THE WOLVERTON SYSTEM OF TRAIN LIGHTING.

The Wolverton equipment is a single battery system utilising a plain shunt wound dynamo. The dynamo is controlled by an automatic field regulator which senses dynamo current and voltage. Drive is derived from an axle mounted pulley. The belt must be tight enough to prevent any slip.

There are two sizes of the equipment, viz.

DYNAMO	REGULATOR	AMPERE CAPACITY
WA	MD	70
WC	CMD	125

The dynamo brushes, pulleys and suspension lugs are the same on both sizes. The physical dimensions of the MD and CMD regulators are also identical.

The MD regulator is a development of the earlier AR and with the exception of the lamp resistance, which in the MD is divided into two sections, is interchangeable with it.

The operation of the MD regulator is described below.

Assume that the lights are OFF.

When the dynamo has reached sufficient speed to generate 26.5 to 27.5 volts, the Dynamo Shunt Relay (DShRe) is energised, closing the Dynamo Shunt Relay contact (DR/1), this in turn energises the Cut In Relay (CIR). When CIR is energised, contacts CIR/1, CIR/2 and CIR/3 close and contact CIR/4 opens. Current from the dynamo will now pass through the Regulator Shunt Coil Resistance (R6) and the Regulator Shunt Coil (RShC). Current from the dynamo also passes through the Dynamo Series Relay (DSeRe), Regulator Series Coil (RSeC) and Regulator Series Coil Stabiliser Resistor (VR1) to the battery. It is mainly due to the action of current passing through RShC that the regulator performs its function. The addition of Rectifier (D1) is to prevent arcing across contact DR/1 when CIR is de-energised. With the lights OFF, the whole of R6 is in series with RShC. The dynamo voltage will be automatically regulated so that it is slightly greater than the battery voltage until it reaches 32 volts. At this time the charging rate will be reduced to a very small value.

When the battery is completely discharged, the rate of charge will be very high. A very large current will flow through VR1 and RSeC. RSeC is so arranged to ASSIST RShC so that the rate of charge of the battery remains within acceptable limits. The function of the Regulator Series Coil Stabiliser Resistor (VR1) is to damp any oscillation of the regulator. The resistance of VR1 can be changed in relation to that of RSeC such that the maximum flow of current to the battery is limited to any desired value.

As the battery becomes fully charged, its terminal voltage rises, current in VR1 and RSeC falls. Simultaneously, due to increased battery voltage, current in RShC rises such that it reduces the current to the battery to a very small value. The Dynamo Field Regulator (R7) is varied according the position of a piston. The piston position is determined by the interaction of the magnetic effects produced by Four regulator coils RSeC, RShC, RTC and RDFShC. RSeC, RShC and RTC are wired to ASSIST one another. RDFShC is wound to oppose them.

Assuming the dynamo revolves below "cut-in" speed, that is the speed at which CIR is energised, the regulator piston is nearly static due to the balancing action of RShC and RDFShC. As soon as CIR is energised, CIR/1 closes, assisting RShC. The regulator piston moves, opening the regulator contacts (not shown), increasing the value of R7. The regulator resistance (R7) is arranged so that the voltage produced by the dynamo is just greater than that of the battery so that the charge is maintained. As the dynamo speed increases, its field current is decreased by the increase of resistance R7. RDFShC has LESS influence on regulator operation. As speed decreases the regulator resistance R7 is at a minimum and CIR/1 opens again, disconnecting the dynamo from the battery.

With the lights ON, the operation of the dynamo is as follows:

With LR/1 closed. Assuming CIR/1 to have closed and CIR/4 to have opened, current from the dynamo will flow to the battery as before, but will also flow through the lamp resistance (R1), the Lamp Resistance Shorting Relay (LRShoR/1), the lights relay contact (LR/1) and on to the lights. The value of the lamp resistance (R1) is such that there is a 2 volt drop across it which allows sufficient potential across the battery to secure correct charging rate while simultaneously preventing the lights from excessive voltage. A section of lamp resistance (R2) is introduced into the lighting circuit when the volt drop across the lights reaches 25.5 volts. An additional volt drop of 4 volts ensures that the battery will be fully charged when the lights are on.

The conditions whereby the Lamp Resistance Shorting Relay (LRShoR) is energised is determined as follows. Consider gradually increasing dynamo speed.

The Voltage Control Relay (VCR1) is coupled to the circuit such that when the lights are ON, VCR1 becomes energised when the voltage at point "A" has risen to 25.5 volts. When this occurs, contacts VCR1/1 and VCR1/2 close. Thus if the Regulator Contact (RC/1) is closed, LRShoR will be energised, but RC/ 1 is operated by the regulator piston itself and will only close when the regulator has reached a specific stage in the regulation cycle.

