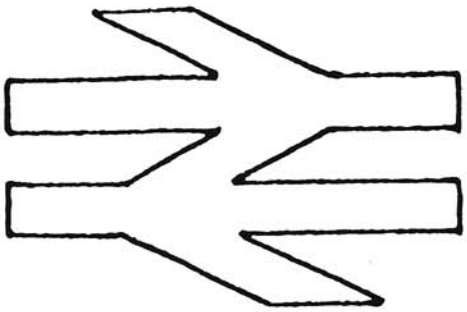
TRAINING

CLASS 47
SCHEMATIC DRAWINGS
AND
INDEX OF INSTRUCTION NOTES

MECHANICAL ≠ ELECTRICAL
ENGINEERING
BRITISH RAILWAYS BOARD · HEADQUARTERS



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This publication is intended for students attending courses at R.M. & E.E. Training Units, and is a precis of the lectures given. Subsequently alterations may be made and it entails upon the person concerned to suitably up-date the information.

RM & EE TECHNICAL TRAINING CENTRE
THE MILL,
BRISTOL STREET
SWINDON

BRITISH RAILWAYS (WESTERN REGION)
C.M. & E.E. DEPARTMENT PADDINGTON

INDEX OF INSTRUCTION NOTES AND SCHEMATIC DRAWINGS FOR BRUSH - SULZER TYPE 4 LOCOMOTIVES.

GENERAL DESCRIPTION

The power output of the diesel engine is converted into electrical energy by the main and auxiliary generators. The main generator supplies power to the traction motors, and the auxiliary generator provides the power for the auxiliary machines, control circuits, and battery charging.

Each traction motor circuit is seperately controlled by its own contactor, together with the reverser and appropriate contactors and resistors for field shunting.

The electrical control equipment is mainly accommodated in the control cubicle, which is adjacent to the generator end of the power unit. A central panel above the control cubicle arch-way carries the warning lamps and instruments associated with the control equipment. Heavy power equipment is mainly disposed of in the lower part of the control cubicle, and relays and small contactors in the upper part. The control cubicle doors are sealed when closed and air is supplied to ventilate and slightly pressurise the cabinet.

Each major item of electrical control equipment is labelled with its function, or usage symbol and relates to the appropriate schematic circuit diagram.

CAUTION : LOCOMOTIVE ELECTRONIC DEVICES MUST BE DISCONNECTED BEFORE USING A MEGGER OR ANY OTHER HIGH VOLTAGE INSTRUMENT ON ANY CIRCUIT OF THE LOCOMOTIVE.

OPERATION

The following information describes the operating sequence and the effect upon the electrical control circuits and auxiliary systems when the engine is started and the locomotive controls are operated.

Lighting and fire extinguishers

All driving and maintenance lights are available from the battery via the isolating switch L.S., or from an external 110 volt supply via shed lighting sockets SLSI or 2 when switch LS is in the 'shed supply' position.

The load is divided into two circuits protected by circuit breakers LCB.1 and 2 or LCB.3 and 4. Light circuits are seperately switched and as far as possible, lights are taken alternately from the two main systems to prevent complete loss of light in the event of a fault occurring in one system.

Fire fighting equipment comprises of carbon dioxide cylinders with push button control, electrically operated gas discharge heads (GDU 1-3). The operating current is always available direct from the battery. In adddition, three hand-operated fire extinguishers are carried in each driving cab.

Driving controls

The following sub-headings relate to the driver's controls and are arranged in the sequence the controls are used during normal driving. The circuits and systems affected as a result of operating a driver's control are listed beneath the appropriate sub-heading.

NOTE: Except where otherwise stated, switch B.C.S. should be in 'BRAKED' or switch B.S.S. in VAC BRAKED as appropriate, all other switches should be in their normal running position and the A.W.S. change end switch ON in the cab in use.

A. Battery isolating switch closed.
This results in the following circuits being energised at 110 volts:

(2) Drivers safety device valve (D.M.V.) (Vacuum fitted locos. only) via control circuit breakers C.C.B.1&2 and contacts 52-53 & 53-54 on the controllers.

(3) Relay FAR, via the compartment fire detectors and the test button .

(4) Cubicle and cab warning lamps light, ENGINE STOPPED lamp is bright, all others dim.

(6) If switch W.P.C.S. is turned to DIRECT the pump motor runs.

(7) If switch EXIS1 or 2 is turned to TEST the appropriate exhauster runs at maintaining speed.

NOTE: The combined pump and exhausters should not be run off the battery unnecessarily.

(8) The A.W.S. convertor runs.

B. Reverser handle to ENGINE ONLY.

(1) Wire 12 is energised.

(2) Restricted application valve R.A.V. (R.A.V.V. on dual fitted locos.) is energised.

(3) Contactor W.P.C.1 closes and the combined pump set runs at slow speed.

NOTE: If delay relay WPDR is fitted, WPC1 will open after 2 minutes if the engine is not started.

(4) Exhauster contactor EXC closes.

(5) If E.P. starting contactors are fitted, compressor contactor C closes (C1 on dual fitted locos.) and the compressor runs under the control of the pre-start governor. The pre-start governor will stop the compressor when the control reservoir pressure reaches 45 p.s.i. This pressure will not show on the drivers air pressure gauge.

NOTE: On dual fitted locos. No. 1 compressor will run. If E.M. Starting contactors are fitted, contactor C1 closes but the compressor does not run until the engine is started.

C. ENGINE START button pressed.

(1) On locos. fitted with E.P. starting contactors, S1 is energised via the cab or local start button, P.C.G. interlocks on VR and the motor contactors.

On locos. fitted with E.M. contactors, SCC is energised via the cab or local start button , interlocks on VR and the motor Contactors. S1 is energised via the main contacts of SCC.

(2) S2 is energised via an interlock on S1. The main generator is connected across the battery and motors the engine up to firing speed.

(3) The auxiliary generator field is open circuited by interlocks on S1 & S2.

(4) The auxiliary earth fault relay (AEFR) is isolated by interlocks on S1.

(5) The stop relay STR is open circuited by an interlock on S2.

(6) The engine run valve (ERV) is energised via interlocks on STR and S2.

(7) The engine fires and runs up to idling speed, oil pressure builds up and the start oil pressure switch SOPS operates at 20 p.s.i.

(8) The ENGINE STOPPED lamp changes to dim.

D. ENGINE START button released.

(1) Contactors S1 and S2 open.

(2) The feed to ERV is maintained through run oil pressure switch ROPS and water pressure switch WPS.

(3) The auxiliary generator field circuit is completed and the auxiliary generator voltage builds up. The exhausters and blowers run, and battery charging commences. The automatic voltage regulator now maintains the auxiliary voltage at 110 volts less 1 volt for each 14 amps of battery charge current.

(4) Voltage relay VR closes.

(5) The compressor runs (No. 1 on dual fitted locos). On locos. fitted with E.P. starting contactors, an interlock short circuits PCG, and the compressor restarts under control of CG which stops the compressor when maximum pressure is reached.

(6) Contactor WPC2 closes and the combined pump runs at high speed.

(8) Auxiliary earth fault protection is restored.

(9) The load regulator runs back to MIN. FIELD, switch LA closes and LRR (where fitted) is energised.

NOTE: LRR is not fitted on Locos. with static field divert or with VER-engines.

(10) As air pressure builds up, control circuit governor C.C.G. operates

(11) On dual fitted locos. valve DMV and feed cut-off valves FCV1 & 2 are energised via contacts 52 - 53 and 53 - 54 on the two controllers and CCG.

E. Reverser handle to FORWARD

(1) Valve DMV (and FCV1 &2 on dual fitted locos) is de-energised and the brake applied, unless the DSD pedal is depressed.

(2) A feed is made available from the reverser control shaft to the power control shaft via the A.W.S. change end switch.

(3) Relay P.C.R. is energised via interlocks on LRR (or switch La), overload relay and starting contactor interlocks.

F. Power control handle to ON.

(1) PCR is held via wire 5, the air and vacuum governors and interlocks on PEFR and the overload relays.

(2) The appropriate reverser coils are energised via wire 7 or 8 and interlocks on the motor contactors; the reverser(s) throw to the required direction.

(3) The motor contactors close, via interlocks on the reverser(s), S1 & S2 & LRR.

(4) The main generator field contactors GX & GZ close via the maintenance switch EMS and interlocks on PCR, PEFR, and the motor contactors.

NOTE DR is also energised on vee engine locos.

(5) The engine speed valve ESV is energised via interlocks on PCR & PEFR.

(6) Low power is applied to the traction motors.

G. Power control handle to ¼ position.

(1) Air pressure from the controller to the engine governor rises and the engine speed increases in response. Increased power is fed to the traction motors.

(2) The load regulator moves to increase power output and switch La opens. LRR is de-energised and the feed to the motor contactors is maintained via wire 28. On vee-engine locos. the feed from wire 28 is made via DSR instead of LRR.
On locos. fitted with static field divert, the feed from wire 28 is made via switch Lb which is closed by the load regulator when it is away from the minimum field position.

(3) Further movement of the controller towards MAX. increases the air pressure fed to the governor; this causes the engine to run at a higher speed and the load regulator moves to keep the generator output such that the engine is fully loaded.

H. Power control handle to OFF.

(1) The feed to wires 5 and 7 or 8 are broken at the controller and PCR drops out, PCR interlocks open and GX, GZ and ESV are de-energised.

NOTE: DR is de-energised on vee-engine locos.

(2) Air pressure to the engine governor is cut off by ESV and the engine speed reverts to idling.

(3) Switch La is closed, LRR is energised, breaking the feed from wire 28 and the motor contactors open. On vee-engine locos. the feed is broken by relay DSR which is energised 2 seconds after DR is de-energised. On locos. fitted with static field divert, the feed from wire 28 is broken by switch Lb opening as the load regulator reaches MIN. field position.

(4) PCR is energised via wire 4 and switch La or LRR interlock.

I. Reverser handle returned to ENGINE ONLY.

(1) The feed to wire 4 is broken and P.C.R. drops out.

(2) Valve DMV is fed via the controller and the DSD pedal may be released.

J. ENGINE STOP button depressed.

(1) Relay STR is energised via either wire 3 or the LOCAL STOP button.

NOTE: If the LOCAL STOP button is depressed it must be pulled out after the engine has stopped or the engine cannot be restarted.

(2) Valve ERV is de-energised by the STR interlock and the engine stops.

(3) As the engine slows down the auxiliary generator voltage falls, relay VR drops out and the auxiliary machines stop.

(4) Contactor WPC2 opens and the combined pump runs at slow speed.

NOTE: On locos. fitted with E.P. contactors the compressor is now controlled by P.C.G.

Field Shunt (divert) control.

Field shunting is effected either by relays which are controlled by the load regulator, or by a static device which is operated by road speed and is independant of relays and the load regulator.
Both systems are described separately.

A. Locomotives with relays.

(1) Full field to weak field stage 1 (FF to WF1) (Loco speed increasing to 33 MPH).

(a) The load regulator reaches Max., switch Lc closes, operating relay SR5

(b) SR5 interlock closes and energises SR2; SR2 holds in via its own interlock and FSC1 interlock.

(c) The load reducing solenoid is energised by SR2 interlock, and the load regulator runs back unloading the generator.

(d) Switch Lc opens and SR5 drops out.

(e) On series parallel locos. the voltage across coil SR1 rises until it operates at a pre-set voltage (32v). On all parallel locos. the voltage across coil SR6 rises until it operates at a pre-set voltage (31v) and completes the circuit to SR1.

(f) SR1 completes the circuit to close FSC1. FSC1 then holds via FSR and its own holding contact.

(g) FSC1 interlock breaks the circuit to SR2. SR2 drops out, de-energises LRV & SR6. SR6 de-energises SR1.

(h) The load regulator is again under the control of the engine governor and the sequence is complete.

(2) Weak Field stage 1 to stage 2 (WF1 to WF2)
(Loco. speed increasing to 45 m.p.h.)

(a) The load regulator reaches MAX. and switch Lc closes, operating relay SR5.

(b) SR5 interlock energises SR3 via FSC1 interlock.

(c) SR2 is energised via interlocks on FSR, SR3 & FSC2. SR2 then holds in by its own holding contact.

(d) SR2 interlock energises LRV causing the load regulator to run back.

(e) Switch Lc opens and SR5 drops out.

(f) On series-parallel locos. the voltage across coil SR1 rises until it operates at a pre-set voltage (32v). On all-parallel locos. the voltage across coil SR6 rises until it operates at a pre-set voltage (31v) and completes the circuit to SR1.

(g) SR1 completes the circuit to FSC2 via FSR and SR3 interlocks; FSC2 then holds by its own holding contact.

(h) FSC2 interlock breaks the circuit to SR2 which drops out, breaking the circuit to LRV & SR6. SR6 de-energises SR1.

(i) The load regulator is again under the control of the engine governor and the sequence is complete.

3. Weak Field Stage 2 to Stage 3 (WF2 - WF3)
(Loco. speed increasing to 61 m.p.h.)

(a) The load regulator reaches MAX., switch Lc closes operating SR5.

(b) SR5 completes the circuit to energise SR4 via FSC2 interlock.

(c) SR4 completes the circuit via FSC3 interlock and FSR to energise SR2. SR2 then holds in by its own holding contact.

(d) SR2 interlock energises LRV and the load regulator runs back .

(e) Switch Lc opens and SR5 drops out.

(f) On series-parallel locos. the voltage across coil SR1 rises until it operates at a pre-set voltage (32v).
On all-parallel locos. the voltage across coil SR6 rises until it operates at a pre-set voltage (31v).
SR6 completes the circuit to energise SR1.

(g) SR1 completes the circuit to close FSC3 via FSR and SR4 interlocks.

(h) FSC3 interlock breaks the circuit to SR2. SR2 drops out, breaking the circuit to LRV & SR6. SR6 de-energises SR1.

(i) The load regulator is again under the control of the engine governor and the sequence is complete.

NOTE: If the main generator voltage reaches maximum (500v) before the load regulator reaches MAX. FIELD, relay VLR will operate and energise SR5 to initiate the field awakening sequence.

(4) Weak field stage 3 to stage 2 (WF3 to WF2) (Loco. speed decreasing)

(a) When the traction motor current reaches a pre-set value (Approximately 800 amps per motor), relay FSR operates and breaks the circuit to FSC3; FSC1 and FSC2 are held by direct feeds via SR3 & SR4 respectively.

(b) The de-magnetising coil of FSR is energised via FSC3 and SR4 interlocks. FSR drops out.

(c) FSR interlocks break the circuit to de-energise SR4.

(d) SR4 drops out and the stage is complete.

(5) Weak field stage 2 to Stage 1 (WF 2 to WF 1) (Loco. speed decreasing)

(a) Relay FSR operates and breaks the feed to FSC2.

(b) FSR demagnetising coil is energised via FSC2 & SR3 interlocks; FSR drops out.

(c) FSR interlocks break the circuit to de-energise SR3.

(d) SR3 drops out and the stage is complete.

(6) Weak field stage 1 to full field (WF1 to FF)(Loco. speed decreasing)

(a) Relay FSR operates and breaks the circuit to FSC1.

(b) FSC1 drops out.

NOTE: The FSR remains in the energised position until the locomotive speed increases, allowing the load regulator to run around to the maximum field position. Just prior to this condition, switch Lb closes to energise the demagnetising coil, and revert the FSR back to its normal condition.

SEQUENCE TEST OF FIELD DIVERT EQUIPMENT

The purpose of this test is to provide a means whereby the operation electrically and mechanically of certain relays and contactors in the field divert circuits may be observed in the event of reported 'loss of power' without actually moving the locomotive.

(1) Run the engine to obtain maximum air pressure to allow operation of E.P. contactors at a later stage.

(2) Stop the engine.

(3) With the master selector shaft in either the FORWARD or REVERSE position, keep the triple pump running and note that the load regulator runs round to the MAX. field position.

(4) Operate by hand the manual engine stop fuel rack in order to drive and to hold the load regulator in the mid-way position.

(5) Switch off the triple pump by operating the rotary switch W.P.C.S.

(6) Check with engine stopped, selector in FOR or REV and load regulator in mid-way position. Manually operate the E.P. valve of any one motor contactor - all motor contactors should now latch in.

(7) Manually operate VLR.

SR5 should energise.
SR2 should energise.
LRV should energise.

(8) Release VLR.

SR5 should de-energise.
SR2 should remain energised.

(9) Manually operate SR6.

SR1 should energise.
FSC1 should energise.
SR2 should de-energise.

(10) Release SR6

SR1 should de-energise.
IN CIRCUIT 1ST. STAGE FSC1.

Repeat the operations 7 to 10 to check second stage and further repeat 7 to 10 to check third stage.

IN CIRCUIT:-

1st. STAGE	FSC1.
2nd. STAGE	FSC1 + SR3 and FSC2.
3rd STAGE	FSC1 + SR3 and FSC2 + SR4 and FSC3.

FIELD REVERSION

Simply operate manually FSR three times in order to revert to full field by way of the second then first stages.

NOTE : During the first and second occasions using FSR it should be noted that the de-magnetising coil will become energised and consequently, care should be taken, to avoid closing the air gap completely in order to prevent latching in FSR. If the armature does latch, gently release it.

(11) 3rd to 2nd stage.
Manually operate FSR.
FSC3 should de-energise.
FSR de-magnetising coil should be energised

(12) Release FSR.
SR4 should now de-energise.

IN CIRCUIT : FSC1 + SR3 and FSC2.

(13) 2nd to 1st stage.
Manually operate FSR.
FSC2 should de-energise.
FSR de-magnetising coil should be energised.

(14) Release FSR.
SR3 should de-energise.

IN CIRCUIT : FSC1.

(15) 1st TO FULL FIELD.
Manually operate FSR.
FSC1 should de-energise.
Release FSR. (Check FSR has reverted to the de-energised position)

B. LOCOMOTIVES WITH A STATIC DEVICE.

On these locomotives field weakening and field strengthening are controlled by the road speed and are independent of the load regulator position and motor current.

The road speed is measured by a probe unit mounted on the right hand side of No. 2 axle. This unit consists of a toothed wheel and a probe which detects the passage of the teeth and feeds impulses to the speed indicating control unit, which is mounted on the right -hand body side terminal box. A signal is fed from this unit to the field divert control unit, which is mounted in the bottom right-hand corner of the left hand section of the control cubicle. At the appropriate road speed, this signal initiates the operation of the appropriate field divert contactor.

