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MULTIPLE FREQUENCY FILTER

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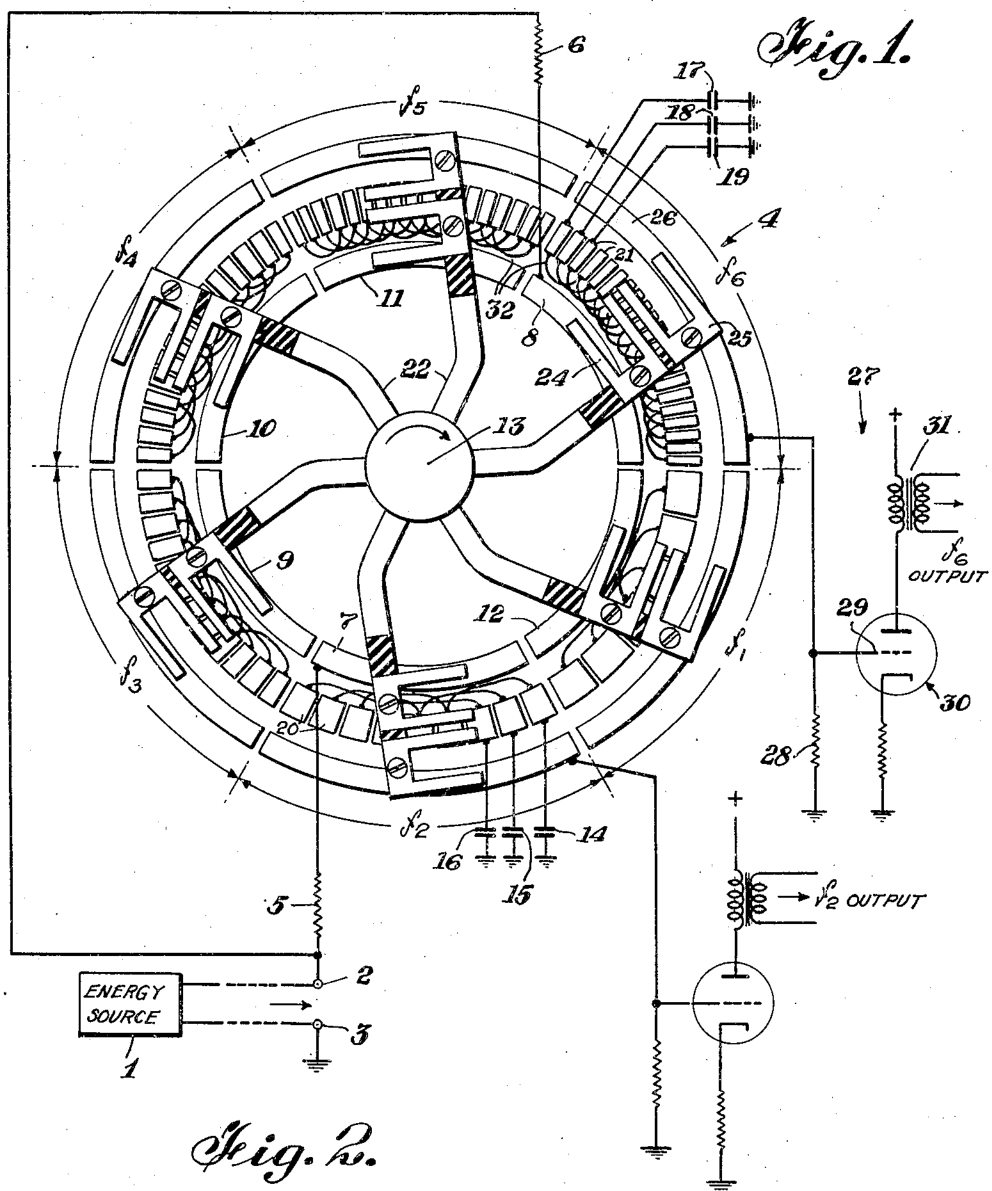

