No. 857,267. PATENTED JUNE 18, 1907.

L. R. AUVERT & A. F. E. FERRAND.

REDRESSING AND REGULATING DEVICE ENABLING TO TRANSFORM A SINGLE PHASE CURRENT INTO A CONTINUOUS ONE.

APPLICATION FILED AUG. 9, 1905.

2 SHEETS—SHEET 1.

Fig. 1.

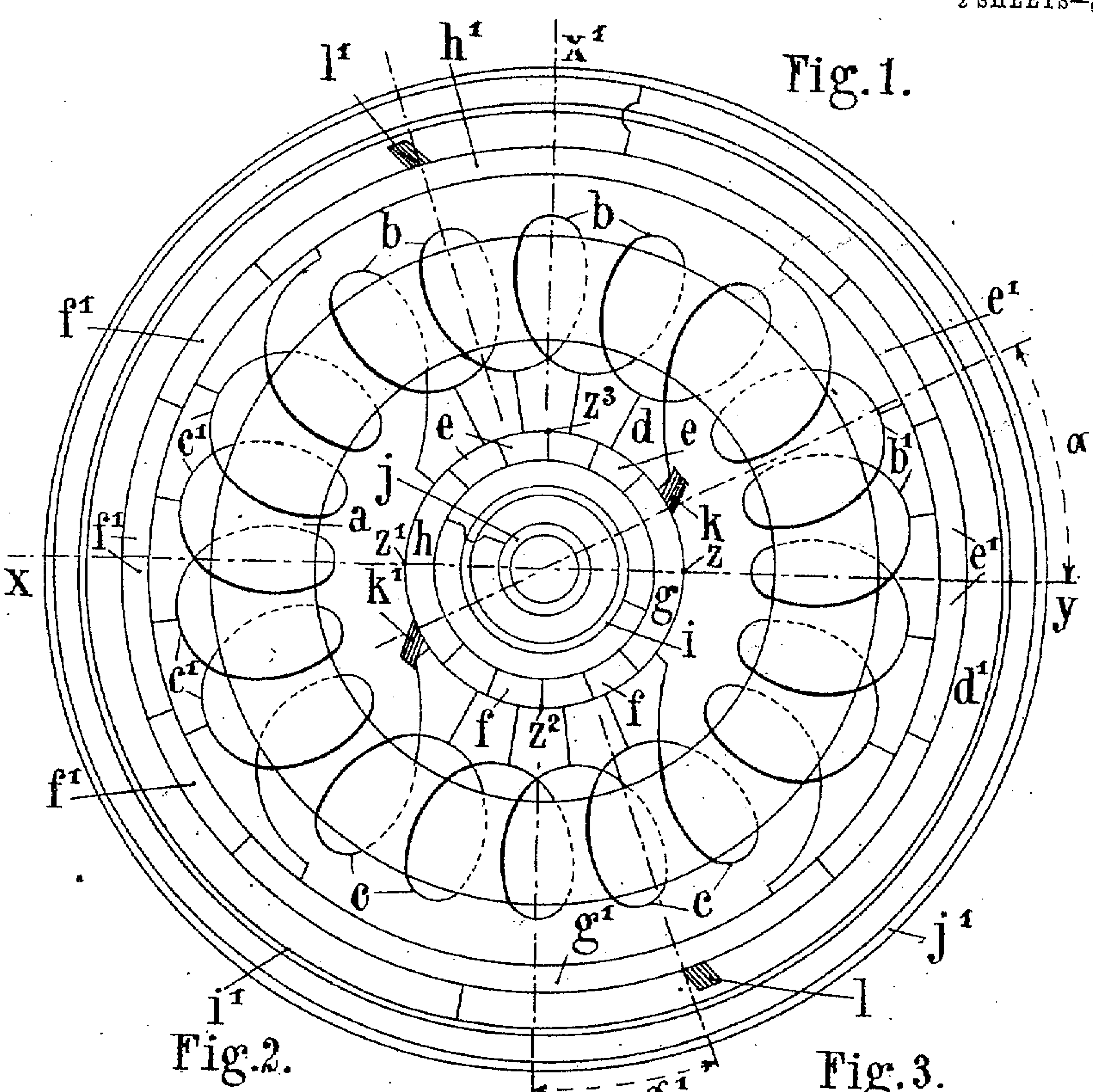


Fig. 2.

