

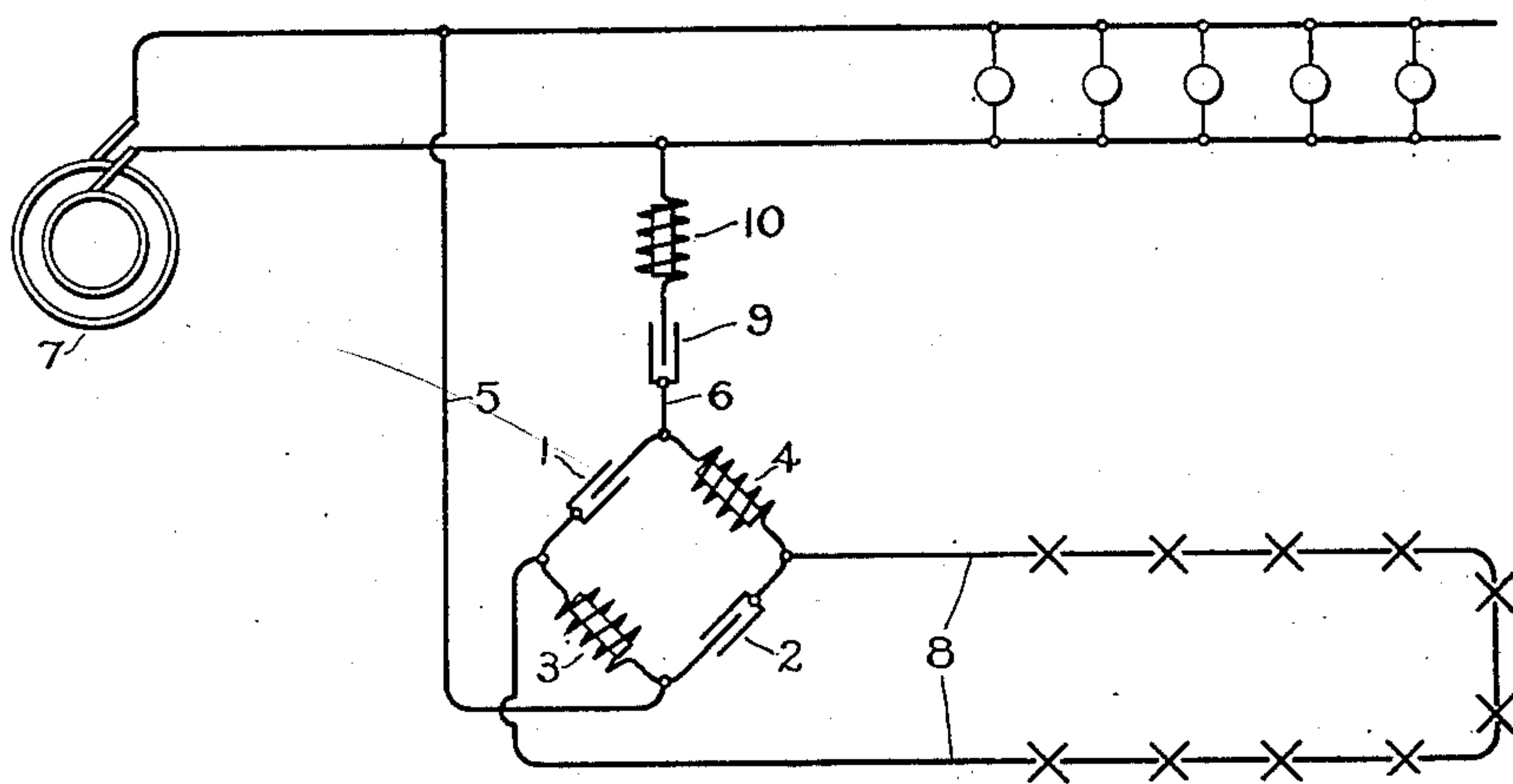
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C. P. STEINMETZ.
SYSTEM OF ELECTRICAL DISTRIBUTION.

