LOCK INSPECTION SYSTEMS LTD.

METAL DETECTOR

Operating and Installation Manual

INTRODUCTION

The Metalchek 9 metal detector in which you have invested is a high quality product utilising the latest in metal detection technology. Please read the whole of this handbook carefully before starting any installation work. Correctly installed the Metalchek 9 will give long trouble free operation. If you are in any doubt regarding the installation or commissioning of this equipment, please contact the Service Department of Lock Inspection Systems Ltd., or one of their authorised distributors.

The Metalchek 9 is a high performance metal detector suitable for detecting ferrous and non-ferrous metallic contamination in a wide range of non-metallic products. It consists of an inspection head known as the Detector Head, an Electronic Control Module and a Power Supply Relay Unit which may be mounted in any convenient position. The product to be examined passes through the aperture in the Detector Head on a conveyor band, an inclined chute or through a non-metallic pipe. A penetrating electromagnetic field is generated within the aperture and metal no matter how deeply embedded in the product will distort the field and can be detected. On detection the Detect Lamp on the M9 Control Module illuminates and the relay in the Power Supply Unit operates. The relay contacts may be used to actuate a visual or audible alarm, stop conveyor motors or actuate automatic reject mechanisms.

Detection Sensitivity

The minimum size of metal that the Metalchek 9 will detect depends primarily on the size of the inspection aperture in the Detector Head. The smaller the aperture the higher the detection sensitivity and the smaller the size of metal that can be detected. A chart is available from Lock Inspection Systems Ltd. or their authorised distributors which provides a guide to the minimum size of different types of metal that can be detected in a range of Metalchek 9 aperture sizes.

Important Note:

The three core cable attached to the Control Module of the Detector Head must only be connected to terminals 14 red, 15 blue/black, 16 green, in the Power Supply Unit. This cable carries a maximum voltage of 20 volts from the Power Supply to the electronic Control Module, it also carries the low level electronic signals from the Control Module to the Relay Timer Unit in the Power Supply. The standard length of Detector Head cable supplied is 5 metres so the Power Supply Unit could be mounted on some convenient structure within this cable length. The cable length is in fact not critical, it can be increased by the user if essential up to approximately 50 metres in length. It must not be run in close proximity to heavy current carrying cables. Movements of this cable does not affect the performance of the detector.

1.1 INITIAL SETTING UP

With the detector installed in position and the electrical connections made, the following procedure should be followed with no product in or passing through the aperture.

(a) Open the cover to the Control Module, set Product Compensation Control to 0 and IN/OUT switch to OUT. Set Sensitivity Control to 5.

(b) Open door on Power Supply Relay Unit and put ON/OFF switch to ON. The Red Power and Balance Indicator Lamps will illuminate, the metal detection relay will be in the metal detect condition.

(c) After approximately two minutes when the automatic self checking circuits have established that the Detector Head search coil assembly has been automatically balanced and the circuits in the Control Unit are all operating correctly, the Balance Indicator lamp will go out and the metal detection alarm relay will go into its normal running condition.

(d) Adjust the alarm time in the Power Supply Unit to give required duration of alarm when metal is detected.

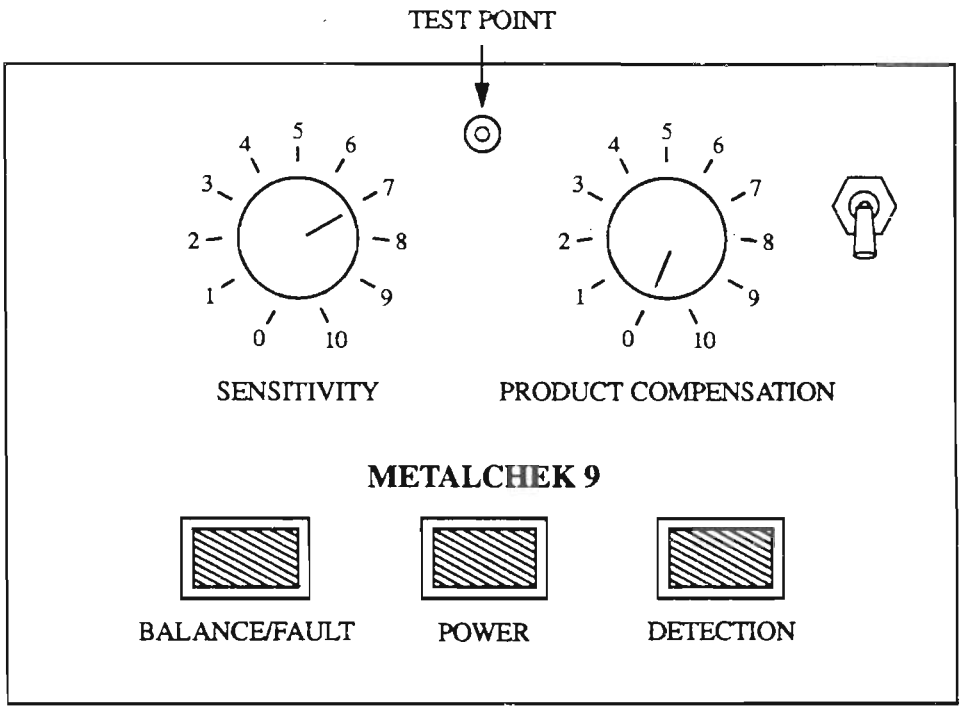


Fig. 1.1 Control Panel of Metalchek 9 Electronics Module

1.2 Metalchek 9 is now ready for use with normal products, i.e. products that have no product effect. Material can be inspected for metal contamination by passing through the aperture. If metal is detected, the Detection Lamp on the M9 Electronics Module will illuminate and the metal detection relay in the Power Supply will operate. Detection sensitivity can be increased or decreased by adjusting the Sensitivity Control on the Electronics Module. Maximum sensitivity is at setting 10, minimum sensitivity is at setting 0.

For inspecting products which have a product effect signal such as pickles, unfrozen

meat products, soups, etc. refer to Section 1.4, Setting up instructions for product effect compensation. Section 3 should also be studied.

When the Metalchek 9 is switched on again after having been switched off, it will go into the alarm condition for approximately two minutes until the automatic self checking circuits have established that the detector is operating correctly.

1.3 METALCHEK 9 OPERATING CONTROLS

Metalchek 9 has the very minimum of controls that need attention by the user.

M9 Electronics Module

The Control Panel on the M9 Electronics Module has the following controls and indicator lights. Fig. 1.1

Detection Sensitivity Control graduated 0-10
Product Compensation IN/OUT switch
Product Compensation Control graduated 0-10
Power ON indicator (Light Emitting Diode L.E.D.)
Balance/Fault indicator (L.E.D.)
Metal Detected indicator (L.E.D.)

Detection Sensitivity Control

Maximum sensitivity is at 10 and minimum at 0. At position the detector is not completely off but has a finite minimum sensitivity. The Sensitivity Control has a range approximately equivalent to three diameters of metal sphere. For example if the detector detects a 1mm diameter sphere at setting 10, it will detect a 3mm diameter sphere at setting 0. If sensitivity at setting 0 is still too high, the sensitivity can be further reduced by moving the cable plug at the bottom right hand corner of the Electronics Control Module from the three right hand terminals into the three left hand terminals. See Fig. 5.1.1.

Product Compensation IN/OUT Switch

This switch is used to connect or disconnect the product effect compensation circuits. With the switch set to OUT the Product Compensation Control is inoperative and the compensation provided is similar to having the switch to IN and the Product Compensation Control set to zero. With the majority of products the IN/OUT switch should be in the OUT position.

Product Compensation Control

This control is effective only when the Product Compensation Switch is set to IN. It is used when inspecting materials which are electrically conductive and give a product effect signal. It can also sometimes be used to give an increase in detection sensitivity to certain types of metal with of course a corresponding reduction in the sensitivity to some other types of metal.

For more information on product effect compensation please refer to Section 3 on phase discrimination and product effect compensation.

Power Supply Relay Unit

This unit contains a stabilised Power Supply, a fuse, a relay and a plug-in alarm Timer Type 9R or an Electronic Memory Unit type M18, or a Programmable Electronic Memory Unit type P64. The following controls are provided in the Power Supply Unit:

ON/OFF Switch
Alarm Time Control
Delay Time Control with M18 and P64 Timers only
Fuse. 1 Amp.

Timer 9R

The Timer 9R Module plugs into the Power Supply assembly and is used when immediate relay action is required when metal is detected in such applications as stopping a conveyor and/or operating an alarm. It is also used to actuate various automatic rejection devices such as solenoid air valves, deflect flaps, drop flaps or plough off mechanisms where the time or distance between detection and rejection is very short. It is not suitable for ram or punch-off systems.

Operation

When metal is detected the relay will de-energise immediately and re-energise again after an adjustable time period (adjustable 0.2 to 10 seconds), known as the ALARM time. Should another piece or more pieces of metal be detected during the ALARM time the timer automatically resets the time period thus extending the ALARM time to allow each piece of metal to reach the reject position and be rejected.

Setting ALARM Time

Adjust the ALARM time to give the required time of operation of any visual or audible alarm. If controlling an automatic rejection mechanism adjust the ALARM time so that the mechanism remains in the reject position long enough to reject a metal contaminated product.

As a general guide the minimum length of product rejected is approximately equal to half the aperture height of the detector head.

M18 Electronic Memory Unit (E.M.U.)

The M18 Electronic Memory Unit uses the shift register principle to store individual detection signals and actuate a rejection mechanism in synchronism with the contaminated products when they arrive at the reject position. The M18 E.M.U. is for use in applications where the time taken from detection to rejection is constant, for example on a fixed speed conveyor. It can be used with retracting band, deflector flaps or plough type rejection systems. The M18 provides a delay time (adjustable 0.5 to 18 seconds) from detection to rejection. The ALARM time (rejection time) is adjustable between 0.25 seconds and 10 seconds.

For applications where the transit time between detection and rejection is not fixed, for example with variable speed conveyors or conveyors under separate start/stop control, the P64 Programmable Electronic Memory Unit together with an external speed sensor should be used instead of the M18. The P64 should also be used where the rejection point is a long distance from the metal detector. Neither the M18 nor the P64 units are suitable for use with straight ram rejectors.

M18 E.M.U. Setting-up Procedures

A metal test sample is needed to accurately set up the Delay and Alarm time controls. With the metal detector set to the required detection sensitivity and the conveyor running at its normal speed find the smallest size piece of metal that can just be reliably detected by the detector. Securely fasten this metal sample to a distinctive plastic block or card so that it will not get lost in the product whilst testing and also so that it is available for future testing.

WARNING: Do not use a metal test sample that is much larger than the smallest size that can be detected at the operating sensitivity as this could cause errors in the setting of the controls.

Delay Time Setting

With the conveyor running at its normal speed allow it to take the metal test sample through the detector head. Adjust the Delay Time Control so that the reject mechanism goes into the reject position just before the metal test sample reaches the reject point.

Alarm Time Setting

Attach the metal test sample to the leading edge of the largest product to be tested. PLace this product on the conveyor and allow it to pass through the detector head. Adjust the Alarm Time so that the reject mechanism starts to return from the reject condition to normal condition just after the contaminated product has been rejected.

Carefully following the above setting up procedure will ensure that all metal contamination that is detected by the detector will be rejected irrespective of the size of the metal or its position in the product.

Programmable Electronic Memory Unit P64

This unit is used when more precise rejection is required than that provided by the M18 unit. The P64 is also used in conjunction with a separate speed sensing probe when the delay time between detection and rejection is variable such as with a variable speed conveyor or a conveyor that is under separate stop/start control.

