No. 693,098. Patented Feb. 11, 1902.

R. E. BALL.

ROTARY TRANSFORMER.

(Application filed Dec. 19, 1900.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

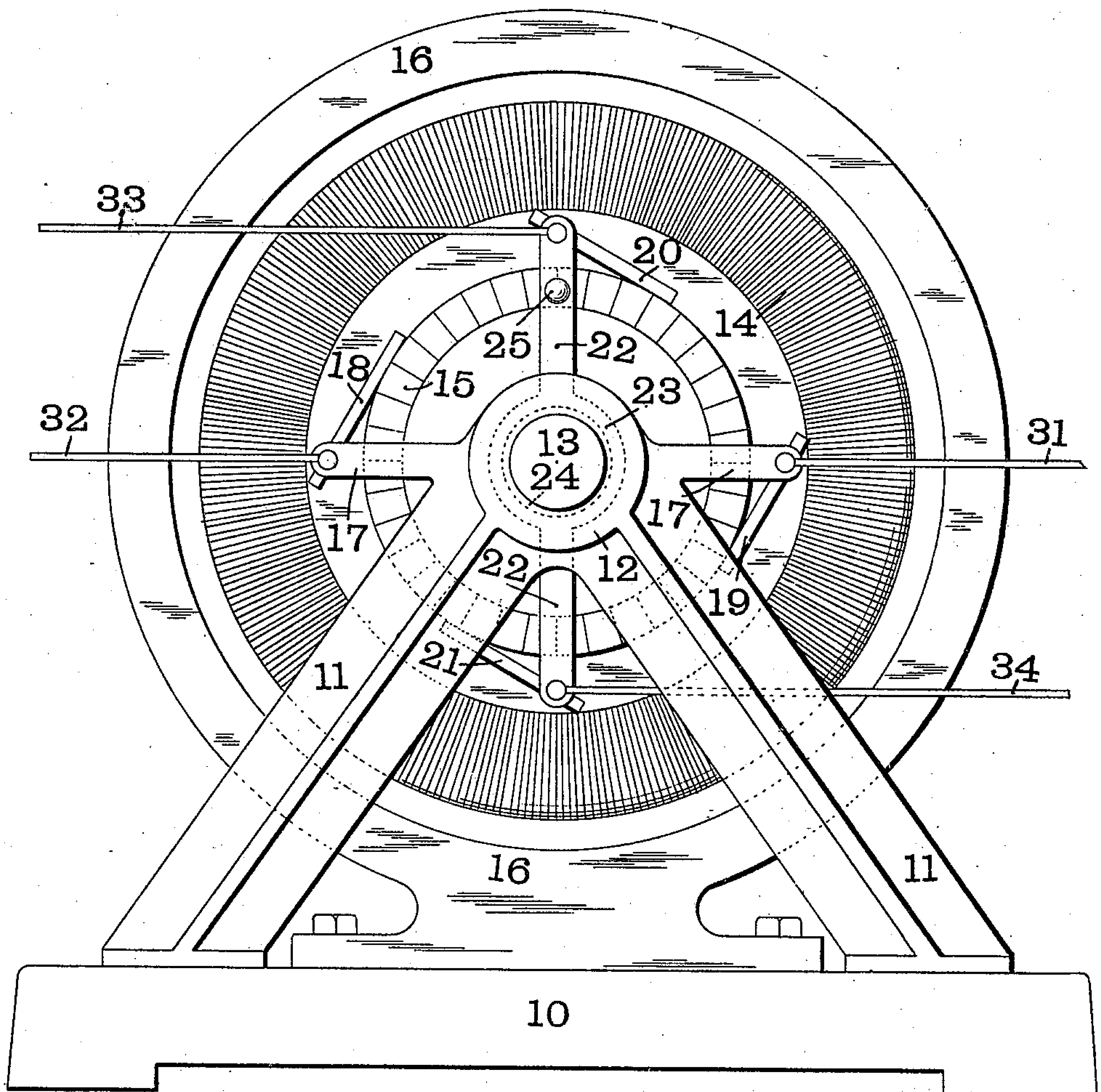

Fig. 2.

