# PCC Equipment type SPS 3-135 FOR MIVG

## CONTROL CIRCUITS

## STUDY OF OPERATION

# P.C.C. EQUIPMENT - TYPE SPS 3-135 FOR MIVG

## I N D E X


| | | Pages |
|---|---|---|
| 1. | Selection of Direction of Travel | 2, 3 |
| 2. | Stationary vehicle | 4 |
| 3. | Starting and series traction | 5 - 9 |
| 4. | Coasting | 10,11 |
| 5. | Position in coasting | 12 |
| 6. | Starting and series parallel traction | 13 -16 |
| 7. | Series parallel traction coupling | 17,18 |
| 8. | Rheostatic braking | 19,20 |
| 9. | Monitoring of rheostatic braking | 21 |
| 10. | Coupling of rheostatic braking | 21 |
| 11. | Return to traction | 22 |
| 12. | Transition to series parallel after series | 23 |
| 13. | Coasting monitoring | 24 |
| 14. | Track brakes | 25 |
| 15. | Dead man | 26 |
| 16. | Cutting out motors | 27,28 |
| 17. | Motor overload | 29 |
| 18. | No voltage | 30 |
| 19. | Safety devices, controls and interlocks | 31,32 |


The description herein applies to the equipment supplied to the MIVG. The MMTB equipment is generally similar, and, wherever appropriate, the MMTB designations are shown following the MIVG designations thus (x-SCU-x). MIVG terminal and wire numbers have been used throughout.

The references 3 Eng 135 and TRA 6910105 refer to ACEC drawing nos. The description is covered generally by ACEC drawing 3 ENG 136

## 1. SELECTION OF DIRECTION OF OPERATION

Selection of direction of travel of the vehicle is made by the driver at the end occupied when he placed the handle of the reverser I(x-RC-x) in the position corresponding to the direction of travel AV (x-FOR-x) or AR (x-REV-x) required.

The reverser I may be operated only if the electrical interlock VI (x-RC1/2-x) is energised. This is energised by pressing button BP (x-RC1/2-x) but not if the normally closed contact(1F-G) of relay LO (x-LOR-x) is closed, in other words, it may be energised only when the vehicle is stationary.

At No. 1 end: the driver presses button BP7 (x-RCI1-x), contact B60-1D closes, and LO being de-energised, the electrical interlock VIa(x-RC1-x) is excited. The reverser handle may then be moved and reset, for example to position AV.

Ia (x-RC1-x) set to AV Its contact B60-1 closes and feeds the coil of the reverser contactor KAV (x-FOR-x) across the normally closed contacts 1-1A of contactor KAR (x-REV-x).

The same sequence applies if from No. 2 end, button BP(x-RCI2-x) has been pressed and reverser Ib (x-RC2-x) is set to position AR.

Ref. 3 ENG 135 (Power circuit)
( KAV (x-FOR-x) closes. Power to the field coils III + IV is made in the sense X2 - KAV - Y2 -Y4 - KAV - X4 and that of field coils I + II in the sense X1 - KAV - Y1 - Y3 - KAV - X3 which corresponds to the direction of rotation required.

If reverser Ia is set to position AR or reverser Ib to position AV : In this case, contact B60-1B is closed and allows feed to the coil of reverser contactor KAR (x-REV-x) across normally closed contact 1B-1C of KAV

Ref. 3ENG 135 - KAR energised. Feed to the field coils
( III + IV is made in the sense X2 - KAR - Y4 - Y2 - KAR - X4 and that to field coils I + II in the sense X1 - KAR - Y3 - Y1 - KAR - X3 which corresponds to a direction of rotation opposite to the above.

The presence of the normally closed contact of KAR in the coil circuit of KAV and that of the normally closed contact of KAV in the coil circuit of KAR prevents simultaneous closing of the two contactors.

For the rest of the description we will consider that the vehicle is ready to put into service, that is:

- the trolley pole is up, the no-volt relay RTN (x-NVR-x) is energised.

the door locking switches ID2 and ID3 are closed. The doors being closed, contacts S2i and S3i are closed, the motor cut out switch is set to 4M. Also we assume No. 1 end is occupied and reverser switch Ia is in position AV

## 2. STATIONARY VEHICLE

The vehicle being at the stop and the pedals released, the coasting monitoring relay RSD (x-CCM-x) and the auxiliary traction relay Rt1 (x-SR-x) are open. In this case, their normally closed contacts 3B-3A and 3B-B60 are closed and allow feed to the auxiliary braking relays RF1 (x-BRI-x) and RF2 (x-BR2-x) which close.

