

# 動詞中心例文集

(無謀、大変無謀な挑戦かもしれませんが、でもがんばりますので応援してください。)

## 趣旨

このセクションの趣旨はあくまでも翻訳・通訳に従事している皆様のお役に立つことを目的にしています。30年以上も翻訳と通訳に従事してきました私ですが、人生も残り少なくなってきました。何か日本の経済界に役立つことはないかと考え、永遠と続く諸外国との貿易、交流等に役立つサイトを後世に残したいとの思いでこのサイトを立ち上げました。一生勉強ですが、今まで自分が経験してきた間違い等を公開することによって、できるだけ正しい英語表現が実現するように望んでおります。日本人の書いた英語は読みづらい、間違いが多い、抽象的過ぎて分かりにくい、などなど、批評は様々です。時間が許す限りできるだけ多くの例文を掲載してまいります。尚、まだまだ未熟な私の間違っただけの訳がありましたら、ご遠慮なくご指摘ください。よろしくお願いたします。

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このセクションでは動詞を中心とした多くの例文を掲載していきます。特に和文英訳に関係している方々にお役に立てれば幸いです。工業英語を中心に掲載していきますが、もともと日常会話の英語とか工業英語等の区分けは利便性を考えて名づけただけで、英語に境目はありません。できるだけ多くの例文を掲載して、簡単なものからよく日本人が迷うような動詞の使い方を中心に、翻訳者がどの動詞を使うことが適切であるか理解できるようにしてあります。なぜ動詞が中心かというと、英語は動詞でできていると言っても過言ではないほど、動詞の使い方が重要となります。

このサイトの使い方は、Adobe 社の Acrobat が必要となりますが、[検索機能](#)や[しおり機能](#)等を利用して、自分の知りたい用語（日本語でも英語でもよい）を選び、その例文を参照するようにしてください。

## 概 要

スクリーン印刷装置 1 (日本語訳文付き)

スクリーン印刷装置 2 (日本語訳予定)

ドアの修復 (日本語訳文付き)

窓の修復 (日本語訳予定)

----- スクリーン印刷装置 -----

SCREEN PRINTING MANUAL (BOOK 1)

[スクリーン印刷取扱説明書 \(第一巻\)](#)

TECHNICAL REFERENCE MANUAL

[技術参考書](#)

INTRODUCTION

## はじめに

### Manual Format

#### マニュアルの構成

It is advisable to read through the Technical Reference Manual first and be familiar with the machine by comparing the components, sensors and assemblies as shown on the machine overviews of Chapter 2 with the actual machine. 最初に技術参考書を読んで、その後第二章のマシンの概要に示してある部品、センサー、及びアセンブリと実際のマシンを比べ、マシンに慣れるようにしてください。

The Technical Reference Manual is divided into 13 chapters.

技術参考書は13の章に分かれています。

Chapter 1 Safety Features, describes the features on the machine that provides the operator safety while the machine is in operation.

第一章 安全機能： マシンが動作中にオペレータを安全に守るためのマシン上の機能について説明しています。

Chapter 2 Machine Overview, with diagrams showing the position of various functions, sensors and assemblies on and around the machine.

第二章 装置の概要： マシン上、及び機械回りの各種機能、センサ、及びアセンブリの位置を図面で示しています。

Chapter 3 Technical Description, describes in detail the sequence of operation of various modules on the machine.

第三章 技術に関する説明： マシンに使われている各種モジュールの動作の流れを詳細に説明しています。

(日本人にはモジュールとは実際に何を指しているのかピンとこない場合が多いようです。モジュールとは“機能単位としての部品集合体”の意味ですが、このマニュアル内では具体的にはマシンに使われている個々の装置、例えば認識装置などを指します。)

Chapter 4 Error Messages, lists and advices on the recovery of each error message reported.

第四章 エラー・メッセージ： 報告されたそれぞれのエラー・メッセージのリストとエラーの解除に関するアドバイスが示してあります。

Chapter 5 Diagnostics, lists and describes the operation of individual diagnostic routings available on the machine.

第五章 装置診断： 装置上で使用可能な各診断工程をリストアップし、その動作の流れを説明しています。

Chapter 6 Electronic Enclosures, shows the electronic cards position in the enclosures and gives a description of the function and configuration of each individual card.

第六章 電子装置： 装置内の電子基板の位置を示すと共に、個別の基板の機能と構成を説明しています。

Chapter 7 Calibration and Settings, gives step by step guidance for calibrating and setting modules on the machine.

This chapter will also give opto and switch adjustments necessary for correct machine operation.

第七章 キャリブレーションと設定： マシンに取り付けられているモジュールのキャリブレーション（較正）と設定の方法を順序を追って説明してあります。

マシンを正しく操作するために必要とされるオプト（光学装置）及びスイッチの調整方法も説明しています。

Chapter 8 Sensor Listing, lists all sensors used on the machine and gives the part number and input ports displayed in the diagnostic menu.

第八章 センサー一覧： マシンに使用されているすべてのセンサをリストアップし、診断メニューに表示される部品番号や入力ポートを記載しています。

Chapter 9 Preventive Maintenance Schedule, specifies the schedule for maintaining the machine periodically and shows personnel classification.

## 第九章 保守・点検： マシンの定期保守とオペレータの分類

Chapter 10 Recommended Spares, lists the consumable packs required to maintain the machine throughout its life span.

第十章 推奨スペア部品： マシンが寿命に達するまでのマシンの保守に必要な消耗部品（パックになっている）をリストアップしています。

Chapter 11 Replacement Procedures, details the procedures for removal, replacement and any subsequent checks and tests of components listed in the 1,2 and 5 year service packs,(Chapter 10 refers).

第十一章 交換手順： 取り外し、交換作業、及びその後の1.2と5年保守用パック（第十章参照）の部品の確認とテストの手順を詳細に示しています。

Chapter 12 Electrical Circuit Listing, lists the electrical circuits on the machine and gives description and drawing reference numbers.

第十二章 電気回路図： マシンに使用されている電気回路をリストアップし、説明と参照図番を示しています。

Chapter 13 General Assembly Listing, lists the mechanical assemblies on the machine and gives description and drawing reference numbers.

第十三章 総体的なアセンブリのリスト： 装置に使われているメカ・アセンブリをリストアップし、その説明と参照図番を示しています。

## CHAPTER 1

### 第一章

Safety features provides safe operating conditions for the machine.

安全機能により安全なマシン操作の条件が与えられています。

The machine is fitted with an emergency safety shut-down press button switch.

マシンは緊急安全遮断押しボタンスイッチを備えています。

External modules in the line can be fitted for connection to a common cable loop line, that provides automatic shut down of all modules, if any single emergency switch is operated, or any frame cover is disturbed during normal operation of the line.

いずれかの緊急停止スイッチが押された場合、またはフレーム・カバーがラインの通常の操作中に開けられた場合、すべてのモジュール（装置）の電源を自動的に遮断する共通ケーブル・ループ回路への接続用に外部モジュールを付けることができます。

Covers fitted with safety interlock switches protect operating personnel from the moving mechanisms.

安全インターロック・スイッチを備えたカバーによってオペレータは可動部から守られています。

Transparent plastic access covers are fitted over for moving mechanisms of the machine and steel safety covers control access to the frame of the module.

可動部に対しては透明なプラスチック・カバーを備え、モジュールのフレームへのアクセス（出入り）を制限するためにスチール製のカバーが取り付けられています。

## PROTECTION FROM HIGH VOLTAGE

### 高電圧保護

#### Mechanisms

##### 仕組み

Machine mechanisms are powered 24 V only and do not pose an electrical hazard to personnel.

マシンのメカ部分は24Vの電圧が印加されますので、オペレータに電気的な危害が及ばないようにしてください。

220/110 V

220/110 ボルト

Where (220/110V) incoming supply voltages are present, protection is afforded by controlling access to the enclosures that house the supply.

供給ボルトが220Vまたは110Vである場合、電源供給装置を収納している囲い内へのアクセスを制限することによってオペレータを保護しています。

The machine is fitted with an interlock isolator switch that cuts power to terminations down stream of the isolator, for example the isolator enclosure. Insulating shrouds offer protection at the isolator switch incoming power terminals.

マシンにはアイソレータの電流の流れに対し電源供給停止をするインターロック・アイソレータ・スイッチが付いています。

Hazard Warning

危険警告

Hazard warning labels "Danger High Voltage", are placed on the outside of enclosures where high voltage (220/110V) terminations are present within and the enclosure is not fitted with a safety interlock.

内部に高電圧(220/110V)終端があり、安全インターロックを備えていないエンクロージャー(囲い物)の外側には危険警告ラベル“危険!高電圧”が貼られています。

Inadvertent access to such enclosures is prevented by the presence of the frame covers.

うっかりしてこのようなエンクロージャーにアクセスするのを防ぐために、フレーム・カバーが備わっています。

EMERGENCY SHUT-DOWN

緊急停止

The machine is fitted with an Emergency shut-down push button switch located on the right hand side of the machine front cover.

マシンの前面カバーの右側には緊急停止押しボタン・スイッチが付いています。

An additional push button is located on the lefthand side of the head cover, this is an optional extra.

ヘッド・カバーの左側には追加のプッシュ・ボタンを付けることができます。(オプション)

Recovery

復帰

When the normal working condition is restored, and the relevant cover is closed then the machine will carry on and complete the cycle.

通常の動作状態が復旧され、関連カバーを閉めると、マシンが動作を継続して一連の動作を完了します。

STEEL FRAME COVERS

スチール製フレーム・カバー類

Frame covers are fitted with safety interlock switches similarly connected to the emergency loop line.

フレーム・カバーには緊急ループ回路に同様に接続されている安全インターロック・スイッチが備わっています。

Removing the cover has the same effect as pressing the Emergency stop button, cutting 24 V power to the

mechanisms of all modules connected into the loop line shuts-down.

カバーを外すことは緊急停止ボタンを押すことと同じ効果をもたらします。つまり、ループ回路遮断装置に接続されているすべてのモジュール（装置）のメカ部分に供給されている 24V の電源を遮断します。

Indication that a cover has been removed (or the E-stop has been pressed) is given by an error message displayed on the control VDU.

カバーが取り外されたか（緊急停止ボタンが押されたか）の判断は、コントロール VDU に異常メッセージとして表示されます。

Recovery

復旧手順

When the cover is re-positioned, normal working condition is restored and the line may be restarted;

カバーを再度取り付けた場合、通常の動作状態に戻り、その回路が再作動します。つまり、

pressing the green system button at the control VDU will enable the machines re-initialization procedure, where this is allowed by the control system.

コントロール VDU の緑のシステム・ボタンを押すことにより、コントロール・システムによって許可されるマシンの再初期化プロセスが実行可能となります。

TWO BUTTON SAFETY SWITCHES

2 ボタン式安全スイッチ

Located at the front of the machine, are the two button safety switches.

2 ボタン式安全スイッチがマシンの前面に備わっています。

The positioning of these buttons are needed to maintain maximum safety for the operator when operating a particular function.

特定の機能を動作させている場合、オペレータの安全を最大限に維持するために、これらのボタンが備わっています。

The two buttons have to be pressed simultaneously to become active.

この二つのボタンを動作させるには、同時に二つのボタンを押さなければなりません。

The use of these buttons are dependent on the function selected at the VDU.

このボタンを使用するか使用しないかは、VDU でその機能を選ぶか否かによります。

For example:

例えば

-Head Lift Up/Down (ヘッド・リフトの上下)

-Board Width (基板幅)

-Load Width (負荷幅)

PRINTHEAD LIFT SUPPORT ASSEMBLY

印刷ヘッド・リフト・サポート・アセンブリ

Function

機能

For the protection of personnel when working beneath the printhead with the printhead raised, a Head Support Assembly, Part No 112975, is provided to mechanically secure the printhead in the raised position.