Separate detailed instructions are provided when the P64 is used.

1.4 METALCHEK 9 USED TO INSPECT "WET" PRODUCTS

(i.e. material that has a product effect)

Some products are themselves electrically conductive, when they pass through the aperture they produce an effect similar to that of a small piece of metal and cause the detection relay to trigger even through there is no metallic contamination present in the product. This is known as product effect. Typical products which exhibit this effect are processed meat, pickles, bread, soups, baby foods, etc. The electrical conductivity is normally caused by the moisture and salt content of the product.

If such metal free products do trigger the detector, it will be necessary to adjust the detector so that its sensitivity to the product signal is reduced so as not to be detected.

Section 3 gives a simplified technical description of the techniques used in the Metalchek 9 to provide high detection sensitivity to all types of metal ferrous and non-ferrous and at the same time very high immunity to random false triggering from the effects of shock and vibration on the detector head. This section also includes a description of the phase discrimination method of product effect compensation which is used in the Metalchek 9. Reading this section will give the user a better understanding of the action of the Product Compensation Control when being used with materials which have a product effect.

Adjusting Metalchek 9 to inspect "wet" products

There are two basic methods of overcoming or reducing the effect of the signal from materials which have a product effect.

Product Effect Compensation Method A

This method is recommended when checking materials which have only a small product effect signal. The overall detection sensitivity of the detector is reduced by adjustment of the Sensitivity Control with the Product Compensation Control switched OUT.

Proceed as follows:

A1. Ensure normal volume of material is passing through the aperture.

A2. Switch IN/OUT switch to OUT.

A3. Slowly reduce the sensitivity by half a division at a time until the metal free product no longer triggers the detector.

A4. Note this sensitivity setting. This is the highest detection sensitivity that can be used with this product.

A5. Set the Sensitivity Control to the required sensitivity if it is less than the setting obtained in A4.

NOTE: If the sensitivity setting obtained in A4 is less than 5, a better working detection sensitivity may sometimes be obtained by employing Product Compensation Method B. Both methods should be tried and compared, a decision can then be made as to which method to use.

Product Effect Compensation Method B

Method B is used with materials which have a large product signal and which need a very low sensitivity setting when method A is used. Method B uses both the Sensitivity and Product Compensation Controls to adjust the metal detector so that it ignores the product effect signal and yet reacts to metal contamination in the product.

Product Compensation Method B1

Adjustment of Sensitivity and Product Compensation Controls with the assistance of an oscilloscope.

Connect an oscilloscope with a vertical deflection sensitivity of 1 volt per centimetre to the test point on the Control Panel of the Electronics Module M9. The product signal passing through the metal detector can be monitored at this point and the correct settings for the Compensation and Sensitivity Controls quickly obtained.

B1.a Set IN/OUT switch IN.

B1.b Set Sensitivity Control to 5.

B1.c Adjust Product Compensation Control to give minimum product signal deflection on the oscilloscope. This is the correct setting for material being tested.

B1.d Setting Sensitivity Control. Having established the correct setting for the Compensation Control now set the Sensitivity Control of the Metalchek 9 so that the amplitude of the product effect signal at the test point is 2 volts peak to peak. This is the maximum sensitivity setting that will permit the detector to operate without being triggered by the product effect.

NOTE: If with the Sensitivity Control set to 0 the product effect signal is still larger than 2 volts peak to peak, it will be necessary to set the detector onto low sensitivity by moving the three pin plug at the bottom right hand corner of the M9 Control Module from the three right hand terminals to the three left hand terminals on the six way Terminal Block and then set the Sensitivity Control so that the product effect signal is 2 volts peak to peak.

With the Compensation and Sensitivity Controls set as above, check the detection sensitivity to small pieces of metal. A decision can then be made whether to operation using method A or method B.

If at these settings of the controls the detector is too prone to vibration the Sensitivity Control setting will have to be reduced until the sensitivity to vibration is at an acceptable level. The settings of the Product Compensation and Sensitivity Controls should be noted for future use when checking this product.

Experience with testing a large number of different products which have large product effect signals indicates that the product compensation setting is usually between 4 and 6.

Method B2

Setting Sensitivity and Compensation Controls for Product Effect Compensation without the use of an oscilloscope.
The settings for the Sensitivity and Compensation Controls should be determined with the normal quantity of material passing through the aperture.

Proceed as follows:

B2.a Set IN/OUT switch to IN.

B2.b Set Sensitivity Control to 0.

B2.c Set Product Compensation Control to 0.

B2.d With metal free product passing through the aperture increase sensitivity until the product signal just triggers the Detection Lamp on the M9 Control Module.

B2.e Slowly rotate the Product Compensation Control and note the range of control over which the product does not trigger the Detection Lamp, this is known as the compensation range. Return Compensation Control to 0. (If with sensitivity set to 0 the product still triggers the Detection Lamp over the full range of the Compensation Control it is necessary to change to low sensitivity operation. See instructions for setting low sensitivity operation.)

B2. Increase Sensitivity Control slightly by, say, 1 division and repeat operation B2.e.

f & g Repeat operations B2.f & g until the compensation zone is reduced to a minimum. This is the true setting for the Product Compensation Control for the particular product being checked. Leave the Compensation Control at this setting and note it for future reference.

B2.h Reduce the Sensitivity Control setting from that obtained on B2.f & g by 1 or 2 divisions to allow for slight variations that may occur in the product. Note the sensitivity setting for future reference when checking this product.

Section 2 - INSTALLATION

2.1 Electrical Connections

2.2 Mounting and installations

2.3 Factors which can affect the working of a metal detector

2.1 METALCHEK 9 POWER SUPPLY UNIT (TERMINAL CONNECTION)

Power Supply - Relay Unit (Fig. 2.1.1 and 2.1.2)

Before mounting the Power Supply Unit ensure that the transformer voltage tapping corresponds to the incoming nominal A.C. supply voltage. To do this remove the two securing screws from the Power Supply assembly, remove it from the box and check that the selector lead is inserted into the correct connector. Replace the Power Supply assembly into its box. Connection details for two typical applications are given at the end of this section.

Terminal No.	Details
1	Connect LIVE electrical supply.
2	Connect NEUTRAL electrical supply.
3	Connect EARTH.
4	LIVE electrical supply is available at Terminal 4 via the ON/OFF switch on the Power Supply Unit. Maximum rating 2.0 amps. This supply is not switched by the relay. The LIVE terminal can be used to supply the A.C. voltage to the metal detector relay contacts, it then provides the facility whereby operation of the ON/OFF switch in the Power Supply Unit will control both the metal detector and any circuits connected to the relay contacts such as alarm bells and reject mechanisms.
5, 6, 7	Relay Contacts. 6 and 7 open when metal is detected. 6 and 5 close when metal is detected.
8, 9, 10	Relay Contacts. 8 and 9 open when metal is detected. 9 and 10 close when metal is detected.
11	Relay Coil. 11 is linked to 12 for normal operation. If relay lock-on facility is required, see note below:
12	Output from Timer or Electronic Memory Board.
13	Conveyor speed dependent signal from an external sensor when using the P64 Programmable Memory Unit.
* 14	Red connection lead from the Detector Head (HT + 20V).
* 15	Blue/Black lead from the Detector Head (HT 0V common).
* 16	Green lead from the Detector Head (detection signals).

NOTES:

A. Relay contacts 5, 6, 7 and 8, 9, 10 are not connected internally to any supply source, they are unpowered contacts for user use.

B. Connections 14, 15, 16 are for connection to the three core cable from the detector head.

C. Relay lock-on facility. If the relay is required to lock-on when metal is detected, remove the link between terminals 11 and 12 and connect a link between terminals 8 and 12 and between 9 and 11. Connect a normally open Reset Push Button across terminals 8 and 9. When metal is detected, the relay will lock-on in the alarm condition until reset by operating the push button.

D. The relay in the Power Supply Unit is normally energised and de-energises when metal is detected. It has two sets of changeover contacts rated at 250V 5amp resistive load.

CONNECTION DETAILS FOR TYPICAL AUTO REJECTION SYSTEM

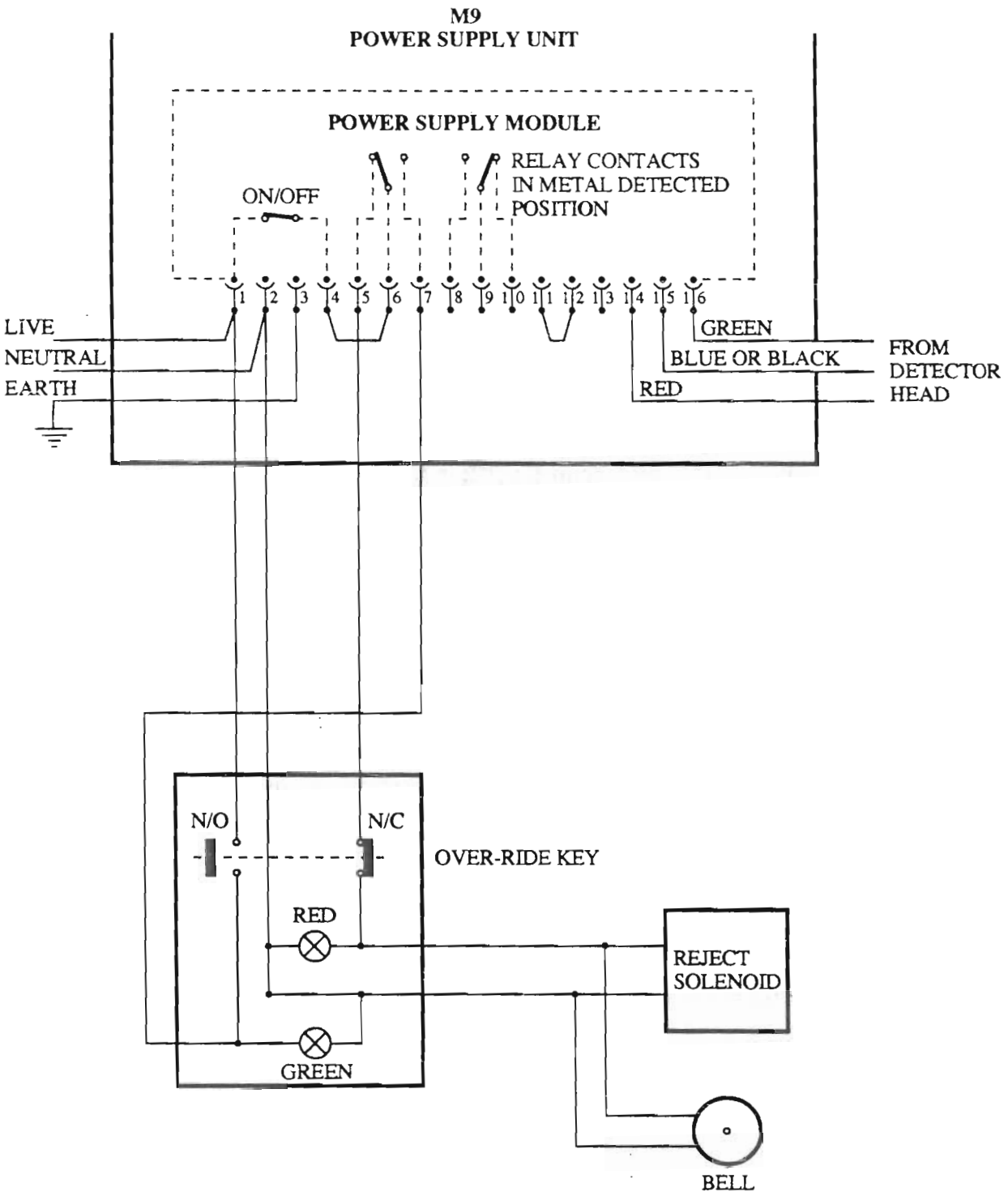


Fig. 2.1.4

2.2 METALCHEK 9 MOUNTING AND INSTALLATION DETAILS

Installing the metal detector

Users who plan to install the Metalchek 9 onto an existing conveyor band or those who intend to construct a special conveyor should study in detail Section 2.3 on factors that can influence metal detector performance. The importance of studying this section and taking note of the information given there is very important indeed. Over 30 years experience with metal detector applications throughout the world has shown that faulty metal detector operation such as random false alarm signals and undue sensitivity to vibration are almost always due to incorrect installation of the Detector Head or some other factors external to the metal detector itself.

