Nov. 1, 1932. C. R. KEITH 1,885,728

HARMONIC GENERATING AND SELECTING SYSTEM

Filed June 19, 1930

FIG. 1

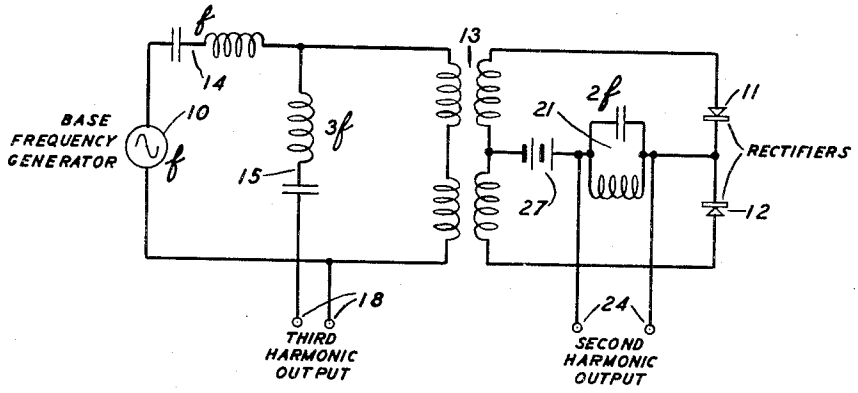
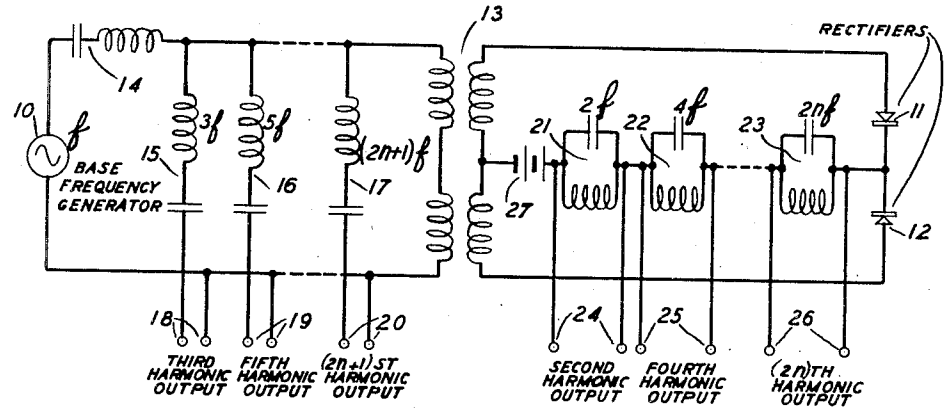


FIG. 2



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UNITED STATES PATENT OFFICE

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HARMONIC GENERATING AND SELECTING SYSTEM

Application filed June 19, 1930. Serial No. 462,169.

This invention relates to a system for generating harmonics of any given base frequency and in particular to a simplified arrangement for uses in which an economy of apparatus and a minimum of attention for maintenance thereof are important considerations.

It is well known that by application of the principle of multiplexing, for example, by means of a system employing a plurality of carrier frequencies, a single telephone line may be fitted to provide several communication channels carrying a plurality of messages simultaneously. It is evident that multiplex operation saves the cost of installing and maintaining a number of additional telephone lines sufficient to carry the same number of messages. It necessitates, however, an increased expenditure for terminal apparatus, the cost of installing and maintaining which must be kept below the cost of providing the additional telephone lines to effect a net economy.

It is in some cases advantageous to provide merely a minimum number of multiplex carrier channels per line, for example, by the installation of what is termed a single channel carrier system, which provides but one additional channel per line. In this way it is possible to utilized apparatus of extremely simple design, thereby reducing the cost and effecting a substantial economy.

The system of the invention is particularly useful in connection with a carrier system of one or two channels in which it may be used to supply a small number of harmonically related carrier frequencies with a minimum of apparatus. In a simple form of the invention the second and third harmonics of a common base are developed and used respectively as the carriers for transmitting and receiving a single carrier channel.

An object of the invention is to provide a simplified system of harmonic generation.

Another object of the invention is to provide means for separating the second, fourth, and other even harmonics from the first, third and other odd harmonics.

A feature of the invention is the use of rectifying or modulating devices having no more than two electrodes each as, for example, the copper oxide rectifier disclosed in U. S. Patent 1,640,335, issued August 23, 1927, to L. O. Grondahl.

In the present invention, a current of the base frequency is supplied to two rectifying or modulating devices having two terminals each, associated with a three-winding transformer. Two substantially independent systems of load circuits are provided in a balanced arrangement whereby the odd harmonic frequencies may be accentuated and utilized in one portion and the even harmonic frequencies in the other. Simple tuned circuits or other selective devices may be provided in each portion of the load circuit for selecting the individual harmonic frequencies.

In the drawing, Fig. 1 illustrates an embodiment of the invention in a simplified form for generating two harmonic frequencies. Fig. 2 represents another embodiment of the invention in a more complex form for generating any desired number of harmonic frequencies.

Referring to Fig. 1, a generator 10 is arranged to supply currents of any desired fundemental frequency f to a pair of rectifying devices 11 and 12. The devices 11 and 12 may be, for example, copper oxide rectifiers. The generator 10 is coupled to the devices 11 and 12 through a transformer 13 having primary and secondary windings, the secondary winding being divided into two portions. The primary generator 10 is connected to the primary winding of the transformer 13 through a connection including a tuned circuit 14 which is resonant to the frequency f.

