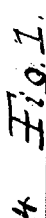


Patented Apr. 30, 1912.

2 SHEETS--SHEET 1.



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1,024,793.

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2 SHEETS-SHEET 2.

Fig. 2.

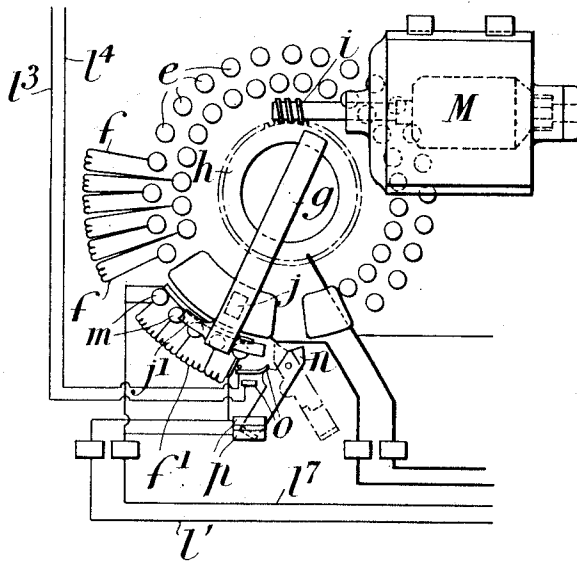
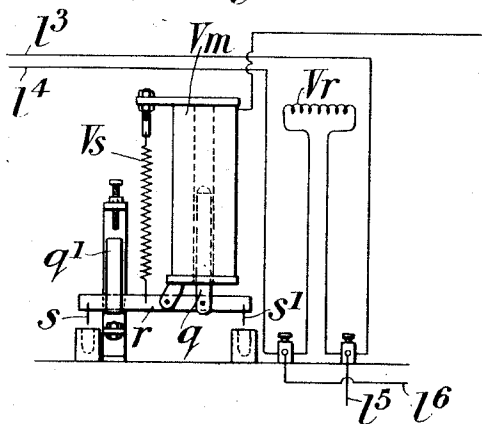


Fig. 3.



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UNITED STATES PATENT OFFICE.

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MEANS FOR REGULATING ELECTRIC CIRCUITS.

1,024,793.

Specification of Letters Patent.

Patented Apr. 30, 1912.

Application filed January 5, 1905. Serial No. 239,791.

To all whom it may concern:

Be it known that we, HENRY LEITNER, residing at Maybury, Woking, and RICHARD NORMAN LUCAS, residing at Lynton, Dartnell Park, Byfleet, both in the county of Surrey, England, subjects of the King of Great Britain, have invented new and useful Improvements in Means for Regulating Electric Circuits, of which the following is a specification.

Our invention relates to certain improvements in electric lighting systems of the class employed on railway trains in which a dynamo conveniently actuated is employed to charge a battery of accumulators, the two together providing current for the electric lamps mounted in the vehicles. In such systems there is a considerable difference in the voltage or E. M. F. of the battery when it is fully charged and particularly when it is being still charged by the dynamo and the voltage of the same when it has been providing the current for the lamps for some length of time. As these conditions occur successively in practice, the lamps are under such circumstances subjected to considerable variations of voltage which produces unsatisfactory effects in the illumination of the carriages and is also prejudicial to the life of the lamps. It is also advisable in such systems that means should be provided for preventing the dynamo continuing to charge the accumulators when they are already fully charged, as this both wastes current and consequently energy and tends to injure the cells.

The object of our invention is to regulate the lighting circuit so as to prevent the variations in voltage of the battery of accumulators under the circumstances above described causing noticeable variations of current and illumination in the lamps, and to put the dynamo out of action when the battery of accumulators is fully charged and so prevent waste of energy and the injury which continuous overcharging of the cells is likely to cause. In addition we provide means whereby the dynamo is gradually brought into action when the voltage of the battery of accumulators sinks to some predetermined value in consequence of having supplied current to the lamps while the dynamo is out of action.