These relays are also energised across contacts B60-3 and 3-3A which are closed in the released position of the dead man pedals HMa and HMb (x-DMC1/2-x).

Rf1 and Rf2 energised

Their contacts B60-6E and B60-6F close causing energisation of contactors R1 and R2 (x-C1 and C2-x).

Contact 3M - 3J of Rf1 closes allowing feed via contact 3J - 3P of R2, also closed to the coils of contactors B1-B2-B3 which are energised in their turn.

Contact 38G - 38F of Rf2, open, prevents feed to the control circuit of relay LO (x-LOR-x) (in BCS (x-SCU-x)) and no motor current being detected by the regulator, relay LO remains de-energised.

Relay RSD being de-energised, its normally open contact 3M - 3N prevents feed to the coil of contactor K2 which remains de-energised.

Ref.TRA 691015-7 The deadman pedal HMa (x-DMC1-x) still being released, its contact 35E - 35C remains open and the transmission brakes, not being energised, remain applied

NOTE:

The operation of the reverser also allows supply to the static power supply panel. This latter being fed, control relay RZ (x-ZR-x) is energised (see chapter - "Regulation")

## 3. STARTING AND SERIES TRACTION

The driver depresses and holds the deadman pedal HMa in mid-position.

Contact B60-3 opens in the circuit of Rf1 and Rf2 but without immediate effect

Contact 5K - 5L closes in the circuit of the LS (x-LB-x) coil and prepares supply to this latter.

Ref. TRA 691015-7

( Contact 35E - 35C closes and energises the transmission
( brakes via the closed circuit of Ia set to AV, BCa
( closed from 0 - 7 and diode D30.
( The transmission brakes are released.

The driver depresses and maintains his traction pedal MCa in a position less than 70°:

Contact 5A to 5G of MCa closes and causes energisation of series traction relay Rt1 (x-SR-x)

The degree of depression of the pedal determines the value of the acceleration instruction passed to the BCS (see "Regulation")

Rt1 energised:

Contact B60 - 3B opens and causes de-energisation of braking relays Rf1 - Rf2

Contact 5l - 5c closes and prepares supply to the LS coil.

Contact 4M - 4N closes and prepares supply to the 0 coil.

Contact 8D - T closes and prepares the traction regulation command for the BCS

Contact 6D - 6E closes and prepares traction supply to R1 (x-C1-x) coil.

Rf1 - Rf2 de-energised (x-BR1 - BR2-x):

Contacts B60 - 6E and B60 -6F of Rf1 open and cut supply from R1 and R2 which open

Contact 3M - 3J of Rf1 opens and cuts supply from B1-B2-B3 which open

Contact 35G -35F of Rf2 closes, and supplies of the command circuit of relay L0 which closes

Contact 5Y - G of Rf1 closes, and prepares the supply of LS coil.

Ref. 3 ENG 135 - The successive closing of contactors R1 and R2 has brought about the elinimation of the cushioning resistors R1 and R2 and the four traction motors coupled in series are now supplied across the series resistors of the accelerator only.

The vehicle has started and the coasting measure voltage provided by the tachometric alternator appears at D2 in the BCS and thus causes closing of the coasting monitor relay RSD (x-CCM-x).

RSD closes:

Contact 4L - 5G opens and interrupts the circuit commanding "forced transition in series parallel".

Contact 3M - 3N closes and prepares the feed circuit to the coil of the premagnetisation contactor K2

Contact 3A -3B opens and interrupts the circuit commanding "braked coasting"

The traction regulator of the BCS being in service, it compares the value of motor current passing through the TR measure transductor with the acceleration instruction supplied from the traction pedal and controls the displacement of the accelerator so as to obtain at any instant and at any vehicle speed the correct ohmic value of the series resistances to maintain the required starting current.

Vehicle speed increases progressively and cutting out of the accelerator resistances continues towards 0 ohms until the speed reached at the required current, allows the motors, fed at half voltage, to operate at their natural characteristics and full field. At this moment, the accelerator reaches position 60, contact 4C -4J closes and causes energisation of contactor 0.

