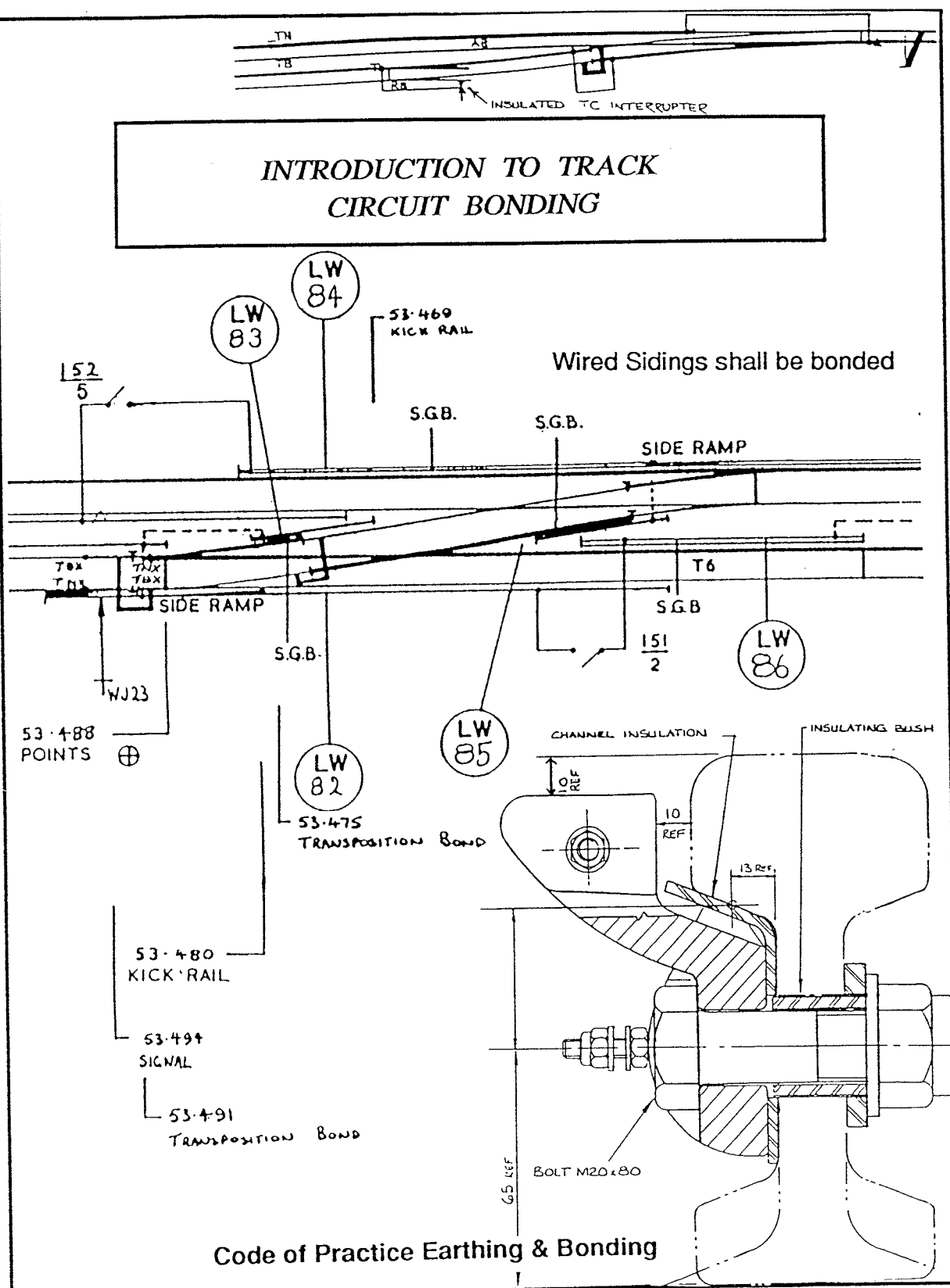


DIRECTOR OF S & T ENGINEERING. WEST MIDLANDS PROJECTS GROUP.

INTRODUCTION TO TRACK CIRCUIT BONDING



Code of Practice Earthing & Bonding

INTRODUCTION TO TRACK CIRCUIT BONDING

The first part of this module will examine the contents of Engineering Instruction S/F/017 which is entitled "Regional Code of Practice for the design of Track Circuit Bonding". The copy that we shall consider was issued by the London Midland Region, but other regions practices should not diversify to any great degree.

S/F/017 makes reference to different types of Track Circuits within its pages, however we shall be concentrating mainly on the Direct Current Track Circuit but we shall also refer to Alternating Current Track Circuits. In S/F/017 there are references to a document titled "Technical Specification AC 101, 50 Hz Single Phase a.c. Electrification Earthing and Bonding", this document is now out of date and has been superseded by "ECP 101: 1984, Code of Practice Earthing and Bonding for 50 Hz Single Phase a.c. Electrification. Within this instruction where there is reference to other Standard Signalling Principles/Engineering Instructions, these documents can be found in the nearest Technical Library.

Shown on Fig. 1 are two examples of how the Track Circuit Bonding appears taken from actual extracts of a Bonding diagram that is currently in use. Example 1 shows an example of "double rail" TC Bonding (though not strictly adhering to S/F/017, both lines should be thin) however the majority of existing double rail track circuits are drawn this way. Example 2 shows a typical example of "single rail" track circuit bonding. The example shown in Fig. 2 depicts how "double rail" TC's should be shown in accordance with Engineering Instruction S/F/017.

Now we have a clear picture as to the form a "bonding" diagram can take we can now examine S/F/017.

A copy of the Instruction follows this module.

INTRODUCTION TO TRACK CIRCUIT BONDING

ENGINEERING INSTRUCTIONS/PRINCIPLES AND USEFUL REFERENCE
DOCUMENT TO CONSIDER WHEN PRODUCING OR AMENDING BONDING
DIAGRAMS.

a) Engineering Instructions/Principles:-

EI S/A/003 EARTHING AND BONDING 50Hz SINGLE PHASE A.C.
ELECTRIFICATION.

Details. RS & TE responsibilities stipulated in "Technical specification AC 101"
(superseded by ECP 101, 1984).

EI S/A/007 CLOSED CIRCUIT TELEVISION FOR LEVEL CROSSINGS, EARTH
BONDING OF CAMERA COLUMNS.

Symbol to be used on bonding plans.

EI S/A/025 ELECTRIFICATION THIRD RAIL SYSTEM CODE OF PRACTICE.

Make reference to above document when working on 3rd rail system of electrification.

EI S/C/003 REPLACEMENT OF RUNNING SIGNAL ASPECTS BY TRACK CIRCUITS.

Positioning of insulated joints.

EI S/C/007 ASTER TC COMPATIBILITY OF "1 WATT" AND "U" TYPE.

Frequency differences between adjacent TC's.

EI S/C/019 GAS POINT HEATERS, POSITIONING OF THERMOSTAT ON TRACK
CIRCUITED LINES.

Positioning of thermostat (remind RCE to position accordingly).

EI S/C/025 TC ALTERATIONS: ELECTRIC POINT HEATERS.

Points contained in one track circuit fed by a common supply transformer (remind RM
& EE if any alteration is likely to contravene this instruction).

EI S/C/032 TRACK CIRCUITS IN AC TRACTION AREAS.

Be aware of the TC fusing arrangements it will help if you have to design the location
or relay room wiring.

EI S/E/009 SIGNALLING CABLES TO BR SPEC 872.

On track cables although not shown on bonding plans be aware of the types used.

S/H/001 Principle 2. GROUND SHUNTING SIGNALS.

Reference to welded stainless steel strip.

S/H/004 Principle 36. TRACK CIRCUIT CLEARANCE POINTS.

Clearance points, plus minimum length of track circuit.

S/H/037 CODE OF PRACTICE FOR THE IDENTIFICATION OF TRACK CIRCUITS.

continued

INTRODUCTION TO TRACK CIRCUIT BONDING

SECTION S/F:- This is the section in the Engineering Instructions dedicated to Track Circuits therefore be conversant with all the instructions but pay particular attention to the following when considering Bonding Plans.

S/F/002 CONTINUOUS WELDED RAIL ADJUSTMENT SWITCHES.

Position of insulated joint from adjustment switch.

S/F/004 TC INTERRUPTERS. (see Fig. 3)

Type and wiring of interrupters.

S/F/007 TC CLEARANCE POINTS.

Depicting insulated joints on plans.

S/F/012 DC TRACK CIRCUITS GENERAL REQUIREMENTS.

Read in conjunction with CS & TE letter dated 24th March 1981 also document C5.

S/F/014 TC's IN AC or DC ELECTRIFIED TERRITORY INSTRUCTIONS FOR
TEMPORARY ALTERATIONS.

Stageworks notification to RM & EE.

S/F/017 REGIONAL CODE OF PRACTICE FOR THE DESIGN OF T.C. BONDING.

Design criteria.

S/F/018 PROCEDURE FOR THE PRODUCTION OF BONDING PLANS ON
ELECTRIFIED LINES.

INTRODUCTION TO TRACK CIRCUIT BONDING

OTHER DOCUMENTS CONTAINING USEFUL REFERENCE MATERIAL.

1. **Electrification - 3rd Rail System Code of Practice for Conductor Rail System Design and Installation.**

Selected extract from this document:-

10.2 Single Protective Board (guard boarding)

Will be used in the following circumstances:-

Between conductor rail and running rail throughout the length where the track circuit rail is adjacent to the conductor rail. (Therefore when designing bonding in 3rd rail territory you must keep the TC rail on the opposite side of the rail to the conductor rail as far as possible). See Figure 4.

2. **50 Hz Single Phase Electrification, Immunisation of Signalling & Telecommunications System against Electrical Interference.**

Selected extracts from this document:-

SUB-SECTION 3.7

EARTHING OF SIGNALLING EQUIPMENT

3.7.2 Signalling equipment to be earthed to the traction system.

The following must be bonded to a traction return rail or a traction earth wire:-

Signal bridges.
Cantilever signal gantries and bracket signals.
Straight post signal structures.

Metalwork of level crossing lifting barriers where earthing is required - see Section 2.9.

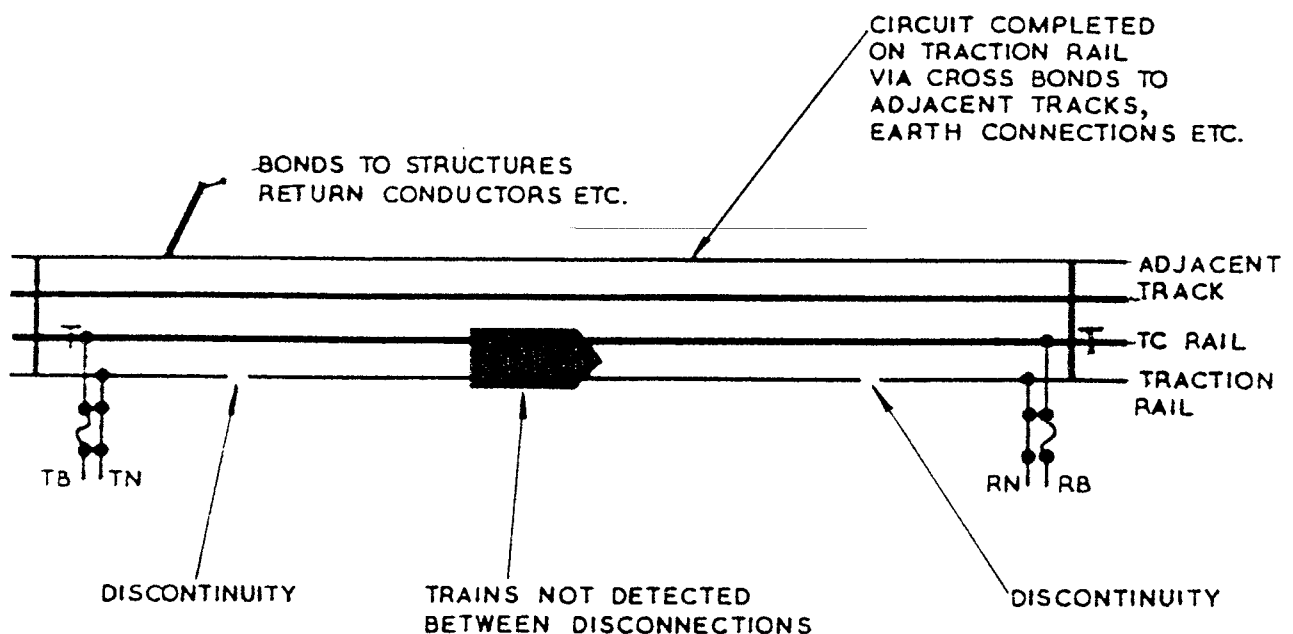
INTRODUCTION TO TRACK CIRCUIT BONDING

3.9.5 Maintenance

It is essential that the traction return and track circuit bonding is maintained in its design condition. In the event of a complete disconnection of some section of the traction return rail from the remainder of the traction return network, there is a real risk of wrongside track circuit failure. This condition is illustrated below.

However, not all defects in track bonding will necessarily result in track circuit failure, but they will lead to a degradation of the telecommunications system and danger to personnel, due to traction return current flowing in cable sheaths.

The bonding connections must be inspected visually and any defect promptly remedied. Any bond or connection showing signs of corrosion (especially galvanised steel bonds which are particularly vulnerable being close to the rail) should be renewed. Defects in bonding which is the responsibility of the C.M. & E.E. must be brought to the attention of the appropriate Officer.



WRONG SIDE FAILURE OF A SINGLE RAIL TRACK CIRCUIT DUE TO A DOUBLE DISCONTINUITY

INTRODUCTION TO TRACK CIRCUIT BONDING

SUB-SECTION 3.9

TRACK BONDING

3.9.3 Track Circuit Bonding

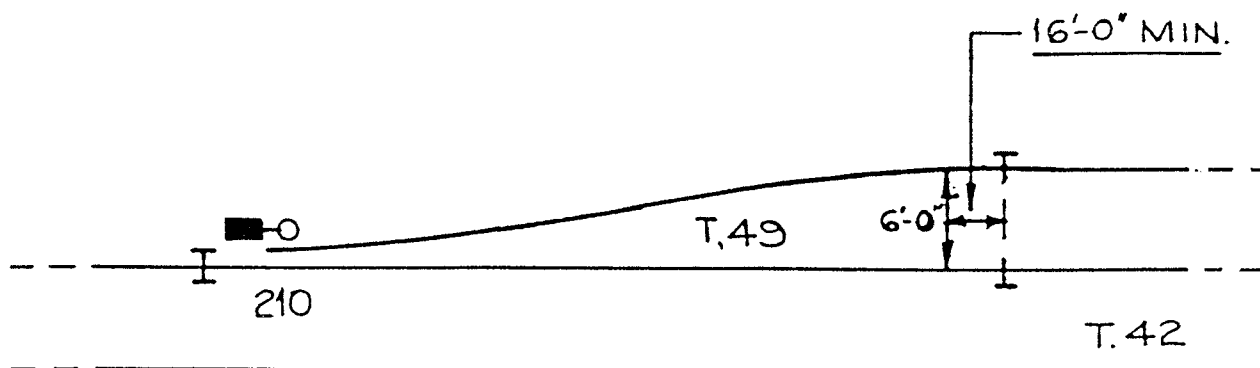
3.9.3.1 Single Rail Track Circuits

The track circuit rail must be series bonded in order to ensure that defective bonding cannot cause a wrongside failure of the track circuit. Accordingly, the bonding arrangement for the track circuit rail must ensure that the conductive path between the track circuit feed connection and the relay or receiver end connection, is interrupted in the event of a disconnection.

Because of traction return considerations, it is not possible for the traction return rail to be series bonded. It is therefore essential to avoid bonding disconnection, to minimise the risk of loss of train shunt. This is partially achieved by the use of heavy gauge continuity bonds, but it is also essential to ensure that each section of the traction return rail is connected to some other part of the traction network at the extremities ie. spur connections are not permissible. This provides a degree of redundancy, since a single disconnection will not then result in a dangerous condition.