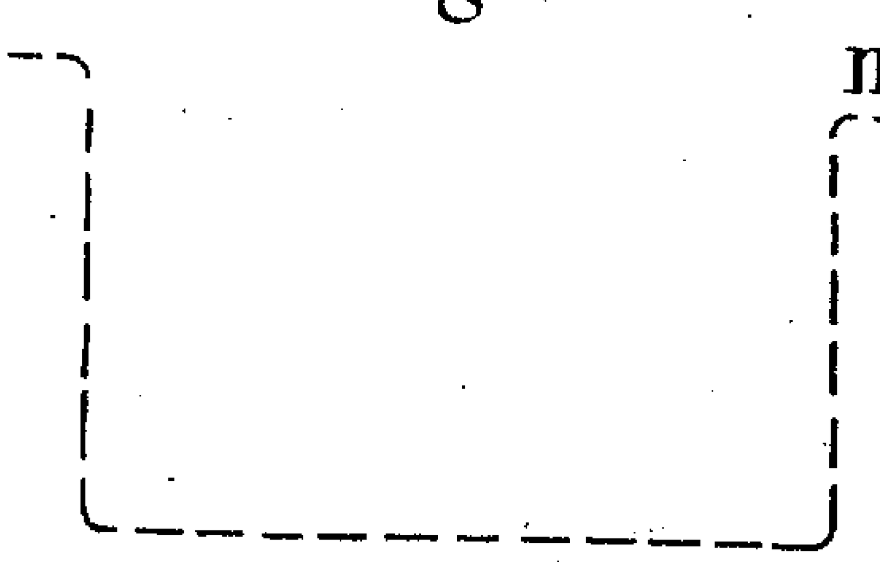


Fig. 3.

