No. 882,531.

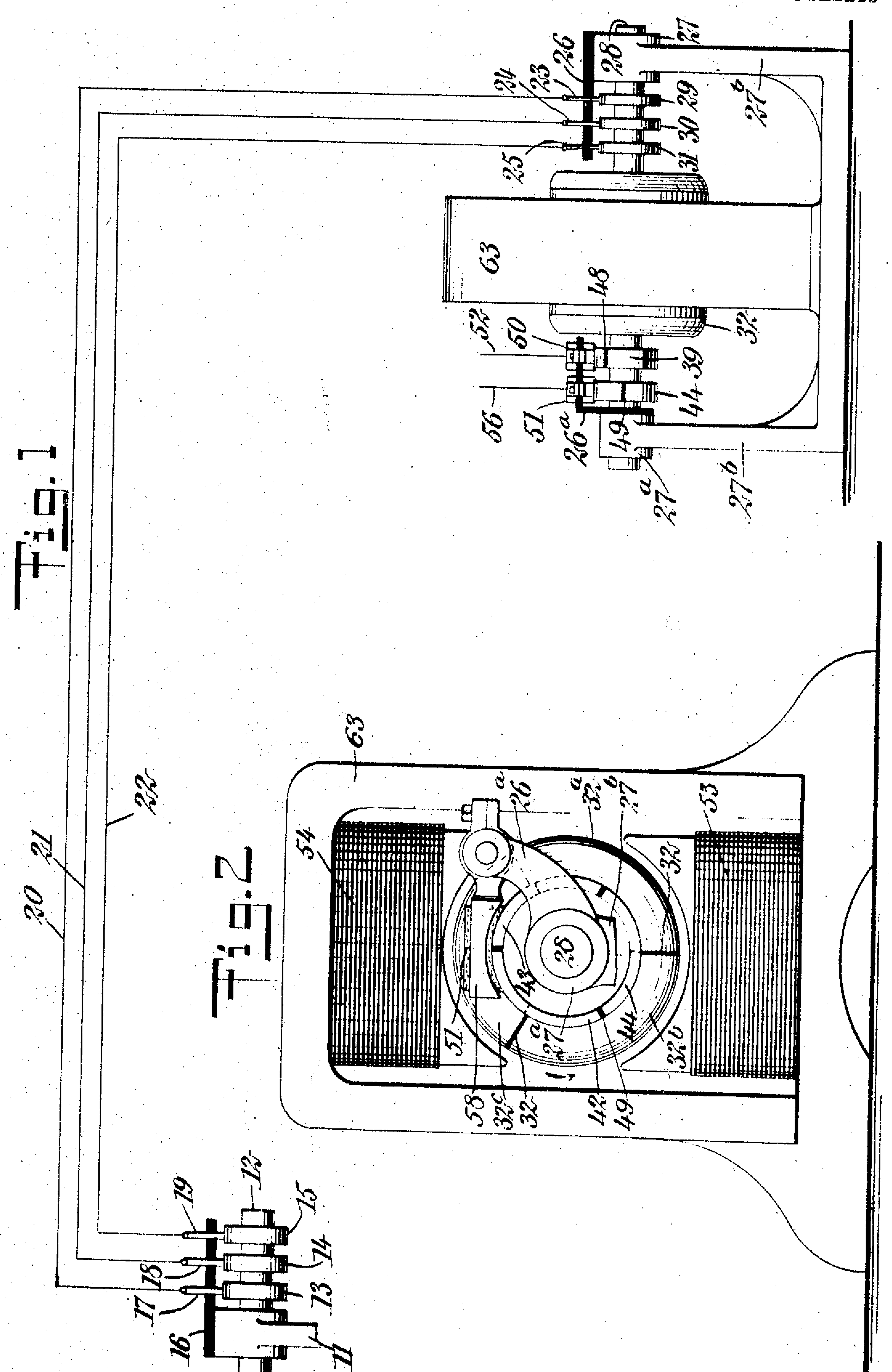
PATENTED MAR. 17, 1908.

J. L. MURDOCK.

ROTARY CONVERTER.

APPLICATION FILED MAR. 28, 1906.