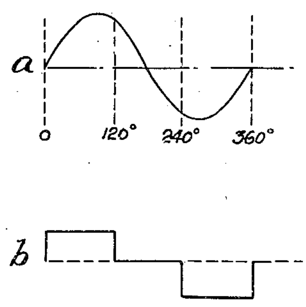

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MULTIPLE FREQUENCY FILTER

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11 Claims. (Cl. 178—44)

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This invention relates to electrical wave filter systems and more particularly to filter systems capable of providing relatively sharp filtering for a plurality of low frequencies with separate outputs.

In my copending application, Serial Number 664,483, filed April 24, 1946, I have disclosed a filtering system which is based on the accumulative effect of stored oscillating energy which is delivered to the system at a given frequency and at a constant phase. The filter as embodied is of the rotary type in its operation and is basically synchronous in that the storage of oscillating energy though in static condition takes place in synchronism with the frequency to be selected and that the switching rate through the rotary operation is related to that frequency. In the filter system of the above-identified application, I have disclosed a system which is adapted for the selection of a single frequency by providing a plurality of like storage means with which there is associated means for applying and taking off cyclically and in a predetermined order energy at a given rate with respect to these storage means. The number of such storage means is such as to make them responsive to a wave of a single frequency only, the speed of the cycle of energy application and take-off being the determinate of the respective selected frequency. The effect of this filter is to operate as a synchronous rectifier for respective portions of the selected wave which are then combined into a resulting alternating current type wave. The wave in that instance is divided into preferably three equal portions of 120°. However, in certain cases, the need arises for the effective selection of more than one frequency.

It is an object of the present invention to provide a filter system which is highly selective in respect to a plurality of frequencies in the audio band.

It is a further object of the invention to provide an electro-mechanical rotary filter for the selection of a number of given frequencies.

It is a still further object to provide a rotary wave filter of the type defined which provides a separate alternating current output for each of a number of selected frequencies.

In accordance with certain features of the invention, I provide in a unitary assembly a plurality of storage means corresponding in number to the number of frequencies it is desired to select. Each of the storage means, which is comprised of submultiple units is associated with energy distributors the number of which is equal

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to the number of frequencies it is desired to select. Each of the distributors in turn, includes a distributing section and a series of segments whose number is divisible exactly by the number of storage means submultiple units. A number of energy distributing arms is provided corresponding to the number of frequencies to be selected to distribute the incoming energy to the storage means over the distributing elements. The arms are rotated from a common shaft at a speed which is related to the number of segments and the frequencies to be selected. Take-off brushes are provided on the distributing arms to provide take-off energy for suitable output circuits. The effect will be similar to the system referred to above in that a synchronous rectification takes place for successive wave portions of a plurality of frequencies, separate square-shaped outputs being obtained which may be filtered back into a substantially sinusoidal form quite readily.

While my invention is defined in the appended claims, and other features and objects of the invention the foregoing will become more apparent upon consideration of the following detailed description to be read in connection with the accompanying drawings in which:

Fig. 1 represents in diagrammatic form an electro-mechanical filter system in accordance with one embodiment of the invention; and

Fig. 2 illustrates the input and output wave forms of the system of Fig. 1.

