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Department of Agriculture
PATENT BRANCH,
New York

Dec 19 1889

St. Louis

N. York

Utama

APPLICATION FOR PATENT

Granting
Utama
Dec 20 1889

W. H. Cook

Receipt made
Dec 20 1889

S P E C I F I C A T I O N .

TO ALL WHOM IT MAY CONCERN:-

BE IT KNOWN, THAT I, NIKOLA TESLA, from Smiljan, Lika, Border Country of Austria Hungary, resident of New York, in the County and State of New York, Electrician, have invented certain new and useful improvements in methods and apparatus for Converting Alternating into Direct Currents, and I do hereby declare that the following is a full, clear, and exact description of the same.

In nearly all the more important industrial applications of electricity, the current is produced by dynamo-electric machines driven by power, in the coils of which the currents developed are primarily in reverse directions or what is known as alternating. As many electrical devices and systems, however, require direct current, it has been usual to correct the current alternations by means of a commutator instead of taking them off directly from the generating coils.

The superiority of alternating current machines in all cases where their currents can be used to advantage, renders their employment very desirable, as they may be much more economically constructed and operated and the object of this invention is to provide means for directing or converting at will at one or more points in a circuit, alternating into direct currents.

Stated broadly, the invention consists in obtaining direct from alternating currents, or in directing the waves of an alternating current so as to produce direct or substantially direct currents, by developing or producing in the branches of the circuit including a source of alternating currents, either permanently or periodically, and by electric, electro-magnetic, or magnetic agencies, manifestations of energy or what may be termed active resistances of opposite electrical character whereby the currents or current waves of opposite sign or direction will be diverted through different circuits, those of one sign passing over one branch and those of opposite sign over another.

The case of a circuit divided into two paths only may be considered herein inasmuch as any further subdivision involves merely an extension of the same general principle.

Selecting then, any circuit through which is flowing an alternating current, let such circuit be divided at any desired point into two branches or paths. In one of these paths is inserted some device to create an electro-motive force opposed to the waves or impulses of current of one sign, and a similar device in the other branch which opposes the waves of opposite signs.

that
Assume, for example, these devices are batteries,
primary or secondary, or continuous current dynamo ma-
chines. The waves or impulses of opposite direction,
composing the main current, have a natural tendency to
divide between the two branches, but by reason of the oppo-
site electrical character or effect of the two branches,
one will offer an easy passage to a current of a certain
direction, while the other will offer a relatively high
resistance to the passage of the same current.. The
result of this distribution is that the waves of current
of one sign will - partly or wholly - pass over one of
the paths or branches while those of the opposite sign
pass over the other.

There may be thus obtained from an alternating cur-
rent two or more direct currents, without the employment
of any commutator such as it has been heretofore regard-
ed as necessary to use. The current in either branch
may be used in the same way and for the same purposes as
any other direct current, that is, it may be made to
charge secondary batteries, energize electro-magnets, or
used for any other analagous purpose.

In the drawings some of the various ways in which
this invention may be carried out are illustrated.

The several figures are diagrammatic in character
and will be described in detail in their order.

Figure 1 represents a plan of directing the alter-

nating currents by means of devices purely electrical in character. A designates a generator of alternating currents and B, B, the main or line circuit therefrom.

At any given point in this circuit at or near which it is desired to obtain direct currents, the circuit B is divided into two paths or branches C, D. In each of these branches is placed an electrical generator which for the present may be assumed to produce direct or continuous currents.

The direction of the current thus produced is opposite in one branch to that of the current in the other branch, or considering the two branches, as forming a closed circuit, the generators E, F, are connected up in series therein, one generator in each part or half of the circuit.

The electromotive force of the current sources E and F may be equal to, or higher or lower than the electromotive forces in the branches C, D, or between the points X and Y of the circuit B, B. If equal, it is evident that current waves of one sign will be opposed in one branch and assisted in the other to such an extent that all of the waves of one sign will pass over one branch and those of opposite sign over the other. If, on the other hand, the electromotive force of the sources E, F, be lower than that between X and Y, the currents in both branches will be alternating, but the waves of one sign will preponderate.

One of the generators or sources of current E, or P, may be dispensed with, but it is preferable to employ both, if they offer an appreciable resistance, as the two branches will be thereby better balanced. The translating or other devices to be acted upon by the current are designated by the letters G, and they are inserted in the branches C, D, in any desired manner, but in order to better preserve an even balance between the branches due regard should be had to the number and character of the devices as will be well understood.