印刷ヘッドを上げた状態で印刷ヘッドの真下で作業しているオペレータを守るために、メカ的に印刷ヘッドを上げた状態で固定させるヘッド・サポート・アセンブリ（部品番号：112975）が取り付けられています。

The support should be used at all times that the printhead is raised and stowed by the machine when not in use.  
マシンを使用しない場合は、印刷ヘッドを上げ、マシンに収納された状態にするようにサポートを常に使用するようになしてください。

The support assembly is colored red and incorporates an internal spring for ease of installation and removal.  
サポート・アセンブリは赤に色づけされ、取り付けと取り外しが楽できるように内部スプリングが組み込まれています。

With the head raised the assembly is positioned to the front left hand side of the machine in the electro-magnetic sockets, ensure that the black end of the support is at the bottom and the silver end at the top.  
ヘッドを上げた状態で、アセンブリは電磁ソケットのマシン前面の左側に位置決めされています。サポートの黒い方が下になっており、シルバー側が上になっていることを確認してください。

#### CAUTION

注意

#### IMPORTANT

重要

The support assembly must be removed prior to selecting printhead lowered.  
サポート・アセンブリは印刷ヘッドを下げることを選択する前に取り外してください。

If an attempt is made to lower the printhead with the support assembly installed, damage to the printhead, actuator and drive card (基板) may occur.  
サポート・アセンブリを取り付けている状態で印刷ヘッドを下げようとした場合、印刷ヘッドが損傷し、アクチュエータとドライブ基板がだめになる恐れがあります。

## CHAPTER 2 MACHINE OVERVIEWS

### 第二章 マシンの概要

すべてイラストで示されているので省略

## CHAPTER 3 TECHNICAL DESCRIPTION

### 第三章 技術に関する説明

#### CAMERA CARRIAGE

カメラ・キャリッジ

The camera carriage can be divided into two sections, the 'X' movement and the 'Y' movement.  
カメラ・キャリッジは“ X 方向移動 ”と“ Y 方向移動 ”の二つの部分に分かれています。

The 'X' movement is defined by the feed direction as facing the front of the machine and the 'Y' movement is defined by the direction of the print stroke as facing the front of the machine.  
“ X 方向移動 ” はマシン前面に向かって送り方向を指し、“ Y 方向移動 ” はマシン前面に向かって印刷ストローク方向を指します。

The carriage is driven by a dc servo motor which has an encoder attached to the motor.  
モータ部分にエンコーダが取り付けられている DC サーボモータによってキャリッジは駆動されます。

The motor is driven from an optimize control card which is housed in the electronic enclosure Y1 position X2.  
モータは電子エンクロージャ Y1、X2 に入っている最適化コントロール基板で駆動されています。

Utilizing together, the dc servo motor and encoder, provides high positional accuracy.  
両方を使うことによって、DC サーボモータとエンコーダが高精度の位置決めを可能としています。

The camera carriage houses the telecentric camera which also houses the board stop.  
カメラ・キャリッジには基板ストッパを収納しているテレセントリック・カメラが取り付けられています。

The single roving (うろちょろ動き回るの意) camera allows speed and flexibility in locating fiducials (認識マーク) during the print cycle.

単動移動カメラによって印刷サイクル(印刷の一連の動作)中に認識マークを探し出すスピードと柔軟性が可能となっています。

(Fiducial とは“天文学上の基準点の意が普通であるが、ここでは認識システムに使用する認識するためのマークを指しています。)

The camera itself can view both the board fiducials and the screen fiducials by opening the relevant shutter.  
カメラ自体は関連シャッタを開くことによって基板認識マークとスクリーン認識マークの両方を見ることができません。

These shutters and the board stop are controlled pneumatically.  
これらのシャッタと基板ストッパは空圧によって制御されます。

When the machine is first powered up, an initialization routine is implemented.  
マシンを最初に起動した場合、初期化処理が実施されます。

This routine for the camera carriage consists of driving the camera in X and Y until the home sensors are detected.  
カメラ・キャリッジのためのこの処理は定位置センサが検知されるまで、X と Y 方向にカメラを駆動することによって成り立っています。

The carriage is then driven out of the sensor until the first index pulse of the encoder is detected then stops.  
その時、キャリッジはエンコーダの最初のインデックス(割り付け)パルスが検知されるまでセンサ範囲外に移動し停止します。

This position then equates to zero counts on the encoder.  
その時のこの位置はエンコーダではゼロ・カウントに相当します。

To insure against machine damage, limit sensors are fitted at either end of each carriage axis.  
マシンへの損傷を防ぐため、各キャリッジ軸の片方にリミット・センサが取り付けられています。

These sensors detect an overrun on the carriage and if detected will report an error message, either Camera X-Axis error or Camera Y-Axis error.  
これらのセンサはキャリッジ上のオーバーラン(逸脱)を感知し、オーバーランが感知された場合はエラー・メッセージ(カメラ X 軸エラーまたはカメラ Y 軸エラー)を出します。

For camera carriage to accurately calculate and position itself over the entire working area, a reference fiducial is positioned on the front rail.  
動作領域全体に渡り正確にカメラの動きを算出し位置決めするために、基準認識マークをフロント・レールに付けてあります。

The home positions are only rough initial settings, therefore, a reference fiducial, positioned on the center of the front rail, is used so that the camera carriage can calculate the board stop and fiducial positions to a closer tolerance.

定位置は最初はおおざっぱに設定されています。したがって、フロント・レールの中央にある基準認識マークを使用して、基板停止位置と認識マーク位置をカメラ・キャリッジができるだけ許容値に近くなるようにしてあります。

This function is carried out in diagnostics and is then stored as part of the printer configuration file on to hard disk. この機能は診断処理の中で実施され、プリンタのコンフィギュレーション（構成）ファイルの一部としてハードディスクに保存されます。

This diagnostic routine needs only to be initiated if the home sensor is replaced or the vane has been removed. この診断処理は定位置センサを交換した場合やペーン（羽板）を取り外した場合は初期化のみを必要とします。

## PRINT CARRIAGE POSITIONING

### 印刷キャリッジの位置決め

The print carriage mechanism moves the pressure assembly along the print stroke length. 印刷キャリッジのメカ部分は印刷ストローク長に沿って圧力アセンブリを動かします。

The stroke length is automatically set when the board width parameter is set. ストローク長は基板幅パラメータが設定されると自動的にセットされます。

When the initialization routine is initiated, the print carriage will move to its home position sensor(rear of the machine).

初期化処理が開始すると、印刷キャリッジはその定位置センサ（マシンの後部にある）へと移動します。

When the sensor change has been detected, the motor will reverse its direction at slow speed until the sensor clears, at this point the motor will stop.

センサの変化が感知されると、モータはセンサがクリア（この時点でモータは停止）されるまで、低速で逆転します。

This is defined as its start position or zero count for the encoder to position the carriage.

これがエンコーダがキャリッジの位置決めするための開始位置またはゼロ点（原点）として定義されます。

## MACHINE PRINT CYCLE

### マシンの印刷サイクル

The routine of the following machine print cycle will be described for Step mode.

以下のマシンの印刷サイクル処理は“ステップ”モードに関して説明されています。

1. Press Run and the camera will position itself to the board stop co-ordinates.

1. [運転] ボタンを押すと、カメラは基板ストップ位置（座標）にカメラ自体を位置決めします。

The board stop will lower into position ready for the incoming board.

基板ストップは搬入されてくる基板を受け入れる準備位置へと下がります。

2. Press Auto Board and the board will be transported into the machine stopping at the board stop, the belts will stop running as soon as the board stop sensor detects the board.

2. [自動基板] ボタンを押すと、基板はマシン内に搬入され、基板停止位置で停止し、基板停止センサが基板を感知するとベルトが回転を停止します。

3. The board clamp mechanism will be energized and the board stop will retract.



3 . 基板クランプ装置が動作し、基板ストッパが引っ込みます。

4. (a) The rising table will drive up to vision height at the same time the rail lift sensors will be monitored, causing a "Rail lifted error" if detected stopping the rising table.

4 . (a) 上昇テーブルはレール・リフト・センサが監視されると同時に認識高さまで上昇します。その時、“レール上昇エラー”を引き起こし、そのエラーが感知されると上昇テーブルを停止させます。

(b) The camera carriage will drive to the position determined by fiducial 1 X & Y co-ordinates.

(b) カメラ・キャリッジは認識マーク 1 の X/Y 座標によって決定される位置へ移動します。

The board 1 fiducial strategy data will be used to detect the board fiducial.

基板 1 認識マーク対応データを使用して基板認識マークを検知します。

The vision monitor will display a small box so that the fiducial can be positioned correctly if necessary.

認識モニターには小さな四角形が現れ、必要な場合は認識マークを正しく位置決めできるようになっています。

5. The X & Y camera carriage clamps are energized and fiducial 1 is located.

5 . X/Y カメラ・キャリッジ・クランプが動作し、認識マーク 1 の場所が突き止められます。

The location of the fiducial is then copied to the Align Data structure.

その時、認識マークの位置は“Align Data (データの整理)”構造部にコピーされます。

The camera shutters will change and then view screen fiducial 1.

カメラのシャッターが変わり、スクリーン認識マーク 1 を見るようになります。

6. The screen fiducial 1 will be located and the location copied to the Align Data structure.

6 . スクリーン認識マーク 1 の場所が突き止められ、その位置が“Align Data”構造部にコピーされます。

The camera carriage clamps will be de-energized and the camera will be driven to board fiducial 2 X & Y co-ordinates.

カメラ・キャリッジ・クランプが動作停止し、カメラが基板認識マーク 2 の X/Y 座標位置に移動します。

The camera shutters will change to view the board fiducial.

カメラのシャッターが変わり、基板認識マークを映し出します。

7. The X & Y camera carriage clamps are energized and fiducial 2 is located.

7 . X/Y カメラ・キャリッジ・クランプが動作し、認識マーク 2 の位置を突き止めます。

The location of the fiducial is then copied to the Align Data structure.

その時、認識マークの位置は“Align Data (データの整理)”構造部にコピーされます。

The camera shutters will change and then view screen fiducial 2.

そして、カメラのシャッターが変わり、スクリーン認識マーク 2 を映し出します。

8. The screen fiducial 2 will be located and the location copied to the Align Data structure.

8 . スクリーン認識マーク 2 の位置が突き止められ、その位置が“Align Data”構造部にコピーされます。

With the data recorded the screen correction is calculated and the X fwd, X rear and Y screen actuators will move to the new position.

データが記録されると、スクリーンのズレが計算され、X fwd (前進) X rear (後退) 及び Y スクリーン・アクチュエータが新しい位置に移動します。

9. The camera carriage will drive to its home position and the Rising table will move up to the print height minus 3mm.

9 . カメラ・キャリッジが定位置に移動し、上昇テーブルが印刷高さから 3 mmを引いた位置まで移動します。

When the screen has finished its correction then the chase clamps are energized and the Rising table will then drive up to the print height.

スクリーンが位置ズレを正した場合、チェース(後追い)クランプが動作し、上昇テーブルが印刷高さまで上昇します。

10. The print carriage will move to the start of the print stroke and both squeegees will drive to their dwell height(5mm above the screen).

10 . 印刷キャリッジが印刷ストロークの開始位置まで移動し、両スキージがドゥエル位置(スクリーンの上 5 mmのところ)へ移動します。(Dwell とは居住の意で、通常留まっている場所、例えば家とかを指します。この場合ドゥエルと訳しましたが工業界では理解されている用語です。電車で言えば、車庫みたいな所かな?)

11. Either the front or rear squeegee will drive down to the calculated pressure setting as set in the board parameter menu.

11 . フロント・スキージまたはリアー・スキージのいずれかが基板パラメータ・メニューに設定されている計算された圧力設定まで駆動低下します。

12. The print carriage will drive at the set speed in the board parameter menu.

12 . 印刷キャリッジが基板パラメータ・メニューの設定速度で動きます。

The pressure transducer will be read after 60mm of the start of the stroke and will cease reading when it is 25mm from the end of the print stroke.

