British Rail

TECHNICAL TRAINING NOTE APT/7.2

CIRCUIT DESCRIPTION
APT POWER CAR

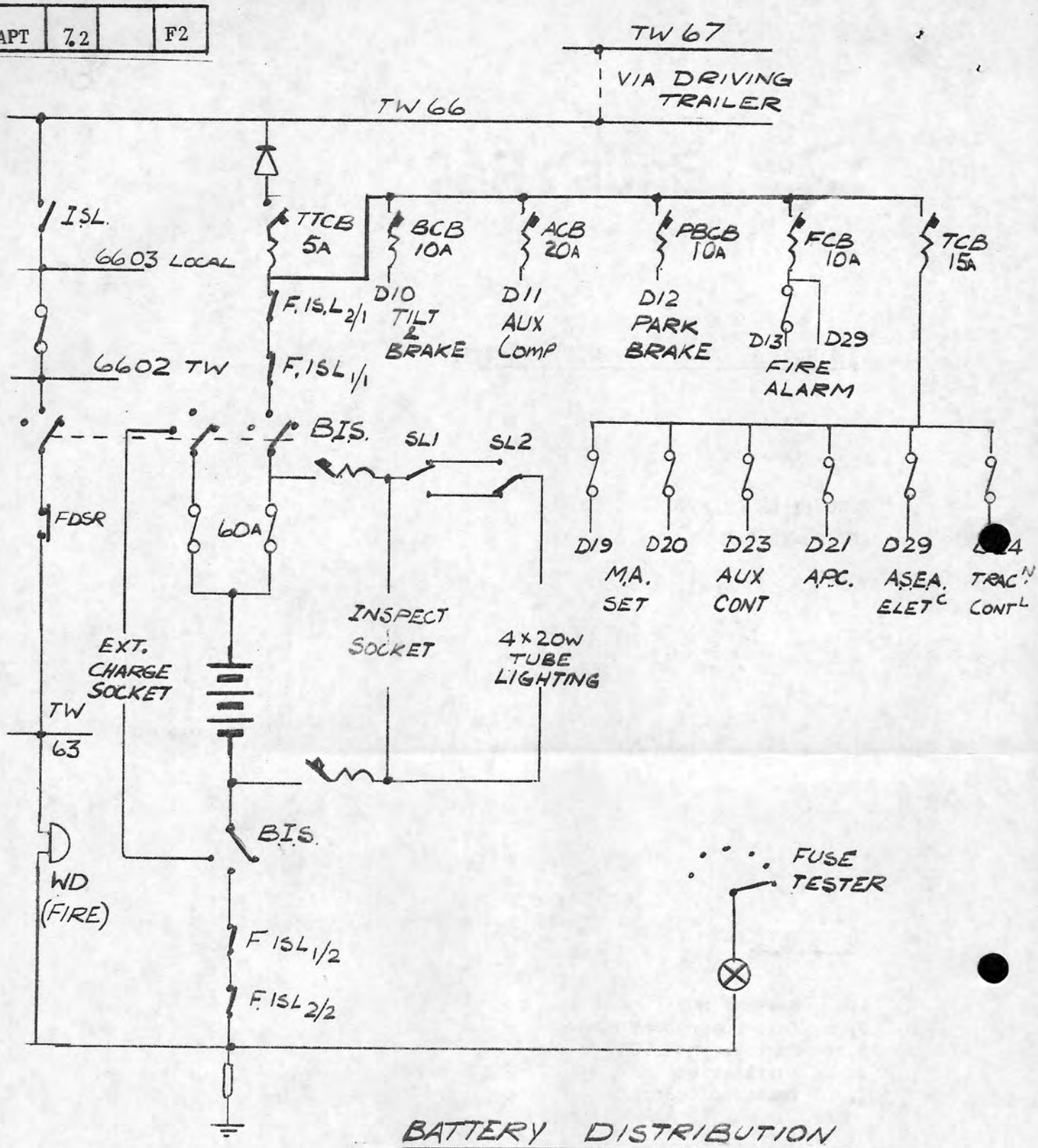
CONTENTS:-

1. Battery Supplies
2. Aux. Compressor System
3. Pantograph & VCB
4. Auxiliaries
5. Traction Control

RAILWAY ENGINEERING SCHOOL,
BRITISH RAILWAYS, DERBY.

APT	7.2		F1

APT	7.2		F2



BATTERY DISTRIBUTION

A.P.T. POWER CAR

TECHNICAL TRAINING NOTE APT/7.2

CIRCUIT DESCRIPTION APT POWER CAR

These notes are based on the following drawings:-

AH-AO-0399	110V Battery Distribution
0018	Sheet 1 Aux Control
"	Sheet 2 " " M.A. Sets
"	Sheet 3 " " Fault Indicators
0017	Aux Power
0013	M.A. Set Power
0010	Traction Power
0067*	Sheet 1 Traction Control
	Sheet 2 " " Fault Indicators
AJ-AO-0119	Cab Controls

* Extracts have been taken from these drawings for training purposes only and reference must be made to the official drawing which will be kept up to date.

1. BATTERY SUPPLIES AH-AO-0399

1.1 Lighting

Available from the battery at all times; controlled by two-way switches SL 1 & 2 located on the left hand side at each vestibule.

1.2 Control Supply

Close the BIS at the battery this will provide the following supplies:-

1.2.1 Traction via TTCB 5X TW66 and from this wire via traction Control Isolating switch onto local wire 6603

1.2.2 Tilt and Brake D10 via BCB 10X

1.2.3 Aux Compressor D11 via ACB 20X

1.2.4 Parking Brake D12 via PBCB 10X

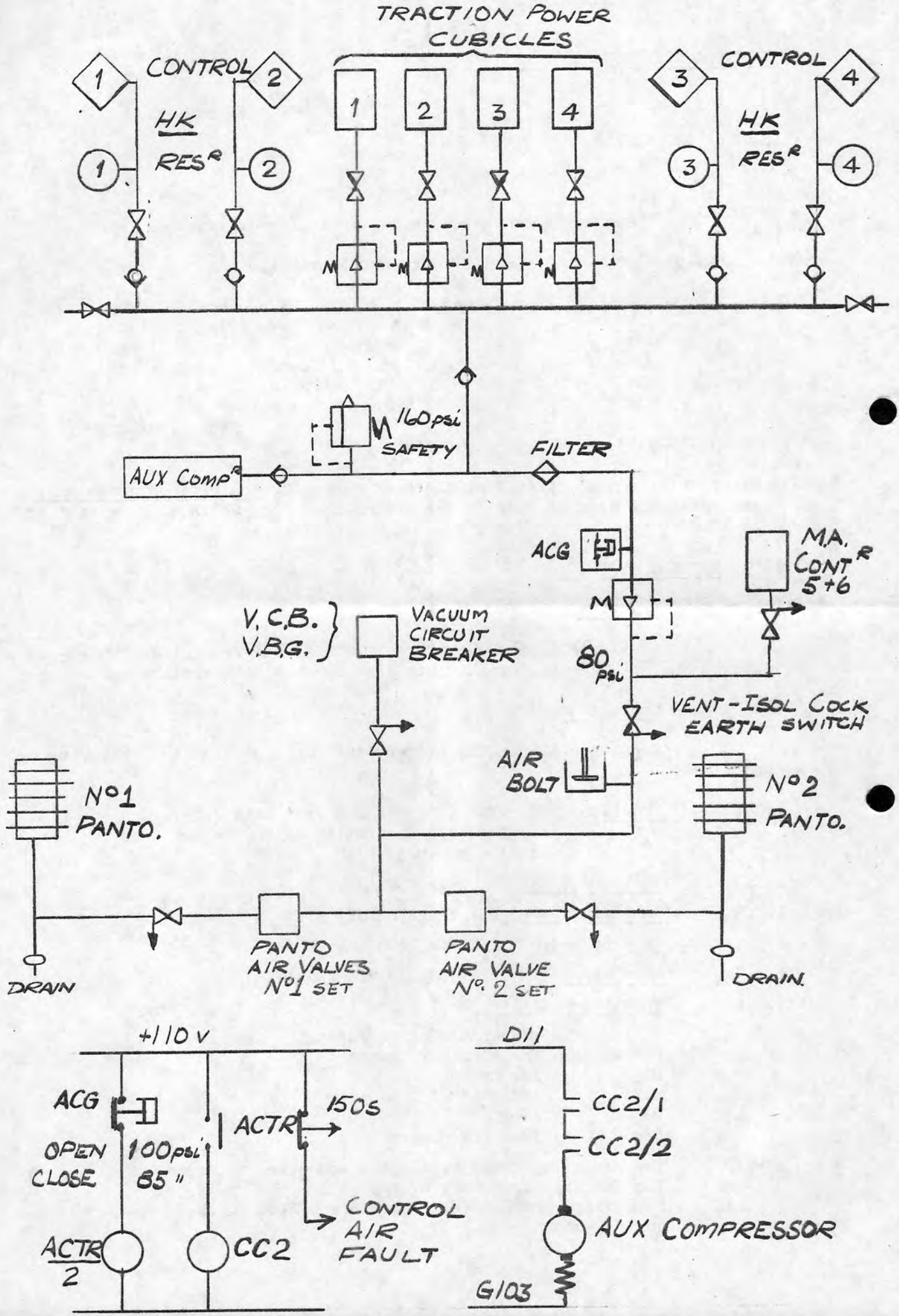
1.2.5 Fire Alarm D13 and D29 via FCB 10X