Ref 3 ENG 135 - The series end coupling contactor 0 being closed, the four traction motors connected in series are fed directly from the line voltage across contact 0 which shunts the series resistance circuit and contact S.

0 closes:

Contact B60 - 4B closes and causes energisation of auxiliary relay Ro (x-0R-x)

Contact 6B - 6C opens and prepares the de-energisation of contactors R1 and R2.

RO closes:

Contact 4C-4K closes and short circuits contacts 4C - 4J and 4J - 4K of the accelerator and contactor S, interlocking the closing of contactor O.

Contact 8D - 8C opens and interrupts the traction regulation command of the BCS which thus passes automatically to coasting regulation.

Contact 8F - 8G opens in the limit switch circuit of the accelerator but without any effect because it is short circuited by closed contact 8F-8G of Rt2 (x-SPR-x)

Contact 5B-4L closes but the contact 4L - 5G of RSD having opened previously, this action has no immediate effect on the equipment.

Contact 5L - 5C closes and doubles the action of Rt1 in the coil circuit of LS.

Contact B60 -2B closes and causes energisation of the shunting contactor F1 which in closing causes in turn energisation of contactor F2.

When the accelerator, positioned by the coasting circuit, reaches position 67 its contact 2A -2D closes and causes closing of shunting contactor F3.

F3 closes:

Contact B60 -2G closes and causes energisation of F4

Contact 2A -2B closes and interlocks the feed of its coil by short circuiting contact 2A - 2D of the accelerator in order to avoid de-energisation of F3 when the accelerator is later positioned between 80 and 124.

Ref. 3 ENG 135 - Shunting Contactors F1, F2, F3 and F4 being closed, the vehicle operates on the natural characteristic of the motors, 50% shunted and fed at half voltage while while the position of the accelerator is governed as a function of speed by the coasting regulation.

Note: For positioning in coasting, see later.

When the accelerator passes position 69 contact 6B-6D opens and causes de-energisation of contactors R1 and R2.

Ref. 3 ENG 135 - Contactors R1 and R2 being de-energised, cushioning resistances R1 and R2 are re-inserted into the circuit but without any effect on traction current because this circulates across the closed contact of 0. These resistances are re-inserted to prepare for their use in case of subsequent passage to series - parallel coupling.

4. COASTING:

The driver releases the traction pedal:

Contact 5A -5G of MCa opens and causes de-energisation of relay Rt1

Rt1 opens (x-SR-x)

Contact 4M - 4N opens and causes de-energisation of contactor O.

Contact B60-3B closes in the coil circuit of Rf1 and Rf2 (x-BR1 and BR2-x) without any effect on these latter because of the previous opening of contact 3B -3A of RSD.

Contact 5L -5C opens in the coil circuit of LS but without effect because of the previous closing of contact 5L-5C of Ro (x-OR-x)

O opens:

Contact 860-4B opens and causes de-energisation of relay Ro

Ro opens:
Contact 5L-5C opens and causes de-energisation of LS

LS opens:

Contact B60-4C opens and causes de-energisation of contactor S

S opens:

Contact 3L - 3M closes and completes the feed circuit to the coil of pre-magnetisation contactor K2 which closes.

The sequence of de-energisation therefore is effected in the following order:-

de-energisation of Rt1
de-energisation of O
de-energisation of Ro
de-energisation of LS and eventually of F1, F2, F3, F4
de-energisation of S
energisation of K2

If the accelerator has not passed position 69 at the moment when Rt1 opens, contactors R1 and R2 remain closed and the sequence of de-energisation becomes

de-energisation of Rt1
de-energisation of R1 and of O
de-energisation of R2 and of Ro
de-energisation of LS
de-energisation of S
energisation of K2

In both cases, opening of LS occurs only after having reinserted in the power circuit a resistance formed as follows:

in the first case:

by that part of the accelerator resistances between position 60 and the position occupied (necessarily beyond position 69)

in the second case:

by resistances R1 and R2 being replaced in circuit by the opening of contactors R1 and R2

Ref. 3 ENG 135 All coupling contactors being open, the traction motors have no current flowing through them and run free. The closing of the pre-magnetisation contactor K2 allows excitation from the battery voltage of field coils I + II. Themagnetising current is limited by the value of resistance Re (x- WD-x) and allows rapid build-up when the traction motors are coupled as series generators to provide rheostatic braking.