The approximate speeds at which the field divert contactors close are:-

FSC1	-	33 m.p.h.
FSC2	-	44 m.p.h.
FSC3	-	61 m.p.h.

The speed at which the contactors open is 3 m.p.h. slower than the closing speed.

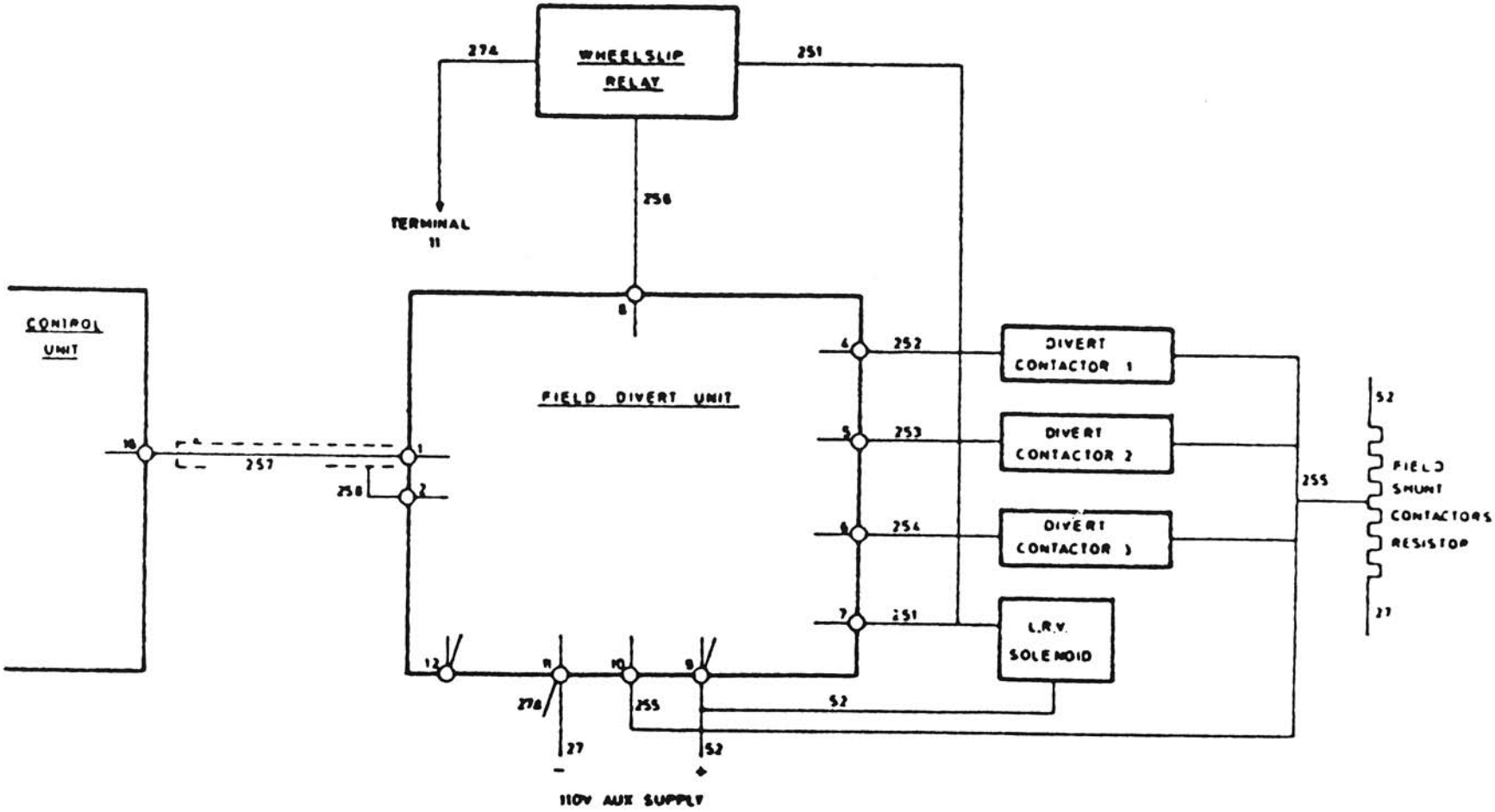
Before each contactor closes, LRV is energised for 6 seconds to reduce load; there is then a 1 second pause before the contactor is closed.

If the apparent speed rises at 6 m.p.h. per. sec. (i.e. if No. 2 axle slips) the sequence is delayed for 8 - 20 seconds.

If a wheel - slip occurs on any axle and a wheel-slip relay closes, the sequence is stopped until 8 - 20 seconds after the relay resets.

1ST STAGE.	2ND STAGE.	3RD STAGE.	3-2 STAGE.
33 MPH.	45 MPH.	61 MPH.	FSR ENER. (CURRENT)
Lc CLOSES	Lc CLOSES	Lc CLOSES	FSC3 DE-EN
SR5 ENER.	SR5 ENER.	SR5 ENER	FSR DE-EN (VOLTAGE)
SR2 ENER.	SR3 ENER.	SR4 ENER	SR4 DE-EN.
LRV ENER.	SR2 ENER.	SR2 ENER.	
Lc BREAK	LRV ENER.	LRV ENER	2-1 STAGE.
SR5 DE-EN.	Lc BREAK	Lc BREAK	FSR ENER (CURRENT)
SR6 ENER.	SR6 DE-EN.	SR5 DE-EN.	FSC2 DE-EN.
SR1 ENER	SR6 ENER.	SR6 ENER.	FSR DE-EN (VOLTAGE)
FSC1 ENER.	SR1 ENER	SR1 ENER.	SR3 DE-EN.
SR2 DE-EN.	FSC2 ENER.	FSC3 ENER	
LRV DE-EN	SR2 DE-EN	SR2 DE-EN	1- FULL FIELD.
SR6 DE-EN	LRV DE-EN	LRV DE-EN	FSR ENERGISED (CURRENT)
SR1. DE-EN.	SR6 DE-EN	SR6 DE-EN	FSC1 DE-EN
	SR1 DE-EN.	SR1 DE-EN.	Lb MAKES
			FSR DE-EN. (VOLTAGE)

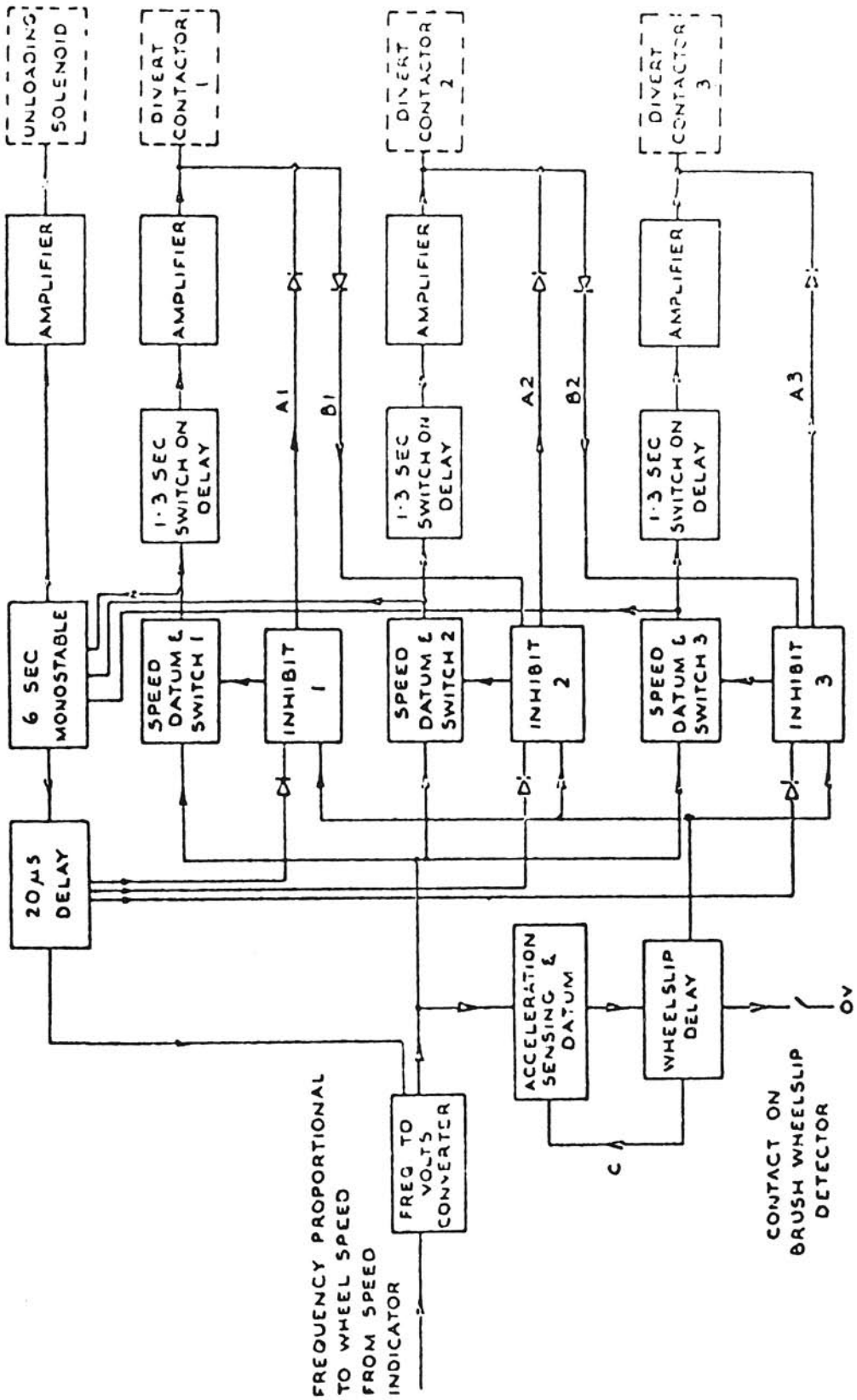
RELAY SEQUENCE FOR FIELD DIVERT.



WIRE No 52

TERMINAL No 5

DIAGRAM OF FIELD DIVERT



FIELD DIVERT SYSTEM WITH UNLOADING

OTHER CAB CONTROLS

A. Train brake valve.

(1) Vacuum fitted locomotives.

This valve has five positions : RELEASE, RUNNING, LAP, ON and EMERGENCY. The valve controls the train brakes via the vacuum train pipe and the locomotive brakes via a proportional or triple valve.

(a) In RELEASE, a switch is closed to energise valve XCV and contactors EXY1 and 2 via wire 15. The exhausters run at high speed, drawing against the full 2 in. train pipe.

(b) In RUNNING, XCV & EXY1 & 2 are de-energised, the exhausters run at half speed, drawing against a 3/8.in. choke in the train pipe.

(c) In LAP, restricted application valve RAV is energised if the brake changeover switch is in UNBRAKED.

(d) In ON, RAV is held energised and air is admitted to the vacuum train pipe to give a controlled brake application.

(e) In EMERGENCY, RAV is held energised and the train pipe is opened to atmosphere to give a rapid brake application.

(2) Dual fitted locomotives.

The valve has six positions: RELEASE, RUNNING, INITIAL, SERVICE, EMERGENCY and NEUTRAL. The valve controls the train brakes directly via the auto-air train pipe on air-fitted trains, and via the auto-air train pipe and the air vacuum relay valve on vacuum fitted trains. The locomotive brakes are applied by a triple valve , which detects an air or vacuum application.

(a) In RELEASE, the auto-air train pipe is charged to a higher pressure than normal so as to release the brakes quickly, at the same time XCV & EXY1 & 2 are energised and the exhausters (if running) speed up.

(b) In RUNNING, the auto-air train pipe is charged at 72·5p.s.i. to keep the train brakes released and the exhausters at maintaining speed (if running).

(c) In INITIAL, pressure in the auto-air train pipe is reduced slightly and a light brake application takes place.

(d) In SERVICE, pressure in the auto-air train pipe is progressively reduced as the handle is moved, with a minimum of 50·5p.s.i. at full service.

(e) In EMERGENCY, the auto air and vacuum train pipes are opened to atmosphere, by-passing the air-vacuum relay valve and giving a rapid brake application.

(f) In NEUTRAL, the valve is isolated and is held in this position by a spring peg.

B. Independant brake valve.

This valve applies the brakes on the locomotive only. It is self lapping and gives variable pressure between 0 and 70 p.s.i. depending on the position of the handle.

C. Anti slip brake button.

This button is in the end of the power control handle. When depressed, the anti-slip brake valve SBV is energised via wire 18, giving a light brake application (12 - 15 p.s.i.).

D. Horn lever.

This lever can be moved in three directions to sound individual horns; forward sounds the high note horn, backward sounds the low note horn, and sideways sounds the high note horn at the rear by the operation of a micro-switch.

E. Drivers safety device.

The pedal or push button must be kept depressed when the reverser handle is in FORWARD or REVERSE.

INTERLOCKS AND SAFETY DEVICES.

A. Controller.

Interlocks are provided to prevent mishandling and to ensure that the control handles cannot be operated simultaneously, or in the wrong sequence.

(1) The master key can only be inserted or removed when the reverser handle is OFF.

NOTE : THE USE OF A DEVICE, OTHER THAN A MASTER KEY, IS STRICTLY FORBIDDEN.

(2) The reverser handle can only be moved when the master key is in place and the power handle is OFF.

(3) The power handle can only be moved when the reverser handle is in FORWARD or REVERSE.

(4) Power cannot be obtained until the A.W.S. is switched on in the cab in use and switched off in the cab not in use. If the A.W.S is defective it can be isolated with the red painted handle and the change-end switch put back into use.

B. Start contactors.

These cannot be energised if:-

(1) The pre-start governor (if fitted) is not closed.

(2) The engine is already running and VR is energised.

(3) A motor contactor is stuck or welded closed.

(4) S2 is stuck or welded in on locomotives with E.M. starting contactors.

C. The engine run valve (ERV).

This valve will de-energise and the engine will stop if:-

(1) Lubricating oil pressure falls below 12 p.s.i.

(2) Cooling water pressure falls below 4 p.s.i.

In addition the appropriate relay will operate and latch to show a warning light on the cubicle.

D. Power control relay (PCR).

This relay cannot be energised if :-

(1) The power handle is away from OFF.

(2) The load regulator is away from MIN. FIELD.

(3) S1 or S2 has not opened correctly.

(5) Slow motion is switched in and the controller is away from MIN. on locomotives fitted with slow speed control.

(6) Exhauster switch EXIS1 or 2 is in TEST on locomotives fitted with E.P. starting contactors.

The power control relay PCR will be de-energised if :-

(1) Main reservoir air pressure falls below 65 p.s.i.

(2) Train pipe vacuum falls below 12½ in HG, except on dual fitted locomotives when working air-braked trains.

(4) power earth fault relay operates.

(5) Pressure in the automatic air train pipe falls below 45 p.s.i. on dual fitted locomotives.

NOTE: When PCR is de-energised its holding interlock prevents it operating until conditions comply with DI to 6. If PCR opens or fails to close, the alarm light changes to bright to warn the driver.

E. Traction Motor contactors.

These cannot energise if:-

(1) The reverser does not throw correctly to the direction selected (both reversers on all-parallel locomotives).

(2) S1 or S2 do not open correctly.

(3) The load regualtor is not in MIN. FIELD on locomotives fitted with field shunting relays, except vee-engine locomotives.

NOTE: When the motor contactors are closed and the load regulator is away from MIN. FIELD they hold themselves closed via wire 28 until the power controller is returned to OFF and the load regulator has run back to MIN. FIELD.

F. Engine speed valve (ESV).

This valve is de-energised and the engine reverts to idling speed if:-

(1) PCR is de-energised.

(2) PEFR operates.

G. Generator field contactors GX & GZ.

These contactors will de-energise if:-

(1) PCR is de-energised.

(2) PEFR operates.

H. Wheelslip detection.

(1) Series parallel locomotives.

When wheel-slip occurs, the slipping wheels lose adhesion with the rails and the traction motor accelerates. Since the traction motors are connected in series-parallel the voltage across the accelerating motor increases and the voltage across the non - slipping motor decreases. The basis of the system is to detect this voltage difference, amplify the signal obtained and use it to operate the wheel-slip relay W.S.R. Consider motors 1 and 2.

The resistance of the centre section of resistor WSRE.1 (Terminals 81 and 82) is set so that the voltage appearing across that part of the resistor is equal to the maximum allowable tolerance in voltage for the traction motors. During normal running, the potential of wire 78 is below that of 81 and above that of 82 and no current flows through the amplifier WSA.1 control windings due to rectifiers MR1 and MR2.

Assume that No. 1 axle is slipping.

The voltage across motor No. 1 increases and the potential of wire 78 falls below that of wire 82 and current flows from WSRE.1 terminal 82 through the WSA1 control, winding via rectifier MR2. This causes a high rectified alternating current to flow from the wheel slip alternator via WSA1, rectifiers MR3 and 4 and WSRAU, closing relay W.S.R.

(a) Contacts WSRc close, and energise the anti-slip brake valve SBV via train wire 2.

(b) Contacts WSRa close, the LRV is energised and the load regulator runs back in the decrease field position.

(c) Contacts WSRb close and the wheelslip alarm light brightens

(2) All parallel locomotives.

Each of the wheelslip relays WSR1 to 4 has two opposing coils which are in series with two adjacent motors. While the motors are running at the same loading the two coils cancel each other magnetically and the relay is inoperative.

If one pair of wheels slip, the associated motor takes less current and the coils of the wheel slip relay are un-balanced. When the difference in current reaches approximately 200 amps the relay operates and energises WSR5.

When WSR5 operates, it energises LRV to reduce power, operates SBV to make a light brake application., and the wheelslip light brightens.

NOTE: On locomotives fitted with static field divert, WSR5 also prevents field weakening as in 3.B.

I. Drivers safety device (D.S.D.).

(1) When the reverser handle is in FORWARD or REVERSE the DSD pedal or push button must be depressed.

(2) If both are released, valve DMV is de-energised and a brake application is initiated.

(3) On vacuum fitted trains, loss of vacuum operates V.G. to de-energise PCR and remove power.

(4) On dual fitted locomotives a drop in train pipe air pressure operates AAG which de-energises PCR.

(5) On dual fitted locomotives, valves FCV1 and 2 are de-energised at the same time as the D.M.V. to isolate the brake valves from the train pipe.

K. Earth fault relays.

(1) Power earth fault relay PEFR.

