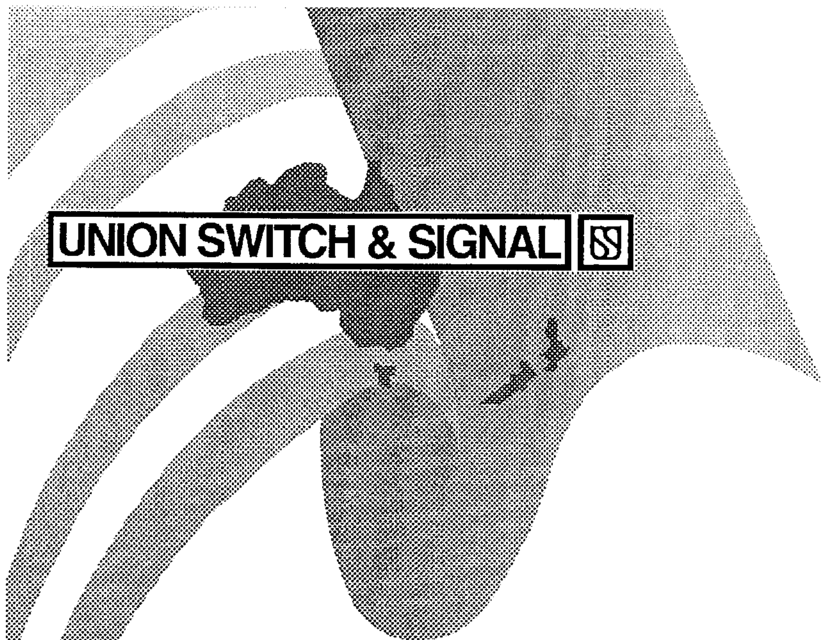

AN APPLICATION OF MICROTRAX

for the

NATIONAL RAIL CORPORATION
ON THE
SRA-NSW NORTH COAST LINE

Presented by Earl. R. Callender
at the
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AN APPLICATION OF MICROTRAX

THE PAPER IS ORGANIZED AS FOLLOWS:

First we will cover some background on coded track circuits. Then we will look at some of the constraints of coded track circuits, or for that matter, track circuits in general. We will briefly touch on the family of MicroTrax products leading into the specific product that was used on the NRC project. Then this product will be described and we will end with the application of it to the NRC, train order loops on the SRA's North Coast Line.

BACKGROUND

Coded Track Circuits have been in existence for many years particularly in the United States. Union Switch and Signal actually supplied their first coded track circuit to the Pennsylvania Railroad in 1926. This first application was for cab signalling.

The initial coded track circuits involved 100 HZ alternating current. The alternating current in the track circuit was interrupted at fixed code rates according to the track conditions ahead, and hence the allowable maximum speed. This message was transmitted to the locomotive and the signal indication would be displayed in the driver's cab.

Subsequent development saw the application of D.C. coded track circuits for the operation of wayside signals. Both of these relay type track circuits were all that was available for many years.

In the late 1970's and 1980's electronic based systems were introduced which were a start in overcoming the limited information that could be handled in a relay system. Several of these products were and are being used here in Australia, particularly in Victoria, South, and Western Australia. Recent developments have seen the microprocessor move into many signalling products including track circuits. The application of microprocessor technology to coded track circuits has resulted in flexible and versatile systems. Union Switch and Signal's product is called MicroTrax.

TRACK CIRCUITS IN GENERAL

Obviously, as a matter of economics, one would like to have track circuits as long as possible in most cases.

The concern is that there are several conditions that one has to deal with simultaneously which ultimately limit the maximum length of the track circuit that can be successfully operated.

One of those conditions is the minimum ballast resistance and obviously, if it is quite low, the signal strength that is received at the other end of the circuit will be at its minimum. So under those conditions one has to ensure that there is sufficient current to operate the relay or whatever the detection device happens to be.

