No. 736,910. PATENTED AUG. 18, 1903.

E. ZIEHL.

FIELD WINDING FOR ELECTRIC MACHINES.

APPLICATION FILED JAN. 12, 1903.

NO MODEL. 4 SHEETS—SHEET 1.

Fig. 1.

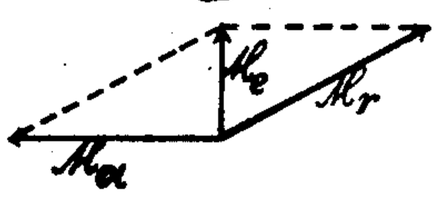


Fig. 2.

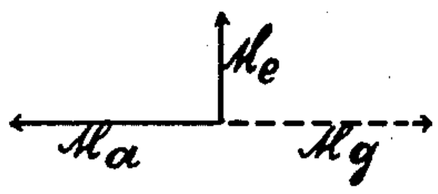


Fig. 3.

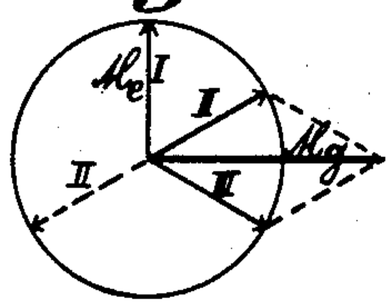


Fig. 4.

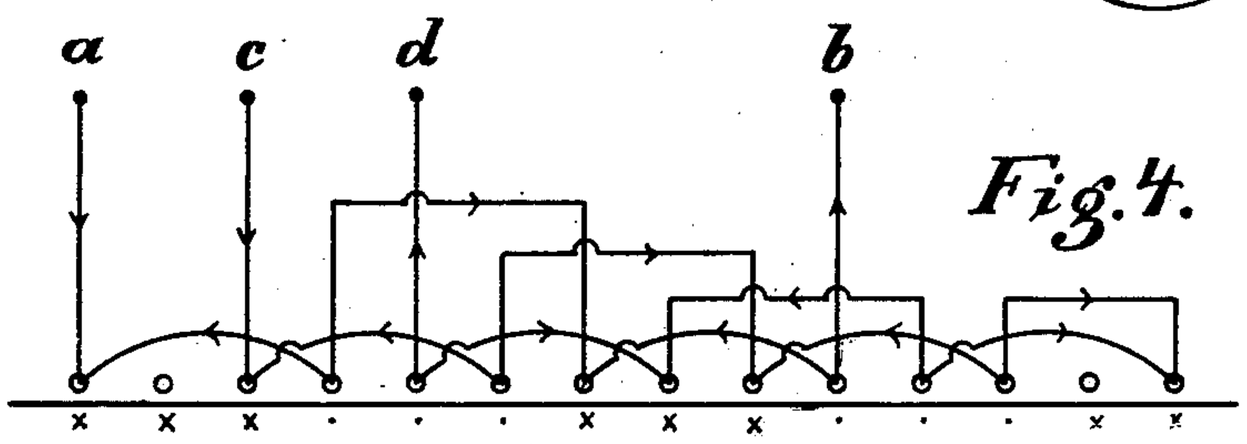


Fig. 5.

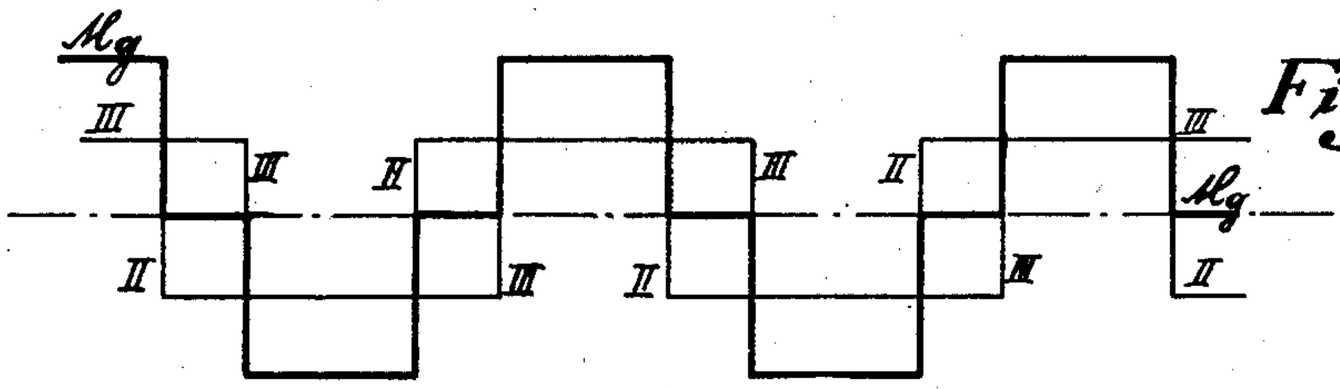


Fig. 6.

