C. LE G. FORTESCUE.

SYSTEM OF CURRENT RECTIFICATION.

APPLICATION FILED JUNE 21, 1912.

**1,158,474.**

Patented Nov. 2, 1915.

3 SHEETS—SHEET 1.

Fig. 1.

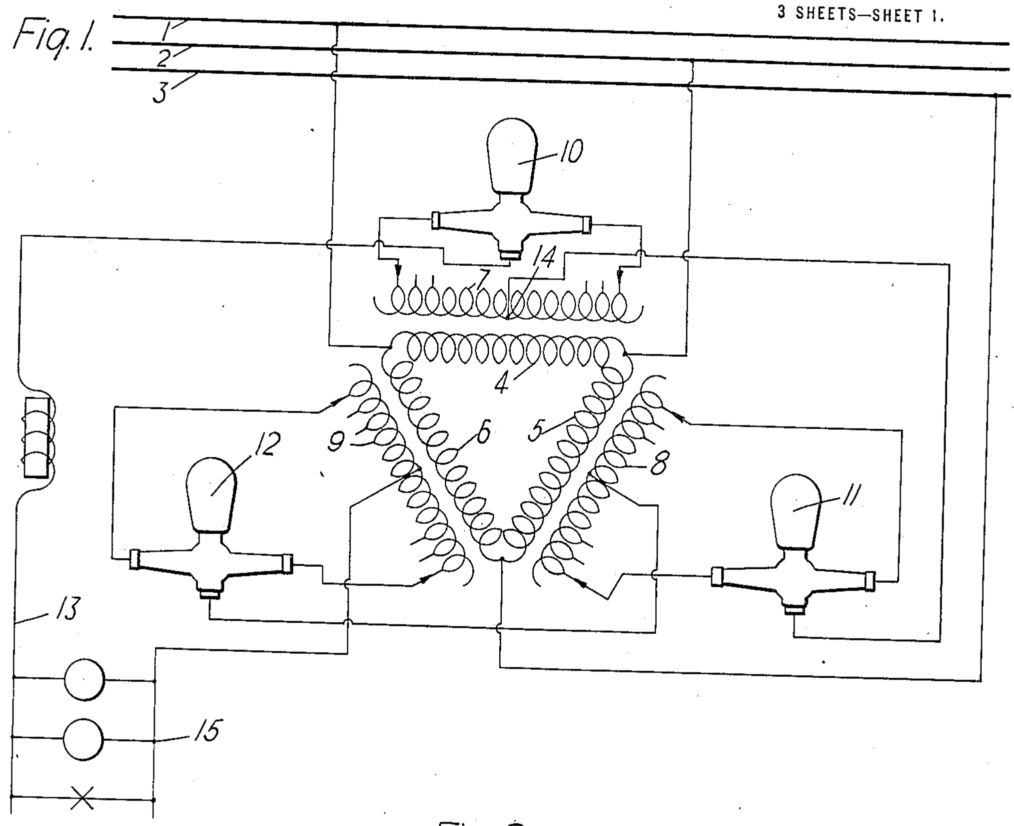
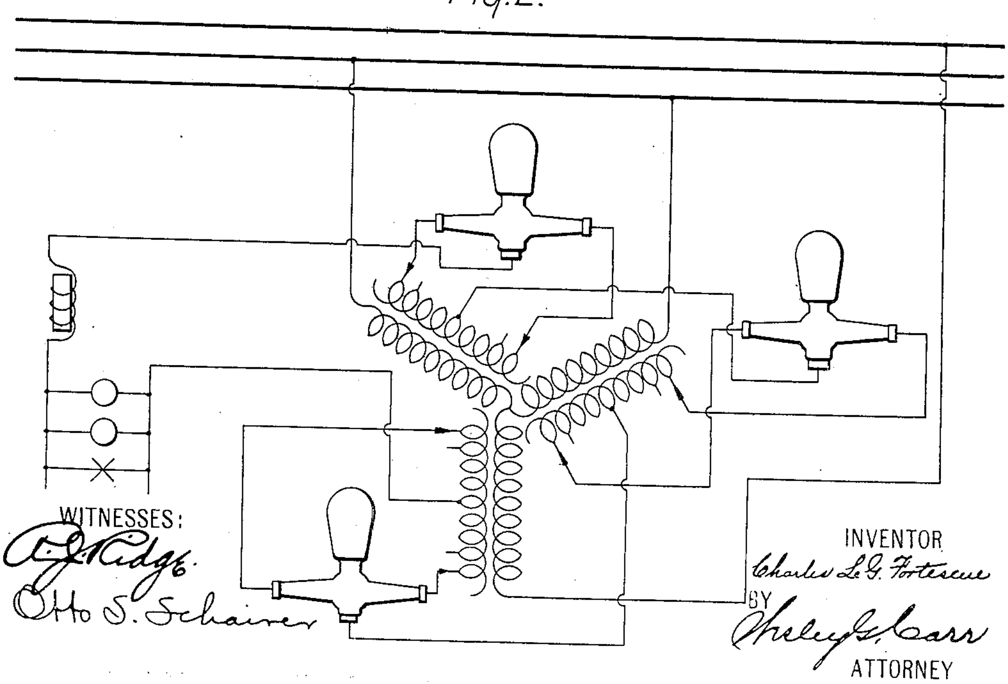