Figures 2, 3, 4, and 5, illustrate what may be termed electro-magnetic devices for accomplishing a similar result. That is to say, instead of producing directly by a generator an electro-motive force in each branch of the circuit, a field or fields of force is established, and the branches led through the same in such manner that an active opposition of opposite effect or direction will be developed therein by the passage or tendency to pass off the alternations of current.

In figure 2, for example, A is the generator of alternating currents, B, B, the line circuit, and C D-the branches over which the alternating currents are directed. In each branch is included the secondary of a transformer or induction coil, which, since they correspond in their functions to the batteries of the previous

figure, are designated by the letters E, F.

The primaries H, H' of the induction coils or transformers are connected either in parallel or series with a source of direct or continuous current J, and the number of convolutions is so calculated for the strength of the current from I, that the coils J, J' will be saturated.

The connections are such that the conditions in the two transformers are of opposite character, that is to say, the arrangement is such that a current wave or impulse corresponding in direction with that of the direct current in one primary as H, is of opposite direction to that in the other primary, H', hence it results that while one secondary offers a resistance or opposition to the passage through it of a wave of one sign, the other secondary similarly opposes a wave of opposite sign. In consequence, the waves of one sign will, to a greater or less extent, pass by the way of one branch, while those of opposite sign in like manner pass over the other branch.

In lieu of saturating the primaries by a source of continuous current, they may be included in the branches C, D, respectively, and their secondaries periodically short-circuited by any suitable mechanical devices, such as an ordinary revolving commutator.

It will be understood of course, that the rotation and action of the commutator must be in synchronism or in proper accord with the periods of the alternation in order to secure the desired results.

Such a disposition is represented diagrammatically in Figure 3. Corresponding to the previous figures, A is the generator of alternating currents, B, B, the line and C, D, the two branches for the direct currents. In branch C are included two primary coils E, E', and in branch D are two similar primaries F, F'. The corresponding secondaries for these coils and which are on the same subdivided cores J and J', are in circuits, the terminals of which connect to opposite segments K, K' and L, L', respectively of a commutator, Brushes b b bear upon the commutator and alternately short-circuit the plates K and K' and L and L' through a connection c. It is obvious that either the magnets and the commutator or the brushes may revolve.

The operation will be understood from a consideration of the effects of closing or short-circuiting the secondaries. For example, if at the instant when a given wave of current passes, one set of secondaries be short-circuited nearly all the current flows through the corresponding primaries, but the secondaries of the other branch being open circuited, the self-induction in the primaries is highest and hence little or no current will pass through that branch.

If as the current alternates, the secondaries of the two branches are alternately short-circuited, the result will be that the currents of one sign pass over one branch and those of the opposite sign over the other.

The disadvantages of this arrangement which would seem to result from the employment of sliding contacts, is in reality very slight, inasmuch as the electromotive force of the secondaries may be made exceedingly low so that sparking at the brushes is avoided.

Figure 4 is a diagram partly in section of another plan of carrying out the invention.

The circuit B in this case is divided as before and each branch includes the coils of both the field and revolving armatures of two induction devices. The armatures O, P, are preferably mounted on the same shaft, and are adjusted relatively to one another in such manner that when the self-induction in one branch as C is maximum, in the other branch D it is minimum.

The armatures are rotated in synchronism with the alternations from the source A. The winding or position of the armature coils is such that a current in a given direction passed through both armatures would establish in one, poles similar to those in the adjacent poles of the field, and in the other, poles unlike the adjacent field poles, as indicated by n, n, s, s, in the drawing.

If the like poles are presented as shown in cir-

cuit D, the condition is that of a closed secondary upon a primary, or in the position of least inductive resistance, hence a given alternation of current will pass mainly through D,

A half revolution of the armatures produces an opposite effect and the succeeding current impulse passes through C.

Using this figure as an illustration it is evident that the fields N, M, may be permanent magnets or independently excited and the armatures O, P, driven as in the present case so as to produce alternate currents which will set up alternately, impulses of opposite direction in the two branches D, C, which in such case would include the armature circuits and translating devices only.

In Figure 5 a plan alternative with that shown in Figure 3 is illustrated. In the previous case illustrated, each branch C and D contained one or more primary coils, the secondaries of which were periodically short-circuited, in synchronism with the alternations of current from the main source A, and for this purpose a commutator was employed. The matter may, however, be dispensed with, and an armature with a closed coil substituted.

Referring to Figure 5, in one of the branches, as C, are two coils M' wound on laminated cores and in the other branches D are similar coils M'. A subdivided or laminated armature O' carrying a closed coil R' is

rotably supported between the coils M' N' as shown.

