W. C. WOODLAND.

SYSTEM OF ELECTRICAL SUPPLY.

APPLICATION FILED DEC. 6, 1911.

1,049,962. Patented Jan. 7, 1913.

Fig. 1.

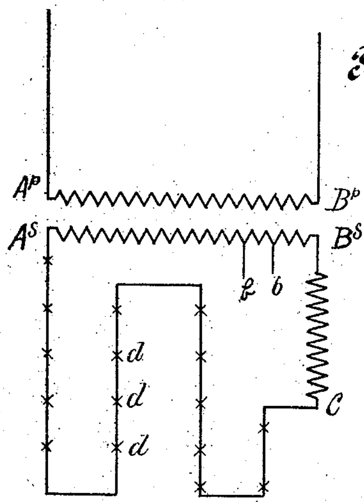


Fig. 2.

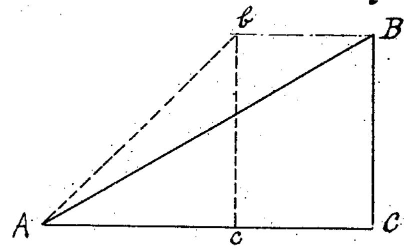


Fig. 3.

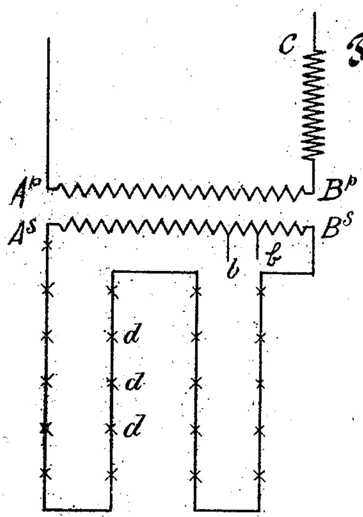


Fig. 4.

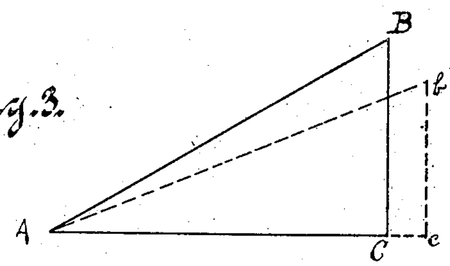


Fig. 5.

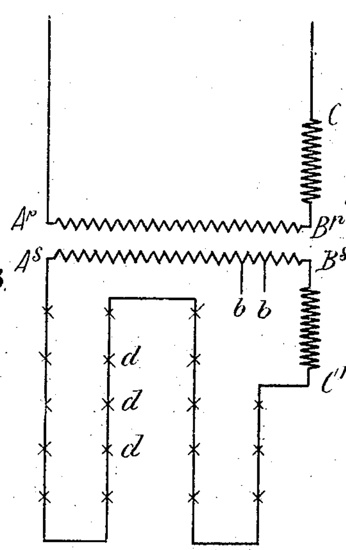
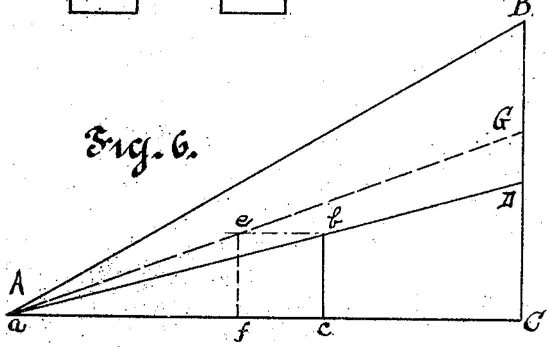


Fig. 6.



WITNESSES

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SYSTEM OF ELECTRICAL SUPPLY.

1,049,962. Specification of Letters Patent. Patented Jan. 7, 1913.

Application filed December 6, 1911. Serial No. 664,196.

To all whom it may concern:

Be it known that I, WILLIAM C. WOODLAND, a citizen of the United States, and a resident of Warren, in the county of Trumbull and State of Ohio, have invented a new and Improved System of Electrical Supply, of which the following is a full, clear, and exact description.

My invention relates generally to a system of electrical supply and more particularly it involves a new and improved series lighting system.