(a) If a fault to earth occurs on the negative side of the power circuits on series-parallel locomotives, or the positive side of the power circuits on all-parallel locomotives, the power earth fault relay will trip.

(b) PGR will be de-energised.

(c) ESV, GX & GZ will be de-energised.

(d) The earth fault light will change to bright and will remain bright until the relay is reset by hand at the depot.

(2) Auxiliary earth fault relay (AEFR).

(a) If a fault to earth occurs on either pole of the auxiliary or control circuits, the auxiliary earth fault relay will trip.

(b) The earth fault light will change to bright and will remain bright until the relay is reset by hand at the depot.

L. Blower Motor Relays.

(1) A relay is fitted in series with each blower motor and operates at a normal running current.

(2) If the current falls for any reason (e.g. an open circuit on a motor or a blown fuse) while the engine is running, the relay drops and the blower alarm light changes to bright.

M. The auxiliary generator field is open circuited if:-

(1) S1 or S2 do not open correctly.

(2) Either of the exhuaster isolating switches (EXIS) is left in TEST on locomotives fitted with E.M. starting contactors.

N. Fire alarms.

Bi-metal switches are fitted in the roof of the locomotives at various points to detect excessive high temperatures. If any switch opens, the feed to relay FAR is broken, the relay drops and completes the circuit to ring the fire alarm bells.

O. Water pump delay relay (WPDR).

This relay de-energises WPC1 and stops the combined pump after 2 minutes. WPDR is de-energised by S1 or VR so that WPC1 remains closed during a start or when the engine is running.

WARNING LAMPS

6 volt 3 watt. lamps are used, each lamp is in series with a dropping resistance, operating on the 110V circuit. A seperate series resistance in each lamp circuit is short circuited by a switch in the warning circuit, causing the lamp to brighten when the switch is closed by a fault.

A. Drivers Lamps.

(1) Engine stopped.
Contacts on VR and SOPS close to short circuit the resistance and indicate a shut-down.

(2) Wheel-slip.
Contacts of WSR or WSR5, as appropriate, close to short circuit the resistance.

(4) General alarm.

The resistance is short circuited by contacts of:

(a) W.L.S. (Mobrey float), indicating low cooling water level (dual fitted and vee-engined locomotives only).

(b) GZ or PCR, indicating loss of power.

(c) VR in series with MBR1 or 2, indicating a fault in the blower motor circuits.

(d) WTS indicating high cooling water temperature. 190°F.

(f) LFS indicating that fuel is running low (38 gallons).

B. Cubicle lamps.

(1) Overload.
The resistance is short circuited by latched contacts of the overload relay.

(2) Blowers.
Contacts of VR in series with MBR1 or 2 short circuits the resistance to indicate a blower motor fault.

(3) Earth Fault.
The resistance is short circuited by contacts of :-

(a) PEFR to indicate a fault to earth on the power circuit.

(b) AEFR to indicate a fault on the 110 volt circuits.

(4) Water pressure or level.
The resistance is short circuited by contacts of :-

(a) W.P.R. to indicate the cooling water pressure is below 4 p.s.i.

(b) W.L.S. on dual fitted and vee-engined locomotives to indicate the level of cooling water is low.

(5) Oil pressure.
The resistance is short circuited by contacts of OPR, to indicate the engine lubricating oil pressure is below 12 p.s.i.

(6) Water Temperature.
The resistance is short circuited by contacts of WTS, to indicate the temperature of the engine cooling water is too high.

SWITCHES

The locomotive is fitted with a number of switches, all manually operated, some being necessary for for normal driving and others to enable the locomotive to be driven after a fault has developed, or for maintenance purposes.

A. Lighting switch (LS).

This is a rotary switch having two positions:-

(1) BATTERY SUPPLY, connecting the lighting circuits to the battery.

(2) SHED SUPPLY, connecting the lighting circuits to the shed supply sockets, to enable the lights to be supplied from an external 110 volt supply.

B. Battery Isolating Switch (BIS).

This is a double-pole ON/OFF switch fitted with flick blades. In the ON (UP) position it connects the battery to the control, starting and loco. charg ing circuits.

C. A.W.S. change-end switch.
This is a two-position, multi-pole switch. In the 'up' position it completes the A.W.S. circuits and also completes the circuits between the reverser handle and power control handle to ensure the A.W.S. is switched on in the cab in use and off in the cab not in use.

D. Wheel-wear compensator (WWC).
This is not a switch but a variable resistance which can be set to trim the speedometers to the true diameter of the wheels.

E. Brake change-over switch (BCS).
This is a rotary switch fitted to vacuum-fitted locomotives. It has two positions:-

(1) BRAKED used when working vacuum-fitted trains; RAV is energised giving a fast D.S.D. brake application.

(2) UNBRAKED used when working loose-coupled trains; RAV is de-energised giving a slow D.S.D. brake application.

F. Brake selector switch (BSS)

This is a rotary switch fitted to dual fitted locomotives to enable the driver to vary the brake to suit the train being worked. There are four switch positions:

(1) AIR PASS used when working passenger trains fitted with air brakes

(a) The exhausters are isolated and the V.G. short circuited.

(b) Both compressors are in use; when CG closes, No. 2 compressor starts 2 seconds after No. 1 compressor to reduce the peak loading on the auxiliary generator.

(c) Valve RAVA is energised to give a fast brake application.

(2) AIR GOODS used when working freight trains fitted with air brakes.

(a) The exhausters are isolated and V.G. short circuited.

(b) Both compressors are in use.

(c) Valve RAVA is de-energised, giving a medium brake application timing.

(3) VAC. BRAKED, used when working vacuum fitted trains.

(a) Both exhausters and V.G. are in use.

(b) Only one compressor runs.

(c) Valve RAVV is energised to give a fast brake application.

(4) VAC. UNBRAKED, used when working loose-coupled trains.

(a) Both exhausters and VG are in use .

(b) Only one compressor runs.

(c) Valve RAVV is de-energised, giving a slow DSD brake application.

G. Slow motion switch (SMS)

This is a rotary switch fitted on some locomotives to enable a driver to switch in the circuit to control the locomotive accurately at very slow speeds. It has three positions: NORMAL, SLOW No. 1 CAB, SLOW No. 2 CAB. Turning the switch to slow effects the following circuit changes:

(1) The Load regulator is disconnected from the exciter field circuit and is replaced by the slow motion controller in the appropriate cab.

(2) Switch La or the LRR interlock in the circuit between wire 4 and PCR is replaced by an equivalent switch on the slow-motion controller in use.

(3) The 0 - 3 m.p.h. speedometers are brought into use.

(4) On locomotives fitted with relay operated diverts, the circuit to SR5 is open-circuited to prevent inadvertent field weakening.

H. Engine maintenance switch (EMS).
This is a rotary switch having two positions: NORMAL and MAINTENANCE. In MAINTENANCE, contactors GX & GZ are open circuited so that the main generator does not develop dangerously high voltages when the engine is checked at top speed.

I. Motor isolating switches (MIS 1-3)
A group of three rotary switches to enable a defective traction motor circuit to be isolated and the locomotive driven by the remaining motors.

J. Earth isolating switch (EIS).
A four position rotary switch to isolate either or both of the earth fault relays, allowing the locomotive to be operated after an earth fault has developed.

K. Exhauster isolating switches (EXIS 1 & 2).
Two rotary switches each having three positions.

(1) NORMAL, the exhausters run normally.

(2) OFF, the appropriate exhauster is shut down.

(3) TEST, the appropriate exhauster runs from the battery, the locomotive cannot be driven with EXIS 1 or 2 in TEST.

On locomotives fitted with E.P. starting contactors, EXIS 1 & 2 open circuit PCR when in the TEST position.
On locomotives fitted with E.M. starting contactors EXIS 1 & 2 open circuit the auxiliary generator field when in the TEST position.

L. Water Pump control switch (WPCS)
This is a rotary switch having three positions.

(1) AUTO, contactor WPC1 is closed via the reverser handle and wire 12.

(2) OFF, contactor WPC1 is open-circuited and the pump does not run.

(3) DIRECT, contactor WPC1 is closed by a direct feed from wire 52 (battery positive) and the pump runs independant of the controller position.

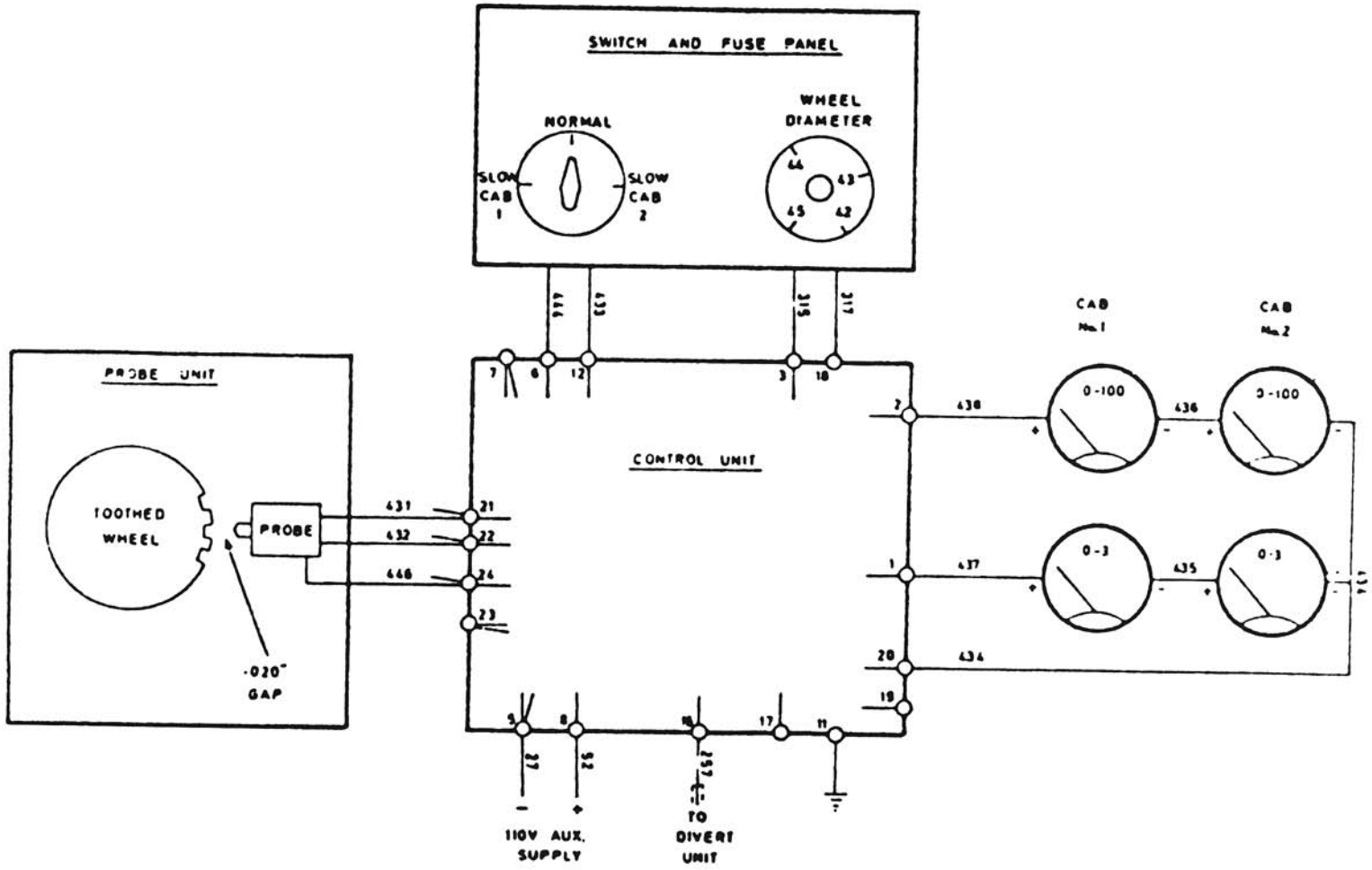
Speed Indicating equipment.

A. Vacuum braked locomotives.

These locomotives are fitted with speed indicating eqipment manufactured by A.E.I. The equipment consists of a generator mounted on the left-hand axle box of No. 2 axle, a trimming resistance WWC to trim the meters when the tyres are turned, and a 0 - 100 m.p.h. meter in each driving cab.

B. Dual fitted locomotives.

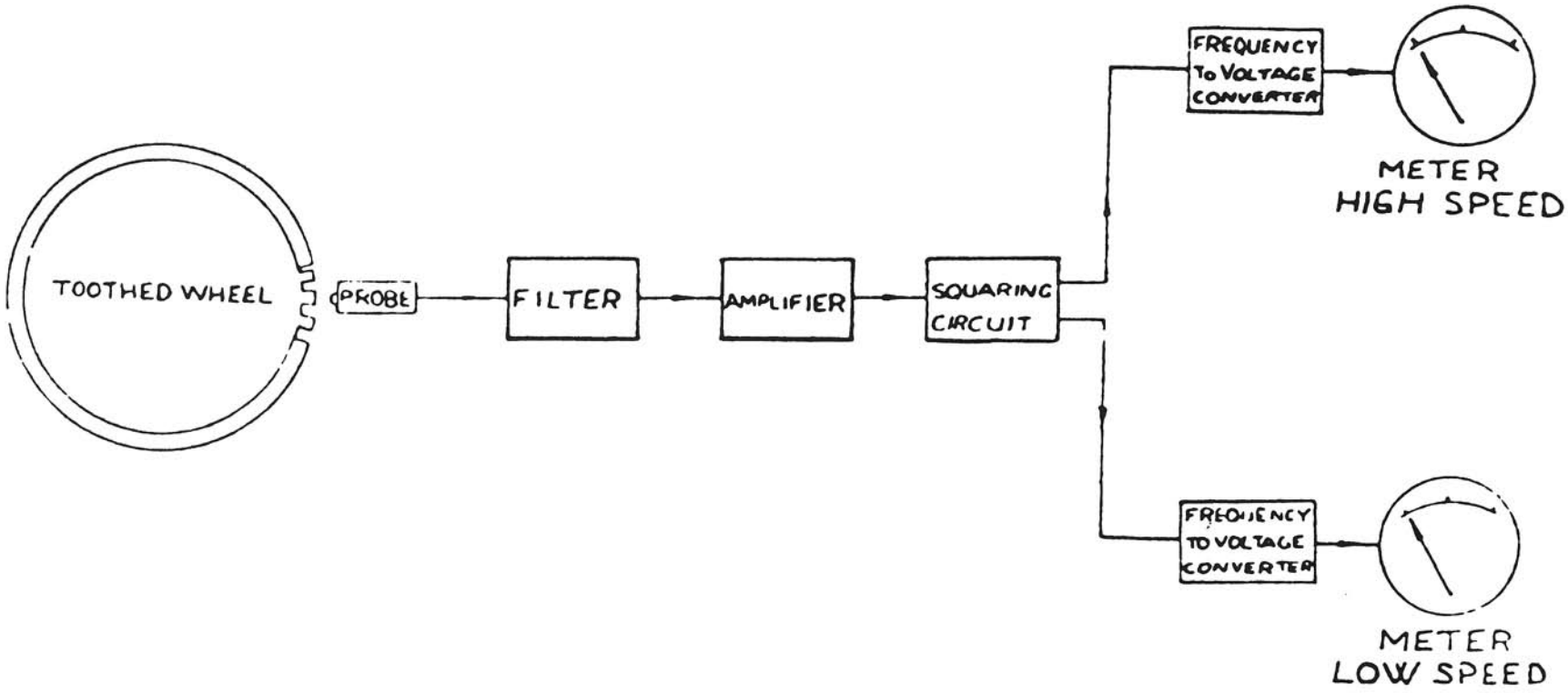
These are fitted with speed indicating equipment manufactured by H.S.D. A toothed disc is mounted on the right-hand side of No. 2 axle with a probe that detects the passage of the teeth. As each tooth passes the probe it sends an impulse to the speed indicator control unit. The control unit feeds a 0 - 100 m.p.h. instrument in each driving cab. When switch SMS is in SLOW, the control unit feeds a 0 - 3 m.p.h. instrument in each driving cab. A trimming resistance (WWC) is fitted so that the instruments can be trimmed when the tyres are turned.



WIRE No. 434

TERMINAL No. 5

DIAGRAM OF SPEED INDICATOR



BLOCK DIAGRAM OF SPEED INDICATOR

SWITCH SETTINGS

PCGa	PRESTART CONTROL GOVERNOR	OPENS	38 p.s.i.	CLOSES	45 p.s.i.
PCGb		CLOSES	38 p.s.i.	OPENS	45 p.s.i.
WPSa	WATER PRESSURE SWITCH	OPENS	4 p.s.i.	CLOSES	8 p.s.i.
WPSb		CLOSES	4 p.s.i.	OPENS	8 p.s.i.
ROPSa	RUNNING OIL PRESSURE SWITCH	OPENS	12 p.s.i.	CLOSES	16 p.s.i.
ROPSb		CLOSES	12 p.s.i.	OPENS	16 p.s.i.
CCGa&b	CONTROL CIRCUIT GOVERNOR	OPENS	65 p.s.i.	CLOSES	75 p.s.i.
AAGa	AUTO AIR GOVERNOR	OPENS	45 p.s.i.	CLOSES	60 p.s.i.
VGa	VACUUM GOVERNOR	OPENS	12½ ins.	CLOSES	15 ins.
CG a & b	Compressor GOVERNOR	OPENS	140 p.s.i.	CLOSES	118 p.s.i.
CG	(NOT DUAL FITTED LOCOS)	OPENS	100 p.s.i.	CLOSES	85 p.s.i.
SOPSa	START OIL PRESSURE SWITCH	OPENS	16 p.s.i.	CLOSES	20 p.s.i.
WTS a &b	WATER TEMPERATURE SWITCH			CLOSES	190°F.
SR1	SHUNT RELAY (S/P)	ENERGISES AT 32 volts.			
SR6	SHUNT RELAY (A/P)	ENERGISES AT 31 volts.			
WPDR	WATER PUMP DELAY RELAY	2 MIN. DELAY ON OPENING.			
C2DR	No. 2 COMPRESSOR DELAY RELAY	2 SECS. DELAY ON CLOSING.			

VLR.	VOLTAGE LIMIT RELAY	1,000 V S/P - 500 V A/P.
FSR	FIELD STRENGTHENING RELAY	1,750 AMP (OPERATING CURRENT)
SBV	SLIP BRAKE VALVE	12 - 15 p.s.i. BRAKE APPLICATION.