圧力トランスデューサがストローク開始点の 60 mm後に読み取りを開始し、印刷ストロークの最後から 25 mmの点で読み取りを止めます。

The average pressure is then calculated and if it differs from the set pressure by more than +/- KG will display a "Pressure error".

その時、平均圧力が算出され、設定圧力と比べ + / - KG 以上の差が見られる場合、“圧力エラー”を表示します。

From this data a new squeegee displacement will be calculated for the next print cycle on the particular squeegee. このデータから新しいスキージのズレが特定のスキージに関する次の印刷サイクルのために算出されます。

13. The squeegees will raise to their dwell heights.

13 . スキージがドゥエル高さまで上昇します。

14. The board count will be incremented.

14 . 基板のカウントが一つ増えます。

The chase clamps will be de-energized and the Rising table will drive down at the speed set by the Print separation speed in the board parameter menu until 3mm clear of the screen.

後追いクランプの動作が停止し、スクリーン手前 3mm のところまで基板パラメータ・メニューの印刷分離スピードによって設定されたスピードで上昇テーブルが下がります。

The Rising table will drive down to its datum height at full speed and de-energize the board clamps.

上昇テーブルは全速力でそのデータ高さまで下がり、基板クランプの動作を停止させます。

RISING TABLE

上昇テーブル

The rising table is the mechanism which transports the board up to the vision height for vision correction and then up to the screen height ready for printing.

上昇テーブルはメカ的に認識修正のために認識高さまで基板を運び、その後スクリーン高さまで搬送して印刷準備状態にします。

The positioning of the rising table is controlled in software utilizing a dc servo motor with a positional encoder fitted.

上昇テーブルの位置決めは位置決めエンコーダ付き DC サーボモータを使い、ソフト上でコントロールされています。

For the rising table to be accurately positioned it must first start from a reference position.

上昇テーブルを正確に位置決めするには、最初に基準位置からスタートしなければなりません。

This achieved by making the datum sensor.

このことはデータ・センサを作動させることによって達成されます。

When the machine is first powered up, an initialization routine is called up which will insure that the rising table is positioned at the home sensor.

マシンを最初に立ち上げた場合、初期化処理が呼び出され上昇テーブルが確実にホーム・センサのところで位置決めされます。

If the sensor is not made then the rising table will be driven downwards at a reduced speed until the sensor has been made.

センサが作動しない場合、上昇テーブルはセンサが作動するまで減速で下降します。

The rising table will then inch upwards until the sensor has just been cleared.

次に、上昇テーブルはセンサが無動作状態になるまで寸動で上昇します。

From this datum the rising table can then be positioned accurately according to the relevant position required.

このデータに基づき、上昇テーブルは必要な関連位置に従って正確に位置決めされます。

The rising table has also a brake fitted so that stability is maintained during the print cycle.

上昇テーブルはブレーキも備えており、印刷サイクル中に安定性が保たれています。

To maintain machine safety there are limit sensors fitted to monitor the position of the rising table.

マシンの安全性を保つために、上昇テーブルの位置を監視するためのリミット・センサが使用されています。

These limit sensors if activated will report an error message "Rising Table error" on the Main Control Screen.

リミット・センサが作動した場合、エラー・メッセージ“ 上昇テーブル・エラー ”がメイン・コントロール・画面に出ます。

The limit sensors consists of Upper and Lower limit, and the reference sensors are the datum and datum interlock.

リミット・センサは上下リミット・スイッチで構成されていて、基準センサはデータとデータ・インターロックで構成されています。

The upper and lower limit switches detect that the movement of the rising table has exceeded its travel.

上下リミット・スイッチは上昇テーブルがその移動量を超えたことを感知します。

The upper limit detects that the rising table is pressing into the screen and the lower limit detects that the rising table has overdriven downwards.

上リミットは上昇テーブルがスクリーンに押し入ることを感知し、下リミットスイッチは上昇テーブルが下降で移動量を逸脱した場合を感知します。

If these are detected then the machine will inhibit the power to the rising table motor.

これらが感知された場合、マシンは上昇テーブルのモータへの電源を阻止します。

The letter 'L' will be displayed on card X1, of enclosure Y1 when the limit switches have been detected.

リミット・スイッチが検知された場合、文字“L”がエンクロージャ Y1 の基板 X1 に現れます。

The datum sensor detects when the rising table has reached its home reference position so that accurate positioning from this datum can be achieved.

上昇テーブルがそのホーム・ポジションに到達したことをデータ・センサが感知し、その結果としてこのデータに基づいて正確な位置決めが可能となります。

Due to the home position being critical there is a another sensor fitted to ensure that the datum is achieved.

ホーム・ポジションの正確性は非常に厳しい精度が要求されるため、データが確実に達成されるようにもう一つのセンサが使われています。

This is the datum interlock sensor.

このセンサはデータ・インターロック・センサと呼ばれています。

When the datum sensor has been made then the datum interlock sensor is checked to see if its vane is also in the sensor, if not then an error will be reported.

データ・センサが作動した場合、データ・インターロック・センサがベーン（羽板）もセンサ内にあるかどうか確認され、ベーン（羽板）がセンサ内にない場合、エレが報告されます。

The datum interlock sensor is checked by the Arcom PC and should be detected before the datum sensor.

データ・インターロック・センサは Arcom PC によって確認され、データ・センサの前に感知されなければなりません。

## SQUEEGEE PRESSURE MECHANISM

### スキージ圧のメカ部

The squeegee pressure mechanism houses two independently driven squeegees and a single pressure transducer used to monitor the set pressure on both squeegees.

スキージ圧のメカ部には二つの独立して駆動されるスキージと単一の圧力トランスデューサがあります。トランスデューサは両方のスキージへの設定圧を監視するために使用されています。

The front and rear squeegee pressure is set, checked and corrected independently of each other.

前スキージと後スキージはそれぞれ別々に設定、確認、及び補正されます。

The calculation required for setting the pressure is initially stored as part of its calibration.

圧力設定に必要な計算方法はそのキャリブレーションの一部として最初に保存されます。

The calibration consists of setting the output voltage of the load cell to equal 160 mV/Kg.

キャリブレーションはロード・セルの出力電圧を 160 mV/Kg とするにします。

This is achieved by applying a precise known load to the squeegee mechanisms and adjusting the electronic amplifier to achieve the required voltage slope.

このキャリブレーションは正確な既知の負荷をスキージのメカ部に印加し、必要な電圧傾斜を得るために電子アンプを調整することによって達成されます。

When the load is applied to the balance which is used is levelled for each weight that is used.

使用されているバランスに負荷を印加すると、使用されているそれぞれの重さに対して分散・均一化されます。

To be able to level the balance the squeegee has to be displaced by a number of steps.

バランスを均一に保つには、スキージを数段階に変位させなければなりません。

The steps required to level between 10kg and 15kg are used to calculate a pressure factor and is stored in the printer configuration file.

10kg と 15kg の間で均一化するために必要な段階を使用し、電圧要素を算出し、それをプリンタ・コンフィギュレーション・ファイルに保存します。

Also as part of the calibration the height of the squeegee from its home position to the top of the screen (virtual zero pressure) is calculated and stored in the printer configuration file.

さらに、キャリブレーションの一部として、スキージのホーム・ポジションからスクリーン（仮想ゼロ圧）の上面までのスキージの高さを算出し、結果がコンフィギュレーション・ファイルに保存されます。

With this information, the set pressure can be calculated as a pure displacement.

この情報を元に、設定圧が純変位値として算出されます。

During the print stroke the pressure transducer is monitored 60mm from the start until 25mm short of the finish of the print stroke.

印刷ストロークの間、圧力トランスデューサが開始点から 60mm、印刷ストロークの完了手前 25mm まで監視されません。

If for any reason the monitored pressure is outside the error window of +/-1Kg it will display the message

"Pressure error" and will show the actual pressure reading against the set pressure.

監視していた圧力が何らかの理由で “ + / - 1 Kg ” の異常表示画面の範囲外の場合、メッセージ “ 圧力エラー ” を表示し、設定圧に対する実際の圧力を示します。

Pressing continue will allow the machine to complete the cycle.

“ continue ” を押すと、マシンがサイクルを完了（ 1 工程を完了させる ）させます。

This action will repeat for the opposite squeegee and will automatically correct the pressure difference for the relevant squeegee.

この動作は反対側のスキージに対しても同じことを繰り返し、そのスキージの圧力差を自動的に修正します。

## CHAPTER 4 ERROR MESSAGES

### 第四章 エラー・メッセージ

#### INTRODUCTION

##### はじめに

If for any reason the machine does not complete a particular sequence in the time allowed for in software, then an error condition will arise.

何らかの理由で、ソフト上で許可された時間内にマシンが特定のシーケンスを完了しない場合、エラー状態となります。

The relevant error message will be displayed on the Main Control Screen.

そのエラーに対するエラー・メッセージがメイン・コントロール画面に表示されます。

Machine Errors will be detected by sensors specifically designed for checking correct machine status (System Power, Pneumatic Power, etc.) or by functions failing to achieve their correct operation.

正常なマシンの状態（システム電源、空圧電源等）をチェック、または正常な動作が達成できない機能のために特別に設計されたセンサによってマシンエラーが感知されるようになっています。

These latter errors are either detected by a limit sensor being operated or by setting a time limit for their completion.

後者のエラーはリミット・センサの作動によって感知されるか、または動作完了までの制限時間を設定することによって検知されます。

The time limits are set so they are 1.5 times the longest possible time taken for that particular operation, after which if not completed an error will be reported on the Main Control Screen.

特定の動作にかかる最大可能時間の 1.5 倍に制限時間が設定され、その時間内に動作が完了しない場合はエラーがメイン・コントロール画面に表示（報告）されます。

When an error occurs the relevant message will be displayed on the Main Control Screen.

エラーが発生すると、関連メッセージがメイン・コントロール画面に表示されます。

The displayed error message will be accompanied by information regarding the possible causes and the corrective action to be taken.

表示されたエラー・メッセージには可能性のある原因と対処方法に関する情報が含まれ（添付され）ています。

The Tricolor beacon will change to red and will record the error in the Event Log file.

三色ビーコンが赤に点灯し、イベント・ログ・ファイルにエラーを記録します。

## ERROR RECOVERY

### エラー状態からの復帰方法

If during an error recovery the same error is repeated a recovery will only be allowed if the action permits, otherwise the message "Unable to recover" will be displayed.

エラー状態からの復帰処理中に同じエラーが繰り返される場合は、動作可能な場合にのみ復帰操作が許されます。そうでない場合、“復帰不可能”というメッセージが表示されます。

In the event of this happening call the Maintenance personnel.

この場合はメンテナンスの担当者をお呼びください。

If any error message is displayed then the following options will be displayed on the Menu Bar.

いずれかのエラー・メッセージが表示された場合は以下の選択肢がメニュー・バーに現れます。

### Abort

アボート（廃棄）

Pressing this option will re-initialize the entire printer ejecting any product that may be in the printer, returning to the Main Control page.

この選択肢を選ぶと、プリンタ内にあるかもしれない製品を排出し、プリンタ全体を再初期化し、画面はメイン・コントロール・ページに戻ります。

### Recover

リカバー（復帰）

Pressing this option will attempt to continue with any cycle that is in operation.

この選択肢を選ぶと、動作中のサイクルでマシンは動作を継続します。

This function will set modules (paste dispenser, print carriage, etc.) to their home position and then eject the board that is currently in the printer without re-initializing the machine.

