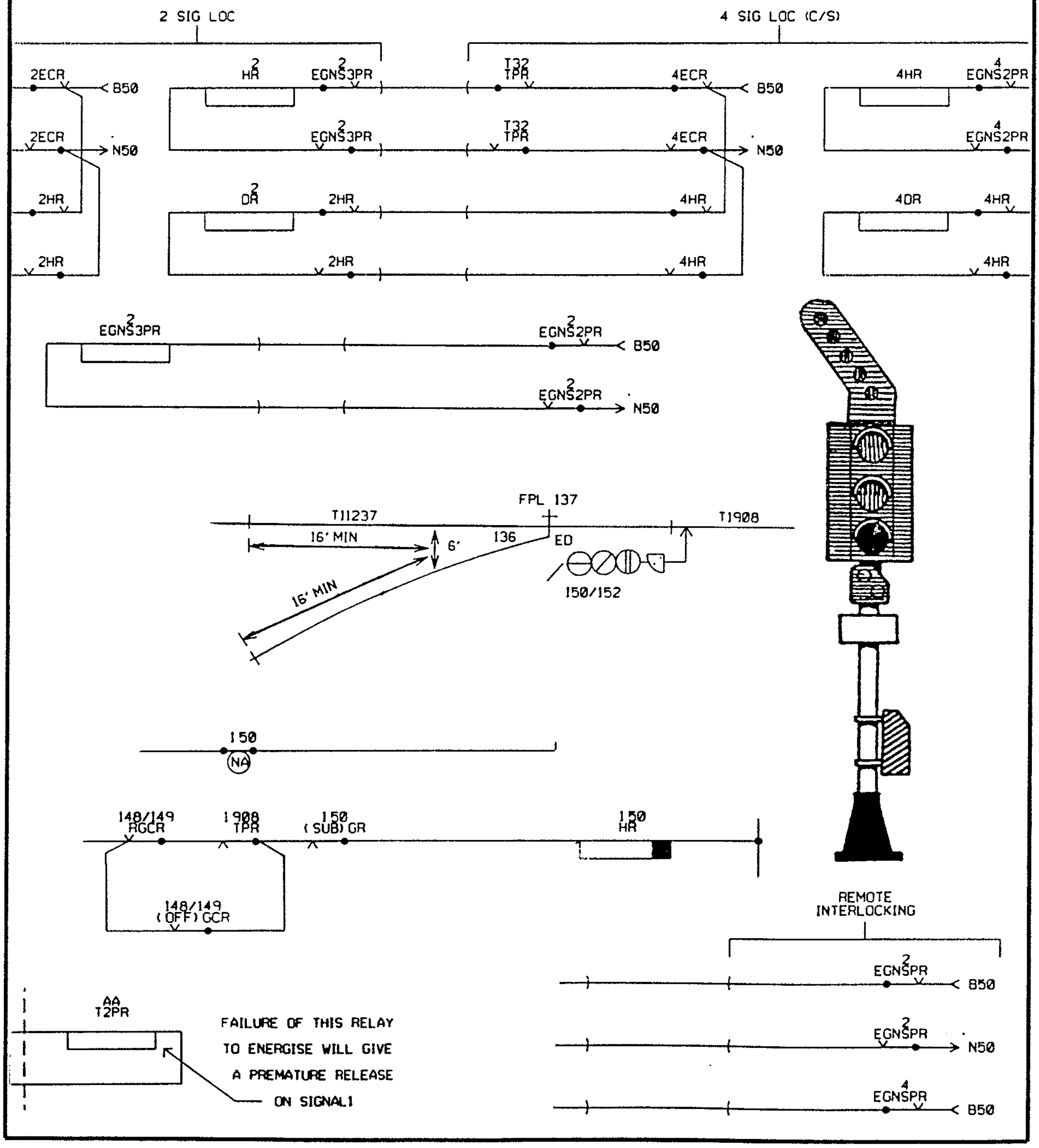
CENTRAL SERVICES
SIGNALLING PROJECTS GROUP

INTRODUCTION TO CIRCUIT DESIGN



INTRODUCTION TO CIRCUIT DESIGN

The aim of this module is to introduce the trainee to some electrical circuitry and terms associated with Railway Signalling. After completing this module you will be able to identify certain circuits and their uses and be able to determine the purpose of relay contacts and equipment in the circuitry.

The circuits examined are generally self contained so as to enable you to see the purpose of them without having to refer to any other documentation.

FIGURE 1 (LIGHT REPEATING)

Look at FIG 1A. It shows a simple "light repeating" circuit of a distant signal using a pyrometer to detect that the signal light is lit. You will see many examples of this circuit but have you considered why the battery is placed where it is?

If the battery was placed as shown in FIG 1B (incorrect design) an earth fault would give an indication showing "light in" irrespective of the pyrometer condition at the signal.

With an earth fault in the FIG 1A circuit the ECR relay would de-energise and this would be known as FAIL SAFE, a condition we should always ensure to achieve in Signal Engineering (Electrically or Mechanically).

At signal 1 if power was available then it would be economic to electrically light all signals at a Signal Box and the circuit illustrated in FIG 1C could be used.

As you can see with any circuit there are many variations and the provisions of the Outline Project Specification (OPS) must be adhered to.

For any further information on the subject of electric lighting of semaphore signals you can refer to sketches CW44/81 issued by Crewe Divisional S & T Engineer on 11 June 1982.

FIGURE 2 (ARM REPEATING)

If we now look at arm repeating circuits you can see that these circuits rely on a "pole change" circuit i.e. the direction of current flowing in the circuit determines the information received at the signal indicator (GK). With semaphore signals the indicators will normally be the mechanical type showing a signal arm, disc, weight bar etc which moves to correspond with the signal out on site.

The examples shown (FIGS 2A, B, C & D) will give an idea of the variation of circuits you can encounter.

Figure 2A:- shows a simple stop arm repeating circuit, where power is not available on site.

Figure 2B:- shows the same signal but utilising the power available at site.

continued

Figure 2C:- shows the slotting repeating when the distant arm for the forward Box 'B' is placed under the Starting Signal of the Signal Box in rear (Box 'A'). The two indications received by the signalman at Signal Box 'B' and displayed on the indicator are:-

No 1 SLOT ON = distant arm on and weight bar worked from Signal Box ON
No 1 SLOT OFF = weight bar worked from Signal Box OFF.

by examining the circuit you can see how these two conditions are indicated.

NB. The distant arm will not show OFF to the driver until the starting signal No 30 arm is OFF. When the signalman controlling the starting signal replaces his signal the distant signal will also replace with the starting signal if it was showing OFF. The signalman controlling the distant weight bar will receive a "SLOT OFF" indication irrespective of the state of the distant arm when he reverses lever No 1.

Figure 2D:- shows a typical ground signal arm repeating circuit, you will note here there is a centre tapped battery connection used to allow the "pole change" to operate because there is only one arm available for use in this small contact box.

The suffix letters A, B or C used with the Indicators denote the resistance value of the particular Indicator which has to be taken into account when a relay is added in series to the circuit.

The Indicator resistor code is as follows:-

A = 50 Ohm	working current = 8.0 mA
B = 250 Ohm	working current = 3.5 mA
C = 1000 Ohm	working current = 2.0 mA

FIGURE 3:- (THE TRACK STICK RELAY AND SIGNAL SELECTION)

In this figure the control circuits are shown for signals 2, 10 and 22 emphasising Track Stick relay circuits and Signal Selection circuits.

To examine the Track Stick circuit first of all consider the route from 22 signal to 21 signal. The control relay (the relay that will energise to allow 22 signal to clear) is 22 UCR (Route Checking Relay) and if all conditions are proved when the signalman reverses lever 22 the UCR will energise and allow 22 signal to show a GREEN aspect.

As you can see when the train proceeds past the signal and occupies T11 the signal is replaced to its most restrictive aspect, RED in this case (first wheel replacement).

If the signalman forgets to replace 22 lever to the Normal position Signal 22 will not clear again when the conditions allow until lever 22 is replaced Normal. The circuit that enforces the signalman to replace the Signal control lever to Normal after the passage of a train every time is the Track Stick (TS). When the train occupies T11 Track Circuit T11 TS

continued

de-energises breaking the feed to 22 UCR and in order to energise 22 UCR again T11 TS must be energised and this can only be achieved by replacing lever 22 to the Normal position.

The Signalman's General Instructions 7.6.1 states:- **"the signalman must replace a stop signal to danger (signal lever replaced to Normal) as soon as the last vehicle has passed the signal or, where points which are facing to the movement, as soon as the last vehicle has passed clear of these points."**

The TS circuit will ensure this replacement requirement. As you can see T11 TS is in the circuit for 10 GR and 22 UCR ensuring the signalman replaces the respective signal lever and T2 TS is achieving the same objective in 2 UCS.

Figure 3 also gives you an example of a signal selection circuit where the route selected by a lever energises the correct control relay by selecting a current path via the point and track circuit conditions being proved in the correct state for each route. Comparing the signalling plan to circuit diagram you can see the reasoning behind the majority of the relay contacts in each circuit.

FIGURE 4:- (SELECTION IN LEVER LOCK CIRCUITRY)

This diagram shows a typical selection circuit but this time controlling Signal Normal Lever Locks, before a signal lever can be moved from the Normal position in the lever frame the conditions must be proved correct to allow the signalman to operate the signal lever for the route he wishes to clear.

NB. Use the same signalling plan shown in Figure 3 to understand the controls in each lock circuit.

FIGURE 5:- (THE ROUTE STICK CIRCUIT)

As you become more familiar with wiring circuits you will find there is a need to apply some "directional" route locking to points in a signalled route (there are cases where this locking is also applied to points out of route for trapping purposes but we will only consider the simple case in this module).

Looking at the layout in figure 5 you will see that 45 points will require to be locked in the reverse position when a train enters the route from signals 46 and 24 or 25.

When the signalman clears 24 or 25 signal, 45 points will be locked reverse by the train occupying T12 TC and through the route by occupying T1 and T15 until the train has cleared T15 when the signalman will be allowed to move 45 points from the reverse position (assuming he has replaced the signal lever 24 or 25 to free the mechanical interlocking).

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The easy way to ensure the previous locking would be to place T12 or 31N, T1 and T15 Track Circuits clear in 45 reverse lock ensuring the signalman could not move 45 lever from the reverse position to normal until the specified track circuits were clear. These controls are correct but restrictive because if a route from 46 over the same route into the Up Goods Loop or Up Siding was cleared 45 reverse lock would then contain TC12 which is not required and would keep 45 points locked reverse once the train had entered the route. The signalman would then have to wait until the train was completely clear of TC12 before normalising lever 45.

In effect we are saying there are two conditions that require satisfying with 45 points reverse and T12 TC.

(a) T12 requires to lock 45 points reverse when a train enters the route from signals 24/25.

(b) T12 does not require to lock 45 points reverse when a train enters the route from signal 46 into the Up Siding or Up Goods Loop.

The method used to effect this "route locking" control is called the "Route Stick Circuit" and to understand the principle of the operation of this circuit is important. This type of circuit is used extensively in relay interlocking systems (see later module: FREE WIRED INTERLOCKING, A SIMPLE ROUTE).

In the case we are examining 45 USR is de-energised for a route in one direction only (from 24 or 25 signals) and the "dropping" of this relay will lock 45 points reverse until the signal lever is replaced, T12 is clear and the dead locking track circuits T1 and T15 are also clear.

When there is more than one track circuit control in the "USR" circuit, a "slow to pick" relay is used to remove the problem of premature clearance of the "USR" due to a light engine passing quickly over an intermediate insulated joint and energising the "USR" and thus releasing the route locking on the points prematurely.