According to our invention we employ a variable rheostat of any convenient type,

but preferably one in which the contacts are arranged circularly, the resistance of this rheostat being designed to be introduced to a greater or less extent in series with the lamps according as the voltage of the battery of accumulators and the current to the lamps vary. On this rheostat is mounted a revolving arm carrying a brush adapted to sweep over and make contact with the various contacts of the rheostat and actuated preferably through worm or equivalent gearing by a suitable motor energized from the lighting circuit. At one position this arm and brush are so arranged that none of the rheostat resistance is in series with the lamps, while at the other end of its travel the whole of this resistance is in series with them. Consequently it is necessary, as far as the lighting circuit is concerned, that the amount of resistance introduced in series with the lamps should correspond with the voltage of the battery and the number of lamps turned on. We effect this by means of a volt meter control arranged in parallel with the lamps. For which purpose we may employ any suitable volt-meter adapted to make suitable contacts, but we prefer to employ a solenoid attracting a core which is arranged to operate a pivoted horizontal bar against the action of a spring. This pivoted bar carries at either end contacts which make circuits through the motor operating the rheostat in such a way that when one of these contacts is made the motor rotates in one direction and when the other contact is made it rotates in the opposite direction, this effect being produced either directly, in which case the field of the motor is preferably reversed by the contacts made, or the result may be attained through the intermediary of suitable relays. It will be understood that the contacts made by the so-called "volt-meter control" are such that when the voltage of the battery rises beyond a certain predetermined amount the motor is operated to actuate the arm of the rheostat so as to increase the amount of resistance in series with the lamps. On the other hand when the voltage sinks below that predetermined amount, the motor is revolved in the opposite direction and removes resistance from the lamp circuit. As the "volt-meter control" is in parallel with the lamps and in series with the rheostat resistance it

operates the apparatus to make the necessary adjustments when a larger or smaller number of lamps are turned on.

In the arrangement described it is obvious that the motor which operates the rheostat would continue to receive current when the rheostat arm was at either end of its course or travel. In order to avoid this we arrange suitable contacts in these positions in series with the motor so as to break the motor circuit when the arm of the rheostat is in either of its extreme positions.

The essential features of our invention, however, are concerned with means whereby we can utilize what is practically the same mechanism (namely that above described) employed for regulating the light circuit, and which in itself is similar to other forms of apparatus previously proposed or in present use, for the purpose of effecting the further objects which we have in view, namely, to throw the dynamo out of action when the battery of accumulators is fully charged and to re-introduce it and cause it automatically to again generate current and charge the cells when the voltage of the latter has through supplying current to the lamps or from any other cause sunk to a predetermined value. To effect this object we arrange a resistance in series with the windings of the apparatus which we have above alluded to as the "volt-meter control." When this resistance is in series with the said "volt-meter control" it causes it to operate on a different scale. This will be most clearly understood from an example. Supposing that the "volt-meter control" when the above mentioned resistance is not in series with it, is adjusted to, say, 24 volts as the normal, that is to say, with both its contacts broken. Then it will make one of its contacts for operating the motor in one direction when the voltage rises to, say, 25, while it will make the other contact when the voltage sinks to, say, 23. When now the before mentioned resistance is placed in series with it, it will have the effect, say, of altering the action so that 30 volts becomes the normal and it only then makes the one contact when the voltage rises to, say, 31, and the other contact (reversing the motor) when it sinks to, say, 29.

In connection with the rheostat mechanism is arranged a switch preferably of the trigger type. This switch is arranged to be operated by the moving arm of the rheostat and brought into one position when that arm is in such a position that it cuts out all the resistance from the lamp circuit while the same switch is thrown into another position when the rheostat arm is at the opposite end of its travel, that is to say, in the position in which all the resistance of the rheostat is arranged to be in series with the lamps. In the first of these positions the

said switch makes one contact and breaks another contact. In the second position it breaks the contact which it has previously made and closes or allows to close the other contact which it has previously broken. The first of these contacts is in series with the shunt winding of the dynamo. The second is in parallel with the resistance designed to be placed in series with the "volt meter control." When the former contact is broken therefore or bridged by a high resistance (as we prefer to arrange) the dynamo is thrown either entirely out of action or very nearly so. When the second contact is closed the resistance in series with the "volt meter control" is short circuited. This said resistance is also short circuited when either of the main lamp switches are closed.

In order that our invention may be the more fully understood, we refer to the accompanying two sheets of drawings in which,

Figure 1 shows diagrammatically the elements of our invention applied to a system of lighting in which a differential main generator is arranged in conjunction with a subsidiary controlling dynamo which latter weakens the field of the former as the speed of driving increases, the main generator being automatically connected to and disconnected from a battery of accumulators by an automatic switch. Figs. 2 and 3 are detailed views of parts of the mechanism shown diagrammatically in Fig. 1.

In the figures the same letters of reference are used to designate corresponding parts, but as there are parts which it is necessary to refer to in Figs. 2 and 3 not shown in Fig. 1 these extra parts are indicated by additional letters of reference.

In the drawings:—G is the armature of the main generator, S^s the shunt field winding of the same.