Another tuned circuit 15, resonant to the third harmonic frequency $3f$, is bridged across the primary winding of the transformer 13. An output circuit for utilizing the third harmonic frequency may be connected into this bridged circuit by means of the output terminals 18.

A tuned circuit 21, resonant to the second harmonic frequency $2f$, is connected between the dividing point in the secondary winding and a point in the secondary circuit between the rectifying devices 11 and 12. A pair of

output terminals 24 are provided for use in connecting a load across the tuned circuit 21 for utilizing current of the second harmonic frequency.

A biasing battery 27 is provided for supplying a suitable biasing current to the rectifying devices 11 and 12. The biasing battery may be connected in such a manner that the biasing currents are neutralized in the secondary winding of the transformer 13 in order to avoid saturation of the magnetic circuit of the transformer.

The rectifying devices 11 and 12 are poled in such a manner that in respect to the serially connected circuit including the secondary winding of transformer 13 and the devices 11 and 12, the conductive directions of the rectifying devices are opposed. In respect then to the parallel circuit including tuned circuit 21, battery 27, the two parts of the secondary winding of transformer 13 in parallel and the devices 11 and 12 in parallel, the conductive directions of the devices 11 and 12 are mutually aiding.

In the operation of the device of Fig. 1, the base frequency generator 10 supplies a current of the frequency f through the tuned circuit 14 and the transformer 13 to the rectifying devices 11 and 12. By virtue of the rectifying or modulating properties of the devices 11 and 12, electromotive forces of the various harmonic frequencies of the generator 10 are produced across the terminals of the devices.

The phase relationship of the harmonic voltages generated in the respective devices 11 and 12 is different for the harmonics of odd order from what it is for the harmonics of even order.

The harmonic voltages of odd order are found to have phases related in such a manner that they will aid in sending currents through the transformer 13 from the secondary winding to the primary winding. The balanced arrangement of the secondary structure will prevent the electromotive forces of odd order from producing current in the branch containing tuned circuit 21.

The electromotive forces of even order on the other hand are found to have a phase relation such that they aid in sending currents through the circuit branch containing tuned circuit 21. These currents are balanced in the secondary winding of the transformer 13 and are not transmitted to the primary winding.

Due to the phase relationships above described together with the selective nature of circuits 15 and 21 respectively, a current of the third harmonic frequency is made available at the pair of terminals 18 and a current of the second harmonic frequency is obtained at the pair of terminals 24.

Referring to Fig. 2, the system illustrated is similar to that shown in Fig. 1 except that additional provision is made for utilizing harmonic frequencies of the fourth, fifth and higher orders in addition to those of the second and third orders. The circuit constituents are for the most part the same as those shown in Fig. 1 and are designated by similar reference characters.

Tuned circuit 16, resonant to the fifth harmonic frequency $5f$, is connected in parallel with tuned circuit 15 and is provided with a pair of terminals 19 for connection to a load circuit. Any desired number of additional branches may be added in a similar manner for utilizing the higher harmonics. For example, a tuned circuit 17, resonant to the frequency $(2n+1)f$, together with a pair of terminals 20 may be provided for utilizing the $(2n+1)st$ harmonic.

Similarly, additional tuned circuits 22, 23 and others as desired may be provided in series with tuned circuit 21 to accommodate the higher even harmonic frequencies and additional pairs of terminals such as 25 and 26 may be added for connection to additional load circuits.

What is claimed is:

1. In a system of harmonic generation, a source of electric current of base frequency, a transformer having a primary winding and a divided secondary winding, a secondary circuit including a pair of rectifying elements serially connected with the secondary winding, the conductive directions of the rectifying elements being mutually opposed, a supply circuit tuned to the base frequency and adapted to connect the source to the primary winding of the transformer, a load circuit tuned to an odd harmonic of the base frequency and bridged across said primary winding, and a second load circuit tuned to an even harmonic of the base frequency and connected between the dividing point of the said secondary winding and a point in the secondary circuit between said rectifying elements.

2. In a system of harmonic generation, a source of electric current of base frequency. a transformer having a primary winding and a divided secondary winding, a secondary circuit including a pair of rectifying elements serially connected with the secondary winding, the conductive directions of the rectifying elements being mutually opposed, a supply circuit tuned to the base frequency and adapted to connect the source to the primary winding of the transformer, a load circuit tuned to the third harmonic of the base frequency and bridged across said primary winding, and a second load circuit tuned to the second harmonic of the base frequency and connected between the dividing point of the said secondary winding and a point in the secondary circuit between said rectifying elements.

3. In a system of harmonic generation, a

source of electric current of base frequency, a transformer having a primary winding and a divided secondary winding, a secondary circuit including a pair of rectifying elements serially connected with the secondary winding, the conductive directions of the rectifying elements being mutually opposed, a supply circuit tuned to the base frequency and adapted to connect the source to the primary winding of the transformer, a group of load circuits respectively tuned to different odd harmonics of the base frequency and bridged across said primary winding, and a second group of load circuits tuned respectively to different even harmonics of the base frequency and connected in series between the dividing point of the said secondary winding and a point in the secondary circuit between said rectifying elements.

In witness whereof, I hereunto subscribe my name this second day of June, 1930.

CLYDE R. KEITH.