No. 613,205. Patented Oct. 25, 1898.

M. HUTIN & M. LEBLANC.

ELECTRIC CURRENT LEVELER.

(Application filed Dec. 16, 1897.)

(No Model.)

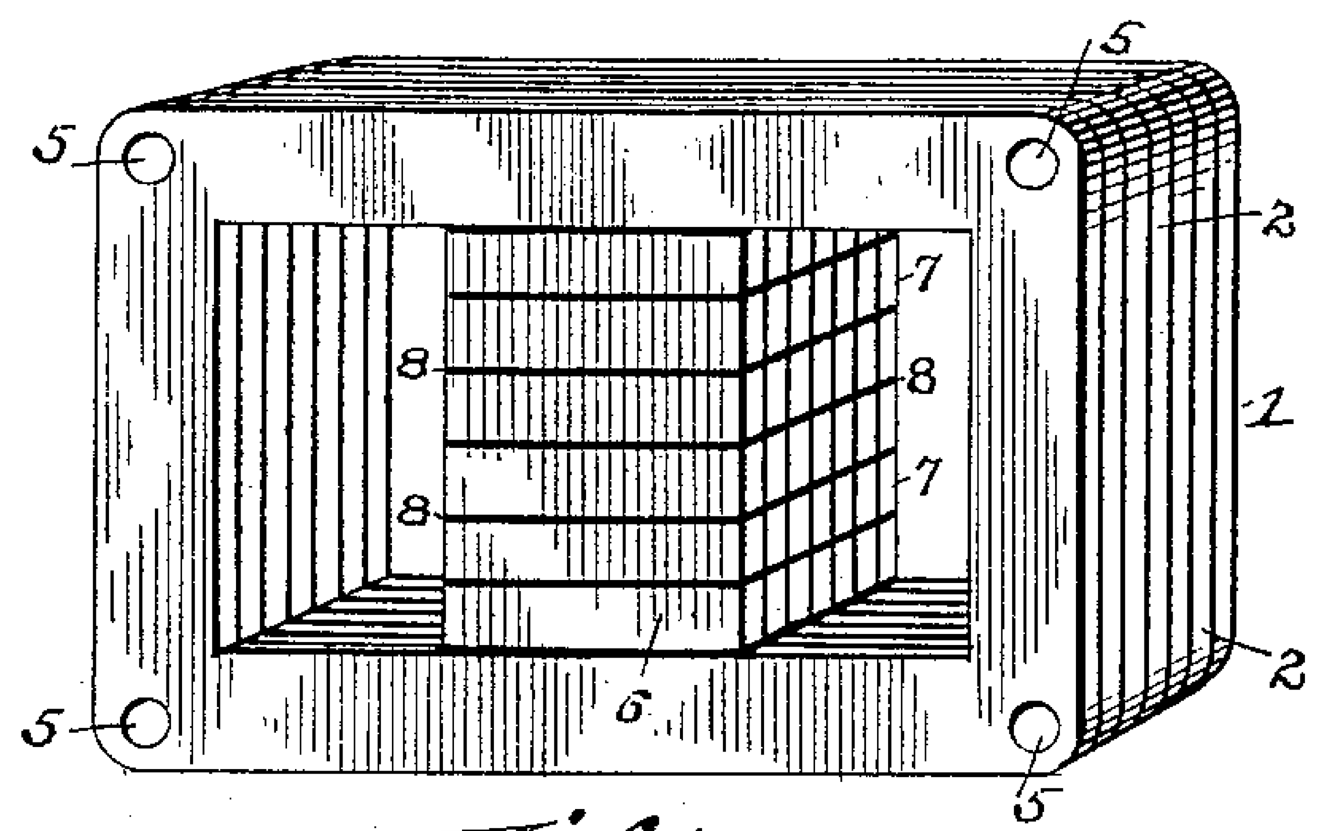

Fig. 1.

