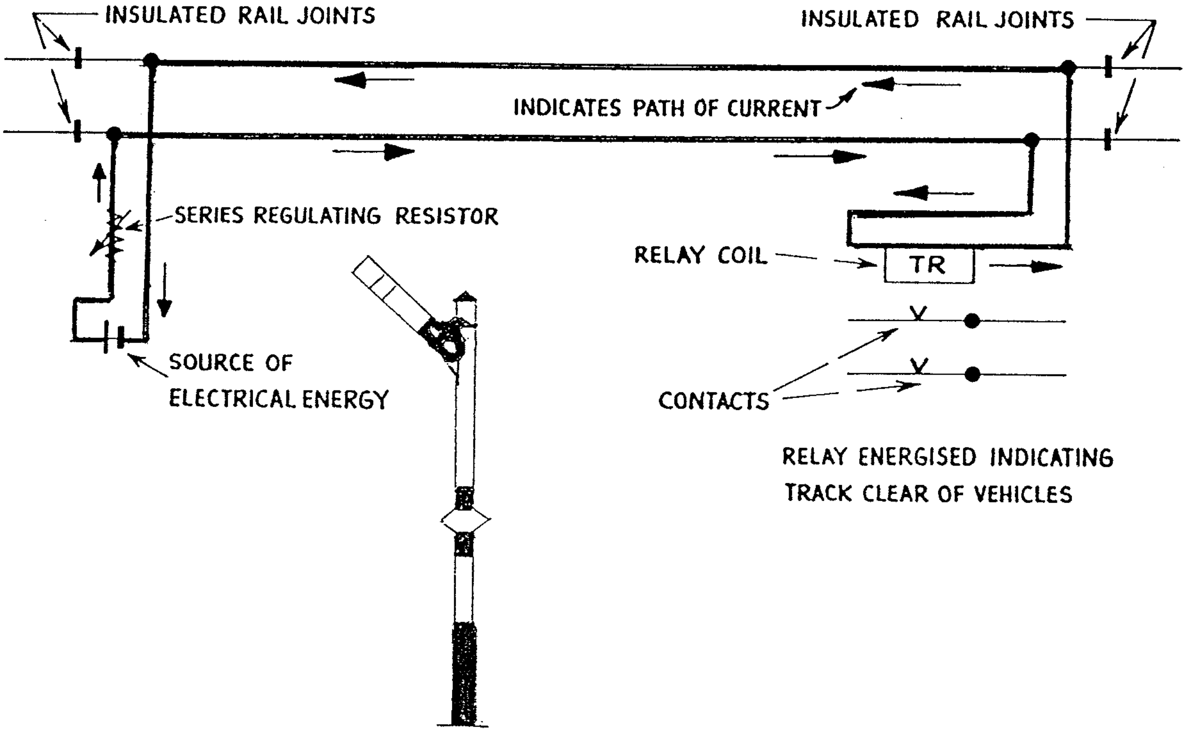
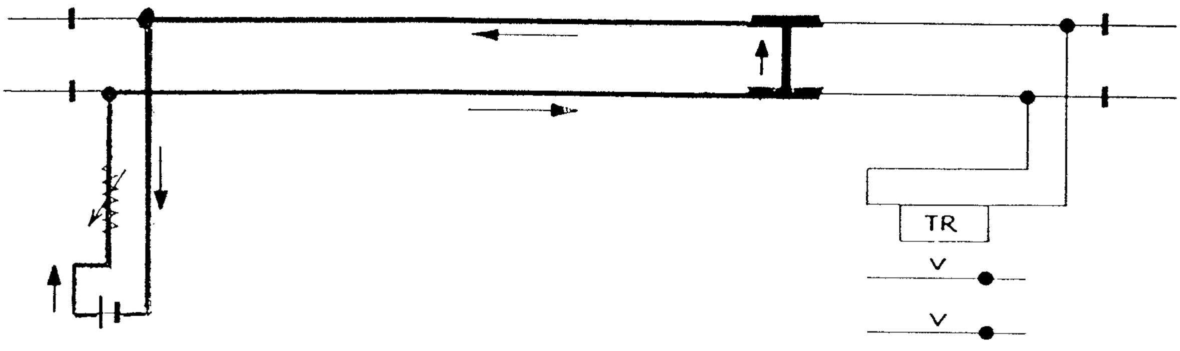
DIRECTOR OF S & T ENGINEERING.
WEST MIDLANDS PROJECTS GROUP.

INTRODUCTION TO TRACK CIRCUITS



RELAY ENERGISED INDICATING
TRACK CLEAR OF VEHICLES



RELAY DE-ENERGISED (CONTACTS BROKEN)
INDICATING PRESENCE OF VEHICLE

INTRODUCTION

A Track Circuit is an electrical circuit of which the running rails of a railway track form a part.

