THE WOLVERTON SYSTEM OF TRAIN LIGHTING

Description of system.

The Wolverton system of train lighting is a single battery equipment employing a plain shunt wound dynamo controlled by an automatic field regulator functioning under the combined influence of current and voltage. Drive from the axle pulley is positive, that is, the belt must be tight enough to prevent slip. There are two sizes of equipment, 70 amp and 125 amp, the respective dynamo being coded 'WA' and 'WC', and the regulators 'MD' and 'CMD'. The dynamo brushes, pulleys and suspension lugs are the same on both sizes. Likewise, the physical dimensions of the 'WD' and 'CMD' regulators are identical.

The type 'MD' regulator is a development from an earlier type known as the 'AR' and, apart from the lamp resistance, which in the 'MD' is divided into two sections, is interchangeable with it. Referring to the skeleton diagram of connections, the operation of the regulator is as follows ...

1) The dynamo having reached a speed sufficient to generate 26.5 to 27.5 volts, the relay shunt coil (8) becomes energised and closes contact (37) which allows current to flow through the cut-in switch coil (10), which in turn operates its piston to close contacts (5), (6) and (36), at the same time opening contact (7). Current then passes, by way of (36) through to the shunt regulating resistance (21) and the regulator shunt coil (17).

2) After passing the series coil (9), the current traverses the series coil (18) and the stabiliser (16) [the stabiliser provides a constant resistance to keep current through the coil low], and enters the battery by the positive terminal, passing thence to the negative terminal of the dynamo. It is mainly due to the action of the current passing through the shunt coil (17) that the regulator piston functions and maintains its position according to requirements. The inclusion of an arc quenching rectifier (38) across the cut-in switch coil (10) reduces arcing at the switch contacts (37). To achieve this the rectifier is opposed in polarity to the flow of current from the dynamo.

3) With lights OFF, as above, it will be noted that the whole of the resistance (21) is in the circuit of the regulator shunt coil (17) across the dynamo terminals. Under these conditions the dynamo voltage will be automatically adjusted so that it is a little above the battery voltage until it rises to about 32 volts, when the charge will be reduced to a very low value.

4) Naturally, by this arrangement, the rate of charge to a completely discharged battery will be high, and consequently a heavy current will flow through the stabiliser (16) and the series coil (18). The latter is so wound that it assists the shunt coil (17) to keep the charge in the battery within permissible limits.

5) The main duty of the stabiliser (16) is to permanently shunt the series coil and damp out any oscillatory influences in the regulator. The resistance of the stabiliser (16) can be so proportioned in relation to the series coil (18) that the maximum current flow to the battery is limited to any desired value.

6) When the battery voltage rises as completion of the battery charge is approached, the current in the stabiliser (16) and the series coil (18) becomes reduced, and the current in the shunt coil (17) is increased due to the rise in the battery voltage, so that finally, the shunt coil (17) takes complete control of the regulation and reduces the battery charge to a negligible amount.

7) The dynamo shunt field regulator has its coils arranged so that the shunt coil (17) and the series coil (18) assist each other, and the coil (19) in series with the dynamo field is wound to oppose them. When the dynamo armature is revolving below the cut-in speed, the effects on the regulator piston of coils (17) and (19) are nearly balanced, and there is no tendency for it to move. As soon as the contact (6) is closed, however, the series coil (18) comes to the assistance of the shunt coil (17), and movement of the piston then commences, resulting in the opening of the contacts (14), one at a time, thereby inserting more and more resistance (15) in the circuit of the dynamo field coil (1) and of the coil (19) in series with the dynamo field. This gradual insertion of resistance (15) allows the voltage of the dynamo to be just a little higher than that of the battery so that the battery charge is maintained as required. The coil (19) gradually becomes less effective as the dynamo speed increases by virtue of the reduction of the dynamo field current consequent upon the insertion of the resistance (15), and coils (17) and (18) thereby become proportionately more effective. The reverse takes place when the speed is reduced until, with falling speed all the contacts (14) are closed and the contact (6) opens, disconnecting the dynamo from the battery.

8) When the dynamo is functioning with the lights ON, the disposition of the circuits is as follows. Presuming contact (6) to have just closed and contact (7) opened, the current will divide at point (34), part going to the battery as previously described, and the remainder flowing through the lamp resistance (11) to the resistance switch (3), on to the main lighting switch (29), to the lamps (30) and thence to the common negative of the battery and dynamo.