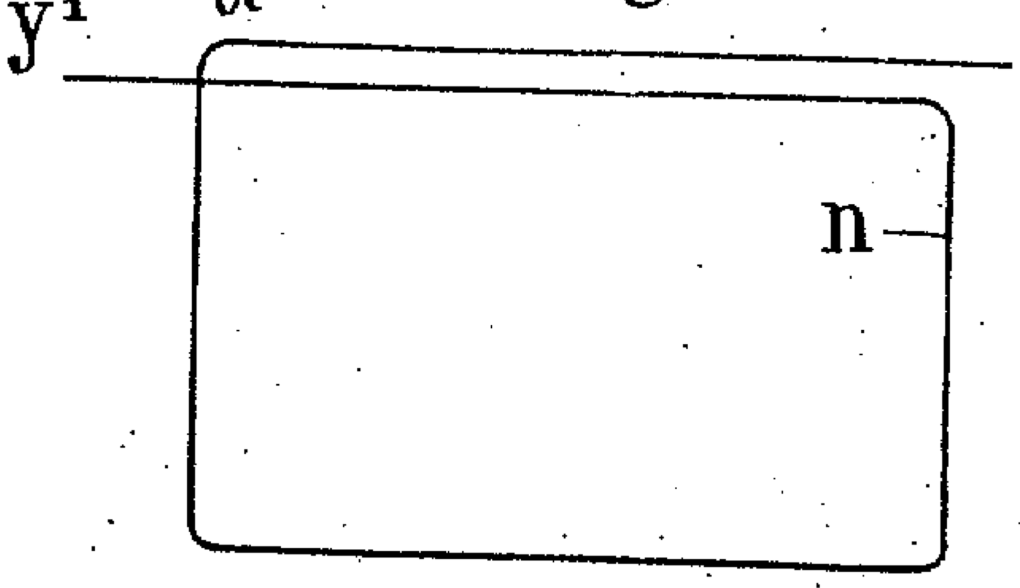
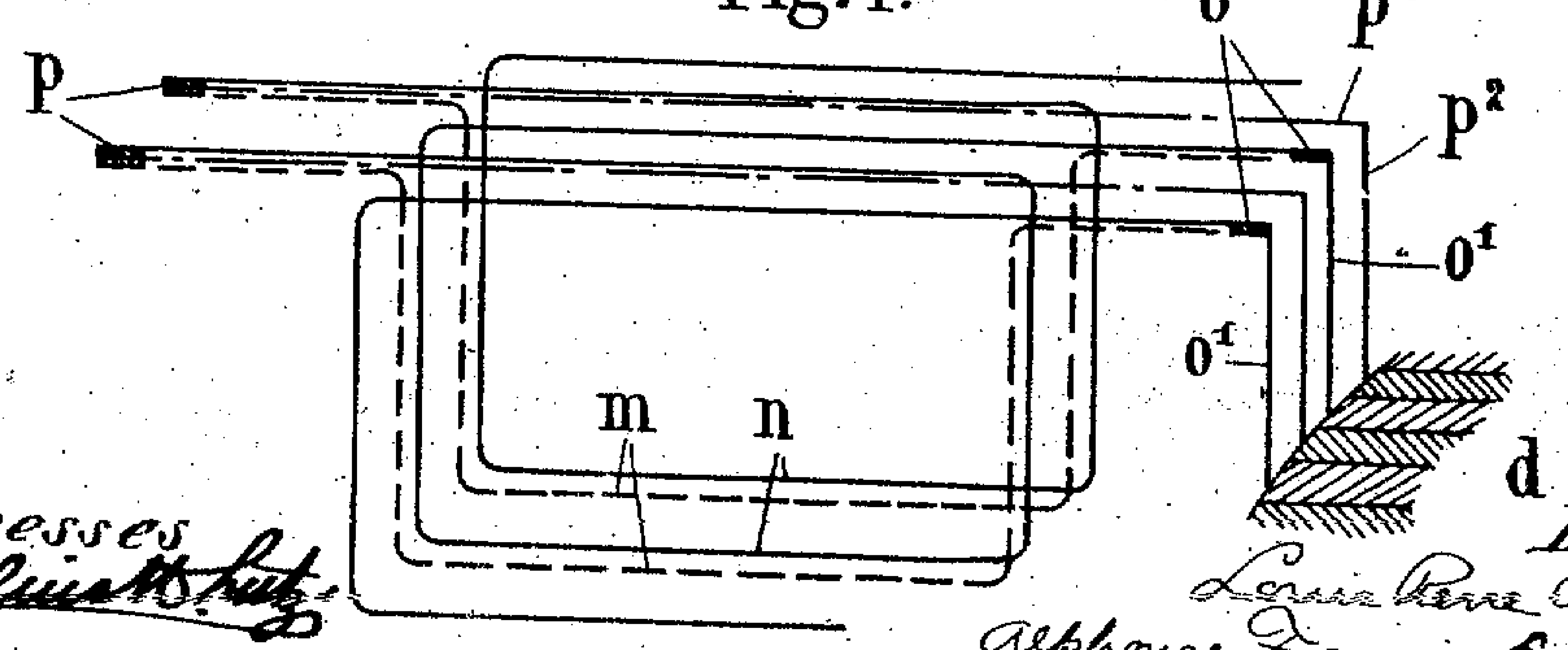


Fig. 4.



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2 SHEETS—SHEET 2.

Fig. 5.