Location of Detector Head

The Detector Head should be located to give easy access to the Control Panel and if the detector is to be placed very close to a wall, the detector should be installed with the removable end plate away from the wall.

Metal Free Zone

For optimum performance no metal should be allowed closer to the aperture than as detailed in the Metal Free Zone Section shown in Fig. 2.2.1. This is generally 1.5 times the aperture height for fixed metal and two times the aperture height for moving metal such as rollers, etc.

Mounting the Detector Head

For trouble free and reliable operation it is very important that the Detector Head is correctly mounted, Figs. 2.2.1, 2.2.2 and 2.2.3 show the recommended way of mounting the Detector Head. The Head and any fixing bolts (Fig. 2.2.2) must be insulated from any metal support framework, i.e. there should be no direct metal to metal contact between the Detector Head and any metal supporting structure. Rigid insulation blocks should be used, flexible mountings are *not* recommended. Nothing, including the product, must be allowed to touch any part of the aperture as this could cause wear of the aperture lining and give random false alarms. Any support platform, skid plate, guide rails, throughput pipe or conveyor belt (including the joint in the belt) which passes through the aperture must be completely free of all metal and must not touch any part of the aperture at any time. Care must be taken to ensure that any skid plate does not distort when carrying product and so touch the bottom of the aperture. The packaging on any product to be inspected must be completely free of any metal such as clips, aluminium foil, metallic labels, staples, lids, etc.

An incorrectly installed metal detector is more likely to perform unreliably than almost any other type of electronic equipment.

Mounting the Power Supply Unit

The three core cable attached to the Detector Head must only be connected to Terminals 14 Red, 15 Blue/Black, and 16 Green, in the Power Supply Unit. The standard length of Detector Head cable supplied is 5 metres so the Power Supply should be mounted on a wall or other convenient structure within this cable length. The cable length is not critical and can be increased by the user if essential up to a length of approximately 50 metres. It must not be run in close proximity to heavy current carrying cables.

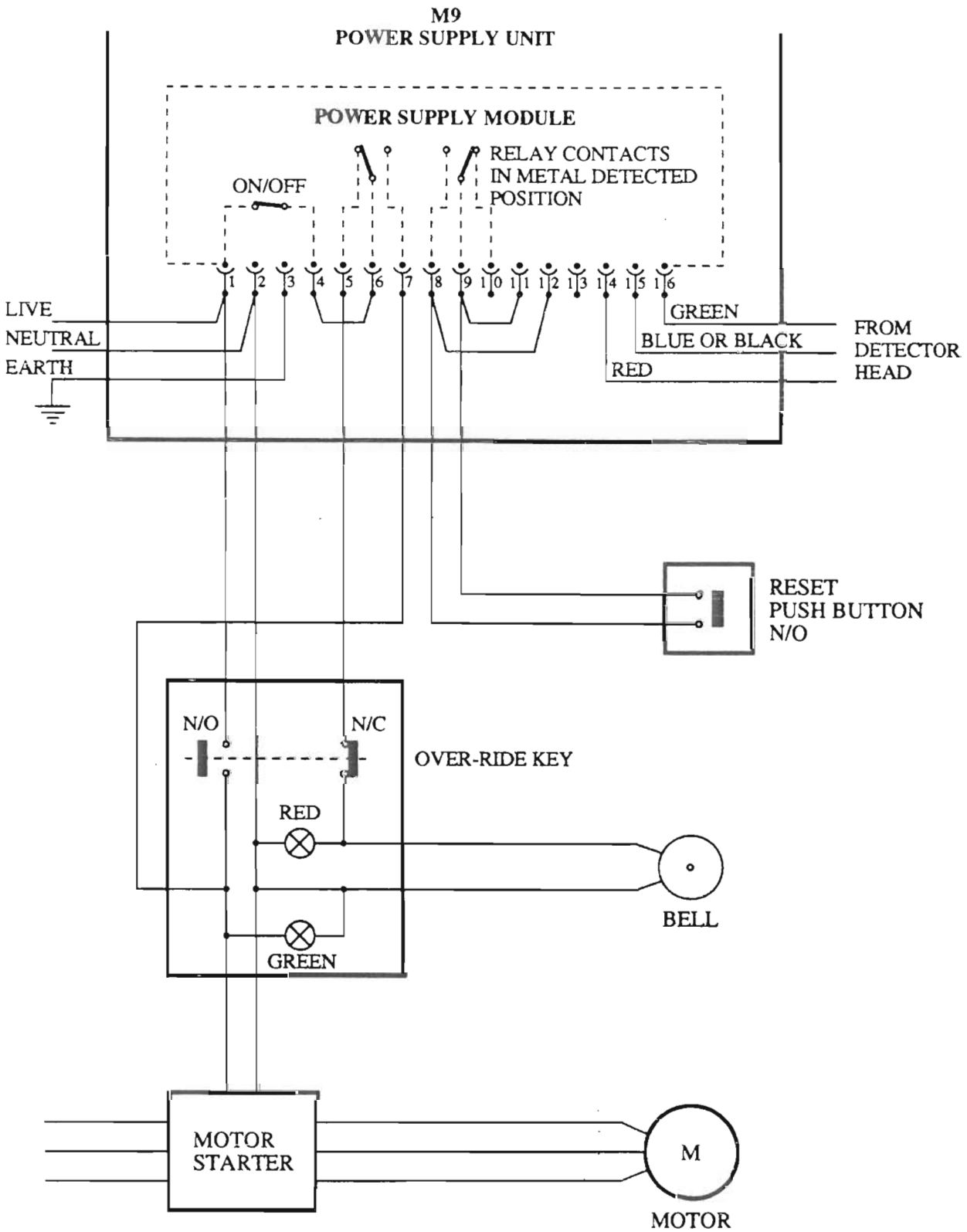
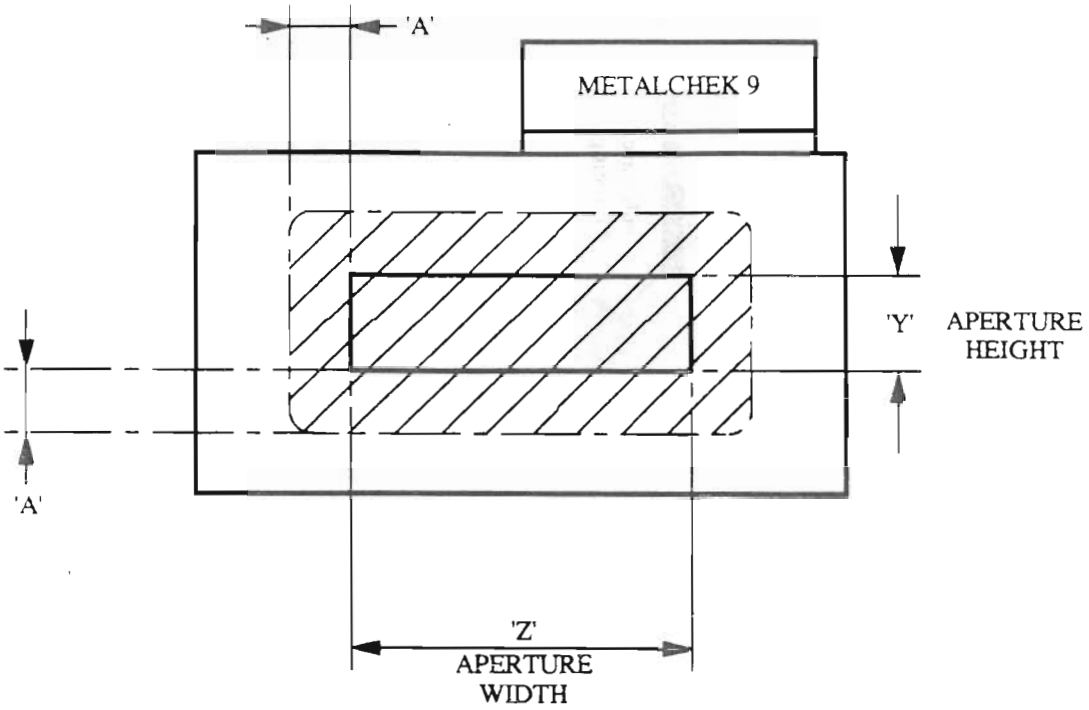
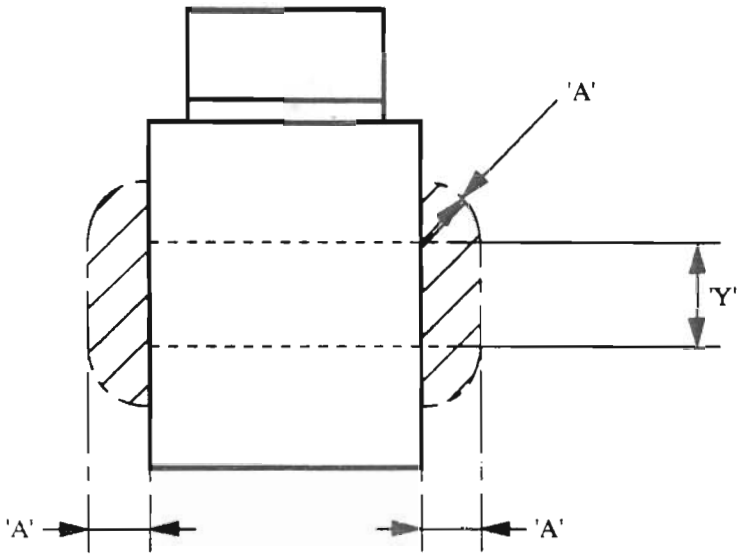

M9
POWER SUPPLY UNIT
POWER SUPPLY MODULE
ON/OFF
RELAY CONTACTS
IN METAL DETECTED
POSITION
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
LIVE
NEUTRAL
EARTH
GREEN
BLUE OR BLACK
RED
FROM
DETECTOR
HEAD
RESET
PUSH BUTTON
N/O
N/O
N/C
OVER-RIDE KEY
RED
BELL
GREEN
MOTOR
STARTER
M
MOTOR

