H. M. HOBART & E. COAD.
ELECTRICAL DISTRIBUTION SYSTEM.
APPLICATION FILED JAN. 4, 1909.

925,102. Patented June 15, 1909.

2 SHEETS—SHEET 1.

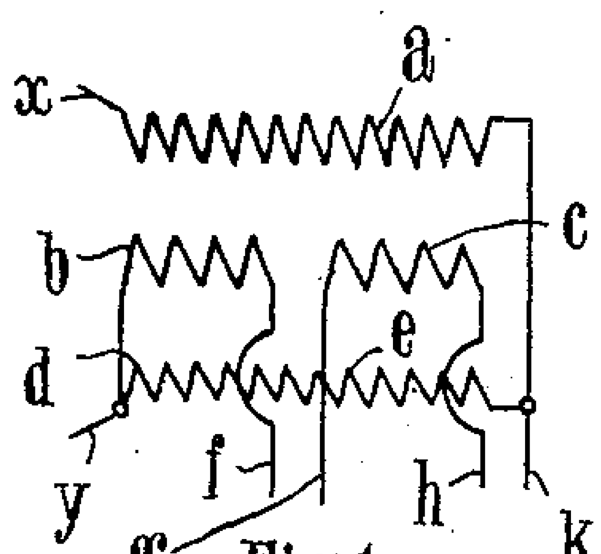

