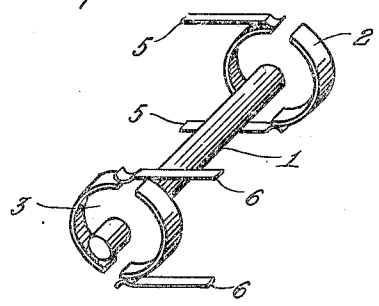
Sept. 13, 1949. C. E. G. BAILEY 2,481,562

ELECTRIC FILTER

Filed Aug. 23, 1945 2 Sheets-Sheet 1

Fig. 1.



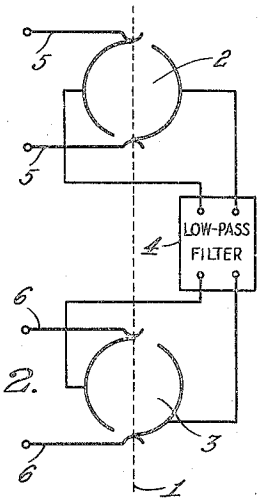


Fig. 2.

Fig. 3.

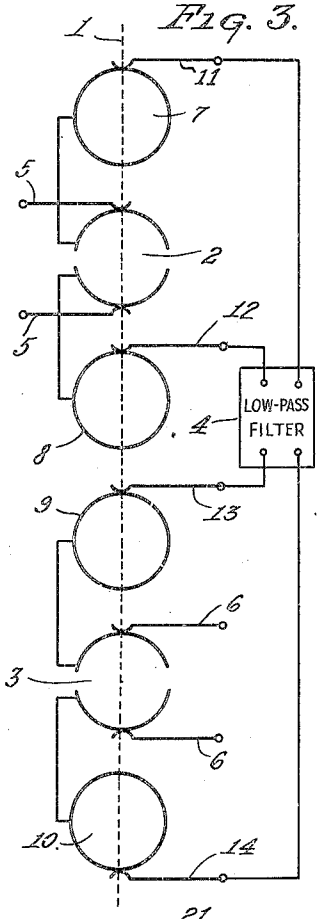


Fig. 4.

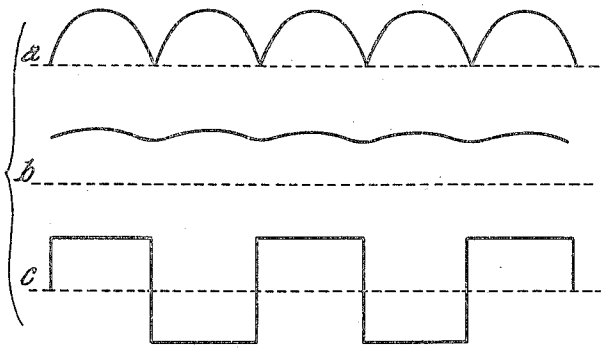


Fig. 5.

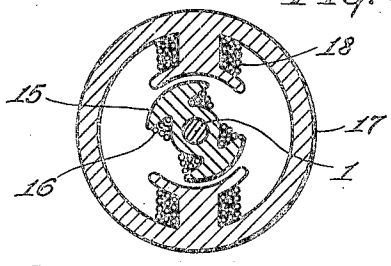


Fig. 6.

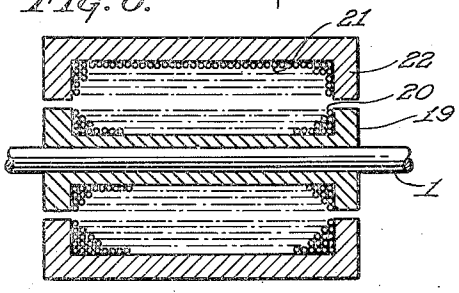
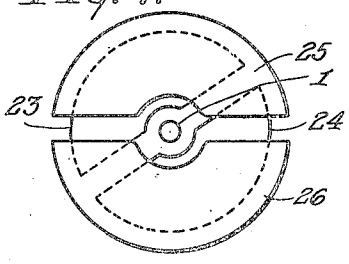


Fig. 7.



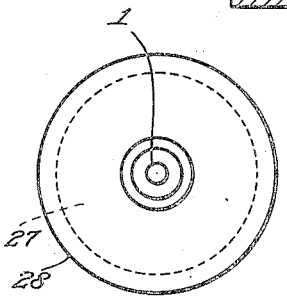


Fig. 8.