3.9.3.3 Shunting Requirements

The positions of insulated block joints and general bonding arrangements, must ensure that the minimum clearances given in Signalling Principle 36 are maintained.



EXTRACT HAZEL GROVE PSB SCHEME PLAN.

INTRODUCTION TO TRACK CIRCUIT BONDING

3. Code of Practice Earthing & Bonding for 50 Hz Single Phase Electrification (ECP 101: 1984).

Selected extract from this document:-

2.7 Connections with Non-Electrified Lines

Where non-electrified lines abut electrified lines two groups of insulated joints shall be provided on the non-electrified line. The spacing of the insulated joints shall be determined by consultation between the D. of M. & E.E. and the R.S. & T.E. but must not be less than 20 metres.

If the non-electrified line is a siding or similar category of line where no signalling exists and does not serve private premises or a low flash point product or oxygen installation, the insulated joints may be omitted unless they are required for track circuiting purposes.

NOTE Where a non-electrified siding serves a goods shed or depot sufficiently close to an electrified line that the exposed metalwork is required to be bonded to the traction return rail under this code of practice, the siding shall be treated as an electrified line for bonding purposes.

2.8 Private Sidings

Wired Sidings shall be bonded as they would be if on BR property and unwired sidings shall be provided with two groups of block joints not less than 20 metres apart in the connection to the electrified track.

4. Crewe Divisional Circular. Dated 14/4/77.

STAGGERING OF TRACK CIRCUITS

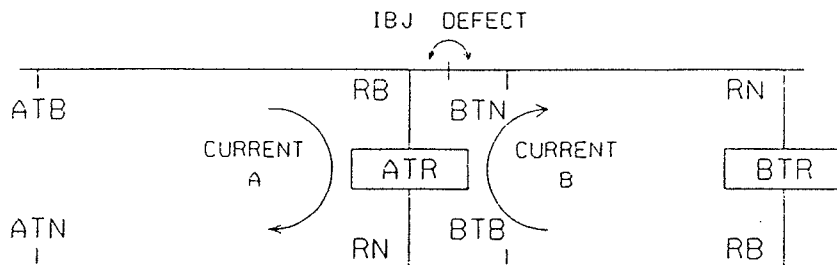
A recent case of a "wrong side failure" of a Track Circuit has once again highlighted the need for **correct staggering** of Track Circuits. The "wrong side failure" in question would not have been prevented by staggering the Track circuits, but if the stagger had been employed a "right side failure" would have occurred **first** indicating that something was amiss with the track circuit.

Where track circuits **butt up** the **polarities** on the respective sections should be **opposing**.

INTRODUCTION TO TRACK CIRCUIT BONDING

As can be seen in Figure A if the insulated joint becomes "shorted out" the currents from the two track circuit feed sets run in **opposite** directions through the track relay which is consequently de-energised.

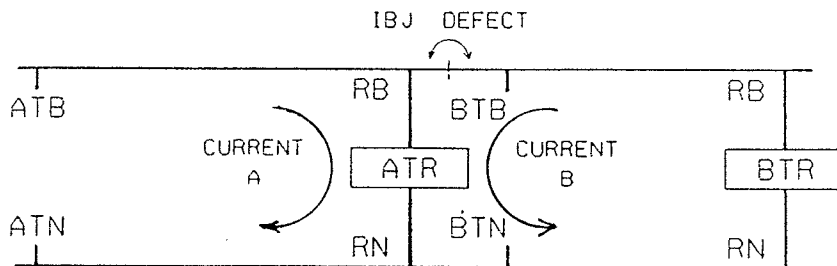
Figure A.



In Figure B, if the insulated joint becomes "shorted out" the currents from the two track circuit feed sets run in the **same** direction through A TR, and both A TR & B TR will remain energised and no fault symptoms will show.

All that is now required for a "wrong side" failure to occur is that a disconnection of the feed from A feed set to A TR takes place. A wire off or a broken rail is sufficient and A TR will be held up by B track feed set.

Figure B.



If only **one** fault develops at any one time then either one track circuit de-energises (Figure C) or **both** track circuits de-energise (Figure D).

Of course if the two faults occur **simultaneously** a "wrong side failure" can still happen, although this is a very unlikely situation.

INTRODUCTION TO TRACK CIRCUIT BONDING

Figure C.

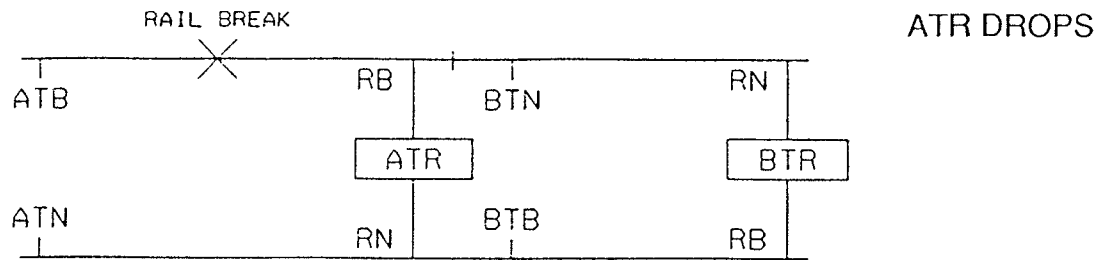
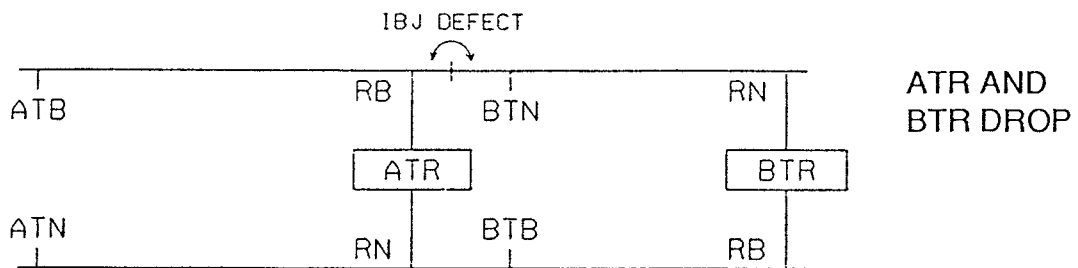


Figure D.



5. **Draft Code of Practice, 19/12/85.**
Operational Length of AC Immune Direct Current Track Circuits in Electrified Areas.

This code of Practice (COP) detailed the **revised** lengths of track circuits in electrified areas when using the **SPEC 867 TRACK FEED SET** and **SPEC 939 TRACK RELAY (20 ohm)**, the text that follows has been extracted from the above COP.

On **multiple** track railways track circuits **not exceeding** 1500 metres are acceptable.

Track circuits **in excess** of 1500 metres can be installed after detailed examination of "on site" readings, on no account must track circuits **exceed** 2000 metres. See COP for details.

On single lines where there are **no** multiple traction return paths available the lengths of track circuits must **not exceed** 1000 metres.

INTRODUCTION TO TRACK CIRCUIT BONDING

PRODUCTION OF NEW BONDING DIAGRAMS

WHEN DESIGNING A BONDING DIAGRAM FOR A NEW LAYOUT THE FOLLOWING PROCEDURE WILL GIVE AN INSIGHT INTO THE MECHANICS INVOLVED BETWEEN THE THREE MAJOR ENGINEERING DEPARTMENTS INVOLVED.

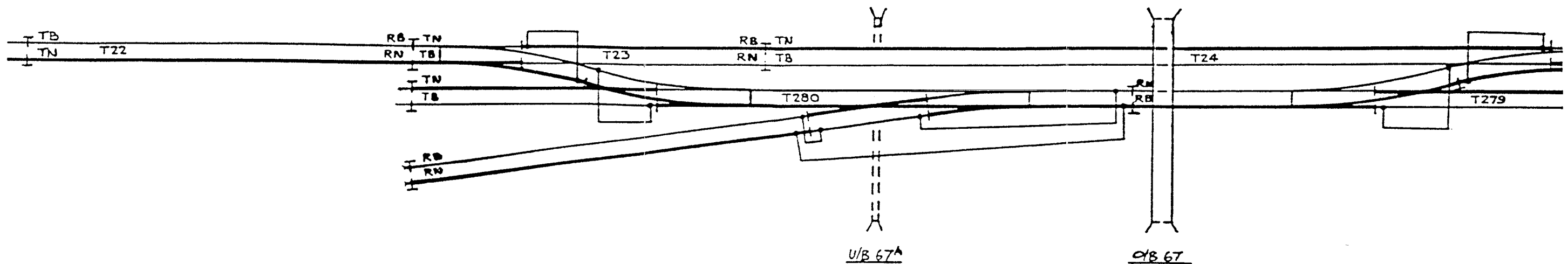
1. Regional Civil Engineer (RCE) produces an approved 1:500 scale layout and issues it to the Director of S & T Engineering (D of S & TE) and the Director of Mechanical & Electrical Engineer (D of M & EE).
2. D of S & TE is in possession of the approved Signalling Scheme Plan for the project.
3. The base track layout plan negative is produced by the D of M & EE and forwarded to the D of S & TE.
4. D of S & TE applies the track circuit bonding.
5. RCE issues two copies of the 1:100 or 1:200 detail layout plans showing points & crossings detail in the areas affected by the project.
6. D of S & TE furnishes RCE with the insulated joint requirements etc. on one copy of the RCE's 1:100/1:200 plan and retains one identical copy in the Drawing Office.
7. RCE issues three final copies of 1:100/1:200 scale plan showing D of S & TE's requirements.
8. D of S & TE checks that the 1:100/1:200 plans are identical to the original request and then issues two copies to the Signalling Works Engineer (SWE) via the Area S & TE office concerned.
9. D of S & TE forwards master bonding negative complete with track circuit bonding to the D of M & EE.
10. D of M & EE adds the traction bonding/structures etc. and returns the master negative to the D of S & TE.
11. D of S & TE checks traction bonding does not interfere with the safe operation of track circuits.
12. After agreement between the D of S & TE and the D of M & EE the bonding plan is then issued to interested parties and a copy negative sent to the D of M & EE.
13. If any "on site" amendments are added to the bonding during commissioning of the scheme D of S & TE will amend the master negative and send a revised copy to the D of M & EE.

continued

FIG 01 OBSITE.

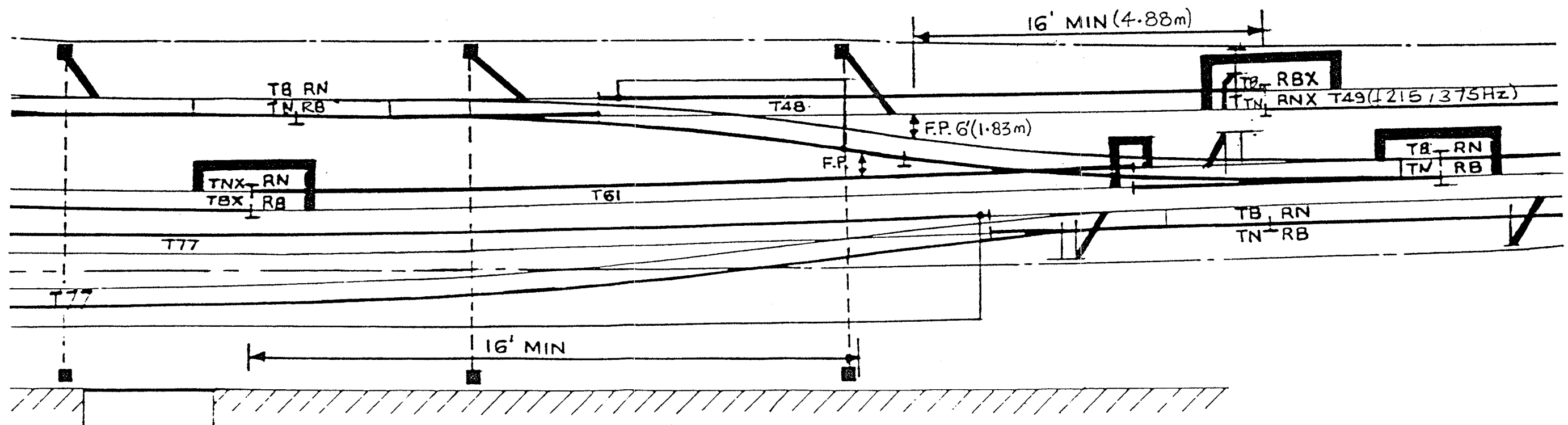
INTRODUCTION TO TRACK CIRCUIT BONDING

1. EXAMPLE OF "DOUBLE RAIL" TRACK CIRCUIT BONDING, WITH THE ABSENCE OF TRACTION RETURN BONDING A MAXIMUM AMOUNT OF "SERIES" BONDING SHALL BE PROVIDED ie. BOTH RAILS SERIES BONDED.



EXTRACT LEICESTER AREA BONDING PLAN

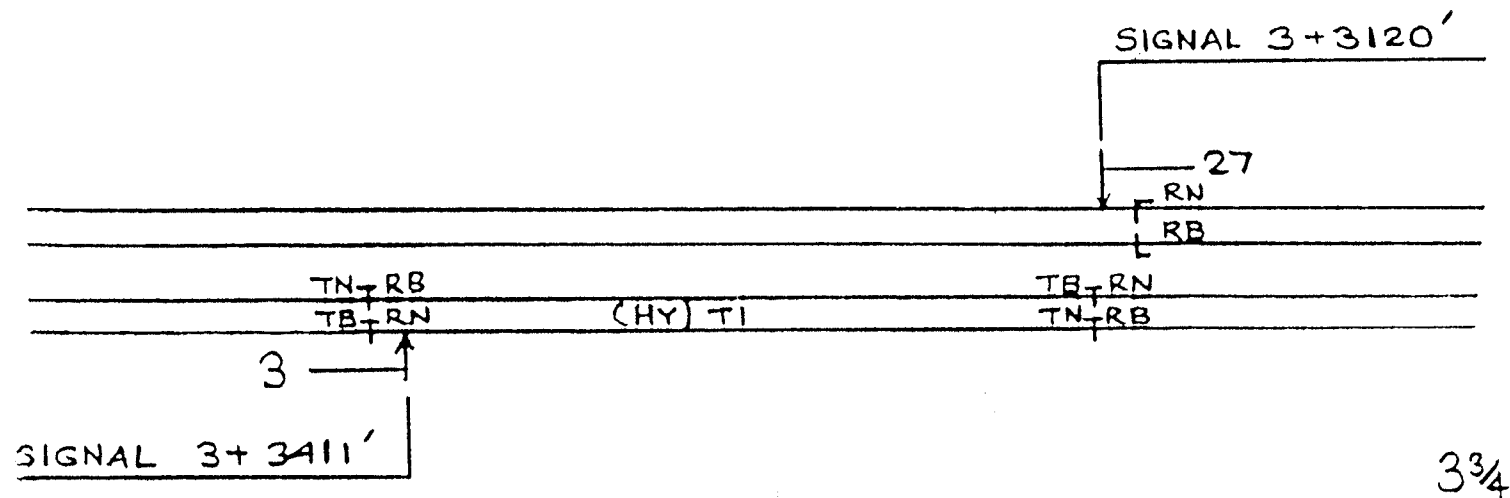
2. EXAMPLE OF "SINGLE RAIL" TRACK CIRCUITS WHERE THE MECHANICAL & ELECTRICAL ENGINEER (M&EE) REQUIRES ONE CONTINUOUS RAIL FOR TRACTION RETURN PURPOSES.