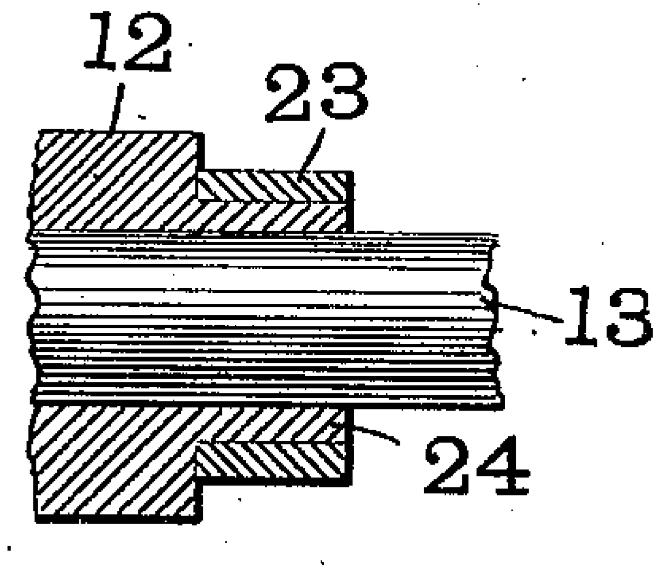

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Fig. 3.