LOAD REGULATORS

GENERAL

The purpose of the load regulator is to control the main generator field current, and hence the voltage generated, such that the engine power remains constant at the value selected by the power handle position irrespective of engine speed.

On these locomotives the load regulator is driven hydraulically, and moves in accordance with the governor mechanism by the use of a slide valve, causing engine oil under pressure, to move a vane motor. The slide valve linkage is actuated by two sources (1) the fuel rack position and (2) the speed setting device, such that for any engine speed setting, then the load regulator will only rest when the fuel rack is at a certain position (determined by the design of the governor), thus fixing the engine power output at that value.

The load regulator also carries auxiliary contacts in the control circuits (La, Lb, Lc.) to initiate weak field operation of the traction motors, and other control functions.

OPERATION.

All load regulators operate on a similar principle, that is, they insert , or cut out resistance in the generator separate field. Thus they primarily consist of sliding contacts or cam operated contacts, with a moving arm or sliding contact carrier.

The type of regulator fitted to the 'series-parallel" connected locomotives is supplied by Sulzer Ltd. Carbon brushes mounted on a rotating arm make contact with copper segments connected to the Asistances. The segments are mounted internally on the periphery of an insulated drum. Current is carried via flexible leads to the carbon brush which makes contact with one or more segments at all times. That is, rather like a commutator inside out. The total sweep of the moving arm is approximately 300°, and it is directly coupled to the oil vane motor used on these locomotives.

The three auxiliary contacts are operated by cams on the main spindle.

The all parallel connected locomotives are fitted with an inductor A.L. mounted on the main generator assembly, and this provides the supply to the main generator separate field. The current through the main generator separate field is controlled by varying the excitation of the inductor alternator field. This field only needs a small current,

Instead of having to adjust the current of the main generator with a load regulator, its size determined by the larger current at the contact surfaces, and needing to use separate resistances mounted in a bank, the use of the inductor alternator enables a small load regulator to be used to control the smaller current in the field of the alternator.

The load regulator is therefore a wire wound variable resistor, using graded wire diameters with larger cross-sections at the high current end. The three auxiliary switches are operated by cams on the main spindle. Unfortunatley there are two different arrangements of auxiliary contacts required, one for locomotives D.1575 - 1681 and D.1715 - 1841 for which load regulator type ZA.1 was originally used. Modifications to this have caused ZA 2 to be used on later locomotives, and both types will be modified to ZA 21.

NOTE: During maintenance exams and fault finding procedure, do not attempt to rotate the main brush arm by hand until the oil servo-motor has been drained.

In order to drain the servo-motor, remove the two drain plugs and gently rotate the regulator ocer its full travel, by hand, which will force oil through the drain holes.

Should it be necessary to check the run-up and run-back times of the load regulator, the enging should be running at idling speed with an engine oil temperature of 160°F, and using the load regulator reducing solenoid to force the run-back. The time of both must be between 10 and 16 seconds, and about 12 seconds is ideal. If either timing should be appreciably greater than 12 seconds, then the servo-motor should be drained and a manual check made for mechanical binding. Further attention may be necessary to the condition of the lubricating oil filter between the engine and the governor to ensure a free flow of oil.

To check the operation of the auxiliary switches.

(a) Series parallel type locomotives.

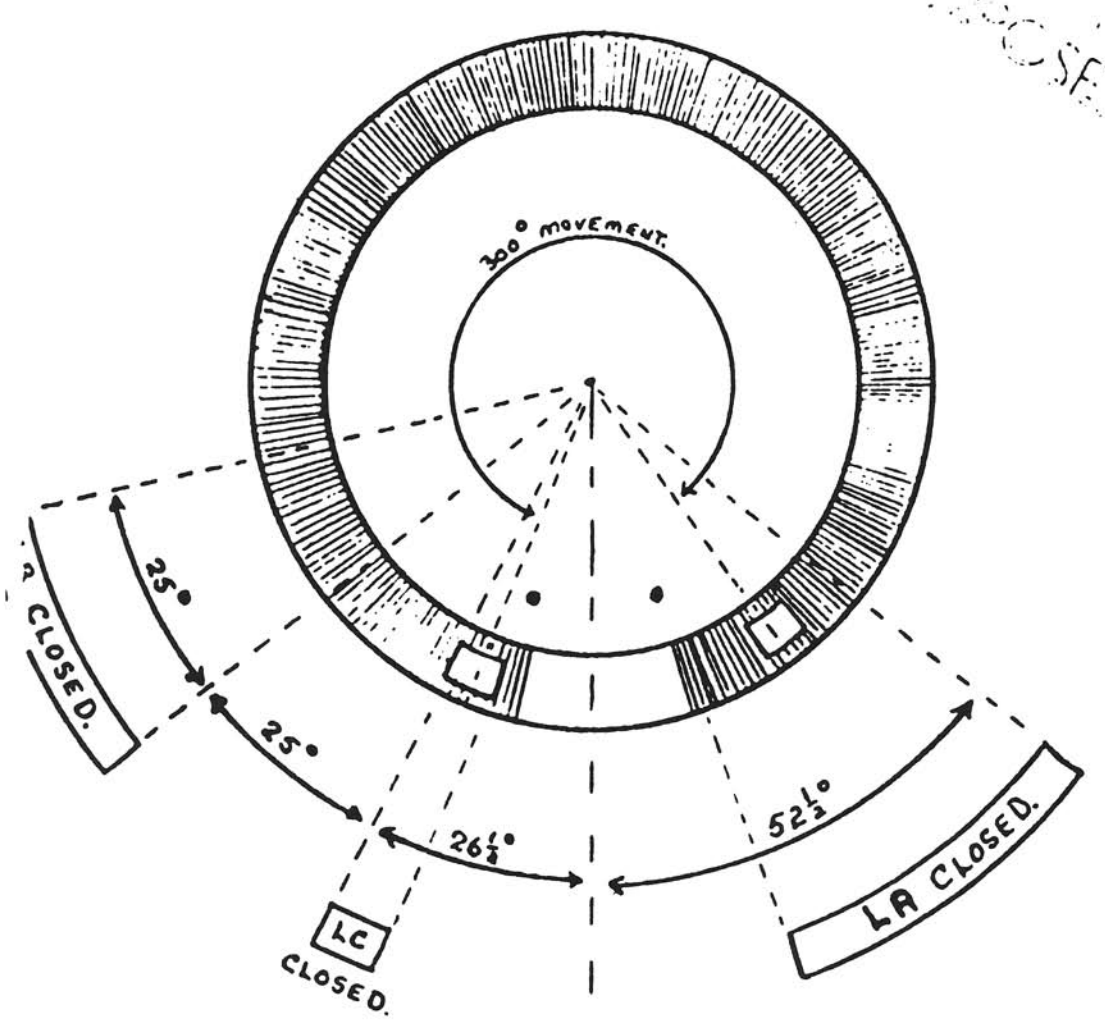
Switch La closes at approximately segment No.40 (i.e. 300°) it is important that it remains closed to the end of the brush arm travel.

Switch Lb closes at approximately segment No. 5 and remains closed until the brush reaches approximately segment No. 3.

Switch Lc must close as the brush reaches segment No. 0 and must remain closed to the end of the brush arm travel.

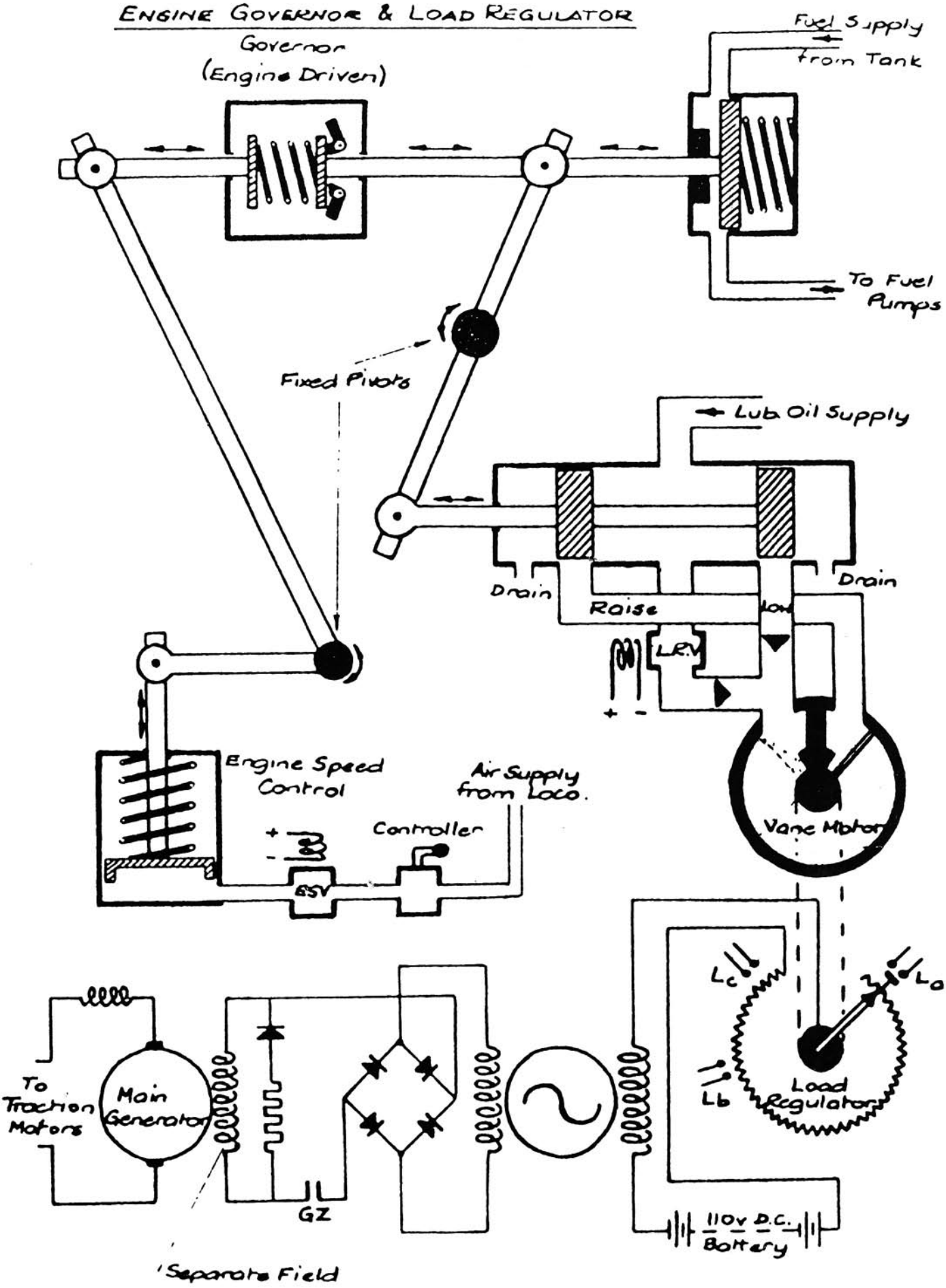
(b) All parallel type locomotives.

(See next sketch)



SCHEMATIC OF AUXILIARY SWITCH OPERATION.

(PLAN VIEW OF TOROSTAT)



CARBON PILE VOLTAGE REGULATORS.

GENERAL

The 'Newton-Derby' Automatic Carbon Pile Voltage Regulator consists essentially of a carbon pile resistance which is connected to the shunt winding of the D.C. auxiliary generator. The operating coil of the regulator is connected across the output terminals of the machine. Circuit resistance of the operating coil is so arranged that any change in the pre-determined voltage across it, affects the resistance of the carbon pile so that regulation is maintained within very close limits.

PRINCIPLE OF OPERATION

When the solenoid is not energised the armature exerts a pressure on the carbon pile by virtue of the cantilever type springs so that its resistance is at a minimum.

Energising the solenoid causes the armature to be magnetically attracted to the core in the magnet housing.

Assisting the magnetic force is another force due to pile re-action. The pile reaction is at maximum when the pressure on the pile is at maximum, decreasing as the pressure on the pile decreases.

The magnetic force together with the force contributed by the pile reaction, acts in the opposite direction to the spring force, so that the pressure on the pile is the difference between the magnetic plus pile reaction force and the spring force. It is the varying magnetic force created by the solenoid that tends to overcome the spring force, thus varying the pressure on the carbon pile. Any change in resistance of the carbon pile affects the output voltage across the generator, which in turn tends to raise or lower the voltage across the solenoid. Since the regulator is sensitive to any change in the M.M.F. of the solenoid, a balance of magnetic and physical forces takes place in the regulator, thus making regulation automatic.

In the case of a voltage regulator connected to the auxiliary generator field circuit, change of resistance of the carbon pile will affect the output voltage, i.e. the voltage across the solenoid operating coil. Any change in the input voltage will therefore tend to raise or lower the voltage across the solenoid coil and the resistance of the carbon pile will be automatically decreased or increased to maintain a balance of forces for a small change of M.M.F. of the solenoid; thus the output voltage will be maintained approximately constant for a wide variation in the input supply.

ADJUSTMENT OF THE REGULATOR.

Three separate adjustments are provided in the regualtor.

(1) Control coil circuit resistance.
(2) Core adjustment or air gap.
(3) Carbon pile compression spring adjustment.

Depots are confined to the use of No.1 adjustment ONLY. The mechanical setting of the regulator must NOT be interfered with other wise poor regulation and hunting will result. Should a fault arise and cannot be overcome by No. 1 adjustment the best course of remedial action would be to change the complete regulator thereby avoiding continual trouble and failure from a maladjusted unit .

The following types of voltage regulators are fitted to these locomotives. Because of the differences in pile loading and resistance range, it is vitally important to make sure when a regulator has to be changed, that the replacement regulator is of the correct type.

800V Train heating generator TG. 160-16 Mk.I
CARBON PILE TYPE NR/4/4/2/66394
110V Auxiliary generator TG 69-16 Mk.I.
Self ventilated. Carbon Pile Type 4/5/66479

110V Auxiliary generator TG 69 - 28 Mk.III
CARBON PILE TYPE NR/4/5/67695
Self ventilated

110V Auxiliary generator TG 69 - 20 Mk. I or Ia.
CARBON PILE TYPE NR 4/5/400726
FORCE VENTILATED by means of a tapping from the traction motor blower ducting.

110V Auxiliary generator TG 69-20 Mk.I or Ia.
HAWKER SIDDELEY DYNAMIC ELECTRONIC TYPE.

ELECTRONIC TYPE VOLTAGE REGULATORS.

The principle of operation is that the current in the field of the auxiliary generator may be varied by varying the period of SWITCH ON and SWITCH OFF of the field circuit using certain electronic components.

The output voltage of the auxiliary generator is controlled by varying the duration of the pulses of excitation current to the generator's field windings. The current which consitutes the pulse is derived from the auxiliary generator itself, e.g. the field current can vary from 2 amps at no-load at 1150 RPM to 20 amps at maximum output of 700 amps at 468 RPM.

It is the average value of the pulsed current which determines the degree of field excitation which the generator receives.

A small decrease in the output voltage of the generator causes the regulator to increase the duration of the excitation pulses, thus increasing the output voltage of the generator. A small increase in the output voltage of the generator has the opposite effect. Thus the regulator counteracts any fluctuations of generator voltage and prevents the voltage varying significantly.

Because the field current is controlled by an ON - OFF device, the power dissipation within the regulator will be small.

This voltage regulator will utilise a large rectifier connected between the auxiliary generator and the battery and thereby will dispense with the conventional type of reverse current relay and battery charge contactor.

In addition to having control over the output voltage, this regulator has seperate current control. This latter feature is used to limit the maximum battery charging current to a maximum of 125 amps.

Safety Circuit.

If the generator output voltage rises above a safe level (130v) a silicon controlled rectifier (S.C.R.) connected across the generator is triggered ON. This in effect places a short circuit across the generator and thereby blow the fuse in the output lead of the generator.

SETTING THE A.V.R.

a) CARBON PILE TYPE:

At approximately half engine speed when the battery charge has dropped below 30 amps, set the A.V.R. i.e. after the engine has been running for a considerable time to allow components to acquire normal working temperature.

(i) Open BATTERY ISOLATING SWITCH.

(ii) Set the A.V.R. to give 109 volts across the auxiliary generator by the adjustment of the trimmer resistance.

(iii) Close the battery switch and check the auxiliary generator voltage is reduced by 1 volt for each 14 AMPS battery charge.

b) ELECTRONIC TYPE

With the engine running at half speed and the battery charge below 40 amps, adjust the A.V.R. potentiometer R.V.I. to give 110 volts across the auxiliary generator.