Fig. 2.1.3



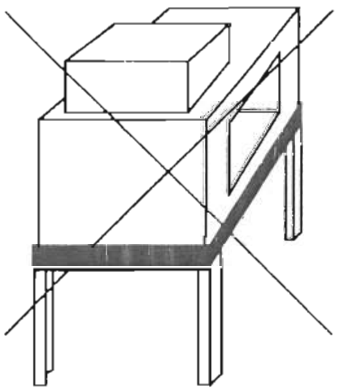


DIMENSION 'A' SHOULD NOT BE LESS THAN
1.5 x 'Y' FOR STATIONARY METAL AND NOT LESS
THAN 2 x 'Y' FOR MOVING METAL

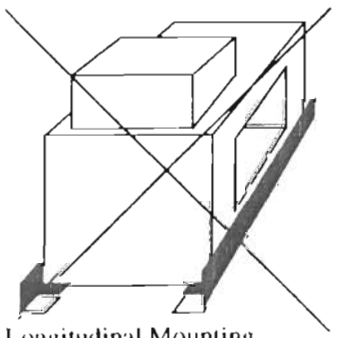
METAL FREE AREA

Fig. 2.2.1

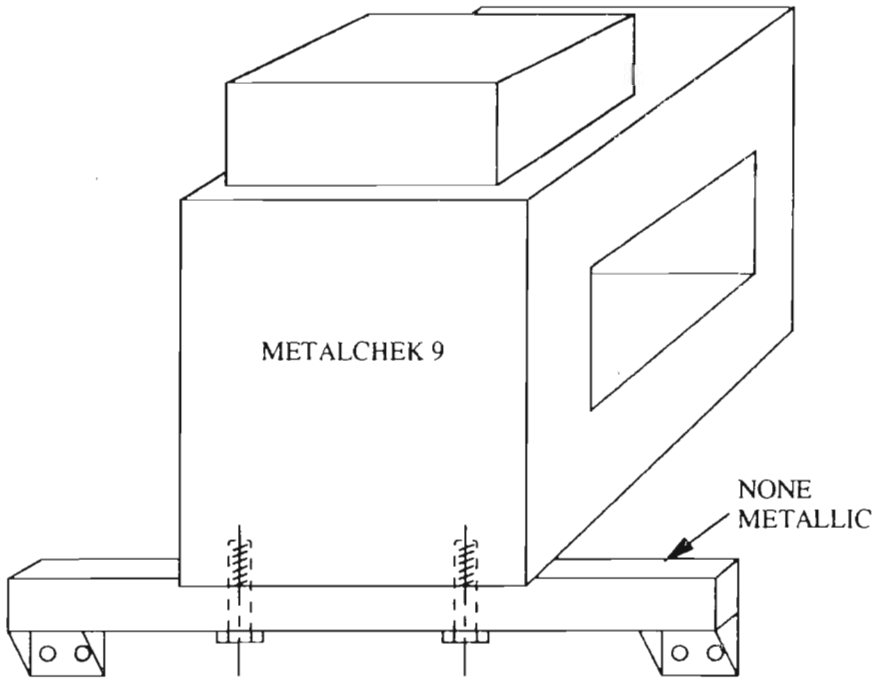
IMPORTANT
PLEASE MOUNT ONLY AS ILLUSTRATED



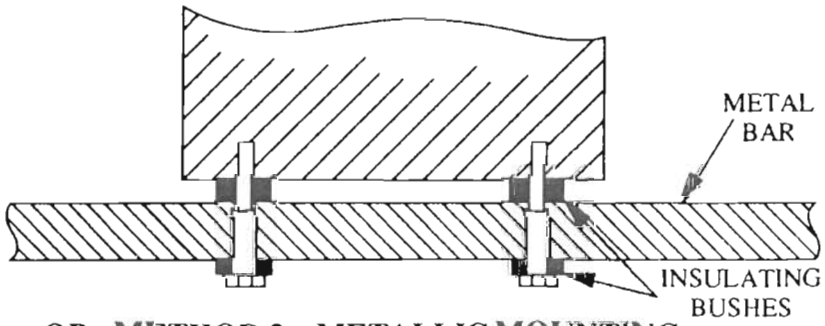
Tray Mounting



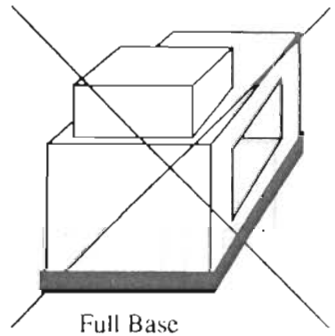
Longitudinal Mounting



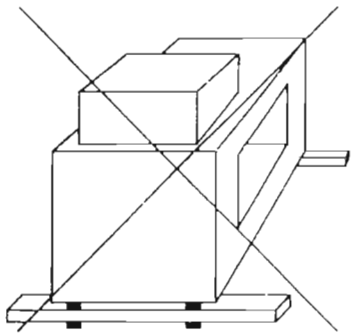
METHOD 1. NONE METALLIC MOUNTING



OR - METHOD 2. METALLIC MOUNTING



Full Base
Mounting



Earthed Mounting

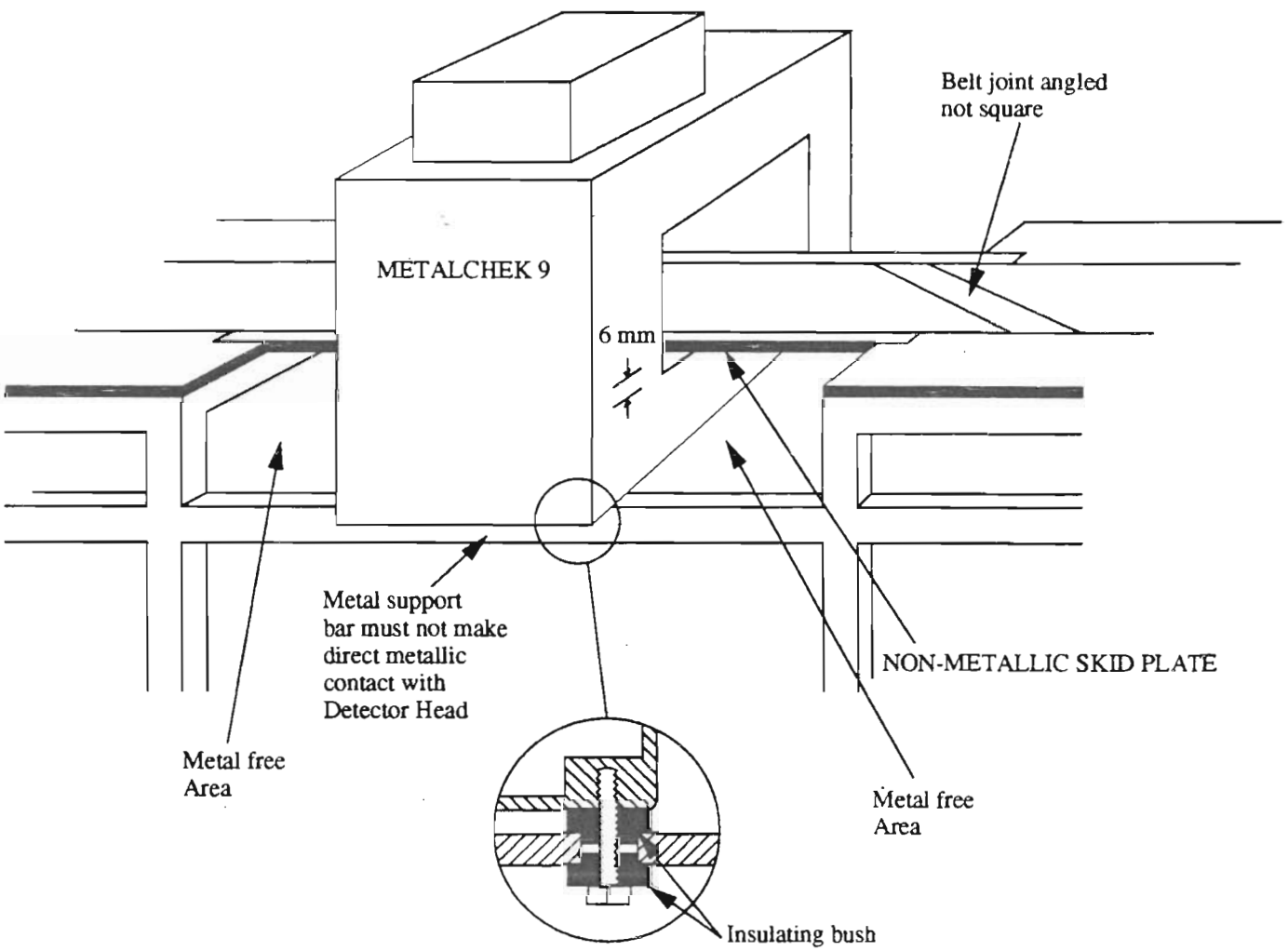
Fig. 2.2.2

Access to the terminal block is obtained by releasing the two screws in the cover.

Electrical connections to the terminal block should then be made according to the details given under Power Supply Unit Terminal Connections.

Metalchek 9 Remote Electronics Package

When the Metalchek 9 is supplied with a remote electronics package the M9 Electronics Module and Power Supply relay assembly are mounted together in a case and connected to the Detector Head by two special screened cables. These screened cables are of fixed length and must be securely fastened. Undue cable movement may cause random false detection alarms.



MOUNTING DETECTOR HEAD

2.3 FACTORS WHICH CAN INFLUENCE THE WORKING OF A METAL DETECTOR

Experience over 30 years has shown that causes external to the metal detector itself are the main reasons for faulty operation or random false triggering. When installing a metal detector on an existing or custom built conveyor system this section should be carefully studied. Only when correctly installed will the equipment be able to give optimum performance. A metal detector may have been correctly installed initially but conditions change, supports get bent or damaged, guide rails get moved. If a metal detector develops fault symptoms such as intermittent triggering the factors in this section should be carefully studied before any electronic servicing is contemplated.

Conveyor Belt

Any conveyor belt passing through the detector must be totally metal free. Sometimes metal particles or grease which has become loaded with metallic dust becomes embedded in the conveyor belt during use especially with woven belts, this contamination will trigger the metal detector each time it passes through the aperture. Plastic, plastic covered or rubber belts should be used whenever possible, the joint in the belt must be made by a non-metallic fastener or vulcanised. The joint must be at an angle diagonally across the belt and not square across the belt. There are two reasons for this, it reduces the possibility of the joint picking up contamination and also the joint passes through the aperture gradually instead of abruptly so that if there is any metallic contamination picked up by the joint it has less effect on the detector.

Anti-static belts which are carbon loaded can cause random alarm signals especially when the detector is operating at a high sensitivity.

Clearances in the Detector Aperture

The conveyor belt, skid plate, product guides or the product itself must be completely free of all metal and must not touch the metal detector aperture in any way whether on the top, bottom or sides of the aperture. Care should be taken to ensure that the skid plate does not distort under load and so touch the bottom of the aperture. A build up of product under the skid plate is a typical cause of false triggering. The belt must not be allowed to wander from side to side and rub on the inside of the aperture as this could damage the aperture lining. Before fitting a skid plate or product guide rails it is useful to check that these are completely metal free by passing them through the detector where possible before installation. Suitable skid plate and product guide materials include Polyethylene, Polypropylene, P.V.C., wood and wood laminates.

Metal in the Packaging Material

The packaging material itself must be totally free from metal clips, fasteners, labels, metallic ink and foil. Certain low grade cardboards contain pieces of metallic foil which may be detected when operating at high sensitivity.

Detector Head Mounting

If the detector head is mounted on a metal framework it should be mounted according to the way shown in Fig. 2.2.1. The metal framework should be of an all welded construction and not screwed or bolted. It should not flex or twist and the detector head itself must be completely insulated from the framework, that is no metal to metal

contact between the head and the metal framework. Any insulating material used should be rigid and not flexible, rubber anti-vibration mounts are not recommended. No metal panel or framework should be within 12mm of the joint on the removable end plate on one end of the detector head.