In the position shown, that is with the coil R' parallel with the convolutions of the primaries N' M', practically the whole current will pass through branch D, because the self-induction in coils M' M' is maximum.

If, therefore, the armature and coil be rotated in synchronism with the alternations of the source A, the same results are obtained as in the case of Figure 3.

Figure 8 is an instance of what may be called in distinction to the others, a magnetic means of securing the results arrived at in this invention. V and W are two strong permanent magnets, provided with armatures V' W' respectively. The armatures are made of thin laminas of soft iron or steel, and the amount of magnetic metal which they contain is so calculated that they will be fully or nearly saturated by the magnets. Around the armatures are coils E F, contained respectively in the circuits C and D.

The connections and electrical conditions in this case are similar to those in Figure 2, except that the current source I of Figure 2 is dispensed with and the saturation of the core of coils E F obtained from the permanent magnets.

In the illustrations heretofore given, the two branches or paths containing the translating or induction devices and in each instance shown as in derivation one to the other, but this is not always necessary.

For example, in Figure 7, is an alternating current generator, B, B, the line wires or circuit. At any given point in the circuit two paths as D D', are formed, and at another point two paths as C C'. Either pair of group of paths is similar to the previous dispositions with the electrical source or induction device in one branch only, while the two groups taken together form the obvious equivalent of the cases in which an induction device or generator is included in both branches.

In one of the paths as D are included the devices to be operated by the current. In the other branch as D' is an induction device that opposes the current impulses of one direction and directs them through the branch D. So also in branch C are translating devices G and in the branch C' an induction device or its equivalent that diverts through C, impulses of opposite direction to those diverted by the device in branch D'.

A special form of induction device for this purpose is also shown. J J' are the cores formed with pole pieces upon which are wound the coils M N. Between these pole pieces are mounted at right angles to one another the magnetic armatures O P, preferably mounted on the same shaft and designed to be rotated in synchronism with the alternations of current. When one of the armatures is in-line with the poles or in the position occupied by armature P, the magnetic circuit of the induction

device is practically closed, hence there will be the greatest opposition to the passage of a current through coils N N. The alternation will therefore pass by way of branch D; at the same time, the magnetic circuit of the other induction device being broken by the position of the armature O, there will be less opposition to the current in coils M which will shunt the current from branch C.

A reversal of the current being attended by a shifting of the armatures the opposite effect is produced.

There are many other modifications of the means or methods of carrying out this invention, but it is not deemed necessary herein to specifically refer to more than those described as they involve the chief modifications of the plan. In all of these it will be observed that there is developed in one or all of the branches of a circuit from a source of alternating currents an active (as distinguished from a dead) resistance, or opposition to the currents of one sign for the purpose of diverting the currents of that sign through the other or another path, but permitting the currents of opposite sign to pass without substantial opposition.

Whether the division of the currents or waves of current of opposite sign be effected with absolute precision or not is immaterial to the invention since it will be sufficient if the waves are only partially diverted or directed, for in such case the preponderating

influence in each branch of the circuit of the waves of one sign secures the same practical results in many if not all respects as though the current were direct and continuous.

An alternating and direct current have been combined so that the waves of one direction or sign were partially or wholly overcome by the direct current, but by this plan only one set of alternations are utilized, whereas by this system the entire current is rendered available.

By obvious applications of this discovery, it is possible to produce a self-exciting alternating dynamo, or to operate direct current meters on alternating current circuit, or to run various devices, such as arc lamps, by direct currents in the same circuit with incandescent lamps or other devices run by alternating currents.

C L A I M S.

1. The method herein set forth of obtaining direct from alternating currents, which consists in developing or producing in one branch of a circuit from an alternating current source an active resistance to the current impulses of one direction, whereby the said currents or waves of current will be diverted or directed through another branch.

2. The method of obtaining direct from alterna-

ting currents, which consists in dividing the path of an alternating current into branches and developing in one of said branches, either permanently or periodically, an electrical force or active resistance counter to or opposing the currents or current waves of one sign, and in the other branch a force counter to or opposing the currents or current waves of opposite sign, as set forth.

3. The method of obtaining direct from alternating currents, which consists in dividing the path of the alternating current into branches, establishing fields of force and leading the said branches through said fields of force in substantially the manner set forth, whereby electro-motive forces of opposite direction will be produced therein.

4. The combination with the branches of a divided circuit carrying alternating currents, of devices including in or connected with the said branches and capable of developing or exerting an active opposition or electro-motive force counter to the current waves of one direction or sign, as herein set forth.

New York December 16th
1889.