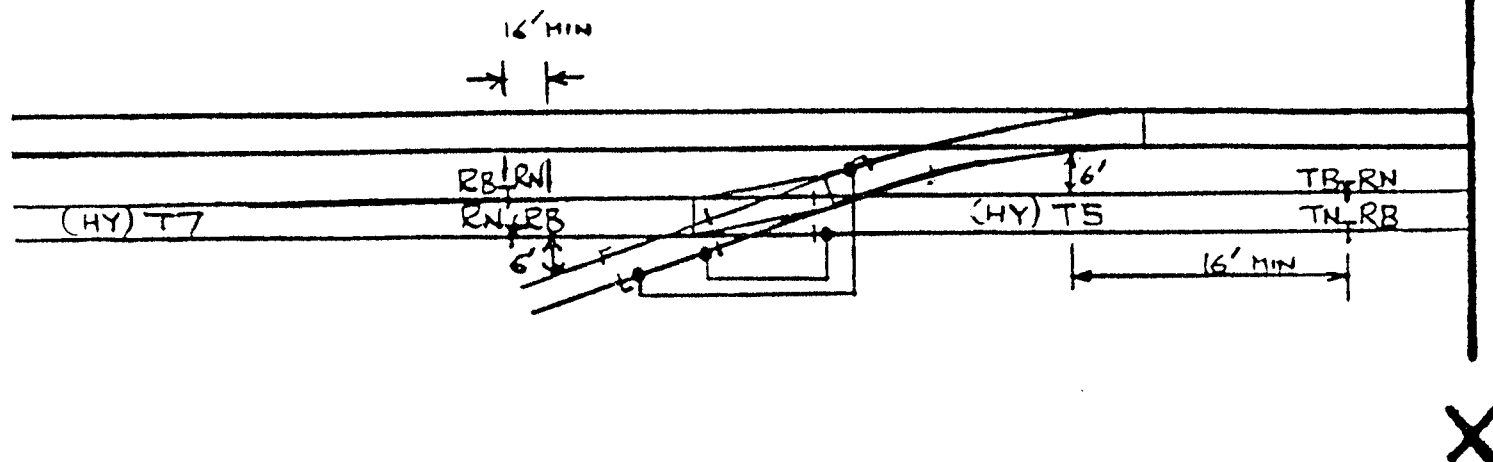
EXTRACT ST PANCRAS AREA BONDING PLAN

INTRODUCTION TO TRACK CIRCUIT BONDING

- EXAMPLE OF BONDING DIAGRAM WHICH DOES COMPLY WITH THE INSTRUCTION FOR DOUBLE RAIL TRACK CIRCUITS AS INDICATED IN S/F/017.

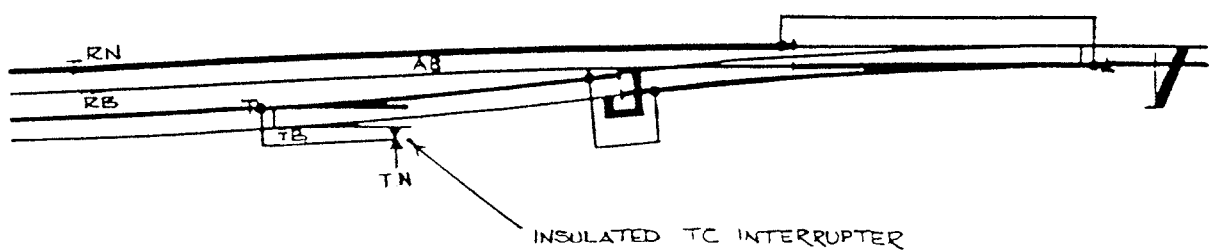
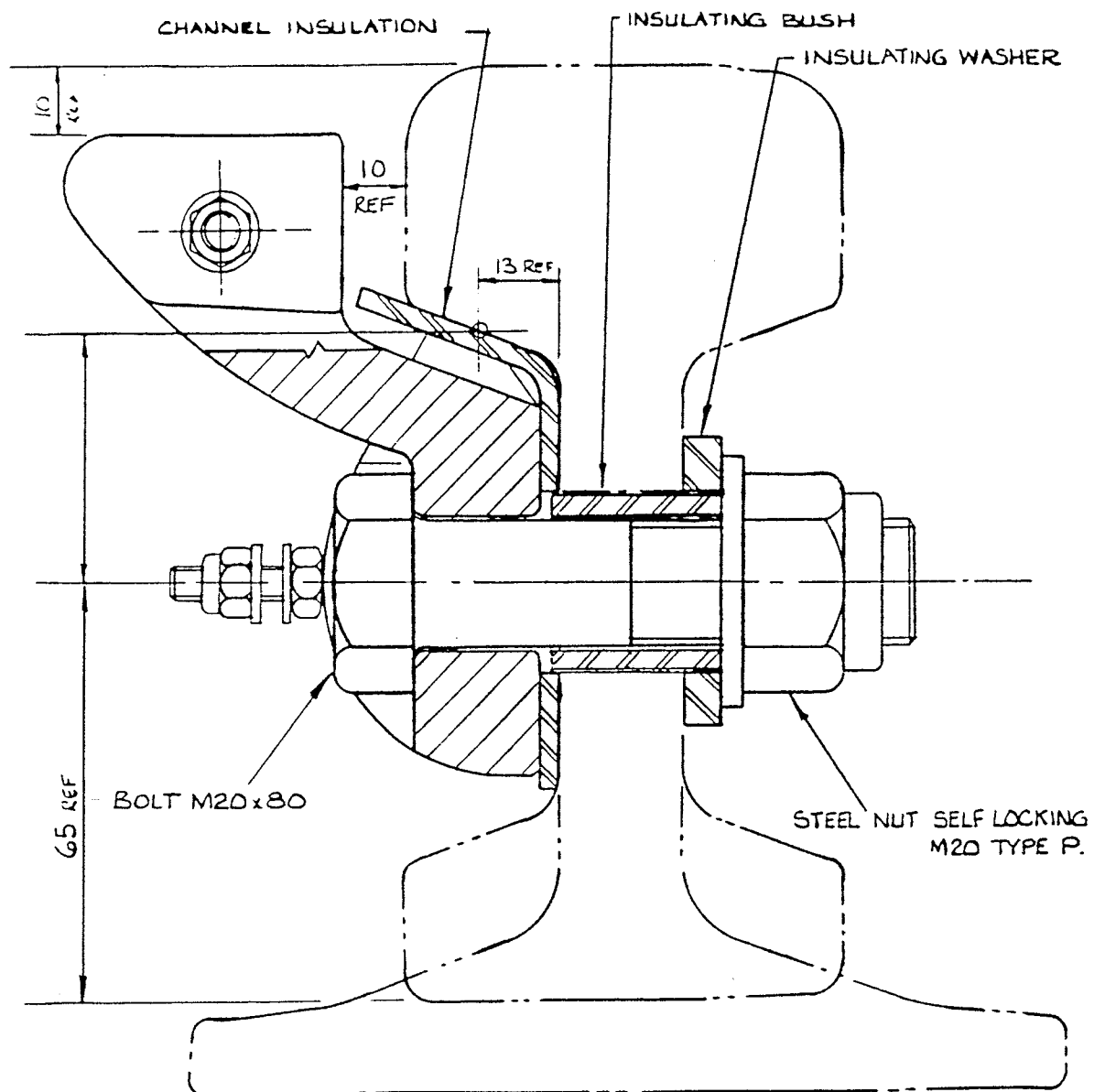


Extract from Hinckley Area Bonding Plan.



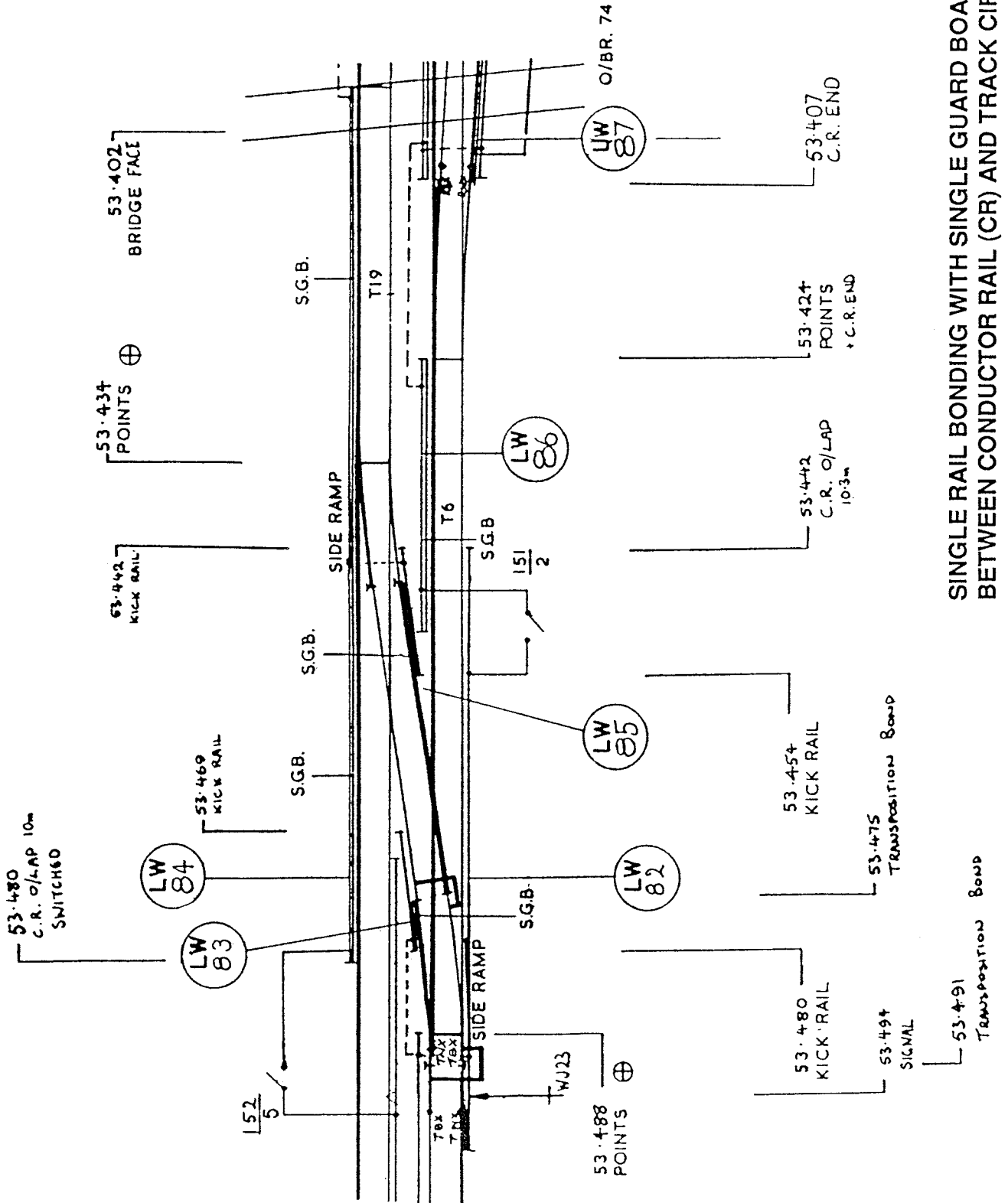
continued

INTRODUCTION TO TRACK CIRCUIT BONDING



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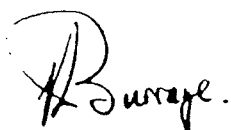
INTRODUCTION TO TRACK CIRCUIT BONDING



SINGLE RAIL BONDING WITH SINGLE GUARD BOARDING (SGB)
BETWEEN CONDUCTOR RAIL (CR) AND TRACK CIRCUIT

BRITISH RAILWAYS LONDON MIDLAND REGION S. & T. DEPARTMENT ENGINEERING INSTRUCTIONS	REGIONAL CODE OF PRACTICE FOR THE DESIGN OF TRACK CIRCUIT BONDING
R.S. & T.E. Ref: 42281	Date: September 1985
Issue No: 1 Circulation B	Instruction No: S/F/017

The attached Regional Code of Practice will become effective from the date of this instruction.



K. W. BURRAGE
Regional S. & T. Engineer
LONDON MIDLAND REGION

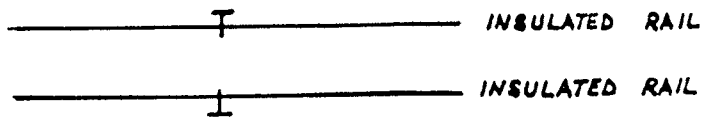
Method of Presentation

The symbols to be used to indicate these arrangements will be as follows:

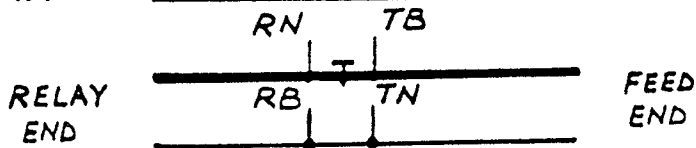
(1) Single Rail Track Circuit



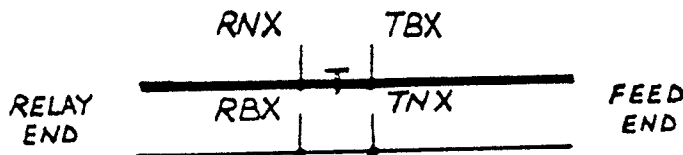
(2) Double Rail Track Circuit



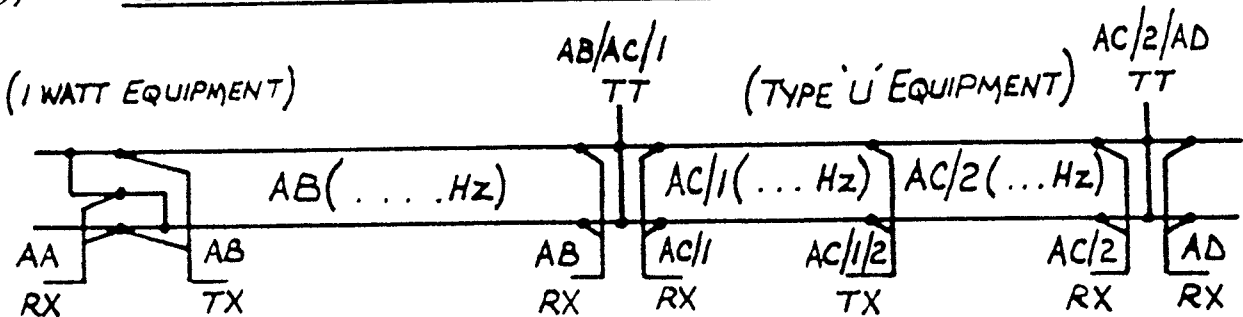
(3) Connections for D.C. Track Circuits



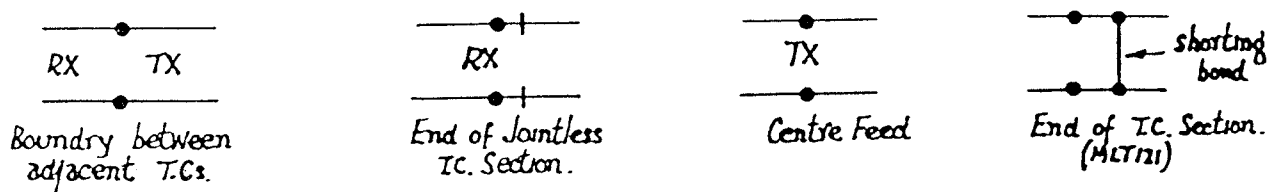
(4) Connections for A.C. Track Circuits (including Jointed Reed)



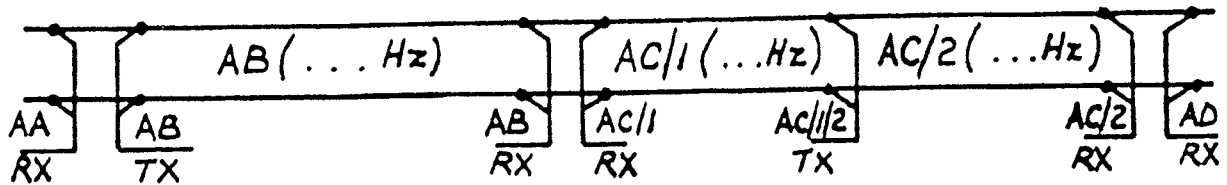
(5) Connections for Aster Track Circuits



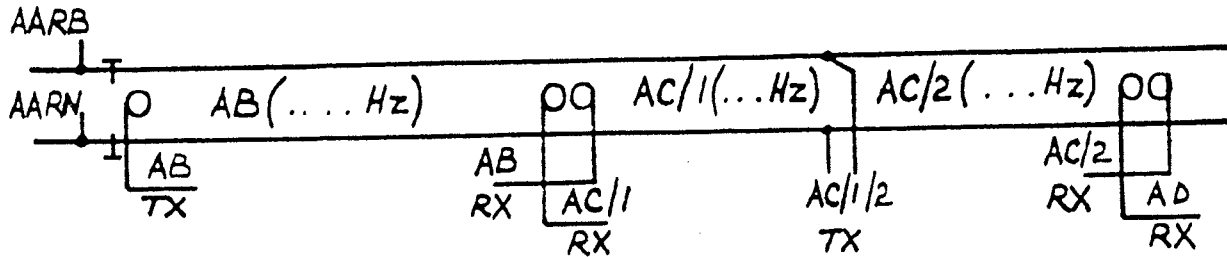
Where the termination of rail connections are shown in the location wiring diagrams the method of displaying rail connections may be simplified as follows and can also be applied to items 6 & 7.



