R. D. MERSHON.

ELECTRIC MOTOR, GENERATOR, AND OTHER APPARATUS.

APPLICATION FILED DEC. 3, 1906.

953,749. Patented Apr. 5, 1910.

3 SHEETS—SHEET 1.

Fig.1

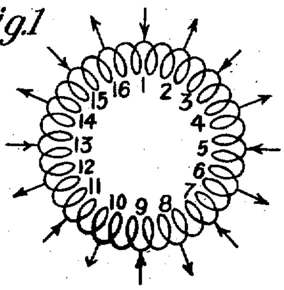


Fig.2

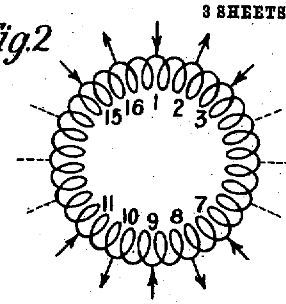


Fig.3

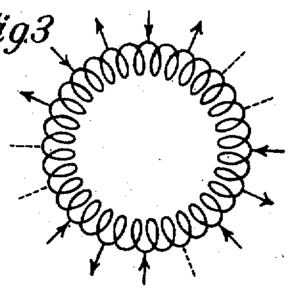


Fig.4

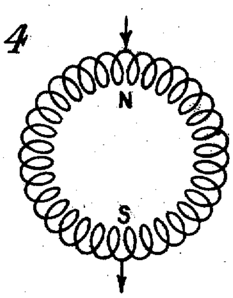


Fig.5

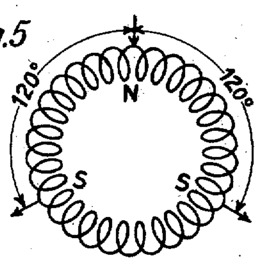


Fig.6

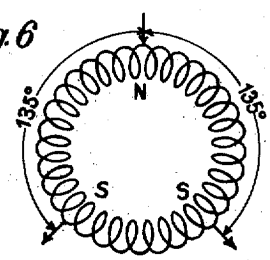


Fig.7

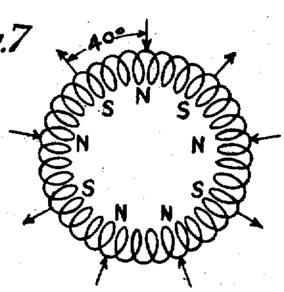
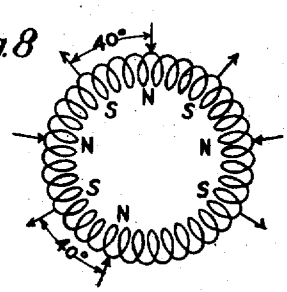


Fig.8



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3 SHEETS—SHEET 2.