1.2.6 Traction Circuits

All via TCB 15X and separate fuses.

D19 and D20	for M.A. Set control 5 & 6
D23	Aux Controls
D21	APC "
D9	ASEA "
D24	Traction Control

NOTE 1. The negative of the battery is connected to frame
2. The fuse tester rotary switch
3. Fire alarm circuit (WD) via BIS and FDSR which is open during running


TRACTION POWER CUBICLES
CONTROL
1
2
3
4
HK
RESR
160psi
SAFETY
FILTER
AUX CompR
ACG
M.A. CONTR 5+6
V.C.B.
V.B.G.
VACUUM CIRCUIT BREAKER
80 psi
VENT-ISOL COCK EARTH SWITCH
AIR BOLT
No1 PANTO.
No2 PANTO.
DRAIN
PANTO AIR VALVES No1 SET
PANTO AIR VALVE No. 2 SET
+110 V
ACG
OPEN
CLOSE
100psi
85"
ACTR
150s
CONTROL AIR FAULT
ACTR 2
CC2
D11
CC2/1
CC2/2
AUX COMPRESSOR
G103

2. AUXILIARY COMPRESSOR SYSTEM

2.1 Operation of Auxiliary Compressor

With no air in the system the contacts of pressure switch ACG will be closed and so energise relay ACTR coil which will:-

a) energise contactor coil CC2 to run the compressor
b) delay for 105 sec any warning of no air in the aux compressor system

The compressor will cycle on/off under the control of pressure switch ACG opens 100 psi close 85 sec and will deliver air at 80 psi to:-

c) the EP contactors of the MA sets
d) Vent-Isolate cocks and air bolt of the earthing switch
e) the vacuum circuit breaker and its VBG
f) the control valves up/down for No 1 Pantograph and to No 2 Pantograph where fitted.

NOTE

The earthing switch must be out i.e. in the "not-earthed" position before the vent cock can be operated to make air available to the air bolt; for operation of the VCB and for operation of the pantograph.

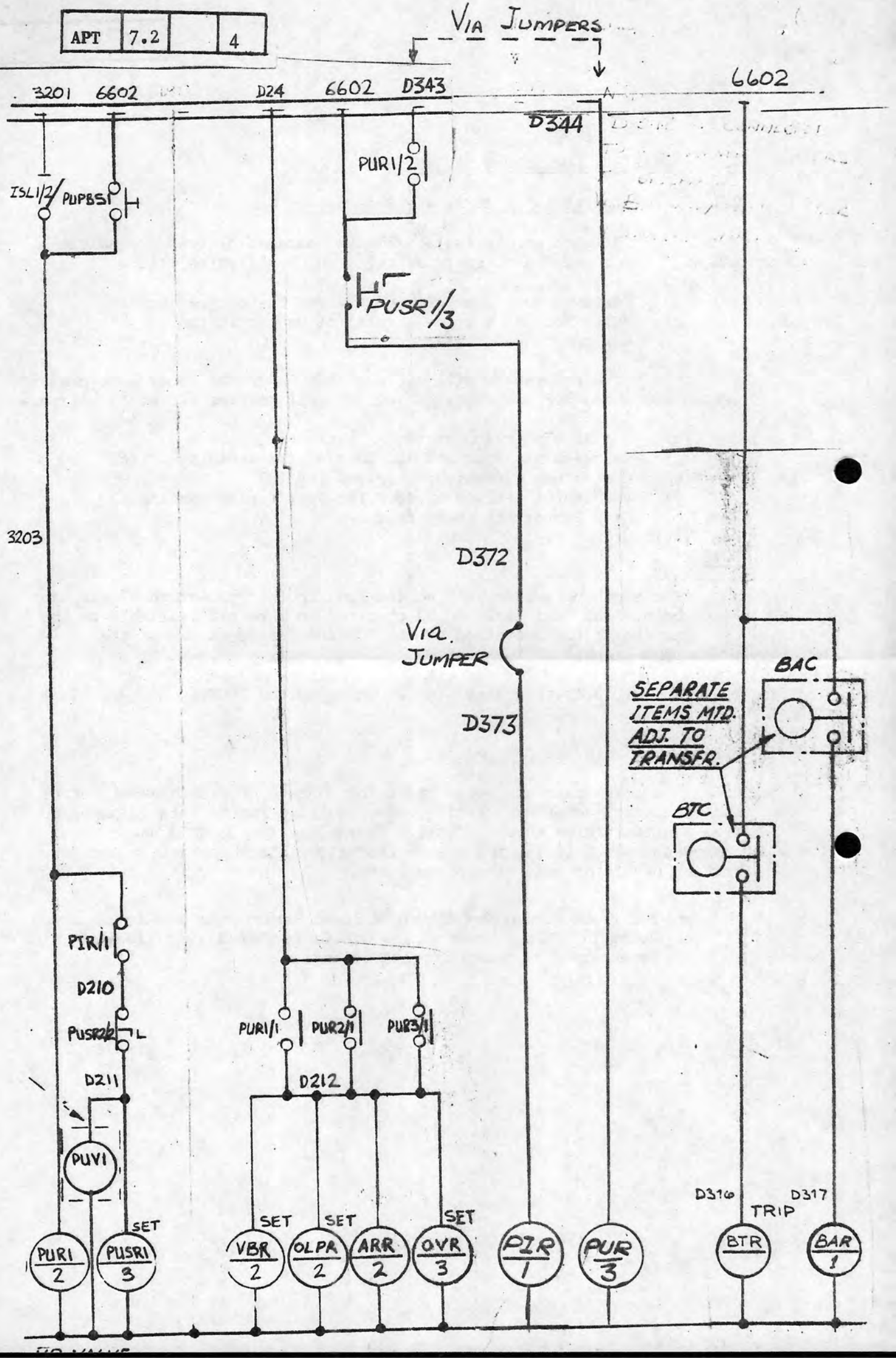
The air bolt then locks the earthing switch "OUT".

2.2 Main Air Compressor

The main air system i.e. for four sets of HK brake (control and reservoir) and four traction power cubicles (at 80 psi) is supplied from the train pipe which is itself charged by the 30 HP 3 phase compressor which is located beside the motor alternator set in the van trailer (FV3) for that rake of vehicles.

* Note Air Blast Breakers (ABB's) of Brown Boveri type are at present being fitted in place of the G.E.C. Vacuum Circuit Breakers. (see page 7 for circuit alterations).