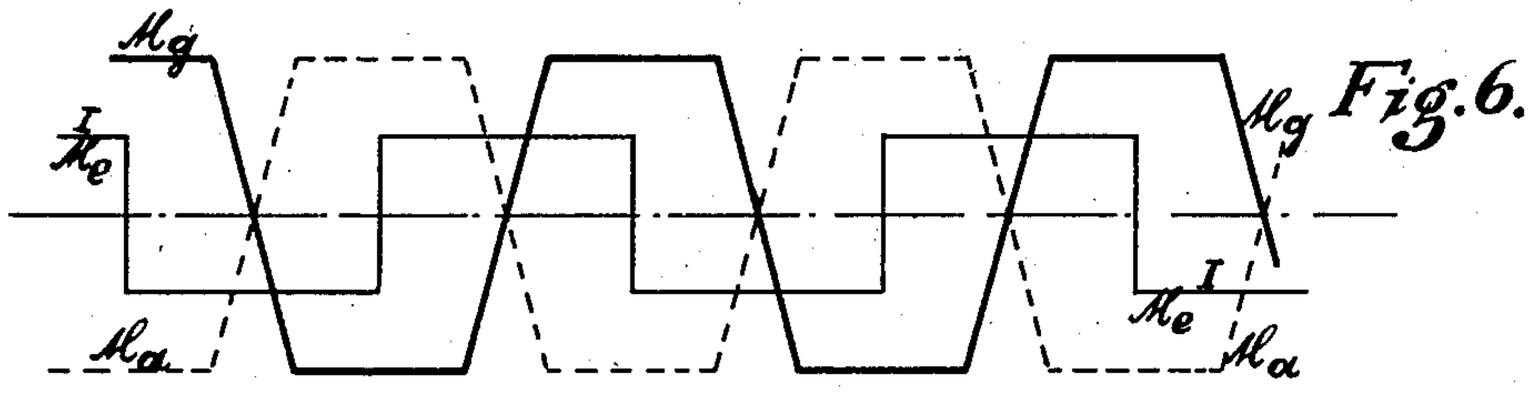


Fig. 7.

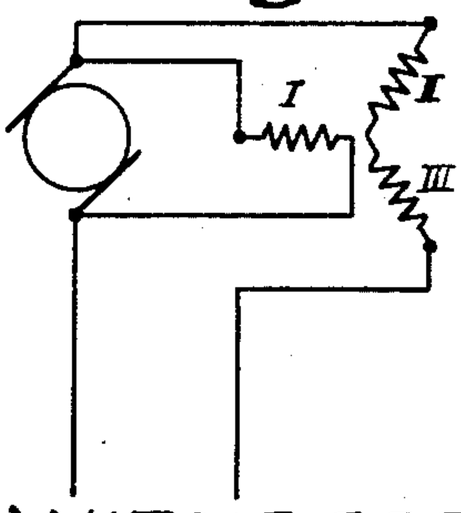


Fig. 8.

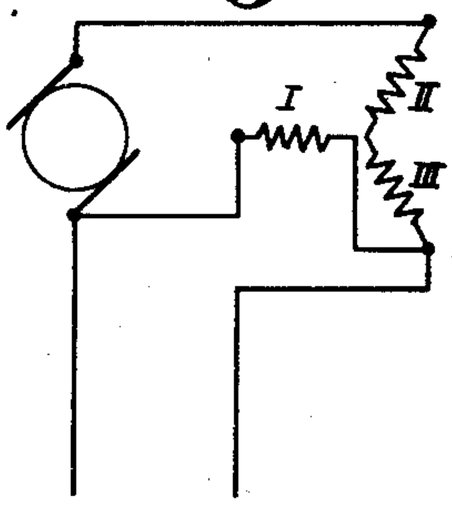
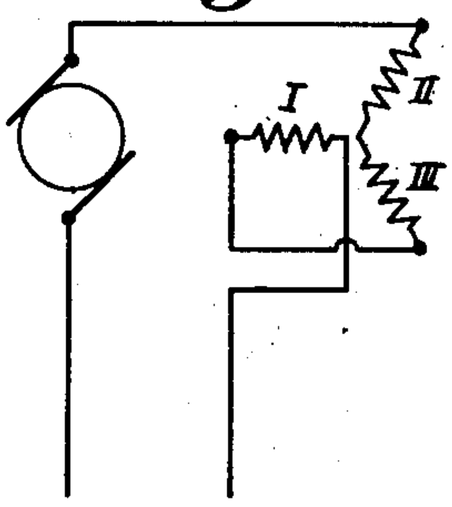


Fig. 9.



WITNESSES

H. M. Kuehl

J. M. Dowling

INVENTOR

Emil Ziehl

BY Richards & Co.

ATTORNEYS.

No. 736,910. PATENTED AUG. 18, 1903.