3 SHEETS—SHEET 1.



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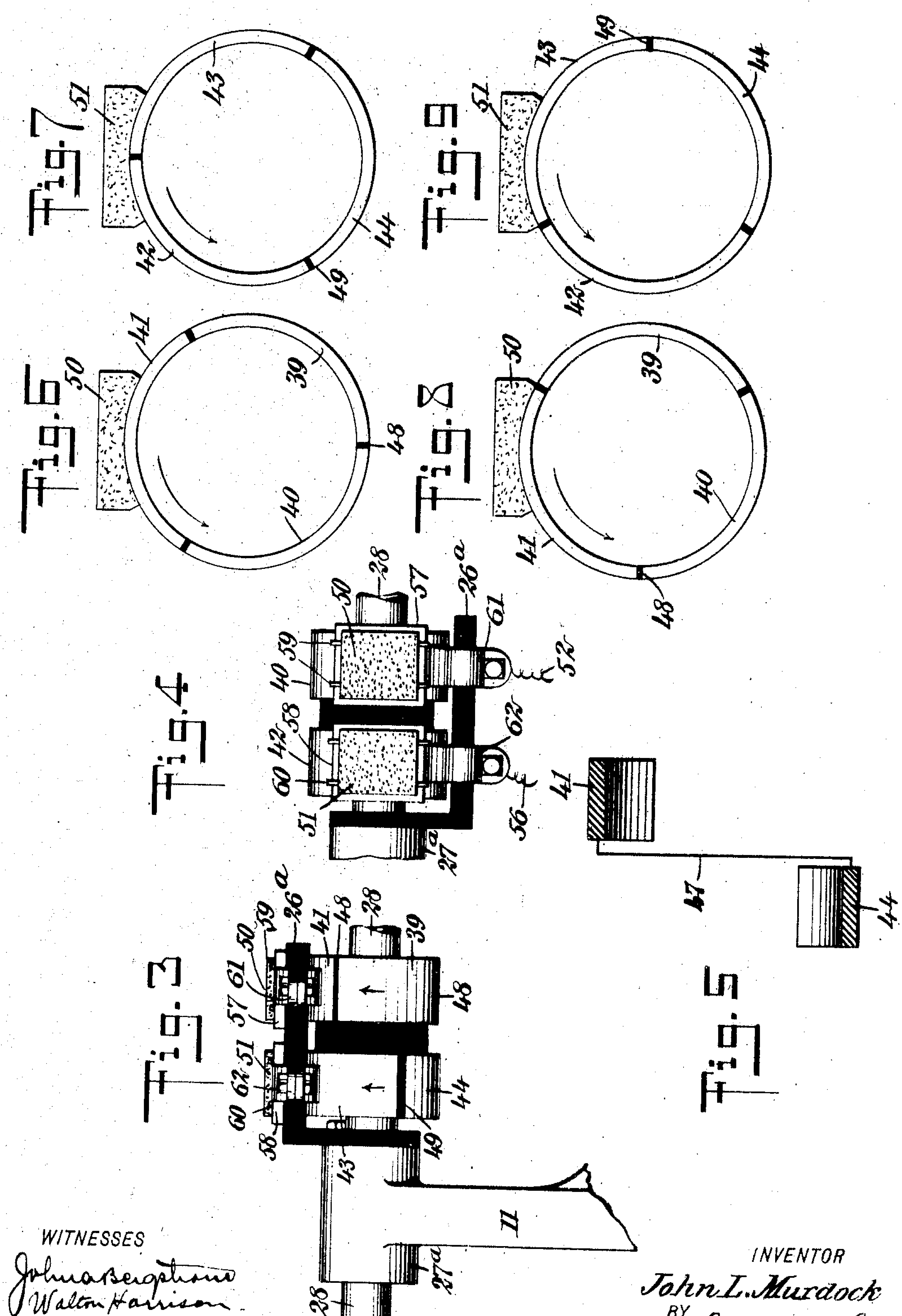

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3 SHEETS—SHEET 3.