この機能はモジュール（ペースト・ディスペンサ、印刷カートリッジ等）をホーム・ポジションに設定し、機会を再初期化しないでプリンタ内に現在存在する基板を排出します。

This option should be the first to be operated if there is an error reported.  
この選択肢はエラーが報告された場合に最初に作動されなければなりません。

#### Diagnostics 診断機能

This will enable the diagnostics to be entered if necessary to clear the problem if it *persists* (しつこく居座る).  
問題がしつこく残りその問題を解決する必要がある場合、この選択肢を選ぶと診断機能が作動します。

#### ERROR MESSAGE LISTING AND INTERPRETATION エラー・メッセージ・リストと解釈

##### Board Stop stuck 基板ストップの停止（つかえ）

This error is reporting that the board stop, which is housed in the camera assembly has failed to lower or retract.  
このエラーはカメラ・アセンブリー内の基板ストップが下降または引き込みに失敗したことを示しています。

##### Board stuck in Rails 基板のレールに引っ掛かり

This error is reporting that the board has failed to either reach the board stop or exit the machine after being printed.  
このエラーは基板が基板ストップに到達しなかったか、印刷後にマシンから出ることができなかったことを示しています。

##### Camera X Axis error カメラ X 軸エラー

This error is reporting that the camera carriage has failed to reach its home position in the X axis.  
このエラーはカメラ・キャリッジが X 軸でそのホーム・ポジションに到達できなかったことを示しています。

##### Camera Y Axis error カメラ Y 軸エラー

This error is reporting that the camera carriage has failed to reach its home position in the Y axis.  
このエラーはカメラ・キャリッジが Y 軸でそのホーム・ポジションに到達できなかったことを示しています。

##### Front Squeegee error 前スキージ・エラー

This error is reporting that the front squeegee has failed to reach its fully up position.  
このエラーは前スキージが完全に上昇位置に達しなかったことを示しています。

##### Front Squeegee Pressure error 前スキージ圧力エラー

When this error is detected then a new window will be displayed.

このエラーが検知されると、新規ウィンドウが開きます。

The window will display the set pressure reading and the actual pressure reading.

そのウィンドウは設定圧と実際の圧力値を表示します。

Paste Carriage error

ペースト・キャリッジ・エラー

This error is reporting that the paste carriage has failed to reach its home position or that it has made the limit switch.

このエラーはペースト・キャリッジがそのホーム・ポジションに到達しなかったか、リミット・スイッチを作動させたことを示しています。

Paste Carriage Tilt error

ペースト・キャリッジ傾きエラー

This error is reporting that the paste cartridge mechanism has failed to either make its up or down limit switches.

このエラーはペースト・キャリッジ・メカ部が上リミット・スイッチまたは下リミット・スイッチを作動させなかったことを示しています。

Pneumatic Power down

空圧力低下

This error message is reporting that the pneumatic supply is either too low or has been disconnected.

このエラー・メッセージは空気の供給が低すぎるか接続がされていないことを示しています。

Print Carriage error

印刷キャリッジ・エラー

This error is reporting that the print carriage has failed to move or that it has reached the safety limit switches.

このエラーは印刷キャリッジが動かなかったか、安全リミット・スイッチに到達したことを示しています。

Rail Width error

レール幅エラー

This error is reporting that the motorized rail has either failed to move or that it has not moved to the correct width setting.

このエラーはモータ駆動のレールが動かなかったか、正しい設定幅に動かなかったことを示しています。

Rear Squeegee error

後スキージ・エラー

This error is reporting that the rear squeegee failed to reach its fully up position.

このエラーは後スキージが完全に上昇位置に到達しなかったことを示しています。

Rear Squeegee Pressure error

後スキージ圧力異常

When this error is detected then a new window will be displayed.

この異常が検知されると、新しいウィンドウが開きます。

The window will display the set pressure reading and the actual pressure reading.

このウィンドウは設定圧と実際の圧力を表示します。

Rising Table error

上昇テーブル異常

This error is reporting that the rising table has either failed to reach its fully down position or that when



attempting to reach the required height during the machine cycle did not achieve the positional accuracy.

このエラーは上昇テーブルが完全に下降位置に到達しなかったか、マシンの動作サイクル中に必要な高さに到達しようとしたが、位置的正確性が得られなかったことを示しています。

Screen XF error

スクリーン XF エラー

This error is reporting that the X forward screen actuator failed to initialize to its central datum.

このエラーは X 前進スクリーン・アクチュエータがその中央データに初期化されなかったことを示しています。

Screen XR error

スクリーン XR エラー

This error is reporting that the X rear screen actuator failed to initialize to its central datum.

このエラーは X 後スクリーン・アクチュエータがその中央データに初期化されなかったことを示しています。

Screen Y error

スクリーン Y エラー

This error is reporting that the Y screen actuator failed to initialize to its central datum.

このエラーは Y スクリーン・アクチュエータがその中央データに初期化されなかったことを示しています。

System Power down

システム電源遮断

This error is reporting that the 24V motor power has been switched off either by the Emergency Stop button being activated (including upline and downline external machines) or that the removable frame access cover has been removed.

このエラーは 24V のモータ電源が「緊急停止」ボタンが作動したことにより（上流外部マシンと下流外部マシンを含む）によって遮断されたか、着脱式フレーム・アクセス・カバーが取り外されたことを示しています。

Unable to find Fiducial

認識マークが見つからない

This error is reporting that the vision system is unable to locate the relevant screen or board fiducial.

このエラーは認識システムが目的のスクリーン認識マークまたは基板認識マークを見つけることができないことを示しています。

## CHAPTER 5 MAINTENANCE

### 第五章 保守

General

概要

With the machine initialized, insert and turn the maintenance key to On to enter the maintenance function, the menu bar will display the following:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

マシンが初期化されている状態で、保守キーを差込、ON にして保守機能を動作させてください。メニューバーが現れ、そこに以下のコマンドが表示されます。

運転、ヘッド、ペースト補給、スクリーン清掃、調整、段取、モニタ、保守

Maintenance

保守

The maintenance function is a means by which the technician may calibrate the squeegee pressure and vision system, download data from hard disk to floppy disk, and set the various machine modes and options, as described as follows:

Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

保守機能とはその機能によって技術者がスキー圧や認識システムのキャリブレーションを行ったり、ハード・ディスクのデータをフロッピーに落としたり、各種マシン・モードと選択肢を設定できる手段であり、それらのコマンドには以下のものがあります。

圧力のキャリブレーション、オフセットのキャリブレーション、認識システムのキャリブレーション、整理（段取り）優先順位の設定、診断、退出

Calibrate Pressure

圧力のキャリブレーション

Selection of Calibrate Pressure will automatically configure the machine ready to accept the Calibration Rig (Pt No. 1141.06), for full details regarding Squeegee Pressure Calibration refer to 'Squeegee Pressure', Chapter 7 - Calibrations, of this manual.

“圧力のキャリブレーション”を選択するとマシンがキャリブレーション・リッグ（整備する道具）（部品番号 1141.06）を受け入れる準備を自動的に整えます。スキー圧キャリブレーションに関する詳細はこのマニュアルの第七章の“スキー圧”を参照してください。

Calibrate O set

オフセットのキャリブレーション

Calibrate O set compensates for any optical discrepancies between viewing up and down of the telecentric camera. “オフセットのキャリブレーション”を選択すると、テレセントリック・カメラの視野上下間の光学上の不具合を補正します。

Calibrate Vision

認識システムのキャリブレーション

Calibrate Vision compensates for any screen movement in the X, Y and Theta direction.

“認識システムのキャリブレーション”を選択すると X、Y、及びシータ（角度）方向のスクリーン動作を補正します。The combination of both calibrations encompasses（達成する、含む）calibration of the vision system complete full details of which are described in Chapter 7 - Vision System Calibration. 両方のキャリブレーションを組み合わせることによって認識システムのキャリブレーションを完璧にすることができます。その詳細は第七章の“認識システムのキャリブレーション”に記述してあります。

Housekeeping

整理（段取り）

The file management system is introduced to enable the user to download data from hard to floppy disk while remaining within the software environment, thus alleviating（軽くする、緩和する、楽にする、（問題を）多少とも解決（解消）する）the requirement to use DOS.

ファイル管理システムを導入することによって、ソフト環境内にデータを維持した状態でデータをハードディスクからフロッピー・ディスクにダウンロードすることが可能となり、DOS 使用の要件を多少とも満たすことができるようになっていきます。

Pressing the housekeeping button displays the menu bar with the following options:

Set Date, Set Time, Print Data, Copy to disk, Copy from disk, Delete Data, Exit

“整頓（段取り）”を選択すると、以下の選択肢を備えたメニュー・バーが現れます。

“データの設定”、“時間の設定”、“データのプリントアウト”、“ディスクへのコピー”、“ディスクからのコピー”、“データの削除”、及び“退出”（メニュー・バー上の選択肢をこのように訳すこと自体が変ですが、勉強のためにあえて日本語にしています。）

Set Date & Set Time

日付と時刻の設定

Selection of Set Date & Set Time options will each open a window displaying the current PC values and allow the

operator to accept these values or change them.

“日付と時刻の設定”を選ぶと、現在のPC値を表示するウィンドウが開き、オペレータがこれらの値を受け入れるか、それらを変更することができるようになります。

Refer to Chapter7 of this manual for setting details.

設定の詳細はこのマニュアルの第七章を参照してください。

Exit will return to the maintenance display and menu bar without any other action.

“退出”を選ぶとメンテナンス画面とメニュー・バーに何ら他の動作なしに戻ります。

## Print Data

### データのプリントアウト

On selection of Print Data button the menu bar will change the following:

Product Data, Event Log, Config Data, Manage Data, SPC Data, Exit

“データのプリントアウト”ボタンを選ぶと、メニュー・バーが以下に変わります。

“製品データ”、“イベント・ログ”、“コンフィギュレーション・データ”、“管理データ”、“SPCデータ”、“退出”

Exit will return to the housekeeping display without any other action.

“退出”を選ぶと整頓（段取り）画面に何ら他の動作なしに戻ります。

Event Log will output the contents of the EVENT.DAT file to the printer port.

“イベント・ログ”はEVENT.DATファイルの内容をプリンタ・ポートに出力します。

Config Data will output the contents of the CONFIG.TXT file to the printer port.

“コンフィギュ・データ”はCONFIG.TXTファイルの内容をプリンタ・ポートに出力します。

Manage Data will change the menu bar to give print to printer or print to file options, then the contents of the MANINF.DAT file will be output in text format to the selected device, if output to file is selected, it will be to A:(backslash)MANINF.PRN.

“管理データ”はプリンタへのプリント・コマンドを送出するか、またはファイル・オプションへプリント・コマンドを送出し、MANINF.DATファイルの内容がテキスト形式で選択した装置に出力され、ファイルへの出力を選んだ場合、“A:(backslash)MANINF.PRN.”に出力されます。

SPC Data will output the contents of the READINGS.DEK file to the printer port.

“SPCデータ”はREADINGS.DEKファイルの内容をプリンタ・ポートに出力します。

Product Data will display a window on screen containing the names of the Product Data files available on hard disk and change the menu bar to the following options:

Print Printer, Print File, Left, Right, Up, Down, Exit

“製品データ”は画面上にウィンドウを表示し、そのウィンドウにはハード・ディスク上の利用可能な製品データ・ファイル名が表示され、そのメニュー・バーには以下の選択肢が表示されます。

“プリンタへ出力”、“ファイルへの出力”、“左”、“右”、“上”、“下”、“退出”

The Left, Right, Up and Down keys will enable highlighting of the required product file

“左”、“右”、“上”、及び“下”キーを使って必要な製品ファイルを反転表示させることができます。

Print Printer will output the contents of the selected Product Data file to the printer.

“プリンタへの出力”を選ぶと、選択した製品データ・ファイルの内容をプリンタに出力します。

Print File will output the contents of the selected product data file, in text format, to the floppy disk, with the same filename but with a .PRN extension.

“ファイルへの出力”を選ぶと、選択した製品データ・ファイルの内容がテキスト形式でフロッピー・ディスクに同じ名前でも出力されます。この場合、名前は同じですが、拡張子は“.PRN”となります。

## Copy to Disk

### ディスクへのコピー

On selection of Copy to Disk button the menu bar will change to the following:

Product Data, Event Log, Test Data, SPC Data, Exit

“ディスクへのコピー” ボタンを選ぶとメニュー・バーが以下のように変わります。

製品データ、イベント・ログ、テスト・データ、SPC データ、退出

Exit will return to the housekeeping display without any other action.