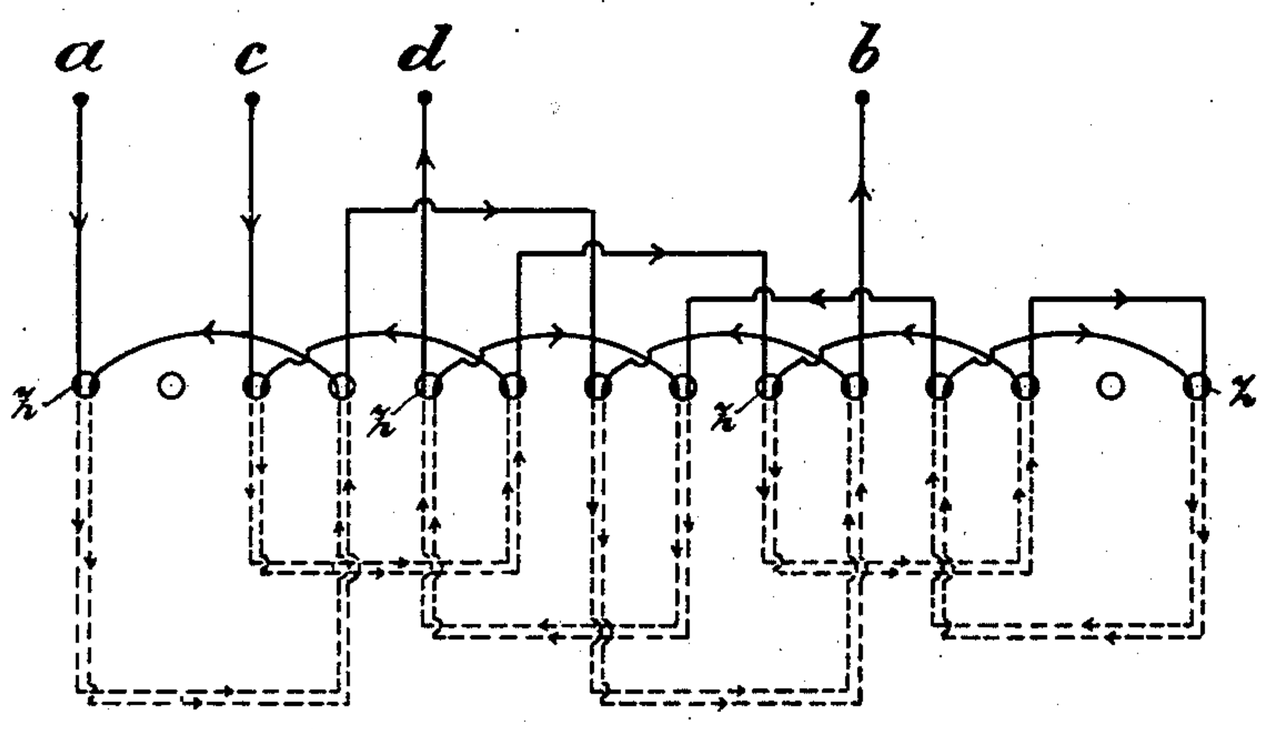
E. ZIEHL.

FIELD WINDING FOR ELECTRIC MACHINES.

APPLICATION FILED JAN. 12, 1903.

NO MODEL. 4 SHEETS—SHEET 2.

FIG. 4a.



Attest
Walter D. Malleson
Edw. L. Reed

Inventor
Emil Ziehl
by Richards & Co
Attys

No. 736,910. PATENTED AUG. 18, 1903.

E. ZIEHL.

FIELD WINDING FOR ELECTRIC MACHINES.

APPLICATION FILED JAN. 12, 1903.

NO MODEL. 4 SHEETS—SHEET 3.

Fig. 10.

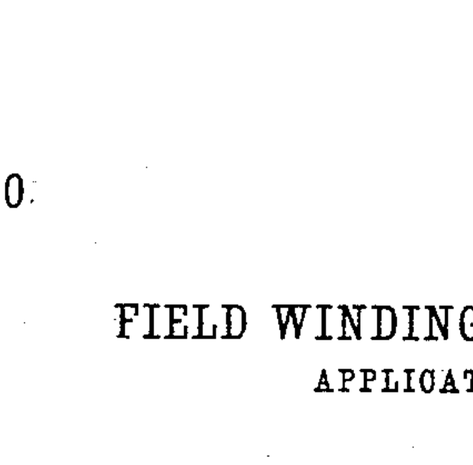


Fig. 11.