Fig. 2.



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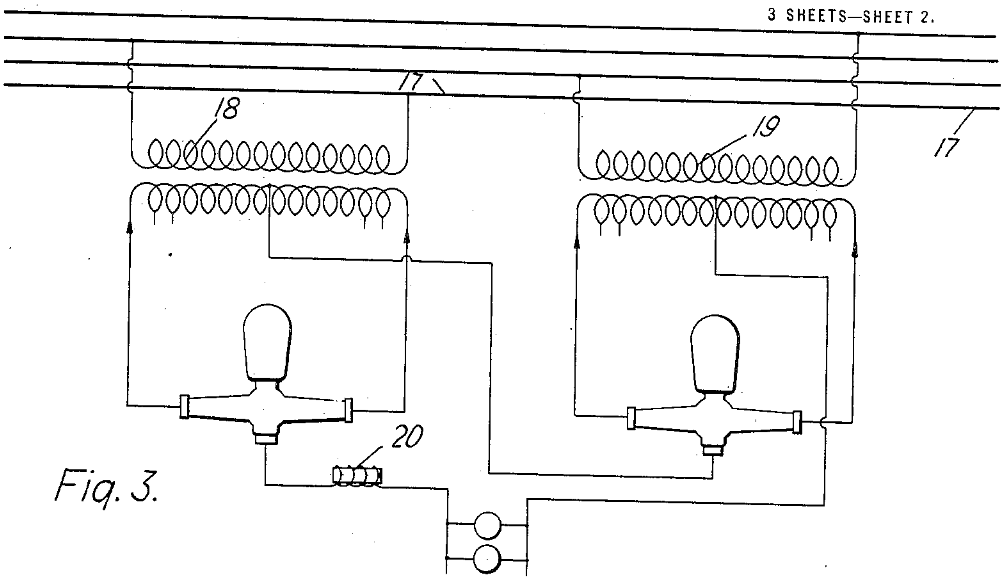


Fig. 3.