Route Stick relays (USR) when de-energised perform a locking function and the "Standard Free Wired Interlocking Typical Circuits" document states:- down proving of relays to prove the correct sequential operation of the system (i.e. ALSR proved down in the HR and last USR proved down in GR) shall be provided.

If 24/25 signals were position light ground signals the "down proving" of the USR would be as shown. Signal 24 or 25 can only show a proceed aspect if 45 USR has been proved de-energised (i.e. the locking of 45 points by the USR is effective).

In our case the signals are semaphore dwarf or disc signals and there is no GR relay to "down prove" 45 USR in, the signal levers have Normal lever locks to prevent the levers from being moved from the Normal position until all conditions are in their correct state. In this case the "down proving" is effected by the introduction of a catch handle repeating relay

continued

('CH'PR) which will de-energise 45 USR and this relay de-energising will initiate the feed to 24 or 25 (N)L, thus proving the USR down before the signal lever can be reversed. Note a rectifier is placed across the lever lock coils to quench the back emf created when the 'CH'PR breaks its front contact to economise the feed to the (N) Lock (prevents the welding of the 'CH'PR front contacts in the lever lock circuit).

FIGURE 6:- (SIGNAL REPLACEMENT)

The replacing of a colour light signal back to its most restrictive aspect automatically, can take various forms due to operating requirements. Considering Signal 150, there are three different types of replacement circuitry to understand.

(a) First Wheel Replacement

The most common of all signal replacement. T11237 effecting the replacement when the "first wheels" of the train occupy the track circuit. As you can see T11237 drops the HR and maintains the HR de-energised if the signalman leaves 150 lever reverse.

(b) Last Wheel Replacement

When the driver is at the rear of his train carrying out a propelling movement it is usual not to allow the driver to pass a signal at red, therefore, an amendment to our circuit is needed. Note the "slow release" on 150 HR holding 150 HR "stick" contact long enough for T11237 TPR to make its back contact.

(c) Last Wheel or Second Track Occupied

In some cases a means of different replacement for selected trains is required. An example of where this type of replacement could be used is when a route normally caters for two types of traffic movement, straight through trains or bay platform trains for example. The replacement of the signal may be "last wheel" for the propelling traffic that will eventually be directed into a bay platform (2 car set, light engines or short trains etc) and second track circuit occupied for the straight through trains (no propelling movements, trains longer than those to be accommodated in the bay platform). NB. With last wheel replacement circuits make sure that the "stick path" does not eliminate the signal "RD" lever band, the signalman must always be allowed to replace his signal at any time.

FIGURE 7:- (TIME OF OPERATION LOCKING)

Standard Signalling Principle 57 states:

"2.1 On running lines where facing points are positioned not more than 22 yards (20 metres) beyond the first track circuit block joint ahead of a main signal then time of operation locking shall be applied.

continued

2.2 Time of operation locking requires that to move the facing points in either direction the signal berth track circuit must be proved clear or occupied for a time sufficient to ensure that an approaching train has come to a stand at the signal. On bi-directional lines this control shall not apply for movements away from the points concerned.

2.3 Time of operation locking is provided to ensure that should a train pass the protecting signal at danger it will not reach the facing points whilst they are moving."

The example shows where this circuit could be applied on a typical mechanical box installation to illustrate the purpose of this principle.

Before the signalman can unlock 7 FPL to enable him to move 6 points T4 must be clear and because of the close proximity of 6/7 points to the commencement of the locking track circuit T4 (less than 20 metres) the track locking is also extended to include T6 which is also required to be clear. If the train has already arrived on T6 the train must occupy T6 for a specified time to prove that it is stationary before the facing point lock lever can be normalised to allow the points to be moved. Of course if the distance is greater than 20 metres this control is not required because a distance in excess of 20 metres is thought sufficient for the signalman to complete the movement of the points, of course in the mechanical situation it depends how quick the signalmans actions are where as in the electrical points operation situation the points "Swing" at a constant rate. Due consideration of whether this control could be eliminated should be taken into account when signalling layouts.

In the "time of operation" circuit the use of a timing device is employed, a thermal type is shown in the illustration and the sequence of operation is as follows:-

1. JS (down), TJR (down) normal state
2. T6 TPR de-energised
3. Thermal coil operates
4. Thermal contacts eventually make
5. JS picks and "sticks" over its own arm
6. JS picking breaks feed to thermal coil
7. Thermal coil cools making its back contact
8. TJR picks
9. TJR operates in 7(R)L circuit.

The JS is "slow to drop" to cater for when the thermal starts to cool (The JS back contact breaks in the TH circuit) and breaks its front contact the JS must stay energised long enough to allow the JS stick contact to establish and hold the JS up.

There are other types of timing relays in use and two other examples are illustrated in figure 7.

continued

FIGURE 8:- (EMERGENCY REPLACEMENT OF AUTOMATIC AND SEMI AUTOMATIC SIGNALS)

Standard Signalling Principle 62 states:-

> **"1.1 Each colour light signal shall be provided with a device which may be used to replace the signal to danger (see also SSP No 11)."**

The standard arrangement for this control applied to automatic signals from a Power Signal Box panel is shown, however the same principle for the Electro Mechanical situation using direct wire will apply.

The method of operation for replacing the automatic signals to danger is as follows:-

1. Normal state of relays EGNSR and repeat relays all energised.
2. Signalman "pulls" the emergency replacement button E on the panel adjacent to the signal.
3. EGNSR de-energises which in turn drops all its repeat relays.
4. Final repeat relay down de-energises HR.
5. HR (down) replaces signal to RED.
6. HR (down) final EGNSPR down, ECR (up) sends an indication back to the panel, proving the RED aspect lit in the signal.

2 EGNS3PR/4 EGNS2PR (down) in the indication circuit ensures signalman only receives the indication when the signal has been replaced to danger by his action.

To restore the automatic signal back to normal automatic working the signalman "pushes" the E button on the panel which re-picks EGNSR which then sticks over its own arm. The signalman then releases the button and the EGNSR remains energised (plus all the repeat relays energise) via the FM button contact and EGNSR stick contact.

The H/O (capacitor/resistor network) holds the EGNSR up if the signalman after picking the EGNSR releases the button and it "springs" back to the middle position, with the possibility of breaking the FM contact momentarily, the H/O will hold the EGNSR for a short time to cater for that occurence.

FIGURE 9:- (COMBINED SIGNAL INDICATION)

When a combined signal has two routes worked from levers which are separated by other levers, the circuit shown applies. This circuit maintains a red indication over the lever that is "normal" but operates the indication correctly over the lever that has cleared the signal. Note a feed is applied to 15 GKE when 21 lever is reversed and vice versa.

continued

Extract from Spec 600 (September 1981 page 34):-

> **"Where a signal is worked by two adjacent levers a common indicator will be provided. If the levers are not adjacent or more than two levers are used, separate indicators will be provided as required and the indicator circuits shall be so designed that only the indicator adjacent to the lever being operated can show 'OFF'."**

A FEW WIRING TIPS

FIGURE 10:- (APPROACH RELEASE OF ASPECTS)

This diagram shows two ways of drawing the line circuits for 'AA' Track Circuit.

The top circuit shows an incorrect method and the lower circuit an acceptable method. When dealing with approach release circuitry ensure that the circuit design is such that the Track Circuit contact which provides the track occupied condition is from a prime relay with the contact controlling the aspect in the rear either off the same relay or a dependent relay (i.e. a repeat off the prime relay) and not vice versa.

FIGURE 11:- (ALLOCATION OF CONTACTS)

Assistance can be given to the testing staff if "double cut" circuits using "plug in" relays are wired as shown. You will appreciate that displaying the contacts as recommended the Tester can "strap" contacts without the risk of blowing a fuse which, in some cases, can originate from a remote location case. With the other method of wiring, once a strap is in A1/A2, the close proximity of the next "strap" makes blowing a fuse a distinct possibility.

It is not always possible or convenient, but a little forethought at the design stage will be appreciated by the Tester/Installer. The Computer Aided Design (CAD) "standard" circuits generated by our own system display contacts to the above rules, but if the system is allowed to allocate contacts by itself, it will select contacts on a strict rotation basis.

FIGURE 12

If a route is set to the UP FAST lever 13 would require FPL 36 lever reverse and lock normal 37 points in the mechanical interlocking. Therefore pulling 13 lever reverse would "back lock" lever 36 (i.e. prevent the signalman from normalising 36 lever until 13 lever has been replaced fully Normal).

On the type of mechanical interlocking frame in our example (LNW TUMBLER) the locking is achieved by lever actuated locking as opposed to the standard "catch handle" type of interlocking.

continued

If the catch block was lifted accidentally on lever 36 whilst 13 signal is OFF a feed would be initiated to the coils of 36 (R)L and energise the lock. This action at first glance cannot do much harm as the lever is "back locked" by 13 lever being reverse, however there are "lock proving" contacts of 36(R)L proved down in the detection circuit of 36/37 points (proving the (R)L is effective).

As you can see from the circuit the (R)L energising will break the feed to 37/36 WKR and 37/36 NWKPR circuit and replace the signal to danger, very disconcerting for an approaching driver.

Remedy:- on the following types of mechanical interlocking frames L & Y tappet, LNW tumbler, Great Western tappet, GW twist, McKenzie & Holland, Dutton, CLC, GC & LNE place the 'NA' lever bands of signals reading through the points in the (R)L of lever 36 so that when the signal lever is reversed a disconnection of the (R)L occurs and an accidental operation of the catch handle will not replace the signal aspect to danger.

NB. It may be more convenient to use a "back contact" of the signal UCR or equivalent (US front contact) in place of the lever bands to achieve the same effect.

FIGURE 13:- (APPARATUS)

Appreciate what you can do with regard to signalling apparatus.

Where sphere type "A" contact boxes are used in (NBDR) locks or (NR) lock circuits, only three wires maximum can be fitted into this contact box, therefore the lever band circuit design has to be rearranged. However the passing contact box type does not have this restriction.

When wiring lock proving contacts on "H" type lever locks, do not wire two wires to a terminal of the proving contacts or the bakelite cover will not fit into position.

With "U" type locks, the problem does not exist as the proving contacts are on open terminals.

The foregoing tips are a few items to be aware of and there are many such rules in Signalling Design and these "helpful hints" have been documented from time to time by experienced designers through drawing office circulars and memos. The literature can usually be found within the more experienced designers' reference notes, you only have to ask.

Recently circuit design information in connection with wiring procedures has appeared within the "Standard Free Wired Interlocking Typical Circuits" (BRS-SW-67) document and also in the handbook "Signalling and Testing Design Guidelines" (BR13445/80) and both of these documents are excellent sources of information to you.