“退出” を選ぶと整頓（段取り）画面に何ら他の動作なしに戻ります。

Event Log will copy the Event.dat file from the hard disk to the root directory of the floppy disk.

“イベント・ログ” を選ぶと、Event.data ファイルをハード・ディスクからフロッピー・ディスクのルート・ディレクトリにコピーします。

Test Data will copy all of the following files from the hard disk to the root directory of the floppy disk,

“テスト・データ” を選ぶと、ハード・ディスクから以下のファイル全てをフロッピー・ディスクのルート・ディレクトリにコピーします。

Test.log; Test.dat; Fiducial.dat; O set.dat; Videoxy.dat; Theta.dat; Config.txt.

SPC Data will copy the Readings.dek file from the hard disk to the root directory of the floppy disk.

“SPC データ” を選ぶと、Readings.dek ファイルをハード・ディスクからフロッピー・ディスクのルート・ディレクトリにコピーします。

Product Data will display a window on the screen containing the names of the Product Data files available on the hard disk and change the menu bar to the following.

“製品データ” は画面上にウインドウを表示し、そのウインドウにはハード・ディスク上の利用可能な製品データ・ファイル名が表示され、そのメニュー・バーには以下の選択肢が表示されます。

Copy File, Left, Right, Up, Down, Exit

“ファイルのコピー”、“左”、“右”、“上”、“下”、“退出”

The Left, Right, Up, Down keys will enable highlighting of the required product file.

“左”、“右”、“上”、及び“下” キーは必要な製品ファイルを反転させることができます。

Copy File will copy the selected product data file from the hard disk to the root directory of the floppy disk.

“ファイルのコピー” を選ぶと、選択した製品データ・ファイルをハード・ディスクからフロッピー・ディスクのルート・ディレクトリにコピーします。

Copy from Disk

ディスクからのコピー

On selection of Copy from Disk a window will display the names of the Product Data files available in the root directory of the floppy disk, and the menu bar will change to display the following:

“ディスクからのコピー” は画面上にウインドウを表示し、そのウインドウにはルート・ディレクトリ上の利用可能な製品データ・ファイル名が表示され、そのメニュー・バーには以下の選択肢が表示されます。

Copy File, Left, Right, Up, Down, Exit

“ファイルのコピー”、“左”、“右”、“上”、“下”、“退出”

The Left, Right, Up, Down keys will enable highlighting of the required product file.

“左”、“右”、“上”、及び“下” キーは必要な製品ファイルを反転させることができます。

Copy File will copy the selected product data file from the root directory of the floppy disk to the hard disk. It will then update the Barcode LUT.

“ファイルのコピー” を選ぶと、選択した製品データ・ファイルをフロッピー・ディスクのルート・ディレクトリからハード・ディスクにコピーします。さらに、バーコード LUT を更新します。

## Delete Data

### データの削除

On selection of Delete Data the menu bar will change to the following:

“データの削除” 選ぶと、メニュー・バーが以下に変わります。

Product Data, Event Log, Test Data, SPC Data, Exit

“製品データ”、“イベント・ログ”、“テスト・データ”、“SPCデータ”、“退出”

Exit will return to the Housekeeping display and menu bar without any further action.

“退出” を選ぶと整頓（段取り）画面に何らさらなる動作なしに戻ります。

Test Data will display the prompt 'Confirm deletion of Test Data' and give a Yes/No option.

“テスト・データ” を選ぶと、プロンプト “テスト・データの削除確認” が表示され、Yes か No を選ぶようになります。

If confirmed any Test.log and Test.dat files should be deleted from the hard disk.

Yes を選ぶと、Test.log と Test.dat ファイルがハード・ディスクから削除されます。

SPC Data will display the prompt 'Confirm deletion of SPC Data' and give a Yes/No option.

“SPCデータ” を選ぶと、プロンプト “SPCデータの削除確認” が表示され、Yes か No を選ぶようになります。

If confirmed the Readings.dek file should be deleted from the hard disk.

Yes を選ぶと、Readings.dek ファイルがハード・ディスクから削除されます。

Event Log will change the menu bar to display the following:

“イベント・ログ” を選ぶと、メニュー・バーが以下のように変わります。

Delete All, Delete Data, Delete Number, Exit

“全て削除”、“データの削除”、“番号の削除”、“退出”

Delete All will display the prompt 'Confirm deletion of All Event Data' and give a Yes/No option.

“全て削除” を選ぶと、プロンプト “全てのイベント・データの削除確認” が表示され、Yes か No を選ぶようになります。

If confirmed copy the contents of the Event.dat file to an Event.bak file, overwriting any previous file, delete all entries in the Event.dat file and then insert a 'New Event Log' entry.

Yes を選ぶと、Event.dat ファイルの内容を Event.bak ファイルにコピーし、同じ名前のファイルがある場合はそれを上書きし、Event.dat ファイルの全ての記録内容を削除し、“新規イベント・ログ” の記録権が挿入されます。

## Set Prefers

Calibr Pressure, Calibr O set, Calibr Vision, HouseKeeping, Set Prefers, Diagnost, Exit

Selection of Set Prefers button display a pop up window and changes the menu bar to display the following:

Next, Prev, Incr., Decr., Exit

Transport Mode

Machine Units

Transfer Protocol

Transfer Period

Comms Protocol

Event Recording

Tooling Hardware

Fiducial Reference

Barcode Hardware

Inspect Rate  
SPC Data Mode

Next and Previous will move the highlight between the parameter values.  
Increment and Decrement will alter the highlighted parameter value.

Transfer Mode  
Sets input and output ends of the printer.  
Left to Right; Right to Left; Left to Left; Right to Right;  
(Default Left to Right)  
Machine Units  
Offers option of units:  
Metric of Imperial units. (Default Metric)

Transfer Protocol  
Set the protocol for transferring boards to adjacent machines:  
Transfer Period  
A programmable time period used by certain transfer protocols:  
Min 0 sec.  
Max 99 sec.  
Increments 1 sec.

Period of Transfer Time- This is the period of time which the 265 allows a transfer of a board before displaying a 'Board Transfer Error' for Upline or Downline  
Period of Waiting Time- This is the period of time which the 265 allows when waiting for the Upline or Downline machine to request a board for transfer displaying a message of 'Waiting for Upline/Downline'

Comms Protocol  
The communications protocol to be used for serial communications to host computer:  
SECS II; BSC

Warning  
Do not select SEC II Protocol without having the Host Comms package fitted. This will result machine lock-out.  
If this is inadvertently selected, call DEK Service for advice.

Event Recording  
Sets whether all or majority events only are recorded in the Event log file:  
Major events only; All events  
Major events- Refers to displayed error messages.  
All Events- Refers to every other event generated within the machine.  
Tooling Hardware  
Set whether Autoflex tooling is fitted:  
Autoflex; Plain

Fiducial Reference

Sets whether the fiducial co-ordinates are specified relative to the front/left or front/right corner of the board:  
Left; Right

#### Barcode Hardware

Sets whether or not barcode reader is fitted:  
Fitted; Not Fitted

#### Inspect Rate

Sets the number of print cycles between Inspection cycles, set to zero for no inspection  
Min 0(0 )  
Max 100  
Increments 1

This will enable a Post-Print Inspection of a fiducial alignment directing this data to file according to SPC Data destination.

#### SPC Data

Sets the destination of the SPC data generated during an inspection cycle  
Serial; Disc.  
Serial- Outputs to serial port.

NOTE: If Host Comms is connected currently this option cannot be used.

Discs- Outputs to a READINGS.DEK file on hard disk.

This data can then be accessed from disk via housekeeping.

#### Diagnostics

This function is described in detail in the following section

### DIAGNOSTICS

#### INTRODUCTION

The diagnostic function is an aid to the user to allow individual access and control to motors and modules. It will allow the user to control the sequence of the machine so that a particular module can be exercised.

To enter the diagnostic mode the key switch on the Main Control Unit must be inserted and turned clockwise. This will enable the Maint option to appear on the Menu Bar:  
Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

Press the Maint button and the Menu Bar will change displaying the Diagnostic option.  
Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

Pressing Diagnostic will enter into the main diagnostic menu. If a password, exists a window will display the message 'Diagnostic Password'. If the password is incorrect control will display the message 'Invalid password entered' and return to the previous menu. If the correct password is entered or no password exists a pop up window will display the following:

System

Print Head

Print Carriage  
Squeegee  
Camera Axis  
Rail System  
Paste Dispense System  
Screen Alignment  
Screen Change  
Screen Cleaner  
Rising Table  
Foreign Machine Interface  
Autoflex Tooling

Next/Prev keys will move the highlight bar up down the list of modules that can be selected.

Select Module key will open a new window displaying the diagnostic functions available for the selected module.  
Exit will return operation to the start of initialization

#### NOTE

Before any diagnostic function is used in any of the modules they must be homed first or they will not be able to initiate a command.

#### SYSTEM

The system diagnostic module contains the following:

- Display all Digital Inputs
- Display all Analog Inputs
- Toggle Red Beacon
- Toggle Amber Beacon
- Toggle Green Beacon
- Data Logging
- Run Alignment Test
- Run Production Test
- Change Edit Password
- Change Diagnostic Password
- Change DOS Password
- Terminate control and Return to DOS

#### Digital Input Status

Selecting this option, a new window will be displayed showing the relevant groups.

PCIB40's are the I/O cards that are housed in the Arcom PC. There are five PCIB40 cards and are numbered as such. Each card has up to five groups, G0-G4 and will monitor and control various drive and control cards in the Y1 and Y2 enclosure.

PCIB40's are divided into Inputs and Outputs.

Selecting each option will display another window displaying the functions that can be switched on or o .



#### Analog Input Status

Selecting this option will display a new window showing the analog output of the load cell amplifier card of the squeegee pressure mechanism.

#### Tri-Color Beacon

Selecting any one of the three colors will toggle them between on and off.

#### Data Logging

Selecting this function will alternately enable and disable data logging during diagnostic operations.

#### Run Alignment Test

Selecting this function will initiate the machine to run Dry Alignment accuracy test.

#### Run Production Test

This option is only used as a cycle test at the base factory and should not be run. In doing so the machine could result in damage.

#### Change Edit Password

Selection of this option will prompt the operator to enter a new password.

#### Change Diagnostic Password

Selecting this option will either allow a password to be inputted or change an existing password. This password protection inhibits unauthorized entry into diagnostics.

#### Change DOS Password

Selection of this option will either allow a password to be inputted or change an existing password. This password protection inhibits unauthorized exit to DOS.

#### Terminate 265 Control and Return to DOS

Selecting this option will terminate the 265 and return to the DOS prompt.

#### PRINT HEAD

The Print Head diagnostic module contains the following:

##### Raised Head Under 2 Button Control

Selecting this option will allow the print head to be raised using the two button safety switches located on the front of the machine. These switches must be operated simultaneously.

##### Lower Head Under 2 Button Control

Selecting this option will allow the print head to be lowered using the two button safety switches located on the front of the machine. These switches must be operated simultaneously.

##### Toggle Head Latch

Selecting this option will alternately switch the print head magnetic latches on and off.

##### Head Up Sensor

This will display the head up sensor status.

#### Head Down Sensor

This will display the head down sensor status.

#### Left Jog Button

This will display the operation of the left button of the two button safety switches located on the front of the machine.

#### Right Jog Button

This will display the operation of the right button of the two button safety switches located on the front of the machine.

### PRINT CARRIAGE

The Print Carriage diagnostic module contains the following:

#### Home Print Carriage

Selecting this option will move the print carriage back to its home sensor position and stop. It is always advisable to home the print carriage before attempting to position it anywhere.

#### Drive Carriage to Front Position

Selecting this option will move the print carriage to a position that will clear the paste dispense unit if operated.

#### Drive Carriage to Rear Position

Selecting this option will move the print carriage to the end of the print stroke.