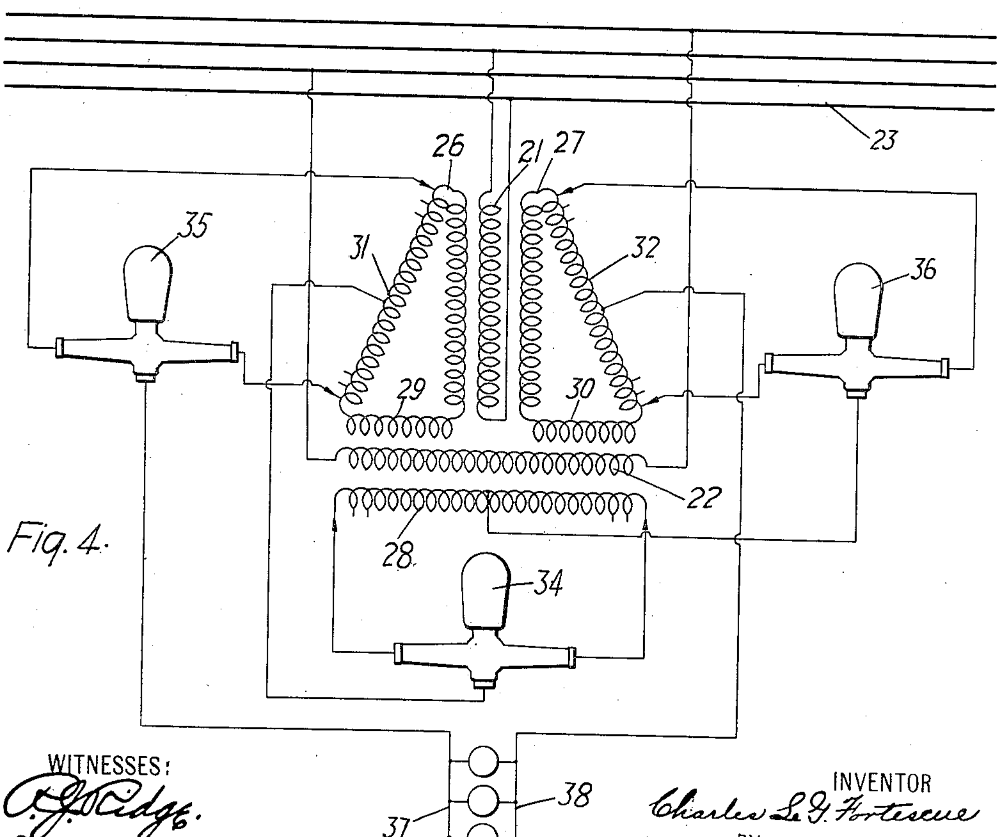


Fig. 4.

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3 SHEETS—SHEET 3.

Fig. 5.

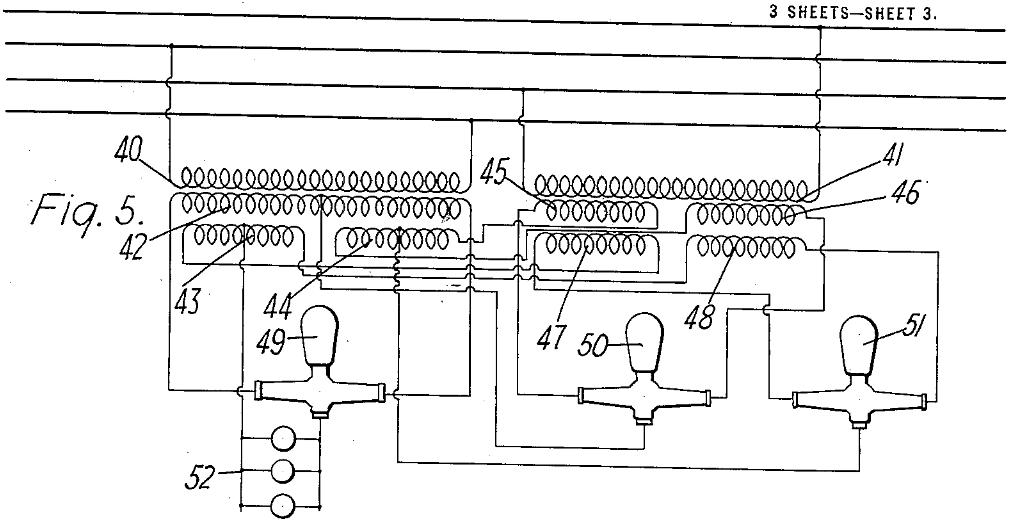
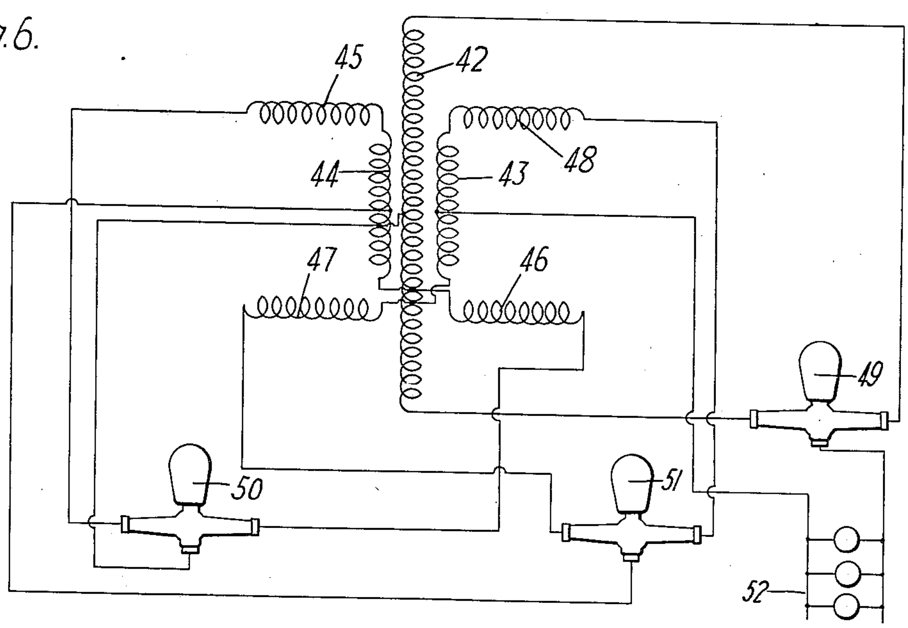



Fig. 6.