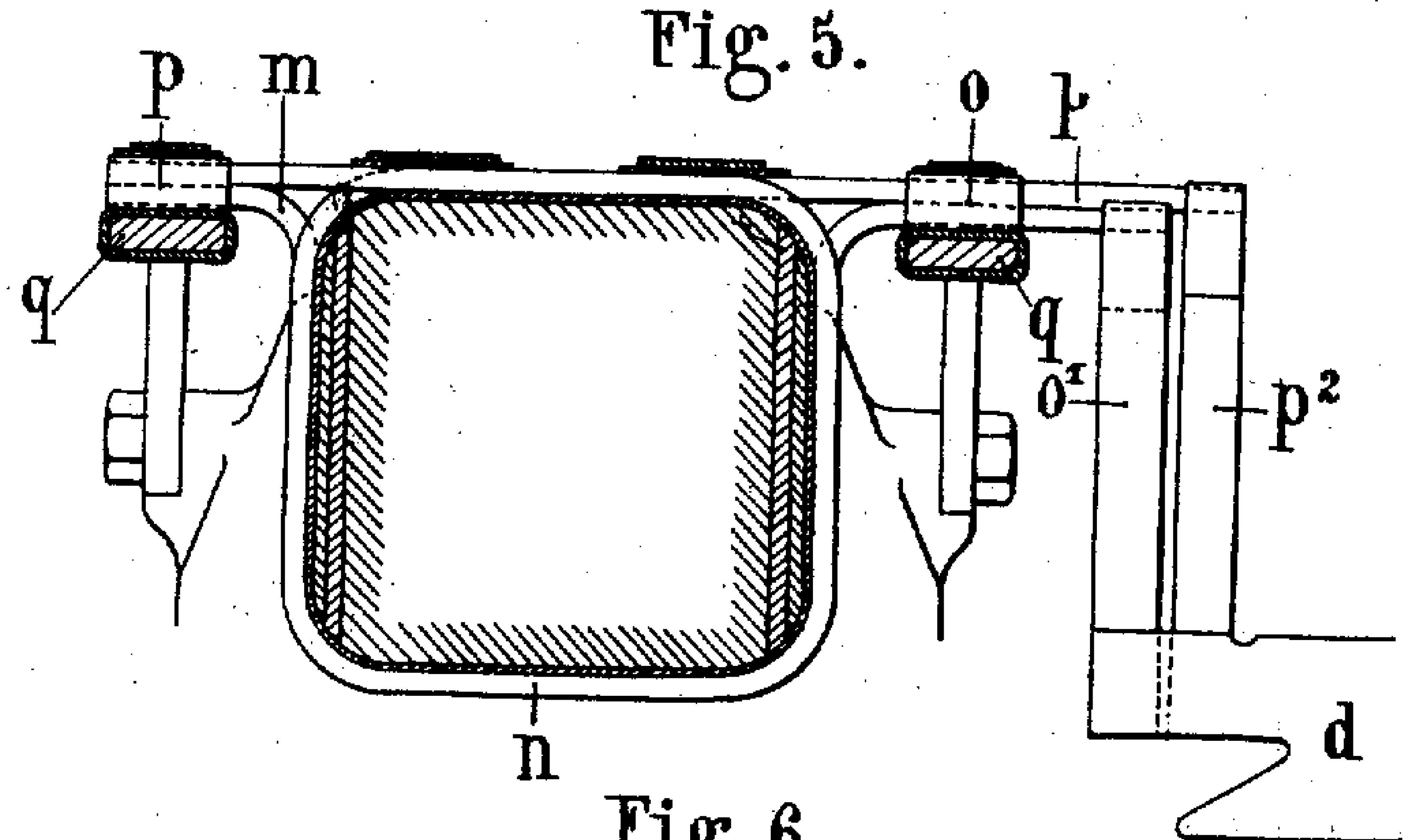


Fig. 6.

