No. 717,065. Patented Dec. 30, 1902.

E. ARNOLD, O. S. BRAGSTAD & J. L. LA COUR.

DISTRIBUTING ELECTRIC CURRENTS.

(Application filed Dec. 31, 1900.)

(No Model.)

Fig. 1.

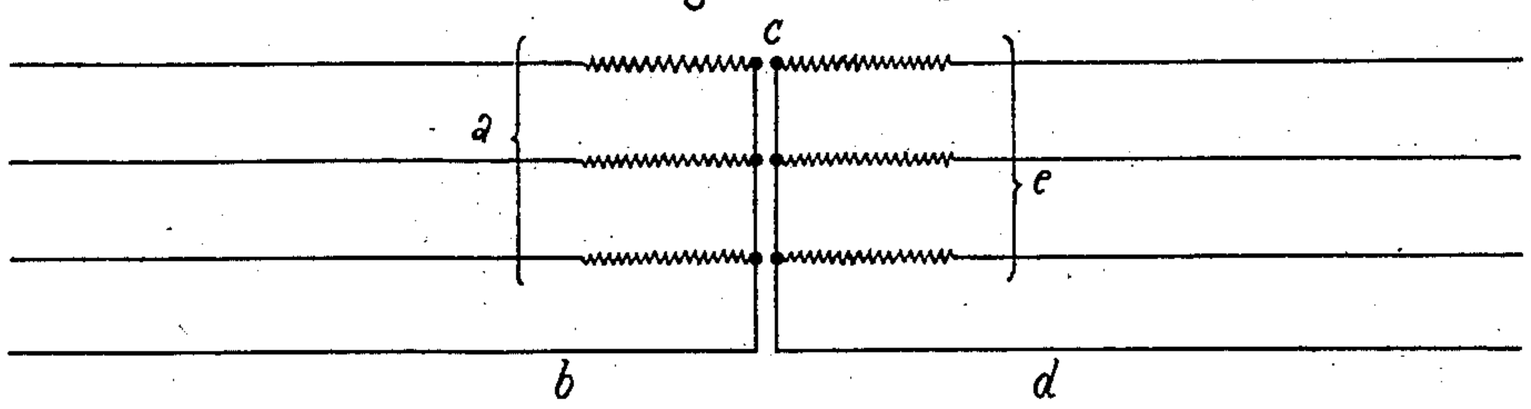


Fig. 2.

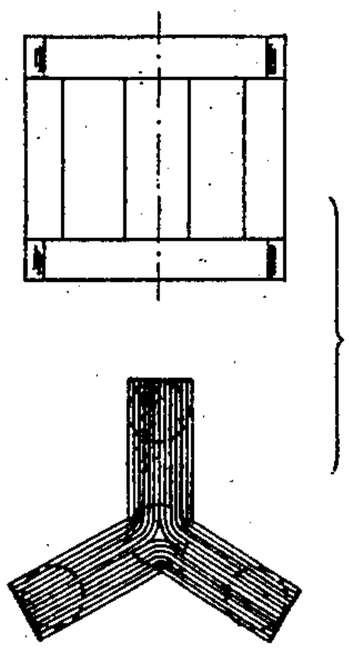


Fig. 3.

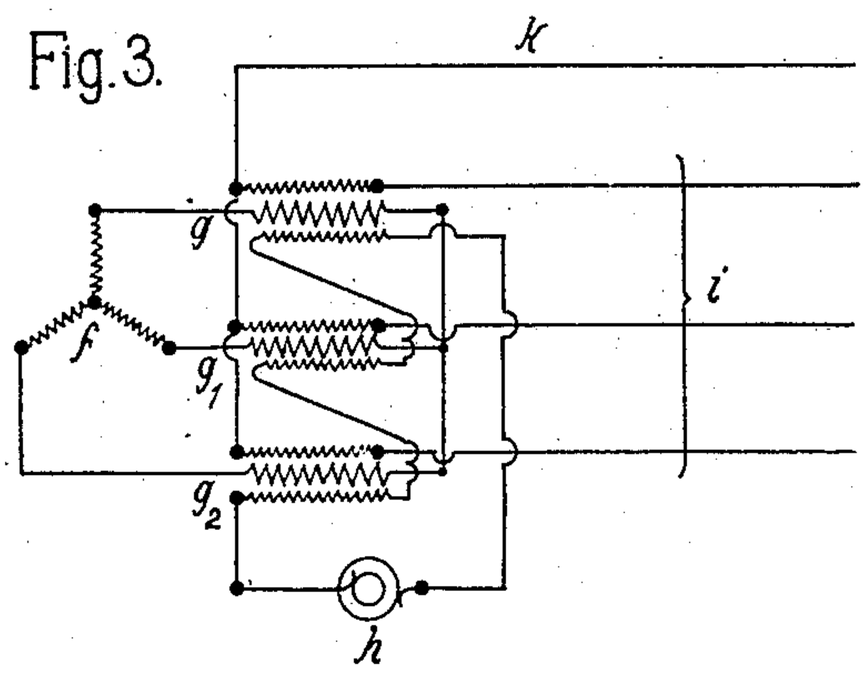


Fig. 4.