Vibration and Mechanical Shocks

Some level of vibration is present in most industrial environments and the Metalchek 9 is designed to operate satisfactorily under these conditions. However false triggering may be caused by sudden bumps or by dumping heavy loads onto the conveyor band, particularly when working at very high detection sensitivities. The detector head or conveying unit should not be fixed directly to a vibrating packaging or processing machine.

Electrical Loops (the largest single cause of faulty metal detector operation)

The Search Coil system in the detector head sets up a high frequency electrical field in the aperture, the metal case of the detector head acts as a screen to prevent metal outside the detector head affecting the Search Coil. Some of the high frequency electrical field from the Search Coil however does escape from the aperture through which the product passes. This field can cause very small electrical currents to flow in near-by metal structures which form closed electrical circuits and take power from the Search Coil System. This causes no problem if the loops are completely closed or completely open but if the electrical path is intermittent than false triggering of the detector is likely. Typical causes of intermittent electrical loops include loose bolts on the conveyor or on the metal detector mounting brackets, corrosion of metalwork, broken welds, open hinged doors, conveyor idler rollers, broken or rubbing contacts. Interference can be overcome by opening the conductive path by using an insulated pad or closing the path by welding or tightening the bolts so that it can not become intermittent. Loop problems in rollers can usually be overcome by mounting the idler rollers closest to the detector head on an insulating block. The metal bolts joining the roller to the insulating block should not make metal to metal contact with the conveyor or detector head.

An intermittent closed loop on a conveyor may also be due to lubricated bearings whose balls act as electrical contacts and therefore whose resistance varies as they move through the lubricant. The source of such loop interference can be very elusive and difficult to locate. The higher the aperture in the detector head the greater the high frequency leakage out of the aperture and the greater the possibility of trouble from loops. Problems from electrical loops will be greatly reduced if the detector head is mounted correctly as shown in Figs. 2.2.2 and 2.2.3 and if due care is taken of the metal free zone requirements as shown in Fig. 2.2.1.

Metal objects near the Detector Head

The metal detector is very efficiently screened and large masses of metal near the top, bottom and ends will not affect the detector performance. However metal positioned close to the aperture can cause interference problems if it moves or vibrates. The area close to the aperture which should be kept metal free is known as the metal free zone. This metal free zone is dependent upon the aperture dimensions and the sensitivity setting of the detector. See Fig. 2.2.1 for metal free zone information.

Metal, or metal rollers close to the aperture act as aerials and pass small electrical currents into the conveyor framework, this results in some or all of the following effects.

1. The detector head becomes more sensitive to vibration. If the detector head is accidentally bumped it will cause relative movement between the detector and the offending metal so triggering the detector.

2. The whole framework may become more sensitive to vibration. If the conveyor is able to twist or flex if there are some loose or badly welded joints the electrical currents will be intermittent so triggering the detector. By removing the metal "aerial" from the metal free zone variations in the framework will have minimal effect.

Electrical Interference

The Metalchek 9 has high immunity to electrical interference.

It is always good practice to suppress electrical interference at its source and if trouble is experienced the offending source should be located and suppressed. If this is not possible, it may be necessary to operate the detector at a reduced detection sensitivity. The Relay in the metal detector is often used to control solenoid valves, power contactors and similar electrical devices, when these are switched off the collapsing field of the inductive winding generates a wide band radial frequency interference which may be picked up by the search coil system in the detector head and cause false triggering. A Capacitor of suitable capacity and working voltage connected across the offending device to ground as close to the device as possible will often provide satisfactory suppression.

Detector Head End Plate

On one end of the detector head is a removable End Plate, this is insulated electrically from the main part of the head by a gasket. The electrical screening properties of the detector head are reduced somewhat all along the joint of the End Plate to the head and a limited amount of leakage field escapes. Any large metal object passed across the area of the joint within approximately 12mm may trigger the detector. Care must be taken when mounting and installing the detector head to keep any metal framework away from this jointed area.

3. METALCHEK 9 PHASE SENSITIVE DETECTION AND PRODUCT EFFECT COMPENSATION

Introduction

When a piece of metal passes through the high frequency electrical field in the aperture it distorts the field and produces a small electrical signal which is amplified and if it is large enough operates the detection relay. The amplitude and phase of the signal produced depends mainly upon the size, magnetic permeability and electrical resistance of the piece of metal. Ferrous metals produce large signals whereas some non-ferrous metals which have low magnetic permeability and high electrical resistance such as non-magnetic stainless steel produce only small signals. Because a metal detector is inherently more sensitive to ferrous than to non-ferrous metals special techniques are employed in the Metalchek 9 to equalise as far as possible detection sensitivity to all metals. The detection sensitivity ratio achieved between ferrous and one of the most difficult metals to detect non-magnetic stainless steel type EN58E, 304L, DIN 4306, is approximately 1 to 1.4 when checking products which have no product effect, i.e. ferrous sensitivity is 1mm dia sphere, non-magnetic stainless steel EN58E sensitivity would be approximately 1.4 mm dia sphere.

The automatic balance control circuits in the Metalchek 9 ensure that at all times the search coil system in the Detector Head is operating in a fully balanced condition, in this state the signal produced by the search coil is zero and it corresponds to point A in the vector diagram Fig. 3.1.

When a piece of metal enters the aperture a signal is produced increasing in amplitude to a maximum as it approaches the first detector coil then decreasing back to zero as it passes the centre oscillator coil and increases again with reverse polarity up to a maximum as it approaches the second detector coil and then reduces to zero again as it leaves the aperture.

The vectors on the diagram in Fig. 3.1 indicate the relative amplitude and phase of the signals obtained from different metals of the same size. The oscillator phase represented by the 0-180° vector is used as a reference. The lengths of the various vectors show that a metal detector is inherently more sensitive to ferrous metals than it is to non-ferrous metals and also that it has the lowest sensitivity to the non-magnetic high resistivity stainless steels. Another important feature to notice on the diagram is that vibration applied to the detector head produces a signal along the 90 to 270 axis. The 0-180° oscillator axis is known as the Resistive axis and the 90°-270° as the Reactive axis.

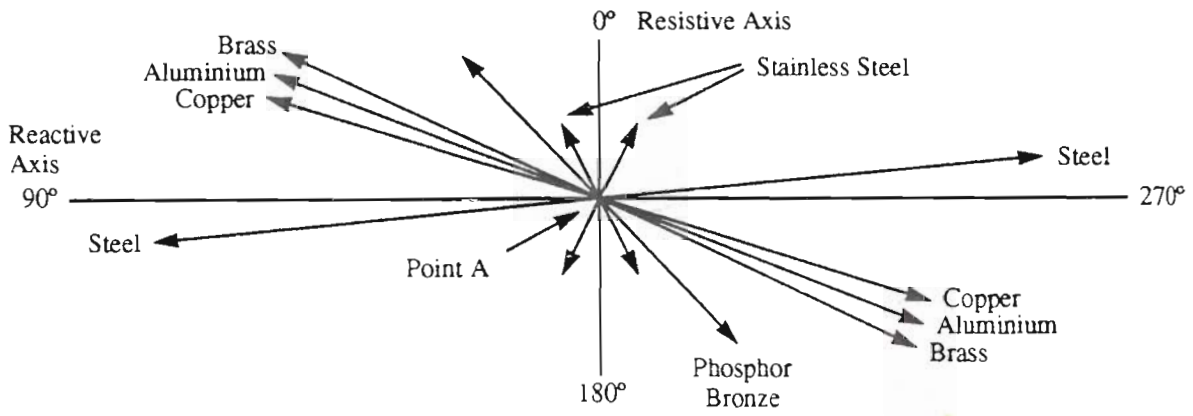


Fig. 3.1 Diagram showing typical amplitude and phase of the signals produced by different metals

Phase Sensitive Detection

The detection sensitivity of the Metalchek 9 is phase sensitive, that is the amount of amplification given to a signal received from the search coil system is dependent upon the phase of that signal with respect to the oscillator axis. The Metalchek 9 detection envelope approximates to that shown in Fig. 3.2. for a signal from the detector head to operate the detection relay it must produce a vector signal large enough to pass through the periphery of the detection envelope. It can be seen from Fig. 3.2 that reactive signals in the 90°-270° plane will have to be very much larger to trigger the relay than resistive signals in the 0-180° plane.

Superimposing the detection envelope in Fig. 3.2 on top of the metal response signals in Fig. 3.1 as shown in Fig. 3.3 indicates how the Metalchek 9 phase discriminator envelope is used to equalise detection sensitivity to different metals, it can be seen that a much larger reactive signal is required from a piece of steel to trigger the relay than resistive signal from a piece of non-magnetic stainless steel. It can also be seen that vibration signals being along the reactive 90°-270° axis also have to be relatively large to trigger the detection relay.

This is the most desirable operating condition of the detection envelope. In this "normal" operating condition it offers maximum immunity to vibration and maximum equalisation of sensitivity to all metals.

When the Product Compensation IN/OUT switch is in the OUT position the Metalchek 9 detection envelope is in this "Normal" condition. Adjusting the Sensitivity control affects the overall amplification of the Metalchek 9, increasing the sensitivity setting increases the amplitude and reducing the sensitivity setting reduces the amplitude of

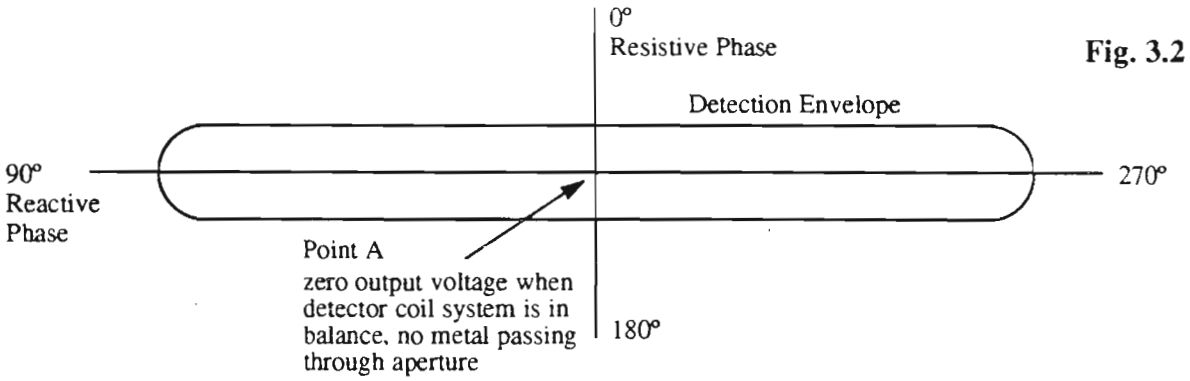


Fig. 3.2

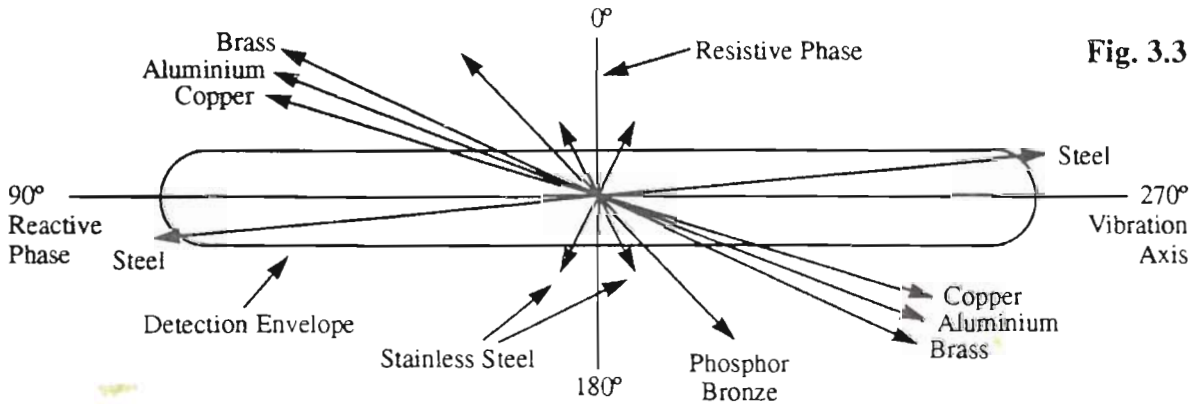


Fig. 3.3

all the vector signals whilst leaving the size of the detection envelope unchanged. Fig. 3.4 shows the amplitude of the vector from a small piece of stainless steel, at the sensitivity control setting being used the vector does not break through the detection envelope and so this piece of metal would not be detected. In Fig. 3.5 the detector is being operated at a higher setting of the sensitivity control, the increased amplification has produced a larger vector signal which now does pass through the detection envelope and will therefore trigger the detection relay.