Fig.1

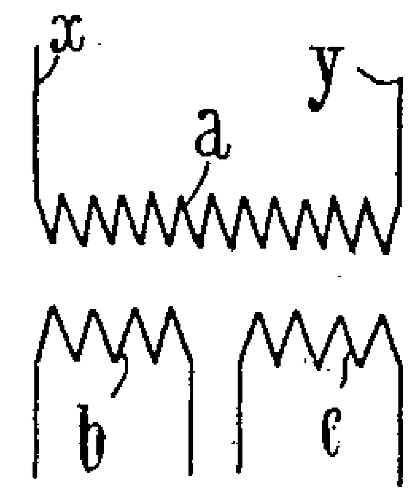

Fig.2

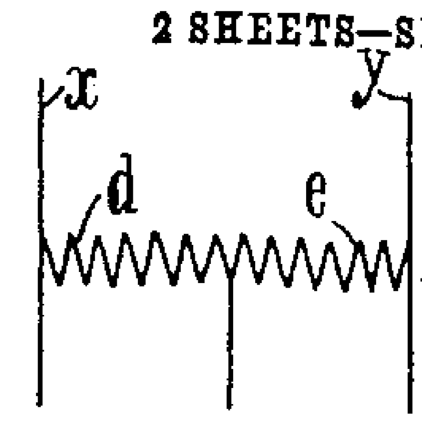

Fig.3

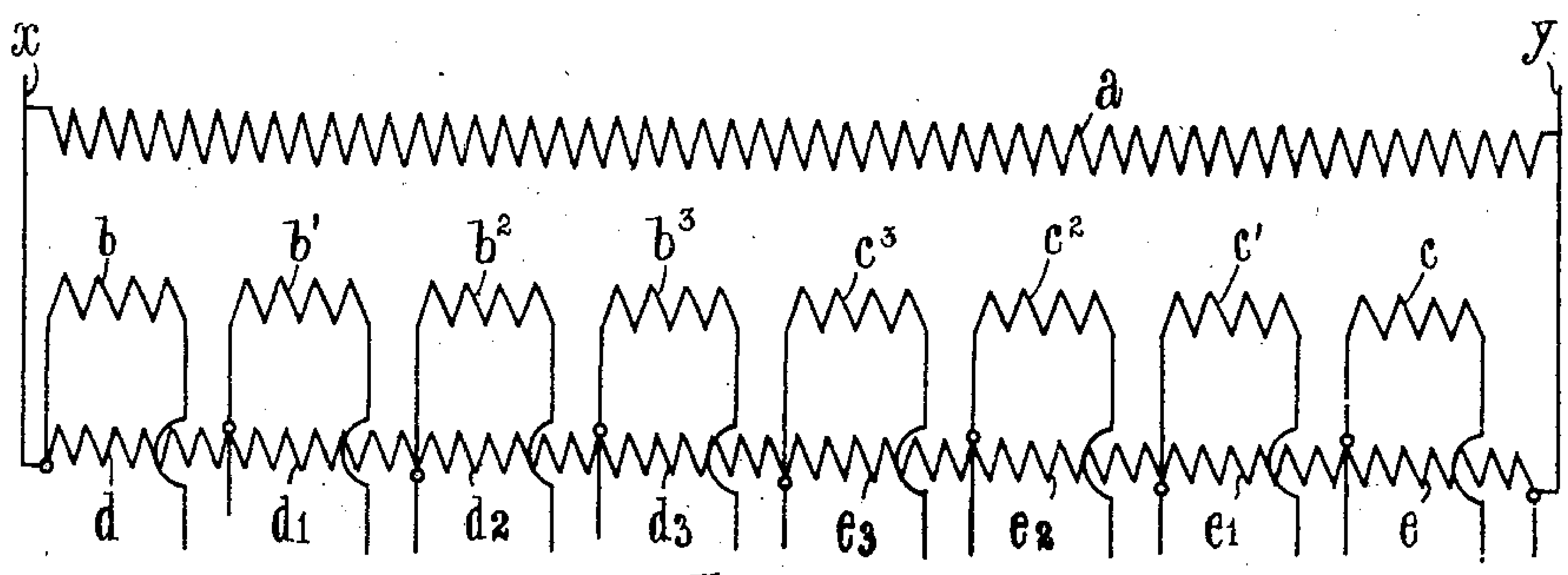

Fig.4