Additionally when VCR1 is energised (voltage control stage 1) current also passes to the Regulator Shunt Resistance (R6) or to be more specific, the junction of R6/1 and R6/2. The additional current in the Regulator Shunt Coil (RShC) thus strengthens RShC which inserts more Dynamo Field Resistance (R7) into the dynamo field circuit thus reducing its output.

Additionally, current also passes through the Voltage Control Relay 2 (VCR2) which itself is energised when the voltage on the lights rises again to 25.5 volts, closing VCR2/1. When contact VCR2/1 closes, resistance R6/2 is shorted which has the effect of strengthening RShC causing the output of the dynamo to fall further, when the battery should be almost fully charged.

As the dynamo speed is decreased the reverse effect occurs until after the Cut In Relay has de-energised. The lights remain across the batteries as long as LR/1 is closed.

The Retaining Resistance (R5) permits sufficient current under certain operating conditions to maintain VCR1 in its energised state. Consider a fully charged battery, small lighting load and the dynamo running at average speed. The regulator will produce an output LOWER than that of the battery. Consequently there will be a brief battery discharge current which will cause CIR to de-energise until the battery voltage has fallen to about 25 volts when CIR will energise again. When CIR de-energises, CIR/2 opens which would cause VCR1 to de-energise opening contacts VCR1/1 and VCR1/2. The action of shorting R5/1 causes sufficient current in VCR1 to retain it in energised state. As the dynamo slows down, VCR1 remains energised due to the current passing through R5/2 to enable VCR1/1 and VCR1/2 to remain closed until the voltage on the lights falls to 24.5 volts. With all the lights on this occurs at the same time as CIR is de-energised, but with small lighting load and a fully charged battery a few minutes passes before VCR1/1 and VCR1/2 open after the dynamo stops.

The Toggle Coil (RTC) has its circuit completed by the Regulator operated contact (RC/1). RTC's action is to ASSIST the closing and opening of RC/1, while RShC remains to regulate the dynamo output as before.

When the dynamo is not generating, current flows from battery positive through Regulator Series Coil (RSeC) and VR1 via contacts CIR/4 and LRShoR/1, LR/1 to the lights and back to battery negative.

Maintenance notes

The four pole dynamo has a brush-rocker which, by the action of brush friction, is moved through a definite angle to maintain constant polarity at the dynamo terminals in both directions of rotation. As the dynamo drive is a positive one the belt tension must be so maintained that slip is avoided. A proper tension is secured if the belt adjustment is such that the lid of the dynamo coupling box is in a vertical position. It should rarely be necessary to change a dynamo pulley. Whenever such a course is taken, every care must be observed to see that the seat of the new pulley is free from dust; that the armature shaft is perfectly clean and that no burrs on the key or keyway prevent a satisfactory seating. before placing the pulley in position, a little oil or grease should be smeared on the shaft. The wave spring washer must be replaced in position and the shaft nut so tightened that the wave washer is almost but <u>not completely</u> flattened. Reinsert the cotter pin.

The dynamo should be examined at infrequent intervals and not more often than once per quarter. Whenever examination is to be undertaken and before the domed cover is to be removed, all loose dust must be brushed away from the joint, and every care taken to prevent dirt or dust from entering the machine. Serious damage can be caused to the commutator by the presence of particles of dirt; they are likely to become embedded in the dynamo brushes and so scour the surface of the commutator. Care must be taken to replace the cover in the groove of the end bracket as, otherwise, water will enter the machine.

Should the dynamo be found to be motoring which would be due to the loss of the belt while the coach is travelling, it may usually be stopped by switching the lights ON momentarily from the lights controller. In the event of this procedure being ineffective, isolate the dynamo from the battery by temporarily removing one of the battery fuses.

The dynamo bearings have ample lubrication reserves and require no attention. They should <u>NOT</u> be examined or interfered with in any way. The point to which systematic attention must be given is to the suspension pin; <u>NEVER</u> let this become short of oil, and see that the screw plugs are replaced after the oil has been introduced.

