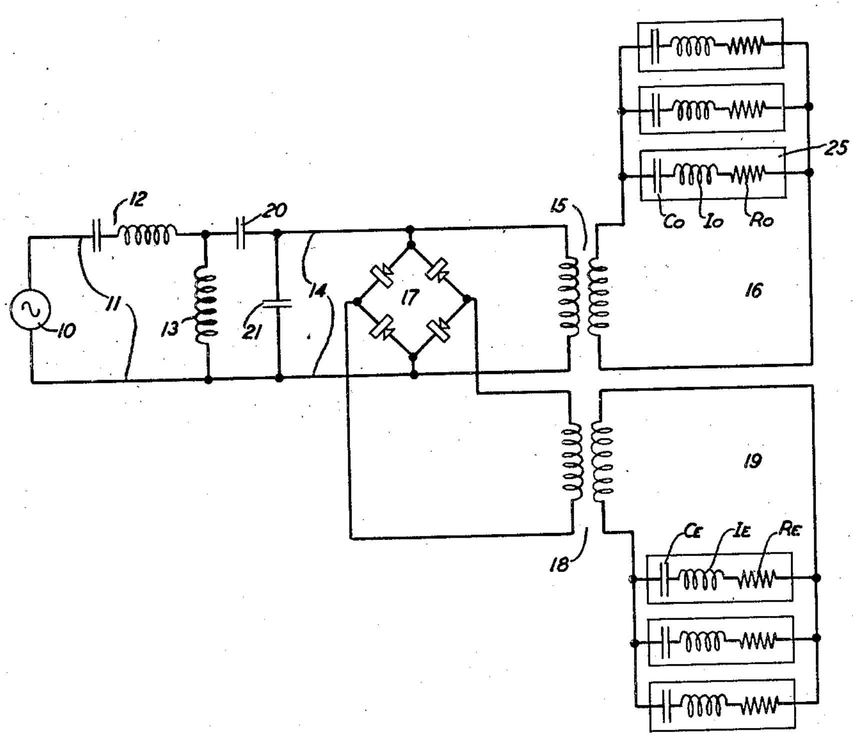
Feb. 7, 1939. M. E. CAMPBELL ET AL 2,146,053

HARMONIC PRODUCER SYSTEM

Filed July 31, 1937



INVENTORS: M.E.CAMPBELL
J. M. WEST

BY H. A. Burgess

ATTORNEY

Patented Feb. 7, 1939 2,146,053

UNITED STATES PATENT OFFICE

2,146,053

HARMONIC PRODUCER SYSTEM

Mark E. Campbell, Pequannock, and Julian M. West, Ridgewood, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 31, 1937, Serial No. 156,706

5 Claims. (Cl. 172—281)

This invention relates to a harmonic producing system and more particularly to circuit modifications for improving the power efficiency of such system.

The copending application of L. R. Wrathall, Serial No. 77,989, filed May 5, 1936, now Patent No. 2,117,752, dated May 17, 1938 and assigned to applicant's assignee, discloses a magnetic harmonic producing system for generating and selecting a predetermined group of odd and even harmonics having uniformly large amplitudes. In that system it was found that in using ordinary harmonic selective networks there was a difference in the power outputs of the various harmonics. This invention is concerned with the provision of optimum load impedances to obtain maximum outputs of all harmonics produced in such a system.

It is an object of the invention to equalize the outputs of both odd and even harmonics.

It is another object of the invention to vary the output of a preselected harmonic relative to the other harmonics in a group.

It is a further object of the invention to obtain maximum outputs of all harmonics.

The aforementioned copending application of L. R. Wrathall discloses a harmonic producing system having a non-linear coil and an alternating current generator for impressing a fundamental frequency thereon, and an output circuit for the coil including a condenser, copper-oxide bridge and filter banks to produce and select a certain group of odd and even harmonics. In the present invention, each filter in the odd and even banks is initially devised with the same impedance and the two banks are coupled to the output circuit by a pair of transformers. The turn ratios of the transformers are so preselected relative to each other that the load impedances are predetermined at such optimum values as will produce both equal and maximum outputs of both odd and even harmonics. With the system adjusted to equalize the harmonic output, a variation of the impedance of a particular filter will cause the output of the harmonic selected thereby to be correspondingly varied. A condenser bridged across the output circuit will further increase in equal amounts the outputs of both odd and even harmonics.

The invention will be readily understood from the following description taken together with the drawing which illustrates the invention in its preferred form.

Referring to the drawing, an alternating current generator 10 impresses a wave of fundamental frequency, for example, four kilocycles, on a primary circuit 11 comprising a tuned circuit 12 and a saturable-core inductance 13 connected in series. A secondary or output circuit 14 including a condenser 20 is coupled through a transformer 15 to a filter bank 16 and through a shunt rectifier-bridge 17 and a coupling transformer 18 to a filter bank 19.