One also has to be concerned with ensuring that the circuit will shunt under all conditions and the situation that gives rise to the worst case for shunting is when there is no ballast leakage. In other words when the ballast resistance is infinity, because it is that situation where the signal received is at its maximum. One has to be assured that, when a known resistance or shunt value is placed across the track, the circuit will then indicate occupancy.

A third situation is one of ensuring broken rail protection. The worst case for broken rail protection occurs at some intermediate value of ballast resistance and when the break occurs at the worst possible place in the track, which is generally the centre of the track. In the case of MicroTrax, the ballast resistance for ensuring broken rail detection under worst case conditions is generally in the range of 3 to 4.5 ohms per kilometre.

I believe these concerns are best illustrated by the three curves on Figure 1 covering track circuit parameters.

TRACK CIRCUIT PARAMETERS

Although the curves are specific for MicroTrax and the 0.06 ohm shunting sensitivity shown is the AAR standard used in the USA, they are representative of the concerns for determining reliable operation for any track circuit.

Curve A indicates the signal strength that is received when the ballast is at its assumed lowest value. In this case it is assumed that it is 0.9 ohms per kilometre.

Curve C is the operating sensitivity of the receiver and, of course, it always has to be at a lower value than the received signal strength to ensure that under worst case ballast conditions that sufficient signal is received so that the circuit will be indicated as not occupied.

Curve B is the received signal in either the worst case of broken rail or shunting. I mentioned the two considerations before. Obviously to ensure that you have broken rail protection and that the circuit will indeed shunt, the operating sensitivity curve has to lie somewhat above that of the received signal in the shunted or broken rail case. In other words Curve C has to be above Curve B.

The intersection of Curves A and B is the location where the maximum possible operating length would exist given all these worst case situations simultaneously. If curve C were placed just slightly above curve B, the maximum length would be 8.25 kilometres, but this would provide no margin for worst case conditions. We place the sensitivity curve up so that there will always be sufficient margin for worst case shunting or broken rail. The intersection of Curves A and C determines the maximum operating length in a practical application. In this case, it is 7.0 kilometres. However, for MicroTrax, as with any other well designed track circuit, we add a little more conservatism by rating the maximum length to be 6.7 kilometres.

You may have noticed that along the vertical scale the signal strength is listed in millivolt..seconds and that is actually the case. MicroTrax actually measures the area under the curve. As will be discussed later, the message that is transmitted through the track is a series of long and short pulses of both polarities and there is a significant amount of distortion that takes place in the track circuit because the tracks are primarily inductive. It is because of that distortion that we have chosen to measure the area under the curve as an indication of the received signal strength. We feel that gives us the greatest amount of security. Of course, with other systems it would not be millivolt seconds, it would be millivolts or volts or amperes or whatever.

MICROTRAX FAMILY OF PRODUCT

I would now like to briefly mention the family of products.

The MicroTrax track circuit, of course, performs train detection. It communicates information through the rails rather than over line wires. It has vital logic and vital input/output capabilities.

The MicroTrax End of Siding Controller performs all of these functions plus, it has a built-in OS track circuit, additional serial communications capability, and an optional local control panel, with non-vital inputs and outputs.

Lastly, there is also an End of Siding Controller that also has the ability to generate cab signalling commands on the track.

The simple MicroTrax Track Circuit was both sufficient and appropriate to the requirements of the North Coast Project and this is the product that I will now describe before going into the specific application.

MICROTRAX TRACK CIRCUIT

DESCRIPTION

The MicroTrax coded track circuit is a microprocessor-based track and line circuit system designed for non-electrified territory. It detects broken rails and defective insulated rail joints. The MicroTrax units provide logic outputs that are used to operate relays or direct drive signal lamps. The MicroTrax unit also provides for logic inputs. Typical inputs are points detection, track circuit status, push button controls etc.

BASIC OPERATION PRINCIPLES

The MicroTrax system is designed to operate according to the same basic vitality principles as an equivalent relay-based system. When an input or output is recognised as a 0, this is the most restrictive state. When the input or output is recognised as a 1, this is the less restrictive state.