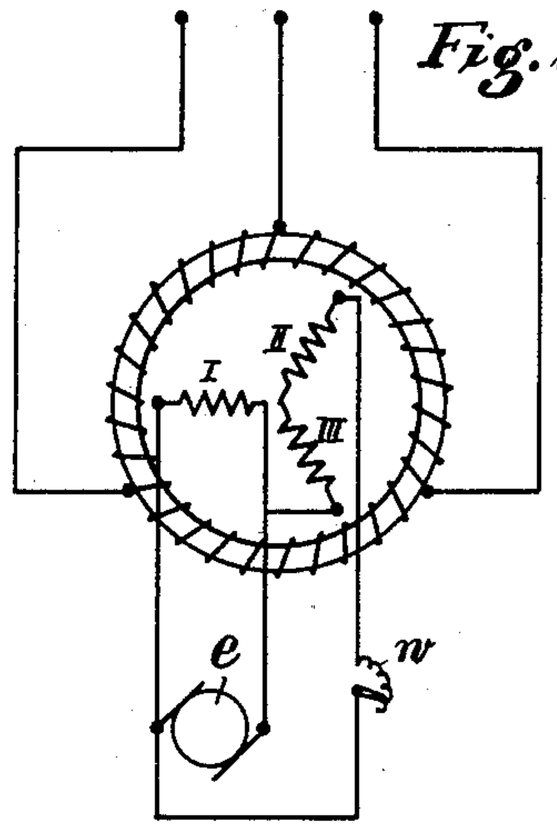


Fig. 12.

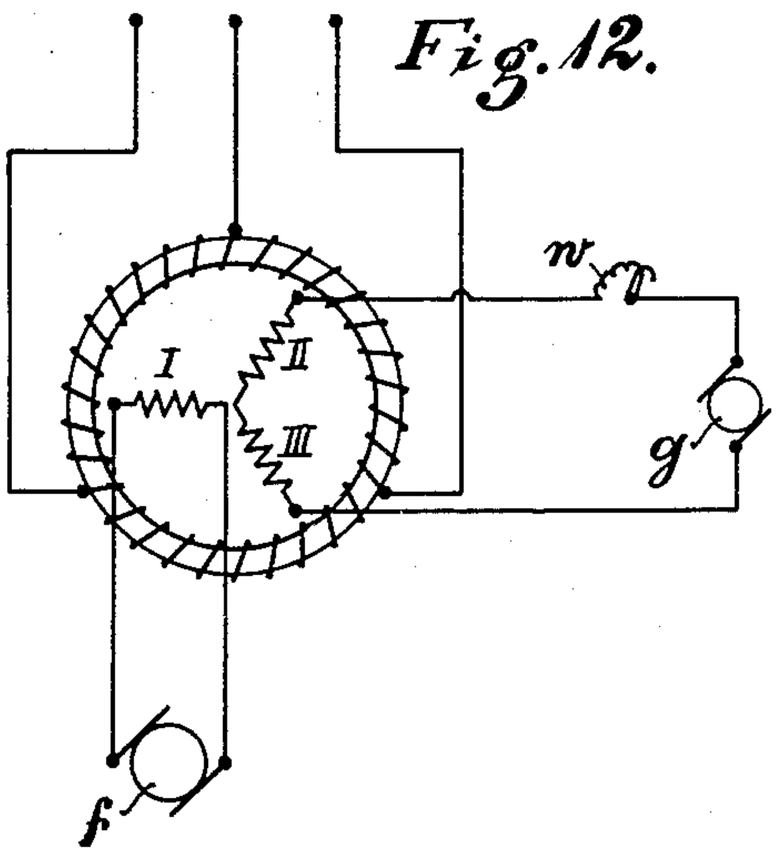


Fig. 13.