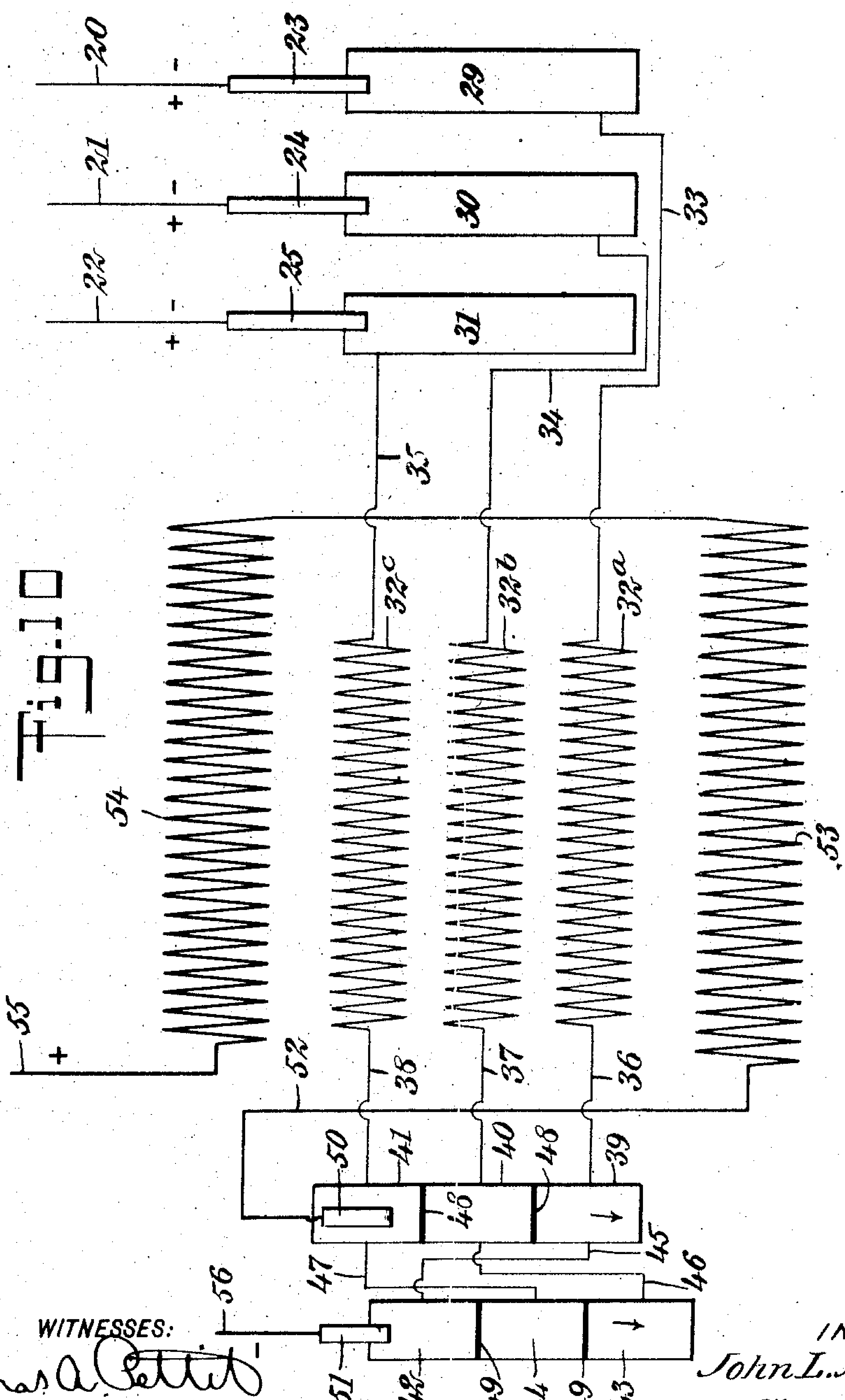

Fig. 10

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ROTARY CONVERTER.

No. 882,531. Specification of Letters Patent. Patented March 17, 1908.

Application filed March 28, 1906. Serial No. 308,477.

To all whom it may concern:

Be it known that I, JOHN L. MURDOCK, a citizen of the United States, and a resident of Boundbrook, in the county of Somerset and State of New Jersey, have invented a new and Improved Rotary Converter, of which the following is a full, clear, and exact description.