## 5. POSITIONING IN COASTING

The object of positioning in coasting is to adjust the position of the accelerator during the absence of traction or braking current to the speed of the vehicle, so that it will always be ready to begin rheostatic braking with an adequate value of braking resistance.

This positioning is attained by a circuit comprised of the coasting rheostat located in the accelerator and the coasting current measuring branch of the acceleration regulator.

This circuit is fed from a tachometric alternator which delivers a voltage after rectification proportional to the speed of the vehicle.

Any variation of speed of the vehicle being expressed by a variation of voltage, the regulator, the role of which is to maintain a constant current in the circuit, causes displacement of the accelerator in a manner to obtain a corresponding value of resistance of the coasting drum.

Accelerator positioning by the coasting circuit is automatically in service:

(a) when the equipment is not in traction or braking coupling (free coasting);

(b) when the equipment reaches series end and parallel coupling is not required.

## 6. STARTING AND SERIES PARALLEL TRACTION

The driver depresses his traction pedal to a position beyond $70^{\circ}$ and then holds it in any driving position whatsoever.

Contact 5A -5G of MC closes and causes energisation of the series traction relay Rt1

Contact 5A -5B of MC closes and causes energisation of the series parallel traction relay Rt2

Rt2 closes

Contact 2A - 2B opens and impedes eventual feed of the series coupling shunting control circuit.

Contact 4K - 4M opens and impedes eventual feed of contactor 0

Contact 5B - 5G closes and interlocks feed to its own coil which causes the relay to remain closed even if pedal MC is retracted to a position less than $70^{\circ}$

The demand for series-parallel coupling is therefore irreversible and it may be cancelled only by retracting the pedal to 0.

This arrangement allows series-parallel coupling to be obtained while returning the pedal to a position giving a minimum starting current instruction.

Rt1 closes

The sequence described for series coupling is repeated point by point until the accelerator attains position 60

Ref. 3 ENG 135 Contactors LS - S - R1 and R2 are closed and the four traction motors are coupled in series and fed across the accelerator at 0 ohms

Accelerator in position 60

Contact 4C - 4J closes and causes energisation of the parallel coupling contactors P1 and P2

Ref. 3 ENG 135 - Contactors LS, R1, R2, S, P1 and P2 are closed, the line voltage is fed to a circuit formed from motors III+ IV in parallel with portion 61 - 95 of the accelerator, all in series with motors I + II in parallel with portion 60 - 94 of the accelerator. The four traction motors are therefore fed in series but the parallel resistances of the accelerator are ready to be placed in service. The transition coupling is thus realised.

P1, P2 closed:

Their contacts B60-4 and 4-4A close and cause energisation of auxiliary relay Rp (x-PR-x).

Their contacts 6-6A and 6A-6B close and ensure holding of contactors P1, P2.

Their contacts 4D-4E and 4E-4F open and cause de-energisation of contactor S.

Ref 3 ENG 135 - Contactor S being de-energised, line voltage feeds in parallel the circuits formed on the one part by motors III + IV in series with portion 60 - 94 of the accelerator and on the other part by motors I + II in series with portion 61-95 of the accelerator. The series parallel coupling is thus obtained.

Rp opens:

Contact 4C - 4G closes and ensures direct feed of contactors P1 & P2.

Contact 6C -6D closes and prepares to hold contactor R1.

S opens:

Contact 6-6B opens but without effect on R1 because this is fed across contacts 6 - 6A and 6B, previously closed, of P1 and P2.

As in series starting, the traction regulator controls the displacement of the accelerator so as to maintain a constant value of starting current.

When the accelerator passes position 69, its contact 6B -6D opens but without effect on R1 because this is fed across the contact 6C - 6D, previously closed, of Rp.

The speed of the vehicle increases, elimination of parallel resistors follows to 0 ohms when the speed attained at the required current allows the motors, fed under full voltage, to return to their natural characteristic with full field.

At the moment when the accelerator passes position 91 its contact 5U - 5T closes and causes de-energisation of the parallel end coupling contactors M1 and M2.

Ref. 3 ENG 135 - Contactors M1 and M2 being closed, the accelerator resistances are no longer used and the traction motors are fed directly through the circuits LS - III + IV - R2 closed - M2 closed and LS - M1 closed - R1 closed - I + II.

M1 and M2 close :

Contact B60 - 2C of M1 closes and prepares feed to the series-parallel shunting circuit.