#### Drive Carriage Using Jog Buttons

Selecting this option will allow the user to position the print carriage anywhere between the front and rear position using either of the two button safety switches located on the front of the machine. The Left button will move the print carriage towards the rear and the Right button will move the print carriage towards the front.

#### Cycle Print Carriage

Selecting this option will start a continuous cycle of driving the print carriage between its front and rear limits pausing at each end for 2 seconds. The speed will be measured and displayed.

The cycle will be terminated if the Stop key is used or that the set cycle count is reached.

#### Actual Carriage Speed

This will display the actual speed during the Cycle Print Carriage option.

#### Cycle Count

Will display the count when the module is being cycled.

### SQUEEGEE

The Squeegee diagnostic module contains the following:

#### Home Front Squeegee

Selecting this option will drive the front squeegee upwards to its home position as detected by its home sensor.

#### Home Rear Squeegee

Selecting this option will drive the rear squeegee upwards to its home position as detected by its home sensor.

#### Front Squeegee to Dwell Height

This option will drive the front squeegee to a position 10mm clear of the top of the screen.

#### Rear Squeegee to Dwell Height

This option will drive the rear squeegee to a position 10mm clear of the top of the screen.

#### Rear Squeegee Flood Height

This option will drive the rear squeegee to the height set by the flood reference height parameter.

#### Drive Front Squeegee Using Jog Buttons

Selecting this option will enable the right jog button to drive the front squeegee up at slow speed and the left jog button will drive it down, stopping immediately the button is released.

#### Drive Rear Squeegee Using Jog Buttons

Selecting this option will enable the right jog button to drive the rear squeegee up at slow speed and the left jog button will drive it down, stopping immediately the button is released.

#### Calibrate Front Squeegee Print Height

This option is used as part of the pressure calibration procedure. The function of this option is that the squeegee will be driven down until some pressure is applied. The Menu bar will change showing the option Confirm.

Pressing Confirm will set the current height of the front squeegee minus the current pressure sensor reading multiplied by the pressure factor. This will be the front reference height parameter and will be stored as part of the printer configuration file.

#### Calibrate Rear Squeegee Print Height

This option is used as part of the pressure calibration procedure. The function of this option is that the squeegee will be driven down until some pressure is applied. The Menu bar will change showing the option Confirm.

Pressing Confirm will set the current height of the rear squeegee minus the current pressure sensor reading multiplied by the pressure factor. This will be the rear reference height parameter and will be stored as part of the printer configuration file.

#### Calibrate Rear Squeegee Flood Height

The function of this option is that the rear squeegee fitted with a flood bar is driven down until the flood blade is just touching this screen. Pressing the Confirm key will store this height as part of the printer configuration file.

#### Pressure Reading A/D...Kg

This is a live display showing the actual pressure being applied to the squeegee.  
With no squeegee fitted the display should show a reading of approximately 3.6 Kg.

#### CAMERA AXIS

The camera system module contains the following:

Camera Axis Home

Selecting this option will drive the Camera X and Y carriages simultaneously to find their datum positions as determined by their home sensors.

#### Camera Axis to fiducial 1 position

Selecting this option will drive both X and Y carriages to the position set by the fiducial 1 x and y coord parameters.

#### Camera Axis to fiducial 2 position

Selecting this option will drive both X and Y carriages to the position set by the fiducial 2 x and y coord parameters.

#### Drive to reference position

Selecting this option will drive both X and Y carriages to the position set by the camera x and y reference parameters.

#### Set reference position

Selecting this option will alter the Printer Configuration file after the camera has been positioned so that it is viewing the fiducial on the front rail. On selection of this option the Menu Bar will display Confirm which on pressing this key will alter the printer configuration file. This is to be used in conjunction with Move camera x and y axis.

#### Move camera X axis using Jog buttons

Selecting this option will enable the Right Jog button to drive the X axis right at slow speed and the Left Jog button will drive it left, stopping immediately the button is released.

#### Move camera Y axis using Jog buttons

Selecting this option will enable the Right Jog button to drive the Y axis right at slow speed and the Left Jog button will drive it left, stopping immediately the button is released.

#### Initialize vision

Selecting this option will initialize the frame grabber board and will display a live image on the vision monitor.

#### Display reference box

Selecting this option will display a super imposed box on the vision monitor.

#### Toggle Look up on/o

Selecting this option will alternately energize the camera Down shutter, displaying On status and de-energizing it will display the o status.

#### Toggle Look down on/o

Selecting this option will alternately energize the camera Up shutter, displaying On status and de-energizing it will display the o status.

#### Cycle camera system

Selecting this option will start a continuous cycle of driving the camera x and y carriages to each of the following positions in sequence, dwelling for 2 seconds at each point, locating the fiducial at each fiducial position, displaying the returned location and then repeating the cycle.

The cycle being the following:

1. Datum
2. Fiducial 1
3. Fiducial 2

If the data logging is enabled the fiducial co-ordinates will be appended to C:\backslashlash\SAN\backslashlash\LOG\backslashlash\CAMERA.DAT file. This continuous cycle will be terminated by selecting the stop key or when the set cycle count has been reached (50).

#### Cycle count

Will display the count when the module is being cycled.

#### RAIL SYSTEM

The Rail System module will contain the following:

#### Home Rail Width

Selecting this option will increase the rail width motor to find its datum position as determined by its home sensor.

#### Drive Rail to Board Width

Selecting this option will drive the rail width motor to the width set by the board width parameter.

#### Drive Rail Width using two button control

Selecting this option will enable the right jog button to drive the rail width motor forward at a slow speed and the Left jog button drive it back, stopping immediately after the button is released.

#### Drive Belts Using two button control

Selecting this option will enable the Right Jog button to drive the belt motors to the right and the Left Jog button to drive them left, stopping immediately the button is released.

#### Toggle Board Clamp

Selecting this option will alternately energize the Board Clamp displaying On status and de-energize it, displaying O status.

#### Toggle Board Stop

Selecting the option will alternately lower and raise the board stop housed in the camera assembly, displaying On status when lowered and O status when raised.

#### Cycle Board on Belts

Selecting this option will start a continuous cycle of driving the belts to the right until the board reaches the right board sensor, dwelling for 2 seconds then driving the belts left until a board reaches the left board sensor, dwelling for 2 seconds and repeating the cycle until stop is pressed or the set cycle count is reached (50).

#### Cycle Board Clamp

Selecting this option will start a continuous cycle of clamping and unclamping the board clamps.

#### Board Stop in Position

Will continuously display the current status of the board stop lowered position.

#### Board at Stop

Will continuously display the current status of the board at stop sensor.

#### Board at Left

Will continuously display the current status of the left board sensor. On will be displayed if a board is detected on the rails at the left of the machine.

#### Board at Right

Will continuously display the current status of the right board sensor. On will be displayed if a board is detected on the rails at the left of the machine.

#### Cycle count

Will display the count when the module is being cycled.

### PASTE DISPENSER SYSTEM

The Paste Dispenser diagnostic module contains the following:

#### Carriage Home

Selecting this option will drive the dispense carriage left to find its datum position as determined by its datum sensor.

#### Drive Carriage to Start Position

Selecting this option will drive the paste carriage to the position set by the paste start parameter.

#### Drive Carriage to End Position

Selecting this option will drive the paste carriage to the position set by the paste stop parameter.

#### Drive Cartridge Down

Selecting this option will drive the cartridge tilt down until the cartridge down sensor is located.

#### Drive Cartridge Up

Selecting this option will drive the cartridge tilt up until the cartridge up sensor is detected.

#### Toggle Paste Dispense

Will alternately energize the paste dispense, displaying On status and de-energize will display O status.

#### Toggle Cartridge Seal

Will alternately energize the cartridge seal, displaying O status and de-energize will display On status.

#### Paste Cartridge Empty

Will continuously display the current status of the cartridge empty sensor.

#### Cartridge in Down Position

Will continuously display the current status of the paste dispense down sensor.

#### Cartridge in Up Position

Will continuously display the current status of the paste dispense up sensor.

### SCREEN ALIGNMENT

The Screen Alignment module contains the following:

#### Home Actuator

Selecting this option will drive the X forward, X Rear and Y Axis actuators simultaneously to find their datum positions as determined by their datum sensors.

#### Drive X Forward Motor Using Jog Buttons

Selecting this option will enable the the right Jog button to drive the X forward actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Drive X Rear Motor Using Jog Buttons

Selecting this option will enable the right Jog button to drive the X rear actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Drive Y Motor Using Jog Buttons

Selecting this option will enable the right Jog button to drive the Y actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Toggle Chase Clamp

Selecting this option will alternately energize the Chase Clamp solenoid, displaying On status and de-energize it, displaying O status.

#### Cycle Alignment System

Selecting this option will start a continuous cycle of driving the screen actuators to each of the following positions in sequence, dwelling for 2 seconds at each point and then repeating the cycle.

If data logging is enabled, every time the screen returns to 0,0,0, locate a screen fiducial and its coordinates appended to c:\backslashSAN\backslashlog\backslashscreen.DAT file. This continuous cycling will be terminated by selecting the stop key or when the set cycle count has been reached (50).

#### Cycle Count

Will display the count when the module is being cycled.

### SCREEN CHANGE

The Screen Change diagnostic module contains the following:

#### Drive Screen Motor

Selecting this option will enable the Right Jog button to drive the screen motor forward and the Left Jog button to drive it back, stopping immediately the button is released.

#### Toggle Drive Coupling Right

Selecting this option will alternately energize the drive coupling right solenoid, displaying On status and de-energize it, displaying O status.

#### Toggle Drive Coupling Left

Selecting this option will alternately energize the drive coupling left solenoid, displaying On status and de-energize it, displaying O status.

#### Toggle Rear Stops

Selecting this option will alternately energize the rear screen stops out, displaying Out status and de-energize them displaying In status.

#### Toggle Screen Clamps

Selecting this option will alternately energize the Screen Clamps, displaying On status and de-energize them, displaying O status.

#### Load Screen from Front

Selecting this option will perform a load screen cycle.

#### Unload Screen to Front

Selection this option will perform an unload screen cycle, using two button control.

#### Cycle Screen (Load/Unload)

Selecting this option will cycle the screen drive stopping when the cycle count has been reached.

#### Screen at Front

This will continuously display the current status of the front screen sensor.

#### Screen at Rear

This will continuously display the current status of the rear screen sensor.

#### Drive at Front

This will continuously display the current status of the drive coupling sensor, displaying when the drive coupling is at the front position.

#### Drive at Rear

This will continuously display the current status of the drive coupling sensor, displaying when the drive coupling is at the rear position.

#### Cycle Count

Will display the count when the module is being cycled.

#### SCREEN CLEANER

The Screen Cleaner diagnostic contains the following:

#### Toggle Cleaner Blade

Will alternately energize the paper feed, displaying Up status and de-energize it, displaying Down status.

#### Toggle Solvent Pump

Will alternately energize the solvent pump, displaying On status and de-energize it, displaying O status.

#### Toggle Screen Cleaner Home Clamp

Will alternately energize the cleaner home clamp, displaying On status and de-energize it, displaying O status.

#### Cleaner Home Sensor



Will continuously display the current status of the cleaner home sensor. When the cleaner is at home the sensor will be displayed On.

## RISING TABLE

The Rising Table diagnostic module contains the following:

### Home Rising Table

Selecting this option will drive the rising table down until it find its datum position as indicated by its datum sensor.

### Raise Table to Vision Height

Selecting this option will drive the rising table to the height set by the vision heightparameter.

### Raise Table to Print Height

Selecting this option will first check that both the camera carriage and the screen cleaner unit are home, if either are not then a message will be displayed "Home Camera and/or Screen Cleaner first". Only if both are home, the rising table will drive up to the height set by the print height parameter.

### Set Reference Vision Height

The function of this option is to set the rising table so that it will view the board fiducials on focus. This is achieved by driving the table up or down while viewing the vision monitor until the fiducial is in focus. Pressing Calibrate Vision Height will change the menu Bar showing the option Confirm. Pressing Confirm will set the current height of the rising table, updating the printer configuration file.