9) The lamp resistance (11) is arranged to induce a 2 volt drop which permits a sufficient pressure across the battery terminals to secure the desired charging rate and at the same time prevents the over-running of the lamps. There is a further section of the lamp resistance (12), which is brought into the lamp circuit by the opening of the switch (3), when, owing to rising battery voltage, the pressure across the lamps has reached 25.5 volts. This induces a drop of a further 2 volts so that the lamps are now operating at about 4 volts less than the voltage across the battery and so ensures that the latter will be fully charged even when the lamps are in use.

10) The operation of the switch (3) is effected as follows, and simultaneously therewith alterations occur in other of the regulator circuits. The voltage control switch coil (24) is coupled to a point (31) on the lamp circuit, which point becomes positive upon the closing of lamp switch (29). With lamps ON therefore, current passes from the point (31) through coil (24) to the contact (5) and the resistance (32) to the negative. The lamp voltage having risen to 25.5 volts, as stated above, this control coil (24) becomes

sufficiently excited to raise its piston and thereby close contacts (22A) and (22B). Current will now pass in three separate circuits each to perform a different function. From (31) current will pass through the switch (22) and contact (22B), coil (4), contact (13) and coil (35) to the negative. It is coil (4) which operates the lamp resistance shorting switch (3). The switch (13) is operated by the main regulator piston and closes after the contact (14A) has been opened. It is opened when contact (14A) closes due to the slowing down of the dynamo speed. This arrangement ensures that the switch coil (4) is only energised when the main regulator has reached a definite stage in the regulating functions.

11) From switch (22) current also passes through contact (22A) to a point (21A) on the resistance (21) on to (21C) and thence to the regulator coil (17). Part of the resistance (21) is thereby short circuited and coil (17) is correspondingly strengthened. The regulator, therefore, inserts more resistance (15) into the dynamo field circuit.

12) From contact (22B) current also passes to coil (25) of the voltage control switch, to resistance (33) and thence to the negative. When the voltage on the lamps again rises to 25.5 this control coil (25) is strong enough to close contact (23). Current will then pass from contact (22A) to contact and switch (23), thence via (21B) and (21C) of the resistance (21) to the regulator coil (17) and to the negative. The shorting out of a further section of resistance (21) strengthens still more the coil (17) and more field resistance (15) is inserted due to the opening of additional contacts (14). The current to the battery will be reduced thereby still more and at this stage the battery should be almost completely charged.

13) As the dynamo speed is reduced the regulator gradually closes the contacts (14) and when contact (14A) is closed the switch (13) is opened. This demagnetises the coil (4) and so closes switch (3) which shorts the lamp resistance (12). Further. reduction in speed causes contacts (5) and (6) to open and contact (7) is closed which cuts out the lamp resistance (11). The lamps are thereby left across the battery so long as switch (29) is closed.

14) The resistance (2) is introduced for the following purpose. If, when the battery is well charged and the dynamo is running at average speed, a small lamp load is switched ON, it will be found that the regulator is regulating at a voltage lower than that of the battery, which may be as high as 27 volts at the moment. In consequence there will be a discharge from the battery for a brief period which will cause the cut-in switch to open and remain out until the peak of the battery voltage has fallen, owing to discharge, to about 25 volts, when the regulator will re-adjust itself and take up the load again. When the cut-in switch "cuts-out" the contact (5) is thereby opened again, and but for the resistance (2), would cause the contact (22) to open by virtue of the breaking of the circuit of coil (24). The resistance (2), however, permits a current to be maintained in this circuit sufficient to retain in position the piston of solenoid (24) until the contact (5) is again closed by the cut-in solenoid. When the cut-out is effected as the dynamo slows down, the solenoid (24) remains sufficiently excited (due to the current passing through the resistance (2)), to keep the contact (22) closed until the lamp voltage falls to 24.5 volts. With a full lamp load this takes place at about the same instant as the cut-out, but with a small lamp load and a battery fully charged it may be a few minutes before the contact (22) opens after the dynamo stops.

15) The purpose of coil (35), which is designated the "Toggle Coil", and has its circuit completed by contact (13), is to make the action of this contact. quite definite. Coil (35) assists the regulator coil (17) and consequently accentuates the opening and closing of contact (13), yet at the same time leaves the shunt coil (17) free to respond to any further adjustments which are required.

16) When the dynamo is not generating, the lamp current passes from the battery positive to the series regulator coil (18) and the stabiliser (16), via the contacts (7) and (3) to the lighting switch (29), thence through the lamps (30) to the battery negative.

Maintenance notes

17) 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.

18) 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.

19) 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.

20) 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.

21) 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.

22) 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

23) 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.

24) 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.

25) When it is ascertained that the dynamo field is either demagnetised or reversed, it should be rectified in the following manner. <u>Remove the main fuse on the dynamo.</u> 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.