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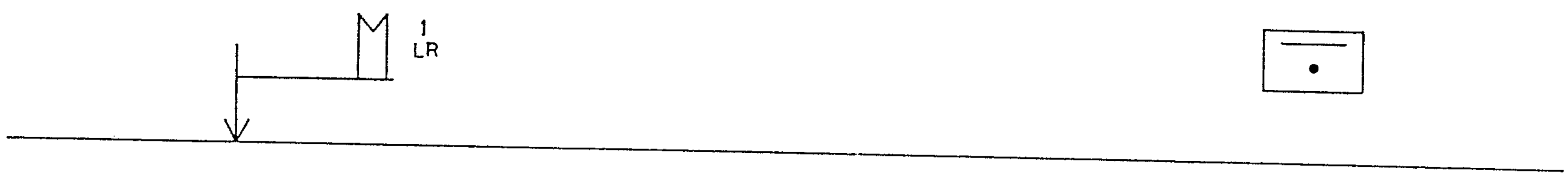

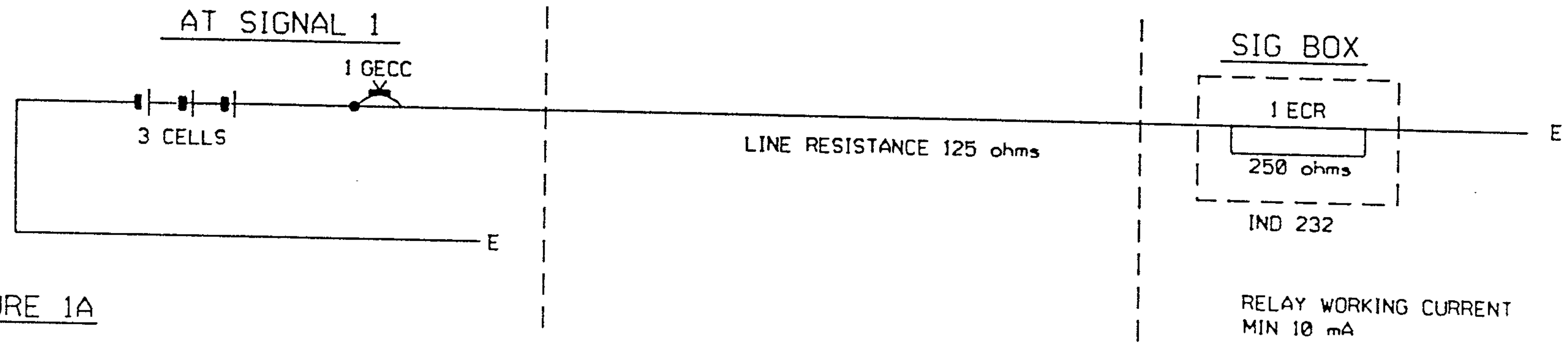

FIGURE 1A

E=CIRCUIT COMPLETED THROUGH EARTH

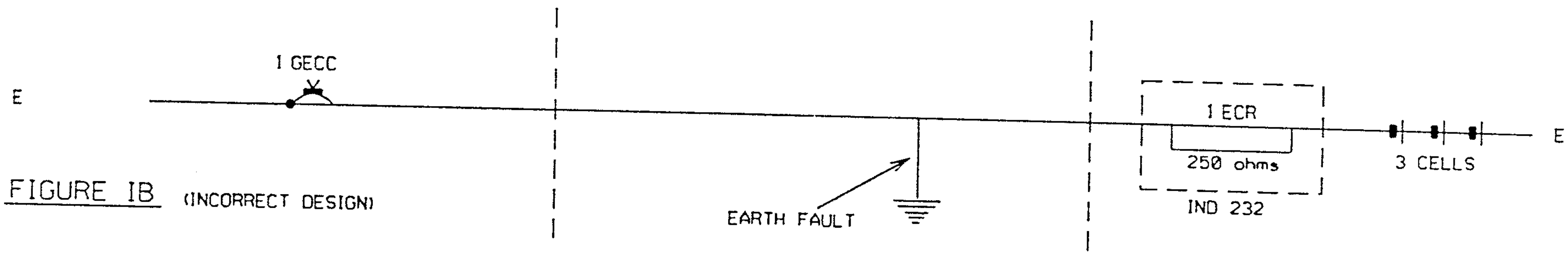

FIGURE 1B (INCORRECT DESIGN)

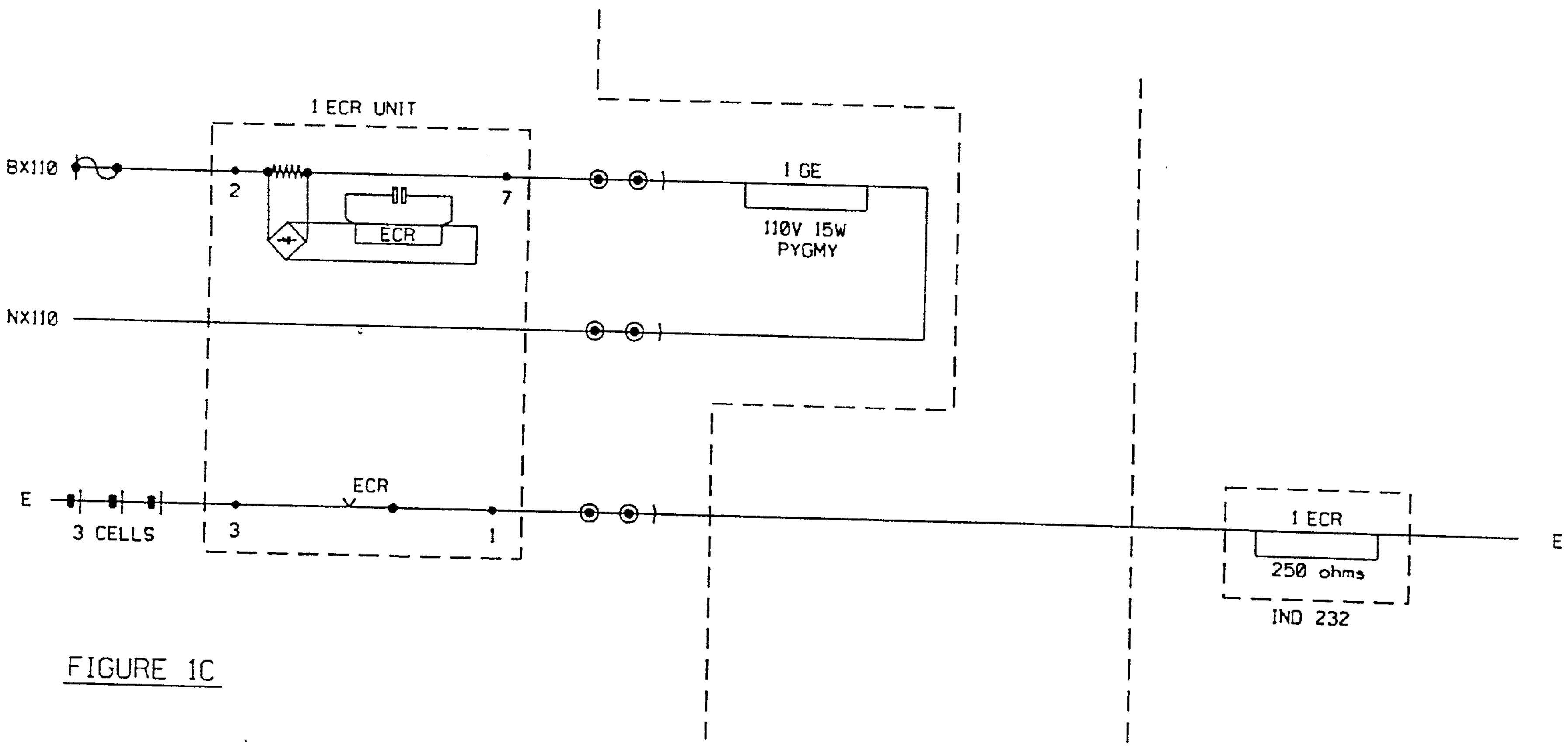

FIGURE 1C

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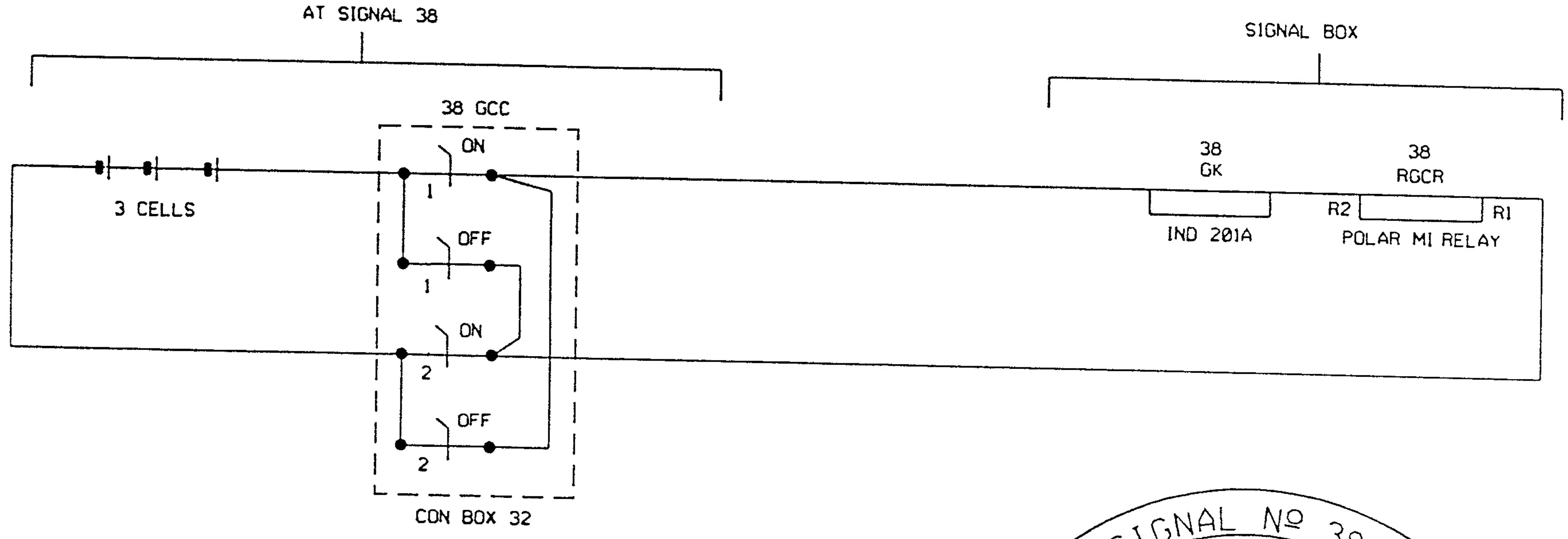
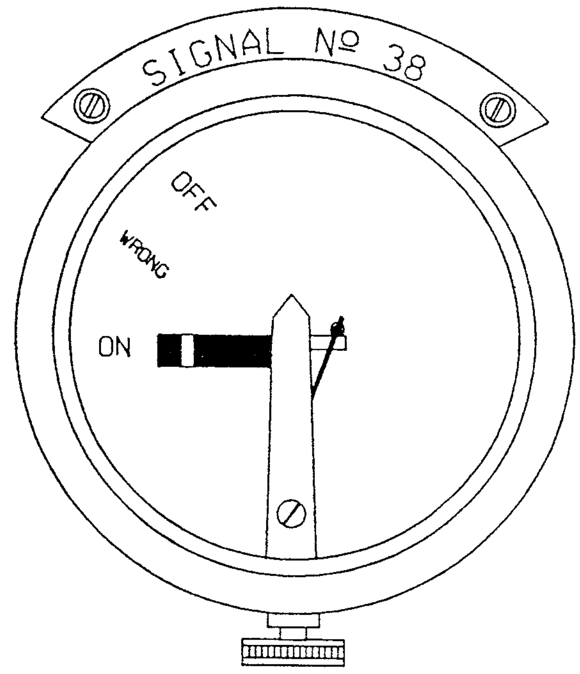


FIGURE 2A (POWER NOT AVAILABLE)