### Set Reference Print Height

The function of this option is to set the rising table so that the zero gap between screen and a zero board thickness is achieved. This is achieved by driving the table up to the screen until it just touches. Pressing Calibrate Print Height will change the menu Bar showing the option Confirm. Pressing Confirm will set the current height of the rising table, updating the printer configuration file.

### Drive Table using Jog buttons

Selecting this option will enable the right jog button to drive the rising table up at slow speed and the left jog button will drive the table down, stopping immediately the button is released.

### Toggle Table Brake

This option will toggle the brake on and off fitted to the rising table. On will be displayed when the brake is on.

### Cycle Rising Table

Selecting this option will first check that both the camera carriage and the screen cleaner unit are home, if either are not then a message will be displayed "Home Camera and/or Screen Cleaner first". Only if both are home, a continuous cycle will start driving the rising table to print height, dwelling for 2 seconds and repeating the cycle until stop is pressed or the set cycle count has been reached (50).

### Rail Lifted Left

Will continuously display the current status of the rail lifted left sensor. O will be displayed when the rail has been lifted.

### Rail Lifted Right

Will continuously display the current status of the rail lifted right sensor. O will be displayed when the rail has been lifted.

#### Table at Home

Will continuously display the current status of the home interlock sensor, or will be displayed when the vane is in the sensor.

#### Cycle Count

Will display the count when the module is being cycled.

### FOREIGN MACHINE INTERFACE

The selection of this module will display the Upline (left hand side of machine) and Downline (right hand side) bits that is used for the interface protocol.

#### MAO-Machine Available Out

This signal is set when the machine is available for communication.

#### RRO-Receice Request Out

Machine is ready to receive a board.

#### ARO-Acknowledge Request Out

This signal is set when the machine has acknowledged a request to transfer a board.

The send and receive request signals indicate the direction of board travel.

#### TRO-Transfer Request Out

This signal is set when the machine is in a position to start a board transfer.

#### SRO-Send Board Request

This signal is set when the machine is ready to send a board to an adjacent machine.

#### GBO-Good Board Out

This signal is set when the board being transferred from the core machine to an adjacent machine is considered good.

#### ARI-Acknowledge Request In

This signal is sent when an adjacent machine has committed to transfer to a board.

The send and receive request signals indicate the direction of board travel.

#### TRI-Transfer Request In

This signal is set when an adjacent machine is in position to start a board transfer.

#### MAI-Machine Available In

This signal will be set when an adjacent machine is available for communication.

#### GBI-Good Board In

This signal is set when the board being transferred from an adjacent machine to the core machine is considered good.

The last letter of the protocol ie. ARI or ARO indicates whether it is an Input or an Output.

## AUTOFLEX TOOLING

### Tooling Pins

Selecting this option will drive all of the pins up or down.

### Clamp Enable

Selecting this option will switch the power to the pin clamps.

### Clamp Power

Selecting this option will toggle the pin clamp power to partial or full power.

### Change Pin Status

Selecting this option will display another window, enabling the user to program a pin matrix.

### Cycle Autoflex Tooling

Selecting this option will continuously cycle all of the pins up or down.

## CHAPTER 6-ELECTRONIC ENCLOSURE

### INTRODUCTION

#### Electronic Enclosure

Electronic Cards that control the Machine are housed within two Electronic Enclosures, Figures 1 and 18 refers. Enclosures are located to the front of the machine in the positions shown.

Enclosure Y1 houses sixteen cards in slot positions X1 to X16, similarly enclosure Y2 houses a further eight cards in slot positions X1 to X8.

#### Nomenclature

In the following pages references to cards will be pre-fixed by the Enclosure Number, Y1Y2, to distinguish cards from different enclosures.

#### Card Types

Similar card types are housed adjacently.

Enclosure Y1 card types include controller cards for servo and stepper motors drivers, and their corresponding driver.

Enclosure Y2 houses cards used to interface the signals from the processor to the process and include the drivers that provide isolation and high power output to motors and solenoids.

Purpose-made cards include the signal conditioner card used to generate a singular output for a combination of logical inputs and the dedicated Personality Card that configures the screen printer to perform within a specific External Machine Interfacing protocol.

#### Card Position & Card Address

Cards are positioned in enclosure slots numbered X1 through to X15. Where a card has an output signal (eg an error output signal) directed to the control system bus, the address for that card will be configured by the setting of an on board bit switch. Cards Y1 (X1 to X4) is assigned to a unique Card Address.

#### LED Display

Features of cards Y1 (X1 to X4) have LED displays that indicate the current status of the card during normal operation. Explanation of the LED display coding is given.

#### Battery-backed RAM

Cards fitted with Eprom (memory) devices have a battery that backs-up the ram storage on the eprom when the machine is not powered. The current state of the eprom ram area must be written when the card is replaced. To do this, use the MINT (Motion Interpreter) software supplied with the machine and the procedure as described in 'Installing a MINT program' later in this chapter.

#### Card Configuration

Cards are multi-function according to the configuration of the card.  
Jumper links fitted to the card configure the card to required function.  
The required link connections are illustrated for each card position.

#### Failsafe Operation

Inputs to the Controller Cards are consistently set to be active-high in the alarm state. Unless alarm inputs are pulled low during normal operation, the card will signal an alarm state and all external drives will stop.

#### Board Communications

Cards Y1(X1-X4) have standard connectors for serial communication to a host machine. Operating and error messages may be passed to and from the Host.

#### Y1 ENCLOSURE, CARD POSITION X1

##### Part No

107668

##### Description

SERVO CONTROL PCB

##### Type

Eurosystem Servo/Step Input/Output Card

The card can provide drive for the control of up to three independent axis of control. A feature of card X1 is the provision for controlling either servo or step motors.

##### Purpose

Provides drive for the servo motors of the Print carriage, Rising Table and the stepping motor of the Rail Width drive, also known as the Moving Rail. The front rail is a fixed position.

##### Card Address

Replacement of an existing board requires that the card address is configured to the slot address.

##### Selected Jumper Links

A summary of the controller card jumper links is set out in the illustration of Card 1

##### Input Range

Jumpers J2 and J3 configure the card to suit the input/output range expected for servo motor application.

## Error Outputs

Jumper links JP2 to JP6 must be made as shown in Card X1 illustration.

Jumper links are used to select the output type for error messages.

An error output provides an error signal to an external circuit for the control of such devices as motors. An error signal is given when the controller card detects an error such as a limit or a programming error. The error output type refers to open collector, open emitter, or push pull. The active state is also selectable between 0 and +12 V. For this application, JP5 only is fitted.

JP5 only-Output pulled down to 0 V when o : Open emitter.

## LED Display

Each card is fitted with a seven segment LED (light emitting diode) display that indicates the current status of the card during operation. The display indicates either the board address or gives status information on the card. The messages associated with normal operation and those giving indication of an error conditions are set out.

## Error Conditions

If an error occurs, the LED will alternatively display the error condition for each axis at 1 second intervals. As there is only a single display, to indicate the axis that is at fault, a full stop will be displayed after the character.

## Safety Stop-Input on pin a25 (controlled from PCIB40#2)

The STOP input to any controller card provides a controlled stop when asserted. The stop input (Card pin a25) is active-high and is connected to normally closed external switch. This arrangement ensures failsafe operation. Stop condition is indicated as "S" on the LED display.

## Card Communications RS 232

Each card is fitted with a serial interface either RS 232 or RS 485. The serial port is set for the following configurations. MINT transmits a carriage return/line feed (<CR><LF>) but only expects a carriage return<CR> from the host terminal.

Although the MINT operation is normally performed via the Parallel data bus, the RS232 connections may also be used. Connections are brought out onto the 9-way D-type connector on the front of the controller card.

## Card Replacement

If for whatever reason this card is replaced then the following has to be carried out:

- i)Configure jumper links
- ii)Set card address
- iii)Download MINT program

Y1 ENCLOSURE, CARD POSITION X2

Part No.

107668

Description

SERVO CONTROL PCB

## Type

Eurosystem Servo/Step Input/Output

## Purpose

Provides drive for the DC servo motors of each of the following:

Axis #0

Camera "X"

See Card X12 for amplifier card

Axis #1

Camera "Y"

See Card X13 for amplifier card

## Card Address

Replacement of an existing board requires that the card address is configured to slot address. The address is entered at the bit-switch in binary code.

## Selectable Jumper Links

A summary of the controller card jumper links is set out in the notes for the illustration of Card X2.

## Input Range

Jumpers J2 and J3 configure the card to suit the input/output range expected for servo motor application. Set the jumpers as shown.

## Error Outputs

Jumper links JP2 to JP6 must set be made as shown in illustration.

Jumper links are used to select the output type for error messages.

An error output provides an error signal to an external circuit for the control of such devices as motors. An error signal is given when the controller card detects an error such as a limit or a programming error. The error output type refers to open collector, open emitter, or push pull. The active state is also acceptable between 0 and +12 V.

For this application, JP5 is only fitted.

JP5 only- Output pulled down to 0 V when o : Open emitter.

## LED Display

Each card is fitted with a seven segment LED (light emitting diode) display that indicates the current status of the card during operation. The display indicates either the board address or gives status information on the card. The messages associated with normal operation and those giving indication of an error condition are set out below.

## Table 2 - LED Display, Normal Operation

### LED Display

#### Description

0- Card Address 1

1- Card Address 2

2- Card Address 3

- 3- Card Address 4
- 8- Servo powered up and idle
- H- Axis is moving to home
- P- Axis is moving to position
- J- Jogging (Velocity) move
- S- Axis stopped

Table 3 - LED Display, Error Condition

LED Display  
Description

- E- Software error
- L- Axis control out of limits
- Servo power o
- F- Pulse following error
- U- Pulse following error

8. Or blank- Voltage drop to below 4.85V (held in Reset)

NOTE: All above displays in Table 3 could have a full stop after the character indicating that this is axis #1 being displayed.

#### Error Conditions

If an error occurs, the LED will alternatively display the error condition for each axis at 1 second intervals. As there is only a single display, to indicate the axis that is at fault, a full stop will be displayed after the character.

Safety Stop- Input on pin a25 (controlled from PCIB40#2)

The STOP input to any controller card provides a controlled stop when asserted. The stop input (Card pin a25) is active-high and is connected to from normally closed external switch. This arrangement ensures failsafe operation. Stop condition is indicated as "S" on the LED display.

#### Card Communication RS 232

Each card is fitted with a serial interface either RS 232 or RS 485. The serial port is set for the following configurations.

MINT transmits a carriage return/line feed <CR><LF> but only expects a carriage return <CR> from the host terminal.

Although the MINT operation is normally performed via the Parallel data bus, the RS232 connections may also be used. Connections are brought out onto the 9-way D-Type connector on the front of the controller card.

See Manufacturer's data sheets or the Appendix 1 for details of connections.

#### Card Replacement

If for whatever reason this card is replaced then the following has to be carried out:

- i) Configure jumper links
- ii) Set card address

iii) Download MINT program  
Y1 ENCLOSURE, CARD POSITION X3

Part No.  
107681

Description  
STEP CONTROL PCB

Type  
EuroStep Input/Output Control card

Purpose  
Provides stepping and directional control for the stepper motors of each of the following:

Axis #0  
X Fwd Screen Actuator  
See Card X5 for driver

Axis #1  
X rear Screen Actuator  
See Card X6 for driver

Axis #2  
Y Screen Actuator  
See Card X7 for driver

Card Address  
Replacement of an existing board requires that the card address is configured to slot address. The address is entered at the bit-switch in binary code.

Selectable Jumper Links  
Input Range

Jumpers J2 and J3 configure the card to suit the input/output range expected for servo motor application.

Error Outputs

Jumper links JP2 to JP6 must set be made as shown in illustration.

Jumper links are used to select the output type for error messages.

An error output provides an error signal to an external circuit for the control of such devices as motors. An error signal is given when the controller card detects an error such as a limit or a programming error. The error output type refers to open collector, open emitter, or push pull. The active state is also selectable between 0 and +12V.