My invention relates to so-called "current shaping mechanism," my more particular object being to produce a rotary converter, for selecting from three-phase alternating currents predetermined portions of said currents, in such manner as to accumulate the effect of the portions thus selected, and thus build up a virtually direct current which is practically constant.

My invention further relates to certain details of construction incidental to carrying out the object above stated, and particularly to mechanism for accomplishing the following purposes, to wit: 1. To avoid sparking at the brushes used for the direct current. 2. To provide a broad bearing surface for the direct current brushes, the entire bearing surface being as completely available as possible. 3. To stop the flow of currents through the armature independently of the breaking action of the brushes relative to the sectors, thus rendering it impossible for a spark to take place when a sector leaves a brush. 4. To dispose the brushes, field magnets, sectors and wire connections, in such manner that the relation of the various parts one to another may be determined by knowing the position of any one of said parts. 5. To employ upon the direct current side of the converter, two groups of commutator sectors and brushes arranged relatively thereto in such manner that one brush always receives positive current from one group of sectors, whereas the other brush always receives negative current from the other group of sectors. 6. To place the direct current brushes exactly on top of the rotating commutator sector rings, in order that said brushes may be readily accessible. 7. To give the direct current sectors and the direct current brushes such relative mathematical proportions as will attain increased efficiency in the converter as a whole.

Reference is to be had to the accompanying drawings forming a part of this specification, in which similar characters of reference indicate corresponding parts in all the figures.

Figure 1 is a side elevation, partly diagrammatic, showing the rotary converter as connected with and controlled by a three-phase alternating line supplied by a three-phase alternating generator; Fig. 2 is an enlarged elevation of the converter, viewed as from the left of Fig. 1, the pedestal for supporting the armature shaft being partly broken away; Fig. 3 is an enlarged fragmentary elevation of the direct current commutator rings and the carbon brushes communicating therewith, the view being somewhat similar to the corresponding part at the right in Fig. 1; Fig. 4 is a plan view of the mechanism shown in Fig. 3, showing more particularly the connection of the carbon brushes 50, 51 with the binding posts 61 and 62 and direct current mains 52 and 56; Fig. 5 is an enlarged section through two sectors, one sector being in the positive sector ring, the other being in the negative sector ring, the two sectors being connected by a wire 47; Fig. 6 is a diagrammatic elevation of the positive sector ring made up of the sectors 39, 40, 41 and engaged by the brush 50, the view representing the parts as they would be seen from the left of Figs. 3 and 4 and showing a brush 50 as engaging the center of the sector 41; Fig. 7 is a corresponding view of the negative sector ring built up of the sectors 42, 43, 44 engaged by a brush 51; Fig. 8 shows the same mechanism as Fig. 6 but with the positive sector ring in a slightly different position; Fig. 9 is a view similar to Fig. 7, showing the same mechanism but with the negative sector ring moved into a relatively different position, and Fig. 10 is a diagram of the wiring and other electrical connections of the entire system.

Referring more particularly to Fig. 1, a pedestal 11 at the transmitting station supports the armature shaft 12 of a three-phase alternating generator. Mounted upon this armature shaft are the usual slip rings 13, 14, 15 which are engaged by the respective brushes 17, 18, 19, the latter being supported upon an arm 16 of insulating material in the usual, or in any preferred manner. The three-phase alternating currents from the brushes 17, 18, 19 are received and transmitted by wires 20, 21, 22 to the receiving station shown at the right in Fig. 1. The wires 20, 21, 22 here connect, respectively, with brushes 23, 24, 25 supported by an arm 26 of insulating material. Bearings 27, 27ᵃ mounted upon pedestals 27ᵇ support the revoluble armature shaft 28 of the rotary converter at the receiving station indicated by the right hand portion of Fig. 1. Slip rings 29, 30, 31 are engaged directly by the brushes 23, 24, 25 in the usual manner. These slip rings 29, 30, 31 are connected, respectively, with armature windings 32^a, 32^b, 32^c separated by insulation 32. Each winding 32^a, 32^b, 32^c occupies, therefore, one-third of the revoluble armature, as will be understood from Fig. 2. The connection from the slip rings 29, 30, 31 to the respective windings 32^a, 32^b, 32^c is made separately by means of leads 33, 34, 35, as indicated in Fig. 10. From the windings, wires 36, 37, 38 lead respectively to sectors 39, 40, 41, constituting the positive sector ring, shown diagrammatically in Figs. 6 and 8. The three other sectors 42, 43, 44 are assembled together so as to form the negative sector ring shown in Figs. 7 and 9. The sectors 39, 40, 41 are respectively connected with the sectors 42, 43, 44 by means of connecting wires 45, 46, 47, as indicated in Fig. 10. Plates 48 of insulating material are sandwiched between the sectors 39, 40, 41, and similarly the plates 42, 43, 44, are separated by insulating plates 49.