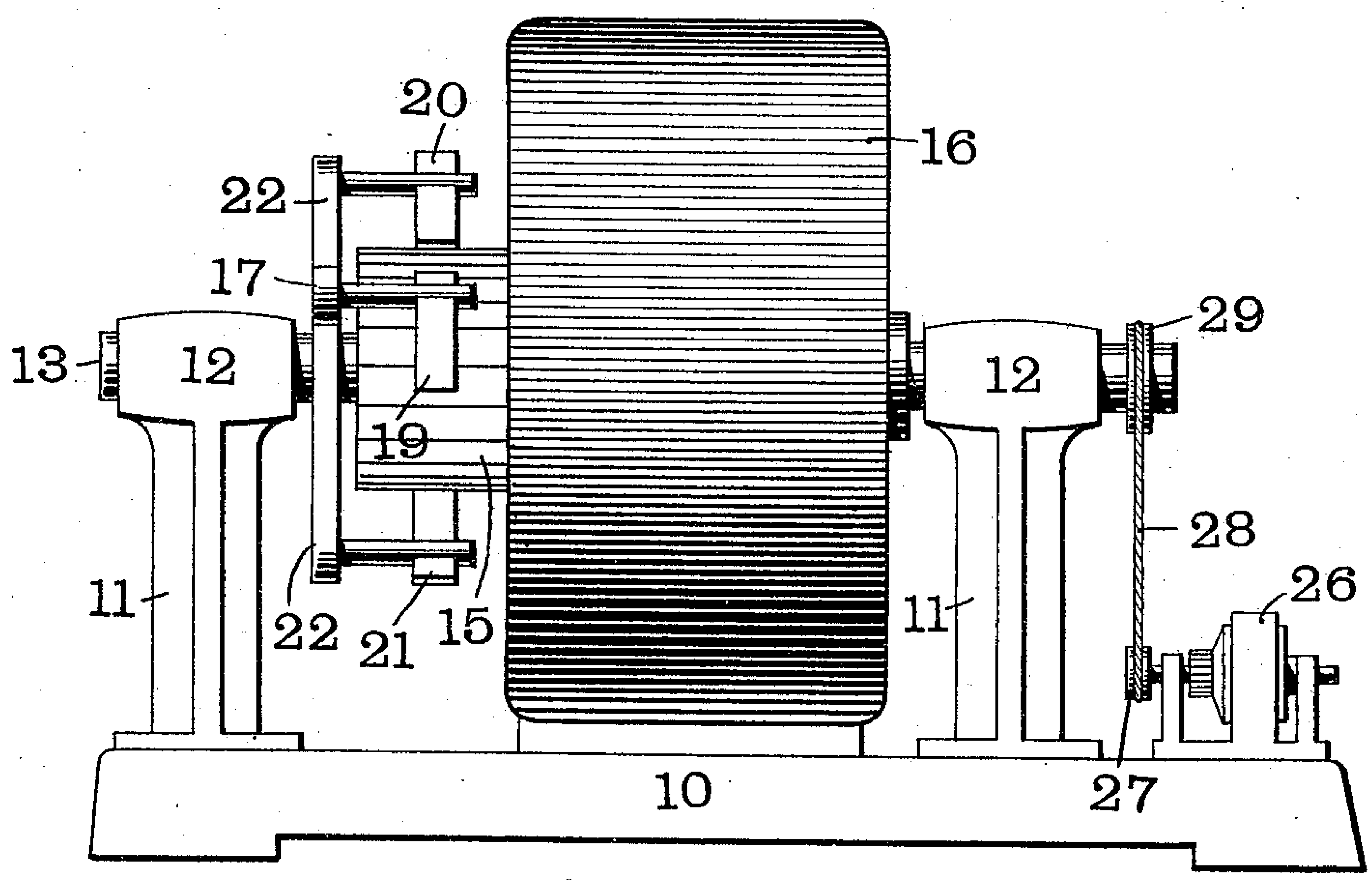

Fig. 4.