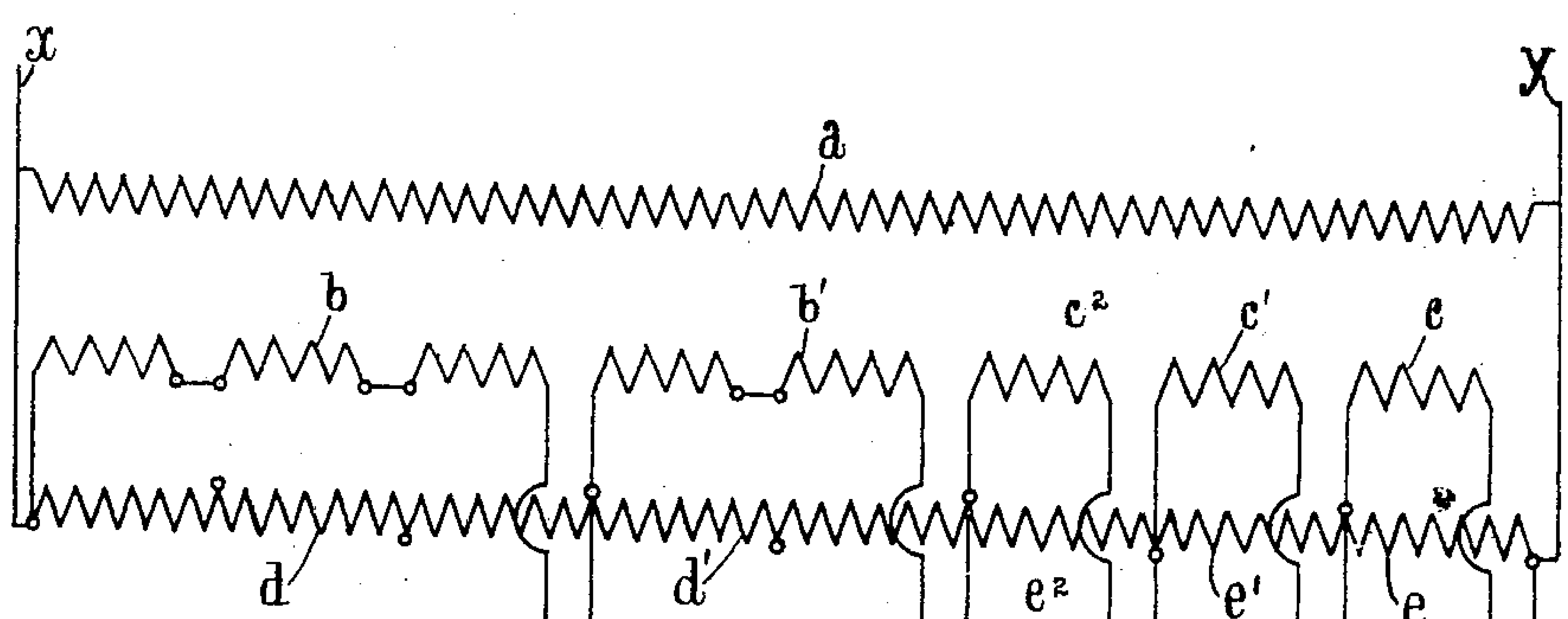

Fig.5

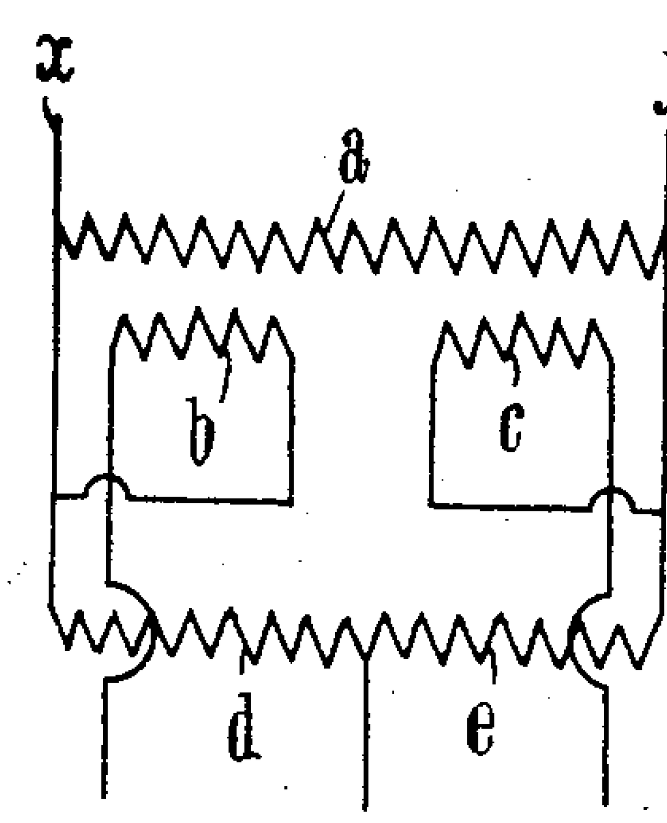

Fig.6

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2 SHEETS—SHEET 2.