The accelerator reaches position 108, its contact 2C - 2A closes and causes energisation of shunting contactor F1 .

F1 closes:

Contact B60 - 2F closes and causes energisation of shunting contactor F2

Still under the control of the traction regulator, the accelerator moves on to position 125, its contact 2A - 2D closes and causes energisation of shunting contactor F3

F3 closes:

Contact B60 - 2G closes and causes energisation of shunting contactor F4

Its contact 2A - 2D closes and short circuits contact 2A-2D of the accelerator, interlocking energisation of F3.

Ref 3 ENG 135 - The contactors LS - R1 - R2 - P1 - P2 - M1 - M2 -
( F1 - F2 - F3 - F4 being closed, the vehicle functions under
( the natural characteristic of the four motors coupled in
( series-parallel and shunted 50%

7. SERIES PARALLEL TRACTION CUT-OFF

The driver releases his traction pedal, which opens contact 5A -5G of MC causing de-energisation of relays Rt1 and Rt2

Rt2 opens:

Contacts 2A -2B, 4C - 4D, 8F - 8G close and its contacts 4G-4K,5B-5G open but without any direct effect on the sequence.

Rt1 de-energises:

Contacts 6D -6E open and cause de-energisation of contactor R1.

Contacts 8D - T open and interrupt the traction regulation command from BCS causing this to pass to coasting regulation.

The other contacts have no direct action on the sequence.

R1 opens:

Contact B60 -6F opens and causes de-energisation of contactor R2.

R2 opens:

Contact 5L - 5X opens and causes de-energisation of the line breaker LS.

Ref. 3 ENG 135. De-energisation of contactors R1 and R2 has the effect of reinserting the cushioning resistances R1 and R2 in each branch of the motors before de-energisation of LS and cut off of traction current.

LS opens:

Contact B60 - 4C opens and causes de-energisation of contactors P1 and P2.

P1, P2 open:

Their contacts B60 - 4 and 4 - 4A open and cause de-energisation of relay Rp.

Rp opens:

Contact B60 - 5U opens and causes de-energisation of contactors M1 and M2

M1 and M2 open:

Contact B60 - 2C opens and causes the eventual de-energisation of the shunting contactors.

Their contacts 3I - 3K and 3F - 3G close and allow

energisation of the pre-magnetisation relay K2.

The traction coupling sequence is finished and the equipment once more is in free coasting, that is to say

no current in the motors,
motors I + II pre-excited, and
positioning of the accelerator as a function of the vehicle speed.

8. RHEOSTATIC BRAKING

The driver depresses the brake pedal, contact 3C - 3A of BC closes, and causes energisation of the braking relays Rf1 and Rf2 (x-BR1 and BR2-x).

Rf1 and Rf2 close:

Contacts B60 - 6E and B60 - 6F of Rf1 close and cause energisation of contactors R1 and R2 (x-C1 and C2-x)

Contact 3M - 3J of Rf1 closes and prepares feed of the braking contactors B1, B2, B3.

R1, R2 energised:

Contact 3J - 3P of R2 closes and in completing the circuit causes energisation of braking contactors B1, B2, B3.

Ref. 3 ENG 135 - Braking contactors B1. B2 and B3 being closed, motors I + II pre-excited, start to generate and feed into the following circuit:-
R1 closed - accelerator 135 -1 - B1 closed - Fields III + IV - B3 closed.
Motors III + IV also start to generate and feed into the following circuit:-
B3 closed - Field Coils I + II - accelerator 134-2 - B2 closed - R2 closed.
The two motor groups have their excitations crossed thus feeding as self excited series generators separately to the two parts of the accelerator.

B1 closes:

Contact +40 - F closes and instructs BCS (x-SCU-x) to pass to braking regulation.

Contact B60-2 closes and, if the accelerator is between positions 135 and 108, causes energisation of contactor F1 which in turn causes energisation of contactor F2.

B3 closes:

Contact 2E -2G opens and, irrespective of the position of the accelerator, impedes closing of contactor F3.

Note that 50% shunting is not used in rheostatic braking. Elimination of braking resistances is effected under the control of the braking regulation of the BCS and the value of the regulated current will be a function of the degree of depression of the brake pedal.

NOTE Contactor K2 remains closed in rheostatic braking but with practically no influence on it.
Speed of the vehicle falls, the accelerator returns towards position 1 and, on passing position 107, causes de-energisation of contactors F1 and F2.