It is not intended that the regulator should be opened unless the state of the battery, or some other item of equipment, indicates defective functioning. Under no circumstances must any adjustment be made to any component of the regulator, nor any parts removed for replacement. If an examination of the regulator is to be made, before disturbing the cover, all loose dirt surrounding the cover must be brushed away. Should the jointing baize come away with the cover, as occasionally happens, the baize must be replaced in the slot in such a way that the joint is positioned at the centre of the bottom slot. Upon removing the cover, care must be exercised to avoid grounding or shorting any of the live metal work by contact between the cover and the live metal. Such contact is liable to reverse the polarity of the dynamo. (An "earth" on any part of the equipment or cable system is likely to produce the same effect.) Trouble of this nature can be avoided by using the bottom edge of the cover as a hinge or fulcrum point when the cover is being removed. Every care must be exercised to prevent dirt entering the regulator.

In no case must the "cut-in" relay or "cut-in" switch be operated by hand as the excessive momentary current is liable to burn the contacts. For a like reason the magnetic 'lights' switch should not be operated by hand. Should the lights be left ON to the extent that the battery becomes too exhausted to operate the OFF coil of the lights switch, the switch may be tripped manually by depressing the shrouded button situated on the underside of the regulator. Whenever the battery is found to be exhausted, this button should be operated as the lights may be ON without there being any evidence of this because the battery voltage is too low to render the lamp filaments visible

Maintenance of the dynamo and regulator is to be confined to main Workshops and NOT undertaken by Outstations. Defective dynamos and regulators must be removed and returned to a Main Workshop and spare equipment must be available at Outstation Depots to enable this procedure to be followed.

The chief symptom of reversed polarity of the dynamo is "blown" battery fuses. Sometimes the field has not been completely reversed but only demagnetised and so in a neutral condition. This results in a discharged battery because current is not generated by the dynamo. A test for a reversed field can be made by means of a "polarised" voltmeter, i.e. a moving coil instrument, by connecting the positive terminals to the respective positive and negative terminals of the dynamo. Remove the dynamo belt and examine the main and field dynamo fuses. Frequently when the battery fuses have been blown, the dynamo main fuse will have blown also. Spin the armature round when, if the field is reversed, the voltmeter needle will move in a backward direction. A correctly magnetised field will cause the voltmeter needle to move in the proper direction across the scale. Should the field be demagnetised the needle will remain at zero.

When it is ascertained that the dynamo field is either demagnetised or reversed, it should be rectified in the following manner. Remove the main fuse on the dynamo. Examine the battery fuses. On B.R. standard coaches these are in the battery fuse boxes, situated on the battery boxes, but on L.M.S. coaches the positive fuse is on the battery box and the negative fuse in the distribution fuse box. If blown, replace them by a new cartridge fuses. Connect the dynamo positive and battery positive terminals on the regulator with a piece of 3/0.029" or similar cable. The cable need only be hooked on the terminals; it merely carries the field current of the dynamo. The connections being made, leave the circuit closed for a quarter minute. Afterwards re-test with voltmeter to see that the field polarity has been correctly established. Then replace the dynamo main fuse and the dynamo belt. If the fault has been rectified the field will operate in the correct manner.

Blown through-control fuses are usually due to a short or earth on the couplings. The most frequent cause of this is failure to replace the couplings when not in use in the pockets provided for them. In the case of B.R. standard corridor coaches the couplings are attached to the gangway and pockets are therefore unnecessary.

All fuses should be inspected periodically to see that they are free from corrosion; that they have not been damaged by overheating and that the fixing screws clamp them firmly to their base. Any fuses showing signs of deterioration should be replaced.

In cases which the lamps go out or are exceptionally dull under travelling conditions, the lamp resistance should be examined and any broken coils replaced by sound ones of the same rating.,

APPENDIX

KEY TO COMPONENT CODES , MK I SCHEMATIC.

Relays / Contactors

Code	Name	Contacts	Power OFF state	Function
DR	Dynamo Relay	DR/1	n.o.	Energises Cut-In Relay. (CIR)
(DShRe and DSeRe)	Shunt & Series coils.			
LR	Lamps Relay	LR/1	n.o.	Energises lamps.
CIR	Cut In Relay	CIR/1	n.o.	Connects dynamo to regulator/ batteries/lamps.
		CIR/2	n.o.	Retaining resistance shorting contact.
		CIR/3	n.o.	Energises regulator shunt coil.
		CIR/4	n.c.	Lamp resistance (R1) shorting contact.
LRShoR	Lamp Resistance Shorting Relay.	LRShoR/1	n. c.	Lamp resistance (R2) shorting contact.
VCR1	Voltage Control Relay 1.	VCR1/1	n.o.	Enables regulation via RShC.
		VCR1/2	n.o.	Energises VCR2 and regulator toggle coil.
VCR2	Voltage Control Relay 2.	VCR2/1	n.o.	Shorts part of regulator shunt coil resistance.