APT	7.2		4


VIA JUMPERS
3201
6602
D24
6602
D343
D344
6602
PUR1/2
ISL1/2
PUPBS1
PUSR1/3
3203
D372
VIA JUMPER
D373
BAC
SEPARATE ITEMS MTD. ADJ. TO TRANSFR.
BTC
PIR/1
D210
PUSR2/2
D211
PUV1
PUR1/1
PUR2/1
PUR3/1
D212
SET
SET
SET
SET
PUR1 2
PUSR1 3
VBR 2
OLPR 2
ARR 2
OVR 3
PIR 1
PUR 3
D316
D317
TRIP
BTR
BAR 1

3. OPERATION OF PANTOGRAPH AND V.C.B.

3.1 By Driver In Cab 1

3.1.1 Pantograph

When a supply of air has been established by the auxiliary compressor (which runs automatically once the BIS is closed) and with "Aux" position selected.

Depress the Pan Up button this will energise TW 32 however dependent on which end cab is used either wire 3201 or 3202 will be energised.

W3201

This via the traction isolation switch will energise PUR1 which will:-

1. Reset VBR OLPR and OVR and pick up ARR *
2. Connect 6602 to D343 and via jumpers to D344 to pick up PUR3 on other power car, NB PUR3 repeats (1) operation on other power car to close its VCB but not to raise its pantograph.

Energise PUV1 which will put up the appropriate pantograph for the driving cab selected.

Energise PUSR1 which will select the appropriate APC control receiver i.e. to coil ADSR via receiver APD1 or APD2 contacts.

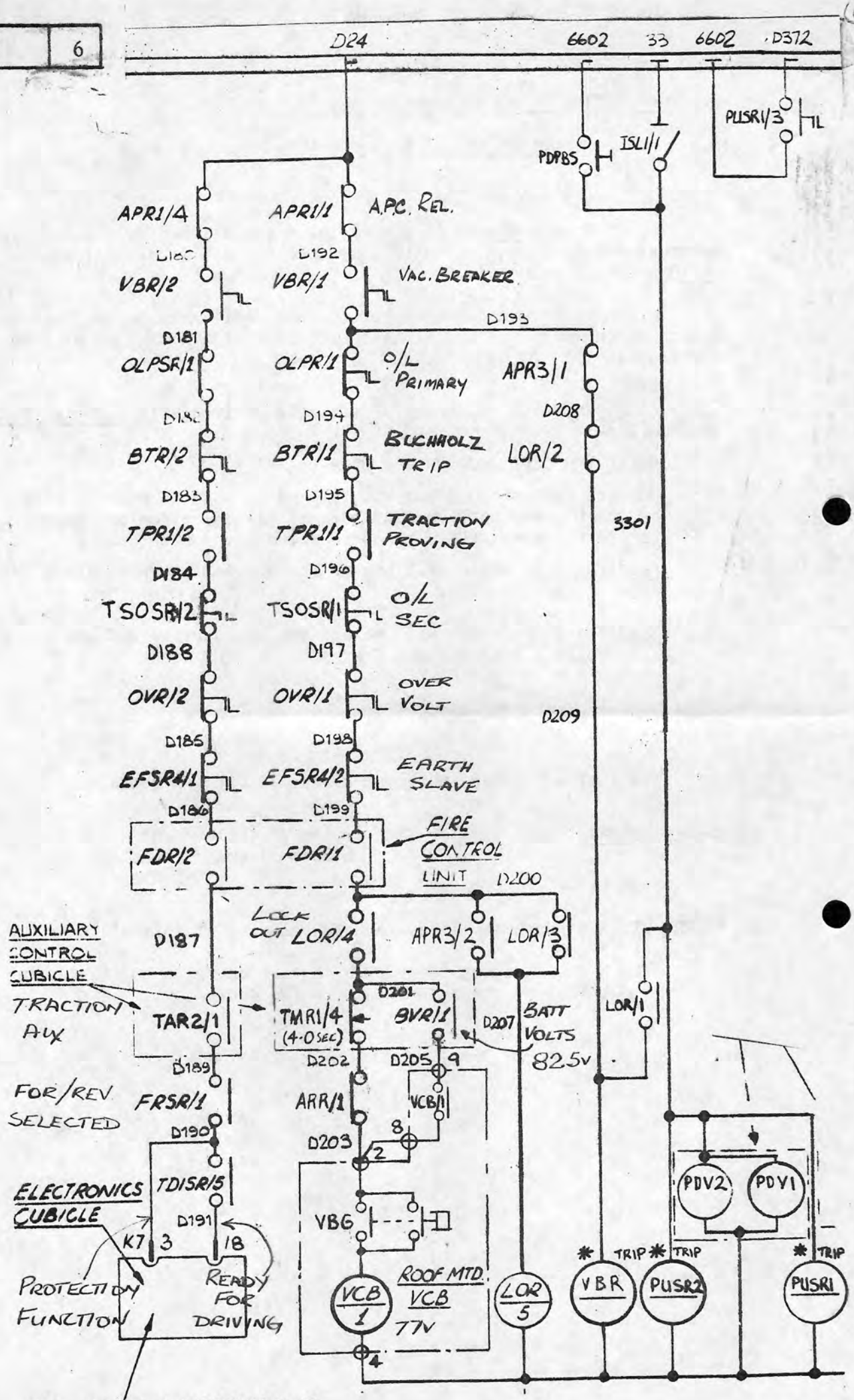
Note. PUSR1 or PUSR2 relays.

The TRIP coil when energised closes /2 Latched contacts
opens /1 and /3 "

The SET coil " " opens /2 (unlatched)
" " closes /1 and /3 contacts

* ARR /1 N/C contact will prevent VCB closing at this stage

/2 N/O will energise APR3 which will energise LOR (lock out relay) to prepare circuit to VCB close coil.


D24
6602
33
6602
D372
PUSR1/3
PDPBS
ISL1/1
APR1/4
APR1/1
A.P.C. REL.
D192
VBR/2
VBR/1
VAC. BREAKER
D193
D181
OLPSR/1
OLPR/1
O/L PRIMARY
APR3/1
D208
D194
BTR/2
BTR/1
BUCHHOLZ TRIP
LOR/2
D195
TPR1/2
TPR1/1
TRACTION PROVING
3301
D184
D196
TSOSR/2
TSOSR/1
O/L SEC
D188
D197
OVR/2
OVR/1
OVER VOLT
D209
D185
D198
EFSR4/1
EFSR4/2
EARTH SLAVE
D186
D199
FIRE CONTROL UNIT
FDR/2
FDR/1
D200
AUXILIARY CONTROL CUBICLE
TRACTION AUX
D187
LOCK OUT
LOR/4
APR3/2
LOR/3
D201
TAR2/1
TMR1/4 (4·0 SEC)
BVR/1
D207
BATT VOLTS
82.5V
LOR/1
D202
D205
9
D189
FOR/REV SELECTED
FRSR/1
ARR/1
VCB/1
8
D190
D203
2
ELECTRONICS CUBICLE
TDISR/5
D191
VBG
K7
3
18
PROTECTION FUNCTION
READY FOR DRIVING
VCB 1
ROOF MTD. VCB
77V
LOR 5
PDV2
PDV1
VBR
PUSR2
PUSR1
TRIP
4
SEE A.S.E.A. INTERFACE DWGS. 6134 144E SHTS 69 & 70

3.1.2 Vacuum Circuit Breaker (Closed)

Release the "Pan Up" button this will de-energise PUV1 but the spool will stay over maining an air supply to allow hold up of the pantograph by its springs.

Relay ARR will also be de-energised and its N/C contacts will close to energise VCB coil which close the vacuum circuit breaker and retain itself via the hold in circuit of BVR (battery volts relay) and VCB interlock.

BVR/1 contacts will open if the battery volts fall below 82.5 V.