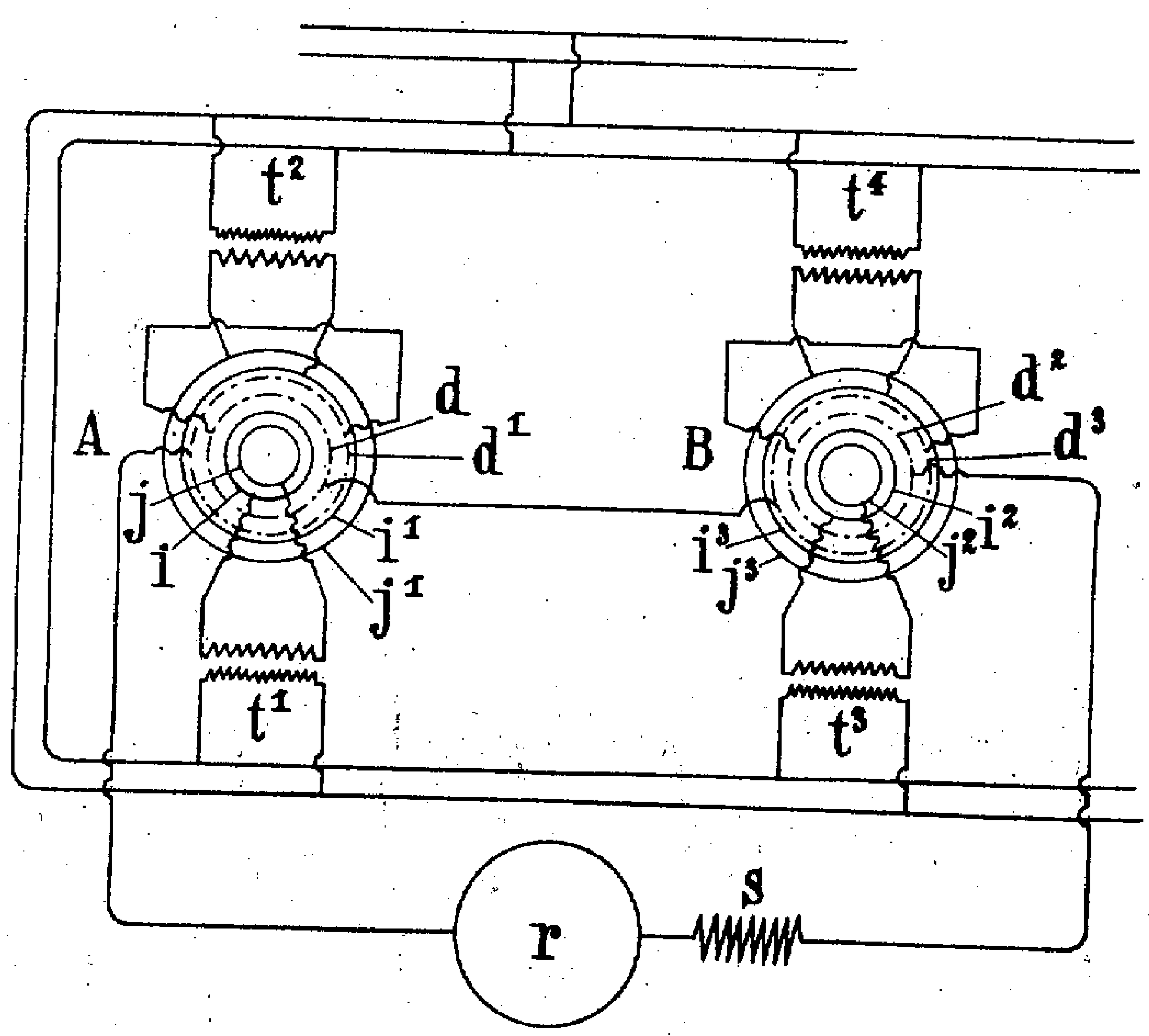
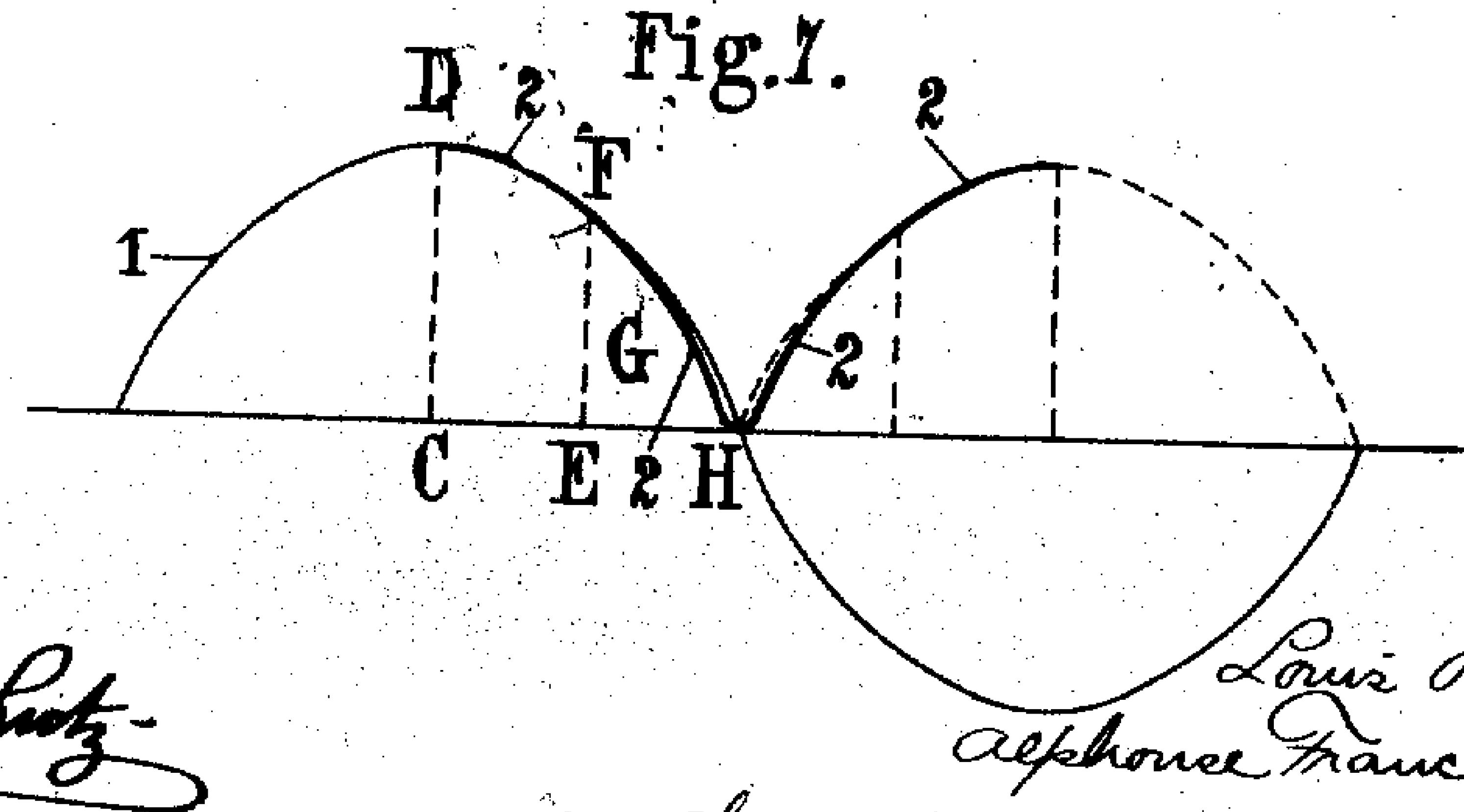