Resistances

Code	Name
R1	Lamp resistance 1.
R2	Lamp resistance 2.
R3	Voltage control resistance.
R4	Voltage control resistance.
R5	Retaining resistance.
R6	Regulator shunt coil resistance.
R7	Field coil resistance. (Varied by action of regulator carbon contacts, which are not shown).

Rectifiers

D1	Rectifier diode.

Other components

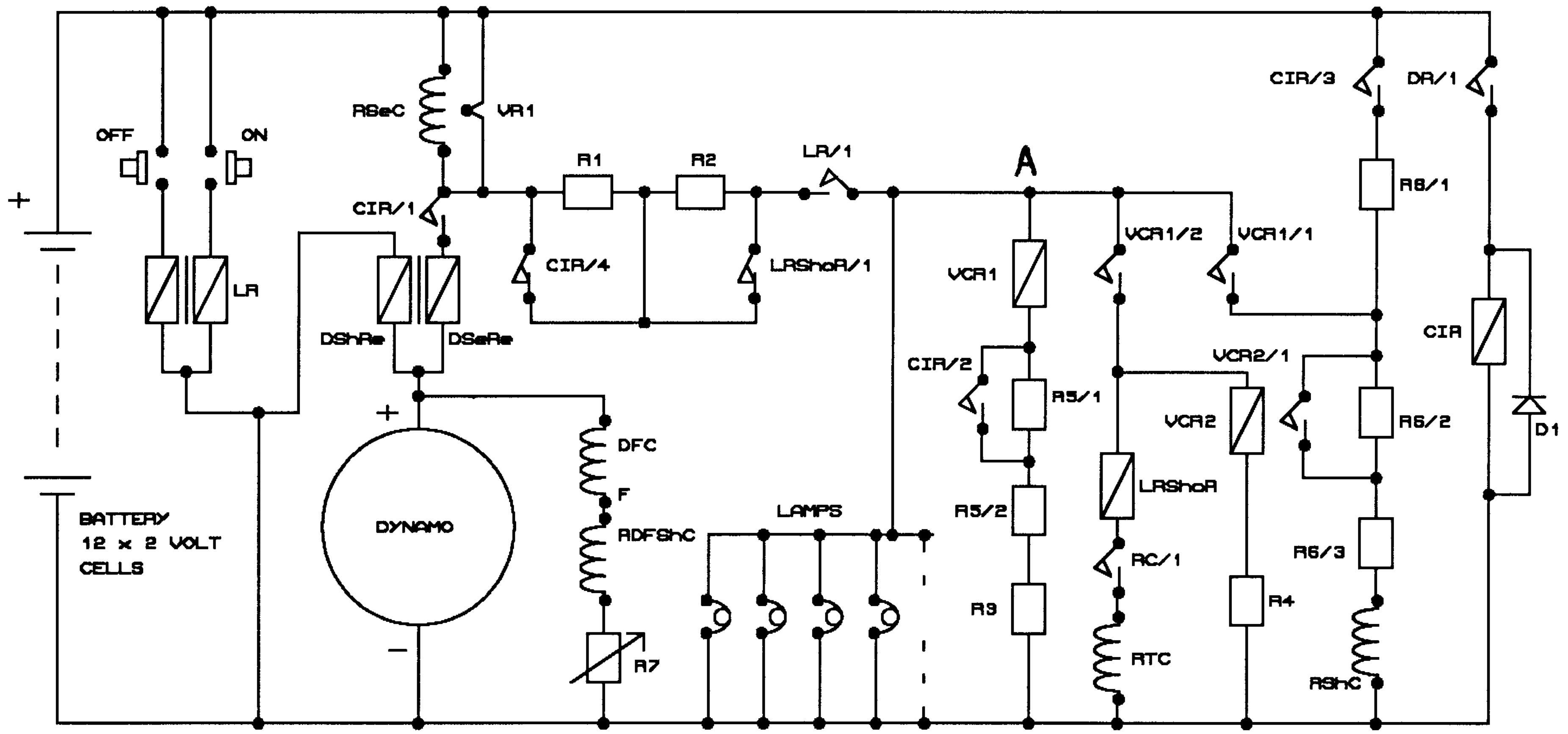
VCR].	Constant voltage resistance.

Regulator coils

RSeC	Regulator series coil.
RShC	Regulator shunt coil.
RTC	Regulator toggle coil.
RDFShC	Regulator dynamo field shunt coil.

Dynamo

DFC	Dynamo field coil.



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