APPLICATION FILED JAN. 2, 1901.

NO MODEL.



Witnesses.

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UNITED STATES PATENT OFFICE.

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SYSTEM OF ELECTRICAL DISTRIBUTION.

SPECIFICATION forming part of Letters Patent No. 729,234, dated May 26, 1903.

Application filed January 2, 1901. Serial No. 41,810. (No model.)

To all whom it may concern:

Be it known that I, CHARLES P. STEINMETZ, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Electrical Distribution, of which the following is a specification.

In cases where a combination of condensers and inductance devices are employed in such a manner that through the reactions of the leading and lagging electromotive forces thereof a constant current may be derived from a constant-potential circuit or the reverse the effect of higher harmonics in the impressed electromotive-force wave exerts an undesirable influence. At light loads the harmonics of higher order than the normal are considerably magnified in the current produced, being increased out of proportion to the value of the fundamental wave of current. At or near full load in the consumption-circuit the harmonics in the current flowing therein appear in about the same proportion as in the electromotive-force wave impressed upon the apparatus. This may roughly be explained by considering that at no load the current flowing in the condenser or condensers consists merely of the charging-current and in the inductance devices merely of the wattless exciting-current. Under these circumstances if the impressed wave be considerably distorted the current due to the higher harmonics is increased in value by the condensers in inverse relation to the order of the harmonics. The effect of the inductances is to damp out these higher harmonics, but since the arrangement of the transforming apparatus may be such that the current in the consumption-circuit may find a circuit through condensers to the supply-mains without traversing the inductance-coils the effect of the inductances in suppressing harmonics does not make itself felt. At light load a distorted wave of impressed electromotive force therefore results in a still more distorted wave of current in the consumption-circuit. At heavier loads, however, the charging-current of the condenser forms only a portion of the total current flowing in the same, and the effect of the condenser in magnifying the har-

monics is therefore less felt, the charging-current then forming only a small proportion of the current flowing.

Although my invention is capable of widely different applications, I have considered that its principle may be sufficiently understood by representing its application to a single form of transforming apparatus of that character permitting a constant-potential system to supply energy, through its instrumentality, to a constant-current circuit or the reverse. The drawing represents such an arrangement provided with a device which acts to suppress the harmonics in the supply-circuit. This suppression of harmonics, by permitting only a pure sign wave of electromotive force to be impressed on the device, improves the constant-current regulation at light loads, in which range the constant current would rise above the normal and prevents the possibility of undesirable resonance effects taking place due to the presence of reactances in the constant-current circuit.

In the drawing four inductances of opposite signs—namely, the condensers 1 2 and the inductance-coils 3 4—are connected in a closed circuit with each other, the condensers alternating with the inductance-coils. Across opposite corners of this closed circuit two supply-mains 5 6 are connected, these mains deriving current from any suitable source of alternating current—as, for example, the generator indicated conventionally at 7. A constant-current circuit 8 is connected also across points in this closed circuit or square, the points of connection, however, being across the remaining diagonal of the square and midway between the points of connection of the supply-mains 5 6, as shown. If an electromotive force of constant value be impressed by the mains 5 6 upon this closed circuit of condensers and inductances, then there will be produced upon the mains of the consumption-circuit 8 an electromotive force which varies in such manner as to maintain a current of constant value therein regardless of the variation of load. As this constant-potential constant-current transforming arrangement of itself forms no part of my present invention, no further description of the mode of operation is deemed necessary. Such a

transforming arrangement is, however, subject to the effect of higher harmonics in the manner above stated, a circuit through the condensers 1 and 2 being afforded to current passing from the main 6 through the condenser 1, then through the constant-current circuit 8, and through the other condenser, 2, to the other main, 5. To eliminate the undesirable effect of higher harmonics, if present, I include in the supply-circuit a device which is, so to speak, transparent to waves of the normal frequency, but which strongly opposes the flow of waves of higher order. This device, as shown, consists of two reactances of opposite sign—as, for example, the condenser 9 and the inductance-coil 10—these reactances being placed in series with each other in the supply-main 6. These reactances are proportioned relatively to each other so as to have exactly equal but opposite effects when acted upon by waves of normal frequency. For waves of higher order—as, for example, the third harmonic—the effect of the condenser is decreased three times while that of the inductance-coil is increased three times. The inductance-coil, therefore, powerfully opposes this as well as still higher harmonics and renders their effect negligible. By the employment of this device for suppressing the higher harmonics I improve the constant-current regulation of the transforming device described, and this without appreciably reducing the efficiency of transformation.

