April 5, 1932. B. F. MIESSNER 1,852,125

ELECTRICAL FILTER SYSTEM

Filed Jan. 8, 1929

Fig. 1.

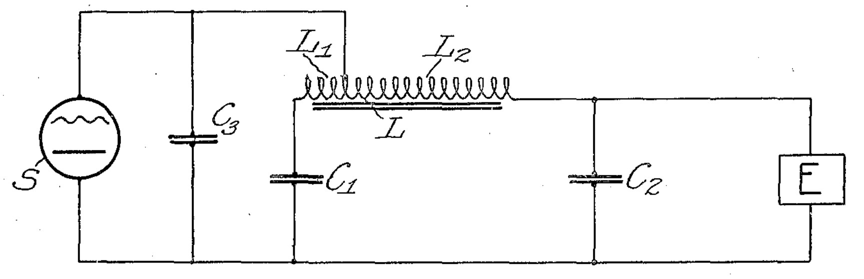


Fig. 2.

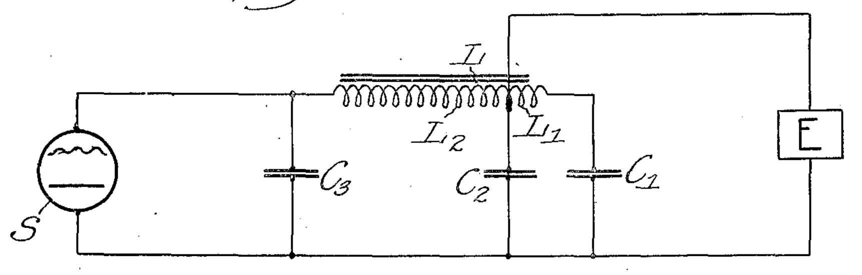
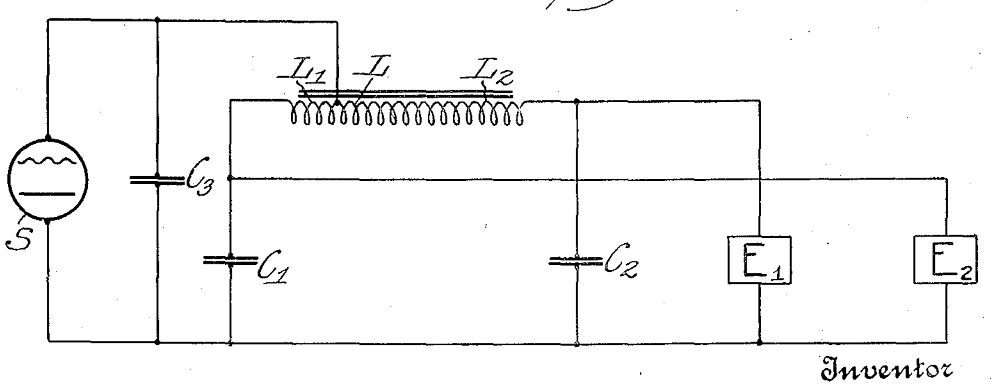


Fig. 3.



Inventor
BENJAMIN F. MIESSNER

By Attorney [signature]

Patented Apr. 5, 1932 1,852,125

UNITED STATES PATENT OFFICE

BENJAMIN F. MIESSNER, OF SHORT HILLS, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

ELECTRICAL FILTER SYSTEM

Application filed January 8, 1929. Serial No. 330,995.

The present invention relates to electrical filter systems for smoothing out unsteady electrical currents, and particularly to arrangements for making such systems efficient in the function of filtration with an economical use of filter apparatus.

An object of the invention is to oppose the effect of the fluctuating component of the current in one part of the system by the effect of the fluctuating component in another part of the system to bring about a neutralizing smoothing out effect, thereby saving in amount of filter material ordinarily required for effective filtration.

Another object is to employ, when a system permits of the division of the direct current component of the work current, opposing flux effects in filter coils to avoid excessive flux conditions tending to lessen inductance values of such coils.

The invention will be understood by reference to the figures of the accompanying drawings in which like reference characters represent like parts so far as possible.

Fig. 1 diagrammatically illustrates a simple electrical filter embodying my invention. Fig. 2 illustrates a modification of the arrangement of Fig. 1. Fig. 3 shows a filter arrangement including the feature of divided direct current components acting to reduce flux intensity in a filter coil.

In Fig. 1 the filter system is shown supplied from a source S with a periodically fluctuating current, such as a rectified alternating current or commutated direct current. The filter system is shown to include an inductance coil L spanned by condensers C_1 and C_2, and is indicated as being connected to a work circuit including load E, such as the plate circuit or circuits of one or more three electrode vacuum tubes requiring direct current energizing for operation, as in a signal current amplifier. A condenser C_3 may be connected across the source of supply S if desired as a storage capacity for supply energy and to aid in smoothing out the supply current in cases where the energy demand is large, or where the fluctuations in the supply current are severe.