Fig. 9

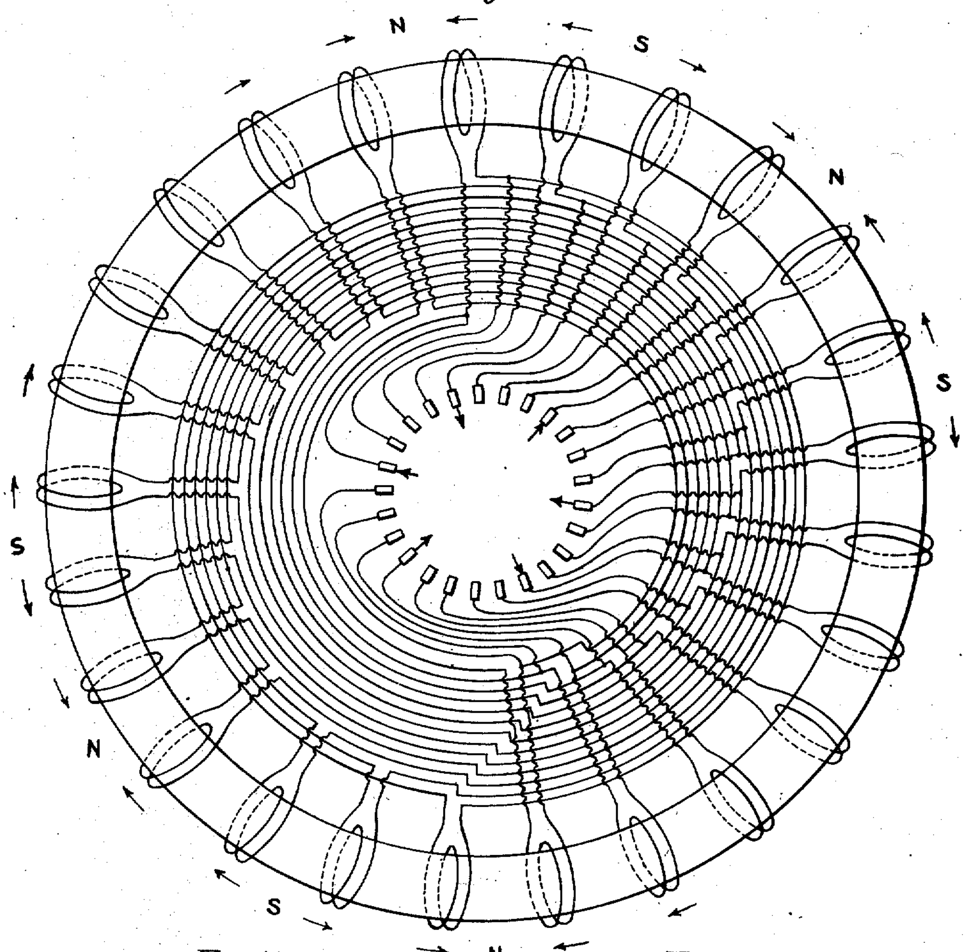


Fig.10

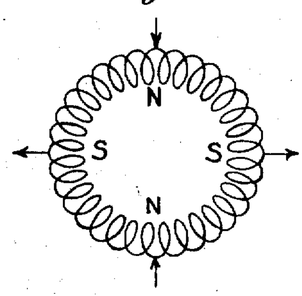
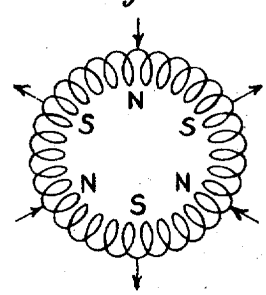


Fig.11



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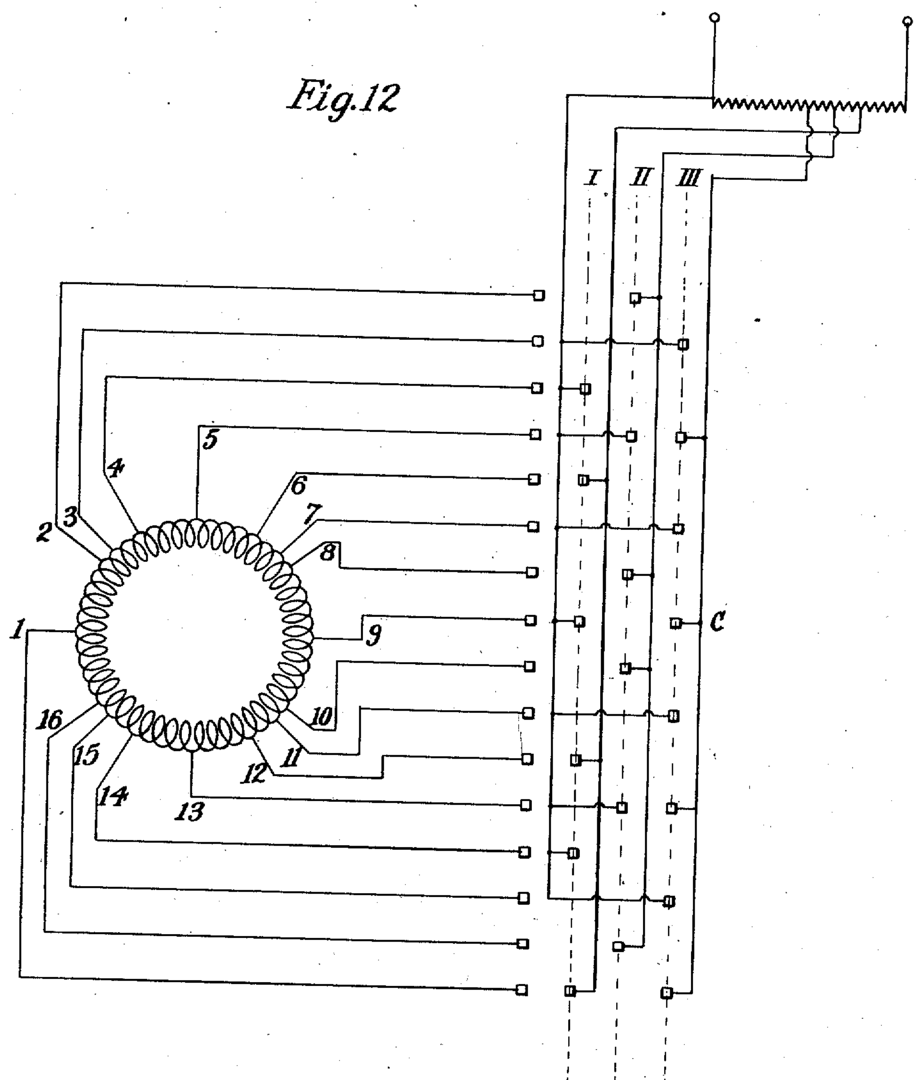
3 SHEETS—SHEET 3.