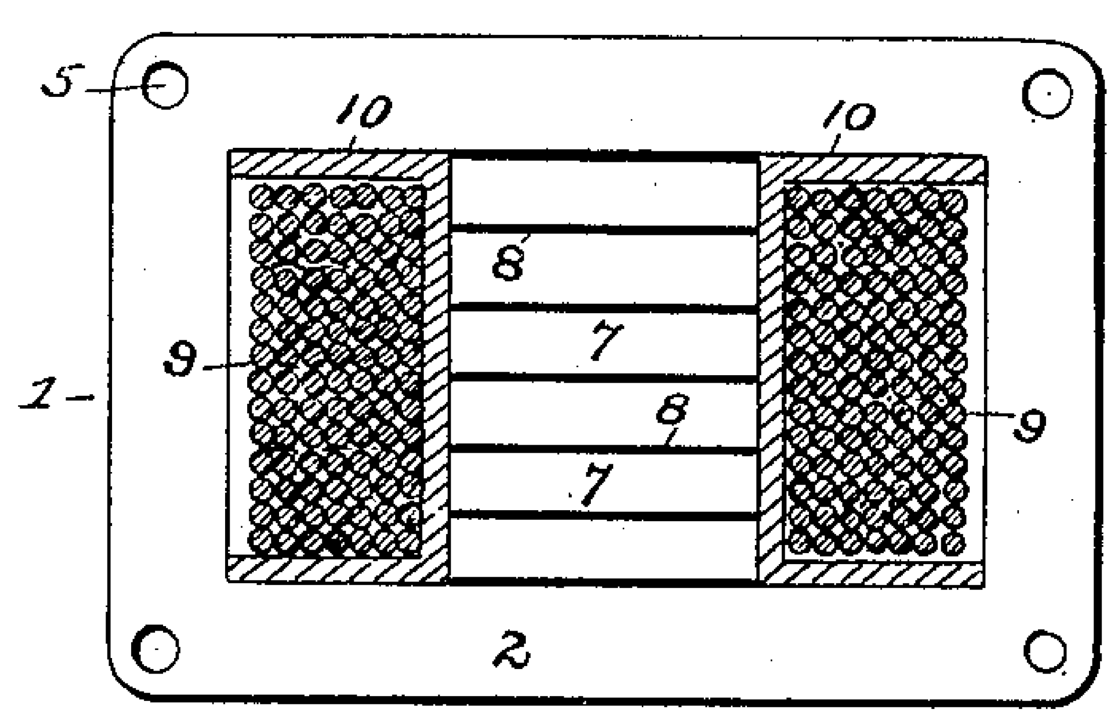

Fig. 2.