The brushes are shown at 50, 51, and are supported by an arm 26^a and the brushes are of such dimensions that each occupies exactly one-sixth of the circle represented by the sectors engaged by the brush. As each sector takes up substantially exactly one-third of the circle, or in other words, as each sector is of 120 degrees, it follows that each brush represents an arc of 60 degrees and occupies one-half the distance represented by the length of a sector. The sectors 39, 40, 41, constituting the positive sector ring, are staggered relatively to the sectors 42, 43, 44, constituting the negative sector ring. The result of this arrangement is that when one of the brushes, for instance 50, rests directly upon the center of a sector, such as 41, (see Fig. 6), the other brush (say 51) rests with one-half of its length upon each of two sectors, say 42, 43. The amount of surface, therefore, engaged by any brush is substantially uniform at all times. For instance, as shown in Figs. 5, 6, 7, 8, 9, a brush must at any given moment, occupy either one-half of a sector, or two fragmentary portions of two sectors, aggregating a surface equal to one-half of a sector.

Since, as above stated, the sectors constituting the negative sector ring are staggered relative to the sectors constituting the positive sector ring, it follows that each negative sector is diametrically opposite an opposing sector, as indicated in Figs. 3 and 5. Each positive sector being therefore connected with the negative sector exactly opposite thereto, as indicated in Fig. 5, it necessarily follows that when a brush, such as 50, engages any particular one of the positive sectors (say, for instance, 41), the negative sector (for instance, 44) being diametrical thereto, must necessarily be out of engagement with its brush 51. There is, therefore, no danger of a current passing through the brush 50 and a sector 41 directly into any sector connected with the brush 51. From the brush 50 a wire 52 leads to field magnets 53, 54, the latter being connected with a main 55. This main, together with a main 56 connected with the brush 51, constitutes the two direct current terminals for supplying electric energy to the line or to the machine in which the direct current is required. Generally speaking, therefore, a three-phase alternating current is supplied by three wires to the alternating current side of the converter, represented by the right hand portion of Fig. 10, and from the positive and negative mains 55, 56 at the other end of the machine the direct current is supplied to the point where it is needed.

The brushes 50, 51 are held by metallic casings 57, 58, being steadied thereupon by pins 59, 60 passed directly into the brushes. Binding posts 61, 62 communicate with the brushes through the metallic casings 57, 58 and are in turn connected with the wires 52, 56, as indicated in Figs. 3 and 4.