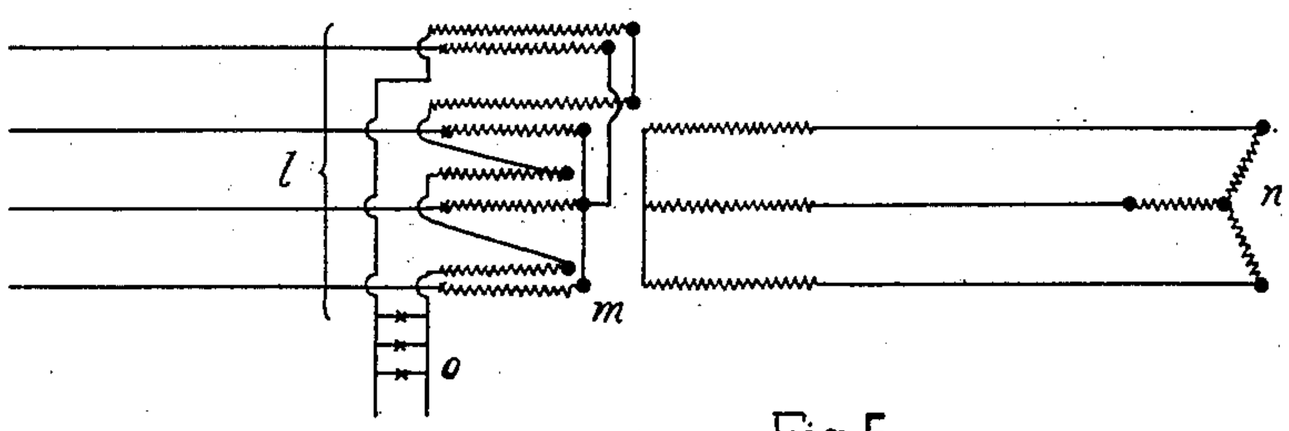
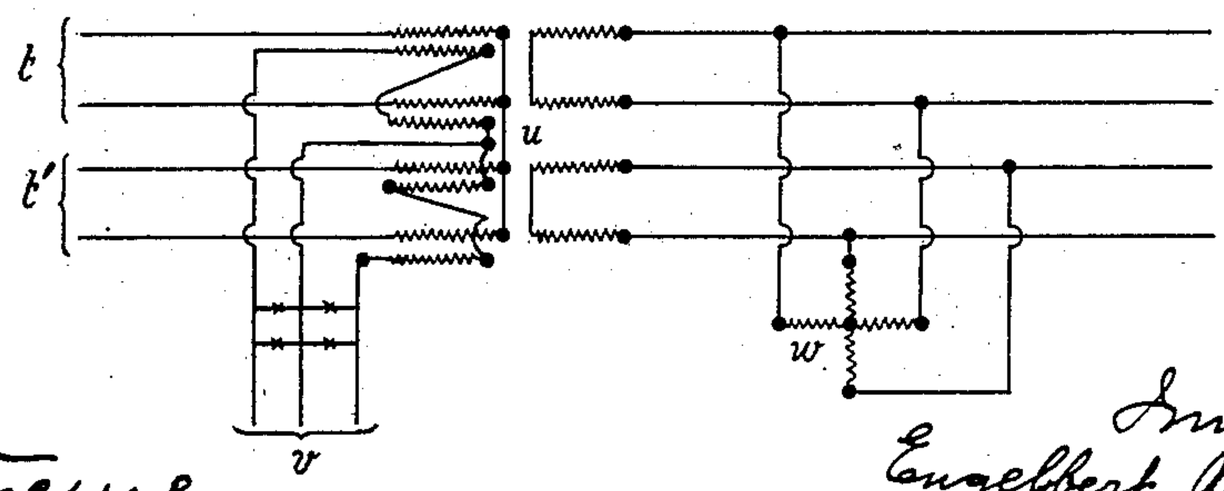


Fig. 5.



Witnesses
H. M. Gillman, Jr.
A. G. Hansmann.

