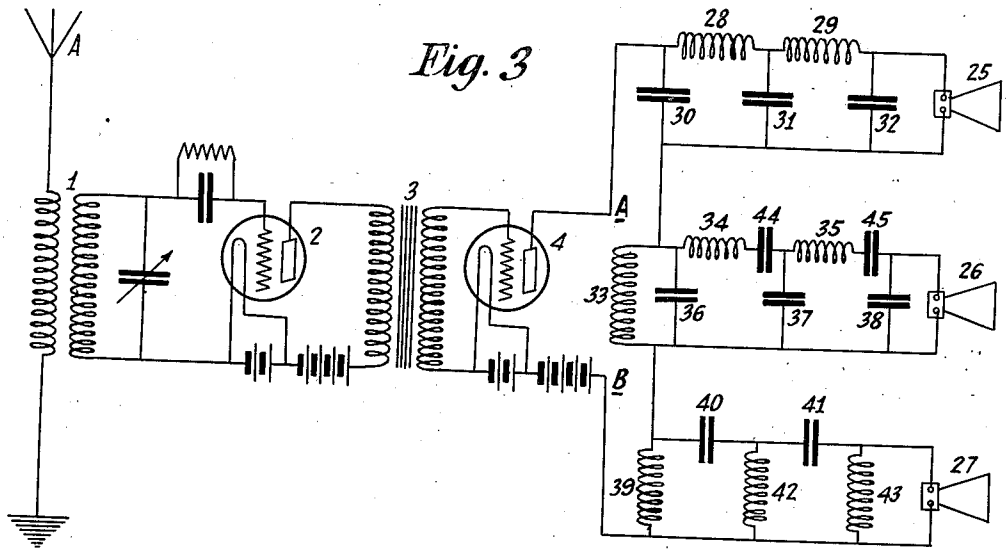


Fig. 4

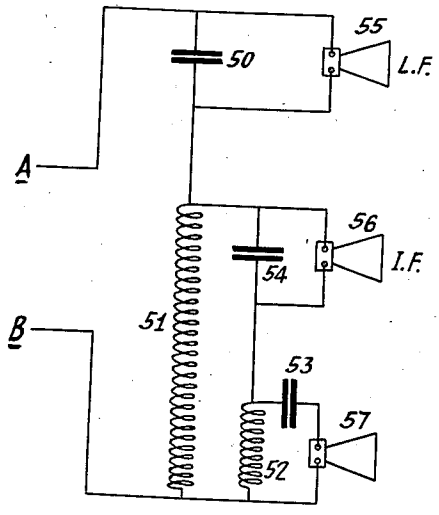
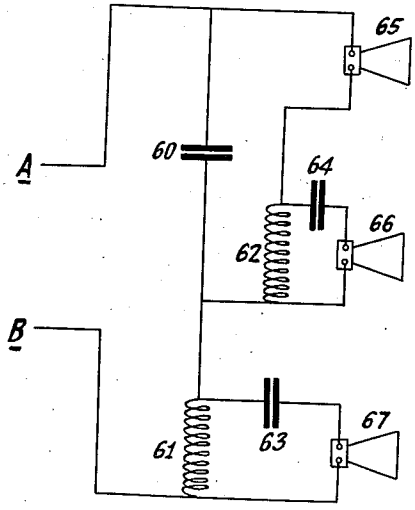


Fig. 5



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Patented June 15, 1937 2,084,160

UNITED STATES PATENT OFFICE

2,084,160

FILTER SYSTEM FOR LOUDSPEAKERS

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Application June 9, 1925, Serial No. 35,893

11 Claims. (Cl. 179—1)

The invention refers to improved loud speaker construction and has for its principal object to provide a device in which different bands of frequencies resulting from a composite or complex sound are separately amplified and thereafter blended to give a true intensified reproduction of the original sound.

A more specific object of the invention is to provide, in a sound reproducing and amplifying device, a plurality of elements responsive to different bands of frequencies with filtering means associated with the several elements to select the band of frequencies appropriate to each element.

Still another object of the invention is to provide a sound producing device in which sounds are caused by current changes in electric circuits, in which several elements are provided for producing sounds corresponding to different bands of frequencies and in which electric frequency filters are associated with the several elements to select the frequencies of the band appropriate to each element and to prevent interference from frequencies outside the appropriate band.

Still another object of the invention is to provide such a filter arrangement in which resonant points or depressions in the sound response of the several units will be corrected for.