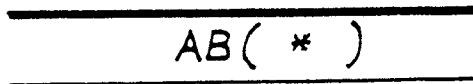
(6) Connections for M.L. Jointless Track Circuits



(7) Connection for Reed Jointless Track Circuits (when approved for use)

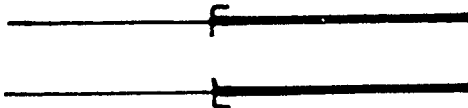


(8) Track Circuit Identification



(*) With the exception of D.C. equipment the particular type and frequency of the track circuit used should be indicated adjacent to the Alpha-numerical track circuit identification.

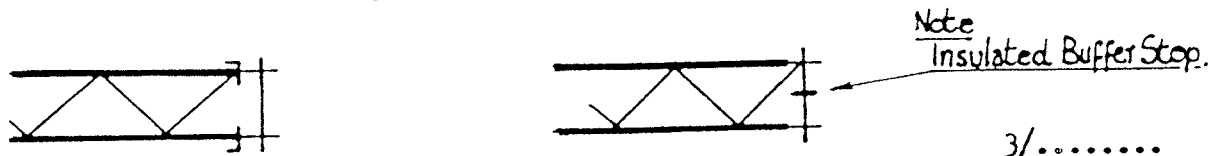
(9) Insulated Rail Joints at end of Track Circuited Line



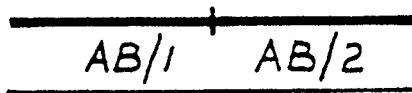
(10) Joint Between Adjacent Track Circuits



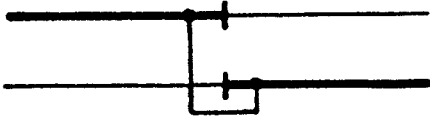
(11) Track Circuit Joint arrangement at Buffer Stops (Non Insulated and Insulated).



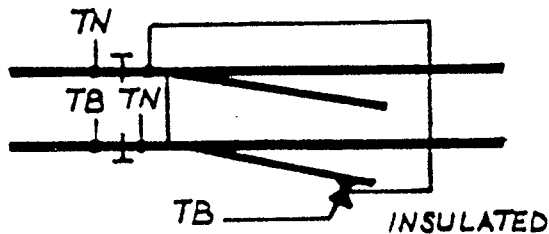
(12) Joint Between Cut Sections



(13) Signalling Track Circuit Jumper Bond



(14) Track Circuit Interrupters



ENGINEERING INSTRUCTION
S/F/004
REFERS

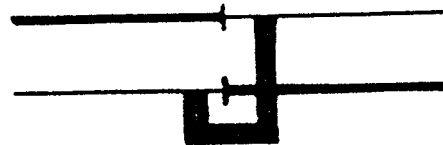
(15) Stainless Steel Strip Welded to Rail Surfaces



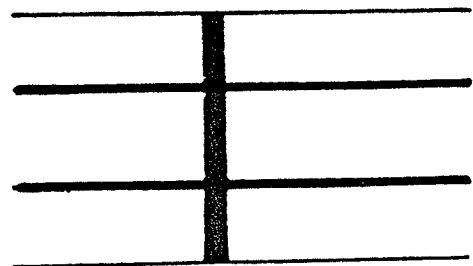
On electrified lines the track circuit bonding plan will additionally indicate.

(1) R.M. & E.E. Traction Bonds

(a) Traction Jumper Bonds

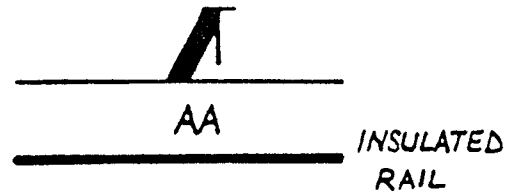


(b) Rail to Rail Bonds
(Cross Bonds)

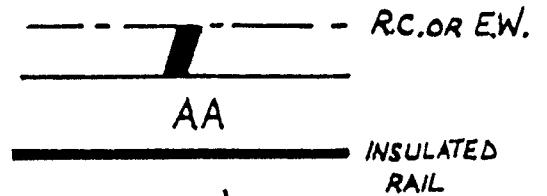


(2) Electrical Connections to Traction Return Rail

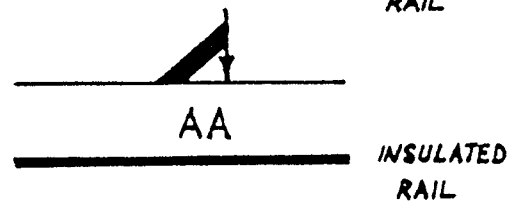
(a) Structure to rail bond.



(b) Return conductor or Earth wire to rail bond.



(c) Signal Post to rail bond.
(Also A.W.B., P.T.I., CCTV,
Barrier Booms etc.)



(3) Rail Bonding on Non-Track Circuited Lines

(a) Rails not bonded non-electrified lines.

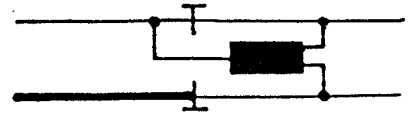


(b) Electrified lines without Track Circuits.

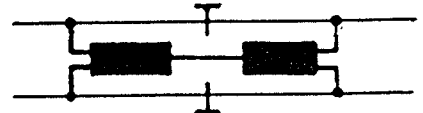
	FORMER SYMBOL	CURRENT SYMBOL
(i) Rail not joint bonded		
(ii) Rail joint bonded		

(4) Impedance Bonds

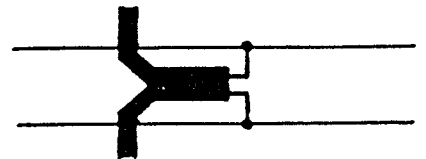
(a) Single rail to double rail.



(b) Double rail to double rail.

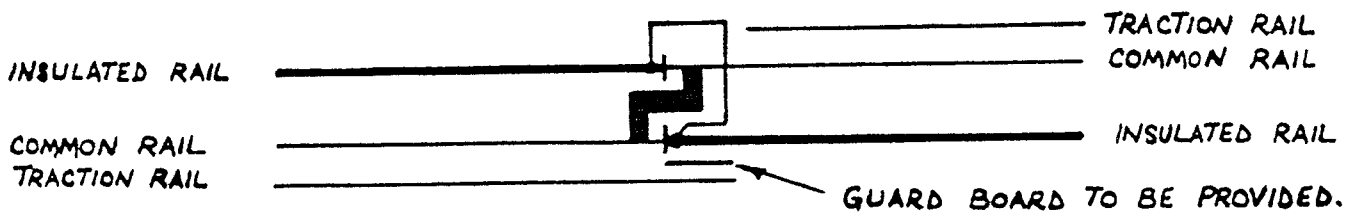


(c) Rail to Rail bonds (cross bonds) using impedance bonds in double rail T.C. areas.



(5) Guard Boarding

Provision of guard boarding will be indicated on the bonding plan by a suitable note.



Basic Objective

The three basic objectives of Track Circuit bonding are -

- (1) To fully track circuit the section of line in accordance with the signalling scheme plan and to ensure the detection of a vehicle within a defined track circuited limit.
- (2) To obtain the maximum amount of series bonding.
- (3) To ensure polarities of adjacent track circuits are in opposition.

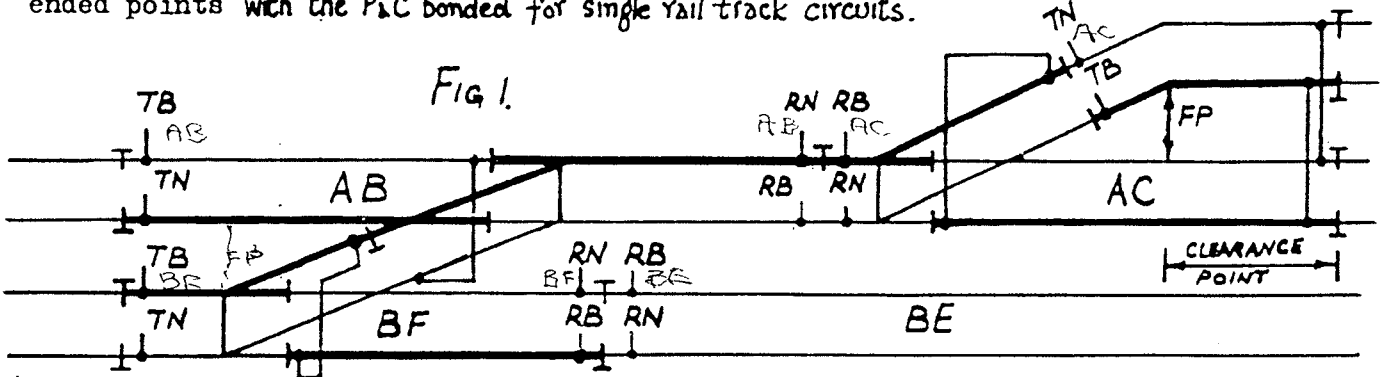
Non Electrified Lines

Plain line will be provided with double rail track circuits.

Point and crossing areas will be provided with double rail track circuits whenever practicable (S/F/012 & S/F/013 refer.)

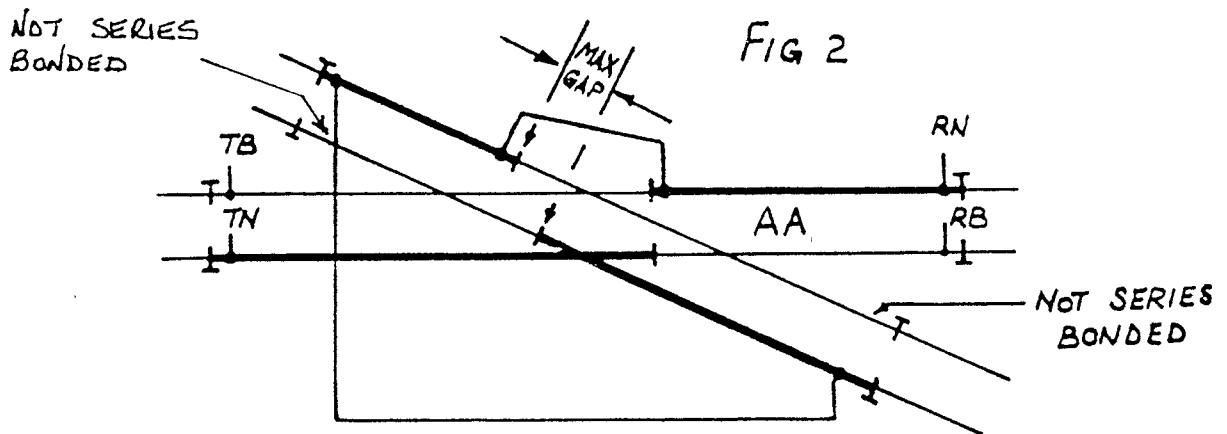
With the absence of traction bonding a maximum amount of series bonding shall be provided.

A typical situation is shown in Figure 1 for a crossover and single ended points with the P&C bonded for single rail track circuits.



Note See Engineering Instruction S/F/007 regarding track circuit clearance points.

In more complex situations where joint positions are limited some relaxations may be considered.

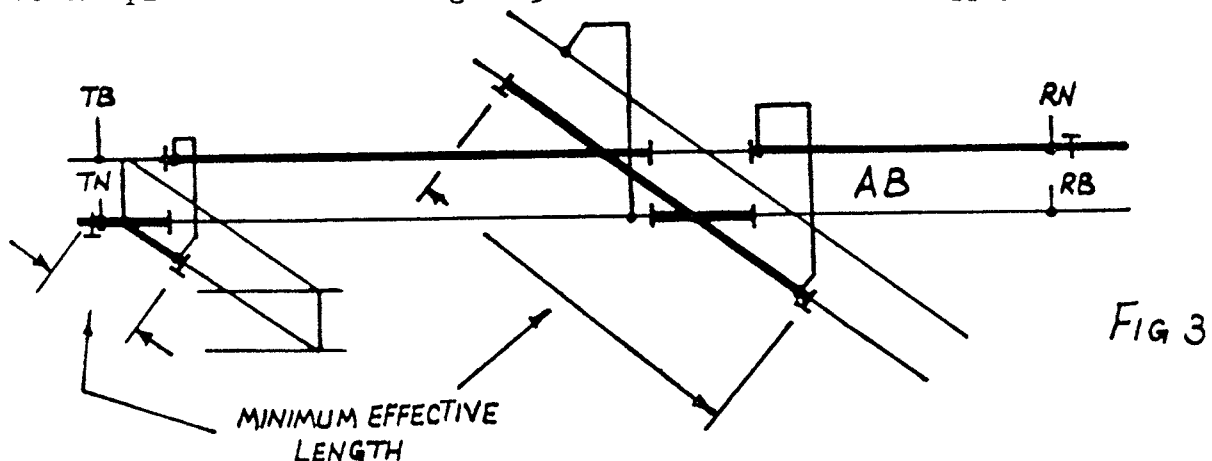


- (1) Where insulated joints cannot be positioned opposite to each other, the section of line between the joints will not operate as the Track circuit. This gap must not be greater than the minimum wheel base of a vehicle which will operate over the line. The maximum gap permitted on a continuous track circuited line shall be 2.6 metres (8 ft - 6 ins).
- (2) In P. & C. there is always a small portion of rail which cannot be series bonded.
An example of this is shown in Figure 2.
The maximum length permitted to be 'hung on' by this method shall not exceed 12.2 metres (40 ft - 0 ins). Wherever possible sections of rail so bonded should not be situated in the main line.
- (3) Where with normal bonding arrangements polarities of adjacent track circuits are not in opposition, additional insulated joints should be introduced to overcome this problem after all reasonable alternatives have been explored.

Lengths of Track Circuits

The minimum effective length of a Track circuit shall be 18.3 metres (60 ft 0 ins). Care must be exercised in P. & C. to ensure this minimum is achieved.

Two examples are shown in figure 3 where this limit would apply.



The maximum lengths of D.C. Track circuits are defined in Engineering Instruction S/F/012.

The maximum length of other types of Track circuit are defined in the Code of Practice for the particular type of equipment concerned.

Application of Stainless Steel Strip

Where the condition of the rail surface is such that the operation of the track circuit may be impaired, consideration must be given to the provision of stainless steel strip or to the application of special types of track circuit.

To give adequate protection against the possibility of rusty rails the R.O.M. should be approached in writing to ascertain the proposed traffic use of track circuited sidings and connections.

On track circuited Terminal Platforms and Sidings stainless steel strip will be provided for a distance of 18.3 metres (60 ft 0 ins) immediately in front of the buffer stops. Where retarding Buffer Stops are installed an insulated Track Circuit Interrupter will be provided and become effective after the Buffer Stops have been depressed beyond the point expected under normal working conditions. The practice of providing Electrical Depression Bars shall be discontinued.

Track Circuit Interrupters

The provision of Track circuit interrupters shall conform with Engineering Instruction S/F/004.

Two examples are shown in Figure 4.

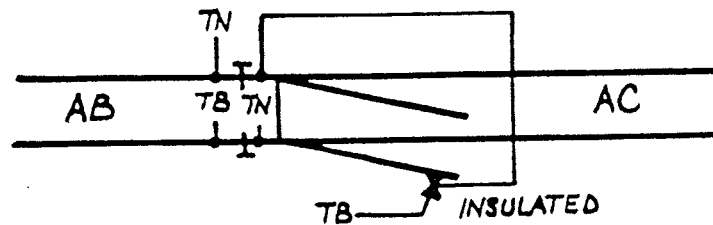


Fig 4 a.