TRA 691015-7 The brake pedal being depressed, contacts 35I - 35B of BC are open and the transmission brakes are fed across contact 35C - 35A, closed of LO (x-LOR-x)and of closed contact 35A - 35 of the accelerator.
When the accelerator returns to position 6 its contact 36A - 35 opens and the transmission brakes, fed this time across resistance WT, are applied in the firstdegree, thus adding to the braking effort and preparing the stop of the vehicle.
With the accelerator in position 1, the braking resistance can decrease no further and, the speed of the vehicle continuing to drop, the rheostatic braking current falls and tends to disappear. At this moment, relay LO opens and the opening of its contact 35C - 35A cuts the power the power to the transmission brake which applies in the second degree and assures stopping of the vehicle.

9. RHEOSTATIC BRAKING MONITORING

If rheostatic braking is demanded, and no current appears in the braking circuit, the braking monitoring relay LO, controlled by BCS, opens.

LO opens:

Ref. TRA 681015-7 ( Contact 35C-35 of LO opens and cuts power to the transmission brakes which are thus applied. Rheostatic brake failure is thus automatically replaced with transmission brakes.

As described previously relay LO is also used to assure stopping of the vehicle at the end of rheostatic braking.

10. CUT-OFF OF RHEOSTATIC BRAKING

If during rheostatic braking the driver releases the brake pedal, contact 3C-3A of BCa opens and causes de-energisation of relays Rf1 Rf2.

Rf1 and Rf2 open:

Contact 3M-3J of Rf1 opens and causes de-energisation of contactors B1, B2, B3

Contacts B60 - 6E and B60 - 6F of Rf1 open and cause de-energisation of contactors R1 - R2.

Ref. 3 ENG 135 ( Contactors B1 - B2 - B3 - R1 - R2 open, the motors run free and the equipment thus moves to coasting coupling.

11. RETURN TO TRACTION

If this return is effected when before the accelerator reaches the series end position, contactors LS - S - R1 - R2 close following the sequence previously described.

Ref. 3 ENG 135 ( Contactors LS - S - R1 - R2 being closed, the four traction motors coupled in series are fed across what remains of the series resistance of the accelerator. The rest of the sequence is identical to that described previously.

If the return is effected when the accelerator has passed the series end position, closing of LS causes closing of contactor S which in its turn causes closing of contactor O. Hence series traction coupling is again established but the re-connection of the motors to the supply is effected initially (S closed and O open) across resistances R1 and R2 as well as the remainder of the accelerator resistances.

If the return is effected when the accelerator has passed position 60 (end of series) and the driver requires series-parallel coupling, closing of contact B60 - 4C of LS causes simultaneous feed of contactors S and P1, P2 but these latter being fitted with 24V coils close more rapidly and the opening of their contacts 4D-4E and 4E - 4F effectively prevent energisation of contactor S.

P1, P2 closed

Their contacts 6 - 6A and 6A - 6B close and cause closing in cascade contactors R1 and R2.

Ref 3 ENG 135 ( At the end of the sequence, the traction motors are coupled in series-parallel and each group is fed across the remainder of the parallel resistance after passing through the stage of elimination of cushioning resistors R1 and R2. The rest of the sequence is identical with that described previously.

## 12. PASSAGE TO SERIES PARALLEL AFTER OPERATION IN SERIES

After operating for some time in series, the driver depresses the traction pedal to the series-parallel position. Remember the following are closed:

Line breaker LS
Contactors S, O, F1 and F2
Relay Ro
Eventually, F3 and F4

Depression of the pedal to the series-parallel position closes contact 5A - 5B of BCa which causes energisation of relay Rt2 (x-SPR-x).

Rt2 closes:

Contact 4K - 4M opens and causes de-energisation of contactor O

Contact 4M - 4G closes and causes energisation of contactors P1 and P2

P1 and P2 close:

Their contacts B60 - 4 and 4 - 4A close and cause energisation of relay Rp (x-PR-x).

Their contacts 4D - 4E and 4E - 4F open and cause de-energisation of contactor S.

Ref. 3 ENG 135 Contactors P1 and P2 being closed and contactors S and O opened, the traction motors, coupled in series-parallel, are fed across the remaining parallel resistance of the accelerator and the corresponding cushioning resistances R1 and R2.

