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W. HOCHHAUSEN.

ARMATURE WINDING AND METHOD OF MAKING SAME.

No. 539,943. Patented May 28, 1895.

Fig. 8.

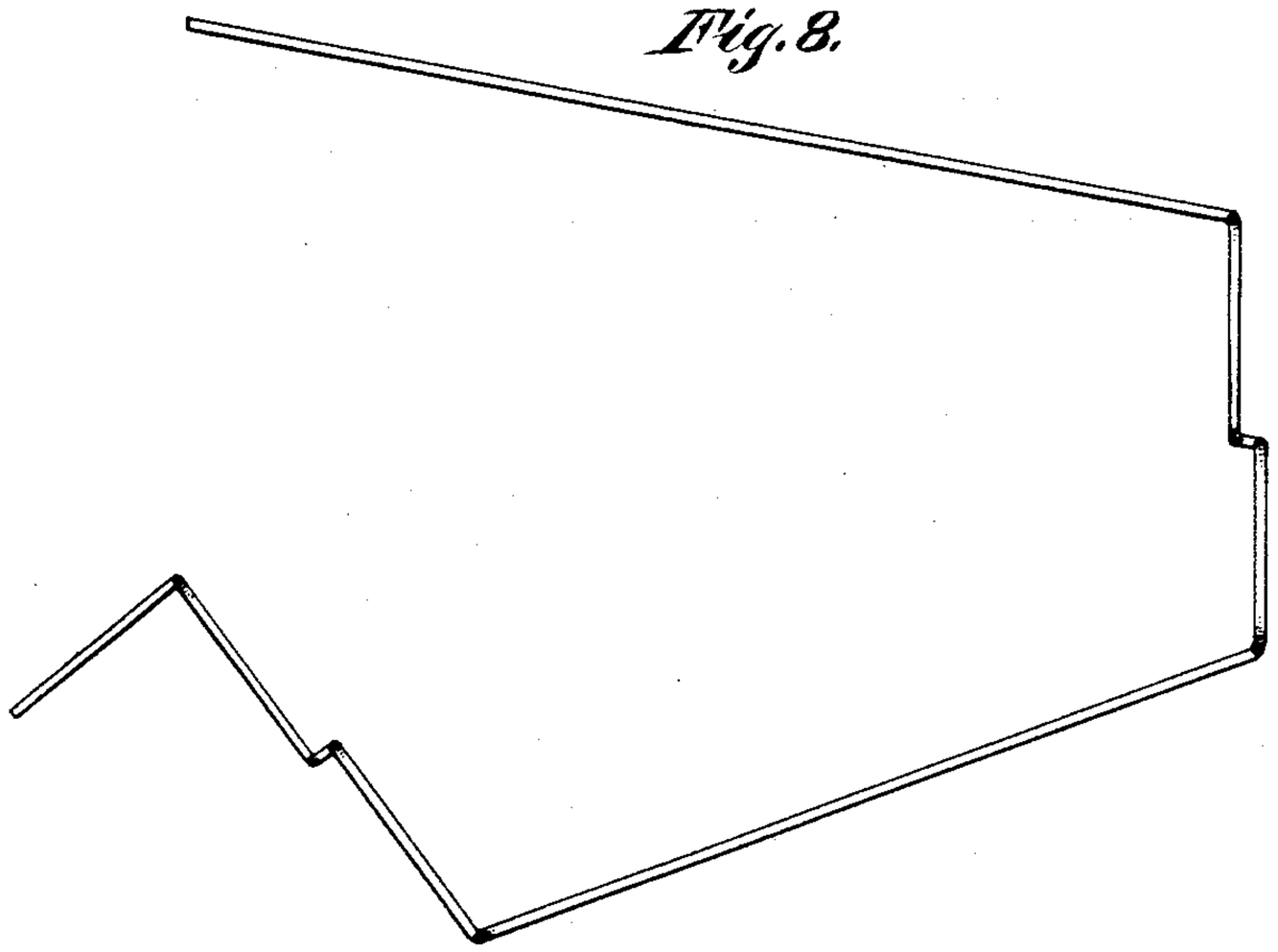
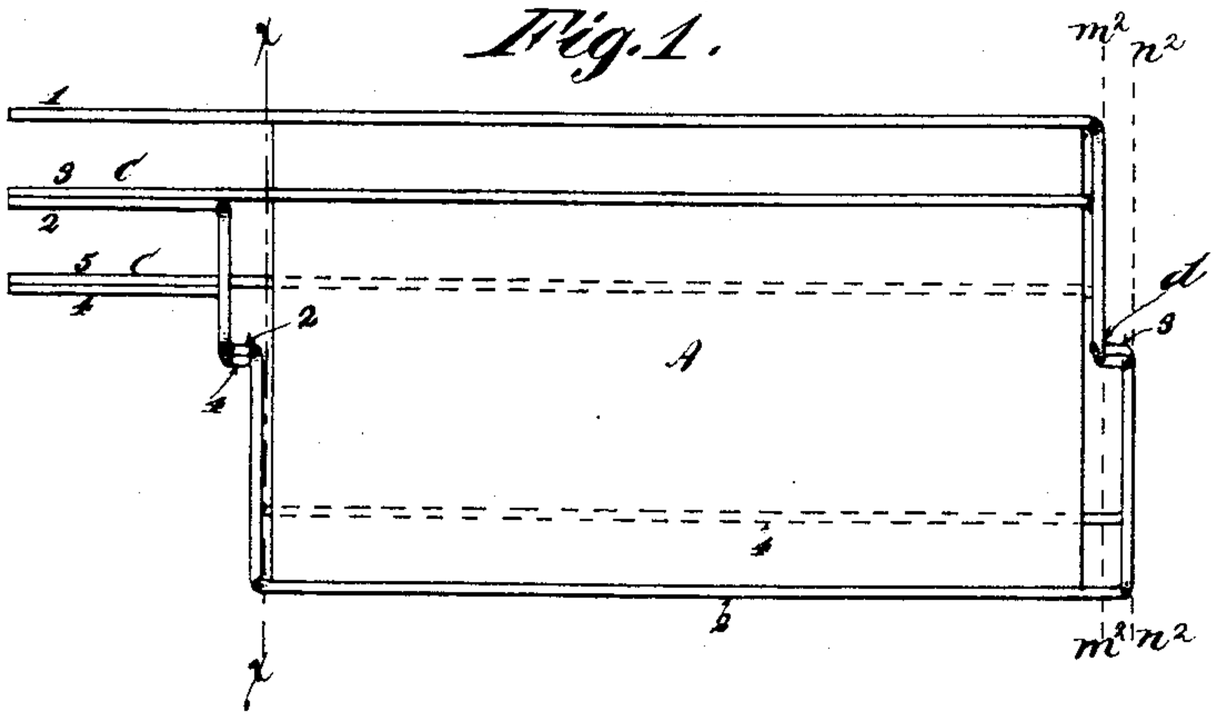