An output or input cannot fail to the less restrictive state. Certain failures can cause an input to be falsely recognised as a 0. This type of failure is permitted because a zero implies a more restrictive state.

The logic portion of the MicroTrax unit is strictly an interpreter that executes and verifies the user's application logic. The application logic must be properly designed to prevent any unsafe actions. Like all processor based systems, the Executive is not capable of detecting and responding to an unsafe configuration in the application logic.

The MicroTrax system uses software-driven internal diagnostics designed to ensure the safest possible operation. There are two types of diagnostics used, background and intrinsic. Background diagnostics perform a unique function separate from the functional code and are not required for basic system operation. Examples include EPROM check sums and CRC tests, timer comparisons and routine trace checks. Intrinsic diagnostics are an integral part of the functional code. For example, certain sections of the code process two sets of data to verify data integrity.

TRACK CODE SIGNAL

This signal is connected to the rails through a Track Interface Panel consisting of a transformer and a heavy current inductor in series with the track lead. The transformer is very large and heavy to avoid magnetic saturation at the very low frequencies of one and a half and three hertz that we use. This also provides excellent isolation of the electronics from many types of surges that may be present on the tracks.

The inductance is 10mH, offering about 10 ohms impedance at 150Hz and proportionally more impedance at higher frequencies. This makes the MicroTrax system compatible with level crossing motion and predictor equipment and audio frequency overlay track circuits without the need of external blocking units.

The MicroTrax track code signal is bi-polar, consisting of a pattern of positive and negative pulses. Each message is two seconds long, contains an equal number of short positive and short negative pulses, and an equal number of long positive and long negative pulses.

There are 26 possible codes. Twenty are available for user applications. The remainder are used for functions such as link-up, invoking sleep mode, or quick tumble down.

SINGLE POLARITY vs BI-POLAR SIGNAL

I am going to deviate here to demonstrate another general principle of track circuit design. Please refer to Figure 2. It is intended to illustrate the basic underlying philosophy and advantage of using an AC signal format on the track instead of a DC signal format. As I mentioned before, coded information on the track is distorted significantly and the amplitude varies significantly as a function of ballast and of course the objective with a track circuit that is also passing information is to not only detect the presence of trains but also to convey information from one end of the circuit to the other, in order to eliminate line wires.

What I have shown in the top half of this diagram is an illustration of the type of distortion that occurs with just a stream of on/off pulses at a relatively low repetition rate and the fidelity of the recovered signal as that signal varies from a very low output to a very high output which of course is a function of ballast. The very top curve A shows lines basically going off the paper due to the signal strength being very high as it would exist when ballast is very very good and the top continuous wave form B is an illustration of the character of the signal when the ballast is very poor.

In a DC system such as being depicted here there can only be a single detection point and I have illustrated on this diagram the intersection of that detection point with that of the received signal and then indicated the asymmetry that results when the signal strength is poor by the train of pulses that's labelled low level recovery as contrasted to the near perfect square wave by the signal depicted as high level recovery. The point is that the distortion is going to occur and the job is the picking out of the signal and then making decisions as to when that distortion is still acceptable to convey the information that is intended.

If you contrast that to the diagrams on the lower half of the sheet you will notice that the distortion that takes place is identical to that depicted above but in this situation we are transmitting a square wave with polarity reversal. If you have polarity reversal, which is of course an AC signal then it gives rise to the ability to have both a positive detection point and a negative detection point. One can space those detection points equally around the centre line. If you follow the intersection of those detection points for the case when the signal is very strong and contrast it to when the signal is very weak, you will notice that the recovered signals at the very bottom of the sheet marked low level recovery and high level recovery result in reception of a perfect square wave under all circumstances. So this is fundamental to the operation of MicroTrax or any well designed system. That is, while we detect train presence, of equal importance is the ability to transfer information from one end of a circuit to another and it is the AC signal format that provides a distinct advantage in that regard. We will now return to the MicroTrax description.