Fig. 7.



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REDRESSING AND REGULATING DEVICE ENABLING TO TRANSFORM A SINGLE-PHASE CURRENT INTO A CONTINUOUS ONE.

No. 857,267. Specification of Letters Patent. **Patented June 18, 1907.**

Application filed August 9, 1905. Serial No. 273,344.

To all whom it may concern:

Be it known that we, LOUIS RENÉ AUVERT and ALPHONSE FRANÇOIS ERNEST FERRAND, both of 20 Boulevard Diderot, in the city of Paris, Republic of France, engineers, have invented a Redressing and Regulating Device Enabling to Transform a Single-Phase Current into a Continuous One, of which the following is a full, clear, and exact description.

Our invention relates to rotary transformers for converting an alternating current into a continuous one, or rather into a pulsating or undulating current.

The object of our invention is to provide a simple and efficient device of the above indicated class, which may be readily adjusted to vary the electrical effect.

Reference is to be had to the accompanying drawings, in which

Figure 1 is a diagrammatic face view of the apparatus, Figs. 2 to 5 inclusive are diagrams illustrating the winding of the coils; Fig. 6 is a diagram showing two similar rotary transformers connected in series to operate one or more motors; and Fig. 7 is a diagram representing the voltage curve.

The apparatus comprises a ring *a* built up of pieces of very thin sheet-iron, similar to the construction of a dynamo core. On this ring are placed two series of coils; those of one series, *b*, *c*, are connected with a collector ring *d*, while the coils *b′*, *c′*, of the other series are connected with a collector ring *d′*. Fig. 1 shows only two coils in each series, but in practice there may be more of them. The two collector rings would be of the same diameter in an actual machine, but for the sake of more convenient illustration they are shown of different diameters in Fig. 1.

Each of the collector rings *d*, *d′* is divided into four equal parts. Those adjacent to the coils *b*, *c*, *b′*, *c′*, are subdivided, forming a series of contact plates *e*, *f*, *e′*, *f′*, each connected with adjacent turns or windings of the respective coil. Between these contact plates are located other contact plates *g*, *h*, *g′*, *h′*, each of which is represented in the drawings as a single contact plate, although in practice we may employ a number of contact plates connected with each other. The contact plates *g*, *h*, are connected with rings *i*, *j*, respectively, and similarly the contact plates *g′*, *h′*, are connected with rings *i′*, *j′*, respectively. All the parts, so far described, are connected to rotate together. In addition to these parts we have provided contact brushes, or their equivalent, which are normally stationary, and engage the contact members as follows: Two diametrically opposed contact brushes *k*, *k′*, which are connected with ends of the coils *b*, *c*, engage the collector ring *d*. Two similar brushes *l*, *l′*, engage the collector ring *d′*, which is constructed in the same manner as the ring *d*, and has contact plates *e′*, *f′*, *g′*, *h′*. The brushes *l*, *l′*, occupy a position with relation to the brushes *k*, *k′*, which is approximately or exactly 90° from the position of said brushes *k*, *k′*. The rings *i′*, *j′*, are connected with the contact plates *g′*, *h′*, respectively. In addition to the parts shown in the drawings there would be stationary brushes engaging the rings *i*, *j*, *i′*, *j′*, respectively. In many cases we prefer to have the brushes *l*, *l′*, and *k*, *k′*, or only one set of them adjustable circumferentially, such adjustment operating to vary the electrical action, as will be more fully set forth presently. In any event, however, the brushes of each set should remain diametrically opposed to each other.