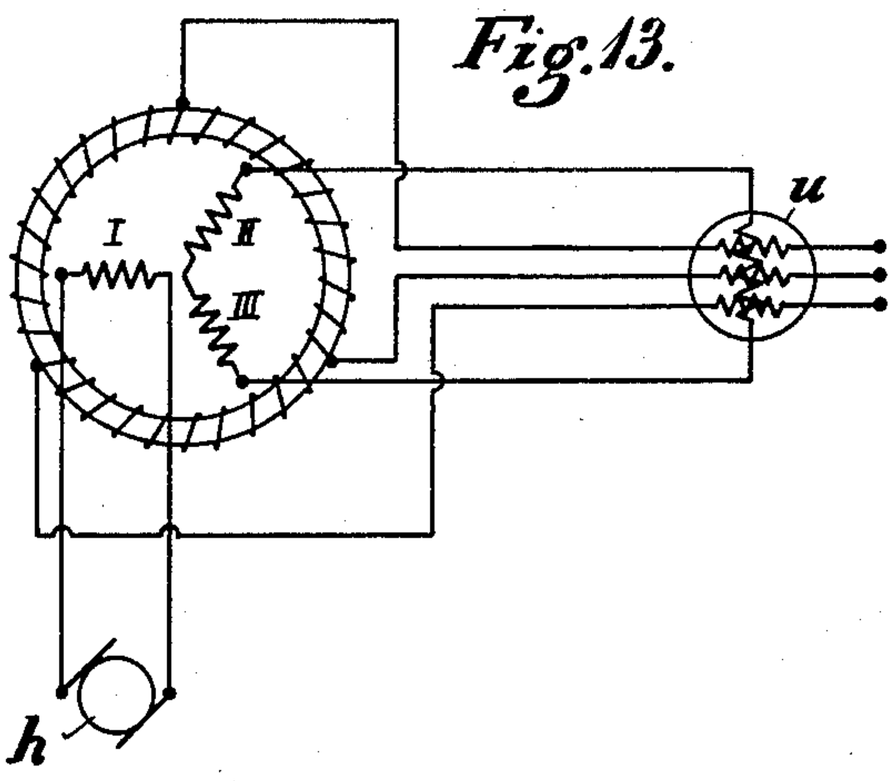
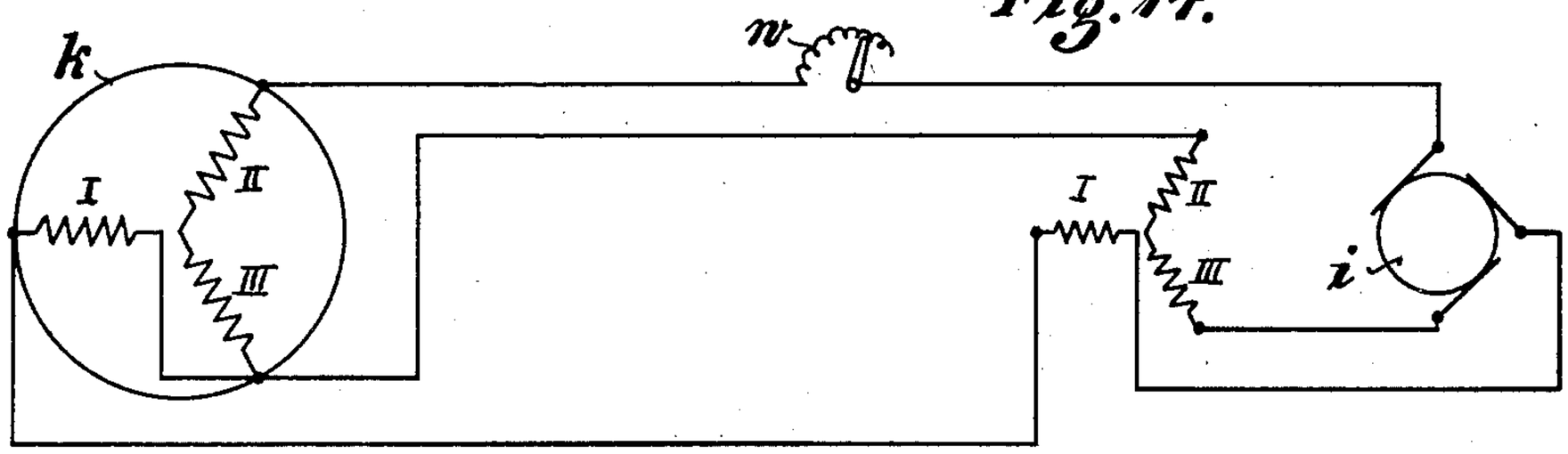


Fig. 14.



WITNESSES

H. M. Kueble

J. M. Dowling

INVENTOR

Emil Ziehl

BY Richardson & Co.

ATTORNEYS

No. 736,910. PATENTED AUG. 18, 1903.

E. ZIEHL.

FIELD WINDING FOR ELECTRIC MACHINES.

APPLICATION FILED JAN. 12, 1903.

NO MODEL. 4 SHEETS—SHEET 4.

Fig. 15.

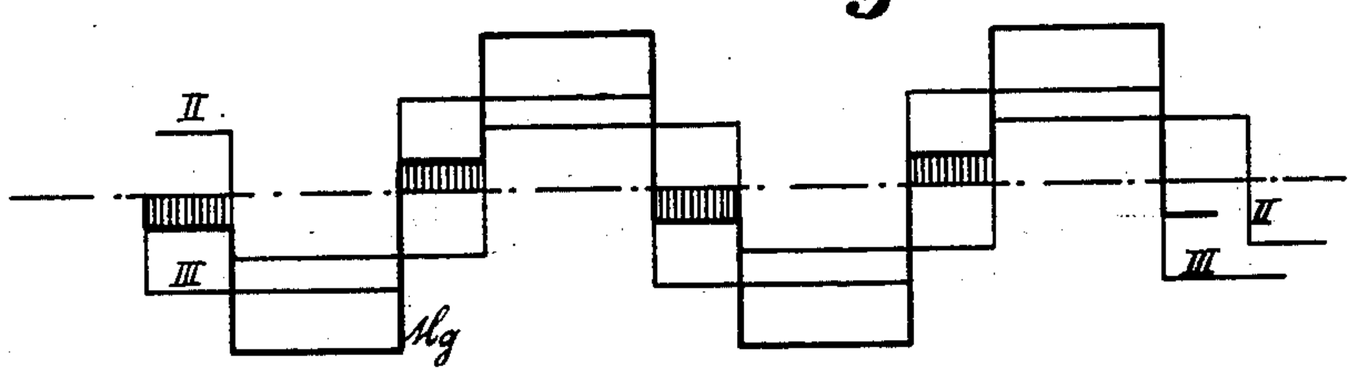


Fig. 16.