It proves the clearance of a stretch of line between "defined" limits (ie. not occupied by a train or any fault condition prevalent. That being done, points may be operated and signals then cleared for trains to move with the assurance that it is safe for the movement to be made.

It is also employed for indicating the presence of trains (or any fault condition prevalent such as:-

a "**broken rail**", "**track jumper disconnection**",
"**insulated joint failure**" or even "**vandalism**" etc.)

on signalling control panels or illuminated diagrams.

HISTORY

Originally, train control was achieved by visual inspection of the line by train drivers and signalmen. Basically it was safe to go as far as the line was clear.

When train movements became faster, and ran at night, it was no longer possible to operate on visual limits.

The line was divided up into "Block Sections", and only one train movement was permitted in them at any particular time. Control of movement into the sections was carried out by manual supervision, or by time interval. Both these methods were not "**FAILSAFE**", and there were resultant disasters. It became evident that some equipment was necessary to remove the manual element in these matters.

Originally, mechanical bars were used to detect trains in sensitive areas, but these were not applicable for long sections of line. This is where the electrical circuit known as the "**TRACK CIRCUIT**" became expedient.

continued

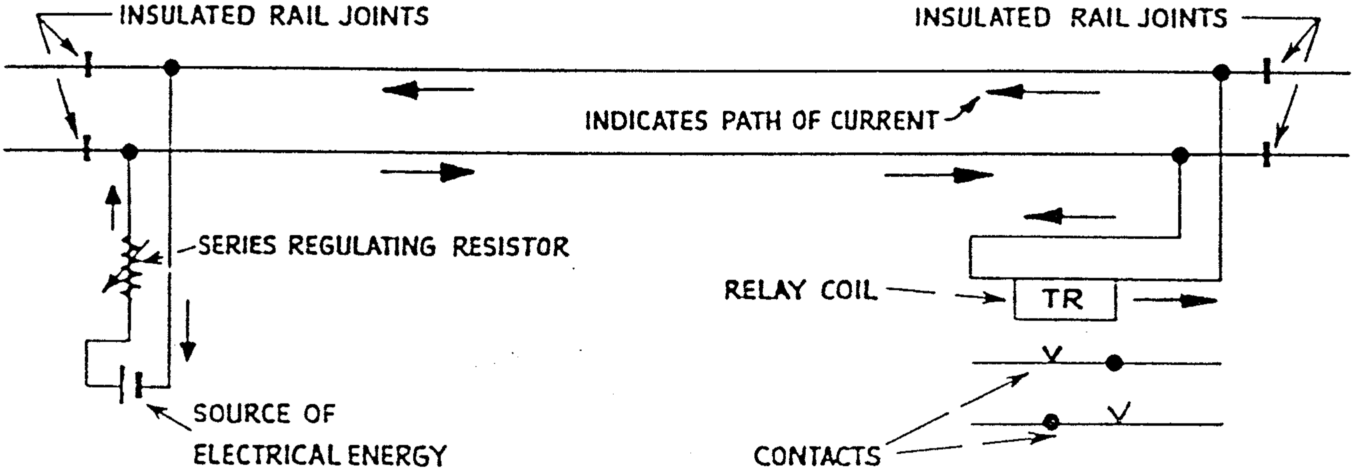
A SIMPLE TRACK CIRCUIT D.C DOUBLE RAIL

The track circuit consists essentially of an insulated section of running rails into one end of which is fed a source of electrical energy, a relay completing the circuit at the other end.

The diagram below shows a simple track circuit of the type which might be found on non-electrified lines where no power supply is available. The running rails of a section of line are electrically isolated by the provision of four insulated rail joints.

One end of the section so isolated is then connected through a variable feed resistance to a primary battery, and the other end to a track relay.

Figure 1 shows the condition when the track circuit is clear.