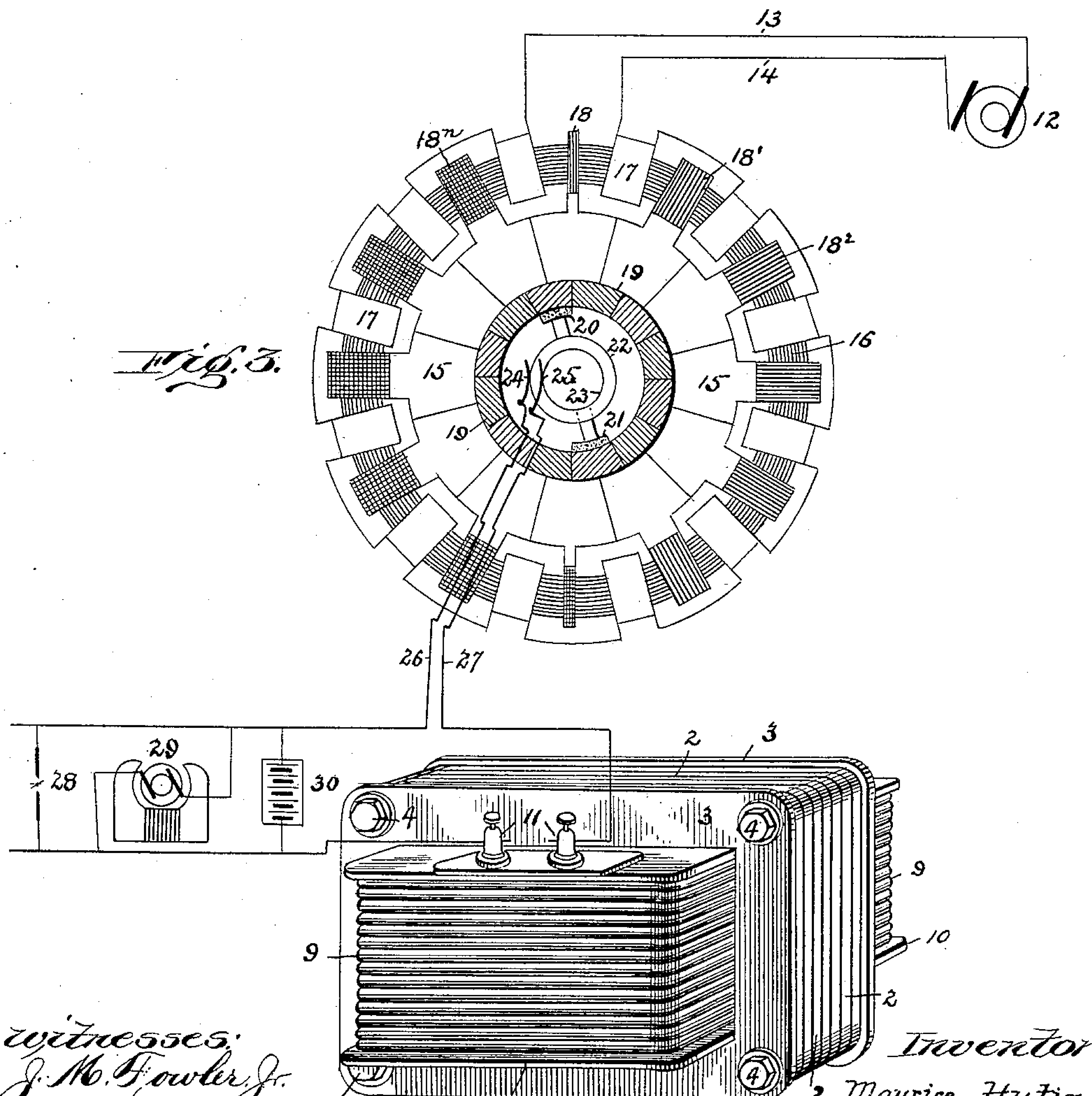

Fig. 3.

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UNITED STATES PATENT OFFICE.

MAURICE HUTIN AND MAURICE LEBLANC, OF PARIS, FRANCE.

ELECTRIC-CURRENT LEVELER.

SPECIFICATION forming part of Letters Patent No. 613,205, dated October 25, 1898.

Application filed December 16, 1897. Serial No. 662,190. (No model.) Patented in France November 27, 1894, No. 224,118; in Belgium December 6, 1894, No. 113,039; in Italy December 10, 1894, No. 37,798/145; in Germany December 11, 1894, No. 82,383; in Switzerland December 22, 1894, No. 9,664; in Hungary January 5, 1895, No. 3,037; in Austria January 11, 1895, No. 45/3 074, and in Spain February 7, 1895, No. 16,765.

To all whom it may concern:

Be it known that we, MAURICE HUTIN and MAURICE LEBLANC, citizens of the Republic of France, and residents of Paris, France, have invented certain new and useful Improvements in Electric-Current Levelers, of which the following is a specification, and for which Letters Patent have been applied for and granted as follows: France, November 27, 1894, No. 224,118; Belgium, December 6, 1894, No. 113,039; Italy, December 10, 1894, No. 37,798/145; Germany, December 11, 1894, No. 82,383; Switzerland, (provisional patent,) December 22, 1894, No. 9,664; Hungary, January 5, 1895, No. 3,037; Austria, January 11, 1895, No. 45/3,074, and Spain, February 7, 1895, No. 16,765.