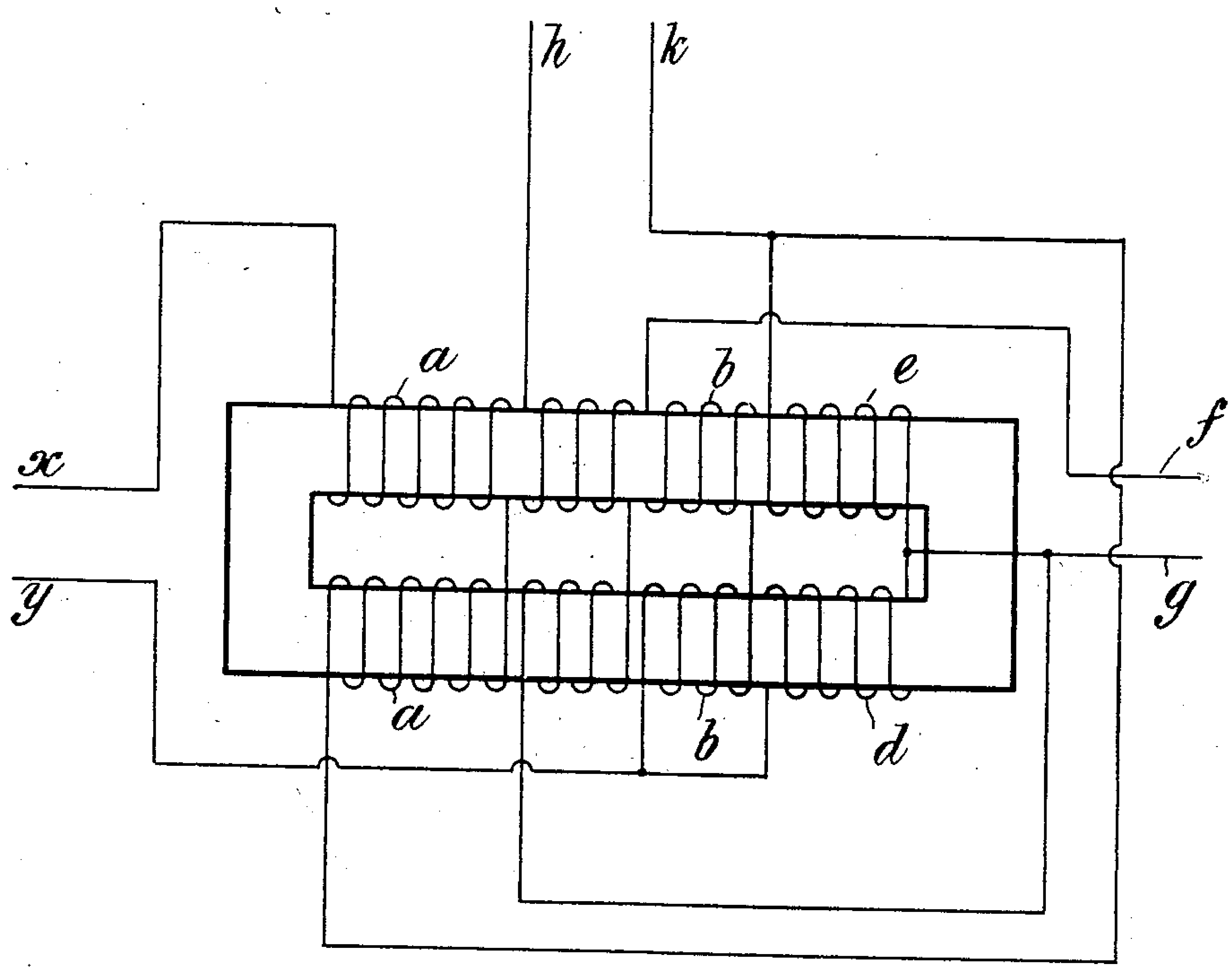

Fig: 7.

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UNITED STATES PATENT OFFICE.

HENRY METCALF HOBART, OF LONDON, ENGLAND, AND EVELYN COAD, OF BREMEN, GERMANY.

ELECTRICAL DISTRIBUTION SYSTEM.

No. 925,102. Specification of Letters Patent. Patented June 15, 1909.

Application filed January 4, 1909. Serial No. 470,701.

To all whom it may concern:

Be it known that we, HENRY METCALF HOBART, consulting engineer, a subject of the King of Great Britain, residing at 34 Norfolk street, Strand, London, England, and EVELYN COAD, electrical engineer, a subject of the King of Great Britain, residing at 43 Verdenerstrasse, Bremen, Germany, have invented new and useful Improvements in Electrical Distribution Systems Wherein Transformers are Employed, of which the following is a specification.

As is well known, if either a transformer or an auto-transformer (*i. e.* a compensator as it is sometimes called) is used to supply a number of subsidiary circuits from a single source, the voltage of each subsidiary circuit varies with changes in the load on the other subsidiary circuits.

It is the object of the present invention to provide a transforming device for supplying such subsidiary circuits which has not this defect, but which supplies each circuit at a voltage independent of the load on the other circuits. For this purpose a transformer and auto-transformer are used in conjunction, a fraction of the transformer secondary winding, (separated from the rest), being put in series with a corresponding fraction of the auto-transformer winding.

The invention is hereinafter explained in detail with reference to the accompanying drawings, in which—

Figure 1 shows a simple example of connection according to the invention. Figs. 2 and 3 illustrate the connections of a transformer and auto-transformer respectively. Figs. 4, 5 and 6 are other examples of connections according to the invention. Fig. 7 shows the arrangement of windings upon a core of ordinary form.

In Fig. 1 an arrangement is shown by which two subsidiary circuits are supplied at a voltage equal to one half that of the mains (x, y).

a represents the primary winding of an ordinary transformer, the secondary of which consists of two equal parts b and c, the sum of their turns being equal to the number of turns on the primary a. In series with the primary winding a, is the winding d, e of an auto-transformer. The two parts d, e are equal, and each is joined in series with one of the secondary windings b, c. Between the terminals f and g or h and k, there is then available an E. M. F. approximately equal to one half that of supply at the terminals x, y; and this E. M. F. between each pair of terminals, is independent of the load on the other pair. To show how this end is attained it is convenient to first consider separately the action of an ordinary transformer and that of an auto-transformer.