It must be emphasised that when checking the voltage settings of these regulators that:-

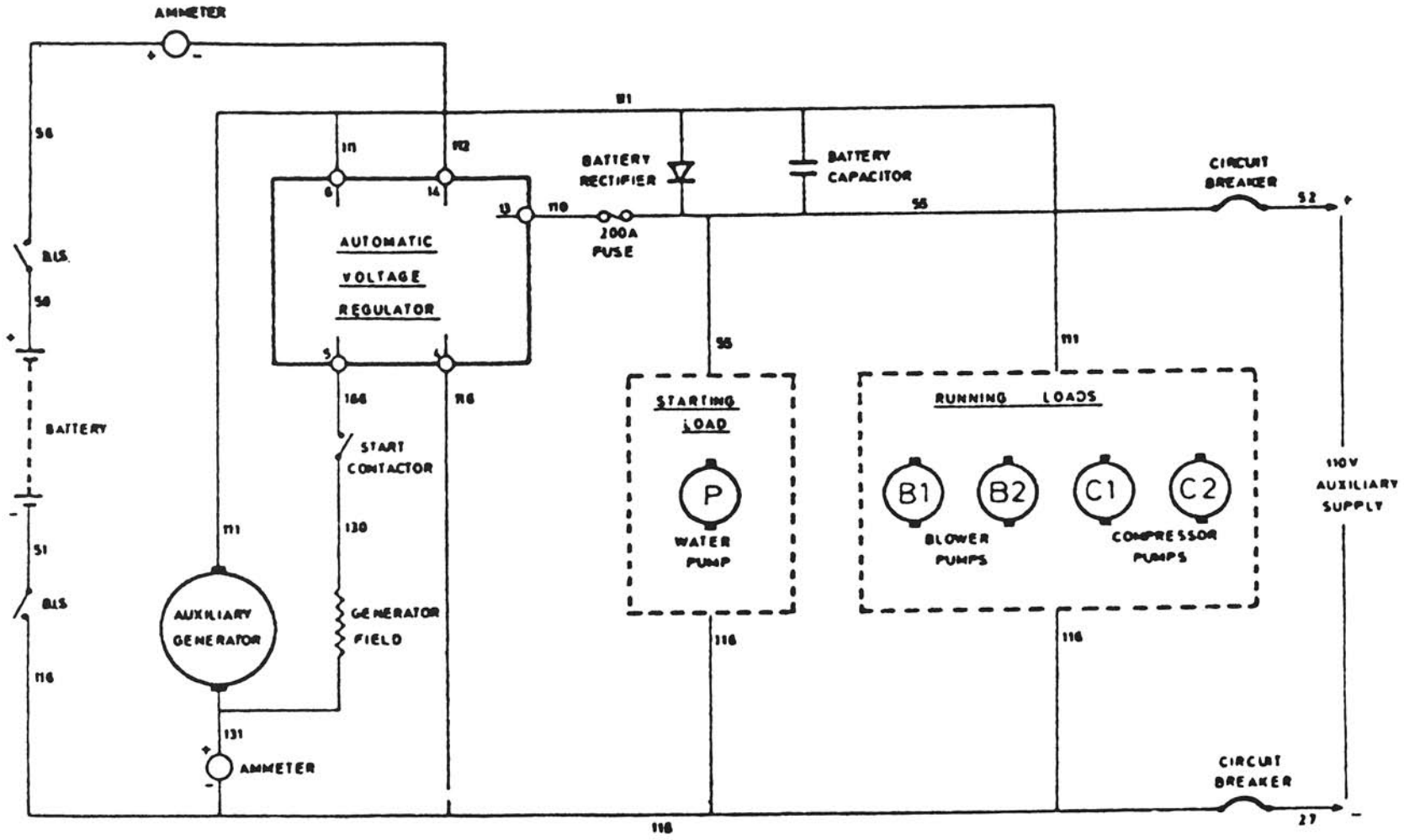
(1) A high grade accurate voltmeter is used.

(2) The maximum voltage reading under high speed light load conditions must not be exceeded. Otherwise excessive gassing will take place with consequent serious damage to the battery plates.

LOCOMOTIVES FITTED WITH ELECTRONIC AVR AND GAS SENSING PROBES

Before adjusting RVI, ensure the battery charging current is below 40 amps. Set the AVR to give 115V across the auxiliary generator.

NOTE: On Locomotives fitted with an electronic AVR (either gas sensing or non-gas sensing) the maximum charging rate should not exceed 125 amps. Should the charge exceed and remain above 125 amps adjust potentiometer RV5 (marked charge) anticlockwise. Ensure lock-nut is re-tightened.



WIRE No. 116

TERMINAL No. 4

DIAGRAM OF AUTOMATIC VOLTAGE REGULATOR

INDUCTOR ALTERNATORS.

SERIES PARALLEL - WHEEL SLIP

ALL PARALLELS - MAIN GENERATOR EXCITATION.

GENERAL DESCRIPTION

The inductor alternator is mounted on the end of the generator assembly shaft, overhung from the auxiliary generator bearing.

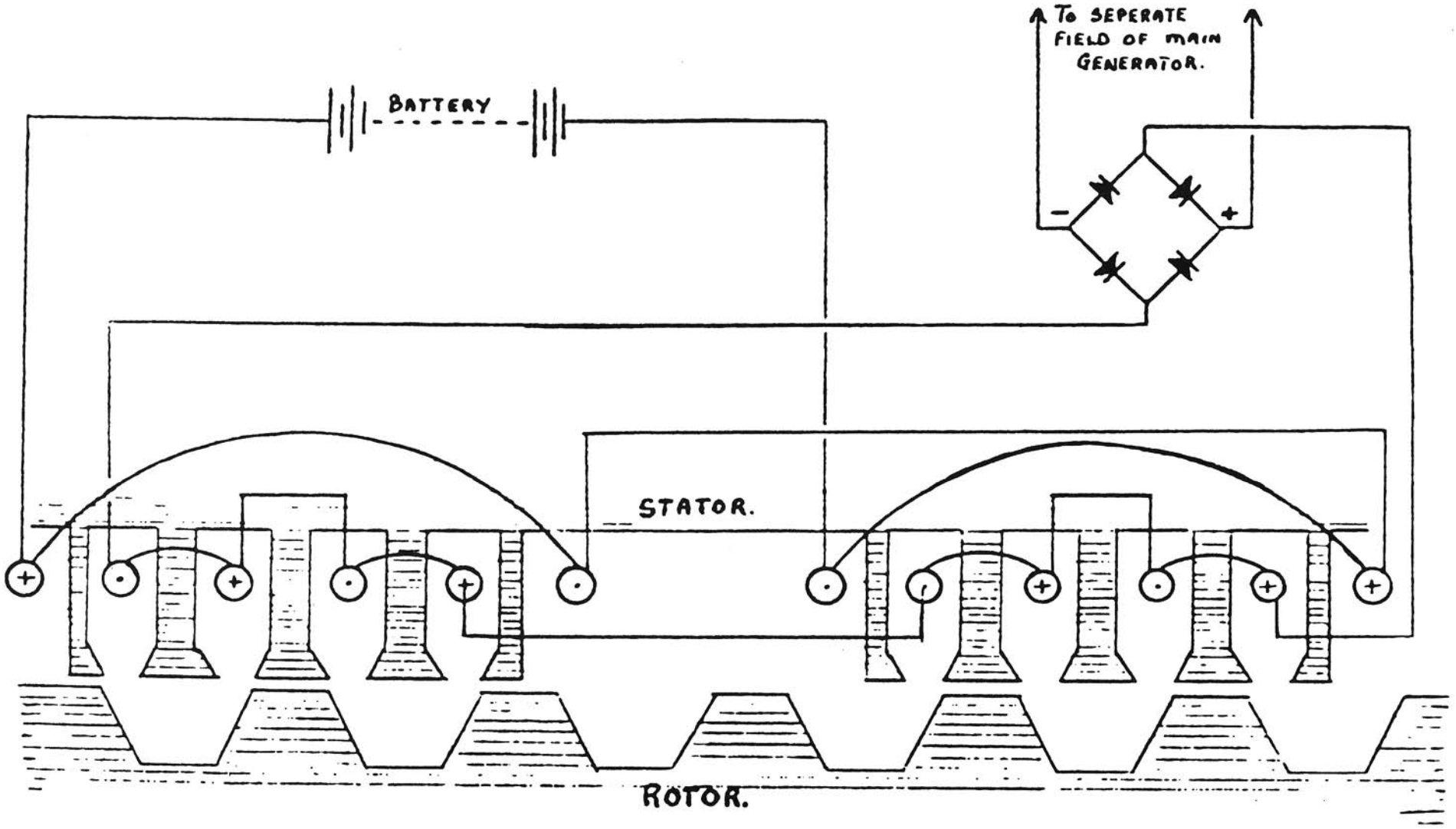
The rotor carries no windings at all, being just a slotted magnetic core. As it carries no windings, no slip rings are required, and no commutator or brush gear to maintain.

The stator (or casing) carries two sets of windings, the D.C. field coils wound on a number of "poles" in the normal manner.

The A.C. output windings are placed in slots in the pole faces and as the armature revolves, the relative movement of the teeth and slots on the rotor passes the windings and induces an A.C. voltage in them.

The rotor is fully laminated in the usual way and the stator is also fully laminated as usual with any A.C. machine.

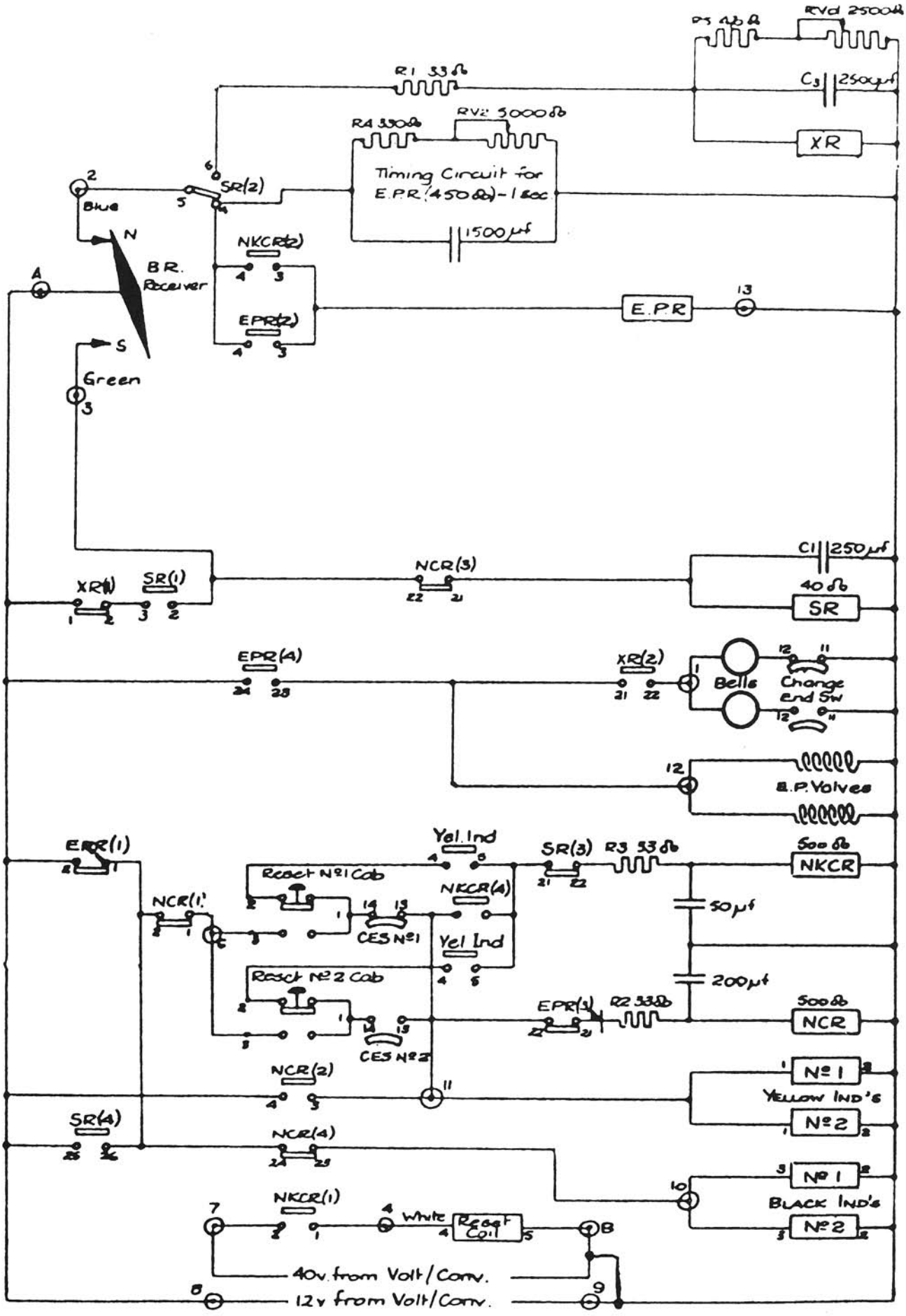
A developed view of the inductor-alternator is provided on the next page.

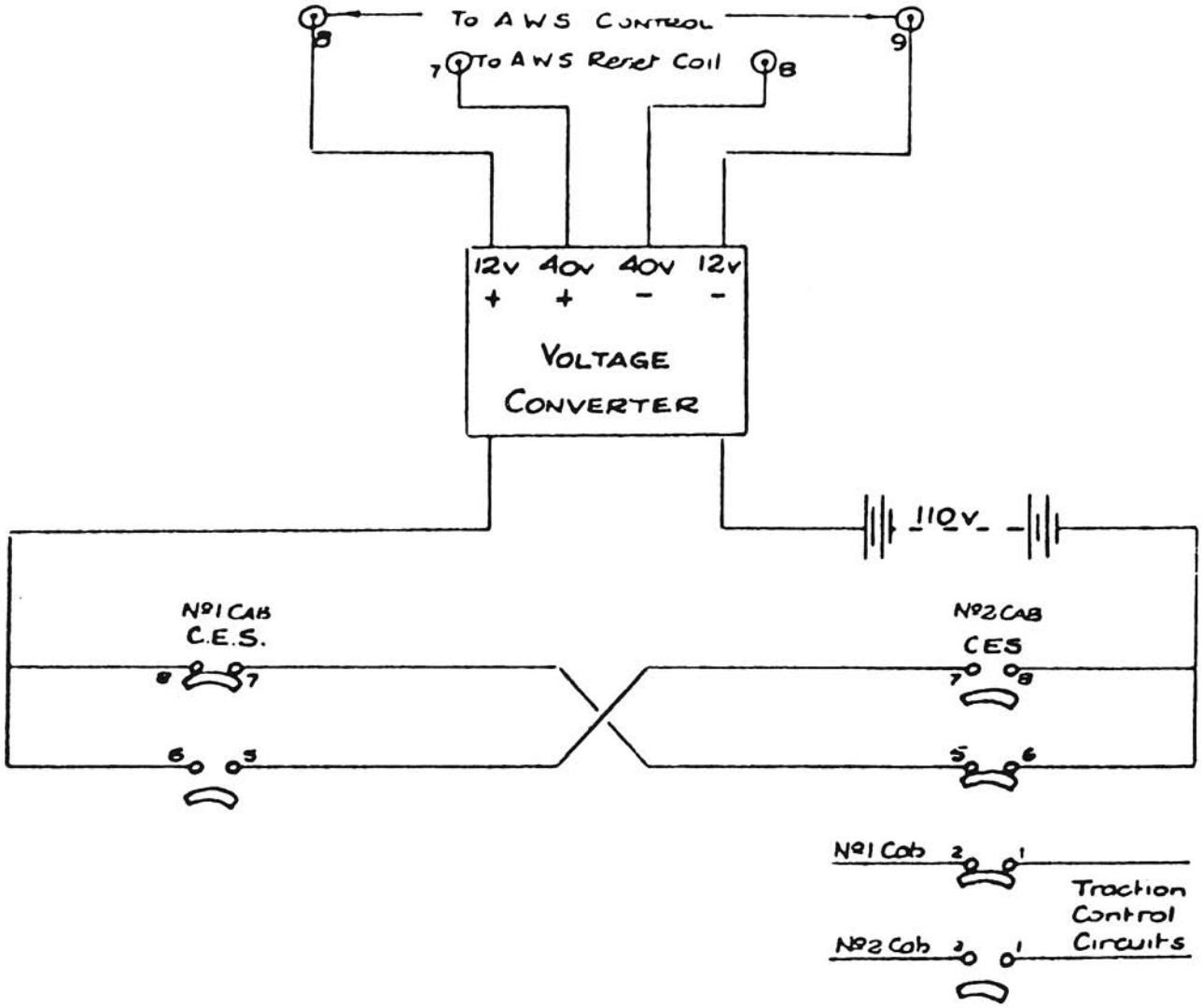


TYPE:	HFA 415 (ALL PARALLEL)	F 793 SERIES PARALLEL.
OUTPUT:	150V. A.C. 28AMPS.	156V. A.C. ·42AMP.
EXCITATION:	60V. DC. 1·5 AMPS.	110V. DC. ·015 AMP.
RATING:	CONTINUOUS.	CONTINUOUS.
WEIGHT:	470 lbs.	56 lbs.

INDUCTOR - ALTERNATORS.

BR-EX-NR DUAL A.W.S. CIRCUIT





XR	Bell Relay
EPR	Electro Pneumatic Valve Relay
EPV	Electro Pneumatic Valve
SR	South Relay
Y IND	Yellow Indicator Relay
B IND	Black Indicator Relay
NCR	North Checking Relay
NKCR	North Detection and Proving Relay
CES	Change-end Switch.