Our invention has reference to a method of and apparatus for smoothing out or leveling unidirectional periodic current impulses derived from any source without appreciable consumption of energy; but the invention finds a conspicuous and particularly useful application in connection with the periodic unidirectional current impulses obtained from monophase alternating current by and in accordance with our invention set forth in our Letters Patent No. 572,510, granted to us on December 1, 1896. In this specific aspect, therefore, our present invention is in the nature of an improvement on our method of transforming single-phase alternating current into continuous current, and vice versa, set forth in our aforesaid Letters Patent.

By the procedure set forth in our said Letters Patent we obtained from single-phase alternating currents currents composed, substantially, of a series of unidirectional impulses periodically varying in strength. Such currents, while sufficiently adapted to the operation of electric motors or other translating devices having considerable self-induction, are not adapted for charging secondary batteries or for any use in which it is essential that the current be not only unidirectional, but also of uniform strength. In the said Letters Patent we have suggested the idea of leveling or straightening out the undulations of the unidirectional current either by the use of a suitably-located condenser or by an ordinary reaction or choking coil. The use of a condenser, however, becomes in many cases impracticable on account of its considerable cost and on account of the care which has to be bestowed upon this device for maintaining it in good operative condition. On the other hand, an ordinary self-induction coil, while it tends to level or straighten out the unidirectional impulses, not only fails to suppress the extra currents and high electromotive forces resulting from sudden variations of load, but, in fact, intensifies such extra currents and electromotive forces. By our present invention these defects and inconveniences are avoided, and in addition thereto the leveling of the unidirectional periodic current impulses is accomplished in a more perfect manner.

The currents with which we wish to deal are, generally speaking, complex currents or currents periodically varying in value and are distinguished from alternating currents in that the total area of the current-curve, reckoning areas above the axis as positive and areas below the axis, if there are such, as negative, has a certain finite value. As an illustration of such currents we may instance currents given by an arc-lighting generator with a three-part commutator, or, indeed, by any generator having a finite number of commutator-segments, or, and more particularly, the currents given by the device shown in our said former application when the said device is used for rectifying single-phase alternating current.

It is well known that by Fourier's theorem any periodic function whatever may be resolved into a series of sine functions plus a constant. Applying this principle to the periodic current impulses under consideration it will be apparent that such impulses may be considered as the superposition upon a perfectly smooth direct current of one or more sine-waves—that is to say, such a series of impulses amounts to a direct current of constant value plus a true alternating current.

Both of these currents, the direct and the alternating, may then be conceived as existing simultaneously in the same line-wires.

In order to completely annul the alternating component of the current-wave, it is only necessary to superpose upon the line a second alternating current of a value which is at all times equal and opposite to that of the first-mentioned alternating wave. We are enabled, practically speaking, to accomplish this result by passing the periodic impulses through the primary of a transformer of special construction provided with a secondary winding whose resistance is considerably higher than that of the ordinary commercial transformer. The counter electromotive force impressed upon the primary coils by the reaction of such a secondary is very nearly equal and opposite to the alternating component of the current-wave, while the direct-current component of the wave produces no current in the secondary of the transformer, and therefore no counter electromotive force in the primary.

The particular device or current-leveler which we prefer to employ is, as above stated, a transformer of special construction having a subdivided magnetic core of the closed magnetic-circuit type, to which may be given any desired permeability. The primary winding of this transformer is made to have a low ohmic resistance in order that it may not appreciably oppose the passage of the direct-current component of the periodic impulses. It is, however, designed to offer great impedance to the passage of the alternating component. The permanently-closed secondary of this transformer may be constituted by the spool or bobbin upon which the primary coil is wound, and in order to prevent the resistance of this bobbin, considered as a closed secondary, from being as low as that of a commercial transformer of the same size it is formed of some high-resistance metal, such as German silver. All this will more fully appear from the following detailed description with reference to the accompanying drawings, in which—

Figure 1 is a perspective view of the magnetic frame of our improved current-leveler. Fig. 2 is a vertical section of the current-leveler complete; and Fig. 3 is a perspective view of the complete current-leveler, showing its connection with a system of transformation of single-phase alternating current into continuous current, and vice versa, of the kind set forth in our Patent No. 572,510.