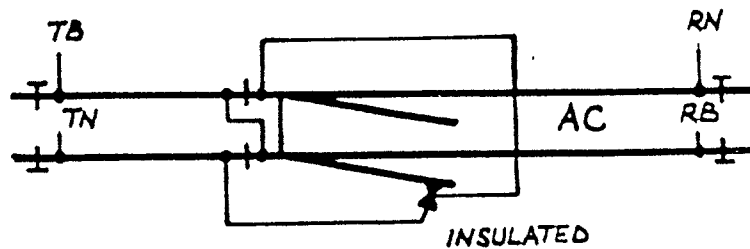


Fig 4 b.

Insulated rail joints may be kept to a minimum by the provision of a track circuit interrupter relay.

Consideration may be given to the provision of a T.C. interrupter relay when the interrupter is not at the extreme end of the T.C. (i.e. figure 4(b)) and where there is a suitable lineside location for the relay.

Where a T.C. interrupter is provided the insulated interrupter must be fixed on the 'throw off' portion of the trap. (i.e. not in 4 ft way)

The provision of a T.C. interrupter relay must appear as a separate function in the control tables for the protecting signal.

T.C. interrupter relays will also be provided where a vehicle derailed at trap or run back catch points may foul an adjacent line.

Electrified Lines (A.C. Traction)

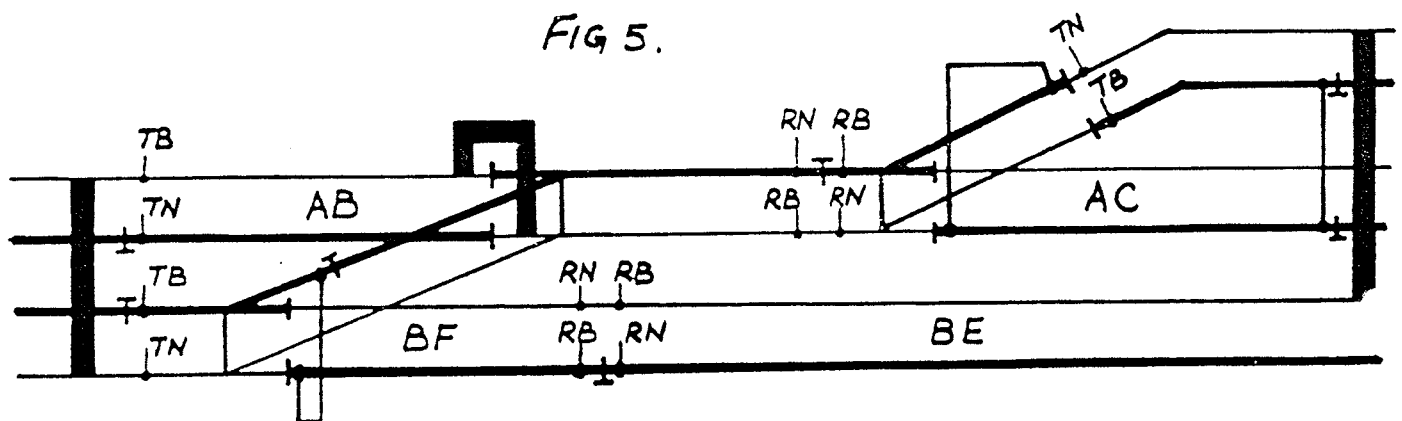
Bonding of track circuits and the provision of traction bonds must comply to the current edition of the "B.R.B. 50Hz Single Phase A.C. Electrification, Earthing and Bonding Technical Specification AC 101". (E.I. S/A/003 ~~refers~~)

All track circuit bonding and the R.M. & E.E. structure to rail and traction rail bonds must be shown on a common bonding plan.

The R.M. & E.E. will normally require only one rail of each track for Traction return purposes.

The provision of the R.M. & E.E. traction bonding for the traction return rail make superfluous the associated signalling T.C. jumper bonds and limits the effective series bonding to the insulated rail only.

The typical situation as depicted in Figure 1 can be redrawn for electrified lines as follows.



Other connections to the traction return rail have been omitted for clarity.

The majority of the structure to rail, Return Conductor to rail, and Signal Post etc., to rail bonds are located in the cess and it is a requirement that the traction return rail is located cess side. (Figure 6 refers).

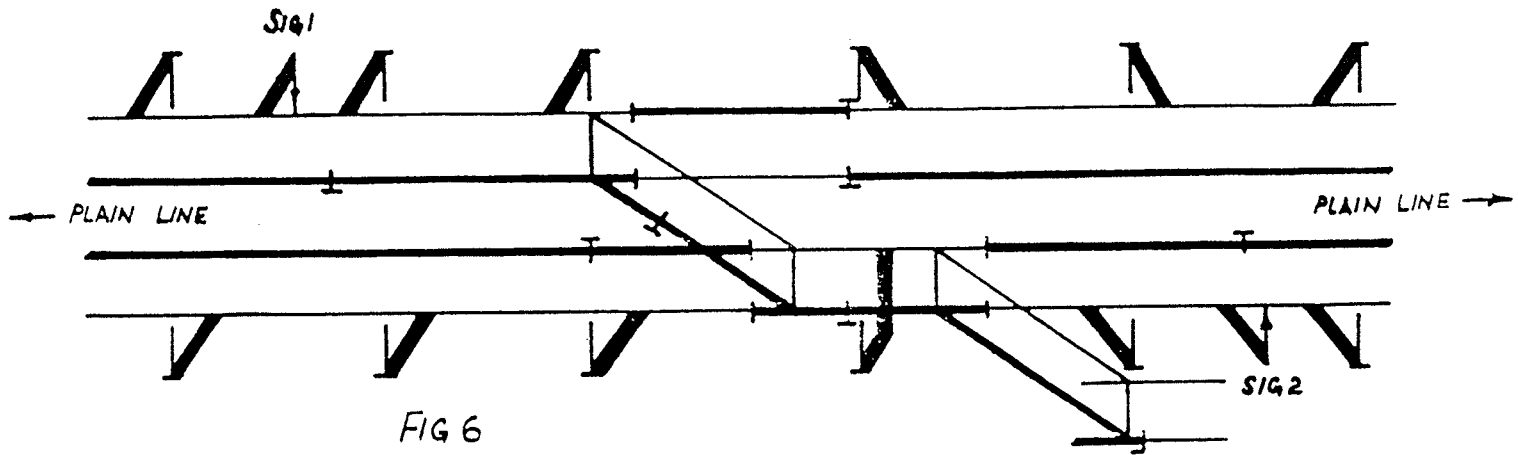


FIG 6

ONLY CONNECTIONS TO THE TRACTION
RETURN RAIL ARE SHOWN ON THIS DRAWING

Where with normal bonding arrangements this is not possible the traction return rail should be transposed to the correct position at the first T.C. joint. Should this distance involve more than 3 or 4 traction structures consideration should be given to the provision of special joints for the transposition to take place.

An example of this arrangement is shown in Figure 7.

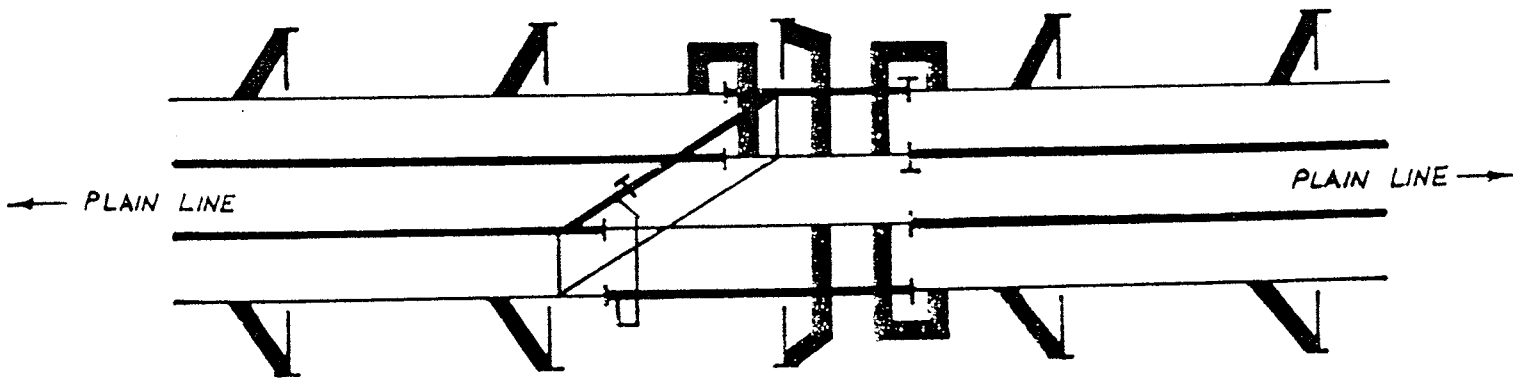
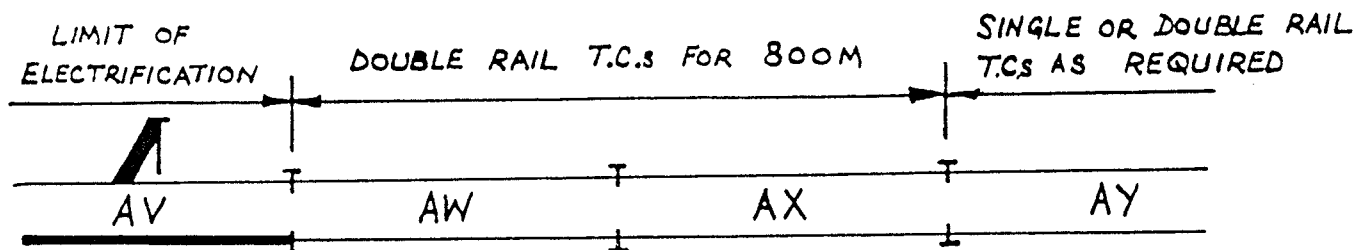


Fig 7.

The bonding plan also requires to show the bonding arrangements for untrack circuited sections of line together with the method of transition from electrified to non electrified areas.

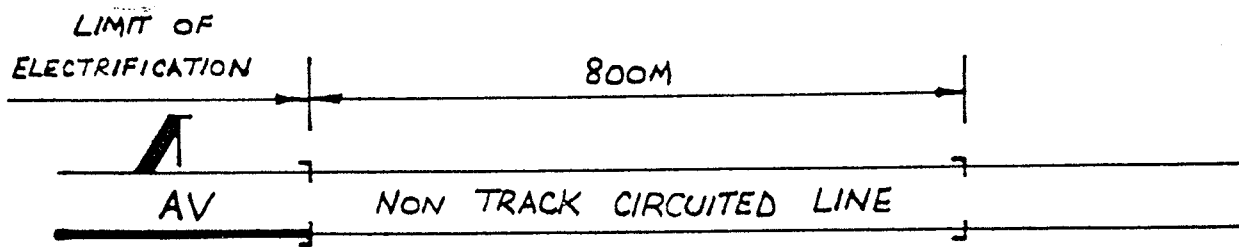
Where electrification conditions cease, it is essential to provide a 'buffer section' to contain the traction return rail current within the electrified portion of the track (B.R.B. Immunisation of S. & T. systems against Electrical Interference, refers).

Figures 8 and 9 show the requirements for track circuited and non track circuited lines respectively.



NOTE. T.C.s AW AND AX EACH TO BE GREATER THAN THE MAXIMUM LENGTH OF LONGEST TRAIN

FIG 8



THE REASON FOR THE PROVISION OF THESE INSULATED JOINTS MUST BE CLEARLY STATED ON THE BONDING PLAN

FIG 9

NOTE THE ABOVE ARRANGEMENTS MUST BE AGREED WITH THE R.M. & E.E.

The R.M. & E.E. bonding requirements for unwired sidings etc., within the electrified area are contained within Specification AC 101.

In cases where track circuits will be brought into operation prior to the completion of the R.M. & E.E. traction bonding the requirements of Engineering Instruction S/F/012 must be observed.

Electrified Lines (D.C. Traction)

The bonding arrangement for overhead D.C. traction follows the same principles which apply to A.C. Traction.

For D.C. 3rd rail traction the bonding of track circuits and the provision of traction bonds must comply with the R.M. & E.E.'s Code of Practice for Conductor Rail System Design and Installation. Engineering Instruction S/A/025 refers.

The basic changes which occur with D.C. 3rd rail traction are as follows:-

- (1) No structure to traction return rail bonds are provided.
- (2) The insulated Track Circuit rail must not run adjacent to the live traction rail.
- (3) The R.M. & E.E. will generally require in plain line for both running rails to be used for traction return and in consequence impedance bonds will be required.

Where it is not possible to avoid the insulated track circuit rail from overlapping the live traction rail, Guard boards must be provided to prevent the application of the short circuit bar. This is to protect the signalling equipment. The short circuit bar would also be ineffective in this area and the maximum distance this can be permitted is 36.5 metres (120 ft 0 ins).

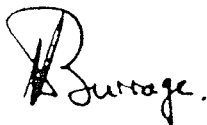
Electrified Lines General

Impedance bonds are required on electrified lines where there is a requirement for Double Rail Track Circuits.

Double Rail Track Circuits are provided where the R.M. & E.E. requires both running rails for traction return or where the R.S. & T.E. requires to obtain extra length of track circuit operation due to poor ballast conditions or some physical constraint effecting the positioning of equipment.

Note:-

The procedure for the production of bonding plans on electrified lines and the procedure for obtaining insulations and drillings etc., from the R.C.E. are delineated in Engineering Serials S/F/018 and S/F/019 respectively.



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LONDON MIDLAND REGION

BASIC SIGNALLING TECHNOLOGY COURSE

TRAINING NOTES

TRACK CIRCUITS & BONDING

Important Note

While these notes are based on the authors' understanding of current railway signalling practice in the United Kingdom and elsewhere, they must not be taken to modify or replace any existing rules, instructions or procedures of any railway administration. Where any apparent conflict exists, reference should be made to the appropriate documents produced by the student's own administration.

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TRACK CIRCUITS AND BONDING

CONTENTS

1. Introduction
2. Principles of Operation
3. Practical Considerations
4. Track Circuit Types
5. Track Circuit Bonding Arrangements

1. INTRODUCTION

Track circuits are used to:-

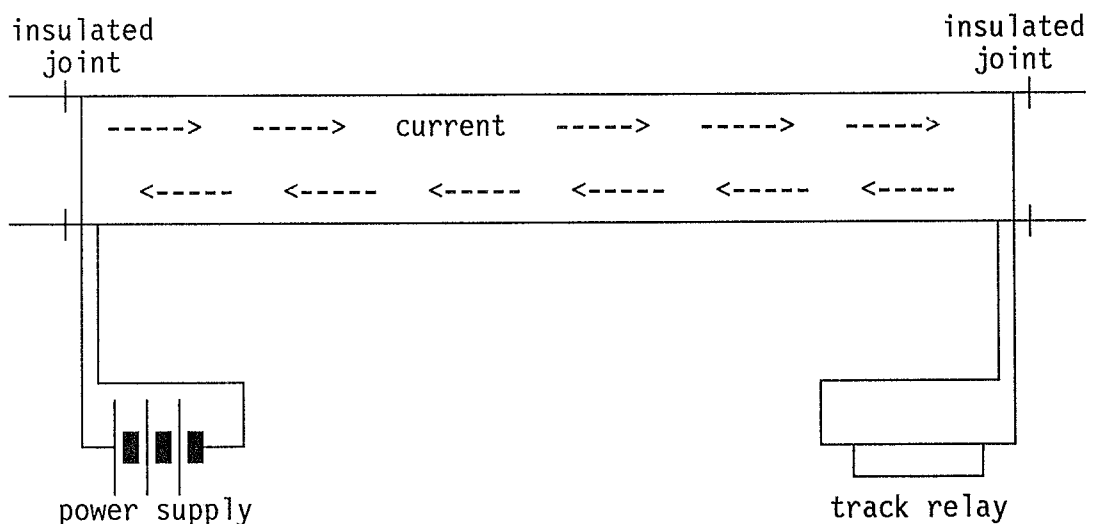
- a) Indicate the position of trains and more importantly to prove the absence of trains from a section of track.
- b) To control the operation of signals and thus prevent a collision.
- c) To lock points if a train is standing on or approaching them.