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Sept. 13, 1949. C. E. G. BAILEY 2,481,562

ELECTRIC FILTER

Filed Aug. 23, 1945 2 Sheets-Sheet 2

Fig. 9.

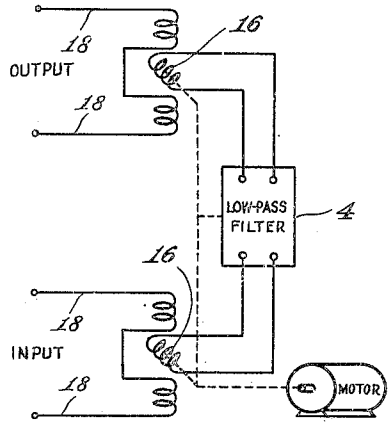


Fig. 10.

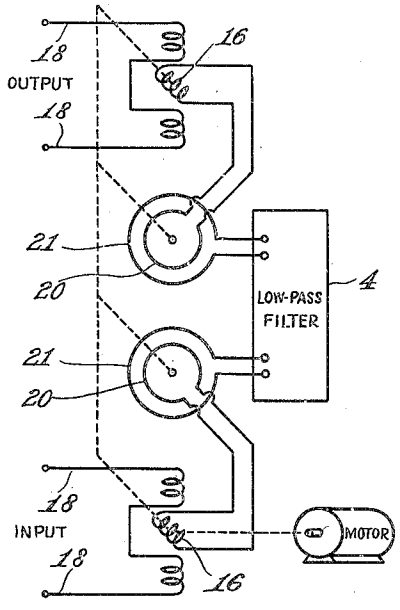


Fig. 11.

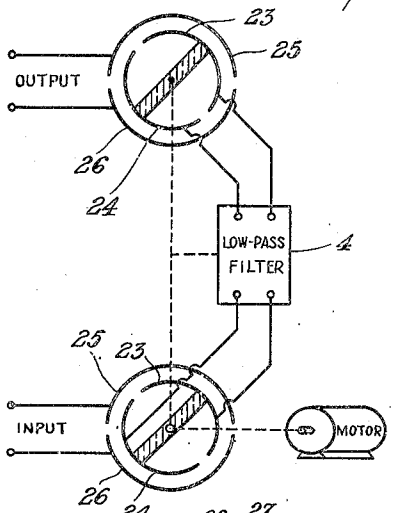
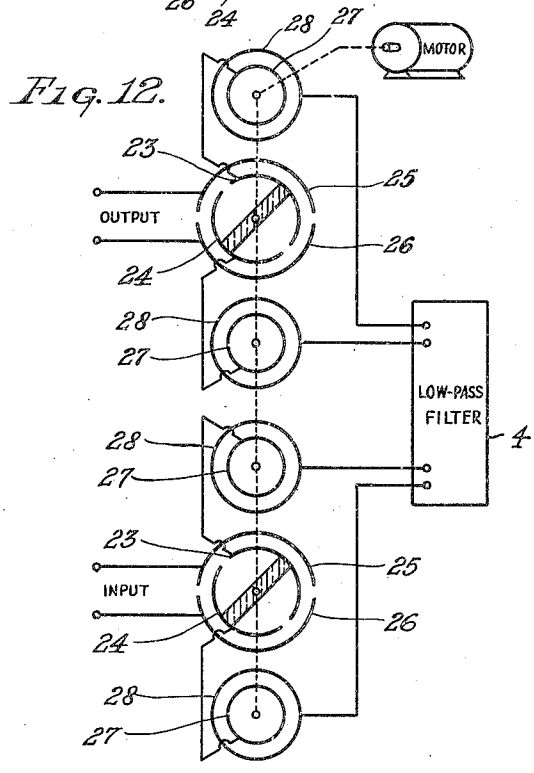


Fig. 12.



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UNITED STATES PATENT OFFICE

2,481,562

ELECTRIC FILTER

Christopher Edmund Gervase Bailey, Bournemouth, Hants, England, assignor to The Hartford National Bank & Trust Company, Hartford, Conn., as trustee

Application August 23, 1945, Serial No. 612,273
In Great Britain September 4, 1941

Section 1, Public Law 690, August 8, 1946
Patent expires September 4, 1961

9 Claims. (Cl. 171—97)

1

This invention relates to the separation from a number of superimposed electrical currents of different frequencies, those whose frequencies lie within narrow limits, or within certain multiples of those narrow limits. Arrangements are known for effecting this end by purely electrical means, such as tuned circuits or band-pass filters; but the discrimination of these filters, viz. the ratio of the frequency band to be selected to its mean frequency, has a lower limit governed by the power losses inseparable from such filters. In particular it is impossible to construct small bulk filters having small discrimination and a low mean frequency. The discrimination of the arrangement to be described is subject to no such limitation.