Fig. 1.



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ARMATURE WINDING AND METHOD OF MAKING SAME.

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Fig. 2.

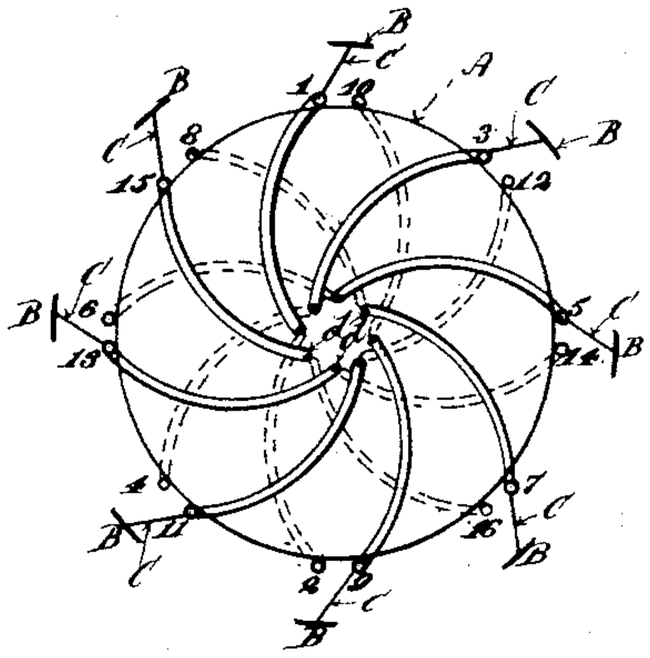

Fig. 3.