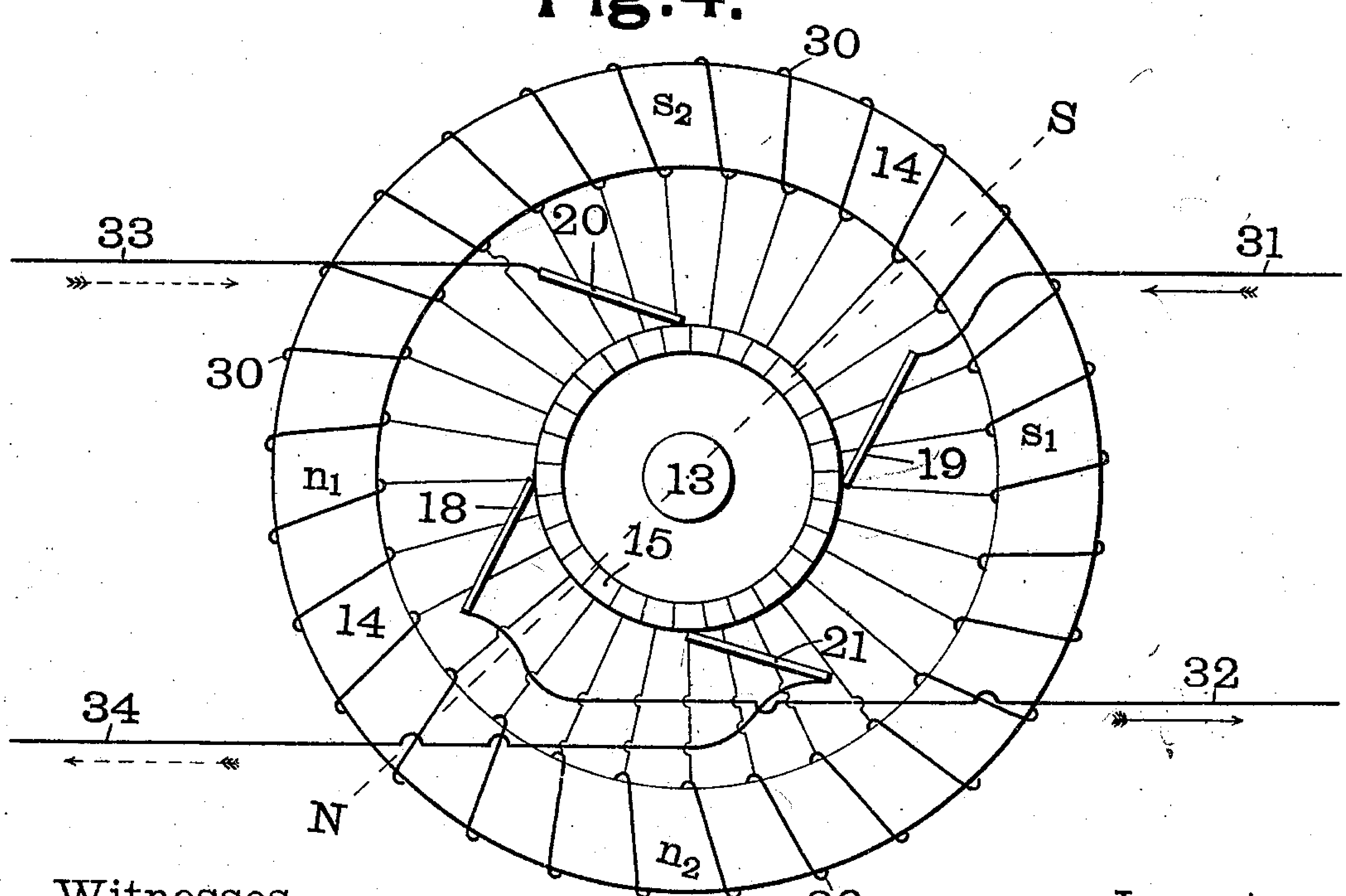

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Fig.5.