One object of the present invention is to provide means for effecting the desired filtering without the above-mentioned limitation.

According to the present invention, the current to be filtered is subjected to commutation such as to produce reversal of alternate half waves of the selected mean frequency, the resultant current is applied to a low pass filter and the output from the low pass filter is subjected to commutation synchronous with that applied to the current to be filtered.

The present invention can be put into effect with mechanical commutation by mounting two identical commutators on the same shaft and inter-connecting them by a low-pass filter, the brushes of one commutator being connected to the input and the other to the output. The shaft is then driven in such manner as to cause reversal of alternate half waves of the input current of the desired mean frequency.

Should it be undesirable for the apparatus comprising the low-pass filter to be rotated at the frequency of the shaft, slip rings may be mounted on the shaft and brushes brought to bear on these slip rings to make external connection to the low-pass filter.

In some cases undesirable electrical disturbances may arise from unavoidable irregularities in the contacts between commutators or slip rings and brushes. These may be avoided by replacing the direct connection from brushes to commutators or slip rings by an inductive or capacitive coupling.

In order that the invention may be more readily understood and carried into effect, it will now be described with reference to the accompanying drawing in which:

Fig. 1 is a perspective view of the filter arrangement according to the invention;

Fig. 2 is a schematic representation of the circuit embodied in Fig. 1;

Fig. 3 is a schematic representation of the circuit for the filter arrangement in which the low pass filter is located external to the commutator shaft;

2

Fig. 4 shows graphically the results obtained with a filter arrangement according to the invention;

Fig. 5 shows an alternative embodiment of the invention in which inductive coupling is employed instead of mechanical commutation;

Fig. 6 shows still another embodiment of the invention employing inductive coupling instead of mechanical commutation;

Fig. 7 illustrates an embodiment of the invention employing capacitative coupling instead of mechanical commutation; and

Fig. 8 illustrates another embodiment of the invention employing capacitative coupling instead of mechanical commutation.

Fig. 9 is a schematic representation of a circuit incorporating the inductive coupling device of Fig. 5;

Fig. 10 is a schematic representation of a circuit incorporating the inductive coupling devices of both Figs. 5 and 6;

Fig. 11 is a schematic representation of a circuit incorporating the capacitative coupling device of Fig. 7;

Fig. 12 is a schematic representation of a circuit incorporating the capacitative coupling devices of both Figs. 7 and 8.

In Fig. 1 and Fig. 2, a shaft 1 which is caused to rotate at the selected mean frequency, carries two two-pole commutators 2, 3 which are interconnected by means of a low-pass filter 4. The composite electrical current to be filtered is fed to the filter by input brushes 5 co-operating with the two poles of the commutator 2 whereas the filtered component is led out by output brushes 6 co-operating with the two poles of the commutator 3. In this arrangement the low-pass filter 4 is mounted on and rotates with the shaft 1.

Should it be undesirable for the low-pass filter to be rotated with the shaft, use can be made of the arrangement of Fig. 3 in which components corresponding to Fig. 1 and Fig. 2 are indicated by the same reference numerals as in that figure. In Fig. 2, the low-pass filter 4 is stationary and is connected to the commutators 2, 3 by slip rings 7, 8, 9, 10 which are carried on the same shaft 1 as the commutators 2, 3 and are directly connected to the poles thereof. The slip rings 7, 8, 9, 10 are engaged by stationary brushes 11, 12, 13, 14 which are directly connected to the low-pass filter 4.

The effect in both the above-described arrangements is the same and is shown graphically in Fig. 4.

Alternate half waves of a sinusoidal E. M. F. having the mean frequency are reversed in sign by the commutator 2 as represented in Fig. 4(a), and this reversed E. M. F. is applied to the input of the low-pass filter 4. The output of the low-pass filter 4 will, if the pass band is low enough in

frequency, consist of an almost constant E. M. F. as represented in Fig. 4(b). This will in turn be periodically reversed by the commutator 3 giving a square-topped wave form as represented in Fig. 4(c).

Any E. M. F. of slightly different frequency will be periodically reversed in a non-synchronous manner. Its average value, appearing at the output of the low-pass filter, will therefore slowly vary and, by making the attenuation of the filter high at the frequency of this variation, the output can be made extremely small. Thus the resultant square-top form of varying amplitude can be also made extremely small.