In our copending application, Serial No. 732,153 filed August 15, 1924 there is disclosed an electro-acoustic device of the loud speaker type in which two or a plurality of sound producing devices each responsive to a particular band of frequencies are provided for improving the production of a compound or complex sound. The present invention is particularly applicable to devices of this nature although, of course, it is not limited to such devices being in general applicable to any case in which it is desired to separately reproduce and amplify a plurality of bands of frequencies in sound producing devices.

If a sound producing device includes a high and low frequency unit in series or in parallel for separately amplifying and reproducing different frequencies there would be disturbance in each unit caused by frequencies to which theoretically only the other units should be responsive. These effects are not so noticeable in the low frequency unit as this arrangement does not ordinarily respond readily to high frequencies. It is important however that none of the low frequencies actuate the high frequency unit for this unit will then induce undesirable harmonics in the low tones thereby interfering with a faithful reproduction of the original sound. A high frequency filter is therefore essential in connection with the high frequency unit. It may also be advisable to use such a filter in connection with the low frequency arrangement under some circumstances and the use of such a device will improve the operation in all cases as it may be used to preserve uniformity and constancy of impedance.

For a more complete disclosure of our invention, reference should be had to the following detailed description which should be read in connection with the accompanying drawings in which,

Fig. 1 shows an application of the invention to a loud speaker system comprising a high frequency and low frequency unit in series,

Fig. 2 shows an application of the invention to a loud speaker system comprising a high frequency and low frequency unit in parallel,

Fig. 3 shows the invention as applied to a loud speaker system comprising a low frequency unit, an intermediate frequency unit and a high frequency unit in series, and

Figs. 4 and 5 show modifications of the arrangement in Fig. 3.

Referring to Fig. 1 a loud speaker system comprising the low frequency unit 5 and high frequency unit 6 in series is connected to a well known type of radio receiver. The receiver comprises the antenna A, antenna coupling 1, detector tube 2, audio frequency transformer 3 and audio frequency amplifier 4. The loud speaker system is connected in the plate circuit of the audio frequency amplifier 4. While only one amplifying tube has been shown, it is obvious that any number in cascade could be used to get the desired amplification, at least two being ordinarily required. The low frequency unit 5 is shunted by a condenser 7 while the high frequency unit 6 is shunted by a choke coil 8 and has a condenser 9 in series with it. The low frequency unit should have a great many turns so as to give it high inductance and consequently high impedance for low frequencies. Its impedance at its operating frequency should be substantially of the order of the internal impedance of the amplifying tube at this frequency. Ordinarily this would be about 20,000 ohms. The high frequency unit should likewise have an impedance of about 20,000 ohms when operating at the frequency at which it will be used.

If the units were connected in series without filters the high impedance of the low frequency unit would absorb most of the energy of the high frequencies and allow only a small amount to reach the high frequency unit. The purpose of the condenser 7 is to bypass the high frequencies around the low frequency unit and it should be so designed as to have small reactance to high frequency currents and large reactance to low frequency currents.

In order to preserve the purity of the low frequency tones from the device it is also desirable to prevent passage of low frequencies through the high frequency device. The voltage drop for

operating the high frequency unit is taken from a choke coil 8 of fairly high impedance at the frequencies to which the high frequency unit will respond but of fairly low impedance to low frequencies. The low frequencies are kept out of high frequency device by the condenser 9 which is designed to offer small reactance to high frequencies but large reactance to low frequencies.

This device therefore permits the production of high frequency and low frequency sounds by separate units and prevents any effect on each unit by frequencies not intended for it. The device will therefore give tones of unusual purity and increased intensity which are faithful reproductions of the original sounds.

Another very useful result may be obtained by correctly proportioning the constants of the filter systems. If it happens that there be any highly pronounced resonant peak in the sound response of both units this peak may be avoided by choosing suitable values of the inductance 8 and condenser 7 thereby causing them to absorb more energy at this particular resonant frequency than at others. Likewise any depression or dip in sound response may be corrected for by a suitable choice of the condenser 9 in conjunction with the inductance of the high or low frequency units causing more energy at the particular frequency to be available in the unit at the dip frequency.

Fig. 2 is similar to Fig. 1 but shows the high and low frequency units in parallel instead of in series. In this case the high frequency unit 16 has condenser 17 in series with it to keep out the low frequencies and the low frequency unit 15 has an inductance 18 in series with it to choke out the high frequencies. The operation of this modification is substantially the same as that of Fig. 1. It should be noted, however, that the choke coil 18 should have low impedance as compared to that of the low frequency unit. The windings of the low frequency unit ordinarily have sufficient distributed capacity to allow free passage of the high frequency current and the choke coil 18 in this case provides the voltage drop by which the high frequency unit is operated.