The principal object of my invention is to provide a series lighting circuit which is inductively controlled, the system being arranged so that the load may be altered, the power factor remaining substantially constant.

A further object of the invention is to provide a new and improved series lighting system which is inductively controlled through the medium of a suitable transformer, together with reactances in the primary and secondary of the said transformer circuits.

Other objects and advantages of the invention will appear as the description thereof proceeds, the novel features being particularly pointed out and included in the appended claims.

In the accompanying sheet of drawings I have set forth diagrammatically in several views proposed systems or circuits for accomplishing the purpose of the invention.

Figure 1 is a diagrammatic arrangement of a series lighting circuit comprising any suitable number of lamps, together with a transformer having taps on the secondary thereof, the secondary circuit being also provided with a suitable inductance coil; Fig. 2 is a vector diagram illustrating the amount and relation of the electro-motive forces at different loads; Fig. 3 is a diagrammatic arrangement similar in purpose to the system shown in Fig. 1, the inductance, however, being placed in the primary circuit; Fig. 4 is a vector diagram illustrating the amount and relation of the electromotive forces at different loads; Fig. 5 is a diagrammatic arrangement of the lighting circuit of the new and improved lighting system having inductances of suitable values in the primary and secondary circuits of the transformer; Fig. 6 is a vector diagram showing the relation and amounts of the electro-motive forces of the system represented in Fig. 5 at different loads.

In series lighting circuits of the character herein described and illustrated, the purpose aimed at is constancy of current; systems now in use are at fault in that they do not permit of the use of the partial load taps on the transformer without altering the power factor unless the amount of inductance in the line is changed at the time the circuit is changed to these partial load taps.

Referring particularly to Figs. 1 and 2, A^pB^p represents the primary circuit of a suitable transformer, A^sB^s the secondary circuit of the transformer, while *b* designates taps, suitable in number, led from certain turns of the secondary; B^sC designates a suitable inductance in the secondary circuit, together with any number of lamps *d*. In representing the amounts and relations of the electro-motive forces (Fig. 2) AC indicates the working voltage applied to the lamps; BC indicates the voltage across the inductance coil, this voltage being in quadrature with the secondary voltage; completing the triangle AB indicates the square root of the sum of the squares of the two previous voltages or the applied voltage which is the amount the secondary of the transformer must furnish in order to overcome the impedance of the circuit made up of the resistance of the line AC and the inductance of the coil BC. If the lighting circuit is now changed to a lower tap *b* on the secondary of the transformer in order to supply a lesser number of lamps, it is apparent that, since the voltage BC remains constant, the working voltage AC will be altered by a larger percentage than the transformer voltage AB; the new working voltage is represented by A*c* while the voltage across the inductance is *bc*, equal in value to BC, A*b* now indicating the voltage which the secondary of the transformer must furnish in order to meet the new conditions. The angle BAC increases to *b*AC, such increase indicating a decrease in the power factor. The power factor may be corrected, however, by reducing the coil voltage BC but this is objectionable inasmuch as every time the number of lamps is varied the coil must be changed.

Inserting the regulating coil in the primary circuit, as shown in Fig. 3, when moving the lighting circuit to any of the taps *b* will have an opposite effect to such movement described in connection with Figs. 1 and 2, that is, the power factor will increase instead of decrease. Referring particularly to Figs. 3 and 4, AC indicates the primary voltage of the transformer, BC the voltage across the inductance in series with the primary and hence the voltage in quadrature therewith, while AB represents the applied voltage. If the secondary circuit is moved to lower taps, such movement will increase the ratio of the transformer, or, in other words, the primary current will decrease, such decrease being followed by a decrease in the voltage across the inductance to an amount indicated at *bc;* when this smaller quadrature voltage *bc* is combined with the original applied voltage AB the angle BAC will decrease to *b*A*c*, thereby indicating an increased power factor.

From all of the above it is seen that by placing the inductive regulating coil in the secondary the power factor will decrease, and by placing the inductive regulating coil in the primary the power factor will increase, when the circuit is moved to lower taps on the secondary; I have discovered, however, that there is a point at which the inductive regulating coil may be divided, part of the coil being placed in the primary of the transformer and part of it in the secondary so that the power factor will remain substantially constant even though the ratio of the transformer is changed by moving the lighting circuit to lower taps.