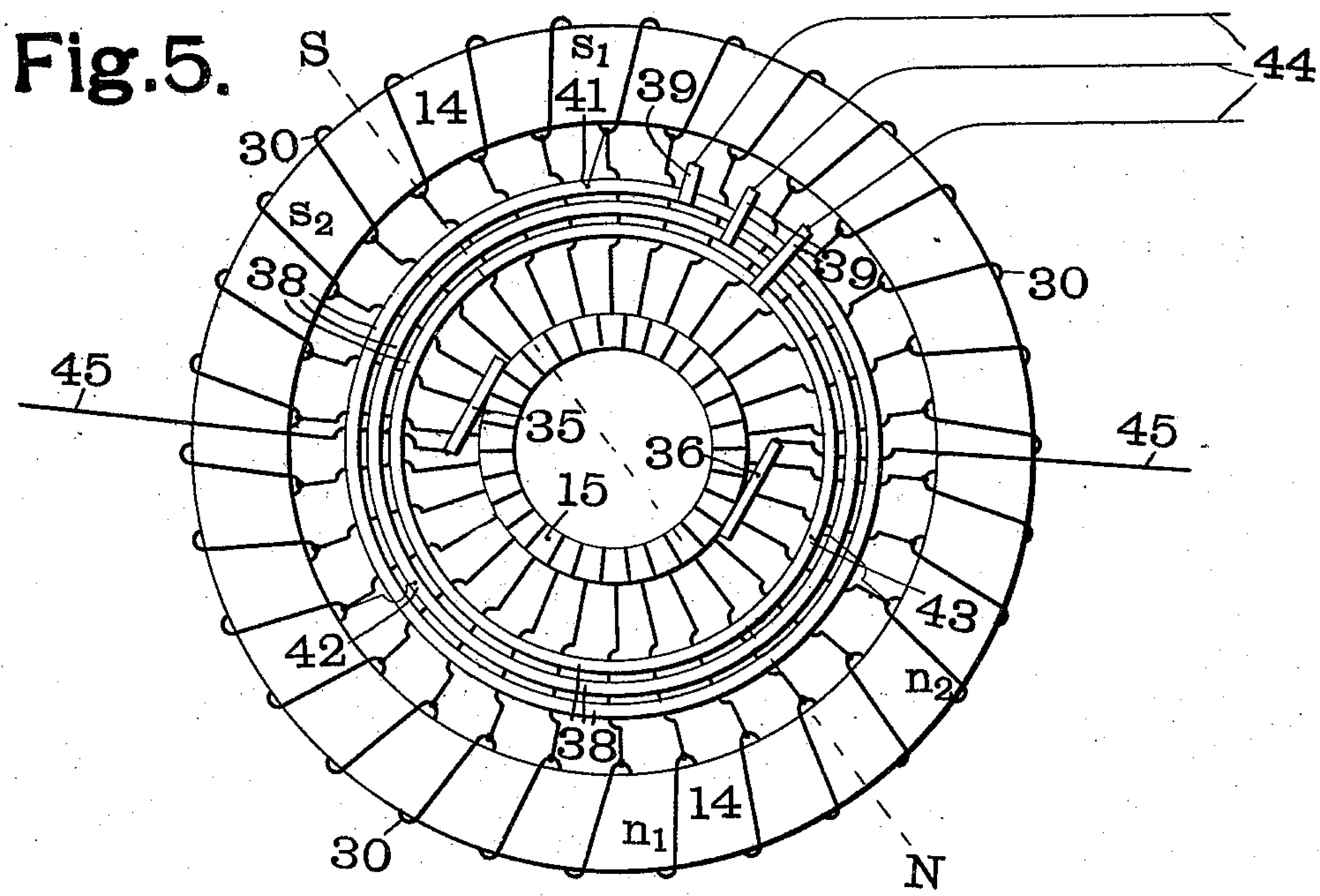
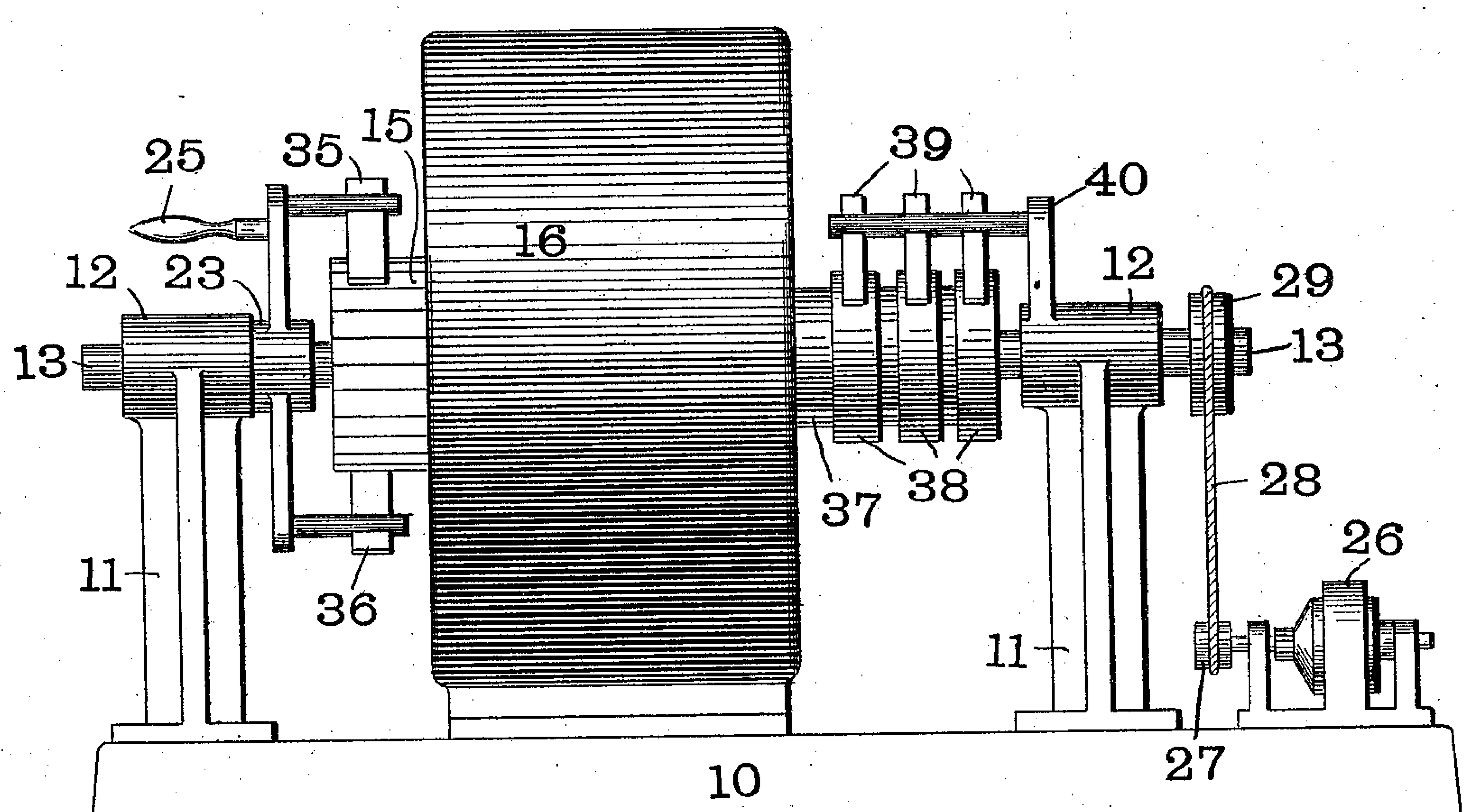