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## SYSTEM OF CURRENT RECTIFICATION.

**1,158,474.** Specification of Letters Patent. **Patented Nov. 2, 1915.**

Application filed June 21, 1912. Serial No. 705,017.

*To all whom it may concern:*

Be it known that I, CHARLES LE G. FORTESCUE, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Current Rectification, of which the following is a specification.

My invention relates to systems of electrical distribution, and particularly to systems in which vapor and similar current-rectifying devices are employed for transforming alternating into direct currents.

The object of my invention is to provide a polyphase system of distribution in which all of the phases of the current are rectified to produce a substantially non-fluctuating direct current, and in which there is no possibility of the occurrence or existence of local or circulating currents.

My invention is illustrated in the accompanying drawing, Figure 1 of which diagrammatically illustrates a system of distribution embodying the same. Figs. 2, 3, 4 and 5 are similar views of modifications of the system of Fig. 1, and Fig. 6 is a simplified diagram of a part of the system of Fig. 5.

The systems of Figs. 1 and 2 comprise a polyphase supply circuit 1—2—3 that supplies current to a plurality of transformer primary windings 4, 5 and 6, respectively, which may be the primary windings of several separate transformers or of a single polyphase transformer, as desired. In the system of Fig. 1, the transformer primary windings are connected in delta relation, and this will generally be found to be the preferable arrangement, though, if desired, they may be connected in star relation, as shown in Fig. 2, or they may be otherwise suitably arranged without departing from the spirit of the invention. Corresponding to the several primary windings are secondary windings 7, 8 and 9, respectively, and corresponding to the secondary windings are mercury-vapor or other suitable current-rectifying devices 10, 11 and 12, the anodes of which are respectively connected to terminals at or adjacent to the ends of the secondary windings. The cathode of the rectifier 10 is connected to one of the conductors 13 of a direct-current distributing circuit, from which power may be supplied to any suitable load, such as lights, motors, a railway system, etc. The neutral or another suitable intermediate point 14 of the secondary winding 7 is connected to the cathode of the rectifier, 11, and the corresponding intermediate point of the secondary winding 8 is connected to the cathode of the rectifier 12, while the corresponding intermediate point of the secondary winding 9 is connected to the other conductor 15 of the direct-current distributing circuit.

It will be observed that the transformer secondary windings are separate from each other to such degree that it is impossible for locally circulating currents to traverse them, which is the case in some systems heretofore provided by reason of the fact that two of the polyphase electromotive forces simultaneously have appreciable values of the same polarity. In the present system, the rectifiers are, in effect, connected in series relation, and the voltage of the direct-current circuit is, therefore, the sum of the unidirectional electromotive forces produced at the same time by the three rectifiers, which voltage will have a substantially uniform value, as distinguished from one which pulsates. By reason of the series connection of the rectifiers, each rectifier is independent of the others to such an extent that the drops of potential in them may vary freely without detrimentally affecting the operation of the system or causing the flow of local currents. As a consequence, the power factor and efficiency of operation of the system are both high.

The invention is not limited in its application to a 3-phase supply system but may also be employed in connection with a 2-phase supply circuit 17, as shown in Fig. 3, in which two transformers are employed having their primary windings 18 and 19, respectively connected to the differently phased pairs of conductors of the said circuit. The connections of the secondary windings of the said transformers are substantially the same as shown in Figs. 1 and 2, except that only two rectifiers are employed. The operation of the system of Fig. 3 is also substantially the same as those of Figs. 1 and 2, though the rectified current will fluctuate somewhat in value, and, for this reason, an impedance coil 20 is preferably employed in the direct-current distributing circuit.

It may often be desirable to obtain a substantially non-fluctuating rectified current from a 2-phase distributing circuit, and, to this end, suitable transforming means may be employed for changing 2-phase current into 3-phase current for application to three rectifiers, the said transformers being so arranged as to provide neutral or intermediate points which may be connected to the direct-current distributing circuit or to the cathodes of certain of the rectifiers. One such system is shown in Fig. 4 in which the primary windings 21 and 22 of two transformers are respectively connected to the differently phased pairs of conductors of a two-phase supply circuit 23. Each of the transformers is provided with a plurality of secondary windings, the windings 26 and 27 corresponding, respectively, to the primary winding 21 and the secondary windings 28, 29 and 30 corresponding, respectively, to the primary winding 22. The convolutions of the secondary windings 26 and 27 are 86.6% of the convolutions in the secondary winding 28, and the convolutions in the secondary windings 29 and 30 are 50% of the convolutions in the winding 28. Terminals of the secondary windings 26 and 29 are directly connected together and the remaining terminals are connected by means of an auto transformer 31. Similarly, terminals of the secondary windings 27 and 30 are directly connected together, and an auto transformer 32 is connected between the remaining terminals thereof. The anodes of a rectifier 34 are respectively connected to the terminals of a secondary winding 28, and the anodes of rectifiers 35 and 36 are respectively connected to the terminals of the auto transformers 31 and 32. The cathode of the rectifier 35 is connected to one conductor 37 of a direct-current distributing circuit, and the cathodes of the rectifiers 34 and 36 are respectively connected to intermediate points of the transformer windings 31 and 28, while an intermediate point of the transformer winding 32 is connected to the remaining conductor 38 of the direct-current distributing circuit.