Fig. 12



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UNITED STATES PATENT OFFICE.

RALPH D. MERSHON, OF NEW YORK, N. Y.

ELECTRIC MOTOR, GENERATOR, AND OTHER APPARATUS.

953,749. Specification of Letters Patent. Patented Apr. 5, 1910.

Original application filed February 1, 1904, Serial No. 191,464. Divided and this application filed December 3, 1906. Serial No. 346,094.

To all whom it may concern:

Be it known that I, RALPH D. MERSHON, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Electric Motors, Generators, and other Apparatus, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

The invention which forms the subject of the present application (which is a division of my earlier application Ser. No. 191,464, now Patent No. 842,966, issued February 5, 1907) relates more particularly to the obtaining of any desired speed, in motors, and any desired frequency, in generators, whether of the induction or synchronous type, though the invention is applicable as well to other apparatus in which magnetic poles are produced, as will appear more clearly from the detailed explanation given hereinafter. Nor is the application of the invention limited to any particular type of apparatus, whether single phase or polyphase, or to any particular kind of windings, whether Gramme ring or drum, uniformly or non-uniformly distributed, etc., but it applies to any winding which will lend itself to the production of the desired angle between poles. For the sake of convenience and brevity, however, the description of the invention will be confined to the case of its application to a single phase induction machine with a uniform ring winding.

It is usual, in alternating current apparatus, to consider that the speed, or the frequency, depends upon the number of poles in the exciting or energizing element, and that a closed, or complete, system of poles must be used; and heretofore, so far as I am aware, only an even number of poles, that is, two or a multiple of two, and a closed system of poles, have been considered in this connection. Hence the obtaining of different speeds and frequencies by variation of the number of poles, either by change in the design of the apparatus or by changing the points of connection, or otherwise changing the connection in any way, when the construction of the apparatus permits such manipulation, is confined to closed systems of poles and to speeds or frequencies corresponding to pole-numbers differing by at least two. This difference may sometimes be greater than is desirable. For example, a motor having 4 poles, operated by currents having a frequency of 3600 alternations per minute, will have a synchronous speed of 900. If the number of poles be increased to 6, the synchronous speed will then be 600, and if the number be reduced to 2, the synchronous speed will be 1800. The difference in the two cases is 300 and 900 respectively, and it may often happen that these variations are too large for the purposes intended. It is therefore desirable to have some method by which practically any difference may be obtained, thereby securing a more convenient control of speed or frequency. It may also at times be desirable to reduce the number of leads to the apparatus even for speeds or frequencies corresponding to an even number of poles, and which would therefore admit of a closed system of poles. This is especially the case with some forms of windings, which are inherently such that the production of certain even pole-numbers would greatly multiply the number of leads to the apparatus.