The effectiveness of the electro-mechanical filter described above is only governed by the useful attenuation at very low frequencies of the low-pass filter, and the inevitable losses in the low-pass filter itself affect only the power efficiency of the whole device, and not its effectiveness as a filter. Hence, for some purposes it will be sufficient to make this filter of a series resistance arm followed by a shunt capacitance arm.

It will be apparent that the filter as described is responsive also to all odd harmonics of its mean frequency; and that the square-topped wave form likewise contains all the odd harmonics of this frequency. In cases where this property is objectionable an electro-mechanical filter as described may be preceded and followed by additional low-pass filters having a cut-off frequency between the mean frequency and its third harmonic. The difficulties hereabove described as inherent to the construction of purely electrical filters of narrow discrimination do not arise in these additional low-pass filters, which are only required to discriminate between frequencies whose ratio is 3:1.

With arrangements as described with reference to Figs. 2 and 3, undesirable electrical disturbances may in some cases arise from unavoidable irregularities in the contacts between commutators and brushes or between slip rings and brushes. There disturbances may be avoided by replacing the direct connection from brushes to commutators or slip rings by an inductive or capacitive coupling of the character illustrated in Figs. 5 to 8.

Fig. 5 shows an inductive coupling to replace a commutator. The shaft 1 carries a two-pole armature 15 having a winding 16 and surrounded by a stator 17 having a two-pole field winding 18 of a conventional type.

Fig. 6 shows an inductive coupling to replace a slip ring. The shaft 1 carries an armature 19 on which a helical coil 20 is wound co-axially with the shaft. This coil is surrounded by a stationary coil 21 which is also helically wound coaxially with the shaft and is carried by an armature 22. The armatures are preferably ferromagnetic.

Fig. 7 shows a capacitive coupling to replace a commutator. The shaft 1 carries a pair of semi-circular vanes 23, 24, which are perpendicular to the shaft. These vanes 23, 24 cooperate with parallel semi-circular fixed vanes 25, 26.

Fig. 8 shows a capacitive coupling to replace a slip ring. The shaft 1 carries an annular vane 27 perpendicular to the shaft and co-operating with a parallel fixed annular vane 28.

The external connections and method of operation with inductive or capacitive couplings are similar to those described with commutators and slip rings with reference to Figs. 2 and 3.

As shown in Fig. 9, when employing inductive means in an arrangement equivalent to Fig. 2, a pair of inductive devices of the type illustrated in Fig. 5 is provided, which devices serve the same function as that performed by the commutators in Fig. 2. The rotor windings 16 of the two devices are intercoupled through low-pass filter 4, the input being fed to the stator winding 18 of one device and the output being taken from the stator winding 18 of the other device. In Fig. 10, there is shown an inductive arrangement analogous to that in Fig. 3, a pair of couplers of the type shown in Fig. 6 being provided to serve the same function as the slip rings in Fig. 3. The low-pass filter 4 is connected between the stator coils 21 of the couplers, the rotor coil 20 of one coupler being connected to the rotor winding 16 of the input device, and the rotor coil 20 of the other coupler being connected to the rotor winding 16 of the output device.

As shown in Fig. 11, when employing capacitative means in an arrangement equivalent to that in Fig. 2, a pair of capacitative devices of the type illustrated in Fig. 7 is provided, which devices serve the same purpose as the commutators in Fig. 2. The rotor vanes 23 and 24 of the two devices are intercoupled through low-pass filter 4, the input being impressed on the stator vanes 25 and 26 of one device and the output being derived from the stator vanes 25 and 26 of the other device. In Fig. 12 there is shown a capacitative arrangement analogous to that of Fig. 3, two pairs of capacitative couplers of the type shown in Fig. 8 being provided to serve the same function as the slip rings in Fig. 3. The low-pass filter 4 is connected between the stator discs 28 of one pair of couplers and the stator discs 28 of the other pair of couplers. The rotor discs 27 of the one pair of couplers are connected respectively to the rotor vanes 23 and 24 of the input device, while the rotor discs of the other pair of couplers are connected respectively to the rotor vanes 23 and 24 of the output device.

From the description with reference to Fig. 4 it will be apparent that in putting the present invention into practice, the reversal of the input current should occur not only at the same periodicity as the selected frequency but also in phase with the component of that frequency in the composite input current, so as to obtain the desired reversal of alternate half-waves as represented in Fig. 4(a).