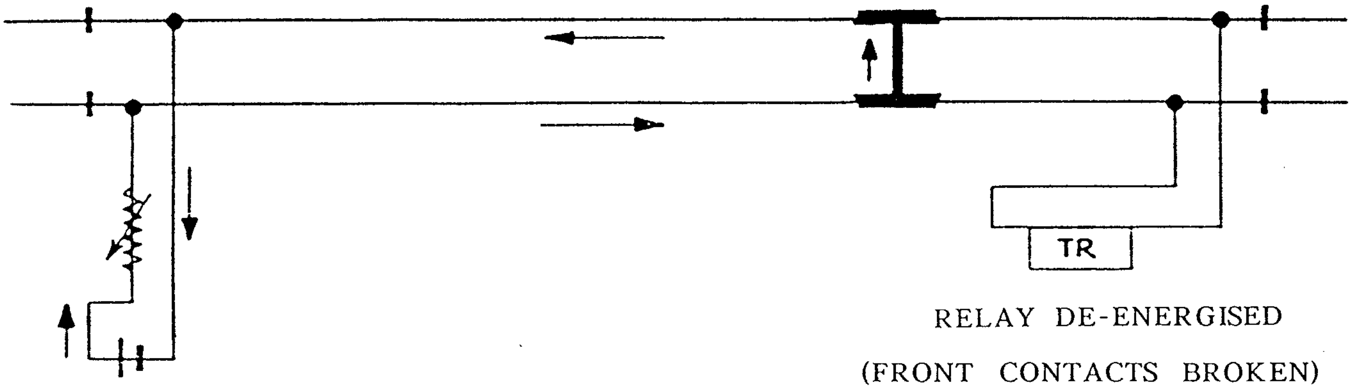


RELAY ENERGISED

Current flows from the battery through the variable feed resistance which regulates the flow of current via the positive track rail to the track relay. It passes through the relay winding, causing the relay to be energised and to close its front contacts, from where it returns through the negative track rail to the battery.

continued

Figure 2 shows the same track circuit occupied by a train.



Current flows from the battery through the variable feed resistance to the positive track rail.

The two rails are now bridged by the wheels and axles of the train whose electrical resistance is negligible compared with that of the winding of the track relay.

The current chooses the line of least resistance and returns through the wheels and axles to the negative track rail and the battery.

The relay is thus by-passed (the proper term is "**shunted**") and practically no current passes through its winding.

Now the coil is receiving insufficient electrical energy it allows the armature to release, so causing the contacts to open.
It will be seen that a disconnection in the path through the rails for any reason (for example, a broken rail), will cause the relay to become de-energised, thus simulating the presence of a train.

This is the more restrictive condition and the track circuit can therefore be said to be "**FAIL-SAFE**".

The track circuit is limited in its workable length by two factors. The first is the leakage of current from one rail to the other, through the rail fixings and the sleepers and ballast (in parallel). The second is the resistance of the rails themselves and the rail bonds. The latter are not required for "continuous welded rail" (CWR) and the resistance is then that of the rails alone.

The rail to rail resistance or "**ballast resistance**", may vary from 50 ohms per 305 metres (1000ft) for well ballasted dry track with insulated rail fixings to as low as 0.5 ohms per 305 metres in wet conditions or when the ballast is dirty.

continued

INTRODUCTION TO TRACK CIRCUITS

It will be appreciated that the ballast resistance is constantly varying with weather conditions, and therefore the adjustment of the series regulating resistor must take into account the highest and the lowest value of the ballast resistance for the track circuit. The series regulating resistor prevents the short circuit being applied directly to the power supply.

The rail resistance figures are so low that for all practical purposes they may be ignored in D.C. track circuit calculations. In this module we do not intend to go into any greater depth on the theory of the track circuit, eg. calculations etc.

You should now be able to appreciate the operation, in simple terms of a track circuit and be able to note certain outstanding features:-

1. The track circuit is a normally closed one and a failure whether it is a short circuit or an open circuit will cause the relay to be de-energised and open its front contacts.

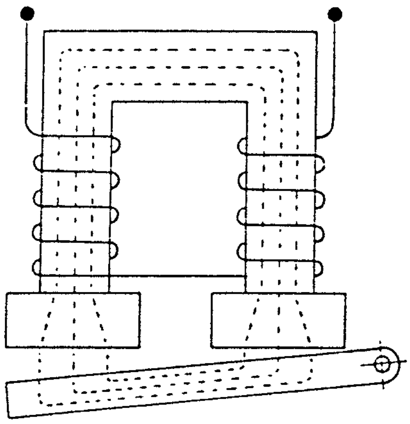
2. The operation of the relay when the track circuit is occupied depends upon the "shunting" of current from the track relay to the wheels and axles of the train.

continued

OTHER TYPES OF TRACK CIRCUIT

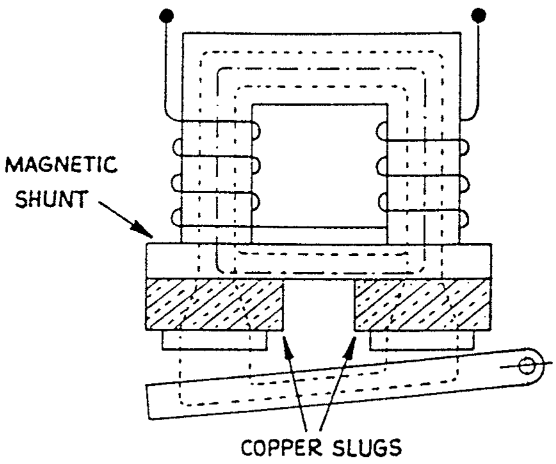
It will be apparent that the simple DC track circuit cannot be used with safety in the presence or vicinity or DC traction, since return currents of many thousands of amperes flow in the running rails and would completely swamp the track circuit current. Simple DC track circuits cannot be used in AC (50Hz) traction territory either, because the DC tractive armature relay can be operated by alternating current unless special precautions are taken.