26) 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.

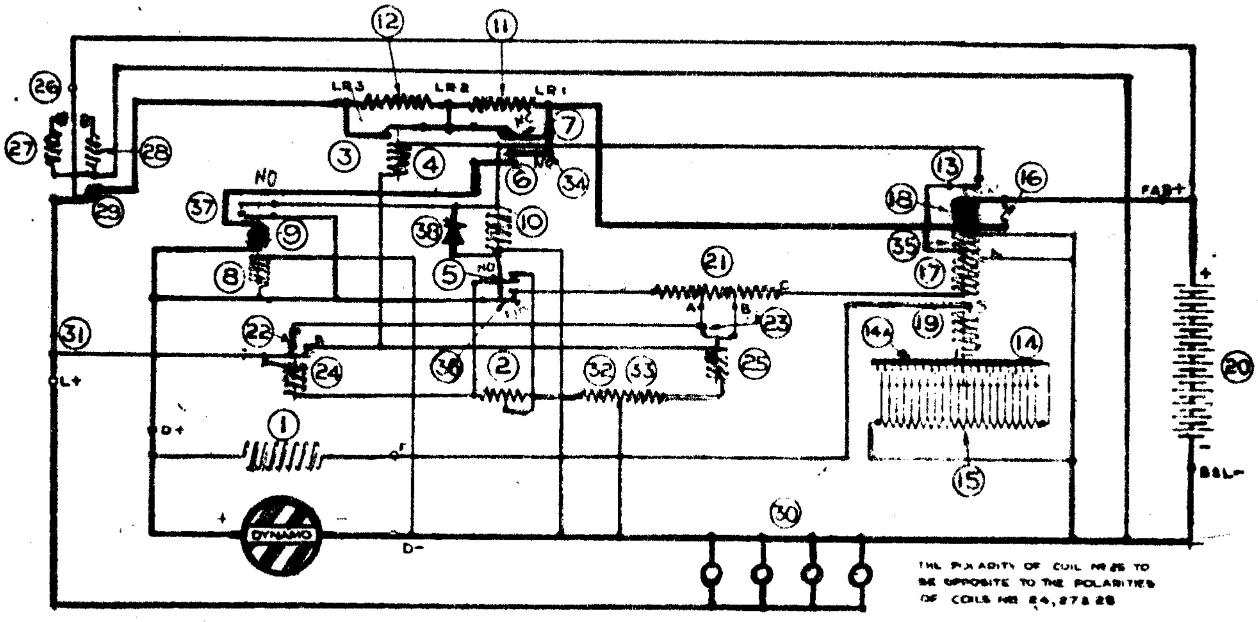
27) All fuses should be inspected periodically to see that they are free from corrosion; that they have not been damaged by overheating and that the fixing screws clamp them firmly to their base. Any fuses showing signs of deterioration should be replaced.

28) 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 <u>same rating.,</u>

(1) DYNAMO FIELD COILS
(2) RETAINING RESISTANCE
(3) LR3 SWITCH CONTACT LR3
(4) " " COIL
(5) SUB-CONTROL SWITCH CONTACT
(6) CUT-IN SWITCH CONTACT
(7) LR1 " "
(8) RELAY SHUNT COIL
(9) RELAY SERIES "
(10) CUT-IN SWITCH COIL
(11) LAMP RESISTANCE LR1
(12) " " LR2
(13) TOGGLE COIL SWITCH

(14) REGULATOR CARBON CONTACTS
(15) FIELD COILS RESISTANCE
(16) STABILISER
(17) REGULATOR SHUNT COIL
(18) " SERIES "
(19) FIELD SHUNT COIL
(20) BATTERY
(21) REGULATOR SHUNT COIL RESISTANCE
(22) VOLTAGE CONTROL SWITCH CONTACTS, 1ST STAGE
(23) " " " " 2ND "
(24) " " " COIL, 1ST "
(25) " " " " 2ND "
(26) LIGHTS CONTROLLER

(27) LIGHTS SWITCH "OFF" COIL
(28) " " "ON" "
(29) " " CONTACT
(30) LAMPS
(31) POSITIVE MAIN TO LAMPS
(32) } VOLTAGE CONTROL
(33) } RESISTANCE COILS
(34) 7
(36) TOGGLE COIL
(34) CALIBRATING RESISTANCE SWITCH
(37) CUT-IN-SWITCH COIL CONTACTS
(38) ARC-QUENCHING RECTIFIER



SKELETON DIAGRAM OF WOLVERTON 'MD' SYSTEM.