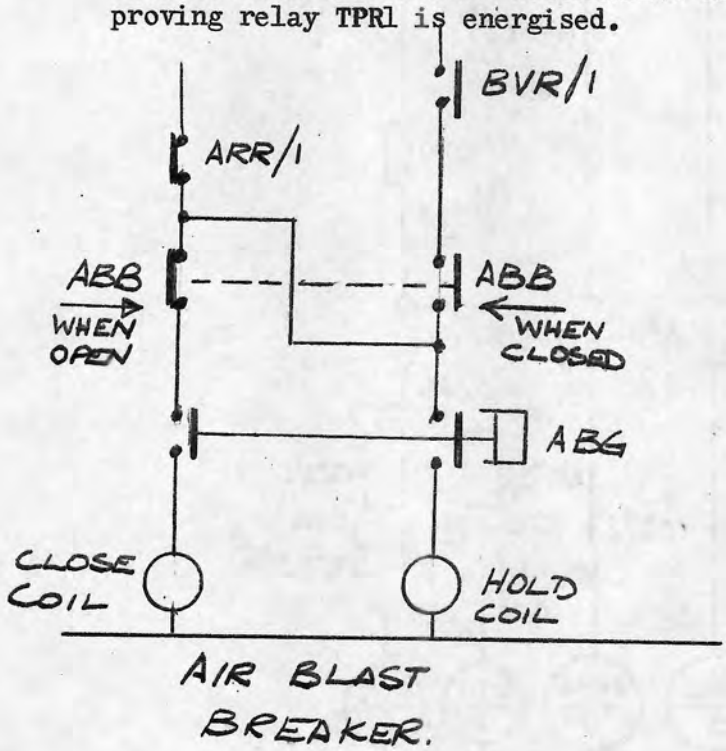
However because the VCB coil can operate down to 77V it is arranged that TMR1 /4 contacts may be used to get the pantograph up and battery charger "ON" in these circumstances.

3.1.3 Pantograph Down & VCB (Opened)

Press the Pan Down button this will energise TW33 and so energise VCB trip coils on both power cars thereby getting VCB main contacts opened.

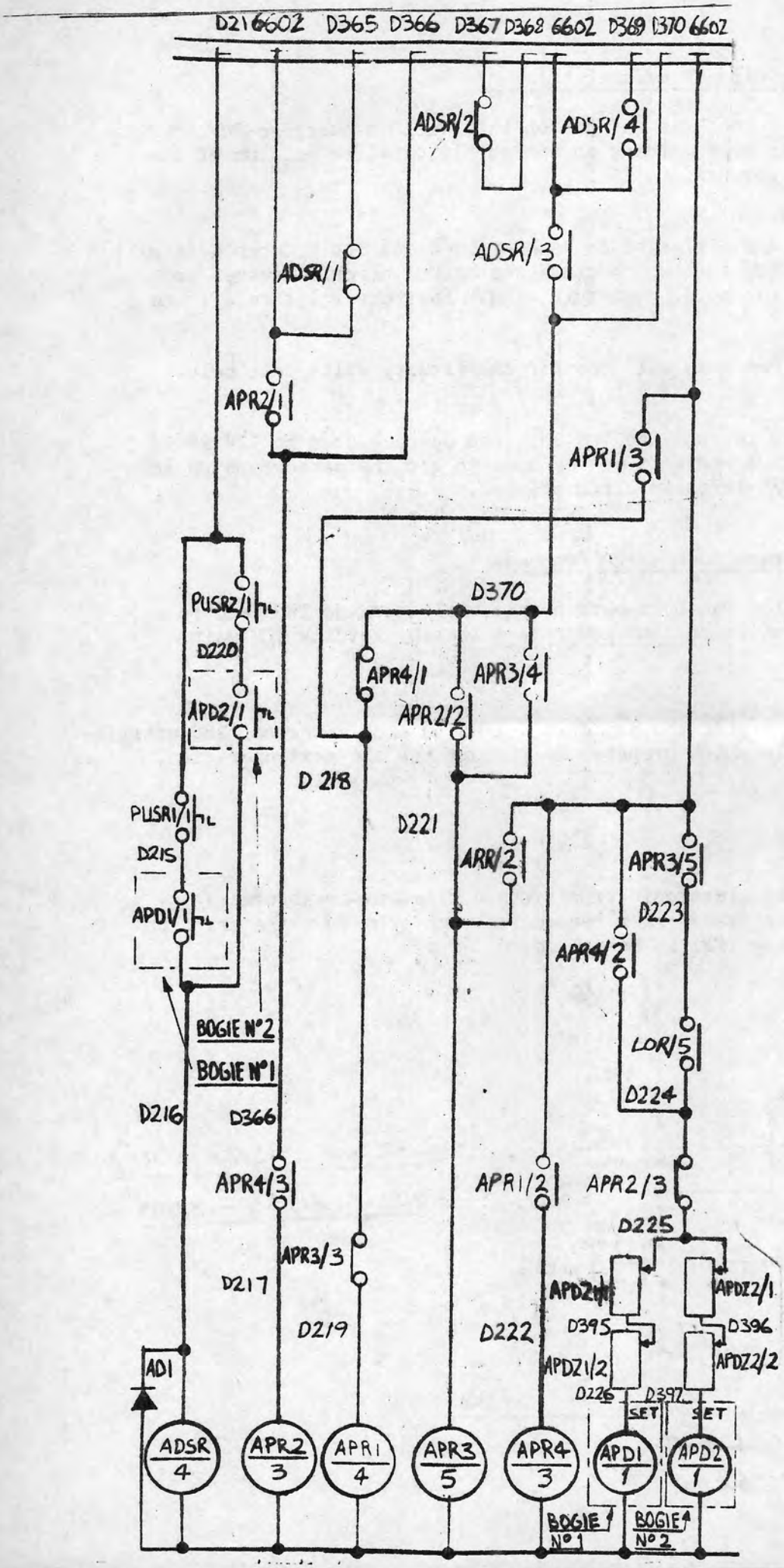
Also energise the pan down valves on each power car and energise PUSR1 & 2 trip coils which prepare the circuit for the next operation.

NOTE Provided the electronic supply/the excite-aux transformer/ and the main transformer secondaries are good then the traction proving relay TPR1 is energised.



CIRCUIT ALTERATION WHEN ABB FITTED

APT	7.2		8


D216 6602 D365 D366 D367 D368 6602 D369 D370 6602
ADSR/2
ADSR/4
ADSR/3
ADSR/1
APR2/1
APR1/3
PUSR2/1
D220
APD2/1
D370
APR4/1
APR3/4
APR2/2
D 218
D221
PUSR1/1
D215
APDV/1
ARR/2
APR3/5
D223
APR4/2
LOR/5
D224
BOGIE N°2
BOGIE N°1
D216
D366
APR4/3
APR1/2
APR2/3
D225
APR3/3
D217
D219
APD2/2
APD2/1
D222
D395
D396
APDZ1/2
APDZ2/2
D226
D397
SET
SET
AD1
ADSR 4
APR2 3
APR1 4
APR3 5
APR4 3
APD1 1
APD2 1
BOGIE N°1
BOGIE N°2

3.2 Operation of VCB By Track Side Equipment (APC Control)

1st Track Magnet — APR1-4 OUT — LOR & VCB IN

(70 ft Before Neutral Section)

TRACK MAGNET
↓
RECEIVER CONTACTS
↓
Pick Up ADSR
↓
Pick Up APR1 → DO VCB & LOR
→ Remove signal to ASEA box
→ Pick up APR4
↓
APR4 → Attempt reset of receiver
→ Pick up APR2

Neutral Section — VCB & LOR OUT APR1 + APR4 + APR2 in

Receiver Reset - DO ADSR

2nd Track Magnet — VCB & LOR OUT APR1 + APR4 + APR2 in

40 ft in Next Live Section

TRACK MAGNET
↓
RECEIVER CONTACTS
↓
PICK UP ADSR
↓
PICK UP APR3 → DO APR1 → DO APR4 → DO APR2
↘ ↙
Pick up LOR → Close VCB

Pass 2nd Track Magnet

Reset Receiver

D.O. ADSR - DO APR3

RESULTS: VCB + LOR energised

Relays APR1 - 4 de-energised

4. AUXILIARIES

HK Brake pump and fan) Must have 3ø Supply AH-A0-0017
Tilt pumps and heating)

4.1 Auxiliary Compressor 110V .75 kw

With no air pressure ACG contacts will be closed (0-100 psi C.85 psi) and energise ACTR which will:

Run the compressor via CC2 under control of pressure switch ACG.

Delay for 105 sec the low control air fault indication.

4.2 With a good battery we will energise Battery Volt Relay BVR and be able to raise the pantograph and close the VCB.

Now with at least 15 kV on the overhead line we will get sufficient voltage from the 240 v winding of the aux/exc transformer to pick up no volt relay NVR (pu 144v) and this sets some of the following circuits.