Nikola Tesla

Signed in the presence of-

Robert F. Payson
Parker W. Page

Fig. 1

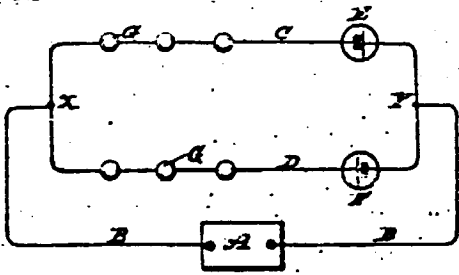


Fig. 2

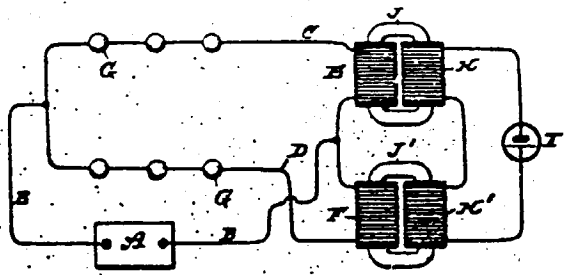


Fig. 3

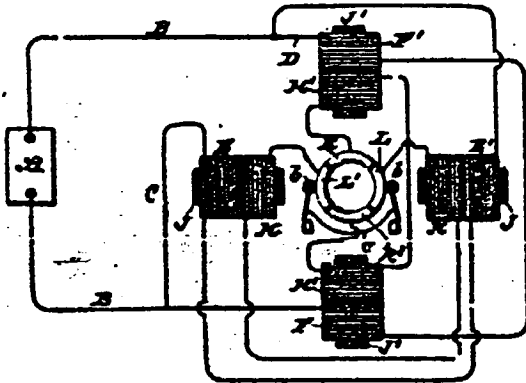


Fig. 4

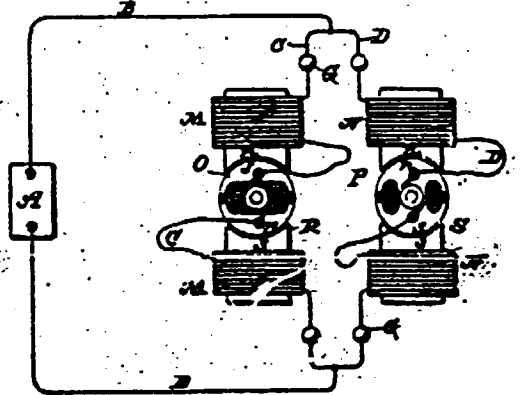


Fig. 5

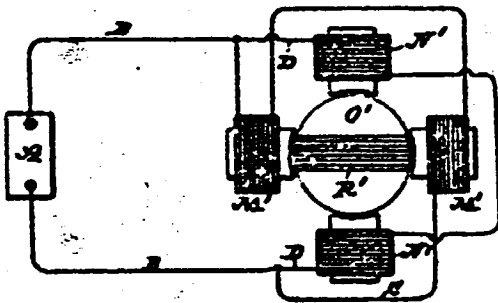


Fig. 6

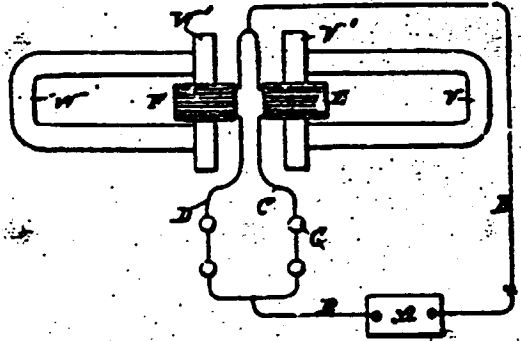
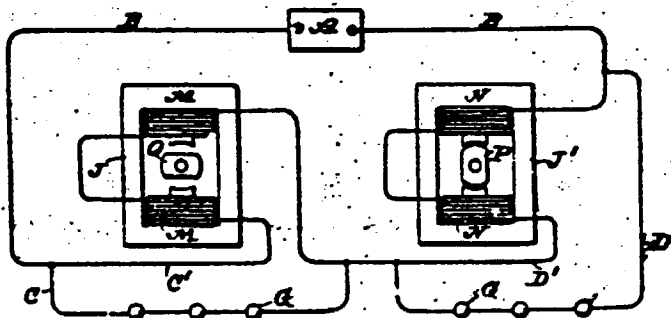


Fig. 7



Witnesses:
John Crist
H. H. Torrey

Certified to be the drawings
referred to in the specification
herewith annexed.

Electrician, Int. Dic. 10th 1889

Nikola Tesla
Inventor

By Young, Crist,

Attorneys