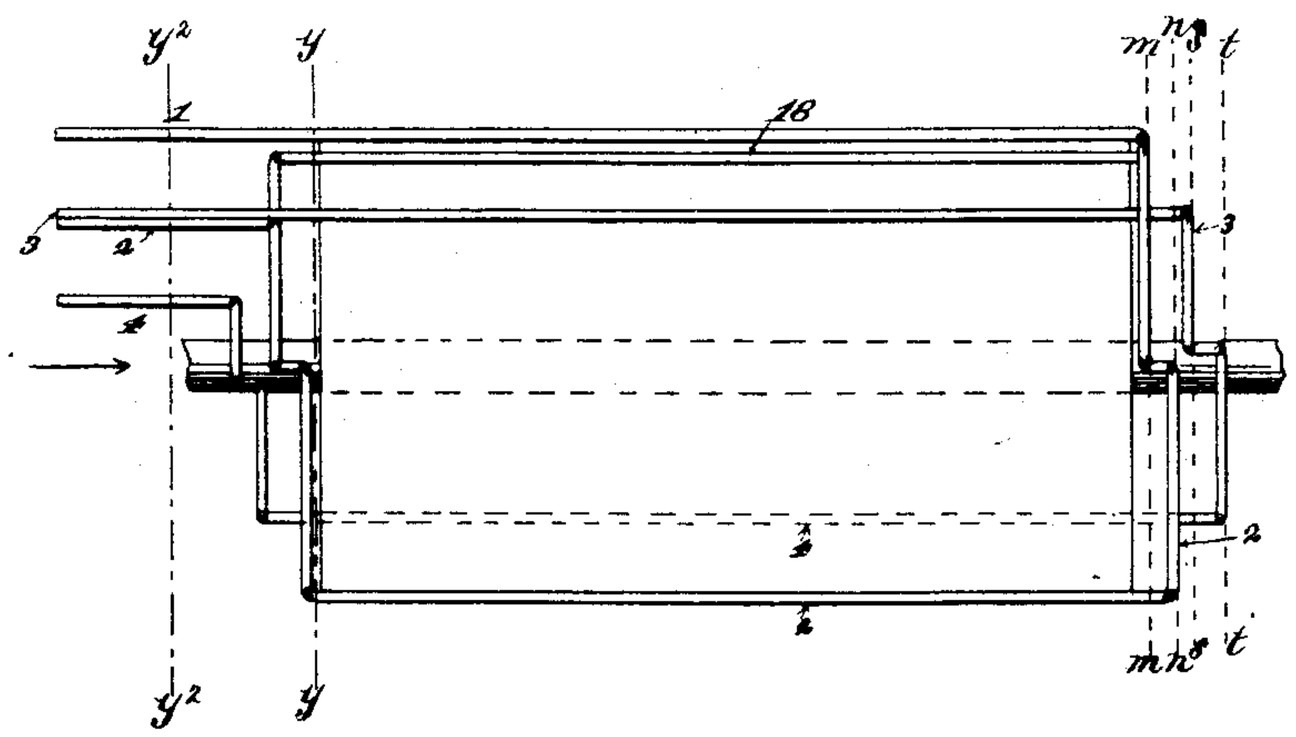

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Fig. 4.