At this stage we should start up ma. sets

4.3 Choke Oil Pump 240 V 4.75 kW
Runs continously via COP.CB 40A

Faulty If flow is less than 300 L/m or temperature of oil rises above 95°C will trip COFTR which is delayed from giving a spurious local indication and, in the cab a traction fault light warning

4.4 Transformer Oil Pump 240 v 4.75 kw

Runs continously via TOPLB 40

Faulty If flow is less than 300 L/m or temperature of oil rises above 95°C will trip TOFTR which will give local indication also a traction fault warning in the cab (Timed to avoid spurious warning during normal starting).

4.5 Car Vent Fan 240 v 3.4 kw

Runs continously via CVCB 30X

Faulty Relay CVR drops out to give local indication and cab Traction Fault.

4.6 Thyristor Oil Pump 240 v 7.75 kw

This has a start then run sequence using TMR1 as follows:

The no volt relay NVR and its slave NVSR will pick up the start contactor PSC which will:

a) Put winding Z1-2 in series with two capacitors in parallel
" " s A1-2 in series with A3-4

b) Pick up timer TMR1 which gives a 4 sec start condition then picks up pump run contactor PRC

NB TMR1 gives 4 sec period to raise panto on low battery volt say 80 v.

4.6 Thyristor Oil Pump Cont'd

PRC will now put winding Z1-2 in series with both capacitors and connect in parallel windings A1-2 and A3-4.

Faulty Motor fault will blow TYOPCB (60X) loss of pressure below 22 psi will open pressure switch TYOPS abd drop out TYOPTR (failure of the PRC will also drop out TYOPTR). This will delay for 10 S before dropping out TAR1 & 2 spurious action in pick up which will bring up bright traction fault light in cab from TAR2 only.

TAR1 - for MA sets
TAR2 - for ASEA electronics

4.7 Radiator Cooling Group Fans 240 v 4 @ 3.4 kw

Once the thyristor pump is running PRC/8 will pick up RCC which will run 2 groups of 2 fans via CB's R11, 12, 21, 22 each 30X.

Faulty Drop out R1R or R2R to give local indication

4.8 Traction Motor Blowers 240 v 8 @ 3.4 kw

Must select FOR or REV to energise F/R S.R.

During thyristor pump start cycle PSC will pick up TMR2 via PRC N/L and this will delay start load of blowers till thyristor pump is running.

e.g. PRC drops out TMR2 - which delays for 5 sec the running of blowers via the pick up of TMSR. Once TMSR energised its contacts will energise TMB (1-4) and drops out TMR3 which will now inhibit fault indication for 105 sec. (i.e. during starting cycle).

Faulty Relays B1-4R will drop out to energise the trip coil of CPR1-4

CPR1/1 Drop out that Motors Proving Relay and thereby isolate that motor

NB Only if this results in less than three motor one power car will the warning system give the driver in the cab the Traction Power Fault Light.

CPR1/2 Gives Local Indication and Cab Traction Fault Light

4.9 HK Brakes 415 v 3 ph. Pump .6 kw Fan 4 kw

Must select FOR/REV to pick up 'Controls ON' relay COR.

Pumps Contacts CDR 1-4 energise BPC1-4 to run pumps via 20X BPCB1-4

Faulty BPOL.1-4 will each drop out BPC1-4 to give local indication on the brake pack

Fans When temperature of braking fluid reaches $55^{\circ}/48^{\circ}$ pick up BFC1-4. to start cooling

Faulty BFOL.1-4 will each drop out BFC1-4 to give local indication

NB Can be run for testing by test switch TS.2 which is located on the Aux Control Panel

4.10 Tilt 415 v 3 ph. TP1 11 kw TP2 5.5 kw

Must select FOR/REV to pick up COR (TW13) to pick up TPC2 to run TP2 5.5 kw.

Once train above 60 kph speed sensing relay SSR will bring in TP2 11 kw pump via load sharing relay LSR.

NB If a DA set on a rake running RW 60 on that rake is energised to pick up LSR.

Faulty TOL1 or 2 will drop out contactors.

NB Can be run for testing by test sw TS2

NB Coil is heated by element OPH and thermostat OPH TS.

Oil is cooled by flow control solenoid SOL1 and thermostat TT close 55°C open 48°C.

4.11 Fire Fighting/Alarm System

Each power car EP4 and driving trailer car (DA set) is fitted with fire fighting bottles detonated by a cartridge firing unit and controlled by relays FDR, FDSR1-2.

With the BIS closed and all detenators on the vehicle good then FDR is picked up (The bell may ring for a short period).

Should heat be detected and FDR dropped out then the bell on that vehicle and in the driving cab will ring and 15s later the bottle(s) on that vehicle automatically fired.

The alarm system may be tested by depressing test switch LFATS.

AUXILIARY MACHINES SUMMARY

BATTERY - RUN AUX. COMPRESSOR

PAN UP & 240V SUPPLY
- → RUN CHOKE OIL PUMP
- → RUN TRANSFORMER PUMP
- → RUN CAR VENT FAN
- → RUN THYRISTOR OIL PUMP
- → BATTERY CHARGER