It will be noted that I connect the source S to the coil L at a point intermediate its ends, thus dividing coil L into two components L_1 and L_2, and the portion L_1 forms an auxiliary alternating current circuit by way of condenser C_1. Because condenser C_1 prevents flow of the direct current component in the auxiliary path including this condenser and the L_1 portion of the coil, the direct current is directed into the work circuit including the load consuming element or elements E. However, fluctuating or alternating current components tend to divide and flow in two directions in coil L, thus permitting choosing proper values of the L_1 portion of the coil and capacity of condenser C_1 with respect to L_2 and C_2 such that the alternating current component in portion L_1 substantially neutralizes the alternating current component in portion L_2, thus leaving the current going to the load E substantially free from fluctuations. Or any desired degree of fluctuations may be left in the working component of the current, as may be desired under certain circumstances, as for example when fluctuation in a succeeding stage of an amplifier system is needed to buck or oppose fluctuation coming from a preceding stage.

I have in general chosen the coil portion L_1 to be about one quarter of the whole coil, and by making the capacity of condenser C_1 adequately large, a larger alternating current component tends to flow through the lower impedance path including these elements than the higher impedance path of the larger portion L_2, condenser C and load E, thus making it possible to substantially eliminate the ripple or fluctuations across the load.

In Fig. 2 the source S is connected to one terminal of the coil L and the load E is connected so as to divide the coil into two portions L_1 and L_2, the alternating current component in L_1 by way of condenser C_1 tending to neutralize the alternating current component in L_2 as in the case of Fig. 1. The selection of the values of the elements in Fig. 2 is substantially the same as in the case of Fig. 1.

Consideration of the elements of Figs. 1 and 2, with an analysis of the inherent actions and reactions thereof when the system functions as described, explains the effectiveness of the system for the elimination of disturbing currents of the frequency especially desired to be eliminated with a small quantity of material. The auxiliary path includes condenser C_1 and coil L_1 very closely coupled to coil L_2 through being wound on the same iron core, so that the mutual inductance between coils L_1 and L_2 is large compared to the inductance of coil L_1 per see with the less than unity ratio between coils L_1 and L_2, I employ in this invention. The consequent large mutual inductance is effective in the auxiliary path, combining with the inductance of coil L_1 to form the total effective inductance, but since the mutual inductance has no resistance component, the resistance is merely that of the smaller coil L_1 in the absence of an effective resistance component in the choice of a good quality condenser at C_1. The larger the effective inductance of the auxiliary circuit, the less, and therefore more economical, can the capacity of condenser C_1 be to eliminate disturbing currents or fluctuations of a particular frequency, and this result I secure by not using a large inductance with corresponding high resistance, but with a small low resistance inductance supplemented by a larger mutual inductance substantially devoid of resistance component.

The arrangement of Fig. 3 is particularly suitable where two loads E_1 and E_2 requiring different degrees of filtering are to be supplied. For example, the load E_2 may be the plate circuit of the tube of the last stage of an amplifier and the load E_1 the plate circuit of a preceding stage in the same amplifier. Because of the amplification which fluctuations in the preceding stage undergo on the way to the last stage it is particularly desirable that the current supplying the plate circuit of the preceding stage be highly filtered. Also, it may be that large fluctuations are desired in the last stage to neutralize amplified fluctuations coming from a preceding stage.

Fig. 3 only differs from Fig. 1 through having the load E_2 connected from a point between the L_1 portion of coil L and condendenser C_1. The current for load E_2 is filtered only by L_1, C_3 and C_1, whereas the current for load E_1 is additionally filtered by condenser C_2 and has the advantage of the larger portion L_2 of coil L. However, as in the case of Fig. 1, the alternating current components in portions L_1 and L_2 oppose and act to reduce the fluctuating component of the current delivered to both loads.

In addition to the opposing alternating current components Fig. 3 provides for flux effects of two direct current components in coil L opposing each other, thus reducing the permanent flux in the core of coil L to avoid any saturation effects adversely affecting the alternating current inductance of the coil. If the direct current load of E_2 is larger than the direct current load of E_1, as is usually the case in amplifying systems, it is obvious that the larger current flowing through the smaller portion L_1 is effective against a smaller current flowing through the larger porton L_2 to more nearly equalize the opposing ampere turns of the two portions. This maintaining of large inductance is of importance to good filtering.

I have found the filter arrangements herein described of great assistance in eliminating hum effects from radio receivers and like amplifiers employing three-electrode vacuum tubes energized by the rectification and filtration of commercial alternating current, and have with the aid of my systems effected great savings in the amount of filter material necessary to commercially acceptable hum requirements in such devices.

Having fully described my invention, I claim:

1. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including an inductance divided into two sections with a ratio of at least 2 to 1 by a tap, one section of said inductance being connected between one terminal of said source and said work circuit, a condenser connected between the other terminal of said source and said tap, and condensers connected between said other terminal and each terminal of said inducance whereby the alternating current component of the current flowing through said inductance is substantially neutralized.

2. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including an inductance divided into two sections with a ratio of at least 2 to 1 by a tap, one section of said inductance being connected between one terminal of said source and said work circuit, a condenser connected between the other terminal of said source and said tap, and condensers connected between said other terminal and each terminal of said inductance, one of said condensers constituting a storage condenser for said source, whereby the alternating current component of the current flowing through said inductance is substantially neutralized.

3. In an elctrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including an inductance divided into two unequal sections by a cap, the larger of said sections being connected between one terminal of said source and said

work circuit, a condenser connected between the other terminal of said source and said tap, and condensers connected between said other terminal and each terminal of said inductance, whereby the alternating current component of the current flowing through said inductance is substantially neutralized.

4. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including an inductance divided into two unequal sections by a tap, the larger of said sections being connected between one terminal of said source and said work circuit, a storage condenser connected between the side of said larger section connected to the terminal of said source and the other terminal of said source, a filter condenser connected between the other side of said larger section and the other terminal of said source, and a neutralizing condenser connected between the untapped side of said smaller section and the other terminal of said source, the capacity of said neutralizing condenser being sufficiently large to cause the field of the fluctuating current flowing through said smaller section to substantially neutralize the field of the fluctuating current flowing through said larger section, whereby the current delivered to said work circuit is materially freed from fluctuations.

5. In an electrical system the combination of a source of rectified alternating current, a plurality of work circuits, and a filter system connected between said source and said work circuits, said filter system including an inductance divided into two unequal sections by a tap, each of said sections being connected between said source and a separate work circuit, a condenser connected between the other terminal of said source and said tap, and condensers connected between said other terminal and each terminal of said inductance, whereby the magnetic flux of said inductance due to the direct current component flowing to either work circuit and alternating current component of the current flowing through said larger inductance is materially reduced.

6. In an electrical system the combination of a source of rectified alternating current, a plurality of work circuits, and a filter system connected between said source and said work circuits, said filter system including an inductance divided into two sections with a ratio of at least 2 to 1 by a tap, each of said sections being connected between said source and a separate work circuit, a condenser connected between the other terminal of said source and said tap, and condensers connected between said other terminal and each terminal of said inductance, whereby the magnetic flux of said inductance due to the direct current component flowing to either work circuit and the alternating current component of the current flowing through said larger iductance is materially reduced.

7. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including an inductance divided into two unequal sections by a tap, the larger of said sections being connected between one terminal of said source and said work circuit, a capacitively reacting connection between the other terminal of said source and said tap, a capacitively reacting connection between the terminal of said larger section of said inductance and said other terminal, and a connection of substantially pure capacitive reactance between the terminal of the smaller section of said inductance and said other terminal.

8. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including two unequal inductance elements coupled together, the larger only of said elements carrying direct current and being connected in the line between one terminal of said source and said work circuit, and a condenser connected across the filter system in series with the smaller inductance, the polarity of the mutual inductance between the inductance elements being the same as would result from winding both the shunt and series inductances as a single coil and passing rectified current through one only of the last mentioned inductances, whereby the alternating current component of the current flowing through said work circuit is substantially neutralized.

9. In an electrical system, the combination of a source of rectified alternating current, a work circuit, and a filter system connected between said source and said work circuit, said filter system including two unequal inductance elements coupled together, the larger only of said elements carrying direct current and being connected in the line between one terminal of said source and said work circuit, and a substantially pure capacitively reactive system connected across the filter system in series with the smaller inductance, the polarity of the mutual inductance between the inductance elements being the same as would result from winding both the shunt and series inductances as a single coil and passing rectified current through one only of the last mentioned inductances, whereby the alternating current component of the current flowing through said work circuit is substantially neutralized.

10. A network for conveying direct current from a source to a load while attenuating alternating currents which includes elements providing a series inductance, a shunting impedance including inductance and ca-

pacity arranged in series, and a mutual inductance between the series and shunt inductances which is substantially greater than the shunt inductance and so poled that the resulting alternating magnetic fields of said inductances are opposed.

11. In a network for conveying direct current from a source to a load while attenuating pulsating currents, a series circuit including inductance and a shunt circuit including inductance and capacity and mutual inductance between said two circuits having a value substantially greater than said shunt circuit inductance, said mutual inductance between said circuits being so poled that the resulting pulsating magnetic fields of said inductances are opposed.

12. A network for conveying direct current from a source to a load while attenuating alternating currents comprising a shunt path including an inductance coil and a series path including an inductance coupled to said first named coil in such a way that the mutual inductance between said two coupled coils is substantially greater than the inductance of said first-mentioned coil, said mutual inductance being so poled that the resulting alternating magnetic fields of said inductances are opposed.

13. In a network for conveying direct current from a source circuit to a load circuit while attenuating alternating currents which comprises an iron-cored inductance coil and two condensers connected in series and forming an electrical circuit, one of said first two named circuits being connected to said network across one of said condensers and the other one of said first two named circuits being connected to said network across said other condenser and a predetermined portion of said coil, said portion being such that the mutual inductance between it and the remaining portion of the coil is substantially greater than the inductance of said first named portion.

In witness whereof, I have hereunto subscribed my name this 5th day of January, 1929.

BENJAMIN F. MIESSNER.