Inventors
Engelbert Arnold
Ole Levin Bragstad
Jens Laurin La Cour
by Fowler & Freeman
Attorneys

UNITED STATES PATENT OFFICE.

ENGELBERT ARNOLD, OLE SIVERT BRAGSTAD, AND JENS LASSEN LA COUR,
OF KARLSRUHE, GERMANY.

DISTRIBUTING ELECTRIC CURRENTS.

SPECIFICATION forming part of Letters Patent No. 717,065, dated December 30, 1902.

Application filed December 31, 1900. Serial No. 41,630. (No model.)

To all whom it may concern:

Be it known that we, ENGELBERT ARNOLD, a subject of the Emperor of Germany, OLE SIVERT BRAGSTAD, a subject of the King of Sweden and Norway, and JENS LASSEN LA COUR, a subject of the King of Denmark, all residents of Karlsruhe, Germany, have invented certain new and useful Improvements in Distributing Electric Currents, of which the following is a specification.

For the different applications of electric alternating currents, phases and periods of different numbers are most suitable in relation to the separate objects. As examples, for driving motors a multiphase current of low frequency is best. For arc-lamps and incandescent lighting a single-phase current of higher frequency is most advantageous. Frederick Bedell has already shown how these advantages are gained by means of superposing alternating currents of different frequency, while currents of different character can be introduced and withdrawn at points of equal potential of a motor-circuit, his invention being protected by Letters Patent of the United States, Nos. 645,907 and 647,741. These arrangements of Bedell by which the direct current or superposed alternating current is introduced at points of the winding of the generators, motors, transformers, or choking-coils of the main system have the disadvantage with alternating currents that the alternating current introduced into the windings of transformers or choking-coils sustains a great drop of potential on account of the self-induction of such current if the windings are not arranged without self-induction.

The method hereinafter described will serve to obviate above disadvantages without the employment of non-inductive windings, because electric currents of different character are not introduced in one and the same wire by means of conduction, but by means of induction. This is effected by means of the superposition of magnetic fluxes in one and the same transformer. Hereby not only is the immediate end gained, but the additional advantage that the same transformer can be used for simultaneously transforming the superposed alternating current of different character.

The principle of our invention consists, in brief, in the simultaneous transformation and introduction or further transmission of alternating currents of different numbers of period and phase over the conductors of a motor-circuit by means of the employment of transformers having two different kinds of inductive primary windings, which in certain circumstances can be reduced to one, and having only one induced, secondary winding, and in the simultaneous transformation and withdrawal of the currents of the transformers with a primary and two secondary windings. Because the currents must be of different frequency and because the drop of potential of any one of the superposed currents in the conductors and transformers is independent of the drop of potential of any other superposed current such a description of system for conducting may be entitled "An independent polycyclic system of distribution." The simultaneous transformation besides lessening the cost of plant has this further advantage that however increased the total output may be the maximum induction in the transformers can by means of a suitable choice of the superposed currents be reduced, and because of this the hysteresis loss is also reduced. The transformers will be correspondingly smaller.

In the accompanying drawings, Figure 1 illustrates the simultaneous transformation of a three-phase current and of a superposed single-phase current by a three-phase transformer with magnetic return. Figs. 3 to 5, inclusive, illustrate the introduction and withdrawing and simultaneous transformation of a superposed alternating current by the transformers of the main system.

In Fig. 1, *a* represents the three main conductors, and *b* the neutral conductor, of a three-phase system. Besides the three-phase current the conductors *a* carry a superposed single-phase alternating current, the return-wire of which is formed by *b*. The four-core transformer *c*, its iron frame being shown in Fig. 2, serves for the simultaneous transformation of the three-phase current and of the superposed single-phase alternating current. As the alternating current flows similarly through the three primary windings, and thus

produces a magnetic force which flows similarly in the three cores, a fourth core is necessary as a return for the fluxes produced by the superposed current. The three secondary conductors *e* serve simultaneously to carry away the transformed three-phase current and for leading out the transformed alternating current which flows back through the neutral conductor *d*. If the ratio of transformation of the three-phase current be determined beforehand, then it is made possible to make the ratio for the single-phase alternating current as large as may be desired by the insertion of windings in the neutral conductor. These windings are wound on the fourth core of the transformer.

Fig. 3 illustrates the employment of the three one-phase transformers of a three-phase system serving as main system for simultaneous transformation and introduction of a superposed single-phase alternating current. *f* denotes the three-phase generator for the generation of the three-phase current. *g g' g²* are the three single-phase transformers, each of which possesses two primary and one secondary winding. Three of these primary windings, each of which belong to a transformer, are star-connected and serve to receive the three-phase current, while the three remaining primary windings are series-connected and serve to receive a single-phase alternating current generated in the generator *h*.