To provide a method which will accomplish these results is the object of my present invention.

The same consists in the novel feature of construction, arrangements of parts and combinations of elements hereinafter described and more particularly set forth in the claims.

It will be more easily understood when explained in connection with the accompanying drawings, in which—

Figure 1 represents diagrammatically a uniformly distributed Gramme ring winding and the connections for sixteen poles; Figs. 2 and 3 show the same element, but with some of the connections, and consequently the corresponding poles, omitted, the remaining connections and poles being as before. Fig. 4 shows a similar winding, with the equivalent of two poles, and Fig. 5 with the equivalent of three poles, so far as speed or frequency is concerned. Fig. 6 shows another arrangement for the equivalent of two and two-thirds poles, giving a corresponding speed or frequency. Fig. 7 shows an arrangement for the equivalent of nine poles, and Fig. 8 another arrangement for the same purpose. Fig. 9 is a diagram showing a ring winding differing in the manner of the connections of its coils from that of the previous figures, and giving an equivalent of twelve and one-half poles. Here the connections are for convenience of illustration shown brought out to a system of contacts in a manner somewhat similar to that in which the leads from a direct current armature are brought out to the commutator segments. The arrows applied to the contacts show the direction of the currents supplied to the winding and the points at which they enter the same. The arrows around the circumference of the ring show the directions of the magnetizing forces in the coils to which they correspond due to the currents in the coils. If the ring shown be say, the primary of an induction motor, the secondary may be considered as outside of the ring, or if the secondary be considered as inside the ring, the various leads inside the ring would be considered as removed to the outside or as displaced a sufficient distance from the plane of the figure. Figs. 10 and 11 show the relative positions of the poles in apparatus with four and six poles respectively. Fig. 12 shows in diagram a single phase system arranged for changing from six or eight poles to the equivalent of seven poles to obtain the intermediate speed corresponding thereto. In the latter case the poles are produced in groups.

It may be noted that Figs. 1 and 4 show closed systems of poles since the poles alternate in sign and are spaced equidistantly around the whole of the circumference; while in arrangements such as indicated in Figs. 2, 3, 5, 6, 7, 8 and 9 the poles do not necessarily alternate in sign throughout, nor occupy the whole of the circumference, the result being an open system of poles in each case.

Referring now to Figs. 1 and 2, it will be seen that the latter is the same as the former with the exception that six poles are omitted. Nevertheless the angles between the remaining poles are the same, and therefore the synchronous speeds or frequencies are the same. This follows from the fact that a conductor moving with the same speed through the fields of poles 7, 8, 9, 10, 11 and 15, 16, 1, 2, 3, will be affected with the same frequency whether it be moving in Fig. 1 or in Fig. 2. Conversely, with the same frequency in each example, the synchronous speed would be the same in both cases. It therefore follows, as previously stated, that the angle between the poles is the determining factor of synchronous speed or of frequency. If the principles be applied to the ordinary form of generators and motors of the "synchronous" type, whether the poles are salient or not, but in which, in general, the coils of the other element embrace angles approximately that of the pole pitch, there will be a tendency for poles to be induced, by the currents in the other element, at the points where excitation is suppressed, and such induction will result unless the field structure be suppressed at these points; but whether the latter be suppressed or not, and if the poles be induced, the principle of my invention is in no way invalidated. In structures of the induction type, in which the circuits of the other element embrace angles in general considerably less than the polar pitch, this inductive effect will extend slightly beyond the excited portion of the exciting element. If the circuits of the other element embrace angles approximately equal to the polar pitch, this inductive effect may, as in the previous case, extend beyond these poles, but, as previously stated, in such case the principle of my invention is in no way invalidated. Bearing in mind then, that the speed or frequency depends upon the angular spacing of the poles, the apparatus shown in Fig. 4 will have a synchronous speed or frequency corresponding to two poles; but in Fig. 5, where the leads are 120° apart, the synchronous speed or frequency corresponds to three poles. Similarly, in Fig. 6, where the leads are spaced so as to bring poles of opposite sign $360 \div 2\ 2/3°$ (or 135°) apart, the synchronous speed or frequency corresponds to 2 2/3 poles. Fig. 7 shows connections for nine poles by spacing the poles 40° apart. It will be noticed that with an odd or non-integral number of poles two poles of the same sign fall adjacent to each other. When their proximity becomes such that they will in any way interfere, either in the exciting winding or in the winding of the other element, as many poles, one or more, as necessary, may be omitted at the place where the interference occurs. For example, Fig. 8 shows the nine-pole connection with one of the north poles of Fig. 7 omitted.