Fig. 3 is substantially similar to Figs. 1 and 2 except that in this case there are three units in the loud speaker device 25, 26 and 27 operating on low, intermediate and high frequencies respectively. As in the previous cases each unit is provided with a filter to select its own frequencies and prevent any other frequencies from reaching its operating coils. The high and intermediate frequencies are bypassed around the low frequency unit 25 by the condenser 30, a filtering system comprising series inductance 28 and 29 and parallel condensers 31 and 32 being provided to improve the filtering action. The intermediate frequency unit 26 is provided with a filter comprising an inductance 33 and condenser 36 in parallel for bypassing the high and low frequencies. The filtering action in this case is also improved by the network comprising the inductance 34 and 35, series condensers 44 and 45 and parallel condensers 37 and 38. The high frequency unit is shunted by an inductance 39 which allows the low and intermediate frequencies to pass freely but offers high impedance to high frequencies. A filtering network is also provided comprising the series condensers 40 and 41 and parallel inductances 42 and 43. It will be noted that generally the filter for the low frequency unit comprises inductances in series with the unit and condensers in parallel with it, the high frequency filter comprises condensers in series with the unit and inductances in parallel to it while the intermediate frequency filter partakes of the nature of both.

While the filtering system shown in Fig. 3 is rather complex and will give excellent results, it is obvious that all the refinements shown are not necessary in all cases. It may be sufficient simply to shunt the low frequency unit with a simple condenser, the high frequency unit with a simple inductance and the intermediate frequency with either an inductance and a condenser in parallel or an inductance alone or a condenser alone. It is furthermore obvious that the system comprising three units can be used with parallel connection of the units as well as series connection.

Further modifications for the three unit system are shown in Figs. 4 and 5. In Fig. 4 the low, intermediate and high frequency units are designated respectively as 55, 56 and 57. The low frequency unit as before is shunted by a condenser 50 offering a low impedance to high and intermediate frequencies. The unit 56 is shunted by a condenser 54 and the unit 57 is in parallel with an inductance 52 and in series with a condenser 53, while the combined intermediate and high frequency system comprising the units 56 and 57 is shunted by the inductance 51. The inductance 51 offers low impedance to low frequencies but high impedance to high and intermediate frequencies so that a voltage drop is obtained across it to satisfactorily operate the intermediate and high frequency units. The condenser 54 forms a high impedance for the intermediate frequency band but a low impedance for high frequencies. The condenser 53 keeps the low and intermediate frequencies out of the high frequency unit while the inductance 52 forms a low impedance by-pass for the intermediate frequencies. The filtering action is substantially the same as that explained in connection with the other figure and each unit will respond to the frequencies for which it is designed and only to those frequencies.

The arrangement in Fig. 5 is substantially similar in its operation to that shown in Fig. 4 but shows a slightly different arrangement of inductances and condensers. In this case the high frequencies are bypassed around the low and intermediate frequency units 65 and 66 through the condenser 60 while the intermediate and low frequencies are by-passed around the high frequency unit through the inductance 61. The low frequencies are blocked out of the intermediate unit by condenser 64 while the low and intermediate frequencies are blocked out of the high frequency unit by the condenser 63.

It will be apparent from the discussion in connection with Fig. 1 that the circuit constants in any of the arrangements in Figs. 2, 3, 4 and 5 can be suitably chosen to correct for resonance points in the sound response of the several units and likewise for any depression or dip in the sound response.

We have therefore provided an arrangement from which sound may be produced with unusual fidelity and intensity and while we have shown several specific examples it will be obvious to those skilled in the art that many other modifications embodying those principles may readily be arranged. We intend therefore to be limited only as indicated by the scope of the following claims.

What we claim is:

1. In combination, an electrical device having an output circuit, means for impressing a signal wave compounded of a plurality of frequencies on said device, a low frequency acoustic device and a high frequency acoustic device serially connected in said output circuit, a capacity shunted across said low frequency acoustic device and an inductance shunted across said high frequency acoustic device.