Referring to Fig. 2, it will be noted that the field magnets 53, 54 are located respectively below and above the armature shaft 28 and exactly in diametrical alinement with the brushes. This arrangement is very convenient as it enables the various operators to ascertain in an instant the exact electric condition of any part of the armature or of any sector, by merely noting its angular displacement relative to that of the field magnets. The arrangement of the parts above described is such that the armature windings 32^a, 32^b, 32^c are positioned exactly in alinement with the sectors 39, 40, 41, and are consequently exactly opposite the sectors 42, 43, 44; hence, when a particular winding 32^a, 32^b or 32^c is passing through the densest of the magnetic fields, that particular winding can be in direct communication with only one of the brushes 50 or 51. Suppose, for instance, that in Fig. 10 the winding 32^c is passing through the densest portion of the magnetic field, and consequently that the brush 50 rests upon the center of the sector 41, if by this arrangement positive current is sent into the brush 50 and consequently through the fields 53, 54 to the line 55, it is self-evident that this same winding 32^c cannot be at the same moment sending current directly through the other brush 51. Suppose now, that the positive current formed within the winding 32^c passes as just indicated, through the sector 41, brush 50, wire 52, fields 53, 54 to the direct current line 55, and then upon doing its work, flows back as a so-called negative current through the main 56 and into the brush 51; it next passes through sector 42, wire 45, sector 39, wire 36 and winding 32^a, thence back to the alternating generator. From this it will be seen that when a current flowing in a particular direction is generated within the winding 32^c, and this current is diverged to the direct current line, the return current can flow back and at least one other winding, such as 32^a, is in proper condition to receive the return current and start it backward, in proper phase, to the generating station. If it should happen that one of the brushes 50 or 51 should engage two sectors, the other brush engaging only one, this makes no difference for the reason that the current flowing between the brush and the one sector is exactly equal to the current flowing between the other brush and the two sectors engaged by it. In this connection it may be noted that in a three-phase system, no matter what may be the direction or the current intensity in a particular wire representing one of the three phases, the sum of the effects in the other wires each representing a phase, is necessarily equal to it, and opposite in direction.

The operation of my system is as follows: Suppose, as would naturally be the case, that the wires 20, 21, 22 are energized successively in such order as to become positive in succession and also to become negative in succession, we will assume, for instance, that a current is flowing through the wire 22 into the ring 31, and this, of course, implies that one or more currents equal in voltage and amperage to the current flowing in through brush 25, and flowing in the opposite direction out through brush 23 or 24, or both brushes 23 and 24, as the case may be. The course of the so-called positive current entering the converter is as follows: brush 19 at transmitting station, (see Fig. 1 left hand), wire 22, brush 25 of converter, slip ring 31, wire 35, winding 32^c, wire 38, positive sector 41 (sector 43 being now out of communication with brush 51) brush 50, wire 52, field windings 53, 54 to main 55 of line, thence returning to main 56, brush 51, negative sector 42, positive sector 39 (now dead, being out of communication with brush 50) wire 36, winding 32^a, wire 33, slip ring 29, brush 23, back through wire 20 to source of alternating current supply. It will be seen that the current thus sent through the mains 55, 56 of the direct current line flows outward through brush 50 and inward through brush 51. A moment later and the rotation of the armature of the converter causes the sector 41 to move partially out from under the brush 50, and likewise causes the sector 39 to make engagement with the brush 50. This same degree of rotation causes the sector 42 to move completely out from under the brush 51 and causes the brush 43 to move beneath this brush, as indicated in Fig. 9. This degree of rotation, it will be noted, is just sufficient to cause current to flow through the wire 20 and the wire 22 toward the converter, and also to cause a current of opposite direction to flow through the wire 21. That is to say: the current flowing through wire 21 toward the alternating generator is exactly equal to the sum of the two currents flowing through wires 21, 22 toward the converter.

The circuit now completed is as follows: wires 20, 22, brushes 23, 25, slip rings 29, 31, wires 33, 35, windings 32^a, 32^c, wires 36, 38, sectors 39, 41, (both now engaging brush 50) thence through brush 50, wire 52, field windings 53, 54 to direct current line, thence returning through wire 56, brush 51, sector 43 (this being the sole sector now engaging brush 51), wire 46, sector 40, (now dead, being now out of engagement with brush 50), wire 37, winding 32^b, wire 34, slip ring 30, brush 24 and wire 21 back to the source of alternating current. In this instance, as before, the current flows outward from brush 50 and inward through brush 51. Further rotation of the armature causes brush 50 to rest centrally upon sector 39 and causes brush 51 to engage sectors 43, 44. When this occurs, the circuit is completed as follows: A current flows from the generator and wire 20 into brush 23 and slip ring 29, thence through wire 33, winding 32^a, wire 36, sector 39 (now in contact with brush 50), brush 50, wire 52, field windings 53, 54, direct current main 55 to line, thence returning by main 56, brush 51, sectors 43, 44 (now engaging brush 51) thence in parallel to wires 46, 47 to sectors 40, 41 (now dead, being out of communication with brush 50), wires 37, 38, windings 32^b, 32^c, wires 34, 35, slip rings 30, 31, brushes 24, 25 and thence through wires 21, 22 back to the source of alternating current supply.