Referring to Fig. 1, a source of oscillating electrical energy having in its output wave forms of various frequencies is indicated at 1 which may be connected to input terminals 2 and 3 of a rotary multiple frequency filter 4 in accordance with the invention. As indicated for frequencies f_2 and f_6, energy is applied over respective input resistances 5 and 6, connected, in parallel in respect to the input terminal 2, to distributing sectors 7 and 8. Similarly, although not shown, energy is applied to the remaining four distributing sectors 9, 10, 11 and 12 which are arranged in a circle about a driving shaft 13. The energy applied to the sectors 7 through 12 is cyclically stored on a number of condensers such as the three condensers 14, 15 and 16 associated with the sector 7, and on the condensers 17, 18 and 19, associated with the sector 8. Each of the six sectors has a series of segments 20 and 21 associated therewith whose number is exactly divisible by the number of condensers provided for that sector. Three condensers are shown here for illustrative purposes. In this case the number of segments should be divisible exactly by three. However, other numbers of condensers may be used instead, in which case the segments should be divisible by the particular numbers respectively; also each frequency section may use any number of condensers without regard to the number of condensers used for the other sections. The number of distributing segments for any one of the sectors is determined in accordance with the ratio of the various frequencies which are to be selected as will be explained at a later point. In order to transfer energy from the sectors to the storage condensers, six distributor arms **22** are provided at equally spaced points about the shaft **13**. Arms **22** are each provided with an input distributing brush **24** which transfers energy from the sectors to the distributing segments as from **8** to **21**, and with a take-off brush **25** which "reads" or takes-off energy from the segments **20**, **21** and transfers it to take-off or output sectors **26**. The take-off sectors **26** are each connected to a separate output circuit **27** as illustrated for the frequency f_6. The output circuit includes in each case a high value grounded resistance **28**, the voltage available across the resistance being applied to a control grid **29** of a triode amplifier **30**. The output from the triode may be obtained over a coupling transformer as at **31**. Since the filter illustrated comprises three condensers for storing energy for each of the frequencies, the distributor segments **20**, **21** are interconnected in such a manner as to provide contact thru the brushes to the same condenser every 120 electrical degrees, the interconnections between the segments being indicated at **32**.

In Fig. 2, graph *a*, a sine wave is shown divided into three portions of 120° each corresponding to the three condensers which have been provided in the filter of Fig. 1 for each of the frequency waves that are to be selected. Each of the three condensers acts as a synchronous rectifier for the respective component of the wave, to which it is periodically subjected through the brush system as by means of the input distributing brush **24**. The segments **20**, **21** which are interconnected so as to form three successive groups separated by 120 electrical degrees are contacted by the input brushes at a cyclic repetition rate which is governed by the speed of rotation of the brush system. Since, as illustrated in Fig. 1 the segments for each frequency differ in width that is, in arcuate extent according to the ratio of the various frequencies to one another, a single speed being used for all the six brushes, the duration of contact is a different one for each of the frequencies. The condensers for each of the frequencies therefore will be charged in synchronism with the frequency to be selected.

When, for instance, the proper frequency, f_2, is present at the input terminals **2**, **3**, the rate of charge of the condensers **14**, **15** and **16** via the bridging brush **24** is governed by the resistor **5**. The time of build-up of stored energy is directly proportional to the value of resistor **5**, hence the band-width of the filter around frequency f_2 is inversely proportional to the value of resistor **5**.

Since a low impedance signal source is always connected across the input terminals whether f_2 is present or not, when f_2 ceases to exist the energy stored in condensers **14**, **15** and **16** proceeds to discharge (via the bridging brush **24**) through resistor **5** and the low impedance signal source to ground. The decay of the filtered signal, thus, is at the same rate as the earlier build-up (likewise governed by resistor **5**).

Since the output resistance **28** in the take-off circuit, is relatively high, the condensers will not be appreciably discharged, the effect rather being that of a "reading" of the respective condenser voltages which is transmitted to the utilization circuit. Thus the wanted component frequency will continue to build up charge in the condensers while unwanted components will not cumulatively build up therein.

The resulting take-off wave form as obtained in the coupling transformer is shown in graph *b* of Fig. 2, if an in-phase relation is maintained between the rotating brush system and the desired frequency.

Ordinarily, when only the frequency of the resulting alternations is desired, rather than a specific wave form, the resulting rectangular shape of the wave form as suggested in graphs *b* of Fig. 2 is satisfactory. This wave form, however, may be easily filtered back into a sinusoidal form if desired.

While the above is a description of the principles of this invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of this invention.