In the star-connected secondary windings of the transformers a three-phase and a single-phase current are simultaneously induced. Contrariwise the two primary windings have no inductive action on each other. *i* represents the three main conductors of the three-phase motor-circuit, while *k* denotes the neutral conductor of same, which serves as return-wire for the superposed one-phase alternating current. This arrangement can be applied to a main system with whatever number of phases—for example, *x*—may be desired, while *x* separate star-connected transformers are employed.

Instead of *x* separate transformers one *x*-phase transformer which provides a magnetic return for the magnetic fluxes excited by the superposed alternating current may also be used. On the iron core serving as return a primary as well as a secondary winding can be wound in which flow only the superposed currents.

Fig. 4 illustrates an employment of a four-wire three-phase system *l* as main system. *m* is the four-core three-phase transformer shown in Fig. 2. In this case the transformer *m* serves for simultaneous transformation and delivery of two currents, of which the main current serves for feeding the three-phase motor *n* and the alternating current for feeding the lighting-circuit *o*.

It is here considered that the fourth core of the transformer is furnished with a primary and with a secondary winding.

With the two halves of a four-phase system used as main system the taking off and transforming can be performed as follows: 1. By the use of four single-phase transformers. 2. By the use of two two-phase transformers with magnetic return. 3. By the use of a four-phase transformer. The last arrangement, 3, is represented in Fig. 5. From a four-phase generator of the generating-station come the conductors *t* and *t'*, which serve simultaneously as the outgoing and return conductors for the superposed alternating current. *u* is the four-phase transformer, *v* is supposed to be a three-wire alternating-current circuit, and *w* represents a four-phase motor.

The secondary windings for taking off the main current may each by itself be star-connected, as shown in Fig. 5. They can as well all be connected in one four-phase star; but in this case the two windings of the four-phase motor, which are displaced ninety degrees, must not be so connected as to form a neutral point. We designate in what follows a such-like star as a double two-phase star wherewith to show that to form a proper four-phase current the two two-phase stars must remain unconnected either in the transformer or in the motors.

If in place of the two halves of a four-phase system two symmetrical three-phase systems which form together a symmetrical six-phase system are used as main system, then, similar to the foregoing, the taking off and transforming can be done as follows: 1. By the use of six single-phase transformers. 2. By the use of two three-phase transformers with magnetic return. Thus these must have at least four cores. 3. By the use of one six-phase transformer.

The method of transformation detailed for the secondary station is by means of simple inversion made available in the primary stations for the transforming and introduction of the superposed currents, and reversely. What before was secondary then becomes primary.

The described principle can of course be extended and include any number of systems superposed one above the other.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. In a system of electrical distribution for the simultaneous transmission of alternating currents of different character by the simultaneous transformation of alternating currents of different numbers of periods and phases, the method of winding the common conductors of the different currents on the transformer-cores so that the different currents generate independent magnetic fluxes superposed one above another which said fluxes again induce in the secondary windings independent currents of different character which currents can be transmitted farther.

2. In a system of electrical distribution for the simultaneous transmission of alternating

currents of different character, by the simultaneous transformation of a single-phase current and of an n-phase current, the method of winding the common primary and the common secondary windings on the cores of n single-phase transformers and connecting in star, whereby both superposed currents can be transmitted together.

3. In a system of electrical distribution for the simultaneous transmission of alternating currents of different character by the simultaneous transformation of a single-phase current and of an n-phase current, the method of winding the common primary and the common secondary windings on the n-iron core of an $(n+1)$-core n-phase transformer and connecting in star, whereby both the superposed currents can be transmitted together.

4. In a system of electrical distribution for the simultaneous transmission of alternating currents of different character by the simultaneous transformation and superposing or division of a single-phase current and of an n-phase current, the method of winding the common primary windings and the secondary windings for receiving the n-phase current on the cores of n single-phase transformers and connecting in star, and connecting in series the secondary windings of all transformers for receiving the superposed alternating current.

5. In a system of electrical distribution for the simultaneous transmission of alternating currents of different character by the simultaneous transformation and superposing or division of a single-phase current and of an n-phase current, the method of winding the common primary windings and the secondary windings for receiving of the n-phase current on n-iron core of an $(n+1)$-core n-phase transformer and connecting in star, and connecting in series the secondary windings of all cores for reception of the superposed alternating current.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

ENGELBERT ARNOLD.
OLE SIVERT BRAGSTAD.
JENS LASSEN LA COUR.

Witnesses:
FRANZ HASSLACHER,
MICHAEL VOLK.