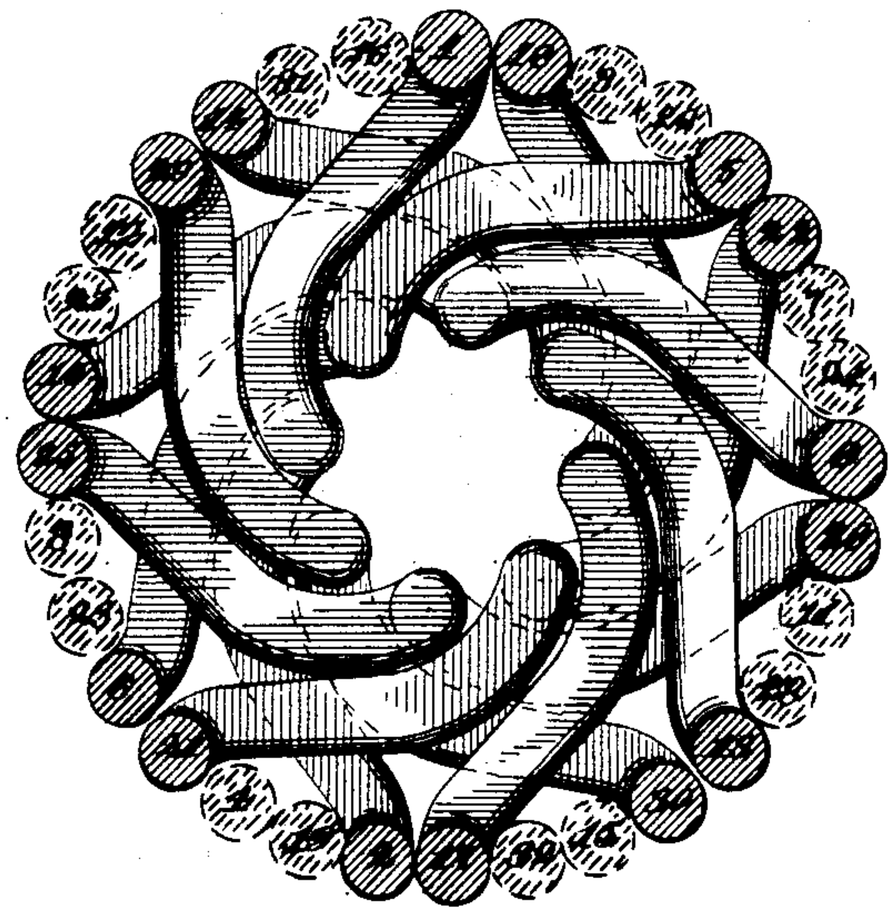

Fig. 5.