Fig. 2 illustrates an ordinary transformer, having a primary winding a and secondaries b and c; and for convenience the device may be considered as identical with the transformer part of Fig. 1 *i. e.* each secondary winding has one-half as many turns as the primary winding.

If the secondary winding b is loaded by a current I in an external circuit, the secondary c remaining on open circuit, a current $\frac{I}{2}$ will flow in the primary winding a; (for the sake of simplicity in this statement and hereinafter, the losses in the transformers are neglected.) As a result there will be a fall of potential on the secondary circuit b, made up of two components—a fall of $I\frac{R}{2}$ due to the resistance of the secondary, and one of $\frac{1}{2}\cdot\frac{I}{2}$ R, *i. e.* $\frac{1}{4}$ I R due to the resistance drop in the primary winding transformed to the secondary voltage, R being the resistance of the primary winding, and therefore $\frac{R}{2}$ the resistance of each secondary winding. In all, then, the fall of potential at the terminals of the winding b under the above conditions is $\frac{3}{4}$ I R.

Suppose now that the secondary c is also loaded with a current I; the current in the primary a will rise to I, and, while the fall of potential in the secondary b due to its own resistance remains the same, the transformed fall of potential (*i. e.* that at the secondary terminals) due to resistance of the primary winding a becomes $\frac{1}{2}$ I R. Consequently the total drop in the secondary b is now I R, an increase of $\frac{1}{4}$ I R or $33\frac{1}{3}\%$ on the drop when c was unloaded.

Consider next the auto-transformer d, e, illustrated by Fig. 3, which is identical with the auto-transformer part of Fig. 1, and assume the resistance of its winding to be R.

If the external circuit joined to one half, d is completed so as to carry a current I, there will be a current of $\frac{I}{2}$ in each part of the winding d, e. The fall of potential due to this external load will be $\frac{I}{2} \cdot \frac{R}{2} = \frac{1}{4} I R$. If, then, the part e is also loaded, the current in the auto-transformer winding will diminish, and will become zero when the two parts are loaded equally, *i. e.* when a load I has been put on e. Under these circumstances the voltage drop will be *nil*, a decrease of $\frac{1}{4}$ I R on the drop when e was unloaded.

It will be noted that the change in the voltage drop on the first circuit due to the loading of the second, in the case of a transformer, is equal and opposite to that in the case of the auto-transformer,—for the transformer the change is an increase of $\frac{1}{4}$ I R for the auto-transformer a decrease of $\frac{1}{4}$ I R. No further proof is required therefore to show that the voltage between the terminals f, g, of Fig. 1 will be unaltered by the change of load on the terminals h, k; for that voltage will be just as much diminished by the increase of resistance drop in the transformer primary a as it is increased by the diminution of resistance drop in the auto-transformer winding d. Naturally the voltage of each circuit is subject to variation with its own load, but this does not affect the argument above set out. The two circuits are not, however, entirely independent if they are of very dissimilar nature, *e. g.* if one is highly inductive and the other non-inductive.