In some cases, as for instance in the case of two circuit multipolar drum or ring windings, it may be necessary or desirable to have the poles in groups, one or more poles being omitted between groups. An example of this is shown in Fig. 9. Here an odd number of coils is used, which of itself prevents the use of an integral number of poles and therefore the use of a closed system of poles, since one of the conditions for a closed system of poles is that the number of poles shall be an even integer. There is another reason aside from that of the odd number of coils, why Fig. 9 would not admit of a closed system of poles for certain pole-numbers, although it might for others, if it had an even number of coils divisible by the number of poles required. An examination of Fig. 9 will show that coils approximately opposite will, if the proper terminals be chosen, be in series. This means that the relation between the poles to which these two coils contribute is fixed so long as the series connection of the coils is employed. For instance, by reference to the figure it will be seen that poles of the same sign are approximately opposite; if the number of coils were even such poles might be exactly opposite. Now the condition of poles of the same sign at opposite ends of a diameter is one which answers for some numbers of poles but not for others, as will be seen on comparing Figs. 10 and 11, representing apparatus similar to that already described, Fig. 10 showing a four pole connection, and Fig. 11 one for six poles. In the former, poles of the same sign come opposite, but in the latter, opposite poles are of contrary sign. It will be evident, therefore, that in a winding similar to that of Fig. 9, even if the number of coils be such as is evenly divisible by an even number of poles, (in which case, therefore, with a winding connected similarly to Fig. 9, poles of the same size will come exactly opposite, instead of approximately opposite, as in Fig. 9), it will be impossible to obtain pole numbers other than those in which poles of the same sign are opposite unless opposite coils be used in other than their series connection, which will necessitate a greater number of leads to the apparatus. In such a winding, therefore, in order to keep down the number of leads, it might at times be desirable to use the opposite coils in their series connection, and in order to do so for the speeds or frequencies corresponding to pole numbers other than those in which poles of the same sign come opposite, it would be necessary to operate with the poles in two or more groups as in Fig. 9, the groups being separated by an unexcited portion of the element. This explanation, which has been made with reference to a winding in which the coils connected in series are opposite or approximately opposite, holds for the series connection of coils bearing any other definite fixed relation, as for instance where the coils are arranged at intervals of ninety degrees.

In Fig. 12 is shown a system, which for the sake of simplicity in the diagram is shown as for single phase and with a uniformly distributed ring winding, adapted for change in the number of its poles by change in the points at which the current or currents are led into the winding. By tracing out the connections through the controller, diagrammatically represented at C, it will be seen that in the first position, indicated by I, current will be supplied to the motor by leads 1—4—6—9—12—14, each 60° apart and therefore producing six poles. In the next position, indicated by II, leads 2—5—8 of one group are 51 3/7° apart, and leads 10—13—16 of another group are also 51 3/7° apart, thus giving a speed equivalent to seven poles. In the next position, indicated by III, the current is fed through leads 1—3—5—7—9—11—13—15, which are 45° apart, giving eight poles. In the intermediate speed corresponding to seven poles, by omitting one lead from the possible total of seven leads, and arranging the two groups of three each with the middle lead of each group on a diameter, the total number of leads is reduced, since by so arranging them not only has the one lead mentioned been omitted, but it has also been made possible to use leads 5 and 13, which are employed in the 8-pole connection. The same principles apply of course to polyphase apparatus, and to windings other than the ring form or those which are uniformly distributed.