Let us take the second case first where we have AC (50Hz) traction. A DC track relay can be made immune to alternating current by insertion of two copper slugs fitted over the cores near the pole pieces and a magnetic shunt is fitted between the cores above the copper slugs. The diagram below shows the principles involved.



NORMAL D C MECHANISM

D C FLUX — — — — — —



A C IMMUNISED D.C. MECHANISM

D C FLUX — — — — — — — —
A C FLUX —·—·—·—·—

To overcome the problem in DC traction areas AC track circuits are used. There are two principal methods of immunising AC track circuits from the effects of stray currents from electric traction systems:-

(a) By the use of a double element relay.

(b) By the use of suitable filters.

continued

JOINTLESS TRACK CIRCUITS

On a modern railway the Civil Engineer uses continuous welded rail in order to keep to a minimum the number of rail joints, since these joints are a source of wear and tear, both on the permanent way and on rolling stock.

The need to know the location of a train through the use of track circuits still remains and thus it has been necessary for the signal engineer to develop track circuits which have reasonably well defined ends and yet avoid putting insulated joints in the rails, a technique which has, until recently, been the conventional method of defining the end of a track circuit. Hence the need for jointless track circuits.

As we have now established these track circuits are called jointless as there is no insulator 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 and 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).

To prevent failure of the electronic “block joint” causing an adjacent track to pick, different frequencies would have to be used.

Two types of jointless track circuits are used for new work on BR. They are the:-

Aster Type U/SF 15 and the ML Style 21.

continued

TRACK CIRCUIT TYPES FOR NEW WORKS ON BR

Attached is a list which was part of letter issued to all the Project Offices on the 8th August 1989 from the Systems Development Engineer (Trackside), MacMillan House, Paddington which states which track circuits, as a designer, you should use in certain application areas.

TRACK CIRCUIT TYPE	APPLICATION AREA			TRACTION IMMUNITY			
	MAIN LINES	SECONDARY LINES *1	P&C	AC	DC	aC/DC	3-PHASE
DC, non-immune	Yes	Yes *2	Yes	No	No	No	No
DC, AC-immune	Yes	Yes	Yes	Yes	No	No	Yes
WR Quick Release	Yes	No	Yes	No	No	No	No
Diode	Yes	Yes	Yes	No	No	No	No
50Hz Vane relay	Yes	No	Yes	No	Yes	No	Yes *3
Reed jointed	Yes	Yes *6	Yes	Yes	Yes	Yes	See *4
Aster Type U/SF 15	Yes	No	Yes *5	No	No	No	No
TI 21	Yes	No	Yes *5	Yes	Yes	Yes	Yes
Jeumont-Schneider Impulse	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTES.

1. Definition of secondary line to be confirmed, provisionally less than 20 trains per day.
2. Subject to providing a minimum rail voltage of 4V.
3. For SR only. For other areas consult Paddington HQ.
4. “No” for DC traction areas. Situation for AC traction areas still to be resolved.
5. Simple layouts only.
6. Only without impedance bonds.

end

BRIEF HISTORY OF THE TRACK CIRCUIT.

The track circuit is not a recent invention. In the 1870s, an American, William Robinson realised that it would be possible to electrically detect the presence trains. He suggested the possibility of using the wheels & axles of the train being in contact at all times with the rails to form a short circuit. He patented the principle of the Track Circuit in the early 1870s and it is still a key component, even in the most modern signalling systems.

Track circuits made a slow start in Britain &, although experiments were carried out in the 1880s & 1890s, track circuits were not in continuous use in this country until 1904, when the London & South Western Railway installed them to control automatic semaphore signals between Andover & Grateley. On the GWR the first regular use of Track Circuits was in 1907 between Pangbourne & Goring, as per the London & South Western, controlling automatic semaphore signals.

It needed a serious accident, & the resultant enquiry, to convince the various companies the value of Track Circuits. On Christmas Eve 1910 a serious accident occurred at Hawes Jcn on the Settle/Carlisle line. Ther was a collision between 3 coupled light engines & an express train, whic resulted in the deaths of nine passengers. From the enquiry into the accident it was recommended by the Inspecting Officer for the Board of Trade, a Colonel Pringle, that more use must be made of Track Circuits thus avoiding the type of accident that happened at Hawes Jcn.

After 1910 the use of Track Circuits increased rapidly where up to the present day most running lines throughout the country are fully equipped with Track Circuits.

Extracts from Reading BSI course & Danger Ahead by R. Blythe.