2. PRINCIPLES OF OPERATION

A track-circuit consists of an electrical circuit, with the rails forming part of the circuit:

To understand the principles of operation we will look at a simple d.c. track circuit as shown below.

SIMPLE D.C. TRACK CIRCUIT

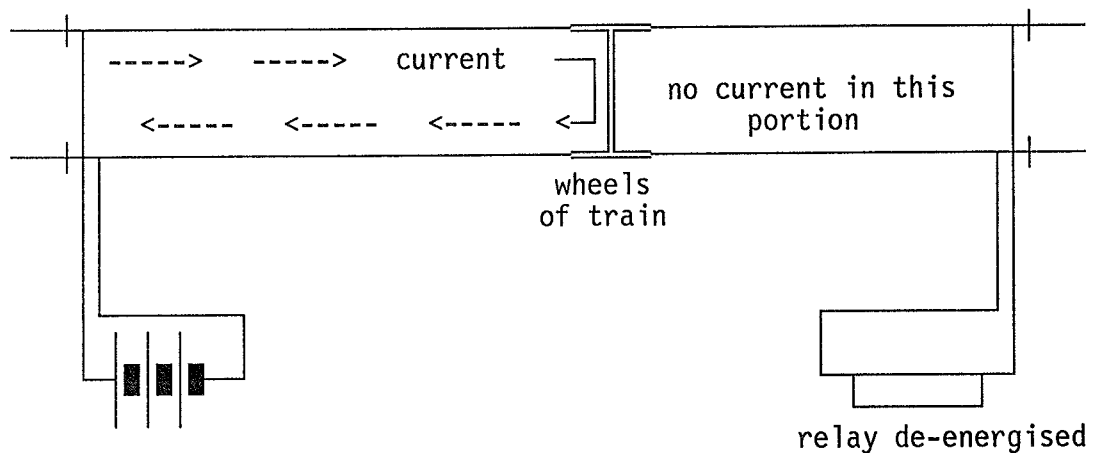


A relay is connected across the rails at one end of the circuit, and a power supply at the other end. The physical limits of the track circuit are defined by insulated rail joints.

When there is no train on the track circuit, the relay will be energised via the full length of each rail. When a train stands on the track circuit the wheels and axles create a short-circuit between the rails. The current bypasses the relay which thus becomes de-energised.

All track circuits depend for their operation on the wheels of a train forming a low resistance path between the rails.

TRACK CIRCUIT OCCUPIED BY TRAIN



The relay is therefore energised to prove that there is no train on the track, and de-energised when there is a train on the track.

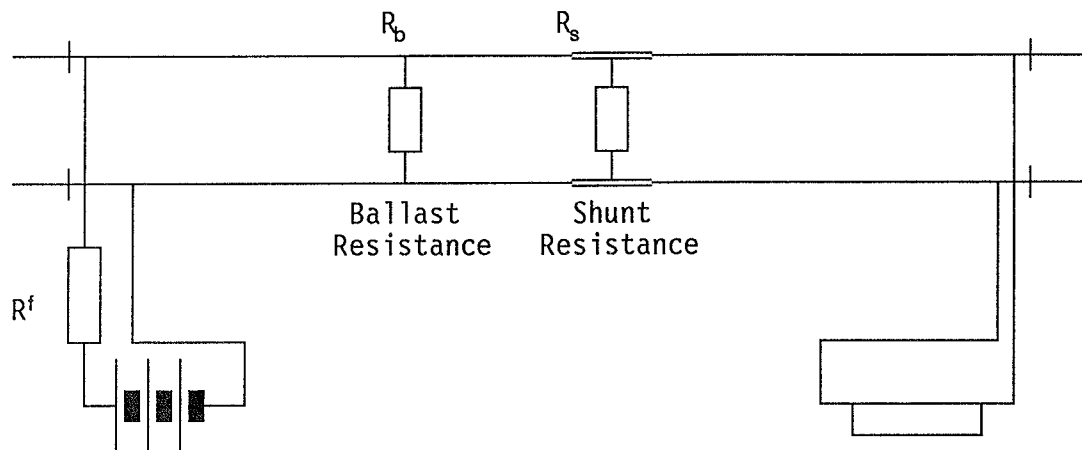
The relay will also de-energise if:

- a) A rail connection becomes detached
- b) The power supply fails
- c) A rail to rail bond is broken or becomes detached
- d) A rail breaks

So the circuit is said to be "fail-safe", as under fault conditions it fails to prove that the track is clear.

However, this assumes that the electrical path through the train between the rails is in fact a short circuit. In some cases this assumption is not correct and additional precautions have to be taken to ensure that the track circuit operates correctly.

3. PRACTICAL CONSIDERATIONS



3.1 Ballast Resistance (R_b)

In a practical track-circuit, the rails are not perfectly insulated from each other. Current "leaks" from one rail to the other, through the sleepers and ballast. The rail-to-rail resistance, or "ballast resistance" of a 1000 ft (305 metre) length of standard gauge track may vary from 50 ohms for well ballasted, dry track, to as low as 0.5 ohm with wet or dirty ballast. To further add to the problems of adjustment, the ballast resistance is unlikely to remain constant as ground conditions vary considerably with the weather.

3.2 Drop Shunt (R_s)

In theory, a train will short-circuit the rails and de-energise the relay. In practice the train is not a perfect short-circuit - the axles have a resistance and the wheels do not always make perfect electrical contact with the rail. This is a particular problem where the trains are infrequent allowing a film of rust to build up on the rail and also where short trains of lightweight vehicles are in use.

The effective value of this resistance is known as the "train shunt" resistance. The track-circuit is adjusted, by varying a resistor (R^f) at the feed end, so that the relay will always drop when a train of any type is present on the track. The "Drop Shunt" of a track circuit is the largest train shunt resistance between the rails which will cause the track relay to de-energise. Most track-circuits must be adjusted so that this value is at least 0.5 ohms. A train may not be detected if its shunt resistance is above this value.

To overcome the effects of poor train shunt resistance, certain additional features may be found on some track circuits. A stainless steel strip may be welded to the top of the rail or a treadle may be cut into one of the track circuit connections. This ensures that the track relay de-energises as soon as the first axle reaches the track circuit. The relay will then remain down as more axles of the train run on to the track and lower the value of the train shunt. Such features are often provided where track circuits control automatic level crossings and accurate timing is vital.

3.3 Maximum Length

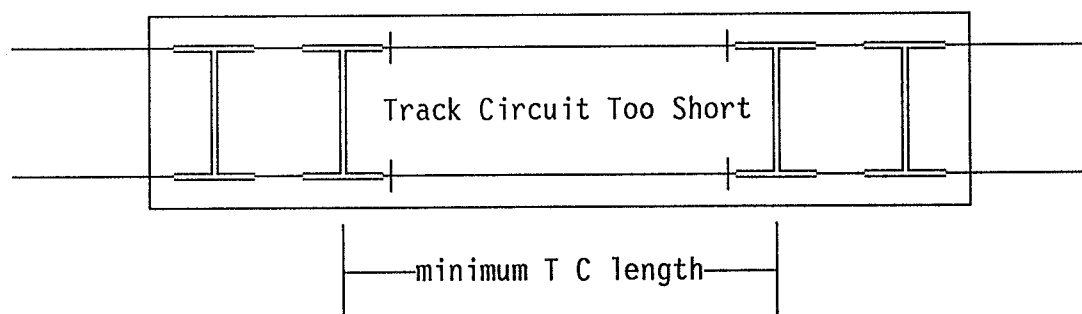
A longer track-circuit will generally have a lower ballast resistance. Eventually, a length is reached at which it is impossible to energise the relay under all ballast conditions.

A setting which keeps the relay energised under worst ballast conditions may give an unacceptably low drop shunt when ballast conditions improve.

Track circuits must therefore be limited in length. A d.c. track circuit is generally limited in length to 1000 yards (914 metres). In electrified areas the maximum length is lower still but this is due also to immunisation requirements.

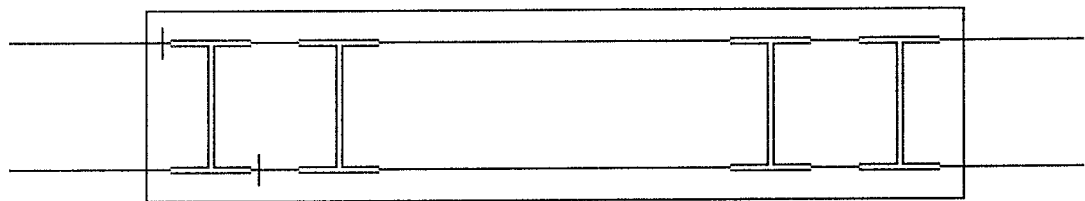
3.4 Minimum Length

If a track circuit is too short, a vehicle with a long wheel-base may stand completely over the track circuit without it being detected. Hence the minimum length of a track-circuit is set by the vehicle with the longest wheel-base. For bogie vehicles, this distance is measured between the inner axles of each bogie. In most cases, this minimum distance is more likely to be determined by bogie vehicles than by two axle vehicles.



3.5 Staggered Block Joints

Insulated joints are normally installed in pairs opposite each other. Through points and crossings, it may not be possible to place joints exactly opposite. Such joints are said to be staggered. When an axle is between staggered joints it will not be detected. As all vehicles have at least two axles, the length of stagger must be limited to ensure that at least one axle remains detected. In addition, staggered joints must not be used to define critical clearance points.



staggered joints

axle not detected

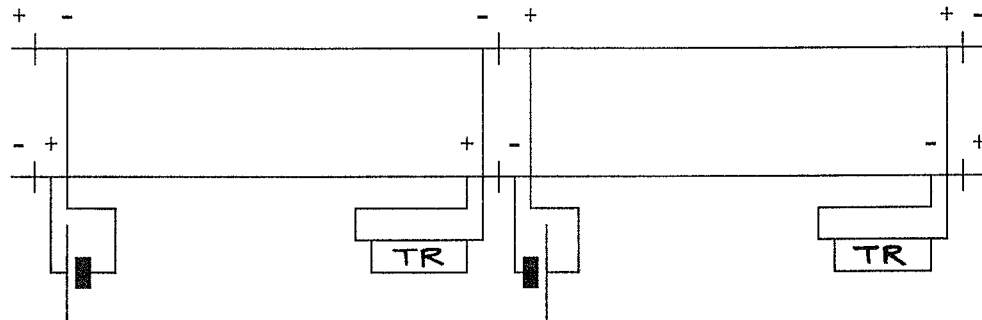
With two adjacent pairs of staggered joints it would be possible to lose detection of a complete two-axle vehicle. Therefore a second pair of staggered joints must not be located within minimum track circuit length of another staggered pair.

3.6. Insulated Block Joints and Polarity

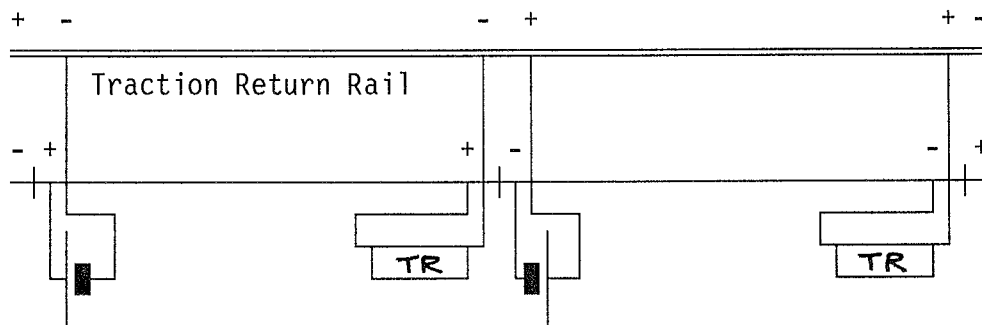
On electrified lines, one rail is normally used for traction current return and is continuously bonded throughout. Block joints will only be provided in one rail. On non-electrified lines it is normal to provide insulated block joints in both rails.

If an insulated block joint failure occurs, it is possible for the relay of one track circuit to pick up from the feed of an adjacent track circuit. This would require both joints to fail on a non-electrified line. This situation is obviously unsafe and must be prevented.

The polarity of the rails must be reversed at each pair of insulated joints. This is called "staggering" the track-circuits (not to be confused with staggered block joints as mentioned earlier). If opposite block joints both fail the two feeds will oppose each other and both relays will de-energise.

STAGGERING OF TRACK CIRCUITSBlock joints in both rails

Failure of both insulated joints will connect negative of one track feed to positive of adjacent track feed (and vice versa). Both relays will drop.

Block Joints in One Rail Only

Failure of the one insulated joint will connect negative of one track feed to positive of adjacent track feed (and vice versa). Both relays will drop.

4. TRACK-CIRCUIT TYPES

Apart from the simple d.c. track circuit, many other different types of track circuit exist.

The choice of track circuit will depend on the following factors:-

- a) Required track circuit length and ballast conditions.
- b) Type of traction system (if any).
- c) Jointed or welded rail and whether or not insulated joints can be installed in welded rail.
- d) Available power supplies.
- e) Cost.

4.1. Types of D.C. Track Circuit

The simplest form of d.c. track circuit derives its power from one or more primary cells. These have to be replaced at regular intervals during routine maintenance.

Where a lineside signalling power supply is available (normally a.c.) this will be used to operate the track circuit, either via a transformer & rectifier or by trickle charging a battery of secondary cells. The choice of feed arrangements will depend upon the reliability of the main power supply. If there are standby arrangements for the supply itself, a battery is not normally considered necessary.

In a.c. electrified areas, d.c. track circuits may be used but with special a.c. immune feed sets and relays. Obviously, d.c. track circuits cannot be employed where d.c. traction is in use.

4.2. A.C. Track Circuits

Low frequency a.c. track circuits are often used on d.c. electrified lines. In place of a d.c. feed, an a.c. source is used, normally connected to the rails via a capacitor and/or transformer.

For a.c. track circuits a vane relay is used. Vane relays cannot be energised by a d.c. voltage. It is usual for Vane relays to be operated by two windings, both of which must be energised simultaneously. One winding is fed locally, the other through the rails. The two relay feeds are then approximately 90° out of phase. If either feed is absent, or the phase angle is wrong, then the relay will not energise.

Two basic configurations of a.c. track circuit are available, Double Rail and Single Rail. In both types the feed resistor is replaced by a variable capacitor. Phase is staggered between adjacent tracks for the same reason as polarity is staggered with d.c. track circuits (i.e. failure of blockjoints, connecting two supplies in antiphase will produce an effective voltage which is insufficient to energise either of the relays).

Double rail track circuits are used where return traction current is required to pass along both rails. At each end of the track circuit is an "impedance bond", which presents a low impedance to d.c. along the rails but a high impedance to a.c. across the rails.