↓

THYRISTOR PUMP & 240V SUPPLY
- → RUN RADIATOR COOLING GROUP FANS
- → SELECT FOR/REV - TRACTION MOTOR BLOWERS

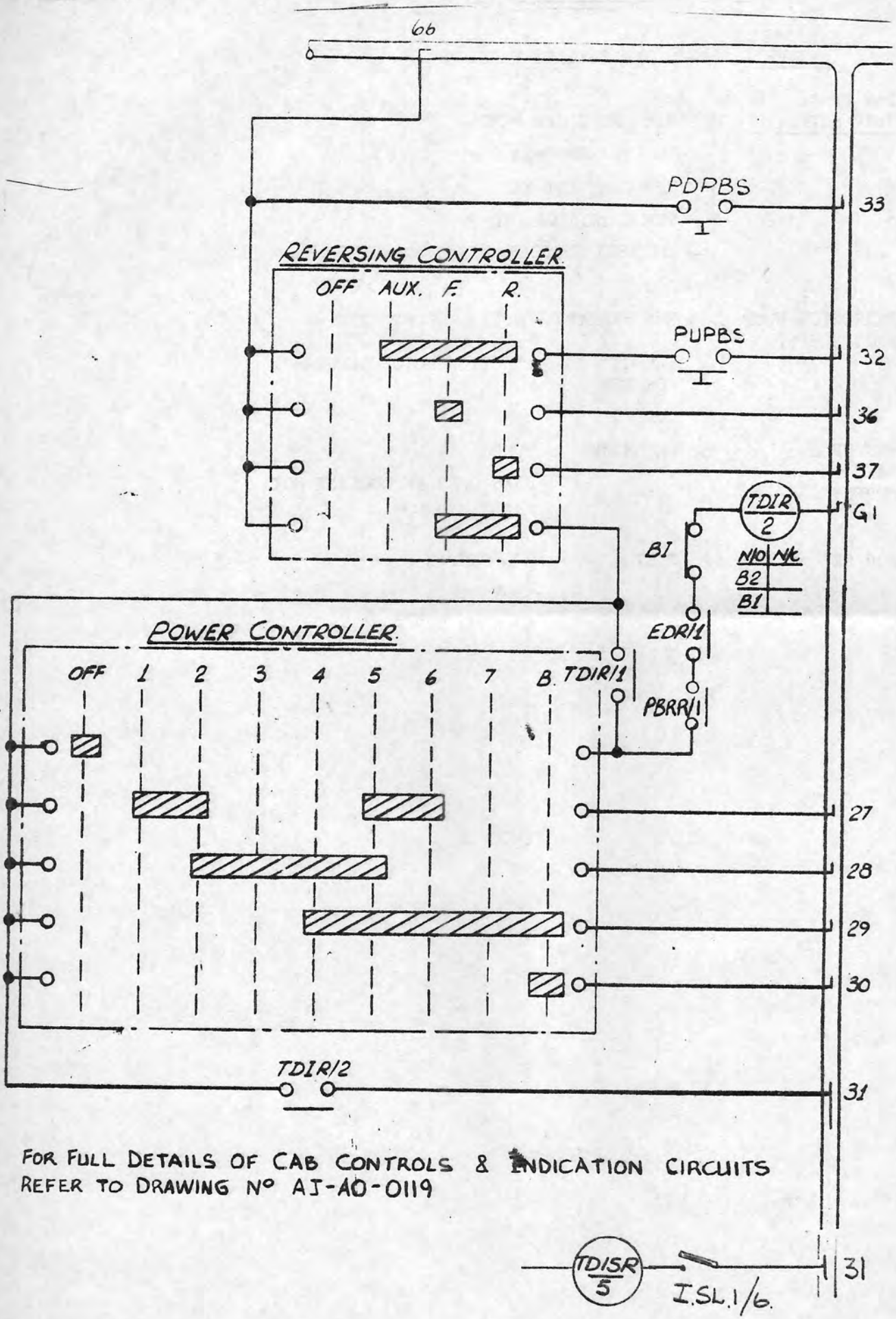
↓

PAN UP & MA 3 PH SUPPLY
- → HK BRAKE — PUMPS
  FANS ONLY IF COOLANT HOT

↓

FOR/REV
- → TILT — RUN PUMP 2
  ABOVE
  60 K PH RUN PUMP 1

APT	7.2		14



FOR FULL DETAILS OF CAB CONTROLS & INDICATION CIRCUITS REFER TO DRAWING Nº AI-AO-0119

5. TRACTION CONTROL

5.1 Traction Demand Relay

(Equivalent to PCR on DE Locomotives)

Selection of FOR or REV will energise the Traction Demand Interlock Relay provided

1. Power handle is at 'OFF'
2. Parking Brake is OFF PBRR/1
3. Emergency Brake Loop EBL is continuous EDR/1
4. Brake Controller at less than notch 2 BI

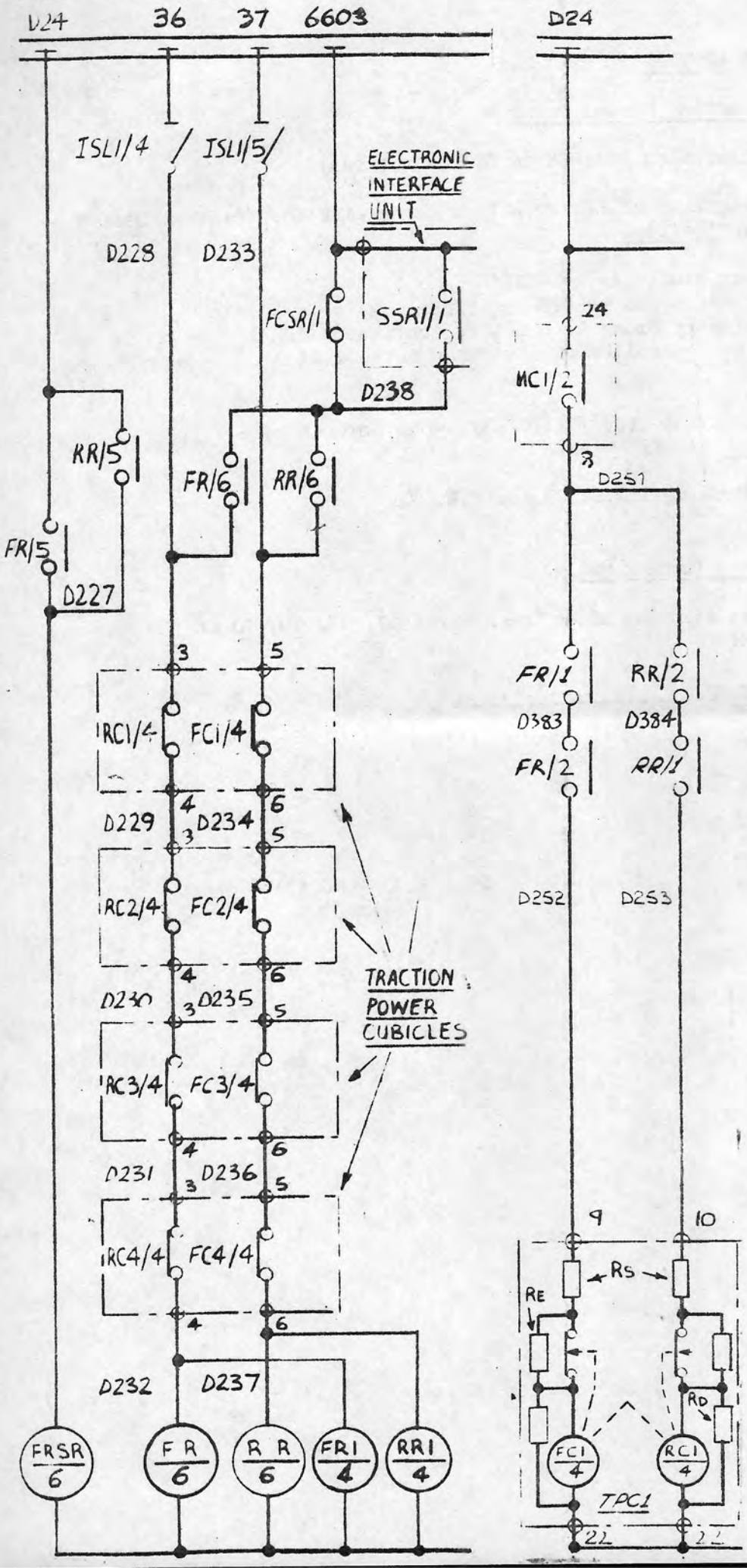
TDIR/1 N/O Retains itself (FOR/REV) when power handle is not at OFF

TDIR/2 N/O Pick up T.D.I.S.R. on T.W. 31.

5.1.1 Power Controller

This will energise train wires 27, 28, 29, 30 in the following position.

OFF	Pick up	T.D.I.R.		
1	TW 27			
2	" 27	28		
3	-	28		
4	-	28	29	
5	27	28	29	
6	27	-	29	
7	-	-	29	
8	-	-	29	+ 30 (BOOST)


D24
36
37
6603
D24
ISL1/4
ISL1/5
ELECTRONIC INTERFACE UNIT
D228
D233
FCSR/1
SSR1/1
D238
24
MC1/2
3
D251
KR/5
FR/6
RR/6
FR/5
D227
3
5
RC1/4
FC1/4
4
6
D229
3
D234
5
RC2/4
FC2/4
4
6
D230
3
D235
5
RC3/4
FC3/4
4
6
D231
3
D236
5
RC4/4
FC4/4
4
6
FR/1
RR/2
D383
D384
FR/2
RR/1
D252
D253
TRACTION POWER CUBICLES
9
10
RS
RE
RD
FC1/4
RC1/4
TPC1
22
22
D232
D237
FRSR/6
FR/6
RR/6
FR1/4
RR1/4

5.2 Select Forward

This will energise TW 36 and also pass a supply to the power handle.

TW 36 will via the traction isolation switch ISL1/4 energise the Forward Relay FR and slave FR1. (provided a reverser is not in the reverse position).