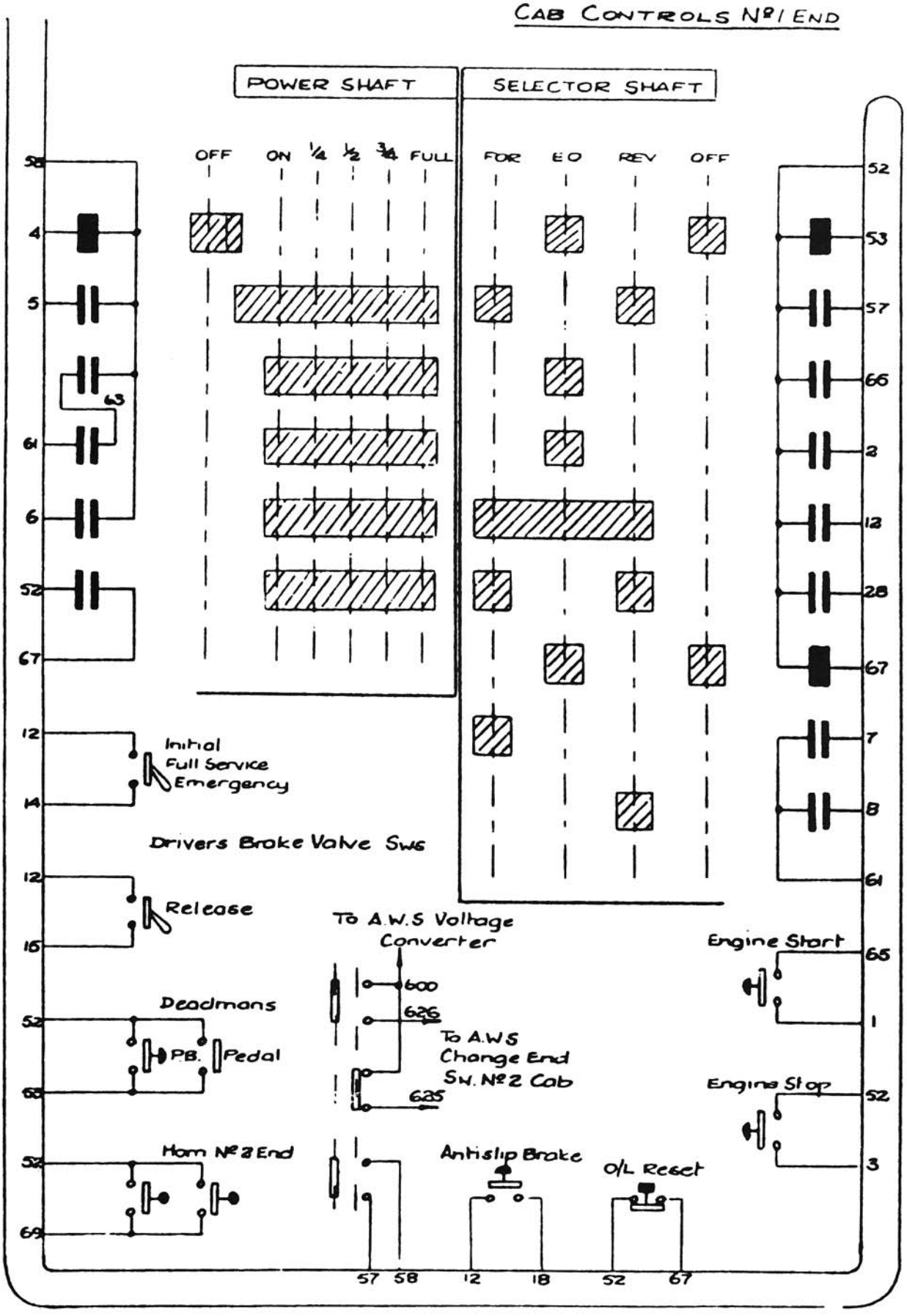
SYMBOLS

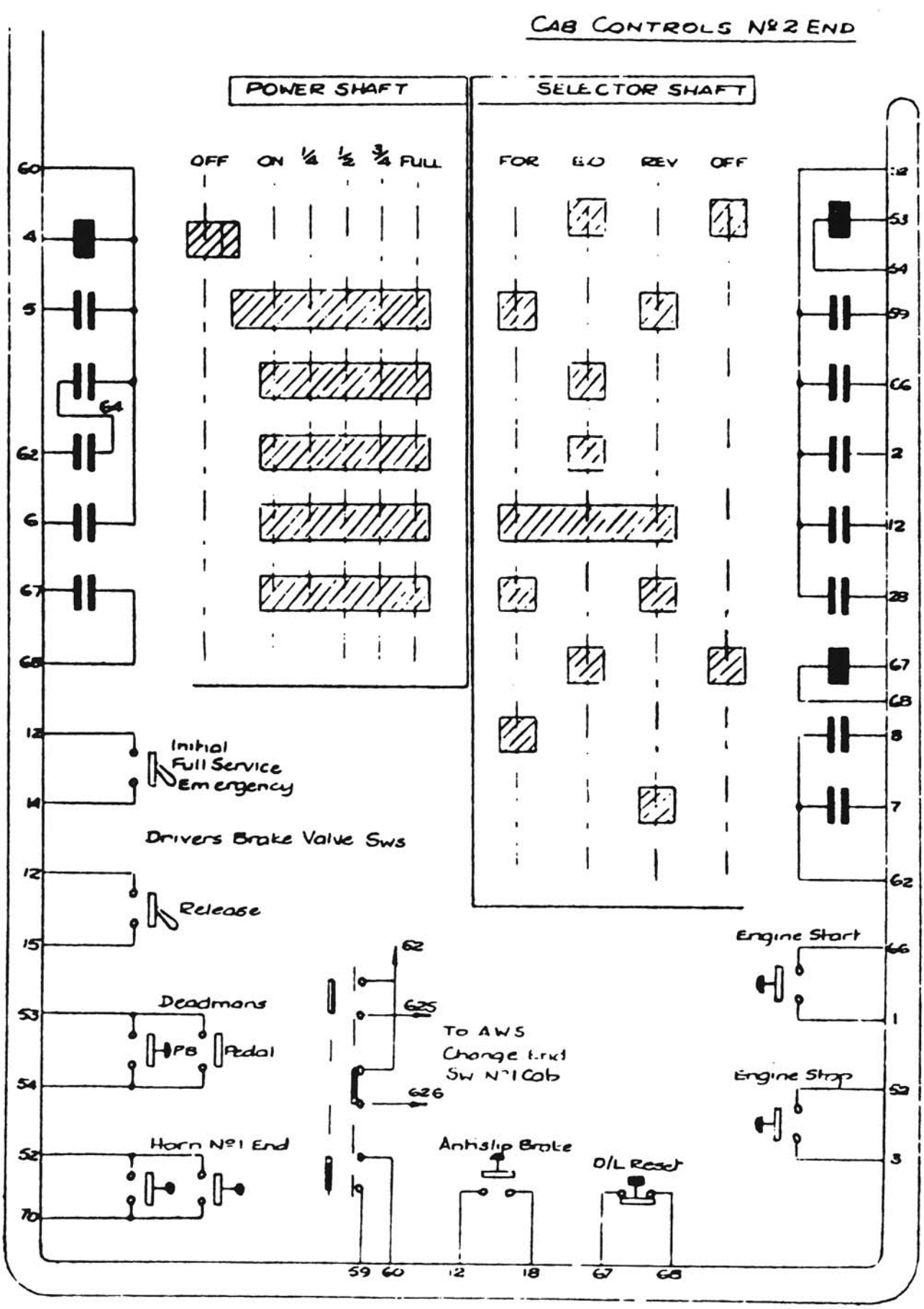
DIAG REF	SWs.	DESCRIPTION	DIAG REF	SWs	DESCRIPTION
Ao, Ab, Ac		Ammeters	EHMSS		E.H.M. Surge Supressor
AAG	1	Automatic Air Governor	EIS	2	Earth Isolating Switch
AEFR	1	Auxiliary Earth Fault Relay	EMS	1	Engine Maintenance Sw.
AEFRE1-2		Aux. Earth Fault Relay Res.	EMT		Emergency Start Terminals
AERK		Alternator Exciter Rectifier	ERV		Engine Run Valve
AERKCP		Alt. Exciter Rect. Capacitor	ERVRE		Eng. Run Valve Resistor
AFL		Aux Generator Field Link	ESV		Engine Speed Valve
AVR		Automatic Voltage Regulator	EXC	1	Exhauster Contactor
A.W.S	4	Auto. Warning System.	EXD		Ex. Cont. Surge Prot. Disc
AWSRE		A.W.S. Series Resistor	EXIS 1-2	4:4	Ex. Isolating Switch
BCF		Battery Charge Fuse	EXRE 1-2		Ex. Divert Resistors
BEMS1-2	1:1	Boiler Emer. Shut Down Sws.	EXY 1-2	1.1	Ex. Divert Contactors
BILRE1-4		Brake Ind. Lamp Resistors	FAR	1	Fire Alarm Resistors
BIS	2	Battery Isolating Switch.	FCD		Field Cont Surge Prot. Disc
			FCV 1-2		Feed Cut Off Valves
			FSC 1-5	3:5:4	Field Shunting Contactors
BRK		Battery Rectifier	FSR	3	Field Strengthening Relay
BRKCP		Battery Rectifier Capacitor	FSRE 1-4		Field Shunting Resistors
BSS	18	Brake Selector Switch	GDU1-3	1:1:1	Gas Discharge Units
C1-2		Compressor Contactor	GX		Main Gen. Sep. Field Cont.
C2DR	1	Comp. Nº2 Delay Relay	GZ		Main Gen. Self. Field Cont.
CCB1-2	1:1	Control Circuit Breakers	HF1-2		Heater Fuses
CCG	2	Control Circuit Governor	HV 1-2		Horn Valves
CDS1-5	1:1:1:1	Cont. Cub. Door Switches	La, Lb, Lc	1:1:1	Load Regulator Aux. Sws.
CF1-2		Compressor Fuses	LCB1-4	1:1:1:1	Lighting Circuit Breakers
CG	2	Compressor Governor	LFS	1	Low Fuel Switch
COF		Cooker Fuse	LRR	3	Load Regulator Relay
CRDRE1-2		Compressor Divert Res.	LRRE1-4	1:1:1:1	Load Regulator Resistors
CRE1-2		Compressor Resistor	LRV		Load Reducing Valve
CS1-2		Battery Charging Sockets	LS	4	Lighting Switch
CWA		Carriage Warming App.	M1-6	6:6:6:6:6:6	Motor Contactors
DMTV		Deadmans Timing Valve	MBF2		Blower Motor Fuses
DMV		Deadmans Valve	MBR2	2	Blower Motor Relays
EHM		Engine Hour Meter	MCD		Motor Cont. Surge Prot. Disc.

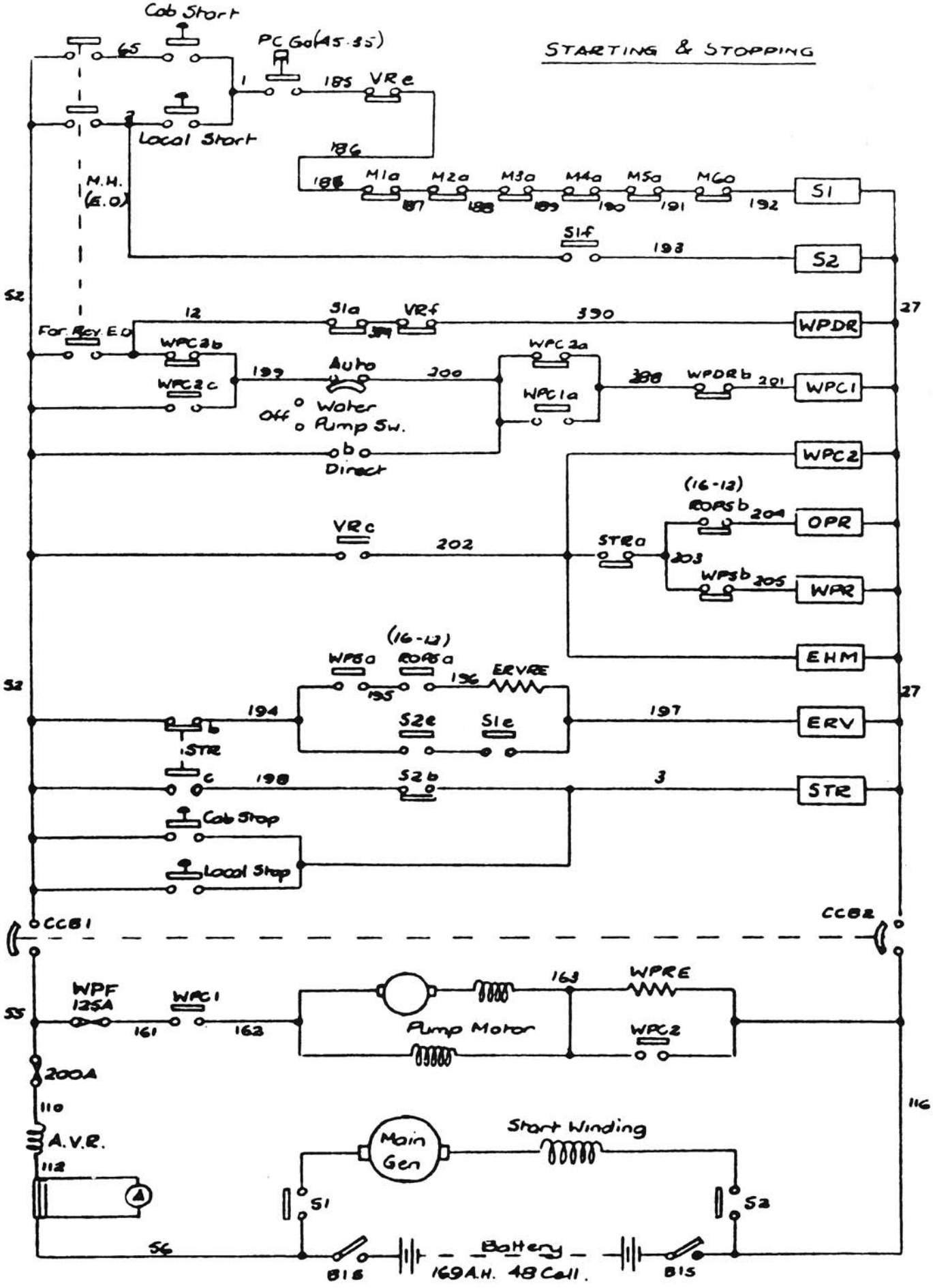
SYMBOLS

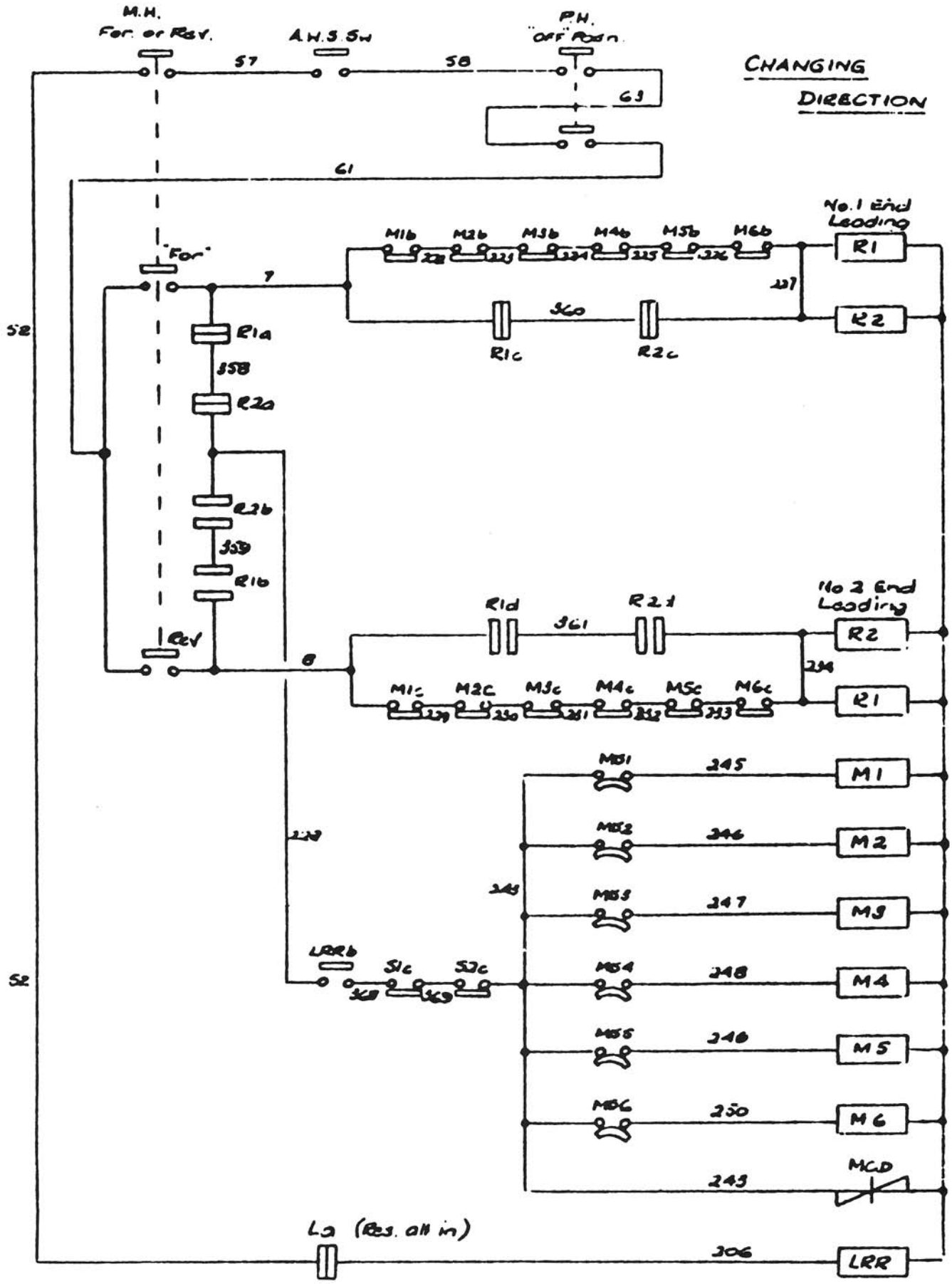
DIAG REF	SWs	DESCRIPTION	DIAG REF	SWs	DESCRIPTION
MIL 1-6		Motor Isolating Links	WPC 1-2	1:3	Water Pump Contactors
MIS 1/2 3/4, 5/6	4 4:4	Motor Isolating Switches	WPCS	2	WP Control Switch
			WPDR	1	Water Pump Delay Relay
OPR	1	Oil Pressure Relay	WPF		Water Pump Fuse
PCG	2	Prestart Compressor Gov	WPR	1	Water Pressure Relay
PCR	3	Power Control Relay	WPRE		Water Pump Resistor
PEFR	3	Power Earth Fault Relay	WPS	2	Water Pressure Switch
R 1-2	4:4	Reversers	WRE 1-5		Warning Resistors
RAVA		Restricted Application v/v Air	WRK 1-4	1 1 1 3	Warning Rectifiers
RAVV		Restricted App Valve - Vacuum	WSR 1-5		Wheelslip Relays
ROPS	2	Running Oil Pressure Switch	WTS	2	Water Temperature Switch
S1-2	6:5	Starting Contactors	WWC		Wheel Wear Compensator
SBV		Slip Brake Valve	XCV		Exhauster Choke Valve
SFDRE		Self Field Discharge Res			
SFRE		Self Field Resistor			
SFRK		Self Field Rectifiers			
SM1-2	1:1	Slow Motion Limit SWS			
SMRE 1-3		Slow Motion Resistors			
SMS		Slow Motion Switch			
SOPS		Start Oil Pressure Sw			
SPFDRE		Separate Field Discharge Res			
SPFRK		Separate Field Rectifiers			
SR 1-6	5.6:C 6.4 1	Field Shunting Relays			
SRCR	4	Steam Remote Cut Off Relay			
STR	3	Stop Relay			
SLS 1-2		Shore Supply Sockets			
VG	1	Vacuum Governor			
Vg RE		Main Gen Voltmeter Res			
VLDR	1	Voltage Limit Drop Out Relay			
VLR	1	Voltage Limit Relay			
VLRE		Voltage Limit Relay Res			
VR	7	Voltage Relay			
WLS	1	Water Level Switch			