When the principle of the invention is thus made clear, it becomes obvious at once, that a great many extensions and modifications may be made on the simple connections of Fig. 1. There may be more than two subsidiary circuits as Fig. 4 shows, where there are eight divisions in both the transformer secondary winding and the auto-transformer winding, each division of the one winding being put in series with a division of the other. In this figure the primary winding of the ordinary transformer is shown at a, the divisions of the secondary at b, b'— and c, c'—, while the divisions of the winding of the auto-transformer are lettered d, d'— and e, e'—, respectively. Moreover, as seen in Fig. 5, these divisions need not be equal, so long as each division of the transformer secondary corresponds in magnitude,—*i. e.* produces the same fraction of the total voltage of the winding—with the division of the auto-transformer winding to which it is joined. In this figure, as in Fig. 4, a is the primary winding of the ordinary transformer, b, b', and c, c', c^2 are the divisions of the secondary, and d, d' and e, e', e^2 the divisions of the winding of the auto-transformer. As shown, the divisions b, b', c, etc. and the divisions d, d', e, etc. are of different magnitudes, each section of the secondary winding, however, being joined to a section of the auto-transformer winding of corresponding magnitude. If this proportionality is not maintained, the voltage of one circuit will vary to some extent with the load on others; but even with a considerable departure from proportionality there is still some advantage in the combination of the two transformers, for the effect of one circuit on another is still less than it would be with a transformer or auto-transformer alone. A single source of power may thus be used to supply subsidiary circuits at several different voltages, each independent of the loading of the other circuits; and as the transformer employed need not be a 1:1 transformer (considered as a whole), but may have any desired ratio between the numbers of turns in its primary and secondary windings, the voltage of a subsidiary circuit is not limited by the voltage of supply, nor governed by the number of other circuits to be supplied from the same source. It is also not necessary that the whole of the auto-transformer winding should be employed; for example, if the voltage required for the subsidiary circuits were less than that given by the arrangement of Fig. 4, all the divisions d, d'— e, e' . . . might be confined within a half or a third of the whole winding. Figs. 4 and 5 further show that the transformer primary a, and the auto-transformer winding d, d', d^2— e, e', e^2 . . . may be connected in parallel instead of in series as in Fig. 1.

Where it is desired to combine two subsidiary circuits into a 3-wire system the connections illustrated in Fig. 6 may be used, according to which two of the terminals of the secondary winding b, c of the transformer are joined to the respective ends of the auto-transformer winding d, e while the three supply wires are connected respectively to the mid-point of the auto-transformer winding, and the remaining ends of the transformer secondary. Care must be taken, of course, to so connect the windings that the transformers are not in opposition. Similar combinations may be made, where there are more subsidiary circuits, for 5-wire systems and so forth. With these connections also, the auto-transformer and the transformer primary may be either in series or in parallel.

As to the practical construction of the apparatus this need not differ from the forms of transformer and auto-transformer already in use. It is advantageous to combine the windings of both transformers on a single core, as this reduces the reactance voltage and therefore improves the regulation on inductive loads. Sections of the auto-transformer winding may conveniently be interspersed among sections of the transformer secondary; and if for any particular case, the heavily loaded sections of the windings are arranged next to those more lightly loaded, a better general cooling effect is obtained. Such an arrangement of interspersed windings upon the core is illustrated in Fig. 7, the connections of which correspond with those shown in Fig. 1.

It is unnecessary to deal in detail with the various purposes which this device in one or other of its modifications may be made to serve. It is applicable in any case where branch circuits are required at constant potential and its utility is easily seen in such a case, for example, as the supply circuits of low potential lamps such as are now coming largely into use.

What we claim is:

1. In a transforming device for alternating current supply, the combination of a transformer having a divided secondary, and an auto-transformer having tappings, and connections between said auto-transformer and transformer secondary by which a section of the one is put in series with a section of the other.

2. In a transforming device for alternating current supply, the combination of a transformer having a divided secondary, an auto-transformer having tappings and connections between said auto - transformer and transformer secondary by which each section of the one is put in series with a section of the other.

3. In a transforming device for alternating current supply, the combination of a transformer having two secondary windings, an auto-transformer having an intermediate tapping, and connections between the terminals of the transformer secondaries and of the auto-transformer, whereby the intermediate terminal of the auto-transformer and two terminals of the transformer secondaries are made the sources of the two supply circuits for a three-wire system.

4. In a transforming device for alternating current supply, the combination of a core, separate windings upon said core forming the primary and a plurality of secondary windings of a transformer, a further winding upon said core having tappings, and connections between the tappings and the secondary windings whereby each of these latter is put in series with a section of the further winding.

5. In a transforming device for alternating current supply, the combination of a core, separate windings upon said core forming the primary and a plurality of secondary windings of a transformer, a further winding upon said core having tappings all of said windings being interspersed, and connections between the tappings and the secondary windings whereby each of these latter is put in series with a section of the further winding.

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

HENRY METCALF HOBART.
EVELYN COAD.

Witnesses to the signature of Henry M. Hobart:
LEONARD E. HAYNES,
GEORGE HUGHES.

Witnesses to the signature of Evelyn Coad:
SIGURD OLSEN,
EDUARD REEB.