INDICATOR 201

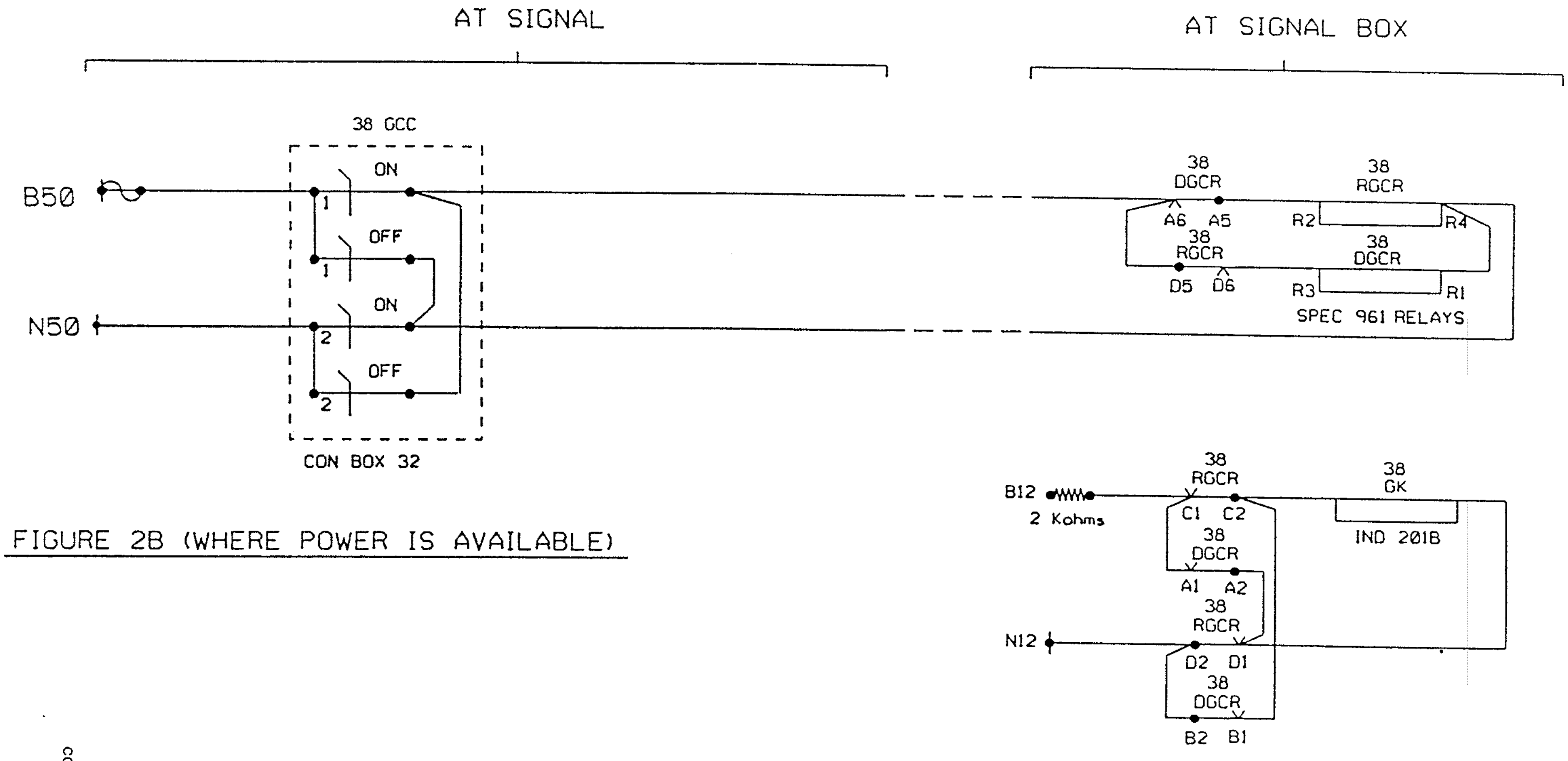


FIGURE 2B (WHERE POWER IS AVAILABLE)

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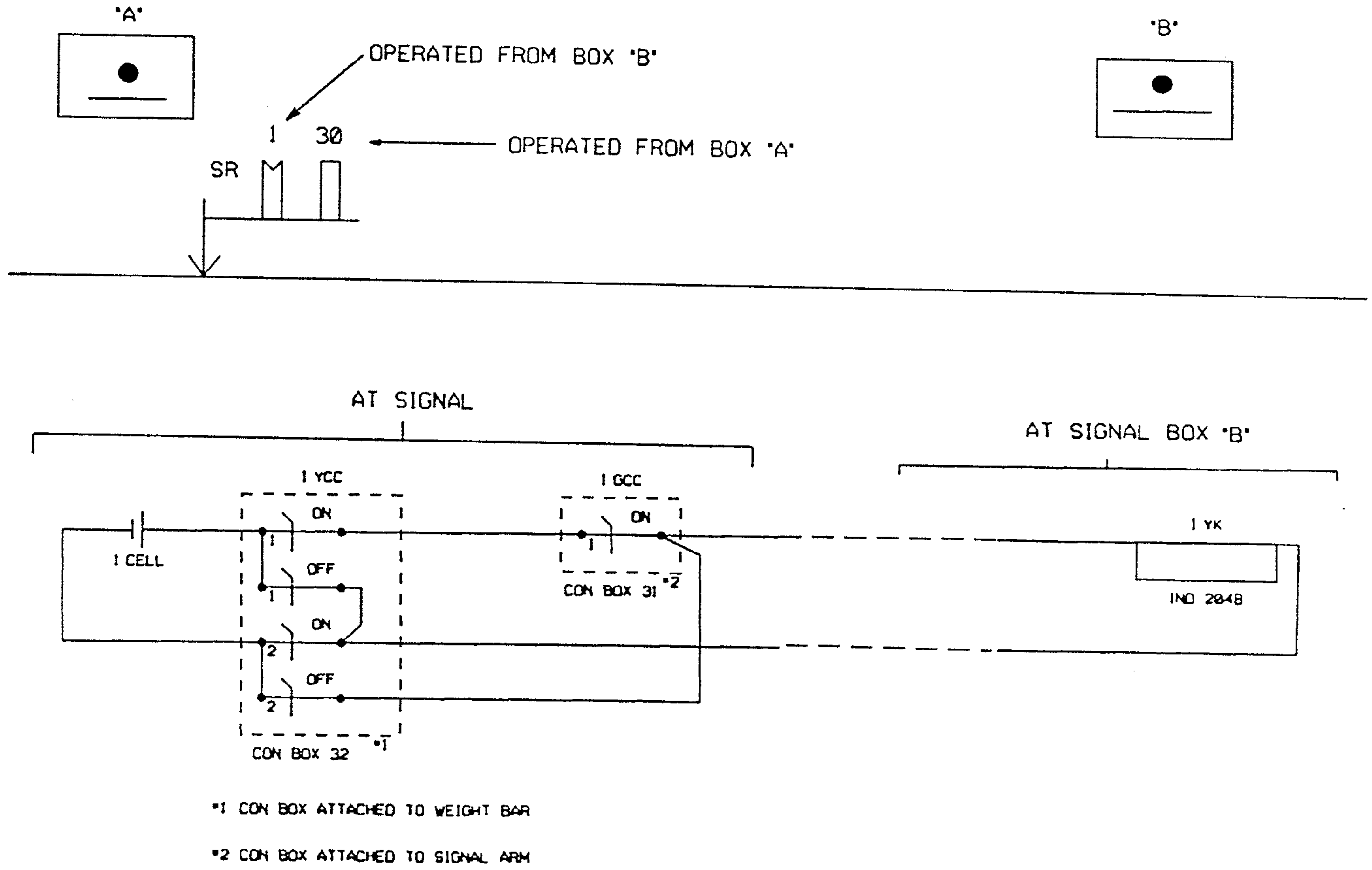
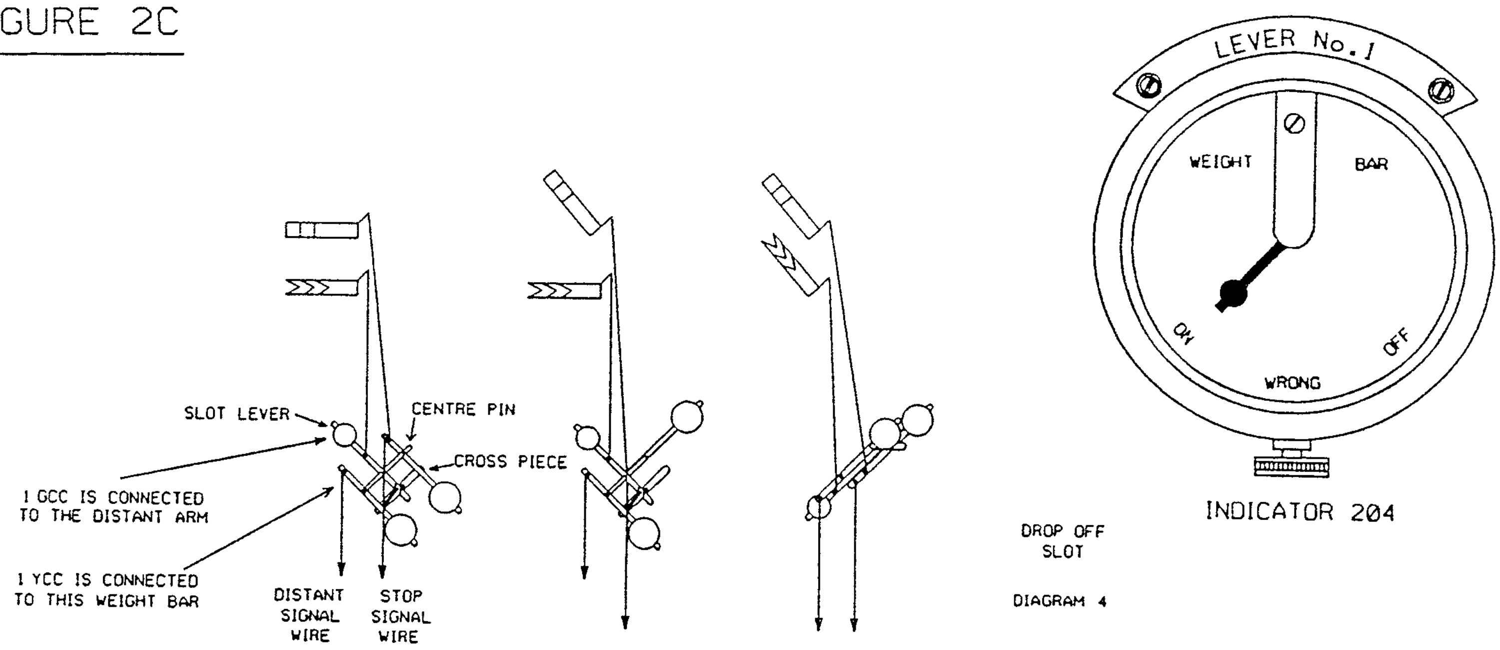