Fig.6.



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UNITED STATES PATENT OFFICE.

ROYAL EDWARD BALL, OF NEW YORK, N. Y.

ROTARY TRANSFORMER.

SPECIFICATION forming part of Letters Patent No. 693,098, dated February 11, 1902.

Application filed December 19, 1900. Serial No. 40,335. (No model.)

To all whom it may concern:

Be it known that I, ROYAL EDWARD BALL, a citizen of the United States, residing at the city of New York, in the county and State of New York, have invented a certain new and useful Rotary Transformer, of which the following is such a full, clear, and exact description as will enable any one skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, forming part of this specification.

My invention relates more particularly to the transformation of continuous currents of one amperage or voltage to other continuous currents of different amperage or voltage and also to the transformation of alternating currents to continuous currents, or vice versa, with or without change in amperage or potential by means of a rotary transformer having but a single coil, which acts both as the primary and secondary coils of an ordinary double-coil rotary transformer.

The object of my invention is to provide a simple and cheaply-constructed rotary transformer which will be effective and practical in cases where the desired range of transformation is not larger than the ratio of two to one, such as in transformation of continuous currents of 9.6 amperes to continuous currents of 6.8 amperes, which is at present in demand for furnishing current to inclosed-arc lamps where it is not desired to discard old general station generating apparatus.

The method of transforming alternating current to continuous current described below in connection with the operation of my apparatus is the subject of another application for patent filed contemporaneously herewith, and in still another application also filed contemporaneously with this one I have specifically claimed the form of my apparatus described herein as devised especially for transforming alternating currents to continuous currents.

In the drawings herewith, in which like characters of reference refer to like parts in the different views, Figure 1 is an end view of my transformer; Fig. 2, a sectional view of an adjustable brush-holder for use with same. Fig. 3 is a side elevation of my apparatus. Fig. 4 is a diagram of the armature-winding thereof and its connection with the commutator bearing the primary and secondary brushes. Figs. 5 and 6 are respectively a diagram of the armature-winding and its connections and a side elevation of the preferred form of my invention for use in transformation from alternating to continuous current, or vice versa.

In Figs. 1 and 3, 10 represents a suitable base, upon which are standards 11, bearing boxes 12, in which the shaft 13 is journaled, bearing rigidly attached thereto the preferably laminated armature-core 14, which bears upon one of its ends the concentrically-disposed commutator 15, composed, as usual, of conducting segments or strips insulated from one another. Also mounted upon the base 10 and closely surrounding the core 14 is the reluctance-reducing ring 16, composed of iron or other magnetic metal. This ring is preferably bolted to the base 10, allowing the armature to rotate within it. It acts to complete the external magnetic circuit of my apparatus, and therefore reduces the reluctance of the field generated in the armature-core, as hereinafter described, thus largely increasing the efficiency of my apparatus. As the reluctance-reducer remains stationary, it is not necessary to have it laminated, and it can be made of cheap material, not being subject to hysteresis or eddy-currents, as it would be in case it rotated with the armature. Upon horizontal arms 17, extending from one of the standards 11, are attached the brushes 18 19, which bear upon diametrically opposite points of the commutator 15. These two brushes are referred to in this description as the "primary" brushes of my transformer; but, as will be seen hereinafter, they may be either the primary or secondary brushes of my apparatus. The secondary brushes are shown at 20 21 as bearing upon the commutator 15 at diametrically opposite points midway between the primary brushes 18 19. These secondary brushes are carried by arms 22, movably attached, as shown by dotted lines in Fig. 1 and by the sectional view, Fig. 2, by means of a collar 23 to a boss 24, projecting inwardly from the box 12 and surrounding the shaft 13. These secondary brushes are thus adapted to be moved to any desired position with reference to the primary brushes