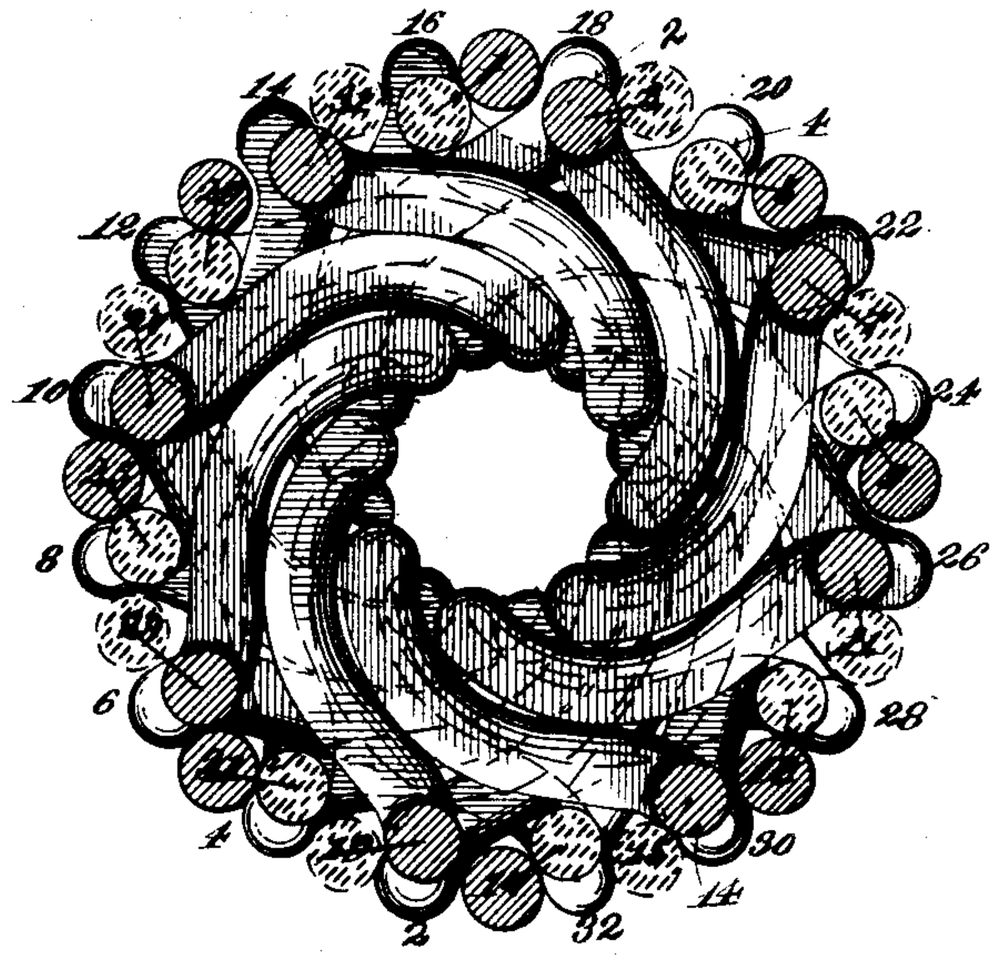

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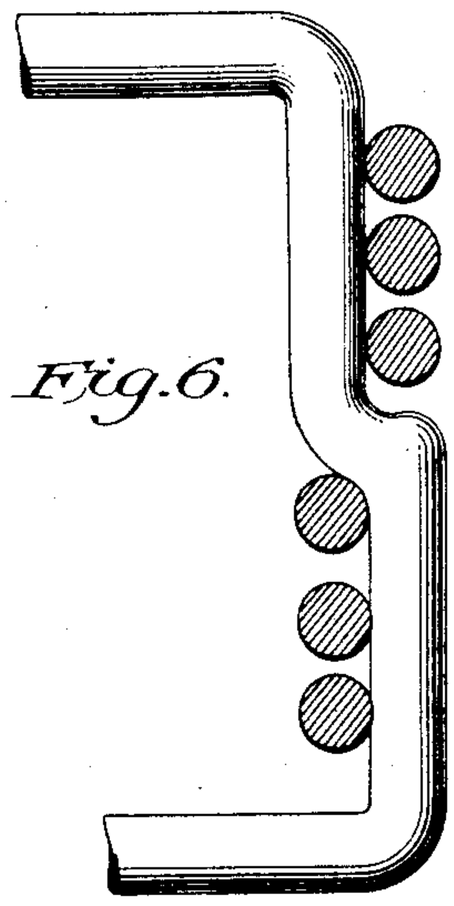
Fig. 7.

Fig. 6.



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UNITED STATES PATENT OFFICE.

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ARMATURE-WINDING AND METHOD OF MAKING SAME.

SPECIFICATION forming part of Letters Patent No. 539,943, dated May 28, 1895.

Application filed February 10, 1888. Serial No. 263,657. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM HOCHHAUSEN, a citizen of the United States, and a resident of Brooklyn, in the county of Kings and State of New York, have invented a certain new and useful Improved Armature-Winding, of which the following is a specification.

My invention relates to the manner of applying and disposing the electric conductors upon the head of a cylindrical armature, and has in view the production of an armature in which the armature winding shall be perfectly symmetrical upon the head as well as upon the periphery of the armature and the resistance of the various sections of armature conductor connected to the various commutator segments shall be exactly alike.

The aim of my invention is also to do away with the objectionable bulging and irregular shape of the mass of conductors on the head of the drum or cylinder.

By the employment of my invention in its simplest form an armature may be produced in which the thickness of wire on the head of the armature will be no more than twice the thickness of wire on the periphery of the armature, and by the employment of my invention in its most approved form the thickness of the armature conductor will be only four times as great upon the head of the armature as upon the periphery thereof, that is to say, if the armature cylinder is covered to the depth of one quarter inch the head will be covered to the depth of one inch.

My invention consists essentially in giving to each armature conductor at the point thereof where it passes over the head, a definite bend or offset in the direction of the armature shaft and preferably at or about the middle of such portion so that each conductor will partly underlie and partly overlie the conductors which it crosses and the whole of the conductors thus mutually underlying and overlying one another will be contained in a thickness substantially equal to twice the thickness of a single conductor. When the wires or conductors are thus given a bend in the direction of the armature shaft and systematically and regularly interwoven they will be found to be disposed in substantially two planes both transverse to the armature shaft.

My invention is realized in its simplest form when all of the armature conductors that pass over the cylindrical surfaces are thus systematically disposed in a common system, but in order to prevent crowding of the conductors at the bend, and also to permit a perfectly systematic disposition of the conductors when the entire surface of the armature is covered, I divide the conductors into two or more sets upon the armature head and correspondingly increase the number of planes in which they are disposed. In order, in this case, to secure equality of length and resistance in the various sections each conductor is arranged at one end of the armature in a plane nearer to the armature head than the plane occupied by the same conductor at the other end, thus avoiding the inequality of length and resistance which would result from placing some of the conductors in planes which would at both ends be nearer to or farther from the heads than the planes occupied by other conductors.

The points at which the bends are formed in the conductor upon the armature are preferably made all in a common circle or within the area occupied by the conductors on the head. The bend or offset may be made at such point as is found convenient with the particular size of head and the thickness of conductor. In practice it will be found that the bends must be located, when the circumference of the cylinder is completely covered, at or near the circumference of a circle described by a radius half that of the armature cylinder. When the armature conductors are divided into sets the circle occupied by the conductors of any one set could be obviously smaller than if all of the conductors were assembled on the head into a common set and in the same set of planes.

My invention relates further to a novel method of building an armature which consists essentially in preliminarily bending the armature conductors in a suitable form or mold, and regularly and systematically, to the exact shape which they should have in order to lie regularly and systematically upon the head of the armature and then applying the conductors to the armature in their proper relative locations so that they will fall in and match with one another as hereinafter described.

The principles of my invention will be more

clearly understood from the following specific description taken in connection with the accompanying drawings wherein I have illustrated the invention diagrammatically as applied to a Siemens wound armature.