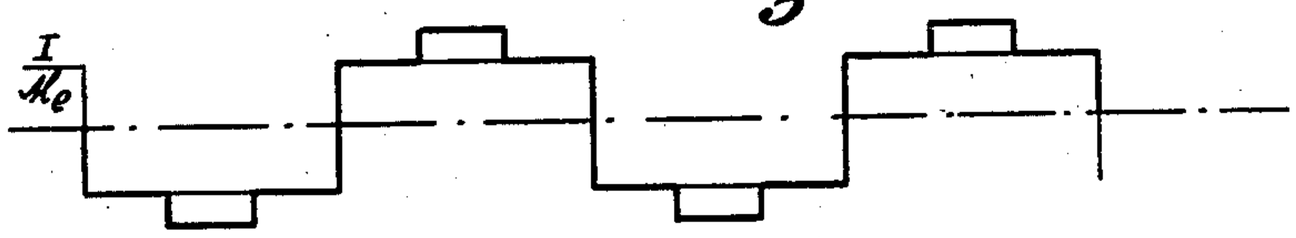


Fig. 17.

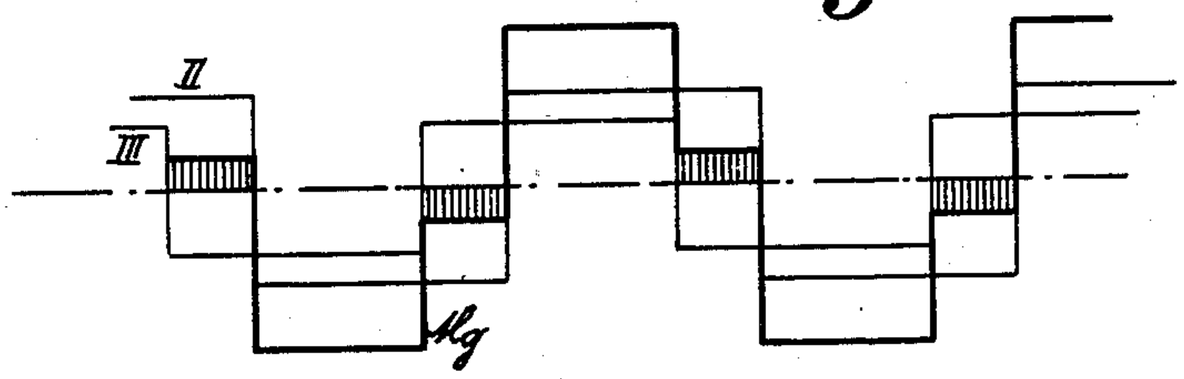


Fig. 18.

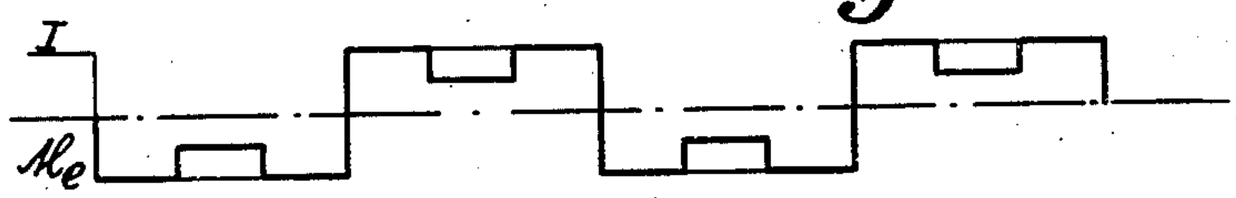


Fig. 19.