APPLICATION AND EXECUTIVE SOFTWARE

The software architecture is basically in three levels that are independent from each other with separate EPROM chips. One is the executive software, which the supplier controls. It is the software that is transparent to the user. The user has no access to it and it fundamentally performs all the checking routines that ensure that the system is operating safely as well the other functions associated with MicroTrax such as displays and monitoring.

The second level is the application software. The application software is developed for the specific installation, either by Union Switch and Signal or the customer. The source program is written and compiled on a computer, using boolean language equations which are familiar to signal engineers. They are based on the operating rules of the client. The finished program is then converted into a form that can be entered or "burned" onto EPROM chips. The user friendly application software techniques, for those of you familiar with Microlok, are virtually identical to Microlok, and as with Microlok, relay equivalent circuits of the logic can be generated.

The third level is E squared prom that involves the site specific data that retains the personality of each unit. The E squared prom is located on the mother board in the back of the unit and once configured retains an identity with that specific unit.

VITAL FAULTS AND SHUTDOWN MODES

The CPU communicates with all other modules over a common data bus. Successful diagnostic tests result in a 250 Hz output to a conditional power supply. This power supply, in turn, maintains energization of a vital cutoff relay (VCOR). Vital or critical faults cause this relay to drop, removing power from all outputs. The back contact of the relay can be used to provide red-retaining on signals if desired.

LOOP OPERATION

The loop points are motor worked by Westinghouse M84 trailable point machines. Control of the points is by operation of a trackside mounted pushbutton. Entry to the crossing loops is via a colour light home signal with special indications. Exit from the loop is via a colour light points indicator.

The home signal is approach cleared by the presence of a train on the approach track circuit which is a Westrak AC/DC type. A landmark warning board is provided at full braking distance to advise train crews of their approach to the station.

If the train is proceeding through the station, the driver needs to do nothing other than control the speed of the train and obey the aspects of the home signal and point indicators.

If the train is to enter the loop, the driver stops the train at the home signal, then operates the signal cancel button and after a two minute timeout period, the points locking frees and the driver operates the points pushbutton to call the points reverse. Once the points have operated to reverse, the loop entry signal clears and the train proceeds into the loop.

When the train is clear of the points track circuit, the points self-normalise and the next train will clear the signals automatically to travel through the station.

When the loop train is ready to depart, the driver operates an exit pushbutton, under authorization by train order, which will operate the points to reverse and clear the appropriate points indicator. After the train departs the loop, the points will self-normalise and the station is ready for the next train arrival.

MICROTRAX CONFIGURATION

To achieve this operational functionality, as indicated earlier, the track circuit type of MicroTrax system was selected. The configuration is shown in Figure 3.

A MicroTrax cardfile is installed at each end of the loop and coded track communications are transmitted through the main line section of the crossing loop. One MicroTrax is designated the master and the other is the slave. The master and slave communicate with each other and transfer status of each interlocking between them continually.

The MicroTrax cardfile is installed in a rack which also houses track circuit equipment, vital and non-vital relays and power supplies. The rack is installed in a pre-fabricated building located near the points at each end of the loop.

To meet SRA requirements, a High Voltage type track circuit is installed over the two points track circuits. As already mentioned, a Westrak type track circuit is installed at the approach to the mainline type home signal, at each end of the loop. These are solar powered. Colour light type points indicators are provided for trailing move indications through the points.

Inputs to the MicroTrax units consists of track circuit, signal normal, and detection status plus pushbutton operation. The MicroTrax outputs are derived from non-isolated I/O modules driving vital 24 volt twin vital relays to BR specification 962. These relays are used to control points and signal operating circuits.

One final point. Portions of this paper included examples that used 0.06 ohm shunting. The SRA requires a higher drop shunt characteristic of at least 0.15 ohms. They desire 0.5 ohms which was met. The consequence of this is that the maximum track circuit length is decreased, but is still far greater than required for this application.