In the accompanying drawings, Figure 1 shows in side elevation two sections of an armature-winding, the skeleton of which is shown complete in Fig. 2 in cross-section. Fig. 2 is a section on the line $x\,x$, Fig. 1, the armature-body being supposed to be removed, so that the interior of the skeleton of conductors at the head remote from the commutator end may be seen. Fig. 3 illustrates in side elevation two of the sections of an armature in which the conductors are divided into two sets and disposed in four planes at the armature-head instead of two, as in Figs. 1 and 2. Fig. 4 shows the interior of the star or assemblage of conductors on the head remote from the commutator end of the armature, the section being supposed to be taken on the line $y\,y$, Fig. 3, and the armature-body removed. Fig. 5 shows in elevation the assemblage of conductors on the end next the commutator, a section being taken through the conductors between the armature and commutator or on the line $y\,y^2$, Fig. 3. In both Figs. 4 and 5 the field is taken looking in the direction of the arrow, Fig. 3, or from the commutator end of the armature. Fig. 6 illustrates the shape of the bend or offset of one of the conductors and the manner in which said conductor partly underlies and partly overlies other conductors passing over the head of the armature. Fig. 7 illustrates the manner in which two or more conductors may be disposed upon the head of the machine at the point of bending in order to permit the symmetrical disposition of the entire armature-winding into a single set or star upon the head of the machine. Fig. 8 illustrates one way of applying the armature-conductor to the armature.

Referring to Figs. 1 and 2, I have illustrated my invention as applied to a cylindrical or drum armature having eight armature sections. The armature conductors are supposed to be divided into two sets the first of which is employed in completing one circuit of the cylinder and making connection to one half of the commutator segments, while the other set completes the connections to the commutator being wound in the same sections as the first set after the manner well understood in the art. In this instance all of the armature conductors are supposed to be assembled into a common system, after the manner of my invention, upon the armature head.

The armature body upon which the wires are applied is indicated in outline by the letter A, and the bend or offset in each wire is made in the neighborhood of the armature shaft at the points indicated by the letter *d*. The form of the bend or offset is illustrated also in Fig. 6, and also in Figs. 4 and 5.

The bends or offsets on the several conductors are disposed as indicated in Fig. 2, in the circumference of a circle, the conductors shown in Fig. 1, being those on the head remote from the commutator and the view being from within. The portion of each conductor shown in full lines is that which is arranged in the plane nearest the armature head which is the plane indicated by the letter $m^2\,m^2$, Fig. 1, while those parts of each conductor which are shown in dotted lines lie in an outer plane indicated by the letter n^2, n^2, the change from one plane to the other being made by the means of the definite bend or offset such as indicated in Fig. 1.

The several segments of the commutator are indicated by the letter B, the segments being disposed in the manner shown in the diagram in order to simplify matters. It will be understood of course that in practice they would be disposed in the circumference of a circle somewhat less in diameter than that of the armature. In Fig. 1, those ends of the conductors, there shown, which are attached to the commutator segments are indicated by the letter C.

The arrangement of the conductors may be traced in detail as follows: Referring to Fig. 2, the conductor numbered 1, being attached to the commutator segment B, passes backward over the armature periphery and then part way across the rear head in the plane m^2, m^2, nearest the armature head to the point *d*, where it has a bend or offset which will carry it into the plane n^2, n^2, in which plane it is continued to the other side of the armature and there appears as the conductor 2, which is carried forward toward the commutator Fig. 2, until it reaches the front head of the armature over which it is carried in a similar manner to that just described and in the plane nearest the armature head to a point approximately half way across the same where it is provided with a bend or offset which carries it into a plane farther removed from said head. After being carried the remainder of the way across the armature it is bent out as indicated in Fig. 1, for attachment to that segment of the commutator with which the conductor 3, of the next section is connected. The latter conductor is carried across the periphery of the armature rearwardly and across the rear head of the same in a similar manner, the bend or offset in the latter being made next to that of the conductor 1, and between two other conductors as indicated by the diagram, so that the said conductor will lie partly above and partly below the other conductors which it crosses. The conductor 3, having been carried across the head is brought forward as conductor 4, and across the front head of the armature for attachment to the segment of commutator with which conductor 5, is connected. It is carried across the front head in the manner already described the offset or bend being made in proximity to that in conductor 2. After coming forward on the wire or conductor 8, for connection to the commutator segment with which 9, is connected it

will be found that the circuit of the armature has been completed and a conductor laid in every section thereof, while connection has been made to one half the segments of the commutator. The operation is now repeated beginning with conductor 9, and following the conductors in the order indicated to complete the winding of the armature, after the manner well understood by electricians as used in the Siemens winding. The bend or offset in the conductors being formed systematically at the points *d*, it will be found on completion that all the conductors of the armature are of substantially the same length and that each conductor appears identically in the same relation to the remainder that every other conductor does.