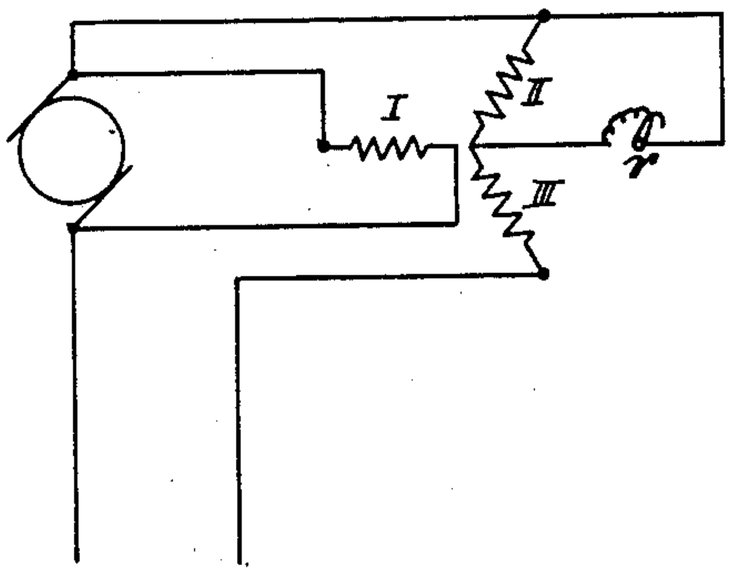
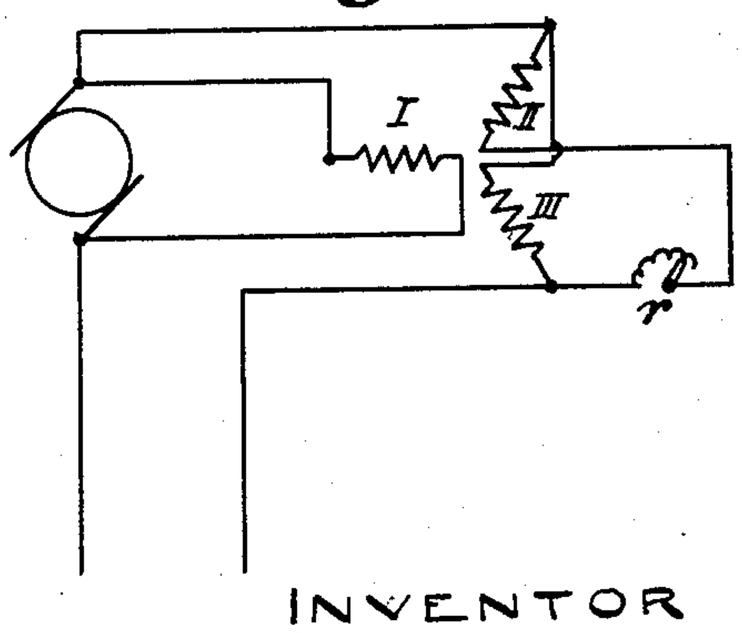


Fig. 20.



WITNESSES

H. M. Kueche

J. M. Downing

INVENTOR

Emil Ziehl

BY Richardson & Co

ATTORNEYS

No. 736,910. Patented August 18, 1903.

UNITED STATES PATENT OFFICE.

EMIL ZIEHL, OF BERLIN, GERMANY, ASSIGNOR TO BERLINER MASCHINEN-BAU ACTIEN-GESELLSCHAFT, VORMALS L. SCHWARTZKOPFF, OF BERLIN, GERMANY.

FIELD-WINDING FOR ELECTRIC MACHINES.

SPECIFICATION forming part of Letters Patent No. 736,910, dated August 18, 1903.

Application filed January 12, 1903. Serial No. 138,686. (No model.)

To all whom it may concern:

Be it known that I, EMIL ZIEHL, engineer, a subject of the German Emperor, residing at Berlin, Germany, have invented certain new and useful Improvements in Field-Windings for Electric Machines; and I do hereby declare that the following is a full, clear, and exact description.

The present invention relates to field-windings for electric machines with continuous-current excitation, and has for its object to equalize or render innocuous the reaction of the armature. Use is made herein of a winding which corresponds to the winding of the well-known three-phase arrangement, and this is so arranged that the one of the three windings serves for the production of the principal field of excitation and the two other windings serve for the production of an auxiliary magnetic field, which is, however, equal and opposite to the armature-field. This opposed field effects the neutralization of the armature-field and consequently of the reaction of the armature.

The current for the principal exciting-field, as well as the current for the equalizing-field, can be obtained from any convenient source of current—as, for instance, from an ordinary shunt-wound machine or a series machine, a compound-wound machine, a battery of accumulators, or a transformer. For the exciting-field and the secondary field various sources of continuous current may be employed.

With continuous-current machines both the current for the exciting-field and also the current for the equalizing-field of the machine may be taken from the machine itself. If the current for the equalizing-field be taken from the machine itself and the equalizing-winding be traversed by the main current of the machine, there will be automatically realized the full proportionality between the armature-current and the equalizing-current. If a separate source of current be employed for the production of the equalizing-field, then the current for the equalizing-winding must be regulated proportionately to the particular main current of the machine. This regulation may be effected by hand or automatically. Moreover, it is possible in alternate-current or polyphase-current machines to feed the equalizing-field by means of a continuous current directly dependent upon the main current by using an alternate-current or polyphase-current continuous-current transformer. If the two equalizing-field windings receive a different number of ampere-turns, then by suitable choice of the proportion between these two numbers of ampere-turns there can be attained the strengthening or the weakening of the exciting-field, according to requirements. The reaction of the armature can, moreover, in this case be compensated if the sum of the ampere-turns be alike in both windings, as in the case where both windings possess the ampere-turns which are requisite for the equalizing of the reaction of the armature in equal number.

The system forming the subject of the present application is illustrated in the accompanying drawings.