Rp closes:

Contact 6C - 6D is closed and causes energisation in cascade of contactors R1 and R2

Ref. 3 ENG 135 Contactors R1 and R2 being closed, the cushioning resistors R1 and R2 are cut out and we return to the series-parallel arrangement described previously.

## 13. COASTING MONITORING

A monitoring circuit incorporated in the BCS continually controls the proper operation of the coasting positioning circuit.

If no coasting measure signal is received bynthe BCS the latter causes de-energisation of the coasting monitoring relay RSD (x-CCM-x)

RSD opens:

Equipment in coast

Contact 3B - 3A of RSD closes: Contact B60 - 3B of Rt1 being closed, the braking relays Rf1 and Rf2 close, causing the equipment to pass to minimum rheostatic braking coupling.

Equipment in series traction

Contact 4L - 5G of RSD closes and, because of the closing of contact 4L - 5B of Ro, causes energisation of relay Rt2, that is, causes forced transition into series-parallel.

14. TRACK BRAKES

Ref. TRA 691015 - 5. Depression of the brake pedal to a position beyond 90° ensures closing of the contact B11 - 360 of BCa which causes energisation of contactor FP

FP closes:

Principal contact B1 - B6 closes and consequent excitation of the track brakes causes them to be applied.

The braking effort produced by the track brakes is superimposed on that produced by the rheostatic braking or transmission braking.

Contact B1 - 37 closes and operates the alarm buzzers BZ1 and BZ2, illuminating the indicator lamps L5 and L6 at the same time.

Contactor FP may also be closed during braking by a signal 360B produced by the anti-slip circuit of BCS.

15. DEAD MAN

Whilst the vehicle is in motion, the driver releases or depresses to maximum the dead man pedal.

Contact 5H - 5L of HMa opens and causes the eventual de-energisation of LS, that is, cuts off traction.

Contact B60 - 3 of HMa closes and causes energisation of the brake relays Rf1 and Rf2

Ref. TRA 691015 - 6 Contact B61-10 of HMa closes and, via the closed contact 10A - 10B of LO, causes closing of relay RHM (x-DMR-x)

RHM closes:

Contact 10A - 10B closes, self-interlocking the relay and making it independent of the state of the LO contact.

Ref. TRA 691015 - 5 Contact B1 - 36 of RHM closes and causes feed to thetrack brakes.
Contact B1 - 37 of RHM closes and causes operation of the buzzers BZ1 and BZ2 and lamps L5 and L6.

Ref. TRA 691015 - 3 Contact GA1 - 28 of RHM opens and cuts power to the doors, freeing the electric lock of these latter.

16. MOTOR CUT OUTS

Each group of motors may be cut out by manipulating the motor cut out switch.

MCO on I + II : motors III + IV cut out
MCO on 4M : 4 motors in service
MCO on III + IV : motors I + II cut out

Assume MCO is placed on I + II

Contact 3E - 3F opens and eventually cuts off energisation of the braking contactors B1, B2, B3, also that to contactor K2.

Contact 4G - 4H opens and eventually impedes energisation of the series parallel coupling contactors P1 and P2.

Contact 4K - 4M closes and short-circuits contacts 4K - 4M of Rt2.

Ref. 3 ENG 135 - Contacts T4 - X2 and M2 - 02 of MCO are open while the points T4 - 02 are short circuited. The motors III + IV are thus completely isolated and continuity of the high tension circuit is assured by the joining of T4 to 02.

TRACTION

The driver depresses his traction pedal to the series-parallel position.

Rt1 and Rt2 close:

Relay Rt1 closing causes the closing sequence in series coupling similar to that described previously.

Ref. 3 ENG 135 ) The contactors LS - S - R1 and R2 are closed and the traction motors I + II are fed under full voltage through the circuit LS - MCO T4/02 - R2 closed - accelerator 2-60, S closed, accelerator 1 - 61, R1 closed.

When the accelerator reaches position 60 under the control of traction regulation, contactor 0 closes, but the contactors P1 and P2, isolated by opening of contact 4G - 4H of MCO, cannot be fed.

Ref. 3 ENG 135 Contactor 0 opens, motors I + II are fed directly by the line voltage and function on their natural characteristic under full voltage and the position of the accelerator is assured by the coasting circuit.