Fig. 3.4

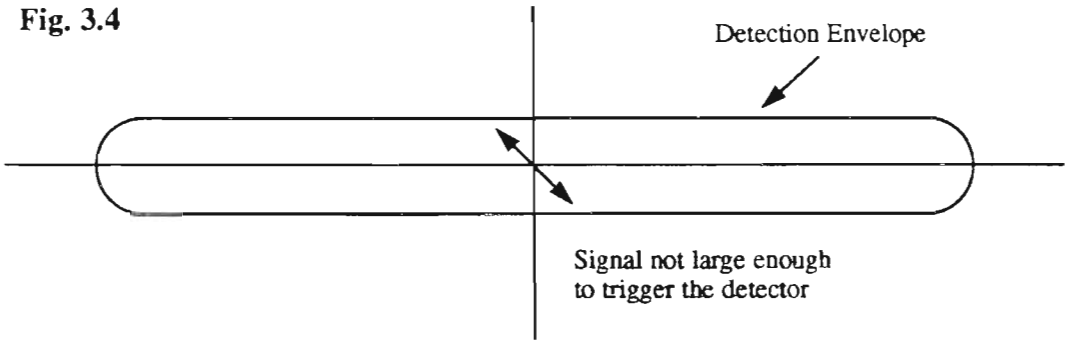
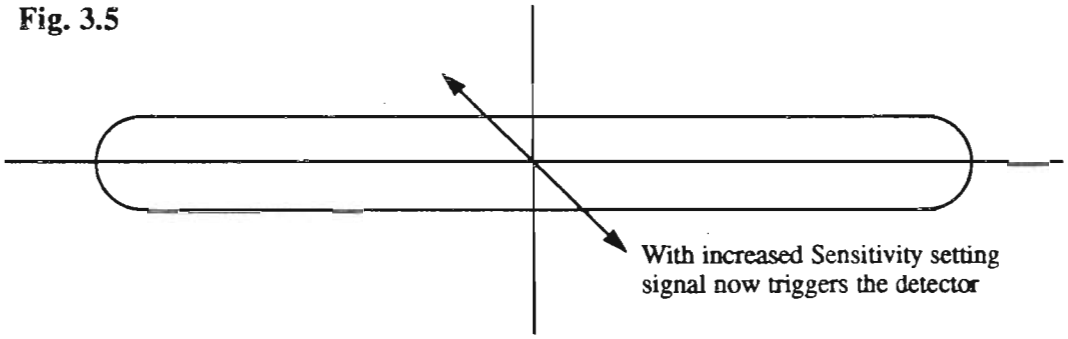


Fig. 3.5



Product Effect Compensator

With the IN/OUT switch set to OUT the Product Compensation Control is inoperative and the detection envelope in its normal position with the major axis along the 90°-270° reactive axis. When the Product Compensation IN/OUT switch is set to the IN position, the Product Compensation Control can rotate the detection envelope from the normal 90°-270° reactive axis at scale setting 0 through the 90°-180° resistive axis at scale setting 5 then back to the 90°-270° reactive axis again at scale setting 10, i.e. the detection envelope can be rotated through a full 180° and set into any required position by adjustment of the Product Compensation Control when the IN/OUT switch is set to IN.

Fig. 3.6 shows the detection envelope positions for three product compensation control settings.

Phase Discrimination used for Product Effect Compensation

Some products referred to as "wet" products are electrically conductive, they influence the detector and are themselves detected even though they do not contain any metallic inclusions. If the metal free product itself triggers the detector it will be necessary to adjust the detector so that its sensitivity to the electrical characteristics of the product is reduced. Product effect compensation Methods A and B are described in Section 1.4. Method B makes use of the phase discrimination facilities in the Metalchek 9 for product effect compensation.

Consideration of the vector diagram Figs. 3.1 to 3.9 will now give a better understanding of what is happening when adjusting the Product Compensation and Sensitivity Controls to compensate for the product effect signal. When "wet" products pass through the aperture they produce a signal which has a specific phase and amplitude depending upon the electrical characteristics of that particular product. Fig. 3.7 is an example of a possible product effect signal.

Fig. 3.6

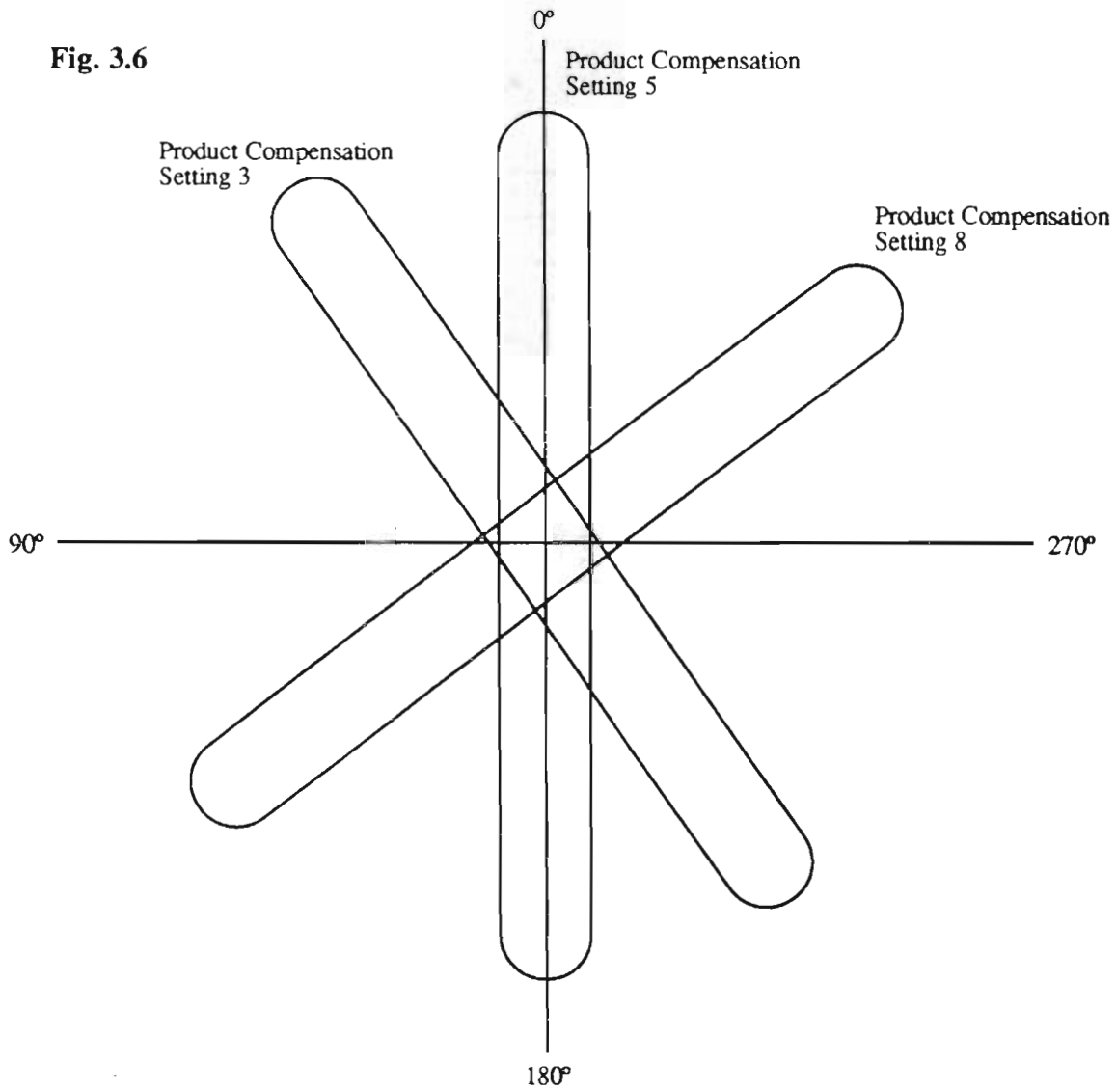
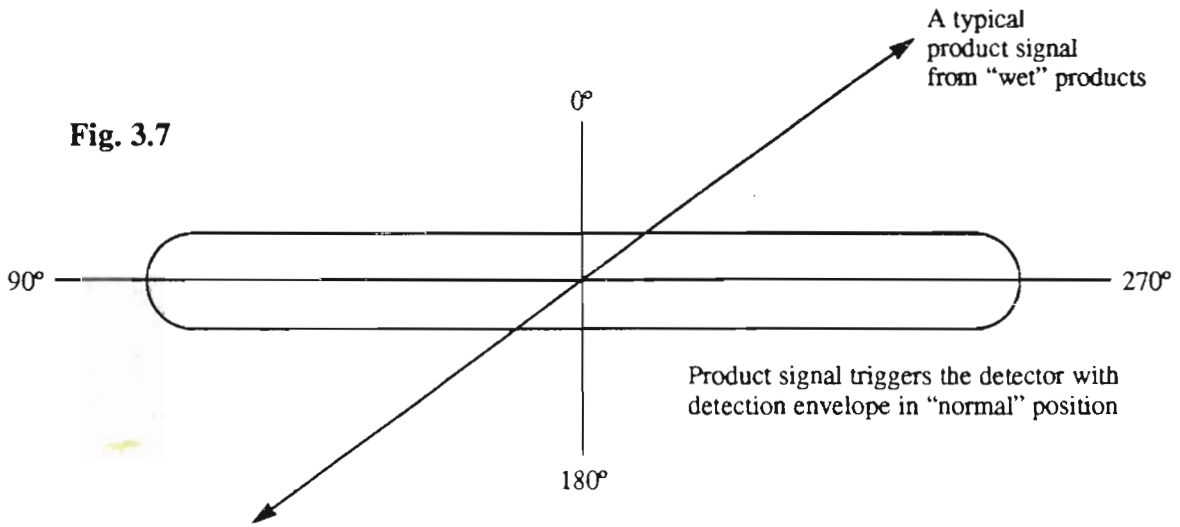
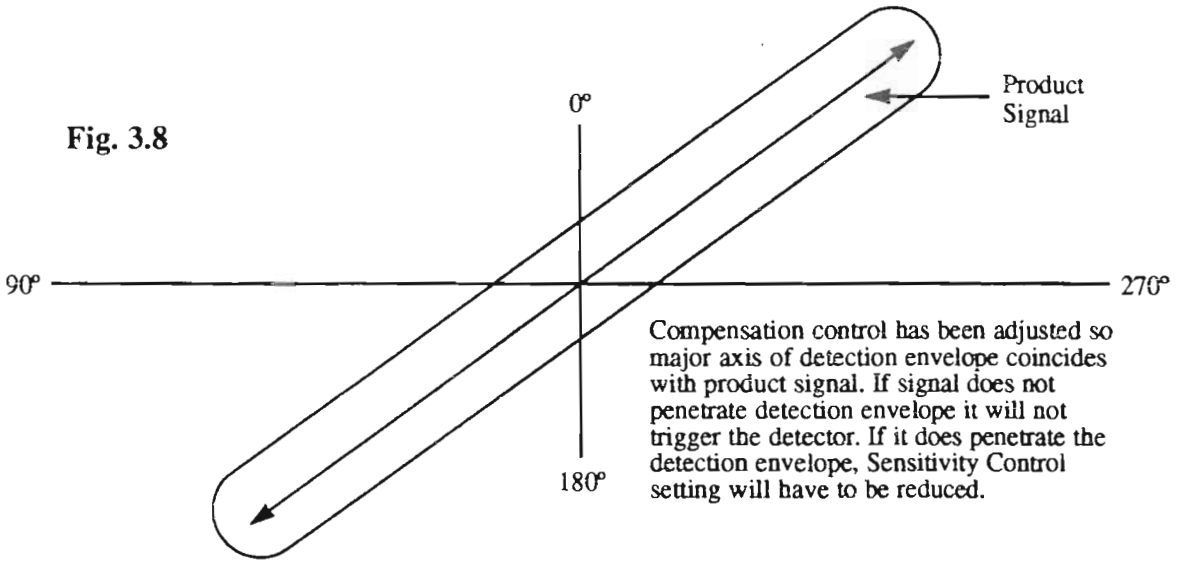