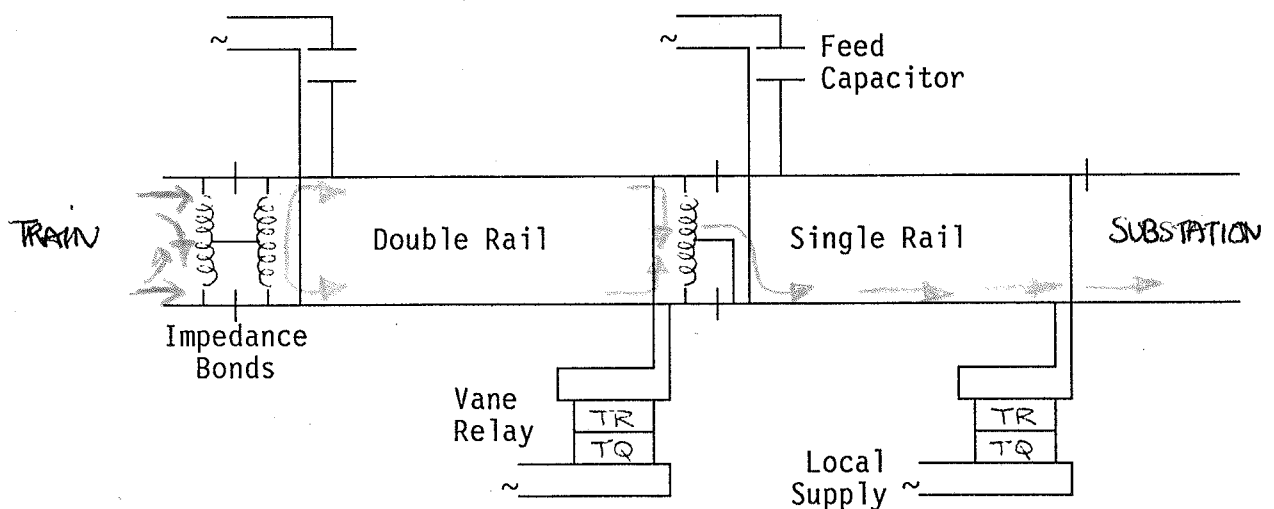
The impedance bond is effectively a centre tapped transformer. The d.c. traction currents in each half of the winding set up opposing fluxes in the magnetic core which cancel each other out. To the a.c. track circuit current, the impedance bond presents a rail to rail impedance which is high compared with the ballast resistance.

Failure of a blockjoint or the disconnection of a traction return bond between rails may unbalance the d.c. currents in the impedance bond sufficiently to saturate the magnetic core of the impedance bond and cause the track circuit to fail.

In addition to the extremities of a track circuit, impedance bonds will also be found:-

- a) Where it is necessary to bond the traction return between adjacent tracks (to provide a lower resistance path).
- b) Immediately adjacent to substations for connection to the traction supply.

Single rail track circuits are used through points and crossings where it is not practical to provide double rail traction return.



Most a.c. track circuits operate at mains frequency (50Hz). In some cases, more than one electrification system is in use on the same line (e.g. 750v d.c. third rail and 25kv a.c. overhead) or lines on different systems run in close proximity. 50Hz track circuits could not operate on such lines, neither could d.c.

One solution is to employ a.c. at a different supply frequency. For a 50Hz traction supply, a frequency of 83.3Hz is normally chosen for the separate signalling supply. Filters are incorporated in both feed and relay ends of the track circuit.

Alternatively an audio frequency track circuit such as the Reed track can be used. This operates at frequencies in the vicinity of 400Hz, (obviously avoiding any 50Hz harmonics) and does not require the provision of a separate signalling power supply at a different frequency.

4.3. Jointless Track Circuits

To avoid cutting the rails at the end of each track-circuit, jointless track circuits are used in areas with continuously-welded rail. These track circuits are called jointless as there are no insulated block joints between adjacent track circuits. In all cases the track circuits are terminated electrically.

The track feed takes the form of a transmitter at a specified frequency. The relay end has a receiver which is tuned to the same frequency, and picks a follower relay if the frequency is detected (track clear). The "blockjoint" normally takes the form of a filter which will prevent signals of the track circuit's operating frequency from penetrating more than a short distance beyond the transmitter or receiver and ensure that adjacent track circuits do not interfere with each other.

Different frequencies must therefore be used for adjacent track-circuits. The frequencies used must also be immune from mains and/or traction interference.

The earliest type of jointless track circuit in common use was the Aster "1 watt" type. This was subsequently developed to the "U type" Aster track circuit which has seen widespread use on BR. The U Type uses four frequencies, 1.7kHz and 2.3kHz on one line and 2.0kHz and 2.6kHz on the other.

Neither type is fully traction immune. A further development is the "TI21" track circuit. This operates at two frequencies 34 Hz apart and modulates between them at 4.8 Hz. The receiver must detect both frequencies and the correct rate of modulation to energise the follower relay. Eight frequencies are available,

Due to the absence of blockjoints the limits of jointless track circuits cannot be as precisely defined as for conventional track circuits. This generally presents no problem on plain line but, as the extremities of track circuits through pointwork need to be precisely defined to ensure safe clearances, block joints must be used. Jointless track circuits are therefore not generally suitable for use through pointwork. Joints are also required at the extremities of jointless sections where they adjoin conventional track circuits.

The GEC Reed track circuit was originally intended for use as a jointless track circuit but on BR it is normally used in its jointed form in d.c. or dual traction areas.

The above is only a brief description of representative types of track circuit in use. Many other types exist which are beyond the scope of this course.

5. TRACK CIRCUIT BONDING ARRANGEMENTS

The design of a signalling installation includes the accurate specification of the track circuit bonding arrangements.

The basic requirements are:-

- a) The limits of each track circuit must be as specified on the signalling plan (to the required tolerance).
- b) As far as possible all sections of rail comprising the track circuit must be connected in series, to ensure fail-safe operation.
- c) Opposite polarity of track circuit voltage on each side of a block joint, and between opposite rails, must be maintained throughout.
- d) All clearance points must be maintained.
- e) Where the line is electrified there must be continuity of traction current return.
- f) Minimum and maximum track circuit lengths must be observed.
- g) Any staggering of block joints must not allow vehicles to remain undetected.

All necessary details required to achieve the above will be shown on a track circuit bonding plan. Unlike the signalling plan, both rails are shown on the track plan.

Positioning of insulated joints on plain line is relatively simple. The nearest available rail joint is often satisfactory, avoiding the need to cut additional joints into the rail. On plain line, jointless track circuits may be used. These generally give a "joint" position accurate only to within a few metres.

Where rails have not already been welded by the permanent way engineer or bonded for continuity of traction return, the rail ends must be bonded together by the signal engineer.

On points and crossings extra block joints will be required, as will jumper leads ("bonds") to ensure that all of the rails are track-circuited in a safe manner. Jointless track circuits, even if they are suitable for operation through points, will also require blockjoints to accurately define their limits.

5.1. Fouling Point and Clearance Point

On converging lines, the fouling point is the point at which vehicles would encroach within a minimum safe clearance of each other. On BR the clearance between vehicles should be at least 1'6" (0.46m). This requires a distance of at least 6'0" (1.83m) between the running edges of the adjacent rails on each track.

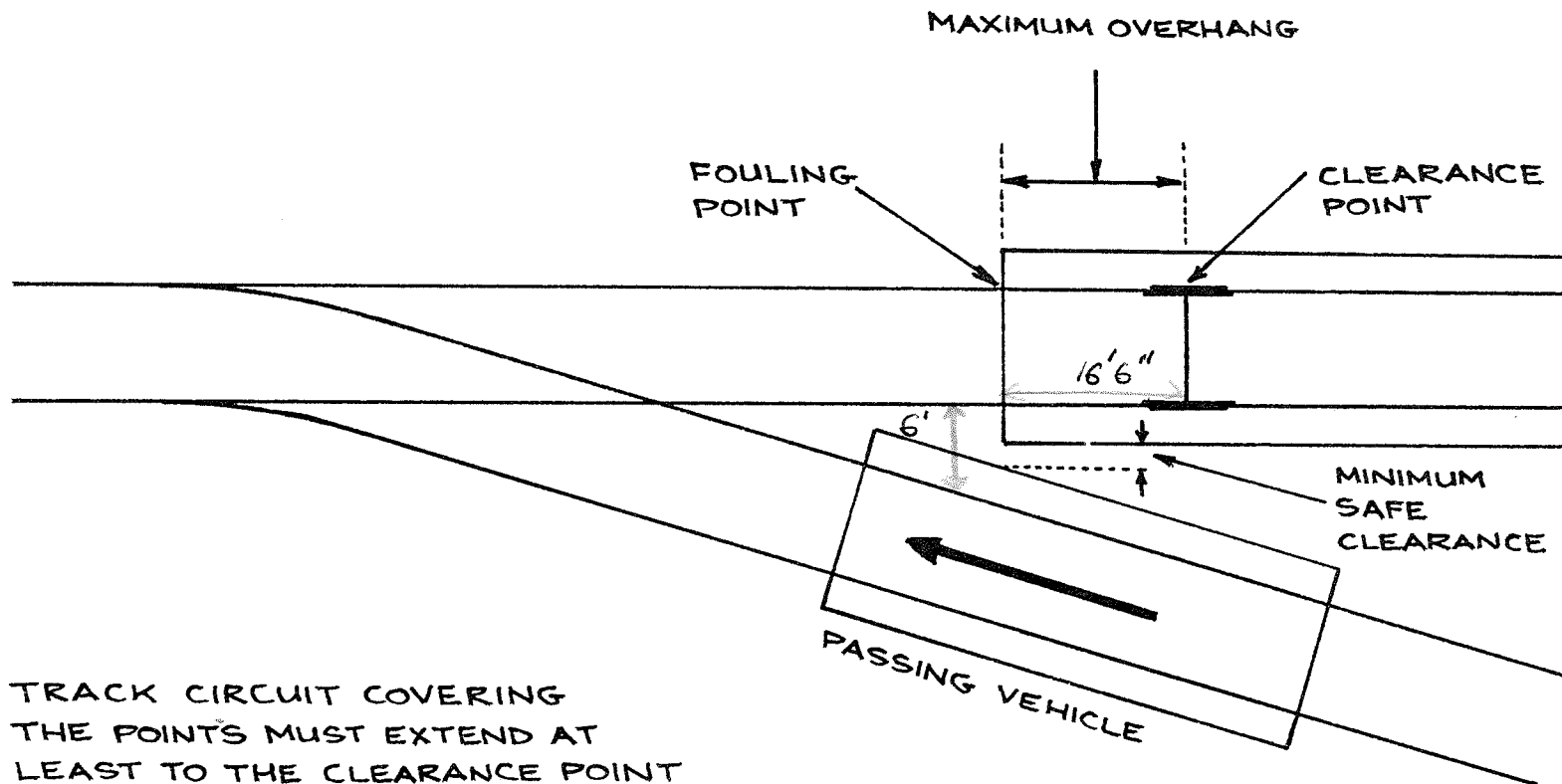
Due to the overhang of vehicles, the track circuit must be proved clear for a further distance away from the points. The Clearance Point is the minimum distance which a track circuit must extend beyond points or crossings in order to ensure sufficient clearance between lines to allow for the overhang at the end of each vehicle.

To summarise, if the wheels are beyond the clearance point the end of the vehicle will be clear of the fouling point. On BR the clearance point is a further 16'6" (4.88m) from the fouling point.

It is not always possible to place joints beyond the clearance point in complex areas. This will create a "foul" track circuit which will need to be proved clear when the other route is set.

The track-plan is not usually drawn to sufficiently large scale to accurately determine the fouling and clearance points. Instead, the Permanent Way Engineer's detail drawings, which are typically at 1:50 or 1:100 scale, should be used for accurate positioning of the joints through points and crossings.

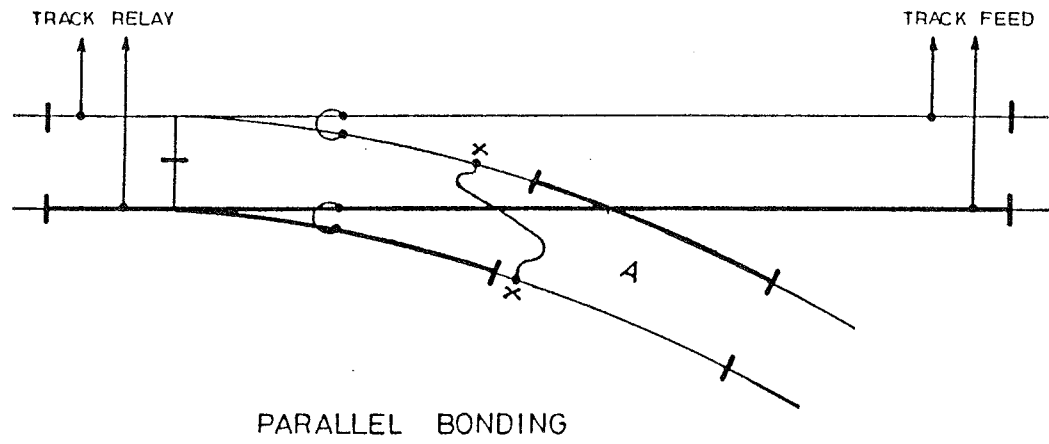
The permanent way engineer will generally have preferred positions for insulated joints (to make maximum use of standard track components). Wherever practical, these should be used to avoid the expense of cutting the rails in additional positions.

FOULING POINT AND CLEARANCE POINT

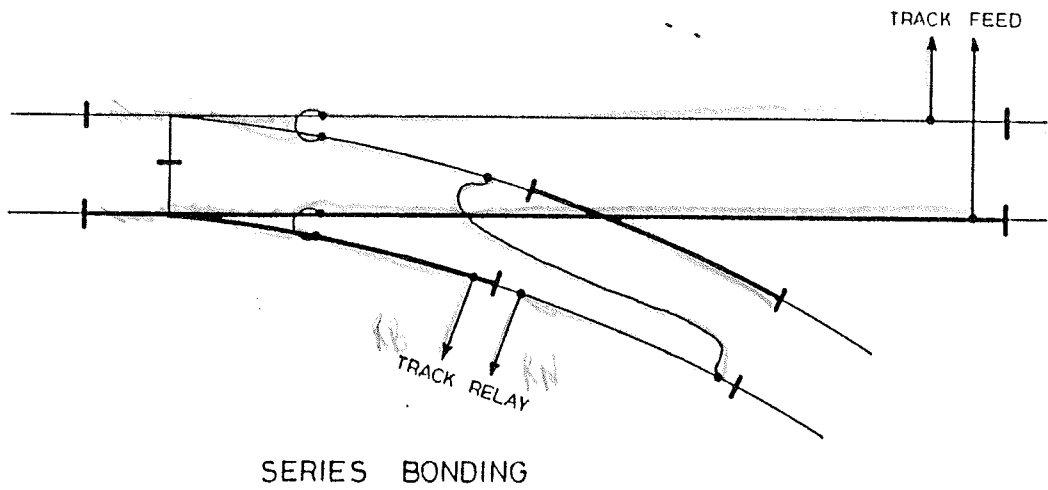
TRACK CIRCUIT COVERING
THE POINTS MUST EXTEND AT
LEAST TO THE CLEARANCE POINT
TO PROTECT MOVEMENTS ON THE
OPPOSITE TRACK

5.2. Series and Parallel Bonding

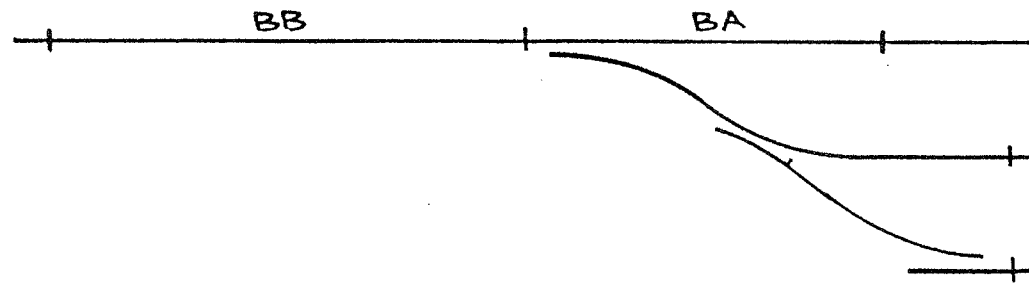
All bonds, rails and jumper cables must be in series, so that the disconnection of any bond or a break in any rail will break the circuit.