BRAKING

The driver depresses his brake pedal but coils B1, B2, B3 being isolated by the opening of contact 3E - 3F of MCO, rheostatic braking is not established which in effect causes through the medium of BCS de-energisation of relay LO.

LO opens :

Supply to the transmission brakes is cut and these are applied, thus replacing the inoperative rheostatic braking.

COASTING

Ref. 3 ENG 135 - The position of the accelerator having to be different in coasting with two motors cut out, a fixed resistance placed in circuit by the closing of contact D2 - D22 of MCO, modifies the ratio of coasting current to coasting measure voltage.

IN CASE OF FAILURE OF COASTING

Relay RSD opens:
Contact 3B - 3A closes and causes energisation of relays Rf1 and Rf2
Contact 8K - 8H closes and prepares feed of the braking command circuit of the BCS

Rf1 and Rf2 close:

Contact 35G of Rf2 opens and cuts supply from the circuit holding in relay LO. As no braking current appears, after about 0.6 seconds the BCS causes de-energisation of relay LO.

LO opens

Contact 8K - F closes and allows feed of the braking regulation control of the BCS which, in the absence of a measured current, causes immediate regression of the accelerator.

FAILURE OF COASTING

A return to traction effected in these conditions therefore will still be made, whatever the speed of the vehicle, with all the starting resistance inserted in the supply to the traction motors.

17. MOTOR OVERLOAD

Ref. 3 ENG 135 - The series coil of the overload relay OL is fed by the traction current and causes energisation of the relay if the value of that current reaches or passes a pre-determined value.

OL closes

Contact 5C - 5E opens and causes de-energisation of line breaker LS

Contact 5C - 5D closes and permits feed of the holding coil of OL

Relay OL thus cannot open unless the driver in returning his traction pedal to the released position causes de-energisation of the traction contactors.

18. NO VOLT

If line voltage is lost whilst the equipment is in traction, the no volt relay RTN (x-NVR-x) opens.

RTN opens:

Contact B60 - 6 opens and causes the de-energisation in cascade of contactors R1 - R2

Contact 4N - 4P opens and causes the eventual de-energisation of contactor 0

Contact 5T - 5V opens and causes the eventual de-energisation of contactors M1, M2

NOTE:
Contactor R1 is de-energised to place the accelerator under the dependence of the coasting regulation.

When the line voltage re-appears, it is applied to the motor circuit but across cushioning resistances R1, R2 and that portion of the resistance between the position occupied by the accelerator and:-

in series, position 50 (contactor 0 de-energised)
in series-parallel, position 95 (contactors M1, M2 de-energised)

The re-appearance of the line voltage also re-closes relay RTN.

RTN closes:

Closing of the contacts causes:
Energisation in cascade of contactors R1, R2
Eventual energisation of contactor 0
Eventual energisation of contactors M1, M2

## 19. SAFETY DEVICES, CONTROLS AND INTERLOCKS

Doors

When the driver closes the door unlocking switch ID3, the opening of contact B60 -B63 of ID3 prevents the energisation of the traction circuits.

When doors 2 or 3 are opened, and when override switches IDP2 or IDP3 are not closed, opening of the door contacts S2i or S3i prevents closing of traction relay Rt1.

Electronic Power Supply

A micro relay, incorporated in the PAS panel, continually controls the proper operation of that unit and causes, in case of fault, the de-energisation of relay RZ (x-ZR-x)

RZ opens:

Contact 5S - 5Y opens and impedes or cuts off supply to the line breaker LS coil.

Contact 8B - 7G opens and cuts off supply to the circuit forming the pedal instruction.

Transmission Brake Signals

Ref. TRA 691015 - 7 Relay TDR, timed for closing, is energised if traction is attempted (contact B2 - 74A of Rf2 is closed) while at least one of the transmission brakes remains locked (Corresponding contact 74 - G is closed).

Relay TDR is similarly excited if traction is attempted while the motor ventilator group is stopped. (Contact 74-G of RC is closed)

Ref. TRA 691015-13 - TDR closes. Contact B3 - 90 closes and supplies the alarm buzzers BZ3 and BZ4.

At the same time, in order to prevent closing of the different sequence contactors, a series ofauxiliary contacts take over the control of the energisation.

Brake interlocks:

Closing of braking contactors B1, B2, B3 is impossible when the traction contactor assembly LS - M1 - P1 - P2 - M2 - O and S are not de-energised.