It will be understood, from the arrangements of the connections shown, that 2-phase current received from the supply circuit 23 is changed to 3-phase current for application to the rectifiers, and that, according to the principles set forth in connection with Fig. 1, the three-phase currents are changed by the rectifiers to a substantially non-fluctuating or uniform direct current.

Another system in which 2-phase current is transformed to 3-phase current and supplied to three rectifiers is shown in Fig. 5, in which two transformers 40 and 41 are employed, the primary windings of which are respectively connected to the differently phased pairs of conductors of the supply circuit. The transformer 40 is provided with three secondary windings 42, 43 and 44, respectively, the windings 43 and 44 having approximately 50% of the convolutions of the winding 42, or being otherwise arranged to have voltages impressed upon them that are approximately half of the voltage impressed upon the winding 42. The transformer 41 is provided with four secondary windings 45, 46, 47 and 48, the convolutions of each of which are approximately 43% of the convolutions of the winding 42.

The terminals of the secondary winding 42 are respectively connected to the anodes of a rectifier 49, and an intermediate point of the said winding is connected to the cathode of another rectifier 50. The anodes of the rectifier 50 are respectively connected to terminals of the secondary windings 45 and 46 that are connected in series relation with each other and with the secondary winding 44, which is interposed between them. An intermediate point of the secondary winding 44 is connected to the cathode of a third rectifier 51, the anodes of which are respectively connected to terminals of the secondary windings 47 and 48 that are connected in series relation with each other and with the secondary winding 43, which is interposed between them. The winding 43 is connected in series with the windings 47 and 48 in inverse relation to the manner in which the winding 44 is connected in series with the windings 45 and 46. An intermediate point of the winding 43 is connected to one conductor 52 of a suitable direct-current distributing circuit and the other conductor of the said circuit is connected to the cathode of the rectifier 49.

A diagram showing only the connections of the secondary windings of the transformers to the rectifiers is shown in Fig. 6, the secondary windings being arranged to illustrate more clearly the relations of the electromotive forces which are applied to the rectifiers. It will be readily seen, particularly from the diagram of Fig. 6, that the electromotive forces applied to the rectifiers are disposed 120° apart, or bear the relations to each other of electromotive forces of a three-phase circuit. Consequently, the rectifier current will have a substantially uniform or non-fluctuating value, as in the systems of Figs. 1 and 2.

I claim as my invention:

1. A system of distribution comprising a polyphase supply circuit, transformers having primary windings associated, respectively, with conductors of different phases of said circuit, each of said transformers having a plurality of secondary windings, current rectifiers one of which has its anodes connected to the respective terminals of one of the said secondary windings and each of

the others of which has its anodes respectively connected to the terminals of different of the remaining secondary windings which are connected together in groups, a distributing circuit the conductors of which are respectively connected to the cathode of one rectifier and an intermediate point of a secondary winding that is not connected to the latter rectifier, and connections between the cathodes of the remaining rectifiers and intermediate points of the remaining secondary windings.

2. A system of distribution comprising a two-phase supply circuit, transformers having primary windings associated, respectively, with conductors of different phases of said circuit, one of said transformers having three secondary windings two of which have approximately one-half the convolutions of the other winding, and the other transformer having four secondary windings each having approximately 43% of the convolutions of the larger winding of the aforesaid transformer, the latter secondary windings being connected in series in pairs with the shorter windings of the former transformer respectively interposed between them, current rectifiers one of which has its anodes respectively connected to the terminals of the long transformer secondary winding and the others of which have their anodes respectively connected to the terminals of the two series sets of secondary windings, means connecting the rectifiers in series relation, and a distributing circuit supplied from the rectifiers.

In testimony whereof, I have hereunto subscribed my name this 18th day of June, 1912.

CHARLES LE G. FORTESCUE.

Witnesses:
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B. B. HINES.