Inasmuch as the invention may be applied in a great variety of ways, I desire a correspondingly liberal interpretation of the following claims thereto.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. The combination of a power-transmission line, a source of current connected thereto the electromotive-force wave of which differs from the sine form, a consumption-circuit supplied from said transmission-line, and means for allowing only a sine wave of current to pass from said transmission-line to said consumption-circuit.

2. The combination of a constant-potential circuit, a constant-current circuit, means for transferring energy between the two circuits, and means in one of said circuits for allowing the free passage of the main or fundamental wave of current but acting to reduce or suppress the higher harmonics.

3. The combination of a constant-potential circuit, a constant-current circuit, means for converting energy in the form existing in one of said circuits into the form existing in the other circuit, and reactances of opposite sign in series in one of said circuits.

4. The combination of a constant-potential circuit, a constant-current circuit, means for converting energy in the form existing in one of said circuits into the form existing in the other circuit, and reactances of opposite sign in series in the constant-potential circuit.

5. The combination of a constant-potential circuit, a device for producing a constant current from energy derived from the constant-potential circuit, and means in said constant-potential circuit for allowing the main or fundamental wave of current to pass but acting to reduce or suppress all harmonics of different order from the fundamental.

6. The combination of a constant-potential circuit, means operatively related thereto for producing a variable electromotive force in quadrature to that of the constant-potential circuit, and means in said circuit for allowing the main or fundamental wave of current to pass freely but acting to reduce or suppress the higher harmonics.

7. The combination of a constant-potential circuit, means operatively related thereto for producing an electromotive force in quadrature to that of the constant-potential circuit, and means in said circuit for allowing the main or fundamental wave of current to pass freely but acting to reduce or suppress the higher harmonics.

8. The combination of a plurality of reactances of opposite sign connected alternately in a closed circuit, a consumption-circuit connected across junction-points between adjacent reactances, a supply-circuit connected across other junction-points between adjacent reactances, and reactances of opposite sign in series in said supply-circuit.

9. The combination of a plurality of reactances of opposite sign connected alternately in a closed circuit, a consumption-circuit connected across junction-points between adjacent reactances, a supply-circuit connected across other junction-points between adjacent reactances, and means in said supply-circuit for allowing the main or fundamental wave of current to pass but acting to reduce or suppress the higher harmonics.

10. The combination of a plurality of reactances of opposite sign connected alternately in a closed circuit a consumption-circuit connected across points in said closed circuit, a supply-circuit connected across points in said closed circuit other than the points of connection of said consumption-circuit, and reactances of opposite sign connected in series in said supply-circuit.

11. The combination of a constant-potential circuit, a constant-current circuit, means for transferring energy between said circuits, and means in the constant-potential circuit for permitting the free passage of waves of a given frequency but acting to oppose the passage of waves of other frequencies.

12. The combination of constant-potential mains, constant-current mains, means for transferring energy between the constant-potential mains and the constant-current mains, and means in one of said mains for allowing the free passage of waves of a selected frequency and for opposing the passage of waves of other frequencies.

13. The combination of a consumption-cir-

5 cuit including arc-lamps or other translating devices, a supply-circuit operatively related to the consumption-circuit and normally supplying current thereto, and means in one of said circuits for opposing the passage of all waves other than those of a predetermined frequency.

In witness whereof I have hereunto set my hand this 29th day of December, 1900.

CHARLES P. STEINMETZ.

Witnesses:

BENJAMIN B. HULL,
EDWARD WILLIAMS, Jr.