As explained in the copending application of L. R. Wrathall, supra, a proper selection of the constants of the inductance 13, condenser 20 and the elements comprising the filter banks produces a desired group of odd and even harmonics having substantially uniform amplitudes. Each filter of the bank 16 is designed to select a certain odd harmonic, while each filter of the bank 19 is designed to select a certain even harmonic. Each filter bank is arranged for parallel operation and may include any number of individual filters. In practice it was found that due to power losses in the rectifier-bridge the even harmonic output was less than the odd harmonic output.

In the preferred embodiment of the invention, the constants of the condenser C_O, inductance I_O and resistance R_O and of the condenser C_E, inductance I_E and resistance R_E comprising the individual filters of the odd and even banks, respectively, are initially fixed at the same value so that the filter terminating impedance is the same for all harmonics. As the odd and even filter banks are coupled to the generator 10 through the respective transformers 15 and 18, the turn ratios of these transformers are so selected relative to each other that the load impedances looking from the generator 10 have such values as will produce equal outputs of both odd and even harmonics. With the turn ratios thus proportioned, a further selection to obtain the absolute turns will produce maximum outputs of all harmonics. Thus the absolute turn ratios of the coupling transformers together with the uniformity of the individual filters provides optimum load impedances whereby the odd and even harmonic outputs are not only equalized but are also produced at their maximum values. It is understood that the determination of the absolute turn ratios includes compensation in the even branch for losses dissipated in the rectifier-bridge.

With the outputs of odd and even harmonics equalized in the aforedescribed manner, the resistance R_O in one of the filters of the odd harmonic filter bank, say filter 25, may be fixed at a value less than that for the corresponding element in the other filters of this bank. This decreases the impedance termination for the odd harmonic assigned for selection by that particular filter. The output of that harmonic is therefore increased above the outputs of the other filters in the same ratio as the impedance is decreased. Similarly, an increase in the output of any even harmonic may be obtained by decreasing the resistance R_E in one of the filters included in the even bank. Accordingly, the output of a particular odd or even harmonic or both can be increased by decreasing the respective filter resistances R_O or R_E. It is obvious that an increase in the impedance of a particular filter will cause a decrease in the harmonic output therefrom.

A still further increase in equal amounts of the outputs of both odd and even harmonics can be obtained by connecting a condenser 21 across the output circuit. Proportioning that condenser together with the condenser 20 to optimum values will more than double the odd and even harmonic outputs obtained with the circuit disclosed in the copending application of L. R. Wrathall, supra. The condenser 21 may also be connected in the output circuit at any one of the following points: (a) in bridge of the primary winding of transformer 15, (b) in bridge of the secondary winding of transformer 15, and (c) in bridge of the secondary winding of transformer 18. With a distorting circuit producing the sixteenth through the twenty-seventh harmonic of a frequency of four kilocycles, the optimum values of condensers 20 and 21 were 0.014 and 0.0055 microfarad, respectively. These condenser values will vary depending on the range of harmonics that is produced.

While the invention is described in connection with a harmonic producing system utilizing a saturable-core inductance, it is to be understood that it is equally applicable to similar systems employing other types of non-linear distorting elements such, for example, as those using thyrite, copper-oxide, vacuum and gas tubes.

What is claimed is:

1. A harmonic producing circuit comprising a distorting device, a source of alternating current of fundamental frequency, circuit means for applying the fundamental frequency to said distorting device so as to produce therein a group of harmonics of the fundamental frequency, an output circuit for said distorting device, and means for substantially increasing the output of the entire group of produced harmonics comprising capacity of substantially optimum value effectively connected in shunt of said output circuit.

2. A harmonic producing circuit comprising a distorting device, a source of alternating current of fundamental frequency, circuit means for applying the fundamental frequency to said distorting device for producing therein a group of harmonics of the fundamental frequency, an output circuit for said distorting device, and means for at least doubling the output of the entire group of produced harmonics comprising capacity of substantially optimum value effectively connected in shunt of said output circuit.

3. A harmonic producing circuit comprising a distorting device, a source of alternating current of fundamental frequency, means for applying the fundamental frequency to said distorting device so as to produce therein a group of harmonics of the fundamental frequency, an output circuit for said distorting device including a capacity and a substantially resistive load in series with said distorting device for making certain that the harmonics in the produced group have uniformly large outputs, and means comprising capacity connected in said output circuit in bridge of the first mentioned capacity and said distorting device and proportioned to substantially increase the outputs of the harmonics in the entire group of produced harmonics.

4. The harmonic producing circuit according to claim 3 in which the second mentioned capacity is proportioned to at least double the outputs of the harmonics in the entire group of produced harmonics.

5. A harmonic producing circuit comprising a distorting device, a source of alternating current of fundamental frequency, means for applying the fundamental frequency to said distorting device so as to produce therein a group of odd harmonics of the fundamental frequency, an output circuit for said distorting device including a capacity and a substantially resistive load in series with said distorting device for making certain that the odd harmonics in the produced group have uniformly large outputs and means for effecting from the produced odd harmonics a group of even harmonics having uniformly large outputs, and means comprising capacity connected in the output circuit in bridge of the first mentioned capacity and said distorting device and proportioned to substantially increase the outputs of the harmonics in the groups of both odd and even harmonics.

MARK E. CAMPBELL.
JULIAN M. WEST.