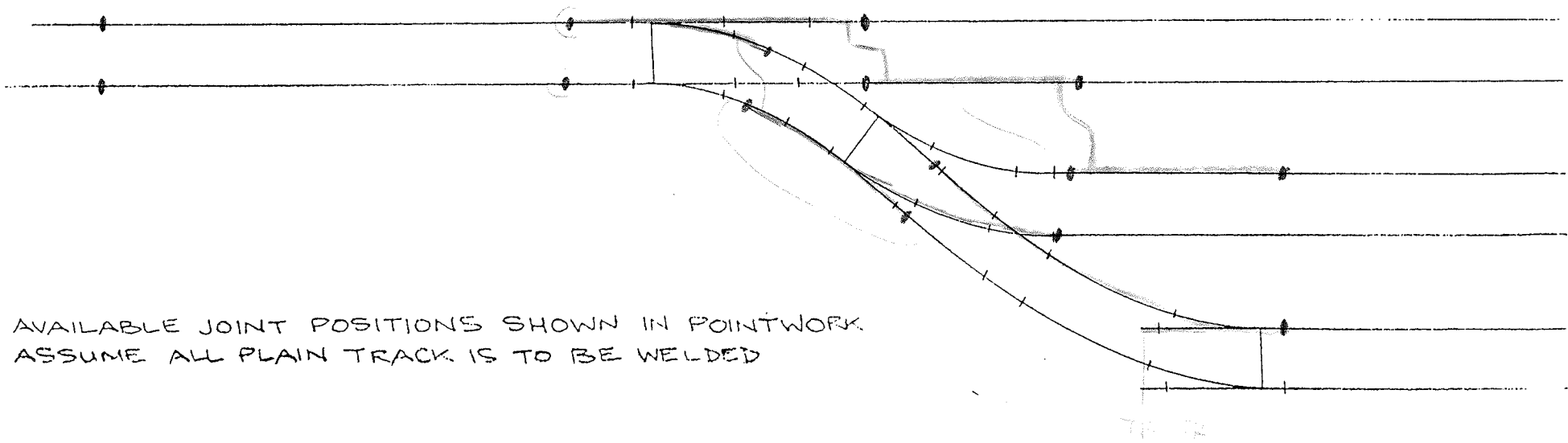
For example, in the above layout, if the bond XX were to break, a train standing on portion A of the track-circuit would not be detected. This arrangement is called Parallel Bonding.



With Series Bonding, as above, the loss of any bond will break the circuit.

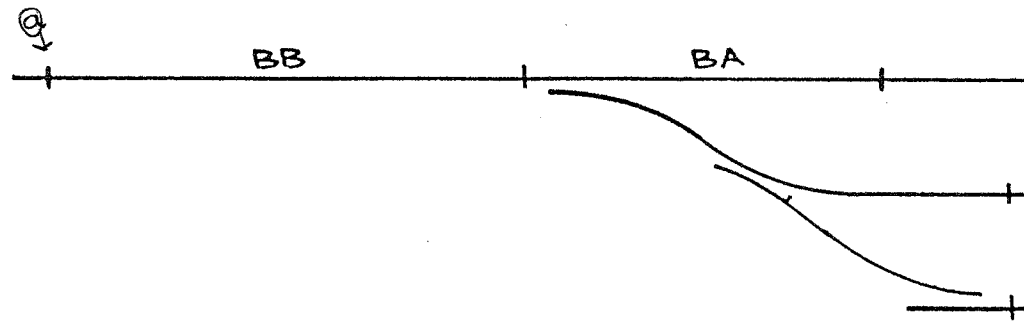


LAYOUT 1

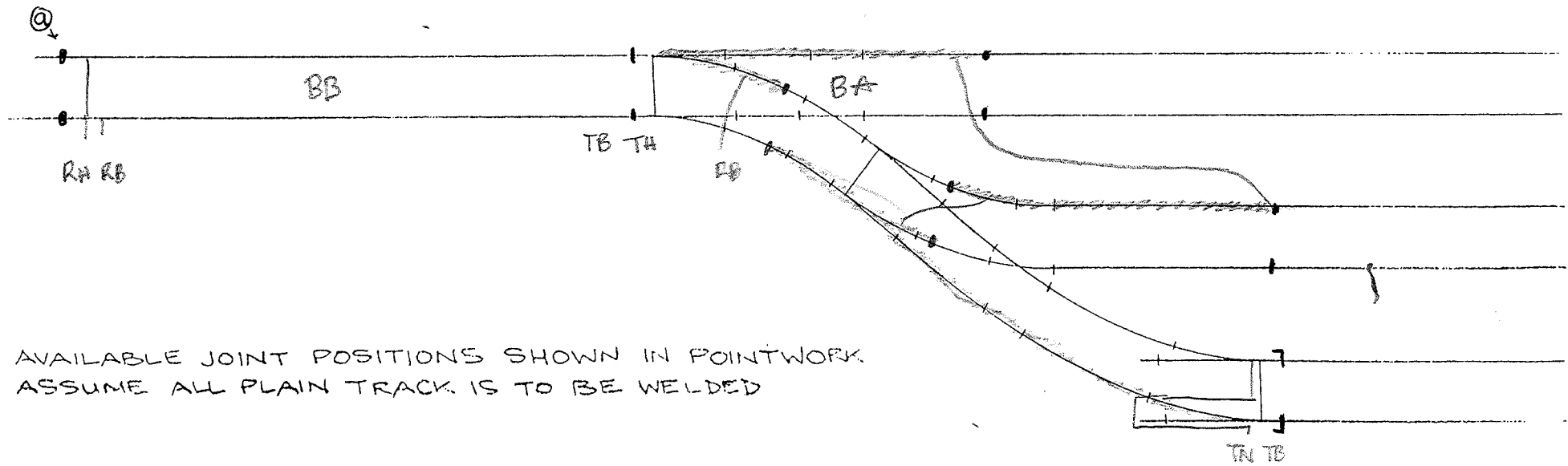


AVAILABLE JOINT POSITIONS SHOWN IN POINTWORK.
ASSUME ALL PLAIN TRACK IS TO BE WELDED

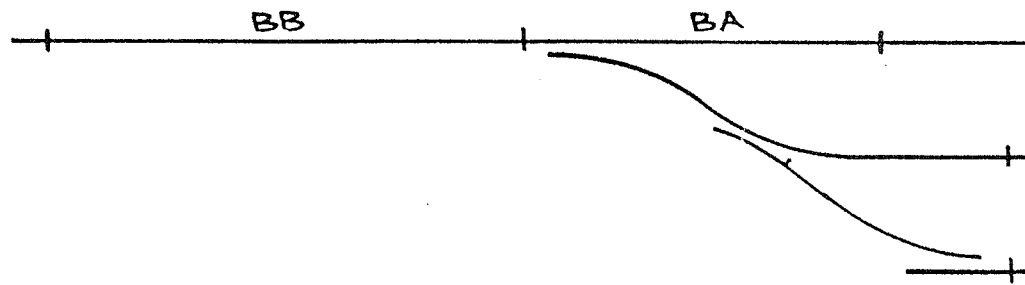
*2 extra pairs of insulated
joints*



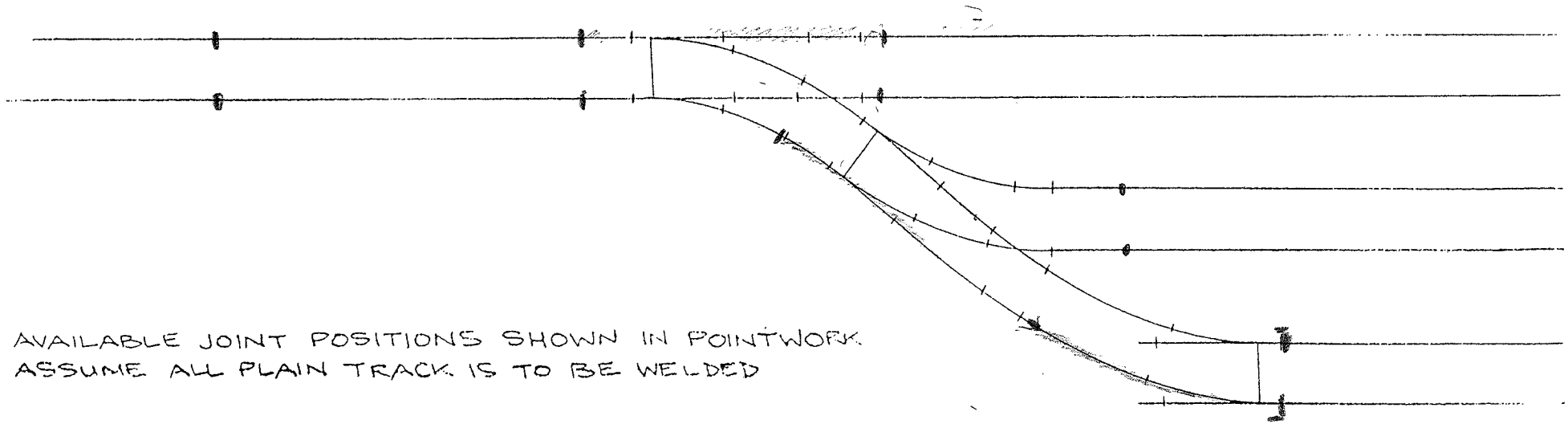
LAYOUT 1



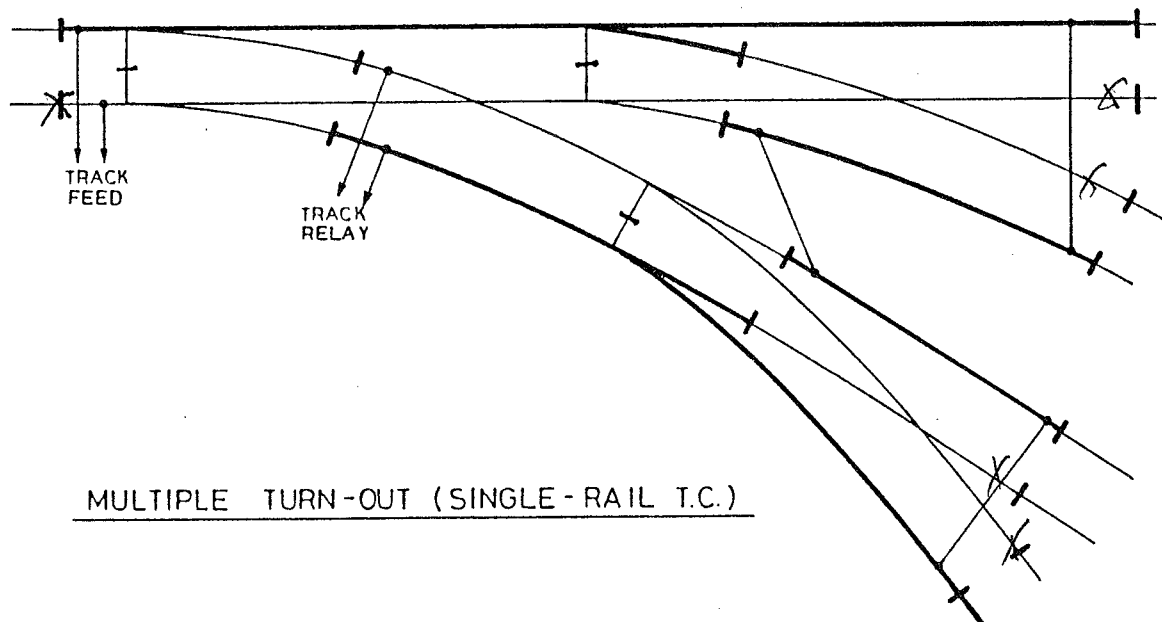
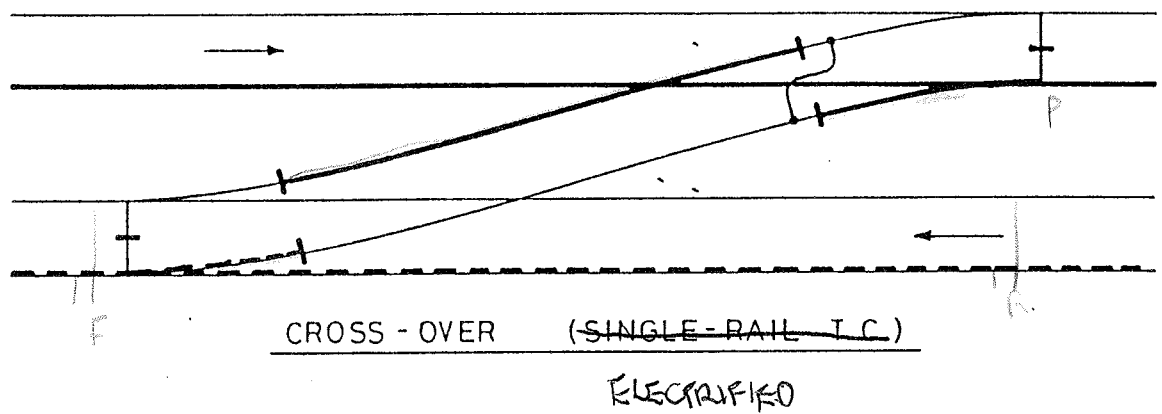
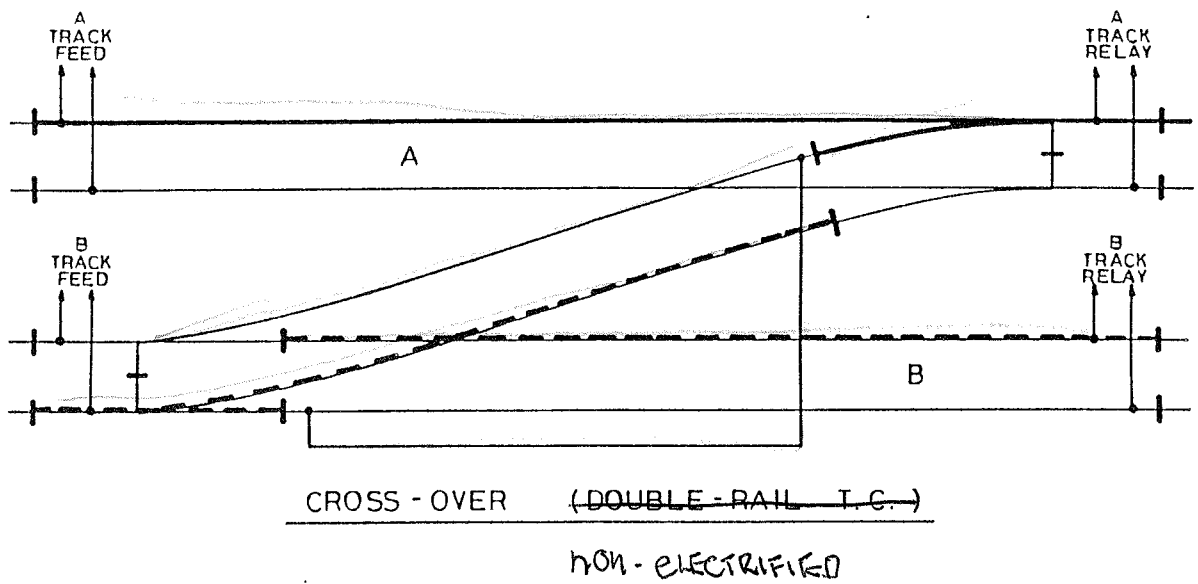
AVAILABLE JOINT POSITIONS SHOWN IN POINTWORK.
ASSUME ALL PLAIN TRACK IS TO BE WELDED



LAYOUT 1



AVAILABLE JOINT POSITIONS SHOWN IN POINTWORK.
ASSUME ALL PLAIN TRACK IS TO BE WELDED



EXAMPLES OF TRACK - CIRCUIT BONDING

In general, both positive and negative legs of the track-circuit should be series bonded throughout, wherever possible. In practice there will usually be short sections that are in parallel but these must be kept to a minimum.

On electrified lines the traction return rail will be parallel bonded. The signal engineer must ensure that the other (signalling) rail is series bonded.

5.3. Track Circuit Interrupters

At trap points, there is a danger that a derailed train may totally leave the rails. The track circuit over the points could then clear electrically even though the derailed train may be foul of the line. To prevent this, a track circuit interrupter is used.

The interrupter consists of an iron casting bolted to the stock rail of the points, and included in series with the track circuit bonding. It is positioned such that the wheel of a vehicle being trapped will break the casting, and so break the track circuit bonding. The track circuit will not then re-energise even if the train completely leaves the rails.

The interrupter is usually insulated from the rail it is mounted on, and is included in the bonding of opposite polarity to that of the rail. This ensures that the track circuit is not remade if the broken casting lands in contact with the rail.

An alternative arrangement is to provide a completely independent circuit for the interrupter. A contact of the interrupter repeat relay is then included in the TPR circuit.

TRACK CIRCUIT INTERRUPTER (cross section through rail)