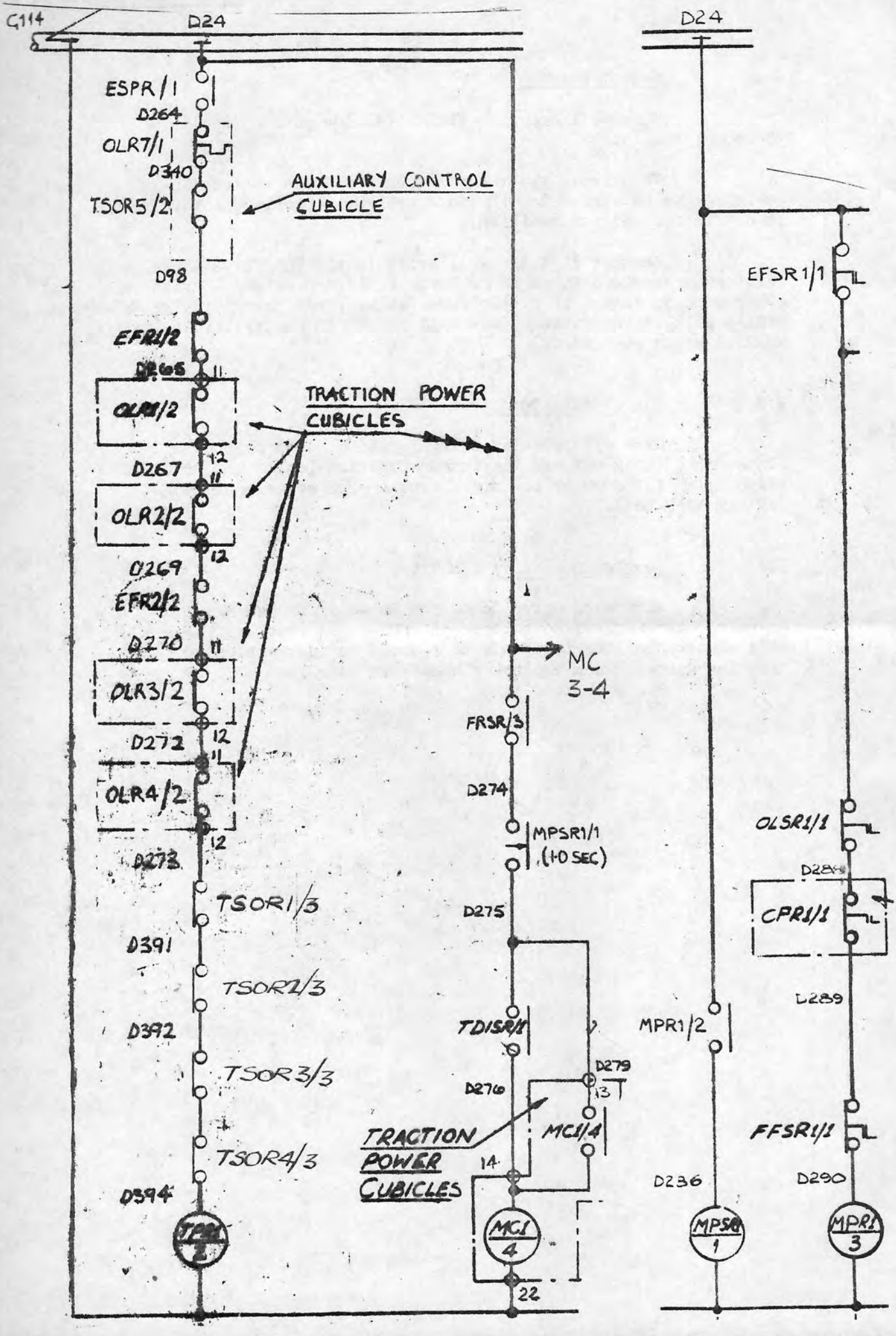
Contact FR/5 N/O will bring in the FOR/REV selected relay FRSR provided there is no Earth Fault - Overload - traction motor cooling fans - thyristor fuse failure, the Motor Proving Relays MPR1-4 will be energised. This will result in their slave relays MPSR1-4 being energised.

5.3 Motor Contactors (page 18)

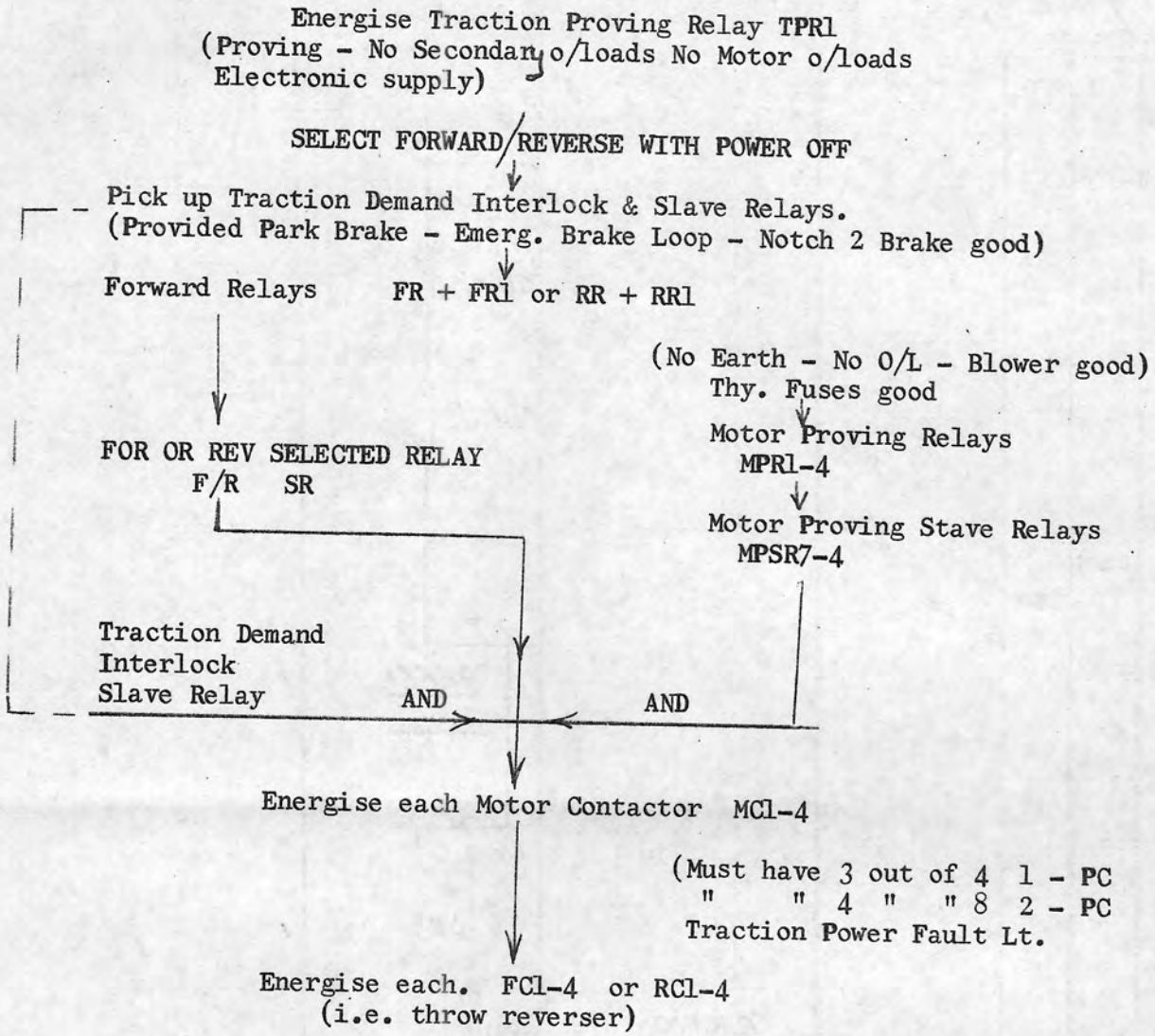
With F/R selected relay in and each Motor Proving Slave relay (MPSR1-4) and the common Traction Demand Interlock Slave Relay TDISR in we can now energise each motor contactor (EP air operated).

5.4 Forward Mechanism (EM Type)

With each motor contactor MC1-4 in we can now energise each Forward contactor coil FC1-4 and instruct the ASEA electronic interface unit to respond to instructions for traction current when the power handle is moved.