FIGURE 2C



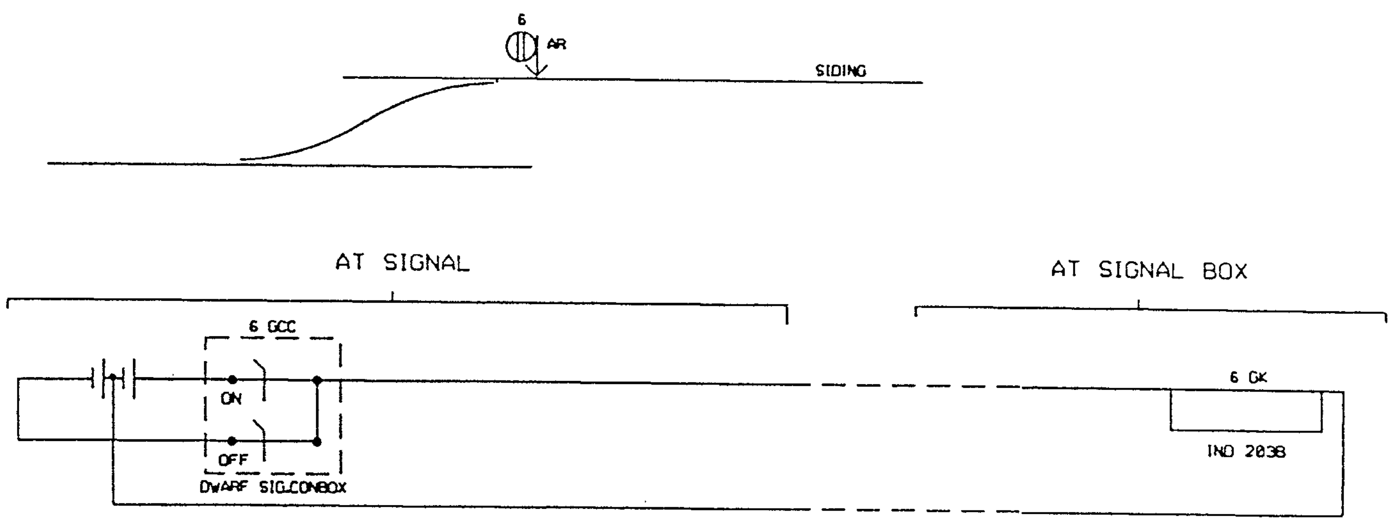
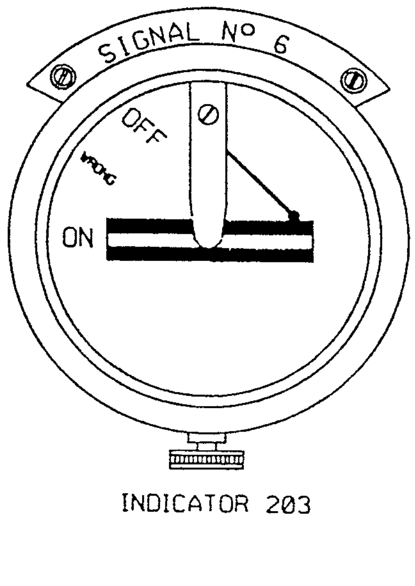


FIGURE 2D(GROUND SIGNAL)



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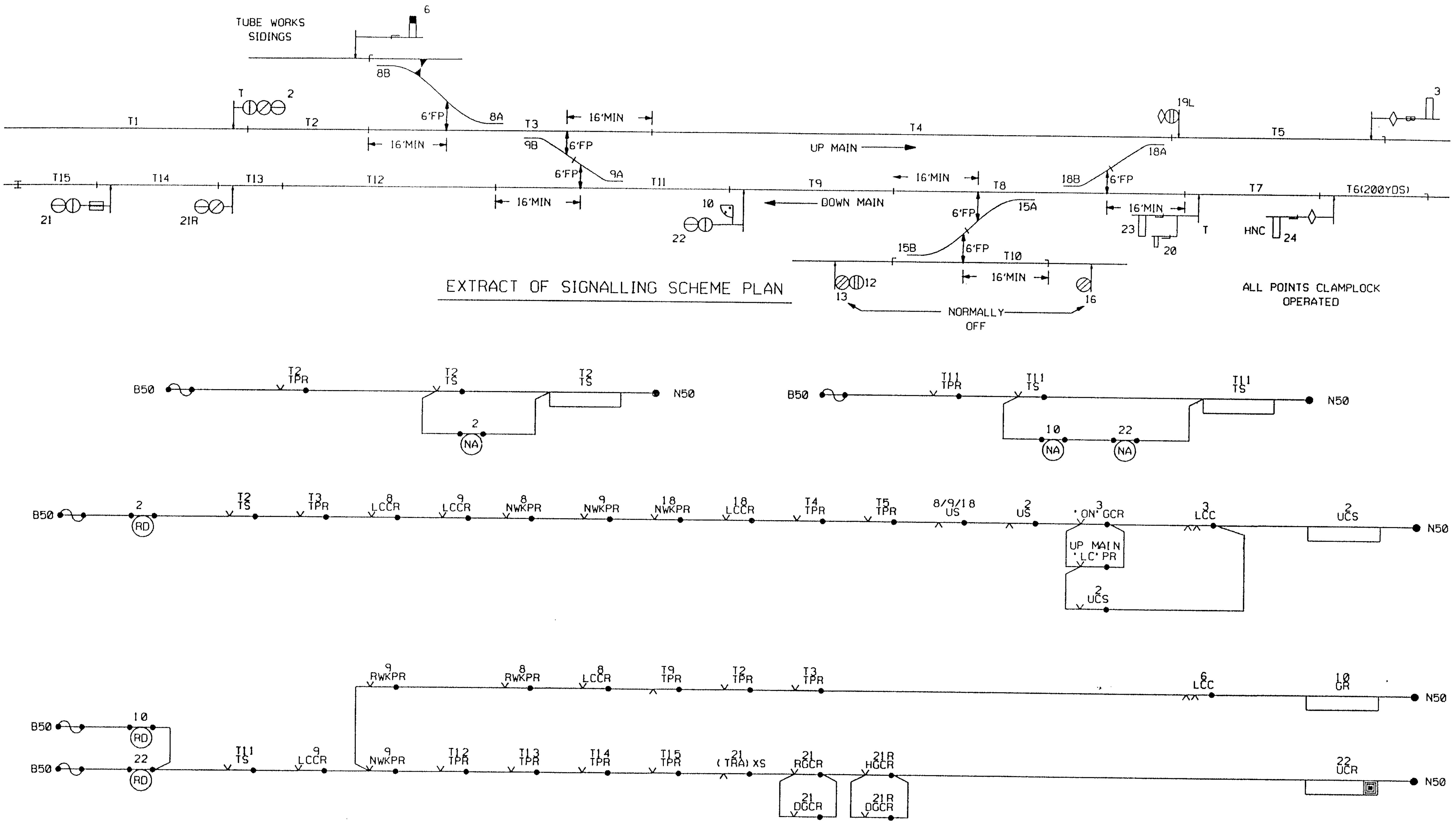

FIGURE 3

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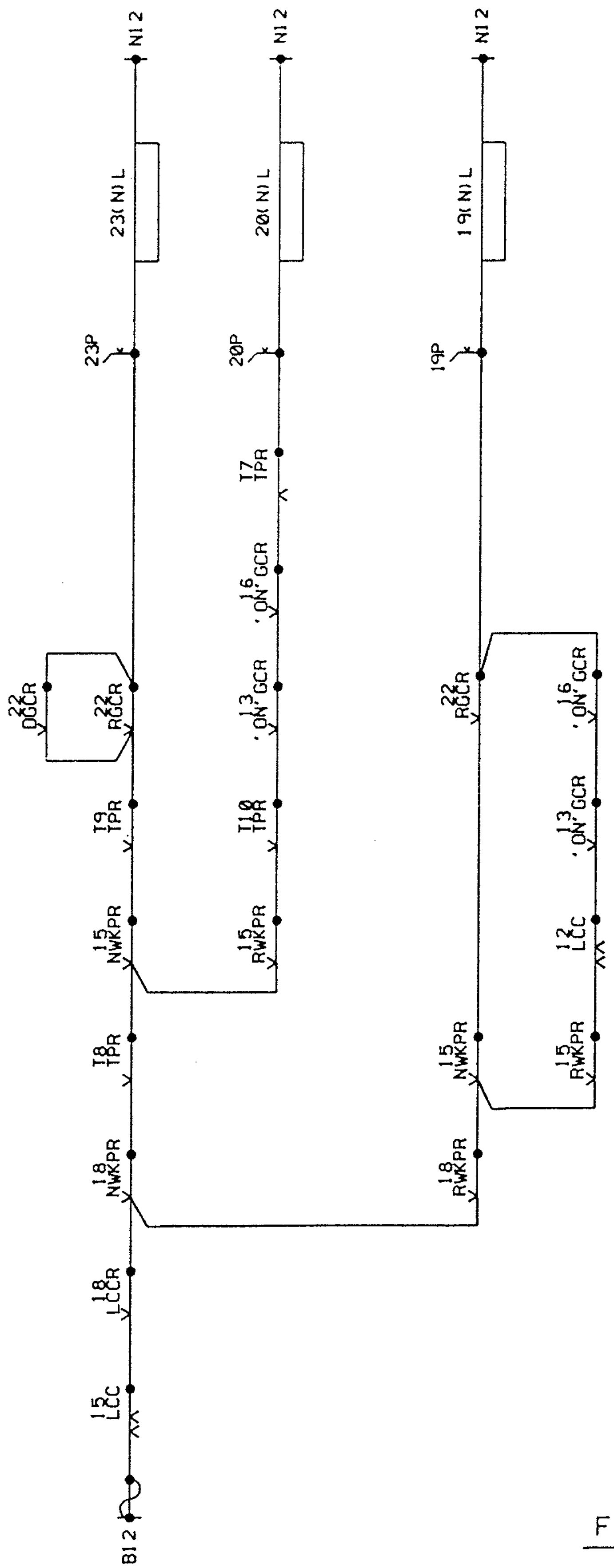

FIGURE 4

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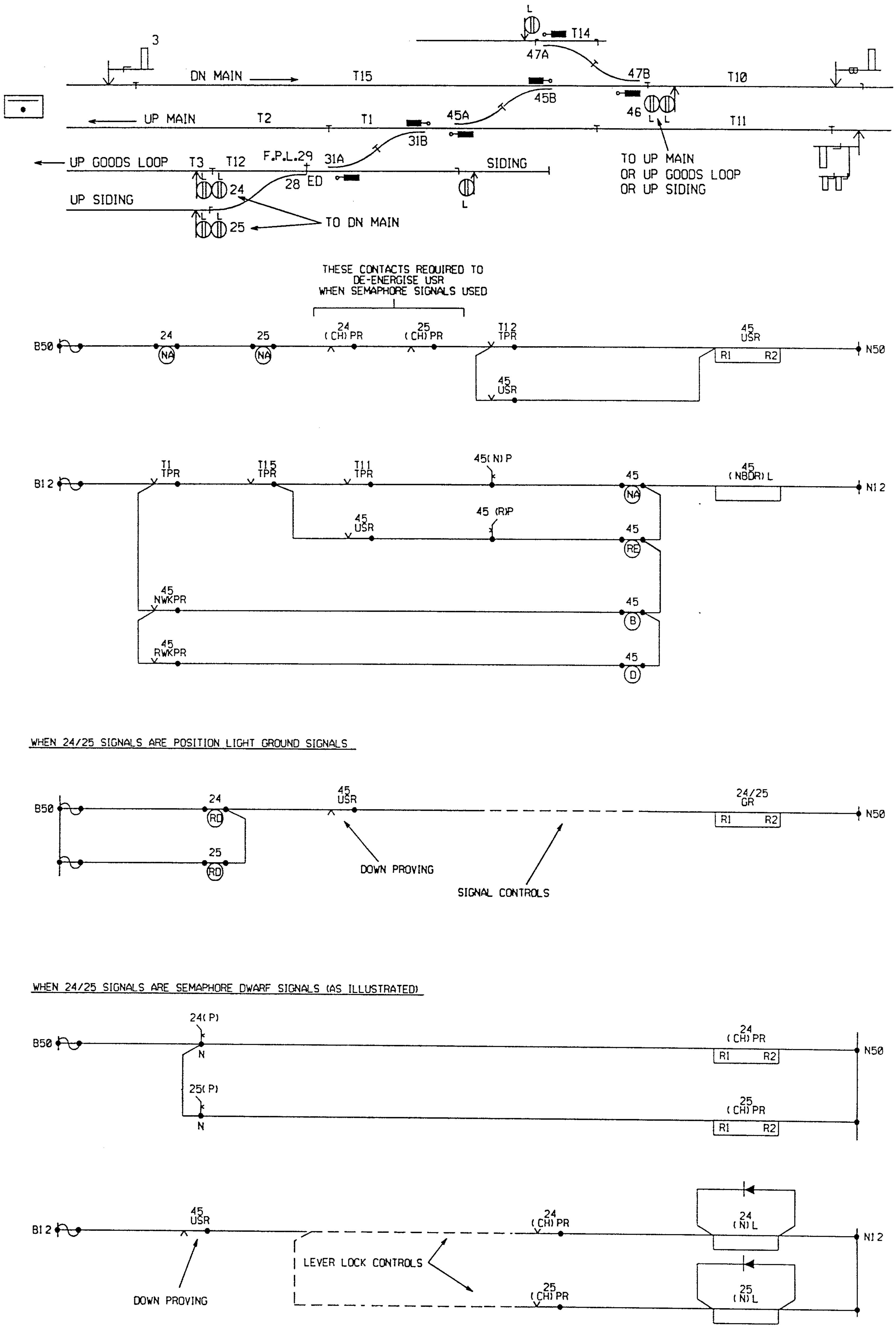