18 19 and are held in that position by the friction of the collar 23 upon the boss 24. This movement may be accomplished by any of the well-known automatic means, if desired; but it is shown in the drawings as being done by means of a handle 25, projecting from one of the arms 22. At 26 is represented a small motor having upon its shaft a power-wheel 27, connected by means of the belt 28 with the driving-wheel 29 of my transformer for the purpose of rotating the core 14 and causing the commutator 15 to revolve beneath the brushes 18, 19, 20, and 21.

Fig. 4 shows in diagram the winding of the armature of my transformer, together with its connections with the primary and secondary circuits. This armature may be either of the Gramme-ring or drum-wound type, the former being shown in the drawings, and it may be either surface wound, as represented, or of the kind known as "iron-clad" or "coil-embedded" armatures. The laminated core 14 is wound with a single continuous coil 30, which is connected at points equally distant from each other to the various conducting segments or strips of the commutator 15. To the brushes 18 19 come the wires 31 32, constituting the primary circuit, and to the brushes 20 21 come the wires 33 34, constituting the secondary circuit.

It will be obvious to those skilled in the art that since there is no essential difference between transformation from continuous current to continuous current and transformation from alternating to continuous current, or vice versa, my apparatus can be used for this latter transformation. A few modifications to suit the varied conditions are, however, desirable. Figs. 5 and 6 illustrate these modifications for transforming three-phase alternating current to continuous current. In Fig. 6, 10 again represents the base; 11 11, the standards; 12 12, the boxes; 13, the shaft; 15, the commutator, and 16 the reluctance-reducing ring. Upon the commutator 15 bear brushes 35 and 36, which are connected with the continuous secondary current system and are made adjustable by being collared onto the flange 23, as shown in detail in Fig. 6 and described above. The handle 25 is used to change the position of the brushes on the commutator 15. From the other side of the core 14 projects an extension 37, which carries three insulated continuous contact rings or strips 38, upon which bear brushes 39, held in position by the arm 40, rigidly attached to the journal-box 12. As before, 29 represents a driving-pulley attached to the shaft 13. Over this pulley runs the belt 28, which also encircles the power-wheel 27 of the motor 26. This motor is preferably of the three-phase synchronous type for a purpose which will be hereinafter specified.

The armature-winding of my three-phase continuous transformer, together with its connections to the contact-rings 39 and the commutator 15, are shown in diagram in Fig. 5. The coil 30, wound on the core 14, is connected at each of three points 41 42 43 one hundred and twenty degrees apart to one of the continuous contact rings or strips 38, upon which bear the brushes 39, which in alternating continuous transformation are connected to the mains 44, carrying the primary alternating current. The coil 30 is also connected at equal intervals to the conducting segments or strips of the commutator 15, upon which bear at diametrically opposite points the secondary brushes 35 and 36, which are connected to the secondary continuous current conductors 45.