2. In combination, an electrical device having an output circuit, means for impressing a signal wave compounded of a plurality of frequencies on said device, a low frequency acoustic device, an intermediate frequency acoustic device and a high frequency acoustic device serially connected in said output circuit, a capacity shunted across said low frequency device, an inductance shunted across said high frequency device and a capacity and inductance in parallel shunted across said intermediate frequency device.

3. In a sound reproducing system, a circuit arranged to be fed from a source and including an inductance and a capacity in parallel, a sound reproducing device included in said circuit, and another circuit in series with said first circuit, said other circuit including another sound reproducing device and an impedence separate from the source and paralleling said other device.

4. In a sound reproducing system, a tunable parallel circuit including in one of its branches, a sound reproducer, and another sound reproducer connected in series with said circuit.

5. An electro-acoustical system for the reproduction of sound comprising wave repeating apparatus, an output circuit for said apparatus, a plurality of series connected sound reproducers, connections for simultaneously energizing said sound reproducers from said output circuit, one of said sound reproducers having response characteristics such that it responds with greatest fidelity over a predetermined band of audible frequencies, another of said sound reproducers having response characteristics such that it responds with greatest fidelity over a different band of audible frequencies, and reactance elements for controlling the energy supplied to said sound reproducers so that each sound reproducer is supplied primarily with the band of frequencies to which it responds with greatest fidelity, said reactance elements being connected in series.

6. A system for the reproduction of sound comprising wave repeating apparatus, an output circuit for said apparatus, a plurality of sound reproducers connected in series for simultaneous energization from said output circuit, said sound reproducers having different response characteristics whereby one sound reproducer is adapted to respond with greatest fidelity over a predetermined band of audible frequencies and another sound reproducer is adapted to respond with greatest fidelity over a different band of audible frequencies, and filter circuits interposed between said apparatus and said sound reproducers, for supplying to each sound reproducer the band of frequencies to which it responds with greatest fidelity and for excluding other frequencies to a substantial extent, said filter circuits including reactance elements connected in parallel with said sound reproducers and in series with respect to each other.

7. Apparatus for the reproduction of sound comprising wave repeating apparatus, an output circuit for said apparatus, a plurality of series connected sound reproducers connected for simultaneous energization from said output circuit, at least one of said sound reproducers having a response characteristic such that it responds with greatest fidelity at the higher frequencies in the audible range, at least another of said sound reproducers having a response characteristic such that it responds with greatest fidelity at the lower frequencies in the audible range, and filter circuits interposed between said sound reproducers and said apparatus, said filter circuits having reactance elements connected in parallel with said sound reproducers and in series with each other, and being designed so that the sound reproducer adapted to respond better at the higher frequencies is supplied primarily with high frequency energy and the sound reproducer adapted to respond better at the lower frequencies is supplied primarily with low frequency energy.

8. Apparatus for the reproduction of sound comprising a wave repeater, an output circuit for said repeater, a plurality of sound reproducers connected for simultaneous operation, said sound reproducers having different response characteristics whereby one of said sound reproducers is adapted to respond with greatest fidelity at the higher frequencies in the audible range and another of said sound reproducers is adapted to respond with greatest fidelity at the lower frequencies in the audible range, filter circuits interposed between said output circuit and said sound reproducers, said filter circuits being designed to supply to each sound reproducer the band of frequencies to which it responds with highest fidelity, and reactance elements arranged in one of said filter circuits to correct for excessive or inadequate response of its associated sound reproducer at any particular frequency within the band of frequencies to which the sound reproducer is adapted to respond with highest fidelity.

9. In acoustic apparatus for sound producing means, a plurality of discrete sound reproducers, a first reproducer responsive to relatively high audio frequencies, a second sound reproducer responsive to lower frequencies, and means associated with the first said reproducer to eliminate sounds of such lower frequency, said means comprising a reactance which is in shunt to the first and in series with the second of said reproducers.

10. In acoustic apparatus for sound producing means, a plurality of discrete sound reproducers, a first reproducer responsive to relatively high audio frequencies, a second sound reproducer responsive to lower frequencies, and means associated with the second mentioned sound reproducer to absorb sounds at relatively high frequencies, said means comprising a reactance which is in shunt to the first and in series with the second of said reproducers.

11. In acoustic apparatus for sound producing means, a plurality of discrete sound reproducers, a first reproducer responsive to relatively high audio frequencies, a second sound reproducer responsive to lower frequencies, and means associated with each said sound reproducer for eliminating the frequencies at which the other said sound reproducers is responsive, said means comprising series-connected inductive and capacitive reactances, each reactance shunting one of the reproducers.

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