OPERATING EXPERIENCE

The MicroTrax crossing loops have now been in operation for several months. Experience to date is that the units and the system operate very reliably. Also, the maintenance staff have adapted easily to the new concepts and procedures required.

CONCLUSION

It appears that processor based technology, such as MicroTrax, can provide safe and reliable solutions for this type and similar types of signalling schemes. Also, while not discussed in this paper, at a cost savings over conventional relay based systems.

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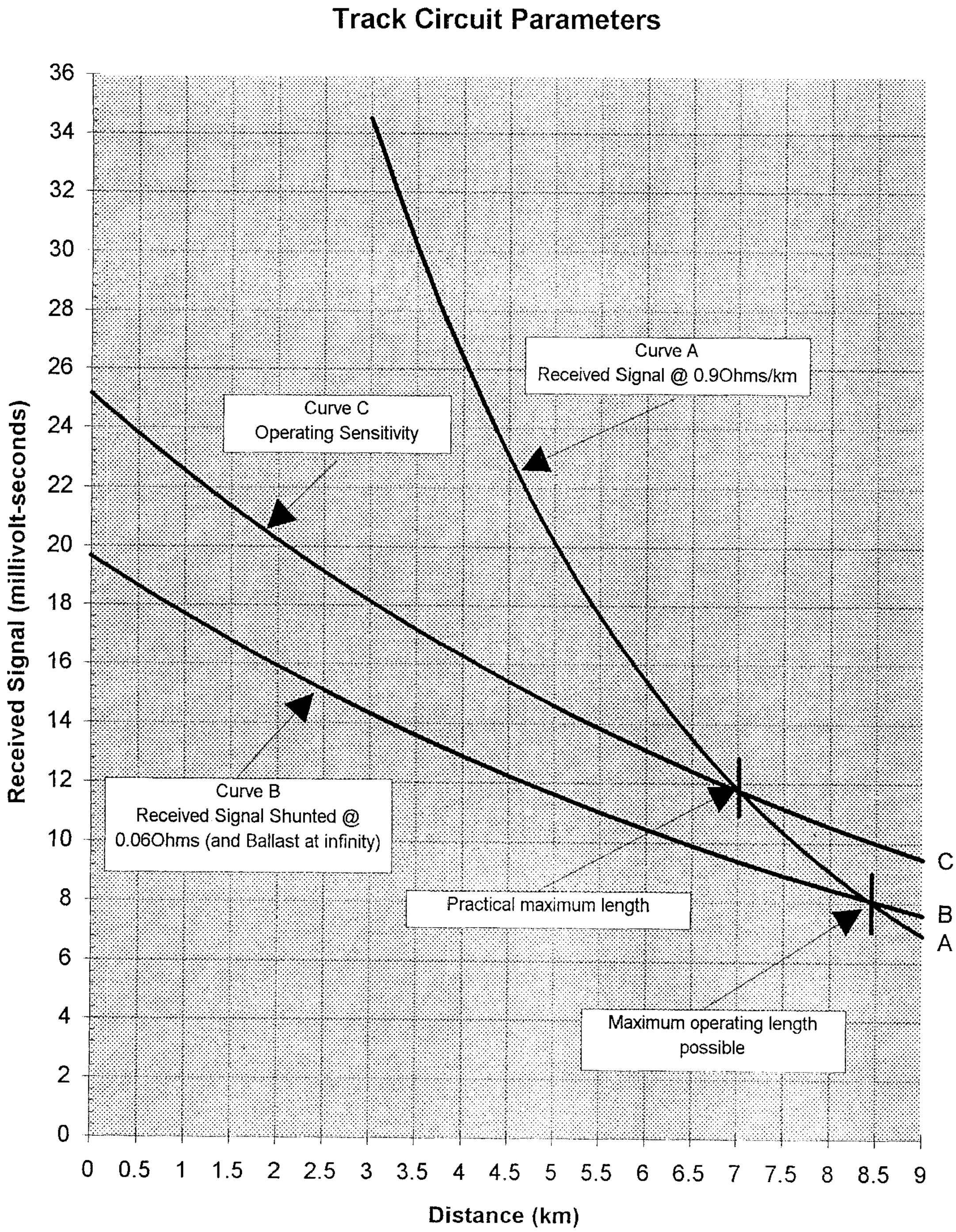
Track Circuit Parameters
Received Signal (millivolt-seconds)
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Curve A
Received Signal @ 0.9Ohms/km
Curve C
Operating Sensitivity
Curve B
Received Signal Shunted @
0.06Ohms (and Ballast at infinity)
Practical maximum length
Maximum operating length
possible
C
B
A
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
Distance (km)