In transforming from continuous current to continuous current the operation of my apparatus may be briefly described as follows: Current from a suitable source is led through the primary brushes and the motor 26 is started, causing the armature of the transformer to rotate. Looking now at Fig. 4, it will be noticed that a primary magnetic field is generated in the core 14, which, supposing the primary current to flow as indicated by the arrows, will have its north pole at n' and its south pole at s'. We now have in a rotating armature a magnetic field stationary with respect to space, which field will be cut by the rotating coil 30, carrying the primary current. This coil will then have generated in it in addition to this primary current a secondary current, giving rise to a secondary magnetic field having its north and south poles, respectively, at $n^2 s^2$. From these two pairs of poles arises a resultant field, as is usual in such cases, having its north and south poles, respectively, at N S. With the secondary brushes in position with respect to the primary brushes, as shown in Fig. 4—that is, at opposite ends of a diameter perpendicular to a diameter connecting the contact-points of the primary brushes—the total wattage of the secondary will at all times be equal to the total wattage of the primary less the iron losses, and the direction of the current will be as indicated by the dotted arrows. The relative voltage and amperage of the primary and secondary currents may, however, be varied by varying the relative position of the primary and secondary brushes. If the secondary brushes are moved in the direction of rotation, the electromotive force generated and the power consumed are reduced. When moved counter to the direction of rotation, the opposite effect is produced, and when moved so that brush 20 is in position with brush 19 and brush 21 in position with brush 18 the coil regarded as a generator of secondary current is inactive.

The operation of my apparatus in transforming alternating current to continuous current is as follows: When three-phase current enters the coil 30 through the wires 44, Fig. 5, brushes 39, and contact rings or strips 38, it is evident that if the armature remained stationary it would have generated in its core 15 a magnetically-rotating field. If, however, by means of a three-phase synchronous motor at 26, connected across the primary mains, we cause the armature to rotate in a direction opposite to the rotation of the magnetic field and with equal frequency thereto, this field will become stationary in space and we will then have precisely the same conditions as in the case of transformation of continuous current to continuous current, described above. Supposing that the primary field has its poles at n' s' and that the secondary field, generated by the induced secondary current in the coil 30, has its poles, as indicated, at n^2 s^2, we will have, as before, the resultant poles N S, before which the primary current acts as motor and the secondary current is generated. Similar variations in electromotive force and amperage of the secondary current may also be obtained by varying the position of the secondary brushes upon the commutator as is obtained by varying the position of the secondary brushes in continuous to continuous transformation.

It is evident that by the use of my apparatus, suitably changed to meet differing conditions, alternating currents of any number of phase may be transformed to continuous current and at the same time modified in amperage or potential, if desired. These changes may, however, be made without departing in the least from my invention.

By the use of my apparatus continuous current may also be transformed to alternating current. In this case both the speed and direction of rotation of the armature are immaterial.

In continuous to continuous transformation I prefer to supply the continuous current to the primary brushes in the form of constant current; but the secondary current may be taken off either as constant potential or as constant current. When supplying alternating current to the primary brushes, I prefer to supply the same in the form of constant potential.

I am aware that many and important changes may be made in my apparatus as herein described. For instance, the armature may remain stationary and the primary and secondary brushes may be caused to rotate over their appropriate contact ring or rings, or the primary and not the secondary brushes may be adapted to have their positions upon their contact-rings changed at will, or other and different means may be employed to rotate the armature in synchronism with the phase displacement of the primary current. Moreover, I do not wish to be understood as confining myself to the use of only one pair or set of primary or secondary brushes, for in proper cases more than one pair of each may be used to form what is commonly known as the "multipolar" connection. All these changes may, however, be made without departing from my invention and are intended to be covered by the claims below.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a rotary transformer, an armature wound with a coil for both primary and secondary currents, a plurality of commutator-segments connected at intervals to said coil, primary brushes conveying current from an outside source to said armature through said commutator, secondary brushes conducting current from said armature, and means independent of said armature for producing rotation between said commutator and brushes.

2. In a rotary transformer, a rotatable core wound with a coil for both primary and secondary current, a plurality of commutator-segments connected at intervals to said coil, primary brushes conveying current from an outside source to said coil through said commutator, secondary brushes conducting current from said coil, and separate means for rotating said core.

3. In a rotary transformer, a rotatable core wound with a coil for both primary and secondary currents, a commutator the segments of which are connected at intervals to said coil, primary brushes bearing upon said commutator and conveying current from an outside source to said coil, secondary brushes bearing upon said commutator and conducting current from said coil, and separate means for rotating said core.

In testimony whereof I have hereunto set my hand and affixed my seal in the presence of the two subscribing witnesses.

ROYAL EDWARD BALL. [L. S.]

Witnesses:

W. H. TAYLOR,

J. SIDNEY BELL.