M^s is the series differential winding on the field of the generator.

D is the armature of the demagnetizing or controlling subsidiary dynamo, preferably mounted on the same shaft as G.

S^d is the shunt field winding of the controlling dynamo. M^d its series field winding.

R¹ and R^h are regulating resistances the former of positive temperature co-efficient and the latter of negative temperature co-efficient, arranged in the system in the manner shown. A^{s1}, A^{s2} and A^{s3} are the fine wire field windings, the armature field winding and the coarse wire field winding respectively of an automatic switch similar to that shown in our Patent No. 728,942, May 26, 1903 for connecting the battery of accumulators b with the main generator G and having an oscillating armature. A¹ is the horizontal lever arm of the said automatic switch which is connected by a link

with the oscillating armature and makes the three contacts A^{c2} , A^{c3} and A^{c4} in the trough containing mercury arranged beneath them which have the effect of connecting the various windings of the main generator G and the controlling dynamo D with the battery of accumulators b . On starting the generator the current from one pole of the armature G will pass through the differential winding M^s of the field of the generator, thence outward by line L' . At the point q^x the current will divide, a part passing by the line L' to the contacts $p p$ thence by L' to the shunt winding of the generator, thence through resistance R^1 to the other pole of the armature.

A^{c1} is a contact made in a mercury trough situated beneath it when the lever A^1 is in its off position, this contact having the effect of short circuiting the resistance R^1 when the generator G is at rest and until it has excited. This takes the current passing through the shunt winding of the generator field from a point between said winding and the resistance R^1 by wires L^8 , L^9 and L^{10} to the contact A^{c1} thence by line L^{11} , 3, 4 L^2 to the armature. At the same time, a portion of the current passing the point q^x passes by the wire 7, thence by the fine wire field and armature winding of the automatic switch, thence to 3, 4 and L^2 to the generator armature, thus actuating the switch and closing the contacts A^{c2} , A^{c3} and A^{c4} . When the contacts A^{c2} , A^{c3} , A^{c4} contact with the mercury in the trough beneath them the main current passes by L' , wires 7, 8 and 9 through the coarse field winding A^{s3} of the automatic switch, thence by contact A^{c3} mercury trough, wires 10, 11 and 12 which then form a continuation of L' to the battery b . The passage of the main current through the coarse winding of the field winding of the automatic switch intensifies the action of the switch and insures the holding of the switch arm in position to maintain the circuits closed at the contacts A^{c2} , A^{c3} and A^{c4} during the operation of the generator. At the point k a connection L^3 leads to the resistance coils of the rheostat and line L^4 leads from the rheostat to the hand switches $d d'$ by which current can be supplied to the lamps $c c'$.

$e e$ (details in Fig. 2) are the contacts of a circular rheostat which are connected by suitable resistance wire f designed to be introduced into and regulate the circuit of the lamps $c c'$.

g is the arm of the rheostat pivoted as shown and rigid with a worm wheel or disk h which engages with the worm i on the shaft of a motor M which is preferably provided with current from the accumulator circuit. The arm g is provided with two brushes j and j' , the former of which is designed to establish contact with the con-

tacts $e e$ as it passes over them while j' is similarly adapted to make contact with the contacts $m m$ connected in series with one another by resistance wire f' similar to but finer in gage than that shown at f .

n is a trigger switch pivoted near its upper end controlled by a spring and provided with a cam like projection which in the position shown in the drawing opens the contact $o o$ connecting the leads L^3 , L^4 , while the lower end of the switch n bridges or unites the contacts $p p$, which likewise connect the leads L' and L'' . The trigger switch n is adapted to be thrown into the dotted line position by the extreme end of the rotating arm g when the latter sweeps around to the opposite end of the crown of rheostat contacts $e e$. In this dotted line position, as will be seen, the contacts $o o$ are bridged or come together while contacts $p p$ are broken and consequently bridged by the resistance wire f' which connects the contacts $m m$ as shown in Fig. 2.

V^m is the upright solenoid of the device which we have above termed the volt meter control (details in Fig. 3). This solenoid is adapted to lift the iron core q which is pivoted to the pivoted horizontal bar or rod r . This rod is controlled by the adjustable spring V^s while the bar r is provided with an upright counterpoise q' , its travel being limited by suitable adjustable vertical stops. The bar r carries at its ends two vertical rods or wires s and s' adapted to dip into and make contact with the mercury contained in the cups situated immediately beneath them.

V^r is the resistance which is introduced in series with the solenoid of the volt-meter control V^m as indicated above.