Referring particularly to Figs. 5 and 6, A^pB^p indicates the primary of a suitable transformer; an inductive regulating coil B^pC is in series therewith; A^sB^s indicates the secondary of the transformer, the regulating coil B^sC' being in series therewith, together with a desired number of lamps *d;* *b* indicates some partial load taps on the secondary winding. In the vector diagram of Fig. 6 the triangle of electro-motive forces there represented is such that the angle at A is correct for a power factor of 80%; in this diagram transformation is represented by changes in the size of the triangle, it being noted that for any given power factor the angles of the triangle will remain constant for any size transformer, the length of the lines varying, however, with the size of the transformer. *ac* represents the working voltage applied to the lamps *d; cb* is the voltage in quadrature with the working voltage *ac* which is supplied by the inductance B^sC' which is in series with the secondary circuit. *ab* is the square root of the sum of the squares of these two voltages and is the voltage supplied by the secondary of the transformer. AD represents the primary voltage of the transformer and has a ratio to the secondary voltage *ab* equal to the ratio of transformation; BD is the voltage supplied by the inductance B^pC in series with the primary winding; AB represents the supply voltage of the entire system. Suppose the secondary is provided with the taps *b* in order to supply 70% of the full load voltage, it is evident that, since the voltage of the regulating coil in the secondary circuit *bc* will be a constant quantity, it will be represented under the new conditions by *ef*, *e* indicating the point of connection of the secondary winding. Transformation will now be represented by projecting the line A*e* to a length represented by the ratio of transformation, namely, to the point G, it being seen that the angle DAC has increased to the angle GAC, the primary current, however, being reduced by the change in the ratio of transformation so that while the primary inductance was formerly represented by BD it is now represented by BG, that is, it has been reduced in the same proportion as the ratio of transformation has been increased; the point B remains unchanged, that is, the angle BAC has remained constant, which indicates that the power factor has remained constant.

It is to be noted that the description of Figs. 5 and 6 is not true of any triangle whatever but only true when it is desired to keep the power factor at a certain value, say at 80% for a 70% tap on the transformer, that is, when the point D divides the line BC into two such parts that BD is 50% greater than DC. Therefore it is evident that under the facts existing, when considering the description of these figures, that to attain the result specified, the primary regulator must be 50% greater than the secondary regulator; in case it is desired to hold the power factor constant at some other percentage, the conditions are necessarily changed, the inventive idea illustrated in the system, however, remaining the same. After a careful examination of the lighting system herein-described I have learned that when the quantities are so chosen that the power factor is constant at 100% load and 70% of the full load capacity of the transformer, that the power factor will vary by a slight fraction of 1% when the transformer is tapped at other points for different percentage loads. The variation from the constant value of the power factor, however, is so small that measuring instruments fail to indicate it, the power factor being substantially constant, thereby adapting the system to efficient service under everyday conditions.

Having thus described my invention, I claim as new, and desire to secure by Letters Patent:—

1. The combination of a transformer, the primary circuit of which is inductively-controlled, the secondary circuit of which is

also inductively-controlled and provided with partial load taps, with a number of translating devices in series with the said secondary circuit.

2. A series lighting system comprising a transformer, each circuit of the transformer being inductively-controlled through the medium of reactances, the value of the reactances bearing a determined relation with respect to each other, together with a number of translating devices in series with the secondary winding.

3. A lighting system comprising in combination a transformer, the secondary winding being provided with partial load taps, a primary reactance, a secondary reactance, the secondary reactance being in series with a number of translating devices, the said secondary reactance being of such value that when partial load taps are used the power factor of the circuit will remain substantially constant.

4. The combination of a transformer having a reactance in the primary winding, a reactance in series with the secondary winding, and translating devices in series with the secondary reactance, the secondary winding being provided with partial load taps, the inductive effect of the said secondary reactance being such that, when the secondary circuit is led from one of the said taps, varying the number of translating devices will leave the power factor substantially constant.

5. The combination of a transformer provided with reactance coils in the primary and secondary circuits, and translating devices in series in the latter circuit.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

WILLIAM C. WOODLAND.

Witnesses:
L. A. MARTIN,
R. H. SNYDER.