Figure 1

SINGLE POLARITY VS BI-POLAR SIGNAL FORMAT

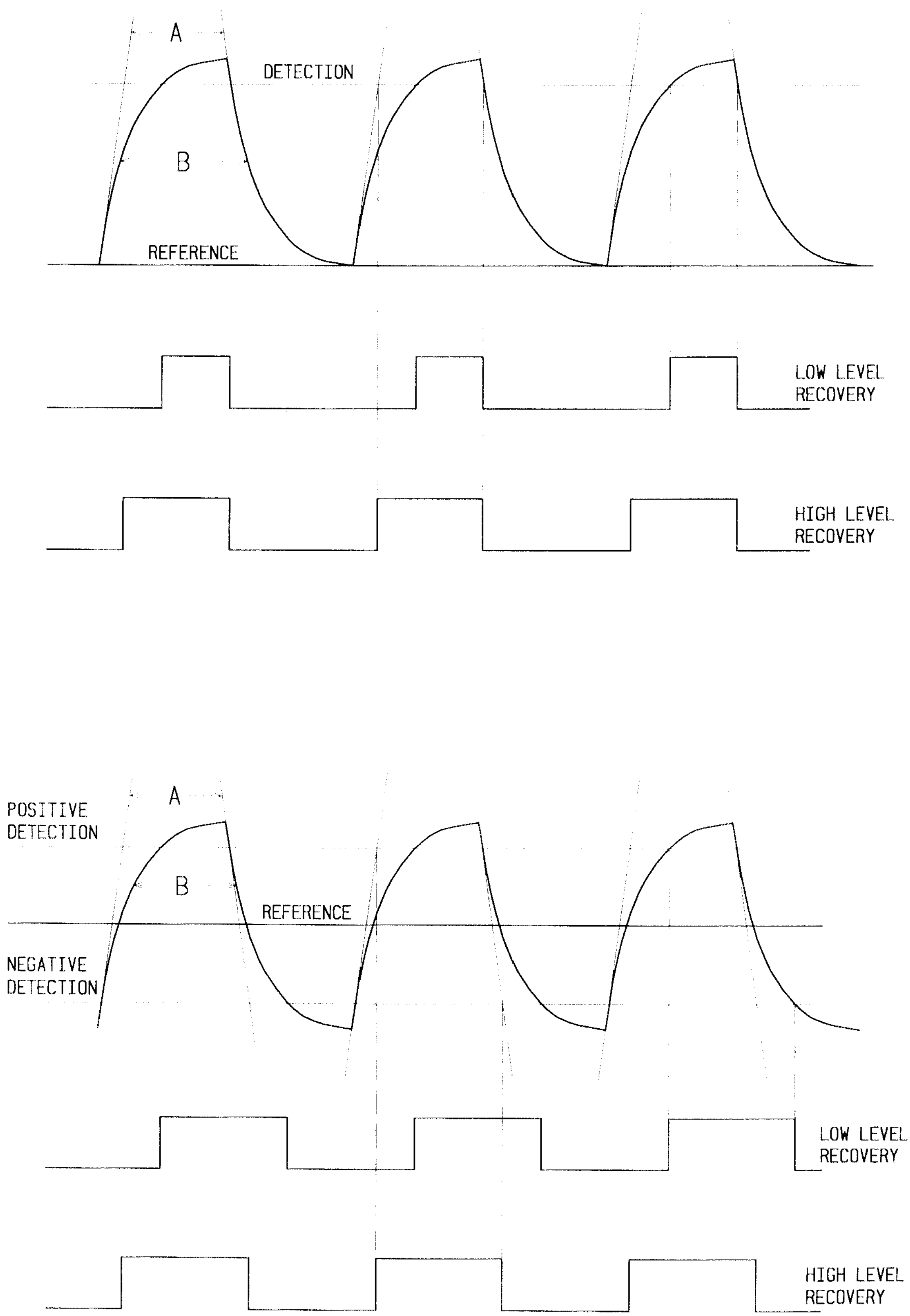