Figures 1, 2, and 3 show diagrams which explain the action of the new field-winding. Figs. 4 and 4ª show diagrammatically the arrangement and connections of a winding which corresponds to the usual three-phase arrangement with the phases superposed. Figs. 5 and 6 show the corresponding graphically-illustrated magnetic fields. Fig. 7 illustrates an arrangement in which the winding for the main exciting-field is connected to the poles of a source of continuous current and the windings for the equalizing-field are placed in the outer current-circuit thereof. Fig. 8 corresponds to Fig. 7, with the difference that the winding for the main exciting-field is not attached to the other pole of the machine, but is connected to the main-current conductor behind the equalizing-windings. Fig. 9 shows the winding for the main exciting-field with the windings for the equalizing-field in series. Fig. 10 corresponds to Fig. 7, with the difference that both windings for the equalizing-field are not arranged in series, but in parallel connection. Fig. 11 illustrates an arrangement suitable for con-

tinuous-current machines as well as for alternate-current machines in which the main exciting-field and the equalizing-field are supplied from one and the same special source of current. Fig. 12 illustrates the corresponding arrangement in the case in which the main exciting-field and the equalizing-field are each supplied from a separate source of current. Fig. 13 shows an arrangement in which the main exciting-field is supplied from a special source of current, while for the equalizing-field a transformer is employed, the continuous current whereof is obtained from the main current of the machine. Fig. 14 illustrates the connection of an alternate-current or polyphase machine with a special exciting-machine whereby both the windings for the main exciting-fields and the windings for the equalizing-fields are each arranged in series. Figs. 15 to 18 illustrate an arrangement in which the number of the ampere-windings of the two equalizing field-windings are different. Figs. 15 and 16 relate to the strengthening, and Figs. 17 and 18 to the weakening, of the main exciting-field. Figs. 19 and 20 show how the variation of the ampere-turns may be obtained in a simple manner.

As is well known, the main exciting-field M^e, Fig. 1, of an electrical apparatus with continuous-current excitation is composed of the resulting field M^r and the armature-field M^a. M^e and M^a are vertical one to the other. The size and direction of M^r alter with the load of the armature. In order to equalize the reaction of the armature to the main exciting-field, there may be produced in addition to the main exciting-field M^e another field M^g, which field equals the armature-field M^a, but is opposite to it, Fig. 2.

According to the present invention the main exciting-field M^e, as well also as the equalizing-field M^g, are produced by a field-winding similar to that of the three-phase system. The new winding is illustrated diagrammatically in Fig. 3. The winding corresponding to the one phase serves for the excitation of the main exciting-field M^e. The windings corresponding to the two other phases, of which the one is opposed to the ordinary winding for three-phase current, are made use of for the production of the equalizing-field M^g. In Fig. 3 the field I serves for the production of M^e and the fields II and III for the production of M^g. As the phase II is in opposition to their ordinary direction, it results that M^g stands at right angles to M^e and M^a is opposed thereto.

In Fig. 4 the windings I of the main exciting-field lie between the two points $a\,b$, whereas the windings II and III of the equalizing-field lie between the points $c\,d$. In Fig. 4 the direction of the current in the windings is indicated by hatches. The windings are represented only by their parts which lie at the front side of the armature; but crosses and points in a manner well known to such skilled in the art indicate that the windings enter the borings of the armature, pass on the rear side of the armature to other borings, and come from the latter back to the front side, and so on. Fig. 4^a shows by dotted lines the situation of the windings in the borings z and on the rear end of the armature. For the sake of clearness only two wires are supposed in every boring. Obviously there might be a greater number of turns. The separate turns of the winding I, as well as those of the windings II III, can be arranged in series, in parallel, or also in groups. The field-diagram shown in Fig. 5 illustrates the field produced by windings II III, from which there results by addition and subtraction the equalizing-field M^g, (indicated by a thicker line.) In reality this line would not be so angular, but would approximate more to the form of a sinus curve, the more so, as usually not all the wires of a winding are placed in a single boring, but in several borings arranged one beside another.

In Fig. 6 consequently a form is given to the equalizing-field M^g which corresponds more nearly to the actual one.

In Fig. 6 there is illustrated in addition to the equalizing-field M^g the main exciting-field M^e, created by the winding I, and also the armature-field M^a. As M^e and M^a stand at right angles to one another, and consequently are displaced ninety degrees one against the other, then it results from Fig. 6 that the fields M^g M^a actually operate direct one against the other and must neutralize one another as long as the ampere-turns are approximately equal. The new winding system may be carried into effect in various ways. A number of examples have been illustrated in Figs. 7 to 14.

In Figs. 7 and 8 the equalizing-field windings are inserted in series in the main-current circuit. In Fig. 7 the main-exciting-field winding is connected as a shunt between the poles of the machine. In Fig. 8 the main-exciting-field winding is connected on the one hand to one pole of the machine and on the other hand is connected behind the equalizing-field windings to the main-current conductor.

In Fig. 9 the main-exciting-field winding is connected in series with the equalizing-field windings in the main-current circuit of the machine.

In Fig. 10 the main-exciting-field winding is again connected to the poles of the machine, whereas the equalizing-field windings are inserted parallel to one another in the main-current circuit.

In continuous-current machines in which the windings for the equalizing-field are arranged in series with the armature the proportionality between the armature-current and the equalizing-field current will obviously be obtainable automatically.

In Fig. 11 there is used a special source of current e for the supply of the windings I, as well as for the supply of the windings II and III. In this case the current of the equalizing-