Filters according to the present invention are specially applicable to direction finding apparatus of the kind described in co-pending patent application 570,656, now abandoned, the commutator shaft described above can be driven from rotating mechanism forming part of the said direction finding apparatus.

I claim:

1. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of superimposed currents of different frequencies, comprising a polarity reversing member responsive to the selected frequency of said current for producing a cyclically varying current of constant polarity, a filter network coupled to said polarity reversing member for removing the cyclical variations in said cyclically varying current, and a second polarity reversing member coupled to said filter network for alternately reversing the polarity of the current derived from said filter network in synchronism with said first polarity reversing member.

2. Electrical apparatus for separating a current component of a selected frequency from a com-

posite current including a plurality of superimposed currents of different frequencies, comprising a first commutator member for converting said composite current into a cyclically varying current of constant polarity, a filter network coupled to said commutator member for removing said cyclical variations in said cyclically varying current, and a second commutator member coupled to said filter network for alternately reversing the polarity of the current derived from said filter network in synchronism with said first commutator member.

3. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of superimposed currents of different frequencies, comprising a shaft member driven at rate synchronous with said selected frequency, a first commutator member mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network coupled to said commutator member for removing said cyclical variations in said cyclically varying current, and a second commutator member coupled to said filter network for alternately reversing the polarity of the current derived from said filter network in synchronism with said first commutator member.

4. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of currents of different frequencies, comprising a shaft member driven at a rate synchronous with said selected frequency, a first commutator member having two segments mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network coupled to said commutator member and mounted on said shaft for removing said cyclical variations in said cyclically varying current, and a second commutator member having two segments mounted on said shaft and coupled to said filter network for alternately reversing the polarity of the current derived from said filter network in synchronism with said first commutator member.

5. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of superimposed currents of different frequencies, comprising a shaft member driven at a rate synchronous with said selected frequency, a first commutator member having two segments mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network mounted independently of said shaft and coupled to said commutator member for removing the cyclical variations in said cyclically varying current, means for coupling said filter network to said commutator member, a second commutator member having to segments and mounted on said shaft, and means for coupling said filter network to said second commutator member whereby said second commutator member alternately reverses the polarity of the current derived from said filter network.

6. Electrical apparatus for separating a current component of a selected frequency from a composite current including a plurality of superimposed currents of different frequencies, comprising a shaft member driven at a rate synchronous with said selected frequency, a first two pole electromagnetic structure mounted on said shaft for converting said composite current into a cyclically varying current of constant

polarity, a filter network coupled to said electromagnetic structure for removing the cyclical variations in said cyclically varying current, and a second two-pole electromagnetic structure mounted on said shaft and coupled to said filter network for alternately reversing the polarity of the current derived through said filter network in synchronism with said first electromagnetic structure.

7. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of superimposed currents of different frequencies, comprising a shaft member driven at a rate synchronous with said selected frequency, an inductively coupled polarity reversing member mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network mounted independently of said shaft and coupled to said polarity reversing member for removing the cyclical variations in said cyclically varying current, inductive coupling means for connecting said filter network to said polarity reversing member, a second inductively coupled polarity reversing member mounted on said shaft, and a second inductive coupling means for coupling said second polarity reversing member to said filter network whereby said second polarity reversing member alternately reverses the polarity of said current derived through said filter network in synchronism with said first polarity reversing member.

8. Electrical apparatus for separating a current component of selected mean frequency from a composite current including a plurality of superimposed currents, comprising a shaft member driven at a rate synchronous with said selected frequency, a capacitatively coupled polarity reversing member mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network coupled to said polarity reversing member for removing the cyclical variations in said cyclically varying current, and a second capacitatively coupled polarity reversing member coupled to said filter network for alternately reversing the polarity of the current derived through said filter network in synchronism with said first polarity reversing member.

9. Electrical apparatus for separating a current component of selected frequency from a composite current including a plurality of superimposed currents comprising a shaft member driven at a rate synchronous with said selected frequency, a capacitatively coupled polarity reversing member mounted on said shaft for converting said composite current into a cyclically varying current of constant polarity, a filter network mounted independently of said shaft and coupled to said polarity reversing member for removing the cyclical variations in said cyclically varying current, a capacitative coupling means for connecting said filter network to said polarity reversing member, a second capacitatively coupled polarity reversing member mounted on said shaft, and capacitative coupling means for connecting said second polarity reversing member to said filter network whereby said second polarity reversing member alternately reverses the polarity of said current derived through said filter network in synchronism with said first polarity reversing member.

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No references cited.