Fig. 3.7



The Product Compensation Control is adjusted until the product effect signal is having the least effect (or no effect) on the performance of the detector. The detection envelope has been rotated by adjustment of the Product Compensation Control until its long axis coincides with the product effect signal Fig. 3.8. The product effect signal may still be large enough to pass through the periphery of the detection envelope and therefore still trigger the relay. Reducing detection sensitivity by turning the Sensitivity Control anti-clockwise reduces the amplitude (length) of the product effect signal (and also the lengths of all other vector signals that may be present) whilst not affecting the size of the detection envelope. When sensitivity has been reduced so that the product effect signal does not pass through the detection envelope the product signal will not trigger the relay.

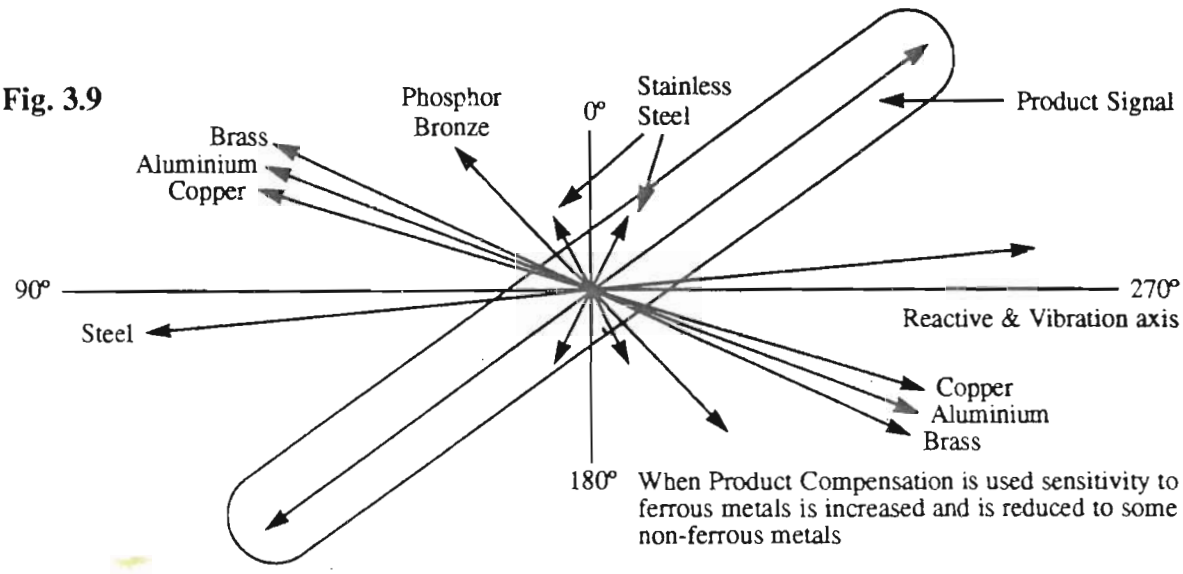
Fig. 3.8



It can be seen from Fig. 3.9 that the detection sensitivity needs to be reduced far less after repositioning the detection envelope than if the envelope is left in its normal position.

Fig. 3.9 also shows when the detection envelope is set in a position other than "normal" the detector becomes more sensitive to reactive signals as obtained from ferrous metals and from vibration, and less sensitive to some resistive signals such as certain types of non-magnetic stainless steel.

Fig. 3.9



In some applications sensitivity to vibration will limit the final sensitivity setting at which the detector may be operated.

It must be understood that the amplitude and phase position of a product effect signal may lie anywhere on the vector diagram and be entirely different to the position given in the above examples.

As a general guide it can be said that product effect signals often lie near to the 0°-180° resistive axis, that is between 4 and 6 on the Product Compensation Control dial. This is the same phase region as the signals obtained from certain non-magnetic high resistance stainless steels and is one of the reasons why with many "wet" products detection sensitivity to stainless steel is often reduced.

4. METALCHEK 9 GENERAL DESCRIPTION AND SPECIFICATION

The Metalchek 9 consists of three main items of equipment, Detector Head, Electronic Module M9 and a Power Supply Relay Unit. The M9 Electronics Module is normally mounted integrally with the Detector Head while the Power Supply Relay Unit can be mounted remote from the Head in any convenient position. The M9 Electronics Module is connected to the Power Supply Relay Unit by a low voltage three core cables. In some Metalchek 9 configurations the M9 Electronics Module is mounted with the Power Supply Relay Unit remotely from the Detector Head and connects to the Detector Head by two special screened cables.

The product to be examined is passed through an aperture in the Detector Head in which a penetrating electromagnetic field is generated and metal no matter how deeply embedded within the product will distort the field and can be detected.

On detection a Relay operates and an alarm light is illuminated. The Relay contacts can be used to stop a conveyor, to sound an audible alarm or to actuate automatic ejection systems.

Automatic Balance Control

The Metalchek 9 has internal automatic balancing circuits which balance the detector Search Coils from switch on and then maintains them in perfect electrical balance at all times ensuring optimum performance even when operating in severe environmental conditions. Automatic balancing removes the need for regular or periodic adjustment to the control settings, this feature along with the self checking circuits incorporated in the Metalchek 9 makes it completely self reliant and it can be operated indefinitely without supervision.

Detection Sensitivity

The sensitivity of a metal detector is governed mainly by the size of the aperture through which the product is passed and is particularly dependent upon the minimum dimension of that aperture. Therefore, in order to obtain a high sensitivity on a given product the aperture size should be kept as small as convenient whilst allowing sufficient clearance around the product to prevent blockages. A wide and low aperture profile will also give a higher sensitivity than a square aperture of the same cross sectional area.

To overcome discrepancies due to the shape of a metal sample sensitivities are always quoted in terms of diameters of spherical samples, this is referred to as "spherical sensitivity".

The following table lists some typical detection sensitivities that can be achieved with the Metalchek 9 when operating in an industrial environment checking materials which have no product effect.

Aperture Size	Diameter Sphere of Ferrous Metal
200mm x 100mm (8 inch x 4 inch)	0.75mm (0.029 inch)
350mm x 125mm (14 inch x 5 inch)	1.00mm (0.039 inch)
500mm x 150mm (20 inch x 6 inch)	1.4mm (0.055 inch)
750mm x 200mm (30 inch x 8 inch)	2.0mm (0.078 inch)

Scaling Factors

Metal detectors are less sensitive to non-ferrous metals than to ferrous metals. A guide to the detection sensitivity of the Metalchek 9 to non-ferrous metals and various grades of stainless steels can be obtained by applying the following scaling factors to the ferrous sensitivity for a particular aperture size.

Ferrous Metal			Scaling Factor 1 x dia ferrous sphere
Non-Ferrous Metal e.g. aluminium, copper, brass, lead, tin, etc.			Scaling Factor 1.1 x dia ferrous sphere
Stainless Steel			
EN58A	302	Din 4300	Scaling Factor 1.1 x dia ferrous sphere
EN60	430	Din 4016	Scaling Factor 1.1 x dia ferrous sphere
EN58J	316	Din 4404	Scaling Factor 1.2 x dia ferrous sphere
EN58E	304L	Din 4306	Scaling Factor 1.4 x dia ferrous sphere

Detectors checking materials that have a product effect may not be able to operate at their maximum level of sensitivity because of product limitation. (See Section on Product Effect Compensation and Phase Discrimination).

Orientation Effects

If a wire sample of a particular metal is passed through the aperture it will be readily detected if the diameter of the wire is equal to or greater than the "spherical sensitivity" in the same metal.

When the diameter of the wire becomes less than the diameter for spherical sensitivity of the same metal then orientation effects will be noticed. The wire will be detected more easily with its long axis presented one way into the aperture than it will when presented in another.

The most sensitive axis depends on the type of metal. Ferrous metals are easier to detect when their long axis passes along the central axis of the aperture in line with the conveyor. Non-ferrous metal is easier to detect with the long axis at right angles to this.

Sensitivity Gradient

Sensitivity is higher around the aperture and somewhat lower along the central axis through the aperture. This variation or sensitivity gradient across the aperture has been kept to a minimum in the Metalchek 9 and is usually less than 2 spherical diameters, i.e. if the spherical sensitivity right on the face of the aperture is 1mm, the sensitivity along the central axis will be approximately 2mm. Quoted sensitivities are always given for the least sensitive area that is along the central axis of the aperture.

Product Effect Compensation

Some products such as bread, meat, sausage, etc. produce an electrical signal when passed through the metal detector making it appear as though there is metal present within the product when in fact there is no metal present at all. This signal is produced because these produce are electrically conductive due mainly to their moisture and salt content. Product compensation is a method by which these effects can be reduced whilst maintaining a high detection sensitivity to actual metal contamination. The Metalchek 9 has a full range of product compensation from a single graduated control. The absence of interaction between this control and any other makes compensation adjustments relatively simple.

Speed of Response

The speed at which product can be passed through the aperture without affecting detection sensitivity has both a maximum and a minimum limitation depending upon the smaller dimension of the aperture. By convention this smaller dimension is referred to as the aperture height. The normal speed of response for the Metalchek 9 can then be defined as follows:

Maximum throughput speed	2.4 metres per minute for each mm of aperture height (200 ft per minute for each inch of aperture height)
Minimum throughput speed	0.036 metres per minute for each mm of aperture height (3 ft per minute for each inch of aperture height)

For example, an aperture 380mm x 50mm would have a maximum throughput speed of 2.4 metres x 50 = 120 metres per minute (aperture size 15" x 2" would have a maximum througput speed of 200 x 2 = 400ft per minute).

Minimum throughput speed in this aperture height would be 0.036 metres per minute x 50 = 1.8 metres per minute minimum throughput speed (3ft per minute x 2 = 6ft per minute minimum speed).

Within this maximum/minimum speed range the detection sensitivity is virtually constant whilst at speeds outside these limits the detection sensitivity would be reduced.

Special versions of Metalchek 9 can be supplied for applications that require operation at speeds which are either above or below these limits. Since most applications are within the standard range, these alternatives are only supplied on request.