In the diagram Fig. 2, the conductors are supposed to fill out but a portion of the space upon the periphery of the armature as would necessarily be the case in order that the bends or offsets might be assembled in a common circle after the manner indicated without being some of them crowded out of line. This arrangement is however applicable to those cases where the armature cylinder is provided with a number of polar projections of considerable width.

In order to afford room for the assemblage of the bent portions of the conductors in a circle as indicated, the bends might be made on the circumference of a circle of larger diameter, that is to say, one which should be nearer the diameter of the armature than is indicated in the figure.

In order to afford ample room for the systematic arrangement of the conductors upon the armature heads I prefer to divide them into sets on said heads, as indicated in Figs. 3, 4 and 5. In this instance, where I have shown them divided into two sets, there would be in all four planes upon each head in which the armature conductors would be disposed. The arrangement may be followed in detail by reference to the numbers applied to the conductors it being remembered that Fig. 4, shows the conductors at the rear head from within, and Fig. 5, shows the arrangement at the opposite head from without looking in the direction of the arrow Fig. 3. Conductors 1 to 16, inclusive form the first set of windings of a Siemens armature, while the remaining conductors form the remaining set required to complete the circuit of the commutator. Conductor 1, for instance being connected with its commutator cylinder will be followed backward over the periphery of the armature to the rear head thereof where it passes across, in the manner shown in Figs. 3 and 4, in the plane *m*, *m*, part of the way, and then by means of a bend or offset in the plane *n*, *n*, to the opposite side where as conductor 2, it continues to the front and then across the front head as shown in Fig. 5. After passing across it is bent as shown in Fig. 3, and is carried to that segment of the commutator with which conductor 3, connects. Conductor 3, being followed rearwardly over the armature is at the rear head carried across the same in the two planes *s*, *t*, and then as conductor 4, is brought forward and across the front head in the plane next to the head instead of in those farthest from the same as it was at the farther end of the armature thus equalizing the length of said conductor with conductors 1, 2, which, as shown in Fig. 3, pass over the rear heads in planes *m*, *m*, next said head and over the front head in planes farthest removed from the same. Conductor 3, appears on the opposite side of the armature as conductor 4, Figs. 4 and 5, and after being carried across the front head connects with the segment of commutator to which conductor 5, connects. Conductor 5, thus is carried over the armature and across the heads in the same planes as conductors 1, 2, the bends or offsets in said conductor being made next to those of 1 and 2.

The arrangement of the bends or offsets with relation to one another of those portions of the conductor which lie in the planes *m*, *n*, is shown more clearly in Fig. 4. As will be seen conductors 1, 2, 5, 6, 9, 10, and 13, 14, of the first set of the Siemens winding lie in these planes *m*, *n*, while the intermediate conductors of this set of the Siemens winding, to wit: 3, 4, 7, 8, 11, 12, &c., lie at the rear end of the armature in the planes *s*, *t*. By this arrangement of the conductors partly in one set of planes and partly in the other the equalizing of the resistances is perfectly attained. The first set of windings having been followed out and terminating, as is well understood in the art, with the conductor 16, which is carried out to the segment with which conductor 17, connects the second set of the Siemens winding may be followed out in the same manner such second set being displaced in the same sections as the first set and likewise alternated between the two sets of planes *m*, *m*, and *s*, *t*, in order to equalize the resistance.

Those armature conductors which connect directly with the same segments of the commutator are joined by a straight line in Fig. 5.

It is obvious that the two sets of conductors on the armature might be alternated between two sets of planes in other ways so as to secure the same result, that is, all the first set might be disposed in planes which would be nearest the head at one end of the armature and farthest from the head at the other, and vice versa, in the case of the second set.

It will be readily seen on reference to Figs. 1 and 3, that the length of the conductor at opposite sides of the periphery of the armature is substantially equal, this equality of length being obtained by the direction in which the offsets at opposite ends of the armature are made.

In order to obtain sufficient room for the orderly and systematic disposition of the conductor upon the head of the armature without dividing the same into sets, I sometimes employ the arrangement shown in Fig. 7,

which illustrates a number of armature conductors arranged to form a common conductor carried over the periphery of the armature and where they are bent with an offset into a common plane which is transverse to the head of the armature. By this means crowding at and near the point of the offset is avoided and it is perfectly practicable to arrange all of the armature conductor covering the entire periphery of the armature in one systematic assemblage on the armature head after the principle I have hereinbefore described.