In operation the brushes bearing on the rings *i*, *j*, are connected with a source of an alternating current, and the brushes bearing on the rings *i′*, *j′*, are similarly connected with a source of another alternating current, which has the same period and the same phase as the first alternating current. As the apparatus is constructed in the drawing the alternating current would be of the monophase kind, that is, it would change its direction once for each revolution of the transformer. The simplest way of carrying out these conditions in practice is to provide two stationary transformers; the primary coils of each would receive their current from one and the same generator, while their individual secondary coils, would be connected with the rings *i*, *j*, *i′*, *j′*, respectively. The apparatus would be rotated by means of a synchronous motor, performing one revolution for each period of the alternating current. The preferred arrangement of the brushes *k*, *k′*, is such that the central points *z*, *z′* of the contact plates *g*, *h*, engage the said brushes when the voltage between the rings i, j, is at its maximum. With this arrangement the brushes k, k', will collect a current which is always of the same direction, although its voltage varies. Supposing that the brushes k, k', are at the points z, z', respectively at the moment where the voltage between i, j, is greatest, such voltage may be represented by the ordinate C. D. (Fig. 7) of the sine curve 1, which represents the voltage of the current supplied to the rings i, j. During one eighth of a revolution, after said position has been reached, the brushes k, and k', are connected directly with the rings i, j, through the medium of the contact plates g, h, and thus the alternating current passes directly to the said brushes. Therefore, the portion of the curve representing the voltage difference at the brushes during said period will be exactly the same as that representing the potential difference of the alternating current, as indicated by the portion D. F. in Fig. 7. During the succeeding one eighth of a revolution the brushes k, k', are connected with the rings i, j, through the coils b, c and the contact plates e, f, of the collector d. The potential curve at the brushes during this period is represented by F G H in Fig. 7. When the brushes k, k' engage the points z^3, z^2, they connect plates of even potential, and therefore there is no difference of potential between said brushes. At this very moment the change of phase or current direction occurs at the rings i, j. Thus both curves 1 and 2 representing the potential of the alternating current and that of the transformed current respectively, pass through the same point H. As the rotation progresses, the direction of the alternating current is reversed, but as the brushes k, k' have passed beyond the points z^3, z^2, the direction of the current at the brushes is the same as before. We therefore obtain at the brushes k, k', a current which varies in voltage, but is always of the same direction. The same thing is true of the current at the brushes l, l'. These two currents may be used independently or when an increased electromotive force as desired, the brush k', may be connected with the brush l, and the current taken off at the brushes k and l' will then have an electromotive force equal to the sum of the individual electromotive forces since the two portions of the machine are connected in series. By adjusting the brushes k, k', or l, l', or both sets circumferentially we may vary the mean potential of the transformed current. If by α and α' we designate the angles formed respectively by the diameters along which the brushes k, k', l, l', are placed and the diameters x, y, and x', y' passing through the points z, z' and z^2, z^3 respectively, that is the diameters passing through the centers of the coils, and if E° sin ωt an E_0 sin ωt represent the varying voltage of the two alternating currents fed to the rings i, j, i', j', then the preferred results under the conditions explained above will be obtained if $\alpha = \alpha' = \frac{\pi}{2} + \omega t$. In practice the mean electromotive force of the two alternating currents will generally be the same.