CAB CONTROLS Nº1 END

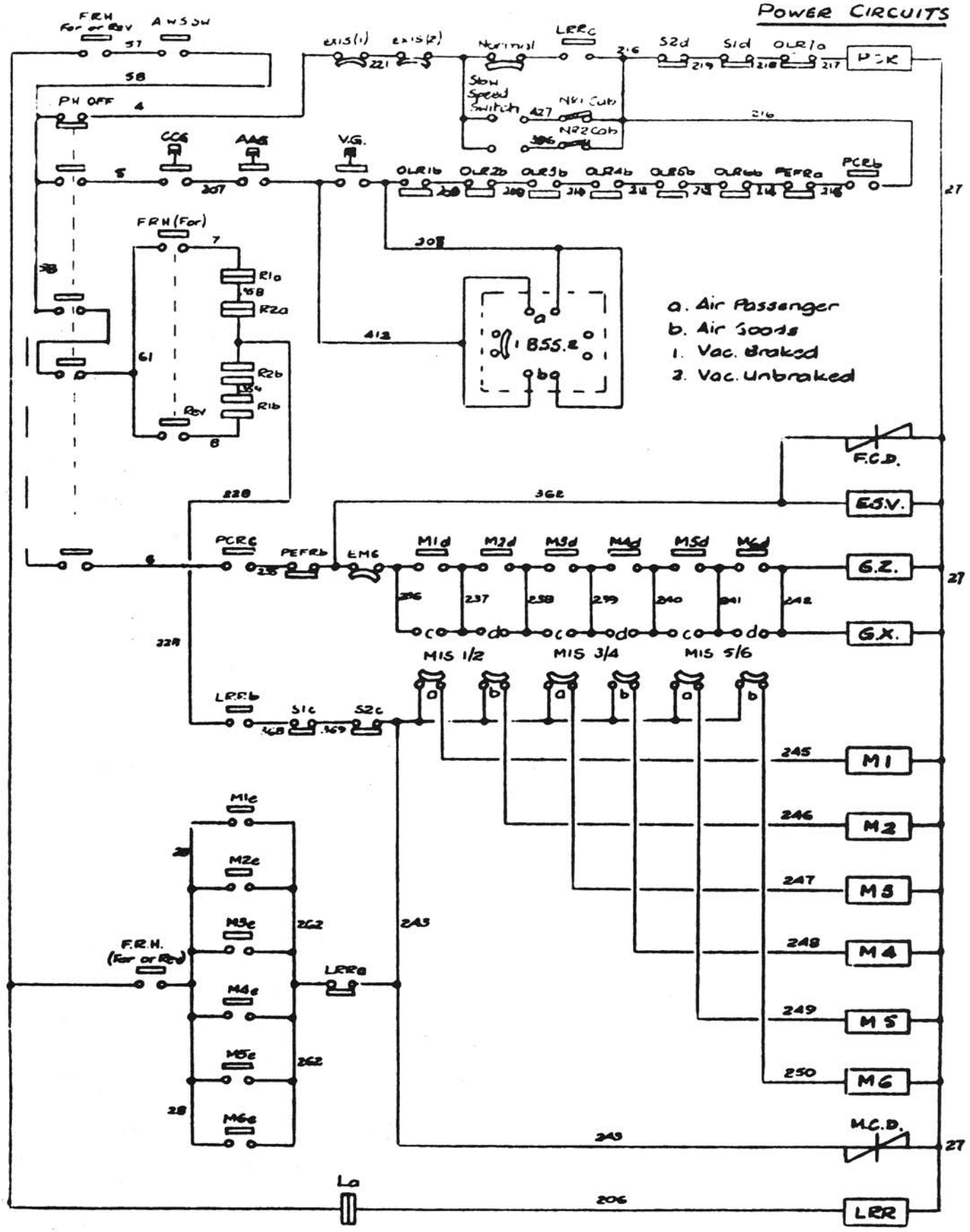


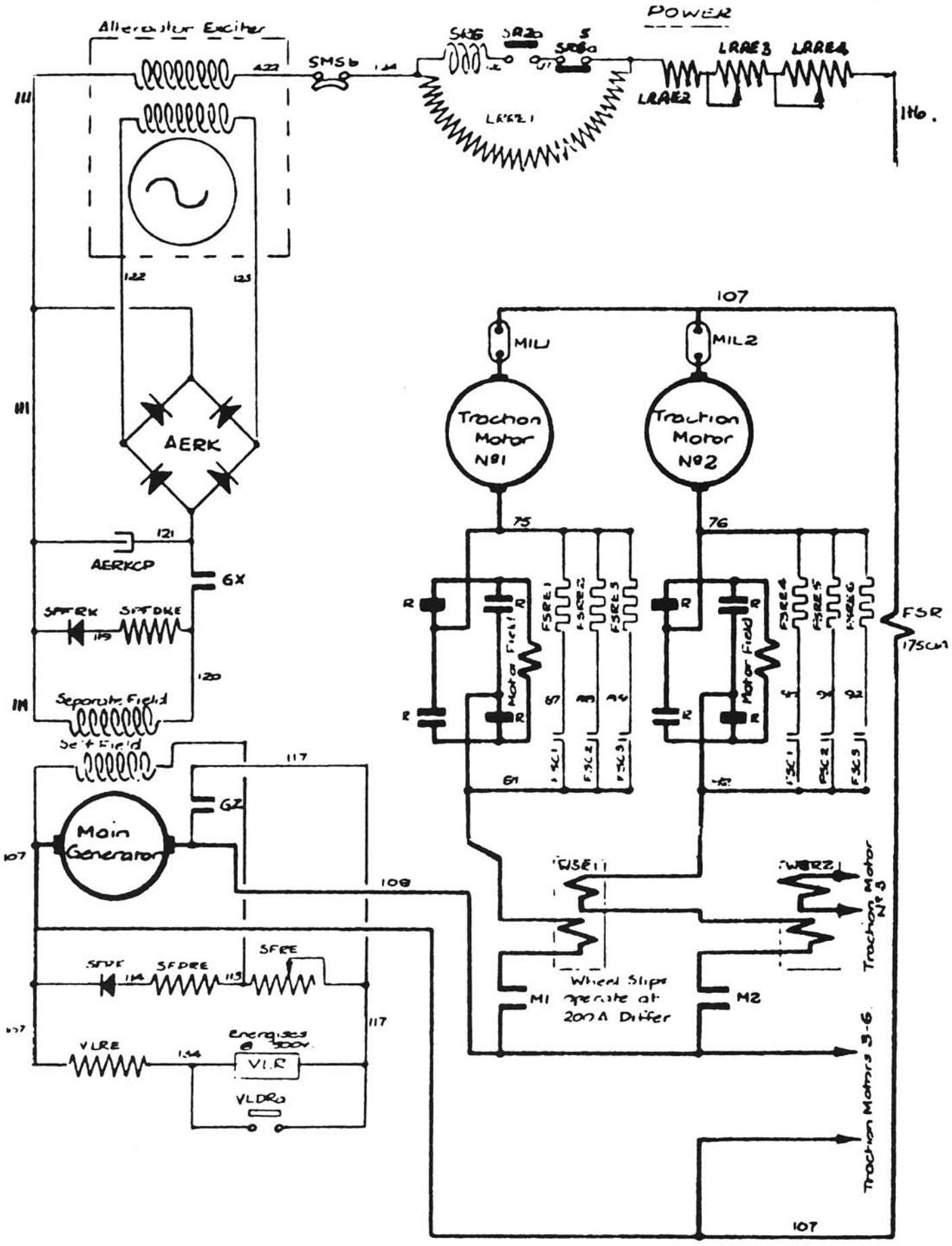




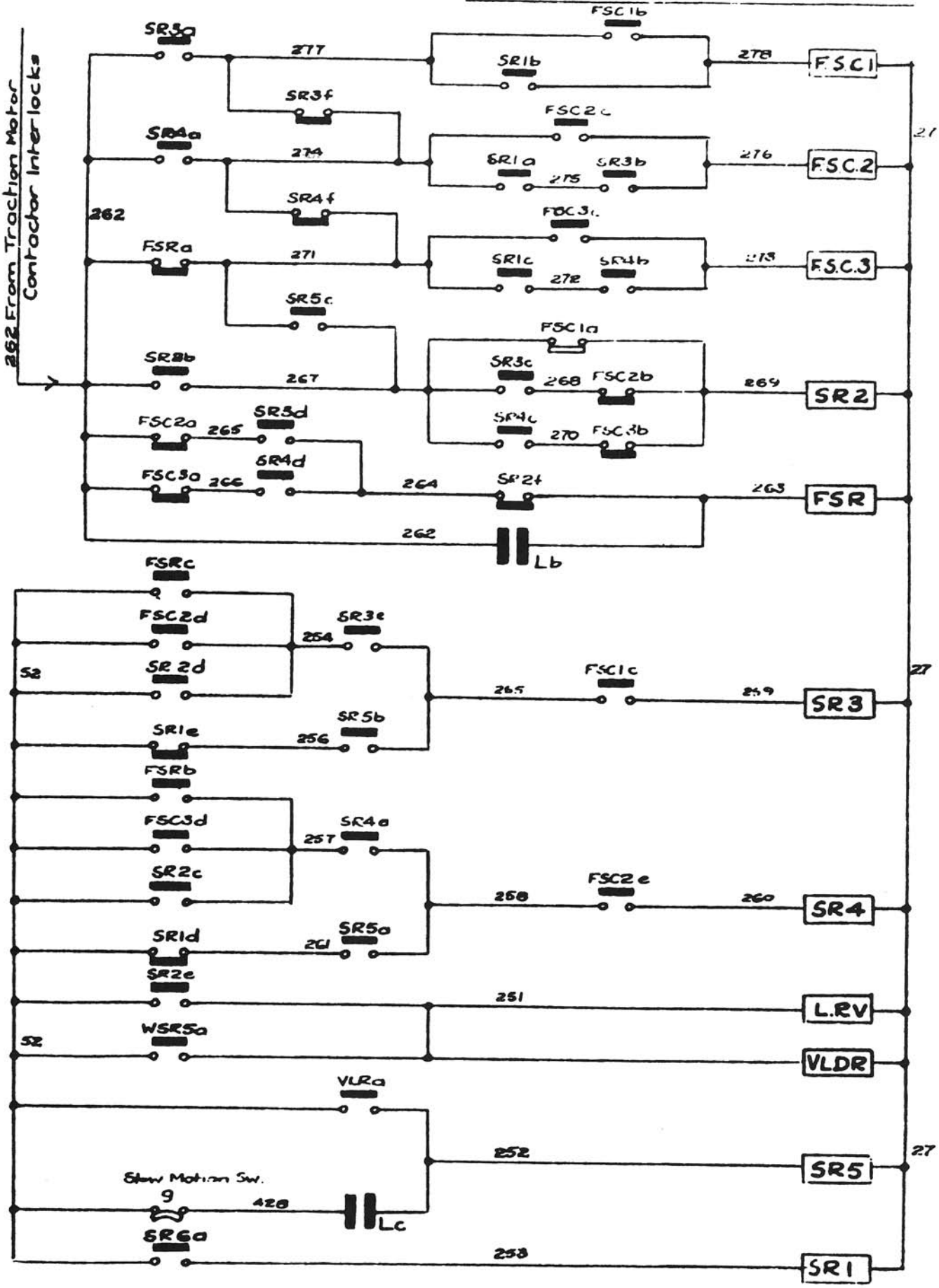


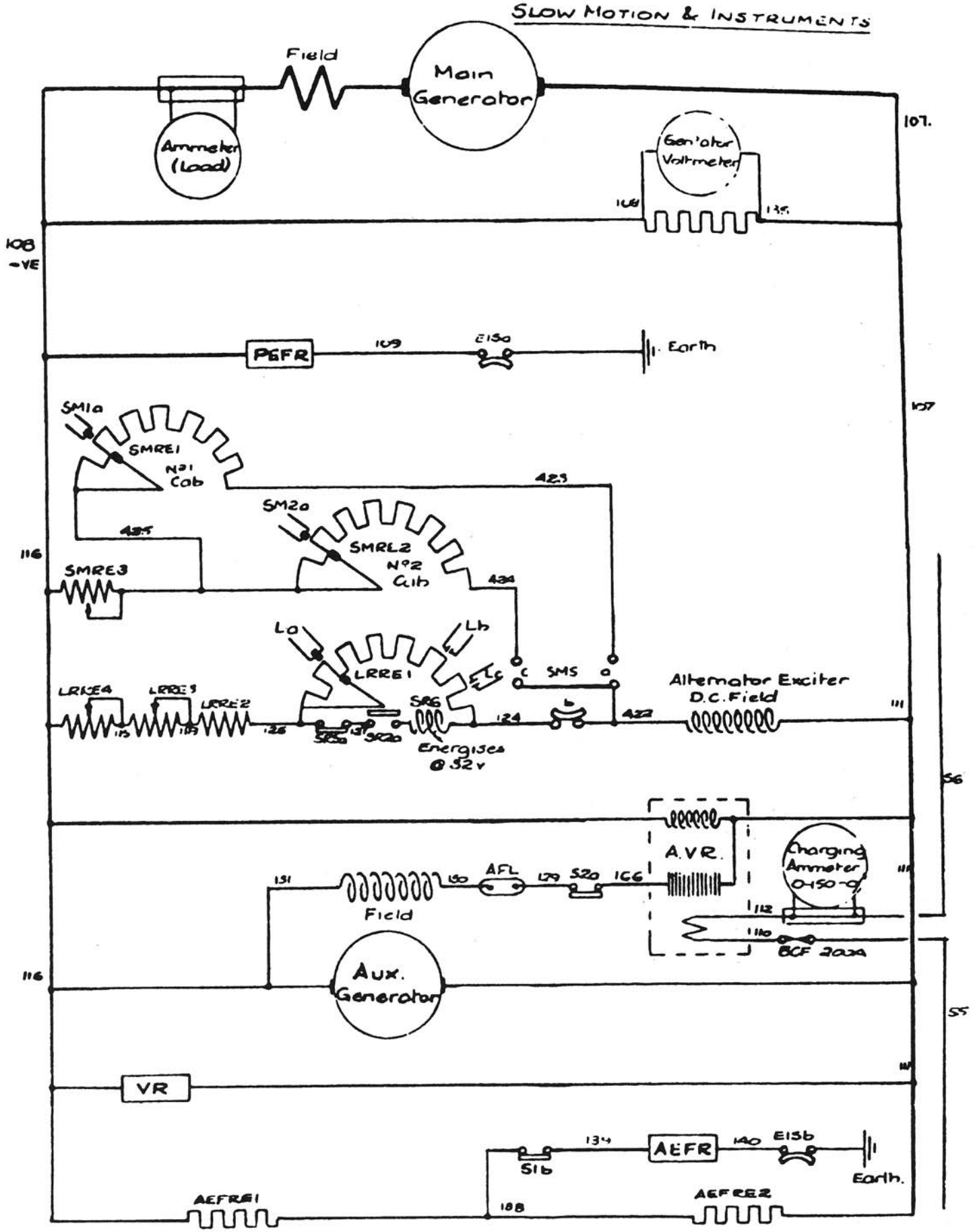
POWER CIRCUITS



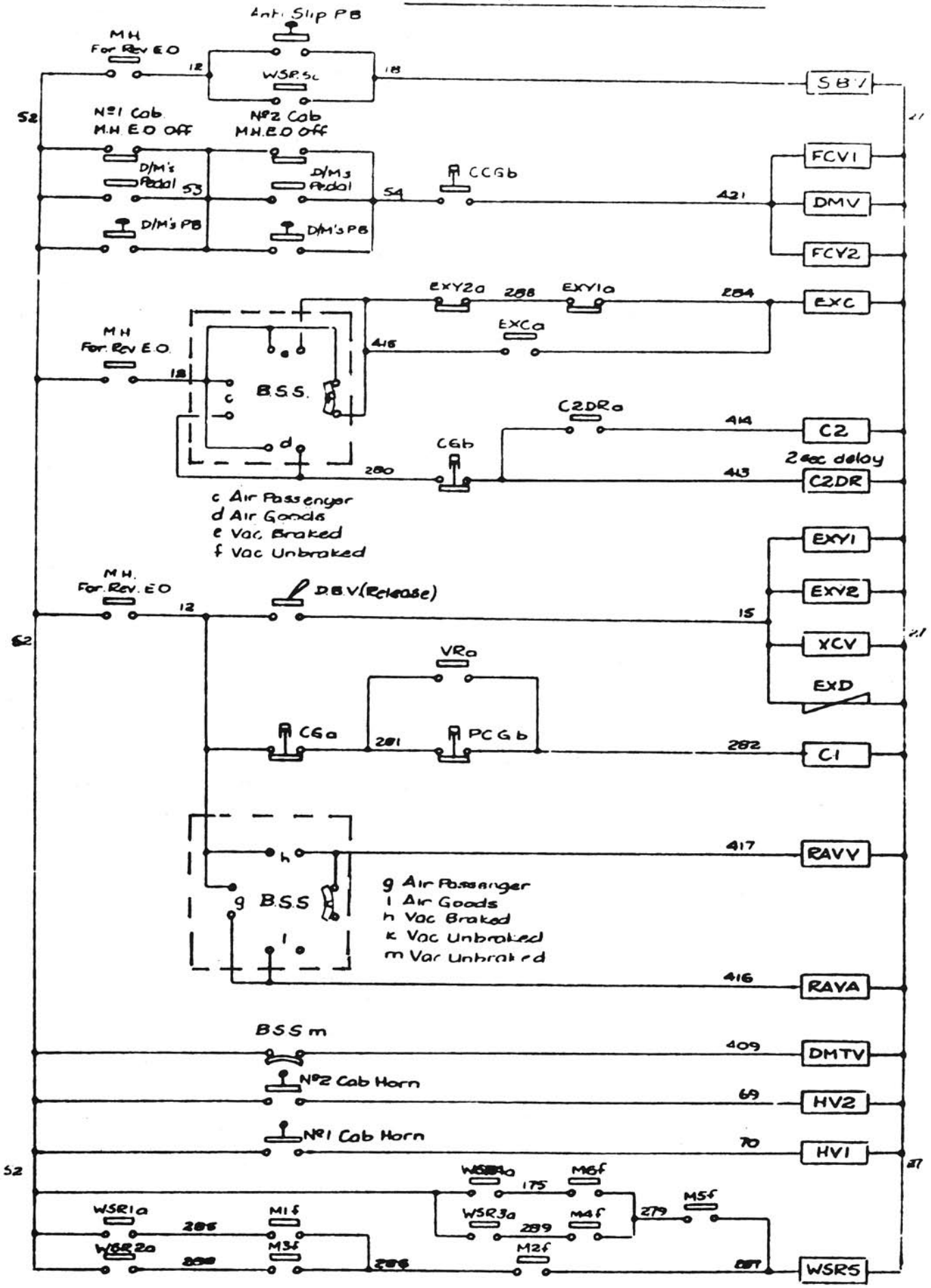


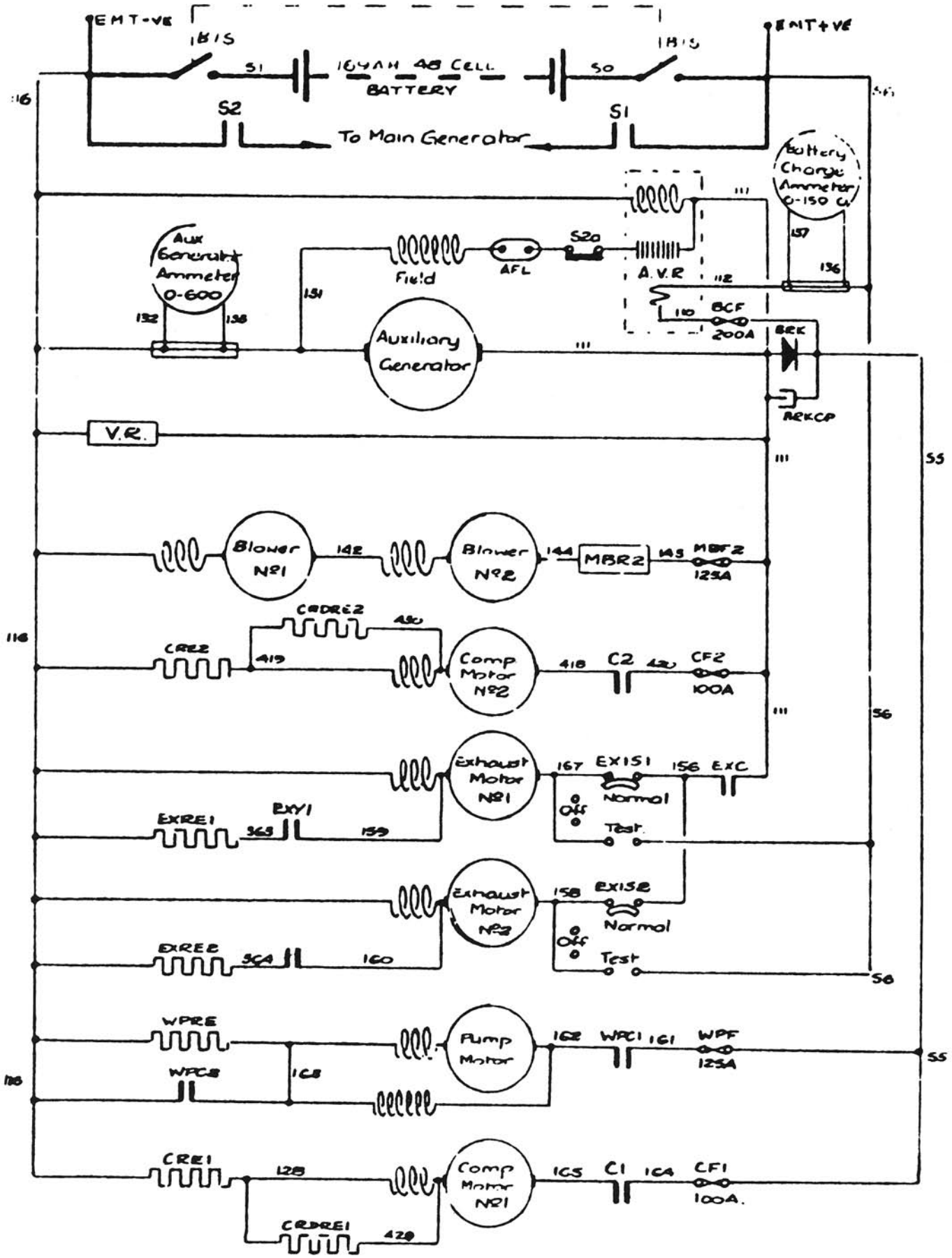
FIELD DIVERT CONTROL CIRCUITS

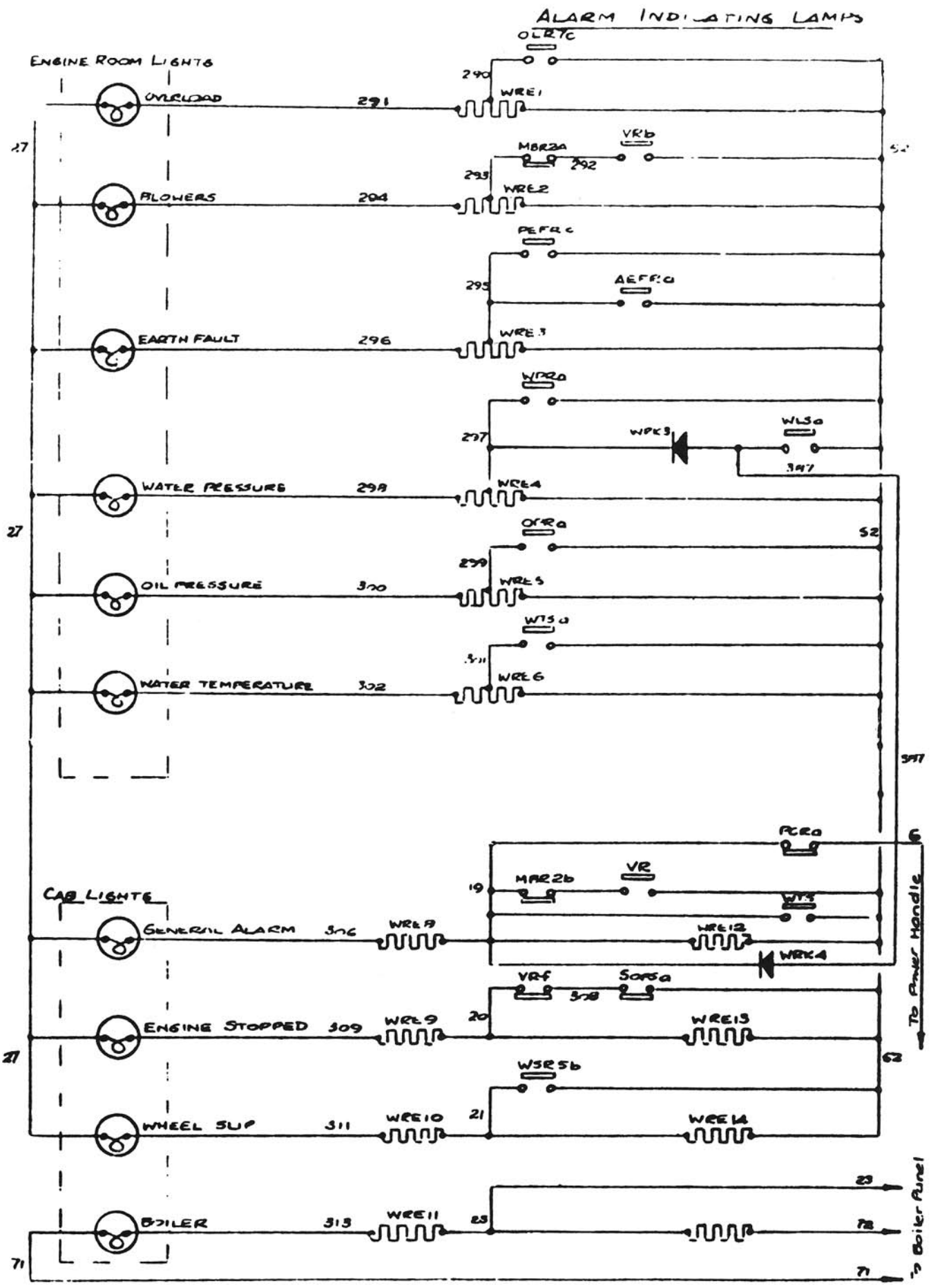