FIGURE 5

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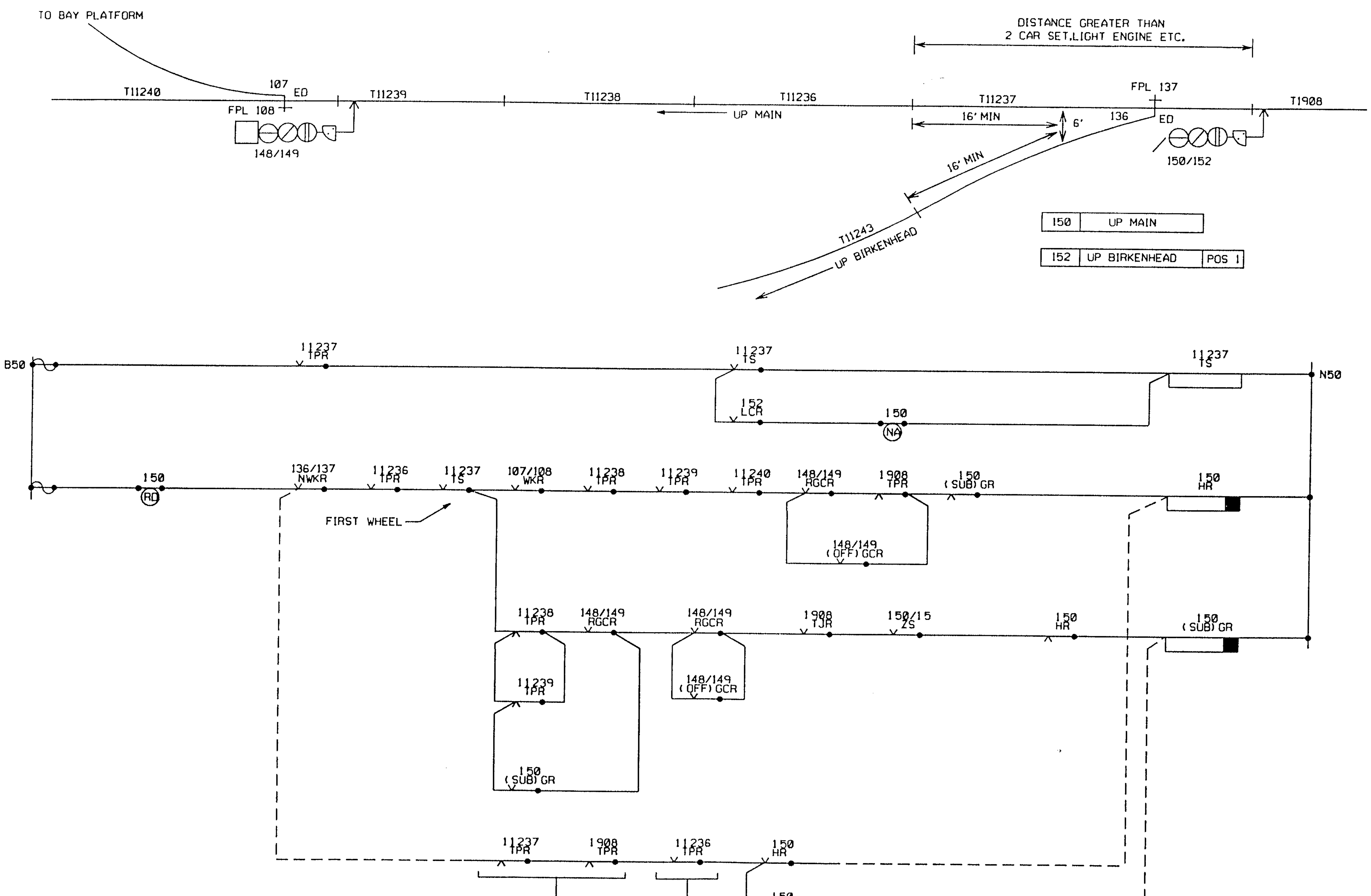

FIGURE 6

CONVENTIONAL LAST WHEEL REPLACEMENT
11237 occ * 1908 CLEAR

WITH THE ADDITION OF THIS TRACK
11237 occ * (1908 CLEAR OR 11236 occ)

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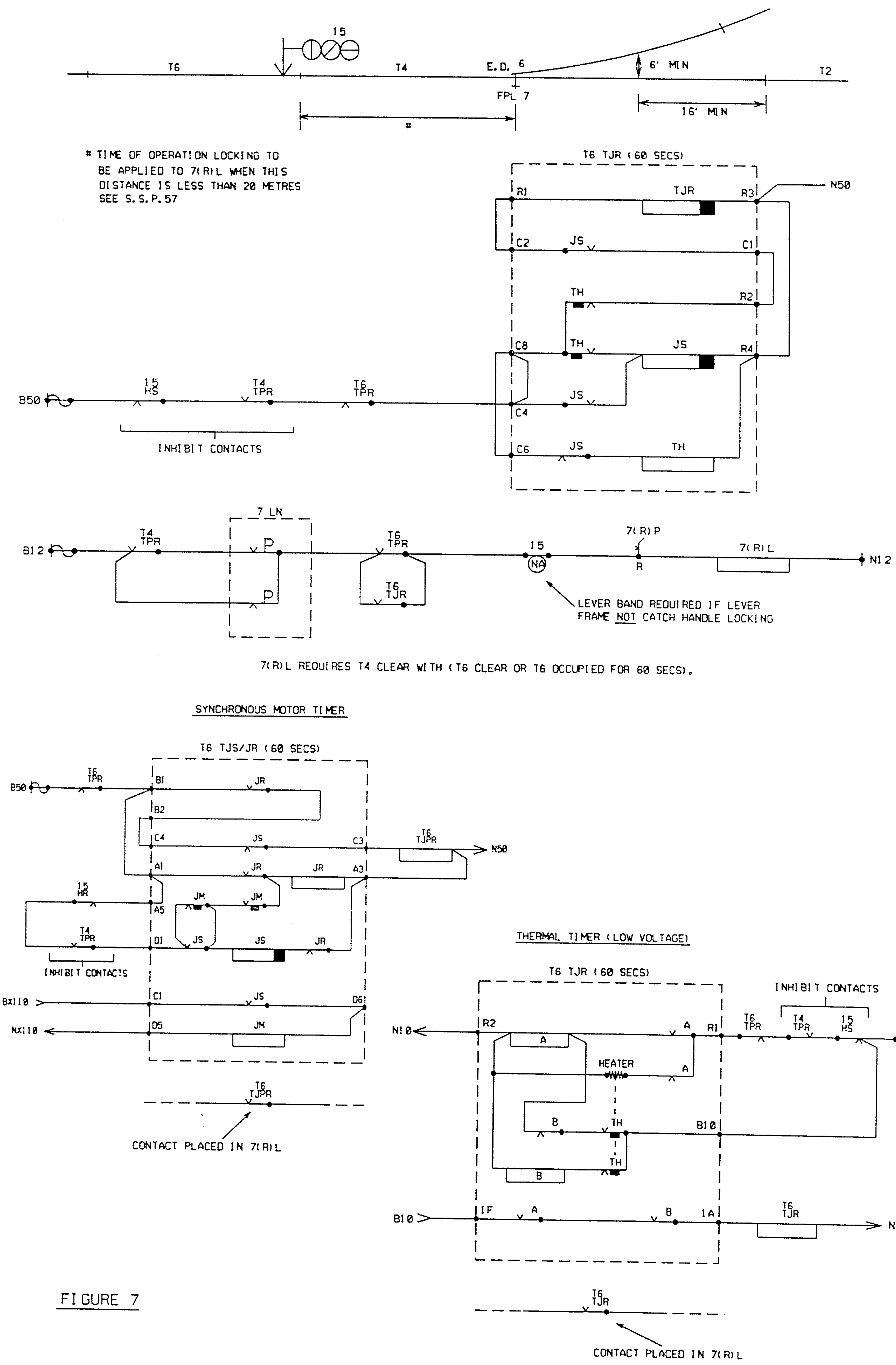

FIGURE 7

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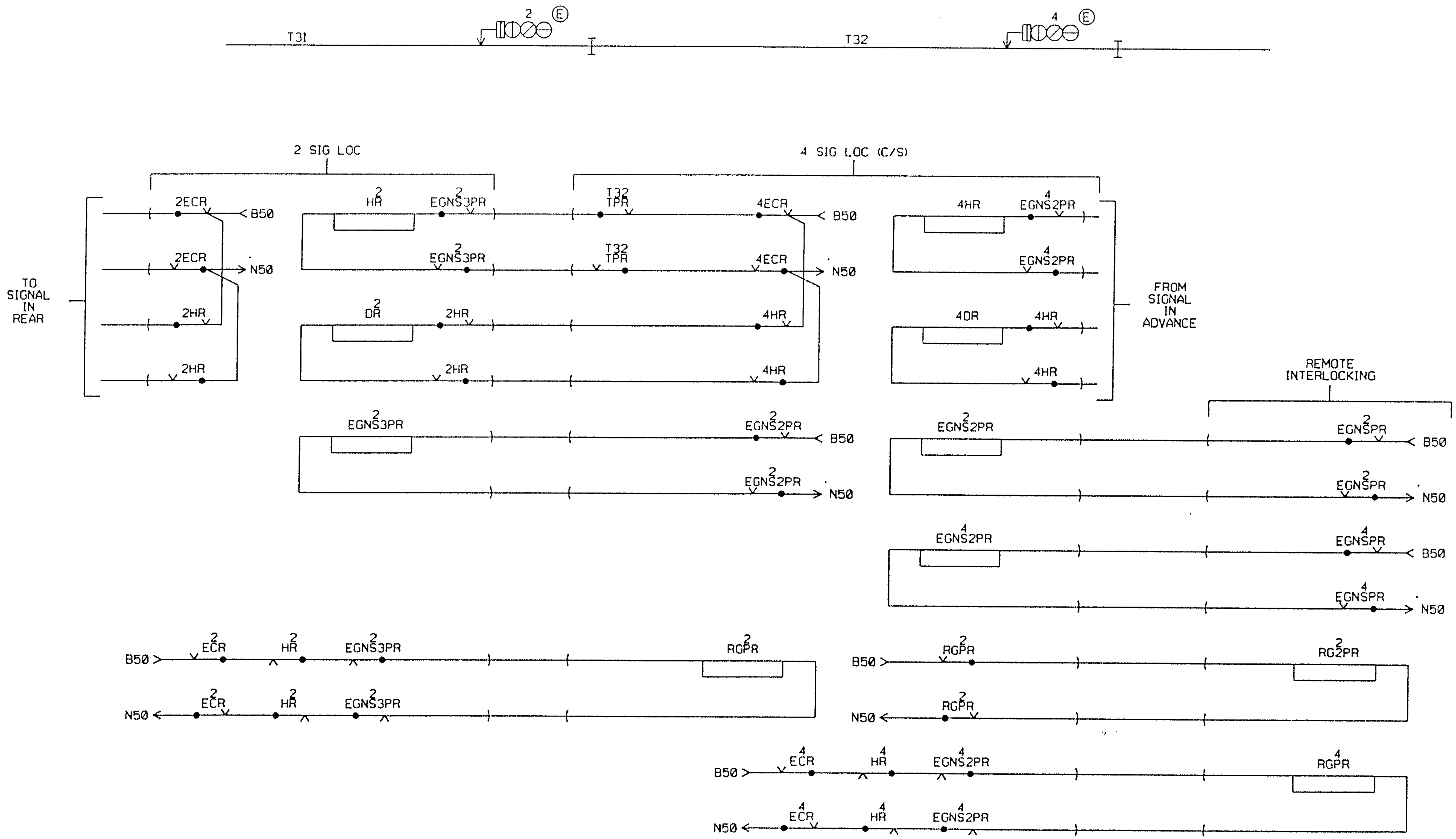