The contacts s and s' and their corresponding mercury cups are so arranged in the circuit and in regard to the motor M by connections indicated schematically in Fig. 1, that when s makes contact the motor M is caused to revolve in one direction while when s' makes contact it rotates in the other direction, thus causing the rheostat arm g to insert resistance in the lamp circuit in the former case and remove resistance therefrom in the latter case. The connections between s and s' and the motor respectively may be and preferably are effected through the intermediary of relays S^r and S^{r1} as in Fig. 1. It is also preferable to arrange contacts at either end of the travel of the lever g as shown in Fig. 1 adapted to be opened when the lever g reaches those positions, in this way depriving the motor M of current when it is unable to revolve.

L^1 is the main positive conductor leading from the positive brush of the main generator G .

L^2 is the conductor leading from the negative brush.

7¹ and 7² are the ends of the shunt winding of the generator G.

It will be seen that the contacts *o o* which come together when the switch *n* is in its dotted line position, Fig. 2, short circuit the resistance V^r. By means of the conductors 7¹ and 7² this resistance V^r is also short circuited whenever either of the hand switches *d* or *d*¹ is closed so as to provide current to either of the banks of lamps *c* or *c*¹.

x and *y* are the normally closed contacts opened by the rheostat arm *g* when at the extreme ends of its travel which have the effect of depriving the motor M of its current thus stopping the travel of the arm *g* in the direction in which it is moving when the circuit is broken, but permitting it to be operated in the opposite direction. At the first movement in the opposite direction the separated contacts *x x* or *y y* as the case may be will be restored to contact. This may be conveniently accomplished by making one of the contacts of each series a spring actuated or spring contact as indicated in the drawings.

M represents conventionally the armature of the series motor which operates the rheostat arm *g*.

S^r and S^{r1} represent two relays energized respectively through the contacts *s* and *s*¹ of the volt-meter control.

M² is the field winding of the motor M connected in the manner shown.

When the relay S^r is energized through the contact *s* it pulls over the double pole switch M² to the left dotted line position where it sends current one way through the field magnet winding M² thus causing the armature M of the motor and with it the rheostat arm *g* to revolve in one direction. This double pole switch is normally held in the full line position shown in Fig. 1, free from its contacts by springs Z², Z³ but can be moved therefrom to the right or left hand dotted line positions by the relays S^r and S^{r1}. The current for energizing the relay S^r is derived from L³ passing by way of L⁵, L⁷, S^r, L⁸ contact *s*, bar *r*, wire *r*¹ and line 25, 26 and 17 to L². As this brings the double pole switch to the left hand position the current to the motor, which is also derived from L³ will pass through the armature M, thence by line 20 to the member Z¹ of the switch, thence by line 21 to the field winding M² of the motor, thence by line 22 to the member Z of the switch, thence by way of contacts *y*, *y* to line 19^a and wire 3. The contact S^{r1} energizes the relay S^{r1}, the current being in this case also derived from L³ and passing directly through L⁵ to the relay S^{r1}, thence to the contact S^{r1}, bar *r*, wire *r*¹, line 25, 26, 17 to L². This will bring the double pole switch to the right hand position and the motor current after passing through the armature will pass to the member Z of the

switch, thence through the field winding of the motor thence by member Z¹ to line 18 to contacts X X, then by line 19, 19^a to 3. This passes the current in a reverse direction through the field winding of the motor and gives it a rotation in the opposite direction and gives the rheostat arm a reverse movement.

The operation of the mechanism is as follows: Let it be assumed that the lights are turned on and the dynamo or generator is charging the battery of accumulators *b* and supplying some current also to the lights. Then if the arm *g* of the rheostat is in the full line position Fig. 2 the apparatus operates like an ordinary automatic rheostat. The current to the lamps enters the rheostat through L³ and emerges at L⁴. With the arm *g* in the said position shown the current does not traverse any of the resistance wire *f*. If now the voltage of the battery begins to rise above the predetermined point at which the horizontal rod *r* of the volt-meter control is horizontal, its core *q* is raised and *s* makes contact operating the relay S^r to energize the motor so as to rotate the rheostat arm *g* clockwise. This inserts more and more resistance between L³ and L⁴ (and in consequence in series with the solenoid of the volt-meter control) until the pull thereof is weakened, and the contact *s* broken. This will occur at a time when the forces of the spring and solenoid are nearly equal and the rod *r* is brought into neutral position as shown in Fig. 1. This breaks the circuit through the relay S^r and the spring Z³ draws the double pole switch back into normal position and the rheostat arm stops. When the voltage of the battery *b* sinks so low as to cause the rod *r* to make contact at *s*¹ the relay S^{r1} will be energized, drawing the double pole switch to the right hand dotted line position when the motion of the motor will be reversed causing the rheostat arm *g* to move back toward its original position removing more and more of the resistance wire *f* from between L³ and L⁴ and in consequence from the lamp circuit till the contact *s*¹ is broken (and the motor stops). If one of the banks of lamps *c* or *c*¹ is turned out by the switches *d* or *d*¹ the volt-meter control operates so as to cause the rheostat arm *g* to make the necessary corresponding adjustment for the variation of current.