I claim:

1. A rotary wave filter for the selection of a plurality of different frequencies from a source of oscillatory energy including at least said plurality of frequencies, comprising for each frequency of said plurality that is to be selected energy storage means having separate submultiple portions, means for applying energy cyclically from a given source to each of said storage portions in synchronism with the recurring portions of the waves of the respective frequencies to be selected, and means for successively obtaining signals from each of said storage portions for each of said selected frequencies, said signals being proportional to the energy stored in said energy storage portions and in synchronism with the respective selected frequencies.

2. A rotary wave filter for the selection of a given plurality of frequencies from a source of oscillatory energy including at least said plurality of frequencies, comprising energy distributing means having component portions equal in number to that of the frequencies to be selected, separate energy storage means associated respectively with said distributing means having separate submultiple portions, energy take-off means having component portions equal in number to that of the frequencies to be selected, and an output circuit for each of the selected frequencies associated with said take-off means portions.

3. A filter according to claim 2 in which the number of frequencies to be selected is six and the number of said component portions of said distributing and said take-off means comprises six.

4. A filter according to claim 2 in which the number of said submultiples of said storage means for any one of said given frequencies is independent of the number used for the other frequencies.

5. A filter according to claim 2 in which the number of said submultiples of said storage means comprises three.

6. A filter according to claim 2 in which said distributing means includes for each frequency a series of conductive segments of a number which is exactly divisible by the number of submultiple portions of said energy storage means, said segments being conductively interconnected

to form cyclically recurring groups effectively spaced a number of electrical degrees apart which is equal to the fraction of the wave of the particular frequency the denominator of which is given by the number of submultiple storage means portions, the width of said segments being determined by the ratio of said frequencies.

7. A filter according to claim 2 in which said distributing means includes for each frequency to be selected an energy input distributing portion, a series of conductive segments of a number which is exactly divisible by the number of submultiple portions of said energy storage means connected thereto, and conductive means for bridging said portions and said segments arranged for movement with respect thereto at a speed related to the frequency to be selected.

8. A filter according to claim 2 in which said energy take-off means includes for each frequency to be selected an energy take-off portion, a series of conductive segments conductively associated with said storage means, and conductive means for bridging said portions and said segments arranged for movement with respect thereto at a speed related to the frequency to be selected.

9. A filter according to claim 2 in which the component portions of said distributing means, the component portions of said take-off means are arranged in concentric circles, and said distributing and take-off means each include a rotary contact element for each of said plurality of frequencies.

10. A rotary wave filter for the selection of six given frequencies from a source of oscillatory energy including at least said six frequencies, comprising for each of said six frequencies to be selected: an input circuit including a series resistor, an energy distributing portion connected to said input circuit, a series of contact segments the number of which is divisible exactly by three and which are interconnected so as to form cyclical groups spaced apart electrically 120° for the respective frequencies, energy storage means comprising three condensers each of which is connected to one of said contact segment groups, an energy take-off portion, an output circuit including a relatively high resistance connected to said take-off portion, and an electrical contact brush each for providing a bridge between said distributing portion and said contact segments and a bridge between said segments and said take-off portion respectively; said distributing portion, said take-off portion and said segments being arranged in concentric circles respectively; and said brushes for each frequency being mounted on a supporting arm for rotation in respect to all of said portions and segments at a speed which is synchronous with the respective frequencies.

11. A rotary wave filter for the selection of N given frequencies from a source of oscillatory energy including at least said N frequencies, comprising for each of said frequencies to be selected: an input circuit, a series of contact segments the number of which is divisible exactly by N/2 and which are interconnected so as to form cyclical groups spaced apart electrically for the respective frequencies, energy storage means comprising N/2 condensers each of which is connected to one of said contact segment groups, and an electrical bridge between said input circuit and said contact segments.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,851,092	Fetter	Mar. 29, 1932
2,430,038	Wertz	Nov. 4, 1947