FIGURE 8A

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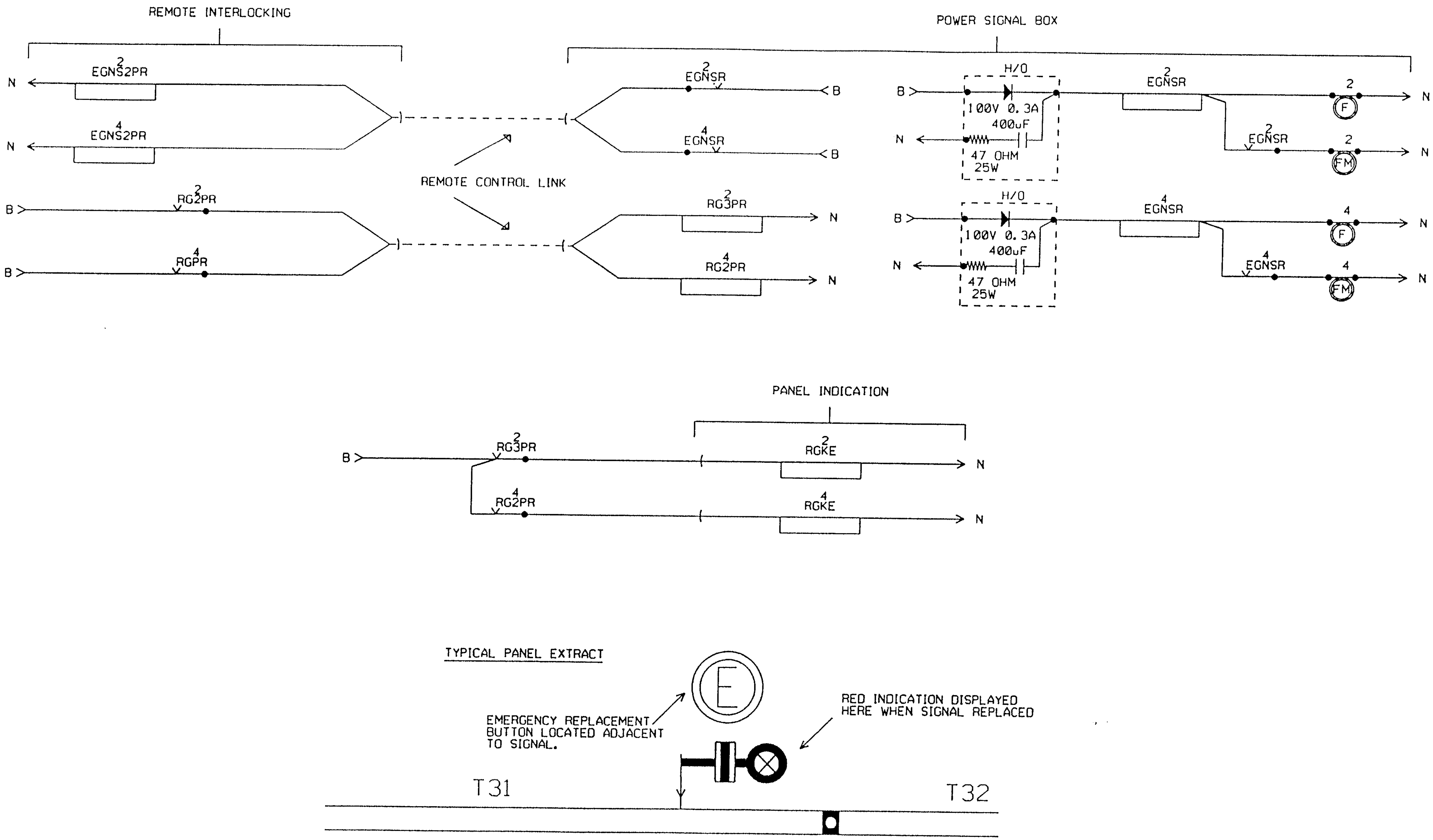

FIGURE 8B

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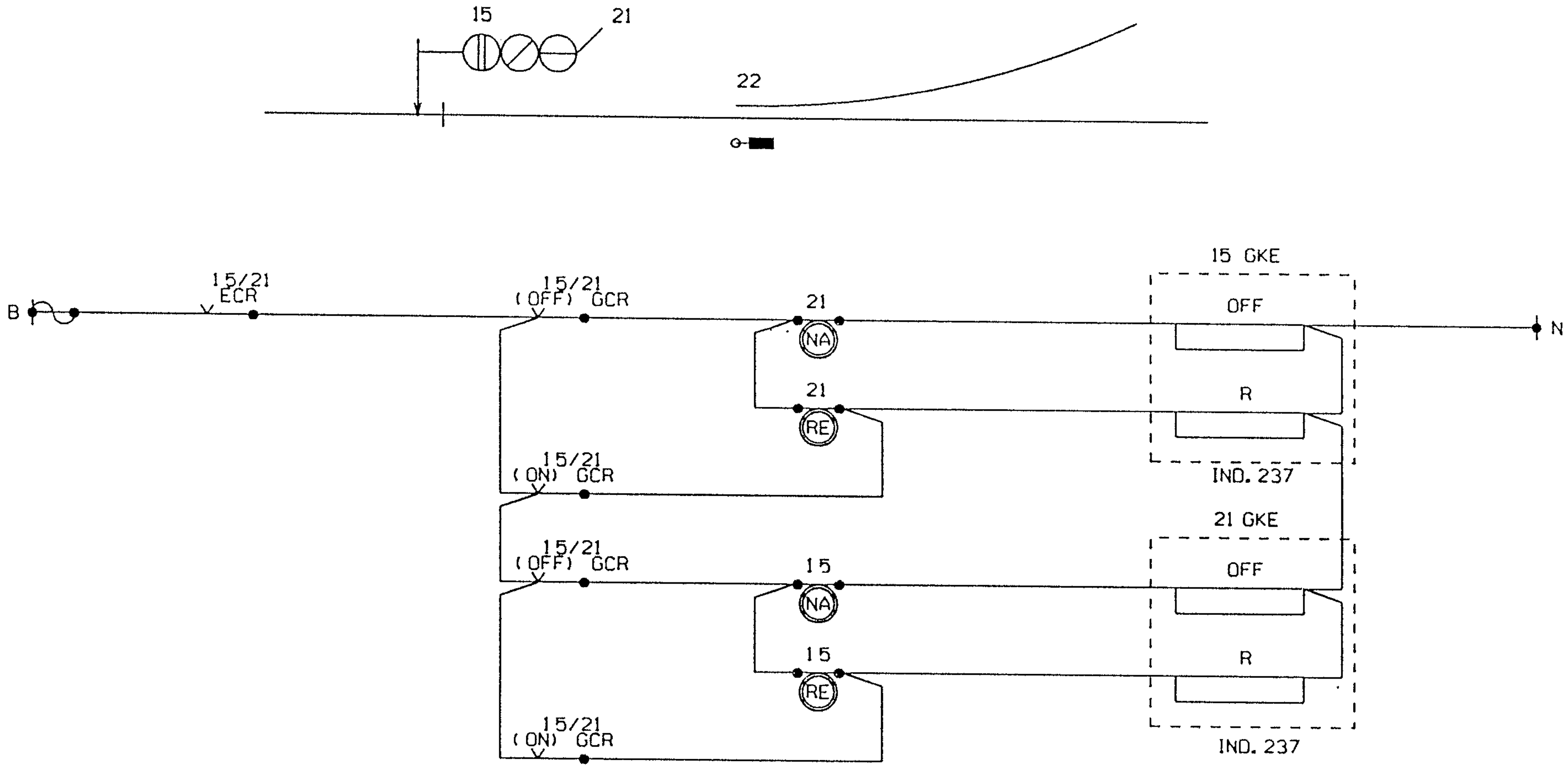

FIGURE 9

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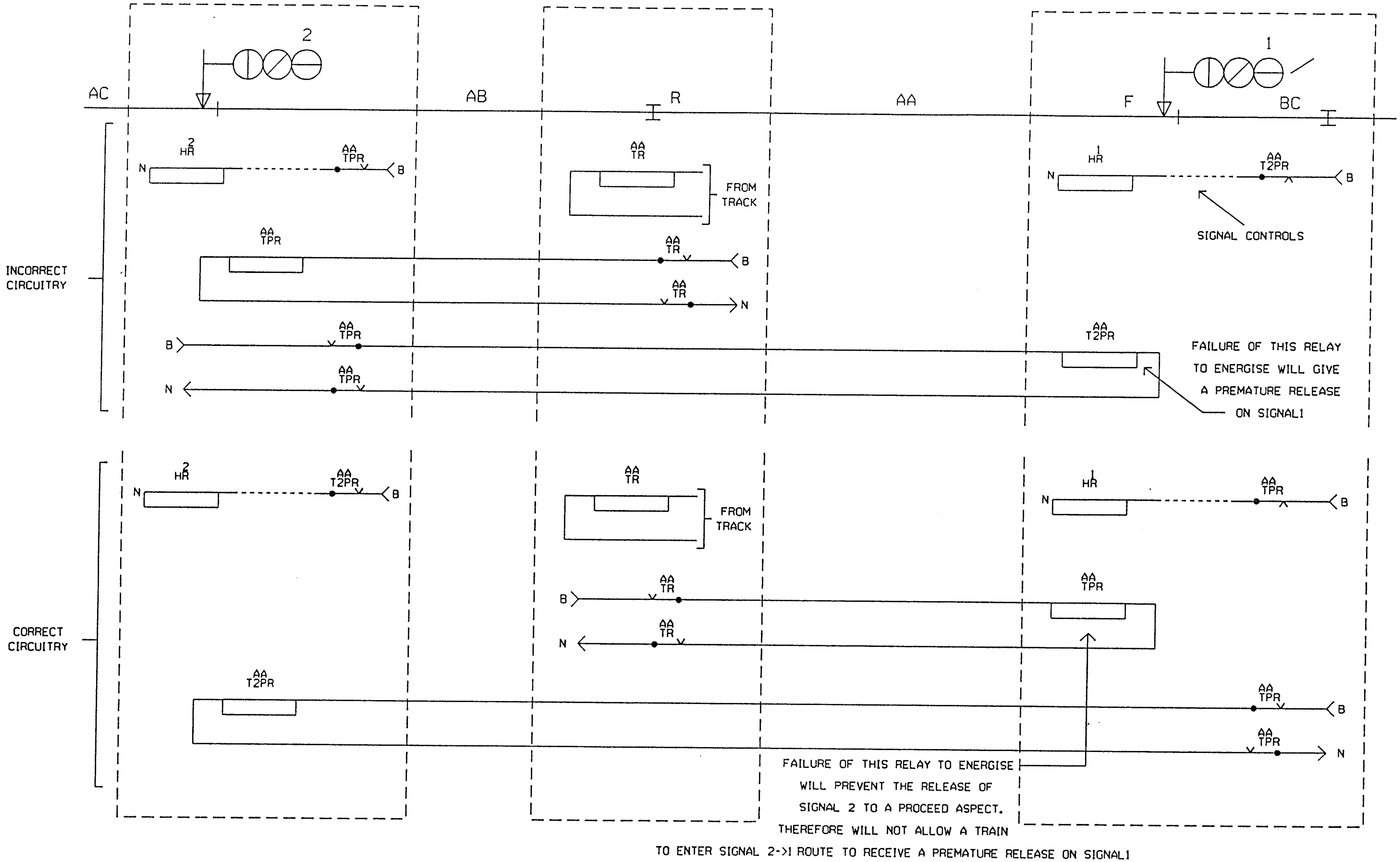