It will thus be seen that no matter in what position the windings of the armature may be, if any current whatever passes through these windings, it necessarily goes out through the brush 50 to the direct current line, and returns through brush 51. Hence, I consider the sectors 39, 40, 41 as positive sectors and the sectors 42, 43, 44 as negative sectors.

It is true that each sector is constantly changing its sign; but this fact is immaterial for the reason that whenever a sector 39, 40 or 41 engages the brush 50, that sector at that instant is necessarily positive. If two of these sectors engage the brush 50 at the same instant, the two sectors taken together are positive relative to the current passing through the other brush 51. Similarly, whenever any one of the sectors 42, 43, 44 is in engagement with the brush 51, at that particular instant the sector thus in engagement is necessarily negative; that is to say,—the current need not necessarily be flowing at that particular instant; but if it flows at all in any part of the sector it necessarily always flows in the same direction through the brush 50 and in the opposite direction through the brush 51; and if the current divides, as above explained, so as to pass in one direction through a plurality of sectors, and in the positive direction through a single sector, the positive and negative currents necessarily balance each other in passing through the respective brushes 50, 51.

Referring now to Fig. 2, it will be noted that the winding 32^c is passing through the densest part of the magnetic field, and consequently is energized to a maximum extent. This occurs at the exact instant when the brush 50 rests centrally upon the sector 41, as indicated in Fig. 6, this being the same instant that the brush 51 rests partly upon the sector 42 and the sector 43, as indicated in Fig. 7. Such being the case, the current passing outward through brush 50 to the direct current line returns to brush 51 and there splits, as indicated in Fig. 7, so as to return through sectors 42, 43. An instant later, however, the several sectors assume the positions indicated in Figs. 8 and 9. The sector 42 is now just leaving the brush 51, and of course this fact would seemingly indicate that a spark might occur as between the brush 51 and the sector 42. Why does not this spark occur? Simply because the partial rotation of the armature shaft 28 has moved the winding 32^a a small fraction of a revolution and the winding 32^a consequently arrives at a point in the magnetic field when the number of lines of force is neither increasing or decreasing, and consequently no current whatever for the moment is generated in the winding 32^a.

Referring again to Fig. 2, it will be noted that if the armature shaft 28 be rotated slightly in the direction of the arrow, the winding 32^a must assume such a position where it is acted upon equally by the two fields, and consequently the lines of force through it are neither increasing or decreasing. In other words: the winding 32^a occupies for a moment a neutral position, and no current is generated in the winding during this moment.

It will be noted that at the exact instant when the winding 32^a becomes dead from the cause just stated, the sector 42 is just pulling out from under the brush 51. The current through the winding 32^a is not stopped by the separation of the sector 42 and the brush 51, but by means altogether independent of this; to wit,—the winding 32^a representing the neutral point of its revolution. What is true of the particular sector, brush and winding just mentioned is true of the others. It is, therefore, impossible that any spark can occur between any brush and any sector at any part of the revolution of the armature. The fact is, the current in any particular winding gradually rises to its maximum and gradually dies away to nothing. Since, however, there are three of these windings, there is no particular instant of time when the current is not flowing through at least two of them. In other words: the direct current flows continuously sometimes through only two of the windings and sometimes through all three of them, yet each winding becomes neutral twice during each revolution of the armature; and whenever a winding becomes neutral, this occurs at the precise instant necessary to prevent sparking between the sectors and their brushes.

Having thus described my invention I claim as new and desire to secure by Letters Patent:

In a three-phase rotary converter, the combination of a stationary field, an armature provided with three windings, two sectors connected with each winding, each of said sectors representing approximately 120 degrees of a circle, and two brushes each having a contact length representing approximately 60 degrees of a circle and being adapted to rest throughout said contact length upon one or more of said sectors.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN L. MURDOCK.

Witnesses:
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JACOB FRIDAY.