If all the lamps are turned out and the switch *n* is in the position shown in the drawings full lines, the resistance V^r is in series with the solenoid of the volt-meter control V^m and this latter accordingly operates on what has been called the higher scale. When the open circuit voltage of the battery or of the generator has risen to a certain high predetermined point, if the battery is injured or is disconnected, the contact *s* is made and energizes the motor so

as to bring the rheostat arm g around clockwise to the extreme end of its travel, when it knocks the switch n into the dotted line position (Fig. 2) and breaks the circuit at contacts $y y$ (Fig. 1) stopping the motor. In this position of the switch n the whole of the resistance wire f^1 in series with the contacts m , Fig. 2, is placed in series with the shunt wire winding of the generator by the opening of the circuit at contacts $p p$. This reduces the output of the generator to a few amperes, or less as arranged. At the same time it will be observed that the contact $o o$ is then made thus short circuiting the resistance V^r and putting the volt-meter control on the lower scale. The motor M consequently is not again set in motion to move the rheostat arm g counter-clockwise until the voltage of the battery of accumulators has sunk to a low point, say 1.85 volts per cell through supplying current to the lamps. In this way "hunting" that is to say, alternately cutting down the output of the main generator and restoring it to its full value again, is prevented. When the voltage sinks to this low value the contact s^1 is then made and the rheostat arm g is operated to move counter-clockwise until it comes right around to its extreme position, knocking the switch n back to its original position, while as it approaches the end of its travel it gradually cuts out the resistance wire f^1 so introducing the full power of the generator gradually, until the break $p p$, is closed. In the extreme position of its travel in this direction the arm g opens the circuit at the contacts $x x$ (Fig. 1) and so stops the motor M .

It will be observed that as either of the lamp switches d or d^1 short circuit the resistance V^r by connecting L^4 and L^5 the volt-meter control never operates on what has been called the higher scale except when both banks of lamps c and c^1 are turned off.

The whole set of arrangements operate both as an ordinary rheostat to control the lighting circuit when the lights are on, to keep the battery fully charged, to cut down the output of the dynamo to little or nothing when the batteries are fully charged; they also prevent overcharging the cells and any undue rise of the voltage of the generator if, owing to any accident the connection between it and the battery, or the connections in the battery itself, are interrupted.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In a system of electric lighting, the combination with the lamps, of a battery of accumulators, in a parallel circuit with said lamps, a dynamo connected with said battery and lamps, a switch for making and breaking the circuits through said lamps, a rheostat for controlling the lamp circuit, a voltmeter for controlling the rheostat, two circuits for supplying current to said voltmeter, a resistance in one of said circuits, said lamp switch being constructed to cut out the said resistance circuit when the lamp switch is closed, whereby the voltmeter works on a higher scale when the lamps are out of circuit, substantially as described.

2. In a system of electric lighting, the combination with the lamps, of a battery of accumulators, in a parallel circuit with said lamps, a dynamo connected with said battery and lamps, a switch for making and breaking the circuit through said lamps, a rheostat for controlling the lamp circuit, a voltmeter for controlling the rheostat, means for supplying current to the voltmeter, a resistance for said voltmeter, means actuated by the closing of the lamp switch for cutting out said resistance, whereby the voltmeter works on a higher scale when the lamps are out of circuit, substantially as described.

3. In a system of electric lighting, the combination with the lamps, of a battery of accumulators for supplying current to said lamps, an electric generator for supplying current to said battery and lamps, a rheostat in the lamp circuit, an electric motor for operating said rheostat, two circuits of opposite directions for operating said motor, a circuit changer for controlling said circuits, a volt-meter for controlling said circuit changer, two circuits of different resistances for supplying current to said voltmeter and means for throwing the current of the volt-meter through a circuit of less resistance when the lamps are in circuit, whereby the volt-meter is caused to operate on a higher and lower scale, substantially as described.

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