The arrangement shown in Fig. 7, is particularly applicable to the case of armatures intended to develop currents of very great volume.

It is quite obvious that if the conductors were disposed upon the surface of the armature in any other way besides that indicated in Fig. 7, they might still be arranged as shown in said figure into a common plane transverse to the armature head at the point of bending or offset.

In constructing an armature in accordance with my invention I propose to give the wires the definite bend or offset described so that they may be systematically assembled upon the armature by bending them in a proper form or mold and then assembling them together in the relative positions described either directly upon the armature or assembling the wires for that head which is remote from the commutator before application to the armature and bending the wires open at the opposite end so as to permit the skeleton to be slipped on over the armature after which the individual wires may be bent down into place and proper connection made to the commutator. When there is a systematic disposition of the wires provided for, as is done in my invention, this method of constructing the armature by putting the wires individually into a proper conformator which will bend them to the shape which they shall occupy in the systematic structure insures the proper and orderly disposition of the wires upon the armature in the same manner for each duplicate thus insuring uniformity of resistance in the output of the factory and rendering it possible to employ cheaper labor.

The manner in which the wires would be bent after being assembled into a basket-work or interwoven structure at the rear head is illustrated in Fig. 8, and where I have shown the manner in which one wire of the structure would be bent.

What I claim as my invention is—

1. In a cylindrical armature, a set of armature coils the wires of which are systematically disposed upon the head of the armature and at such part are bent or offset in the direction of the armature axis as described so that each will partly underlie and partly overlie the wires which it crosses.

2. In a cylindrical or drum armature, a set of armature wires having those parts which lie on the armature head integral with the parts on the periphery and systematically arranged on the head in different planes each wire being partly in one and partly in another plane, and the change from one plane to another being made by a bend or offset in each wire at a point between two other wires.

3. In a cylindrical or drum armature, electric conductors the parts of which on the head and periphery of the armature are integral and are systematically disposed over the armature head in two different planes by means of bends or offsets formed in said conductors on the circumference of a circle included within the area occupied by such conductors upon the armature head.

4. An armature having its conductors divided into two or more sets each of the conductors of said sets having its portions in the periphery and head of the armature integral and arranged in two different planes on the armature head while those conductors which are in a plane nearer the armature head at one end are displaced to a plane correspondingly farther from the head at the other end, as and for the purpose described.

5. In a cylindrical or drum armature, conductors passing from the periphery over the head of the armature as continuous wires or conductors, and provided on the head with a bend or deflection sufficient to displace the conductor in the direction of the armature axis a distance equal to the thickness of said conductor.

6. In a cylindrical or drum armature, armature conductors the parts of which on the periphery and head of the armature are integral, said conductors being divided into two or more sets disposed in four or more different planes on the armature heads, those conductors which at one end of the armature are arranged in the two outer planes being disposed at the other end of the armature in the two inner planes.

7. In a cylindrical or drum armature, a compound conductor consisting of two or more strands properly disposed in any desired manner upon the cylindrical surface of the armature and arranged upon the armature head as a flattened web whose edge is presented thereto, as and for the purpose described.

8. In a cylindrical or drum armature, a multiple conductor having its strands assembled into a cable on the armature periphery and flattened upon the armature head so as to cover a less superficial area on the head than upon the periphery.

9. In an armature, a multiple conductor the strands of which are arranged in any desired relation upon the armature periphery and as a flattened web upon the armature head, said conductor being bent or deflected on the head in a direction parallel to the shaft, as and for the purpose described.

10. In a cylindrical armature, armature coils or wires systematically disposed on the head of the armature with an offset in the di-

rection of the armature axis as described, the lengths of the coils or wires of any turn on opposite sides of the axis of the armature being of equal length, substantially as described.

11. The herein described method of constructing cylindrical armatures which consists in bending the conductors with an offset at the part lying on the armature head and then applying them to the armature in their proper systematic assemblage with the portion of each spool or winding where it crosses the head arranged to underlie one half and to overlie the remaining half of the other spools or windings, as and for the purpose described.

12. The herein described method of constructing a cylindrical armature which consists in giving to the conductors a definite bend or offset at a portion thereof which passes over the armature head, assembling the said conductors into a basket-work system with their parts at one side of the offset overlying and at the other side underlying other conductors, and then applying the assemblage to the structure, as and for the purpose described.

13. The herein described improvement in constructing cylindrical armature conductors which consists in giving to the conductors the part thereof which passes over the armature head, a definite offset or bend prior to applying it to the armature and corresponding to that which it should have when the conductors are systematically disposed upon the armature.

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