Like numerals of reference indicate like parts throughout the drawings.

The outer portion or yoke 1 of the magnetic frame is composed of a number of thin iron annular laminæ 2 2, insulated, as usual, and held together by end plates 3 3, as seen in Fig. 3, and bolts 4 4, passing through the holes 5 5. (Shown in Figs. 1 and 2.)

The core 6 of the transformer, upon which the primary and secondary circuits are placed, is also composed of soft-iron laminæ of the usual thickness, though the thickness of the laminæ, both of the core and of the yoke, is necessarily exaggerated in the drawings; but it is necessary that the iron of the transformer should not be saturated by the direct-current component if, for the purpose above set forth, it is to respond to the superposed alternating impulses. In order to prevent this saturation, we prefer to build up the core of a number of comparatively narrow strips 7 7, set side by side on edge, as shown in Fig. 1, and in such a way as to form in the particular structure shown six similar laminated parallelepipeds. These parallelepipeds are separated from each other by any material of low magnetic permeability, preferably also an electric insulator—as, for example, sheets of paper, which are represented by the heavy lines 8 8. It is thus possible to build up a magnetic circuit of any desired permeability and to prevent the iron from being saturated by the passage of the direct-current component of the periodic impulses. For example, we may so design the core and the yoke that the passage of the direct-current component will create in the magnetic circuit a flux of a specific intensity equal to ten thousand centimeter gram second lines of force to the square centimeter, in which case the alternating current, which we have imagined as being superposed on the continuous current, may cause a variation of this induction between the limits of eight thousand and twelve thousand lines to the square centimeter, which upper limit is well below the saturation-point of good soft iron. In this way we are enabled to produce a core which will readily and accurately respond to any variation of the current passing through the transformer, which obviously would not be the case if we allowed the magnetic circuit to become saturated or nearly saturated by the direct-current component alone.

The coil 9 is wound upon the bobbin or spool 10, surrounding the core 6, and is connected at its extremities to terminals 11 11. (Shown in Fig. 3.) The spool 10 is made, as above stated, of some metal having a comparatively high specific resistance—as, for example, German silver. In the drawings the thickness of the metal of this spool has been exaggerated for the sake of clearness. It will be seen that this spool constitutes the secondary of the transformer and forms a closed comparatively high-resistance circuit of a single turn, embracing the core of the transformer and in close inductive relation to the primary winding.

In Fig. 3 we have shown our improved leveler applied in connection with the particular device shown in our above-mentioned prior patent. In this figure, 12 is a source of single-phase alternating current feeding, through the wires 13 14, the current-converting apparatus 15, shown and more fully described in our said former patent, to which reference is hereby made. In this connection it will only be necessary to briefly describe the apparatus, which is constituted as follows: At 16 is shown a closed magnetic circuit—as, for example, a ring built up of soft-iron wire—upon which are wound a number of similar bobbins 17, supplied with current from the alternating-current source 12 through the wires 13 14. These bobbins so supplied generate in the ring 16 a simple circular alternating flux, which may be assumed to follow a sine law. The secondary bobbins 18 18′ 18^2, &c., are connected to each other and to the commutator 19 as are the separate coils of an ordinary Gramme winding. These secondary bobbins are not, however, as in a Gramme ring, all wound in the same direction and with the same number of turns, but are wound in accordance with a sine law—that is to say, if there are n secondary coils successively displaced from each other by an angle $\frac{2\pi}{n}$, and if α be some small constant angle, then the number of turns in the various secondary coils 18, 18′, 18^2, to 18^n are as follows, respectively:

$$a \sin. \alpha$$
$$a \sin. \left(\alpha+\frac{2\pi}{n}\right)$$
$$a \sin. \left(\alpha+\frac{4\pi}{n}\right)$$
$$\overline{}$$
$$a \sin. \left(\alpha+\frac{2(n-1)\pi}{n}\right)$$