FIGURE 10

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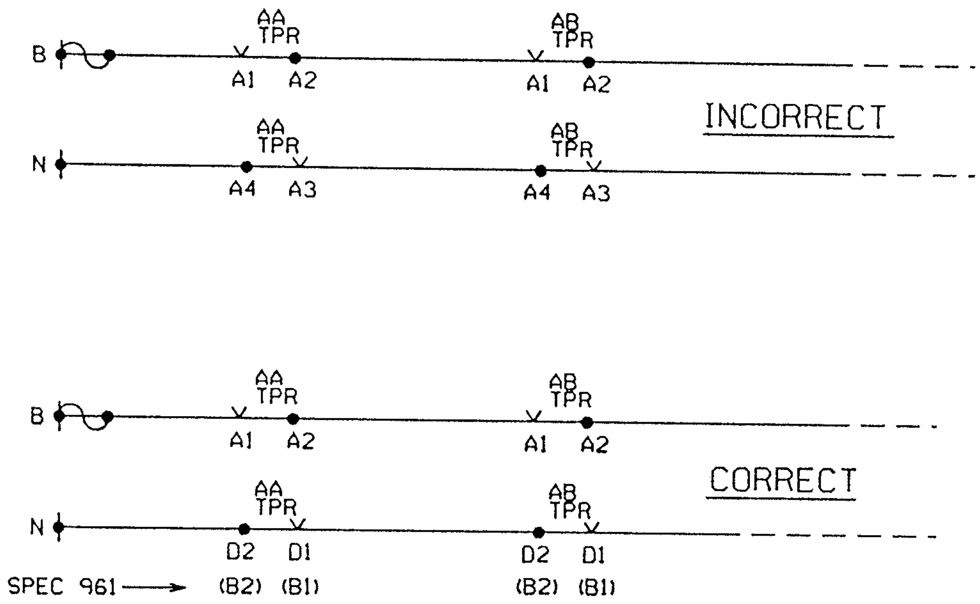
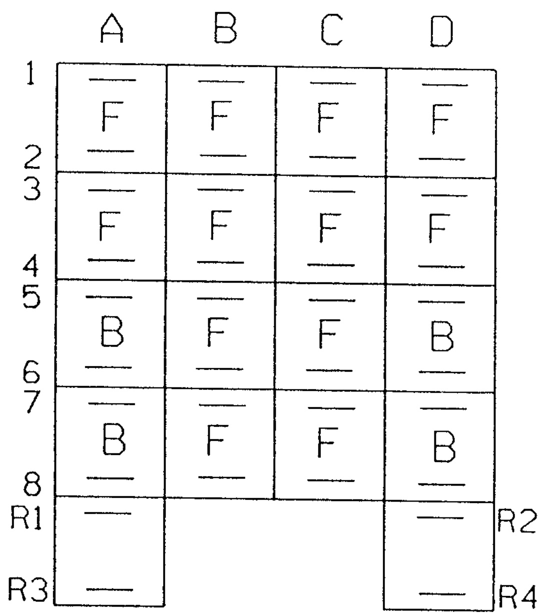


FIGURE 11



CONTACT POSITIONS FOR SPEC 931
12F 4B BRB PLUG IN RELAY

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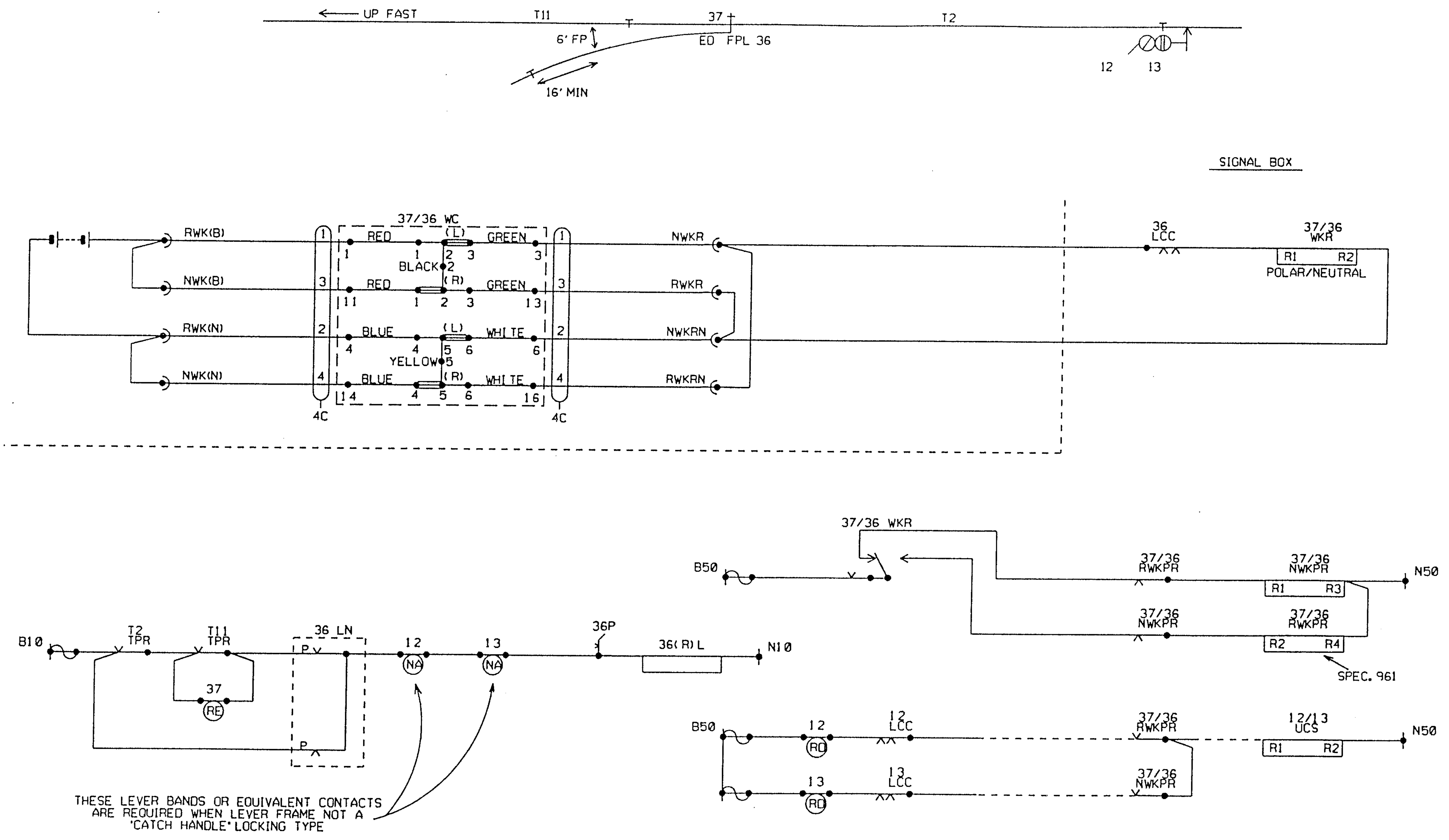

FIGURE 12

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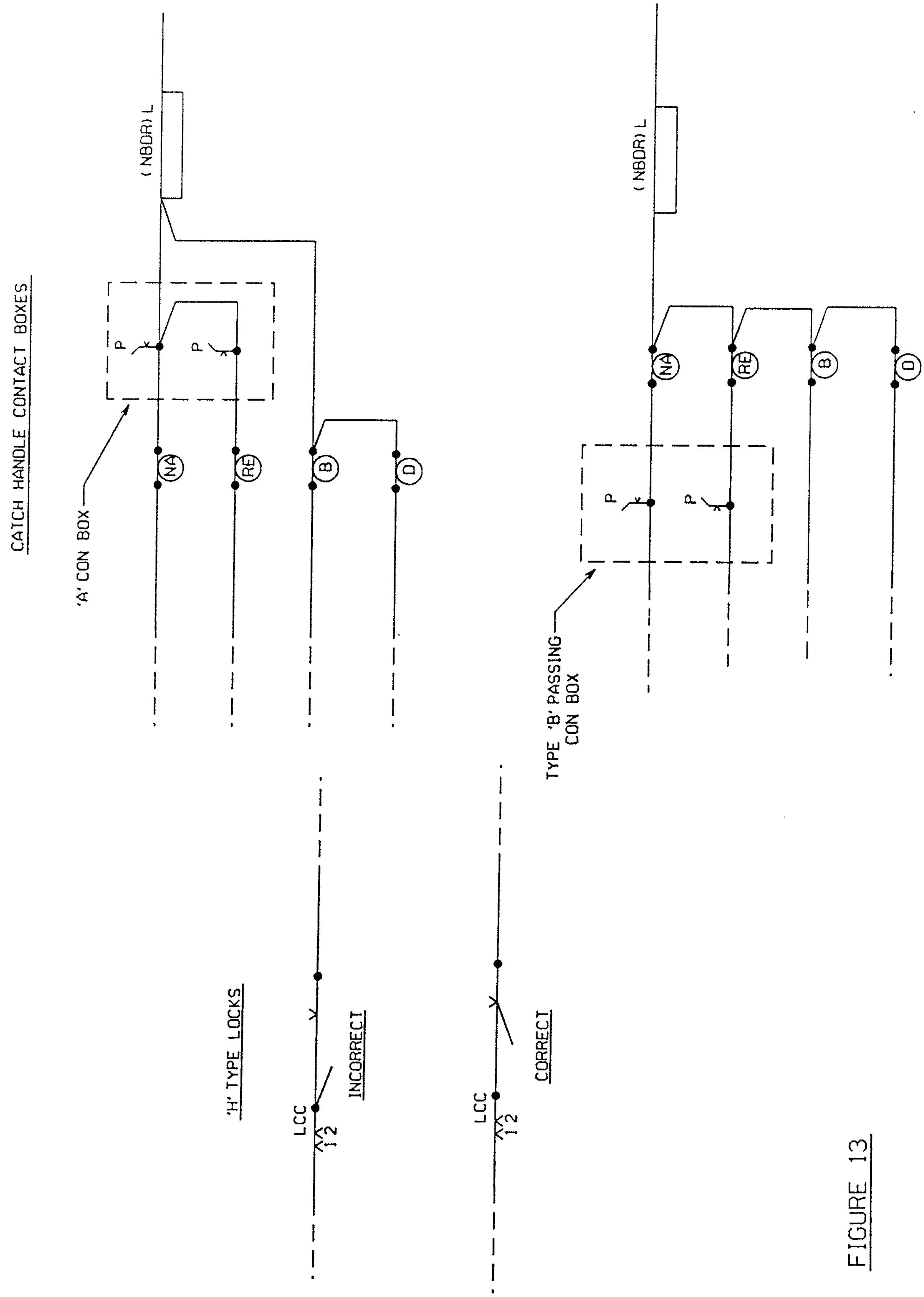

FIGURE 13

end