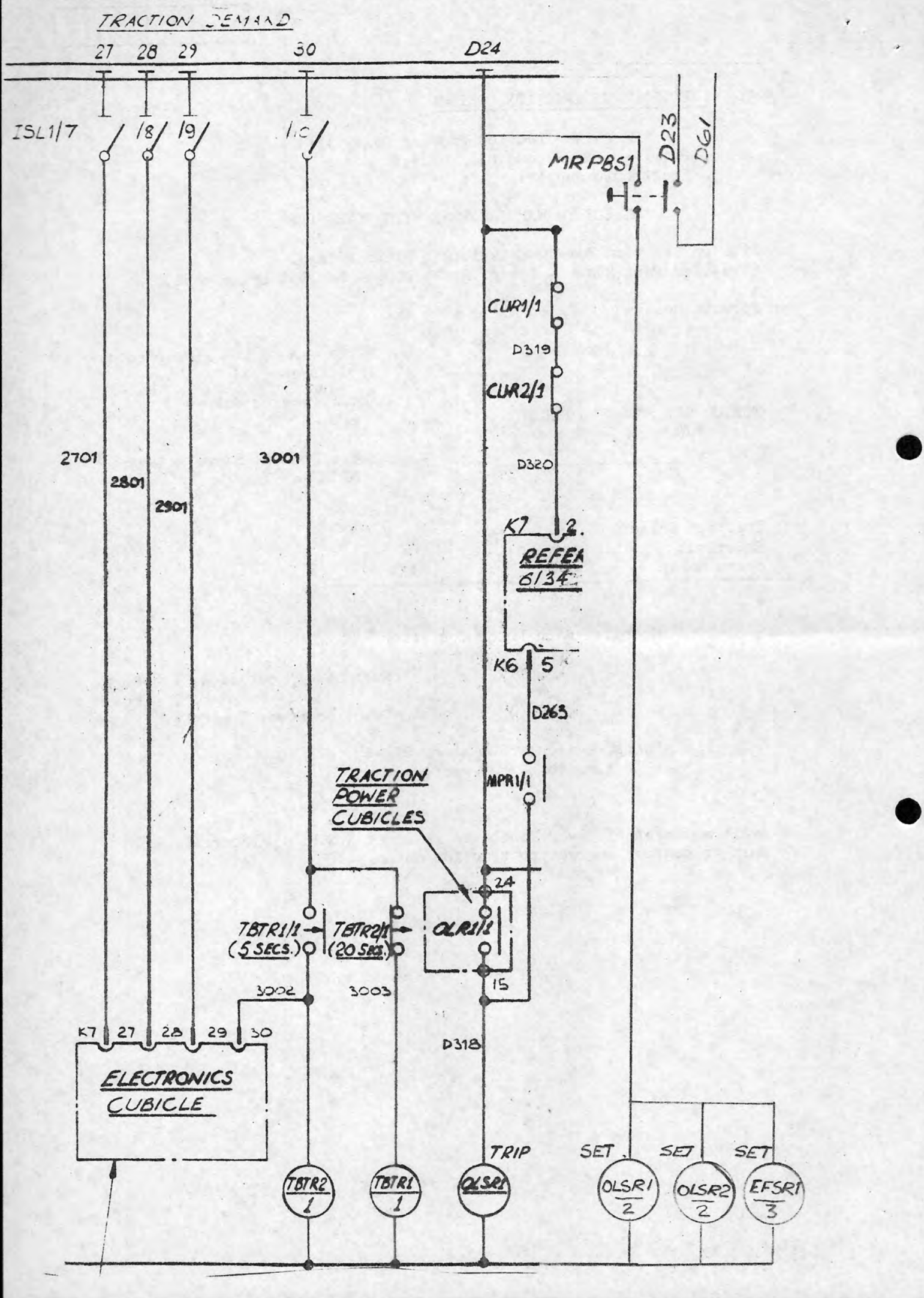

G114
D24
ESPR/1
D264
OLR7/1
D340
TSOR5/2
AUXILIARY CONTROL CUBICLE
D98
EFR1/2
D265
OLR1/2
TRACTION POWER CUBICLES
D267
OLR2/2
D269
EFR2/2
D270
OLR3/2
D272
OLR4/2
D273
TSOR1/3
D391
TSOR2/3
D392
TSOR3/3
TSOR4/3
D394
MC 3-4
FRSR/3
D274
MPSR1/1 (1·0 SEC)
D275
TDISR/1
D276
D279
MC1/4
TRACTION POWER CUBICLES
22
D24
EFSR1/1
OLSR1/1
D288
CPR1/1
D289
MPR1/2
FFSR1/1
D236
D290
MPS0 1
MPR1 3

5.5 SEQUENCE OF TRACTION CONTROL



Await movement of Power Handle to instruct A.S.E.A. electronic unit to control current to traction motor.

APT	7.2		20


TRACTION DEMAND
27
28
29
30
D24
ISL1/7
/8
/9
/C
MR PBS1
D23
DG1
CUR1/1
D319
CUR2/1
D320
2701
2801
2901
3001
K7
2
REFER
6134
K6
5
D263
MPR1/1
TRACTION POWER CUBICLES
24
TBTR1/1 (5 SECS.)
TBTR2/1 (20 SECS.)
OLR1/1
15
3002
3003
K7
27
28
29
30
D318
ELECTRONICS CUBICLE
TRIP
SET
SET
SET
TBTR2 1
TBTR1 1
OLSR1
OLSR1 2
OLSR2 2
EFSR1 3

5.6 Traction Control

Movement of the Power Handle will energise T.W. 27, 28,29 and 30 in a sequence such to instruct the A.S.E.A. electronic cubicle that a traction current has been demanded by the driver and the system will then phase forward the conduction of the four thyristor bridges till the demanded circuit is actually met.

NB The T.D.I. SR relay also tells the A.S.E.A. electronic cubicle to phase forward the fields of the traction prior to receiving the actual command to phase forward the armature thyristors, thereby ensuring a field on the motors for starting purposes.

The traction power light on the desk will now be lit indicating power on.

5.6.1 Boost

With the power handle held against a spring in Boost position T.W. 30 will pick up relay TB TR1 which will pass a signal for 5 sec (TBTR1/1) to the control box.

NB This signal will boost the field of the motors thereby giving extra power for traction.

This signal will then be delay for 20 sec (TBTR2/1 contacts) before a further application of boost i.e. 5 sec on 20 sec off.

TRAIN WIRES: NUMBER & FUNCTION

1.) 2.) P.W.M. For Brake

3.) 4.) Emergency Brake

5.) 6.) Public Address

7.) 8.) Driver Guard

9.) 10.) Spare - Looped into Contactor Panel on Trailer Cars

11. Lights ON

12. Lights OFF

13. Controls On

14. Air Conditioning On

15. Air Conditioning Off

16. Tilt Fault Indication (Trailer Cars)

17. Close Transient Pressure Valve

18. Trailer Car Fault (Van Trailer/Van Trailer)

19. Spare (looped into Contactor Panel on Trailer Cars and Aux Control Cubicle on Power Car)

20. A Side Doors Unlock

21. Doors Unlock B Side

22. All Doors Close & Lock

23. All Doors Open (Guard)

24. A Side Doors Unlocked Indication

25. B Side Doors Unlocked Indication

26. Passenger Communication Alarm Line

27.) 28.) 29.) 30.) Traction Demand

31. Traction Demand Interlock

32. Pantograph Up

33. Pantograph Down

34. Spare

35. Wheelspin

36. Forward

37. Reverse

38. Spare

39. Line Volts Indication

40.) 41.) Spare (looped into Traction Control Cubicle)

42.)
43.) Spare

44. Traction Fault

45. Traction Overtemperature

46. Auxiliaries Fault

47. Handbrake Apply

48. Handbrake Release

49. Handbrake On Indication

50. Handbrake Off Indication

51. Start Diesel Alternator (Local) plus Run Indication

52. Start Diesel Alternator (Remote) plus Run Indication

53. Start Motor Alternator (Local) plus Run Indication

54. Start Motor Alternator (Remote) plus Run Indication

55. Stop Diesel Alternator (Local)

56. Stop Diesel Alternator (Remote)

57. Stop Motor Alternator (Local)

58. Stop Motor Alternator (Remote)

59. Diesel Alternator Interlock

60. Motor Alternator Interlock (plus Load Shedding)

61. Spare)
62. Spare) (Looped into Auxiliary Control Cubicle)

63. Fire Alarm Relay

64. Traction Power Indication

65. Passenger Communication Indication

66. Traction Control Positive

67. Auxiliary Control Positive

68.)
69.) H. Force Measurement (For Test Purposes Only)

70.)
71.) Destination Indicator Controls

72.)
73.) Spare (Looped into Electronics Interface Unit on Power Cars)

74.)
75.) Spare
76.)
77.)

78 - 111 Run between Van Trailer Car and Power Cars Only.