In other words, the number of turns on the various coils are proportional to the sines of their angular displacements from some arbitrarily-assumed point on the ring. Those coils which have an angular displacement whose sine is positive are obviously wound in one direction, while those coils which have an angular displacement whose sine is negative are wound in the opposite direction, as is indicated by the different shading in Fig. 3.

Brushes 20 21, driven in synchronism with the single-phase alternating current by any suitable means and connected through the rings 22 23 with the brushes 24 25, bear upon the commutator 19 at diametrically opposite points. The brushes 24 25 are connected through the wires 26 27 with the direct-current-translating devices 28 29 30, which are an arc-lamp, a direct-current motor, and a storage battery, respectively.

By the action of a machine thus constituted, which is fully set forth in our above-mentioned patent, there is obtained a periodically waxing and waning unidirectional current, which may be considered as the superposition of an alternating current upon a uniform direct current.

In order to eliminate the alternating component of this current, we connect in series with the secondary brushes 24 25 the terminals 11 11 of our improved current-leveler, as shown in the drawings.

The action of a system thus constituted is as follows: Single-phase alternating current is generated at 12 and, passing by the wires 13 14 to the coils 17, induces a simple alternating flux in the core 16, which in turn induces alternating electromotive forces in the coils 18 18′, &c. The brushes 20 21 collect from the secondary winding a current due to a unidirectional periodically-varying electromotive force. This current passes through the primary winding 9 of the current-leveler. This primary winding 9 by reason of its high impedance acts as a reaction or choking coil to eliminate the alternating component of the current as it comes over the line in the normal operation of the system. Such action of the choking-coil is well understood. Should, however, some sudden change occur in the resistance or counter electromotive force of the translating devices or should any other sudden changes occur in the current flowing in the system taken as a whole, the choking-coil would not have sufficient capacity to counteract the change. It is at this point that the high-resistance closed-circuit secondary comes into play to take up and store the extra current which would thus be induced by a sudden change in the current in the system taken as a whole. Thus if the working current should be suddenly interrupted the tendency to arc would be largely reduced, since the high-resistance secondary would harmlessly absorb the energy residing in its magnetic field in the form of a current in this secondary.

It will be evident that various changes in construction and arrangement may be made without departing from the spirit and scope of our invention. We therefore do not limit ourselves to the specific forms shown and described; but

We claim as our invention and desire to secure by Letters Patent—

1. As a means for reducing the alternating component of a complex current-wave flowing in an electric circuit, a transformer provided with a primary in series with said circuit, and with a short-circuited high-resistance secondary in inductive relation to said primary, substantially as described.

2. The combination with a source of alternating current, of a current-rectifier connected thereto, and so actuated as to produce a substantially unidirectional periodic current-wave from the alternating current, translating devices supplied with said direct current from the rectifier, and a transformer with its primary in series between the translating devices and the rectifier, and its high-resistance secondary closed upon itself, substantially as described.

3. A current-leveler composed of a magnetic circuit, a metal spool mounted thereon, forming a high-resistance closed secondary,

and a primary winding upon the said spool, in the circuit carrying the current to be leveled, substantially as described.

4. The combination of a magnetic, laminated core, a high-resistance metal spool thereon, a winding on the spool and a series of annular iron laminæ surrounding the core to close its magnetic circuit, substantially as described.

5. A current-leveler composed of a core built up of parallelepipeds separated from each other by material of low magnetic permeability, a yoke closing the magnetic circuit of said core, a metal spool on said core, and a primary winding upon said spool, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

MAURICE HUTIN.
MAURICE LEBLANC.

Witnesses:
EDWARD P. MACLEAN,
PAUL BOUR.