BRAKES, HORNS & WHEELSLIP

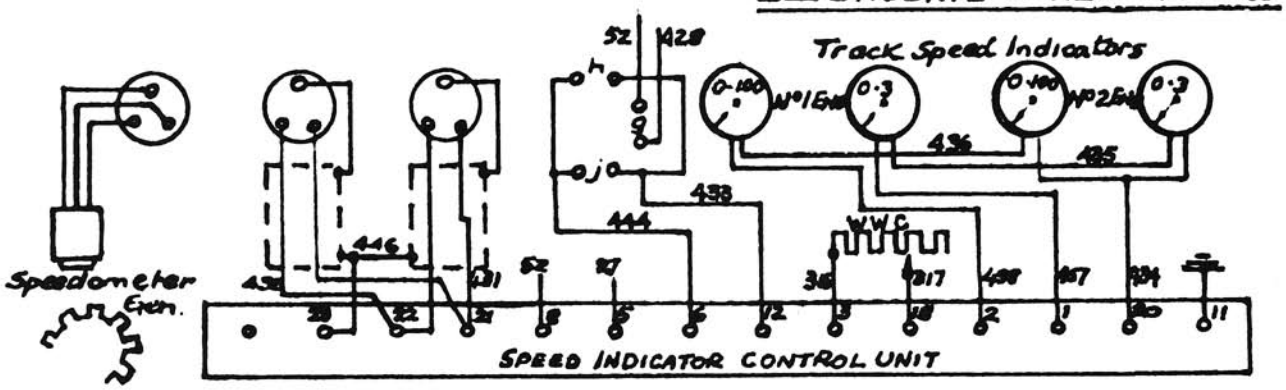




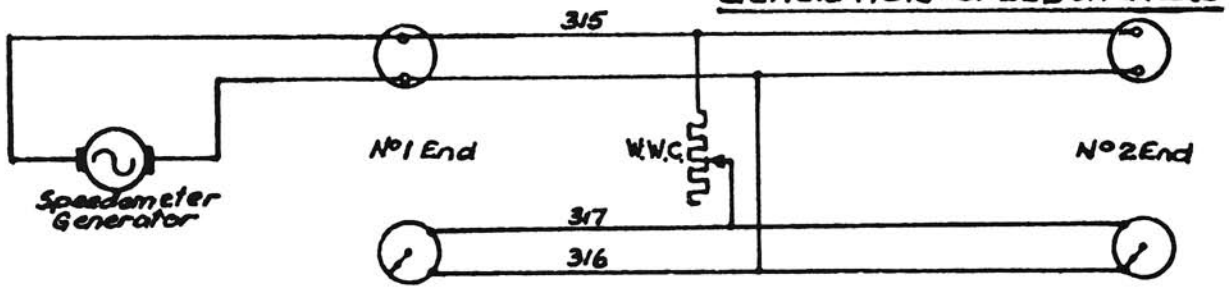


SPEEDOMETERS.

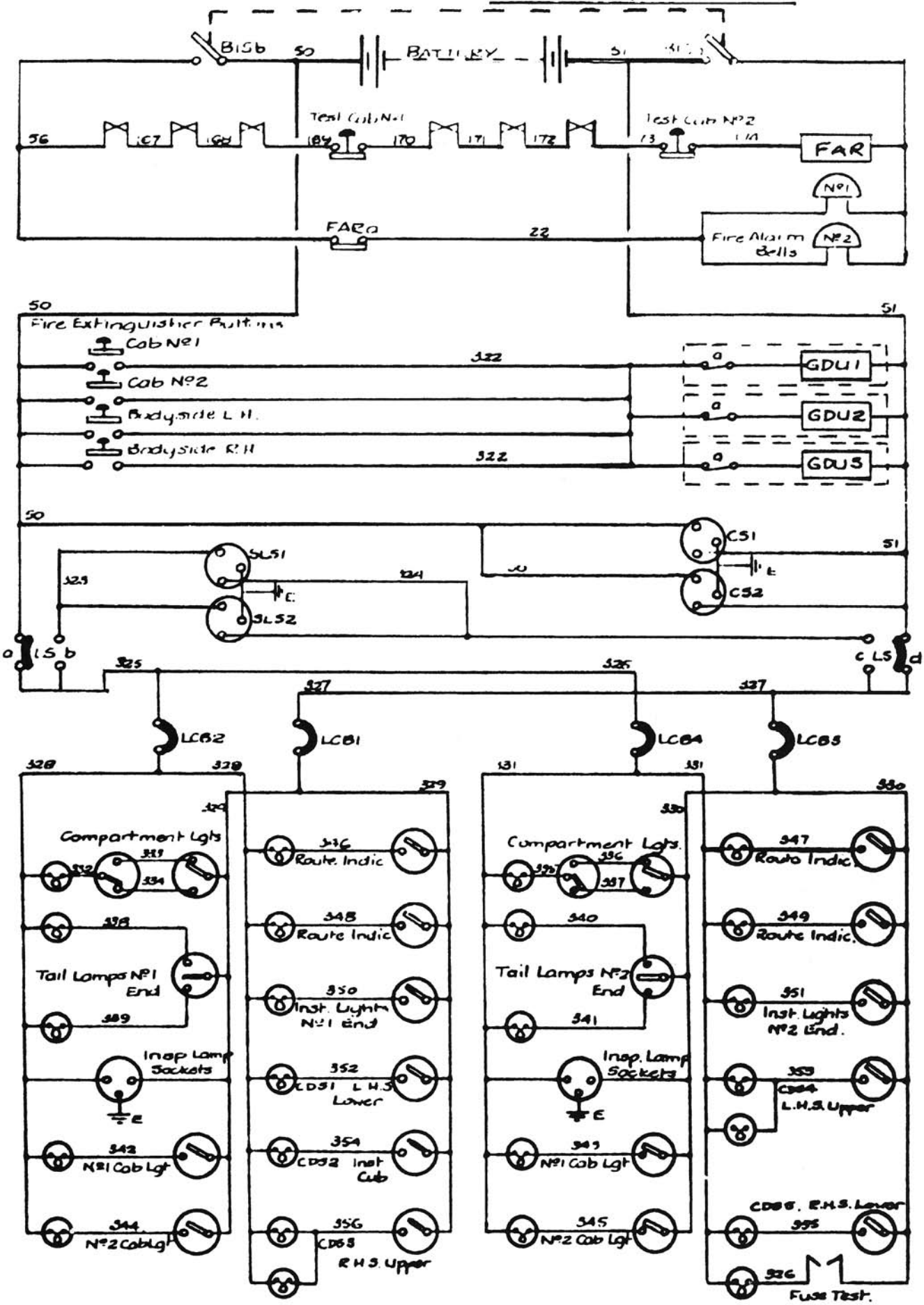
ELECTRONIC SPEEDOMETERS

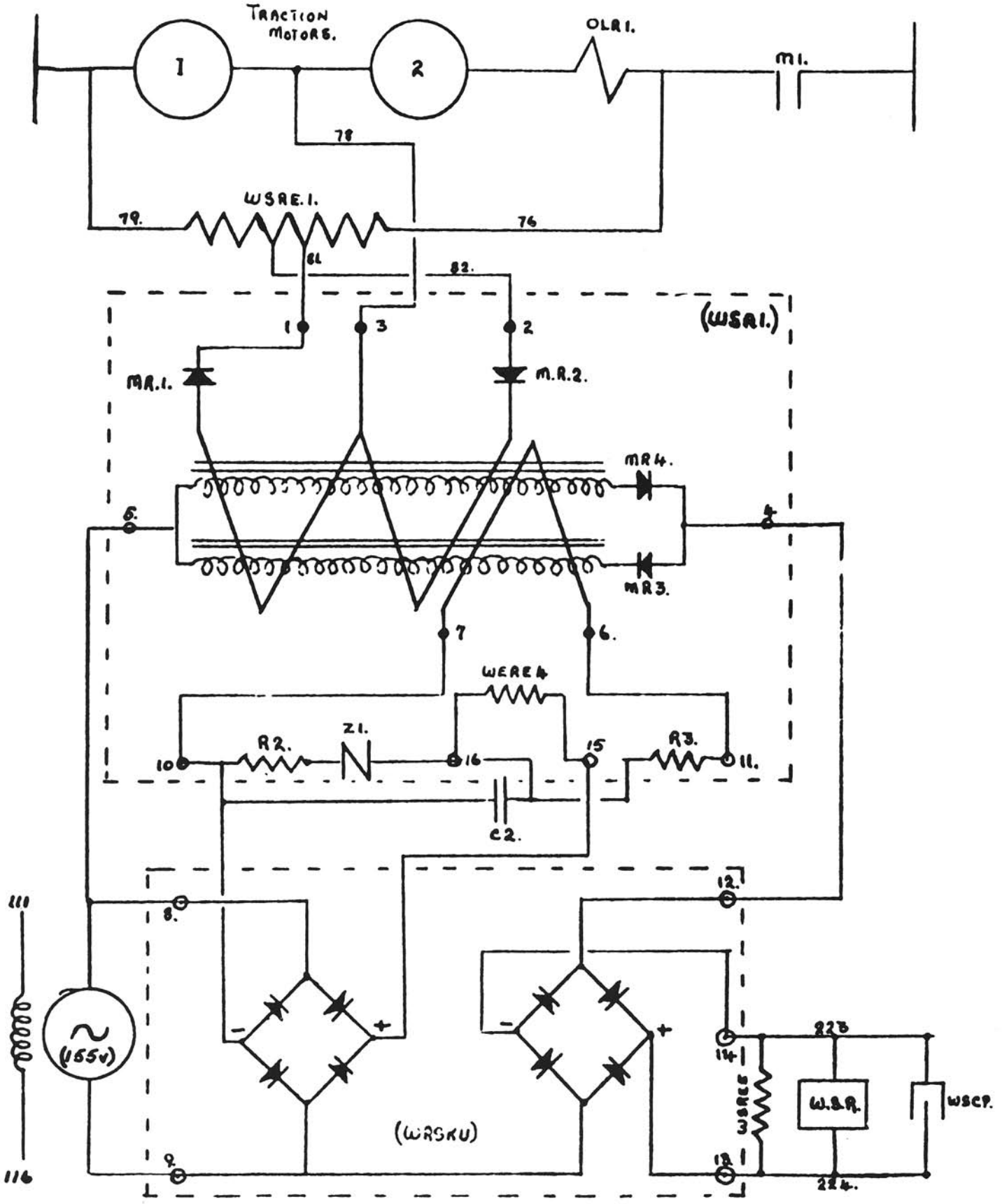


GENERATOR SPEEDOMETERS



FIRE ALARM & LIGHTING





WHEEL SLIP DETECTION DEVICE (S/P LOCOS.)
(SHOWING ONE PAIR OF WHEELS ONLY.)