FIG. 2

MICROTRAX CONFIGURATION

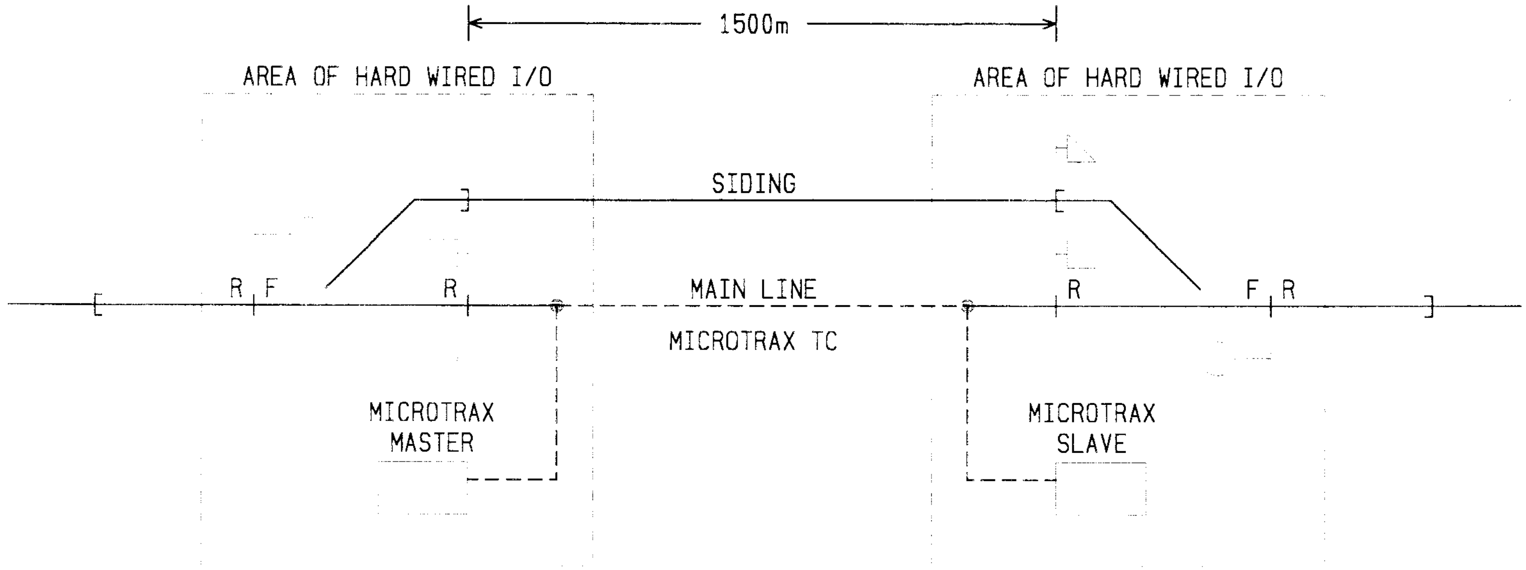

FIG. 3