It will be understood, of course, that while for the sake of simplicity the invention has been described in connection with apparatus having only one lead per pole, it may be applied as well in connection with my method of obtaining a desired magnetic flux distribution wherein more than one lead per pole is employed, as more fully described, and claimed broadly, in my copending application, Serial Number 174,698.

What I claim is:

1. The combination of an alternating current machine having a primary element provided with leads for consecutive even numbers of poles and for poles whose angular spacing is intermediate thereto, and a controller in circuit with said leads, as set forth.

2. The combination of an alternating current machine having a primary element provided with leads for a given number of poles with given angular spacing, and with additional leads, whereby the same number of poles may be produced with different angular spacing, and a controller in circuit with said leads, as set forth.

3. The combination of an alternating current apparatus in which the speed or frequency depends upon the spacing of the poles, an external circuit, and means for connecting the apparatus with the said circuit to produce in the former as regards speed or frequency an effect corresponding to the spacing of an odd or non-integral number of poles, as set forth.

4. The combination of an alternating current machine having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with

angular spacing corresponding to an odd or non-integral number of poles, and means for variably connecting the machine with an external circuit, as set forth.

5. An alternating current machine having a primary element provided with leads connected thereto at points to produce poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

6. An alternating current machine having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

7. The combination of an alternating current motor having a primary element provided with leads for consecutive even numbers of poles and for poles whose angular spacing is intermediate thereto, and a controller in circuit with said leads, as set forth.

8. The combination of an alternating current motor having a primary element provided with leads for a given number of poles with given angular spacing, and with additional leads, whereby the same number of poles may be produced with different angular spacing, and a controller in circuit with said leads, as set forth.

9. The combination of an alternating current motor in which the speed depends upon the spacing of the poles, an external circuit, and means for connecting the motor with the said circuit to produce in the former as regards speed an effect equivalent to the spacing of an odd or non-integral number of poles, as set forth.

10. The combination of an alternating current motor having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with angular spacing corresponding to an odd or non-integral number of poles, and means for variably connecting the motor with an external circuit, as set forth.

11. An alternating current motor having a primary element provided with leads connected thereto at points to produce poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

12. An alternating current motor having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

13. The combination of an induction motor having a primary element provided with leads for consecutive even numbers of poles and for poles whose angular spacing is intermediate thereto, and a controller in circuit with said leads, as set forth.

14. The combination of an induction motor having a primary element provided with leads for a given number of poles with given angular spacing, and with additional leads, whereby the same number of poles may be produced with different angular spacing, and a controller in circuit with said leads, as set forth.

15. The combination of an induction motor having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with angular spacing corresponding to an odd or non-integral number of poles, and means for variably connecting the motor with an external circuit, as set forth.

16. An induction motor having a primary element provided with leads connected thereto at points to produce poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

17. An induction motor having a primary element provided with leads for producing poles with angular spacing corresponding to even numbers of poles and for producing poles with angular spacing corresponding to an odd or non-integral number of poles, as set forth.

18. In combination, an induction-motor having a primary winding provided with terminal connections for producing different pole numbers and intermediate taps between said terminals, and a controlling-switch in circuit with said taps.

19. In combination, an induction-motor having a primary winding provided with terminal connections for producing different pole numbers and intermediate taps between said terminals, and a controlling-switch adapted to connect either set of terminals or the intermediate taps to a source of current.

20. In combination, an induction-motor having a primary winding provided with terminal connections for producing different pole numbers and intermediate taps between said terminals, and a controlling-switch having its contacts arranged to connect a set of terminals for one number of poles to a source of current, then to break said connections and to connect the intermediate taps successively to the source, and finally to connect the terminals for the second number of poles to the source.

21. In combination, an induction-motor having a primary winding provided with terminal connections for producing different pole numbers and intermediate taps unsymmetrically arranged between said terminals,

and a controlling-switch adapted to connect either set of terminals or said taps to a source of current.

22. In combination, an induction-motor having a primary winding provided with terminal connections for producing two different pole numbers and intermediate taps corresponding in number to the terminals for the smaller number of poles but unsymmetrically placed, and a switch adapted to connect either set of terminals or said taps to a source of current.

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Witnesses:

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