A particular construction of the coils, which offers great advantages as to strength and ease of manufacture, is shown in Figs. 2 to 6 inclusive. This construction comprises half windings m, (Fig. 2) and entire, or complete coils or windings n, (Fig. 3). These entire and half windings are connected and soldered together and placed upon the core ring a in the manner indicated in Fig. 4. The terminals o are connected by short wires o', with the insulated sections of the collector ring d; the terminals p are provided with long connections which consist of a thin strip p', placed on the periphery of the ring between the wires of the main coil, and a radial strip p^2 running to the collector ring. The soldered ends of these windings form symmetrically at the right and the left of the ring an even projection which may be easily hooped, and is therefore of great strength. In Fig. 5 we have shown a ring q, which is carried by the sleeve serving to clamp the sheet-metal sections of the core. On this ring rest the connections of the coil, and a very durable construction is thus secured.

The transformer above described may be employed for various purposes, among which we will refer especially to electric traction. The electric current taken from the line wires would be transformed on the car into a continuous undulating current which would then actuate the motors. The advantages of convenient transmission to a distance possessed by alternating currents and the advantages of great safety and flexibility presented by direct current motors would be combined. Starting can be effected readily by temporarily shifting a set of brushes, or both, circumferentially, so as to vary the voltage, as above described.

Since the electromotive force of the transformed current may be different from the one required for operating the direct current motors, it may be necessary in some cases to provide a plurality of rotary transformers of the type above described. Thus in Fig. 6 we have shown an arrangement comprising two such rotary transformers connected in series and this arrangement would be employed if the voltage required by the motor is twice that supplied by the transformed current. A, B, indicates the two rotary transformers; t', t^2, t^3, t^4, the stationary transformers the primaries of which receive their current from the same generator or source of electricity, while their secondaries form four entirely independent circuits. The primaries of these stationary transformers may be connected in series or in parallel as shown, but the secondary coils of the stationary transformers should be independent of each other. *r*, designates the motors of the car, which may be connected in any suitable manner, and *s*, is a self-induction coil, by means of which the undulating current, produced by the two rotary transformers may be rendered more or less uniform at the terminals of the motors. The self-induction coil is not required when the motors have laminated field magnets, and are energized in series, since in that case the field magnets have a sufficient self-induction to make the tension of the transformed current practically uniform.

The device hereinbefore described may also be used as an electric brake and as a power accumulator. If, for instance, the motors are driven by a direct current, or in any other way, and should the speed of the motor exceed a certain limit, so that the potential at the motor terminals would be greater than the mean potential difference of the rotary transformers, then a direct current opposed to the actuated current will be produced in the circuit and will exert a braking action. At the same time this will produce an alternating potential at those contact members of the rotary transformers which are connected with the secondary coils of the stationary transformers, greater than the potential of the said secondary coils; thus the ordinary function of said stationary transformers will be reversed, their secondary coils acting as primaries, and their primaries as secondaries, so that electrical energy will be supplied to the line wires.

A particular advantage of the rotary transformer when provided with adjustable brushes is that a starting resistance need not be employed, since the voltage can be varied considerably by simple circumferential adjustment of the brushes such as *k*, *k'*, and *l*, *l'*.

We claim:

1. A rotary transformer comprising the following parts held to rotate in unison: a ring of magnetizable material, two series of coils on said ring, two collector rings connected with the respective coils, conducting rings each connected with one of the several collector rings to convey two separate alternating currents to said collector rings, each collector ring comprising insulated contact plates; and stationary brushes engaging said collector rings to receive a direct current therefrom.

2. A rotary transformer comprising the following parts held to rotate in unison: a ring of magnetizable material, two series of coils on said ring, two collector rings connected with the respective coils, conducting rings each connected with one of the several collector rings to convey two separate alternating currents to said collector rings, each collector ring comprising insulated contact plates connected with said coils at different points; and stationary brushes engaging said collector rings to receive a direct current therefrom, said brushes being adjustable circumferentially to vary the mean potential of the transformed current.

3. A rotary transformer comprising the following parts held to rotate in unison: a ring of magnetizable material, two series of coils on said ring, two collector rings connected with the respective coils, conducting rings each connected with one of the several collector rings to convey two separate alternating currents to said collector rings, each collector ring comprising insulated contact plates, and each coil consisting of complete windings and half-windings connected with said contact plates by long and short leads respectively; and stationary brushes engaging the collector rings to receive a direct current therefrom.

The foregoing specification of our redressing and regulating device enabling to transform a single phase current into a continuous one signed by us this thirteenth day of July 1905.

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ALPHONSE FRANÇOIS ERNEST FERRAND.

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