Self Checking

The Metalchek 9 has built in fail safe checking circuits which continuously monitor the operating condition of the detector and automatically switches the detection relay into the alarm state and illuminates the Fault Lamp should any kind of fault develop which has the effect of reducing detection sensitivity.

System Check

This optional extra unit provides an overall system checking facility. When a piece of metal has been detected, the System check will check that the complete system including Time Delay, Memory Unit and any mechanical reject system all function correctly.

POWER SUPPLY/RELAY UNIT

The Power Supply and Output Relay are contained within a metal enclosure which is separate from the Detector Head. This unit is connected to the Electronic Control Module in the Detector Head by means of an unscreened three core cable. A cable length of 5 metres is supplied as standard but any length of cable up to approximately 50 metres can be used without detrimental effect.

Line Voltage Selector Range

100V A.C.	+ 10%	- 15%
110/115 V A.C.	+ 10%	- 15%
220V A.C.	+ 10%	- 15%
240V A.C.	+ 10%	- 15%

Terminal Connections

See Connection Sheet.

Line Frequency 50/60 Hz

Maximum Power Consumption 30 VA

Circuit Protection

Transformer secondary fused with a 1 amp fuse, D.C. supply short circuit proof.

The stabilised 20 volt D.C. output can be short-circuited for long periods without endangering the supply.

Relay Output Contacts

2 pairs of changeover contacts.

Relay Contact Rating

250V A.C. at 5 amp non-inductive

Relay Condition

Normally energised if terminals 11 and 12 are linked together. De-energises when metal detected.

Latch or Hold-off Facility

Remove any link between terminals 11 and 12 and connect a normally open push button across terminals 9 and 8. Link terminals 8 to 12 and 9 to 11.

When metal is detected the relay will de-energise and remain de-energised until reset.

Alarm Time

Three alternatives plug in circuit modules are available type 9R, type M18 and type P64.

Timer Type 9R

When metal is detected the relay de-energises immediately and is re-energised after an adjustable time period. Should a second, third, or more pieces of metal be detected during the alarm period, the Timer re-sets for each piece thus extending the alarm time to allow each piece of metal to reach the reject point.

Alarm Time Range

0.25 seconds to 10 seconds.

Applications

For reject mechanisms of various types suitable for deflector flap or plough type systems. Not suitable for the straight ram type of ejector.

Electronic Memory Timer M18

The Electronic Memory Timer M18 provides the appropriate delay signals for operating rejection systems and should be used in place of the type 9R Timer when the rejection position is remote from the detector head and where the time taken for the product to pass from the detector head to the reject point is constant, for example on a fixed-speed conveyor.

The M18 Memory Unit remembers that a piece of metal has been detected but delays the operation of the Relay and Rejection Mechanism until the contaminated product has reached the reject position. The use of the M18 Timer Unit ensures reliable rejection with a minimum of product rejected.

Delay Time Range

0.5 seconds to 18 seconds.

Alarm Time Range

0.25 seconds to 10 seconds.

The length of time for which the rejector remains in the reject position is adjustable by means of the Alarm Time Control.

Environmental Conditions

The Metalchek 9 will operate under the following environmental conditions.

Operating Temperature Range	-10°C to +45°C
Storage Temperature Range	-10°C to +70°C

Dust and Waterproofing

Sealing of Metalchek 9 S.P. is dustproof and splashproof, it is sealed better than specification IP64.

Metalchek 9 H.P. Dustproof and hoseproof to better than specification NEMA4 and IP65.

Metalchek 9 Model H.D.S. Dustproof and suitable for high pressure hoseproof cleaning. Sealed to better than specification NEMA4 and IP66.

To meet the American NEMA4 specification the Detector Head and Control Unit has to withstand a stream of water from a hose 25.4mm diameter nozzle delivering 246 litres of water per minute from all angles at a distance of 3 to 3.6 metres for a period of 5 minutes.

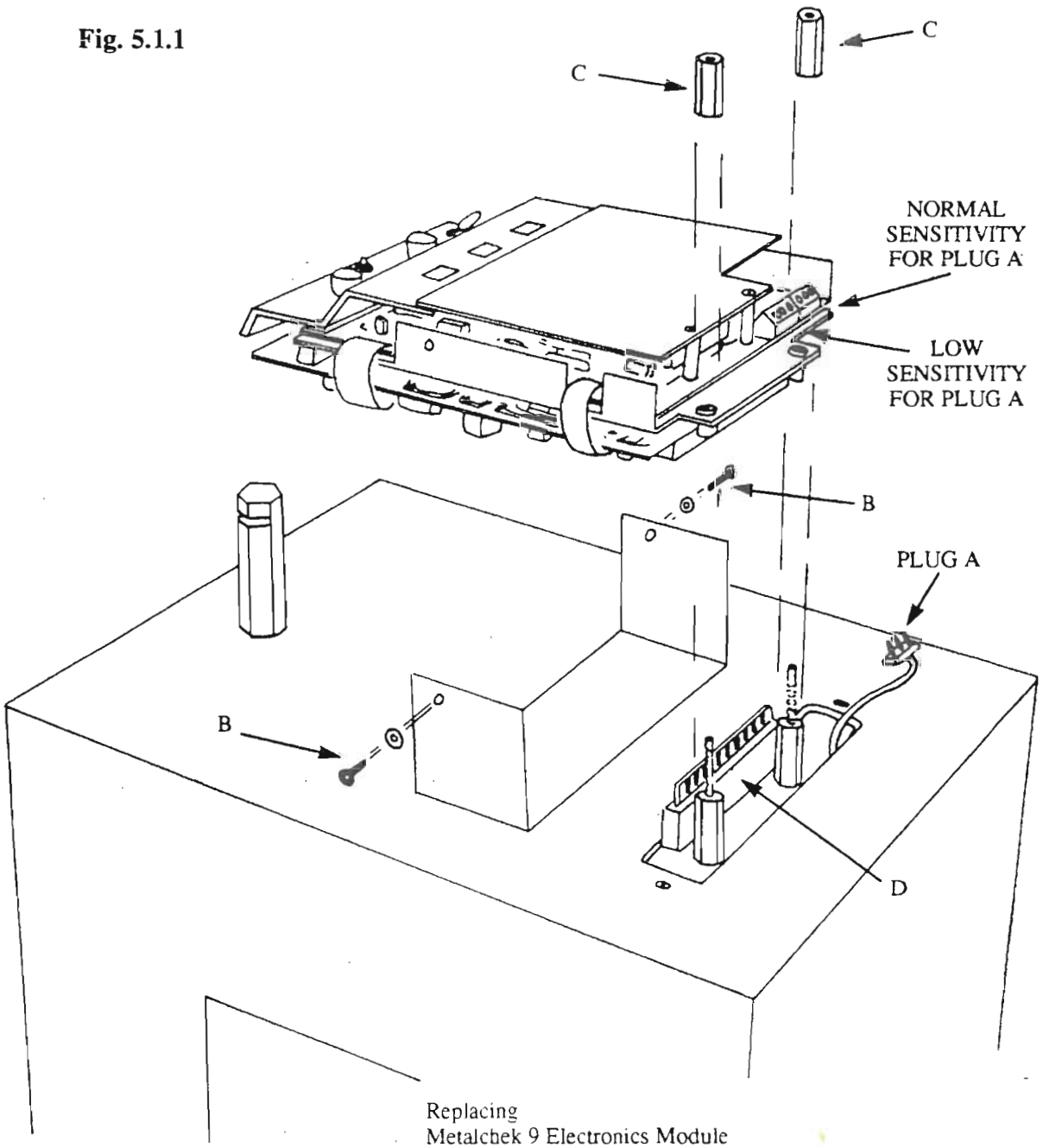
5. SERVICING
REPLACING THE M9 ELECTRONICS MODULE

In the unlikely event of an electronics failure the Metalchek 9 Electronic Module is easily changed, it *must* be replaced by a Module with the same type number. The type number is included in the code number given on the label inside the door of the Control Module Housing. The type number is also given on the label on the back of the M9 Control Module.

Warning:

DO NOT TAMPER WITH THE PRE-SET CONTROLS IN THE DETECTOR HEAD

Fig. 5.1.1



Replacing
Metalchek 9 Electronics Module

5.1 To Replace M9 Module

See Fig. 5.1.1

1. Make sure all electrical supplies have been switched off. Loosen the screws in the 6 pin plug at the bottom of the Control Module and unplug the 3 pin plug. (This plug connects the M9 Electronics Module to the Search Coil System). Note if the plug is in the three right hand terminals (normal sensitivity) or in the three left hand terminals (low sensitivity) Fig. 5.1.1, item A.
2. Loosen the screws on each side of the Module which fasten the Module to the Support Bracket. These screws must be well loosened as the Support Bracket is slightly springy. Fig. 5.1.1, item B.
3. Remove the two screws at the bottom of the Module which fasten it to the Detector Head. Fig. 5.1.1, item C.
4. Make sure the 3 pin plug has been removed from the bottom of the Module, *carefully* lift the Module away from the Detector Head to unplug it from the Connection Block in the Head. Fig. 5.1.1, item D.

Fitting a Replacement M9 Module

1. Make sure the Module has the same type number as the one it is replacing.
2. Very carefully plug the Module into the Connector mounted in the Head, Fig. 5.1.1, item D. Push it fully home making sure the screws Fig. 5.1.1, item B, engage in the slots on each side of the Module.
3. Tighten the two screws Fig. 5.1.1, item C, at the bottom of the Module to fasten it to the Detector Head.
4. Tighten the two screws Fig. 5.1.1, item B, on the side of the Module to fasten it to the Support Bracket.
5. Replace the 3 pin plug at the bottom of the M9 Module into the same terminals as originally. Securely tighten the three retaining screws in the Terminal Block. Loose screws will cause random false triggering.

The Module is now ready for use. Set Sensitivity Control, Product Compensation Control and IN/OUT Switch to the same positions as on the old Module or alternatively follow the initial setting up operating instructions given in the manual.

5.2 Replacing the Power Supply and Timer Module

Make sure the incoming supply voltage is switched off. The Power Supply and Timer can be easily replaced because the Terminal Block unplugs from the Power Supply Chassis so there is no need to disconnect all the incoming leads. Do not remove the cover from the Terminal Block.

1. Remove the two outside screws. Fig. 2.1.1.A, from the terminal Block and carefully unplug the Terminal Block from the Power Supply Unit.
2. Remove the two Power Supply Chassis retaining screws, Fig. 2.1.1.B. Carefully lift the Power Supply Assembly out of the box.

Before fitting a new Power Supply Assembly make sure the voltage select lead is securely inserted into its correct terminal according to the incoming supply voltage from which it is to be used.

LOCK

INSPECTION SYSTEMS LTD

LOCK INSPECTION SYSTEMS LTD

Neville Street, Oldham OL9 6LF, Lancs, England.
Tel: 0161-624 0333 Fax: 0161-624 5181

LOCK INSPECTION SYSTEMS INC

207 Authority Drive, Fitchburg, MA 01420-6094.
Tel: (508) 343-3716/(800) 227-5539 Fax: (508) 343-6278

LOCK INSPECTION SYSTEMS (SCHWEIZ)

Bahnhofstrasse 52, 8001 Zurich, Switzerland.
Tel: 01 214 6709 Fax: 01 401 1290

LOCK INSPECTION SYSTEMS GMBH

Postsach 100427, D-41704 Viersen, Germany.
Tel: 02162 13588 Fax: 02162 13642

For service overseas contact your local Authorised Distributor of Lock Metaldetectors

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