For this application, JP5 only is fitted.

JP5 only- Output pulled down to 0V when o : Open emitter.

LED Display

Each card is fitted with a single LED (light emitting diode) display that indicates the current status of the card



during operation. The display indicates either the board address or gives status information on the card. The messages associated with normal operation and those giving indication of an error condition are set out below.

Table 2 - LED Display, Normal Operation

LED Display

Description

- 0- Card Address 1
- 1- Card Address 2
- 2- Card Address 3
- 3- Card Address 4
- 8- Servo powered up and idle
- H- Axis is moving to home
- P- Axis is moving to position
- J- Jogging (Velocity) move
- S- Axis stopped

Table 3 - LED Display, Error Condition

LED Display

Description

- E- Software error
  - L- Axis control out of limits
  - Servo power o
  - U- Pulse following error
  - 8. Or blank- Voltage drop to below 4.85V (held in Reset)
- NOTE: All above displays in Table 3 could have a full stop after the character indicating that this is axis #1 being displayed.

Error Conditions

If an error occurs, the LED will alternatively display the error condition for each axis at 1 second intervals. As there is only a single display, to indicate the axis that is at fault, a full stop will be displayed after the character.

Safety Stop- Input on pin a25 (controlled from PCIB40#2)

The STOP input to any controller card provides a controlled stop when asserted. The stop input (Card pin a25) is active-high and is connected to from normally closed external switch. This arrangement ensures failsafe operation. Stop condition is indicated as "S" on the LED display.

Card Communication RS 232

Each card is fitted with a serial interface either RS 232 or RS 485. The serial port is set for the following configurations.

MINT transmits a carriage return/line feed <CR><LF> but only expects a carriage return <CR> from the host terminal.

Although the MINT operation is normally performed via the Parallel data bus, the RS232 connections may also be

used. Connections are brought out onto the 9-way D-Type connector on the front of the controller card. See Manufacturer's data sheets or the Appendix 1 for details of connections.

#### Card Replacement

If for whatever reason this card is replaced then the following has to be carried out:

- i) Configure jumper links
- ii) Set card address
- iii) Download MINT program

Each card is fitted with a single LED (light emitting diode) display that indicates the current status of the card during operation.

#### Y1 ENCLOSURE, CARD POSITION X4

Part No.

107681

Description

STEP CONTROL PCB

Type

EuroStep Stepper Drive Controller Card

Purpose

Provides control for the stepper motors of each of the following:

Axis #0

Rear Squeegee

See Card X15 for driver.

Axis #1

Front Squeegee

See Card X14 for driver.

Axis #2

Paste Dispenser

See Card X8 for driver

Card Address

Note: The Card Address is 3 for Card Slot Position X4.

Replacement of an existing board requires that the card address is configured to slot address. The address is entered at the bit-switch in binary code.

Selectable Jumper Links

Input Range

Jumpers J2 and J3 configure the card to suit the input/output range expected for servo motor application.

## Error Outputs

Jumper links JP2 to JP6 must set be made as shown in illustration.

Jumper links are used to select the output type for error messages.

## LED Display

Each card is fitted with a seven segment LED (light emitting diode) display that indicates the current status of the card during operation. The display indicates either the board address or gives status information on the card. The messages associated with normal operation and those giving indication of an error condition are set out below.

Table 2 - LED Display, Normal Operation

### LED Display

#### Description

- 0- Card Address 1
- 1- Card Address 2
- 2- Card Address 3
- 3- Card Address 4
- 8- Servo powered up and idle
- H- Axis is moving to home
- P- Axis is moving to position
- J- Jogging (Velocity) move
- S- Axis stopped

Table 3 - LED Display, Error Condition

### LED Display

#### Description

- E- Software error
- L- Axis control out of limits
- Servo power o
- U- Pulse following error
- 8. Or blank- Voltage drop to below 4.85V (held in Reset)
- F- Maximum following error exceeded

- E- Software error
- L- Axis control out of limits
- Servo power o
- U- Pulse following error
- 8. Or blank- Voltage drop to below 4.85V (held in Reset)
- F- Maximum following error exceeded

NOTE: All above displays in Table 3 could have a full stop after the character indicating that this is axis #1 being displayed.

## Error Conditions

If an error occurs, the LED will alternatively display the error condition for each axis at 1 second intervals. As there is only a single display, to indicate the axis that is at fault, a full stop will be displayed after the character.

Safety Stop- Input on pin a25 (controlled from PCIB40#2)

The STOP input to any controller card provides a controlled stop when asserted. The stop input (Card pin a25) is active-high and is connected to from normally closed external switch. This arrangement ensures failsafe operation. Stop condition is indicated as "S" on the LED display.

Card Communication RS 232

Each card is fitted with a serial interface either RS 232 or RS 485. The serial port is set for the following configurations.

MINT transmits a carriage return/line feed <CR><LF> but only expects a carriage return <CR> from the host terminal.

Although the MINT operation is normally performed via the Parallel data bus, the RS232 connections may also be used. Connections are brought out onto the 9-way D-Type connector on the front of the controller card.

See Manufacturer's data sheets or the Appendix 1 for details of connections.

Card Replacement

If for whatever reason this card is replaced then the following has to be carried out:

- i) Configure jumper links
- ii) Set card address
- iii) Download MINT program

## INSTALLING A MINT PROGRAM

Procedure

If the error message "Motor Comms Failure" appears in the Message Prompt Bar, then it is likely one or more of the Optimized Control cards has failed to run its internal program.

There are four Optimized Control cards (numbered 0,1,2,3) in the machine system and each one has its own internal program held in battery backed RAM. The battery, a rechargeable NiCad, is charged when the machine is powered up and will retain memory for approximately 6 weeks if not recharged.

The procedure for downloading the MINT programs should be adhered to rigidly.

1. Enter into Maintenance by the use of the keyswitch and select Diagnostics, then highlight System by use of the the Next or Prev keys.
2. Press Select Module then highlight Exit to DOS. Press Run Diagnostics. The C:\backslashPRINTER prompt will be displayed.
3. At the DOS prompt type, c:\backslashMINT then press return. Type, LOAD, then press return. This will start the MINT program.
4. The Main Control Screen will display a menu bar.

Using the Auto Download option will automatically abort all four cards and then download the relevant files for each

of the cards. Using the Manual Download will allow the user to abort the cards then establish communication link between the Arcom PC and the Optimized Control Cards and then individual file download for each of the four cards.

The Manual Download can be used to establish which of the four cards that maybe at fault.

5. Use the Auto Download firstly and attempt to download the files. View the Control Screen while down-loading the files to see if the cards have been aborted and that the link has been established.

6. Exit from the MINT Program then switch the machine o and wait for approximately 30 seconds.

7. Power up the machine and check that the machine will initialize correctly.

If the error is still repeated, then call the service personnel.

#### Y1 ENCLOSURE, CARD POSITION X5

Part No.

107682

Description

STEP DRIVE PCB

Type

RS Stepper Motor Drive Card

Purpose

Provides Drive for the Stepper motors of each of the following:

"X" Forward Screen Actuator.

(See Card X3 for controller details).

Card Configuration

No card configuration required. The card performs in full step mode when there is no connection to pin 25.

#### Y1 ENCLOSURE, CARD POSITION X6

Part No.

107682

Description

STEP DRIVE PCB

Type

RS Stepper Motor Drive Card

Purpose

Provides Drive for the Stepper motors of each of the following:

"X" Rear Screen Actuator.

(See Card X3 for controller details).

Card Configuration

No card configuration required. The card performs in full step mode when there is no connection to pin 25.

Y1 ENCLOSURE, CARD POSITION X7

Part No.

107682

Description

STEP DRIVE PCB

Type

RS Stepper Motor Drive Card

Purpose

Provides Drive for the Stepper motors of each of the following:

"Y" Screen Actuator

(See X3 Eurostep card for the motor control)

Card Configuration

No Card Configuration is required. The card performs in full step mode when there is no connection to pin 25.

Y1 ENCLOSURE, CARD POSITION X8

Part No.

107682

Description

STEP DRIVE PCB

Type

RS Stepper Motor Drive Card

Purpose

Provides Drive for the Stepper motors of each of the following:

Paste Dispenser

(See X4 Eurostep card for the motor control)

Card Configuration

No Card Configuration is required. The card performs in full step mode when there is no connection to pin 25.

Y1 ENCLOSURE, CARD POSITION X9

Part No.

107683

Description

## LIMIT SWITCH CON.PCB

### Type

Limit Switch Conditioner

### Purpose

Provides singular logical output signal for any out of limits movement by the X or Y camera. The output signals Limit 0/1 are used to stop X and Y camera drives.

### Input

Y camera Home Limit

### Output

L0

Y camera Away Limit

X camera Home Limit

### Output

L1

X camera Away Limit

### Indicators

Each channel is fitted with a LED indicator to indicate the status of the input. When the vane enters the hall effect the output will be high. The output of the OR gate will be high and the buffer will be open circuit. The buffer has an open collector output and with a high input the current will be allowed to flow through the resistor and the led illuminating.

Circuit Ref 107683

### Card Configuration

No Card Configuration required.

Y1 ENCLOSURE, CARD POSITION X10

### Part No.

110742

### Description

SERVO AMPLIFIER

### Type

Euroamp/8 Servo motor Drive Card

### Purpose

Provides Drive amplifier to the DC Servo motor of the Print Carriage. For this application the amplifier is used to convert the analog input voltage to a proportional output voltage and direction to drive the armature of the DC motor.

### Indicators

Indicator lamps fitted to the edge of the board have the meanings set

out in the Notes accompanying the illustration of the card Y1 X10.

#### Trimmers

All potentiometers are factory set and require no setting.

#### Selectable Jumper Links

Selectable Jumper links J1 through J4. Links have the following meaning:

J1 to J4 used to configure the amplifier as a velocity controller. Not used in this application.

J5 used to configure the output type for the error output signal.

#### Selectable Jumper Links

Selectable Jumper links J1 through J4. Links have the following meaning:

J1 to J4 used to configure the amplifier as a velocity controller. Not used in this application.

J5 used to configure the output type for the error output signal.

#### Safety Stop

External Enable Input Pin 2z (controlled from Y1, X1 and detected by PCB40#4)

Enable (Pin 2z) provides immediate stop to drive motor (Enable is active low).

If Enable is left unconnected or connected to a voltage of between 5V to 12V, then the current loop of the amplifier is disabled and zero current is delivered to the motor.

#### Auxiliary Supplies

The amplifier card is able to supply ancillary circuits from the on-board power supply. These supplies remain active at all times. Not used in this application.

#### External Supplies

30 volts ac is used to supply the drive to the servo motors. This voltage is rectified on board to supply the d.c. voltage required to power the servo motor.

Y1 ENCLOSURE, CARD POSITION X11

#### Part No.

110742

#### Description

SERVO AMPLIFIER

#### Type

Euroamp/8 Servo motor Drive Card

#### Purpose

Provides Drive amplifier to the DC Servo motor of the Rising table. For this application the amplifier is used to convert the analog input voltage to a proportional output voltage and direction to drive the armature of the DC motor.

#### Indicators

Indicator lamps fitted to the edge of the board have the meanings set out in the Notes accompanying the illustration of the card Y1 X11.



#### Trimmers

All potentiometers are factory set and require no setting.

#### Selectable Jumper Links

Selectable Jumper links J1 through J4. Links have the following meaning:

J1 to J4 used to configure the amplifier as a velocity controller. Not used in this application.

J5 used to configure the output type for the error output signal.

#### Safety Stop

External Enable Input Pin 2z (controlled from Y1, X1 and detected by PCB40#4)

Enable (Pin 2z) provides immediate stop to drive motor (Enable is active low).

If Enable is left unconnected or connected to a voltage of between 5V to 12V, then the current loop of the amplifier is disabled and zero current is delivered to the motor.

#### Auxiliary Supplies

The amplifier card is able to supply ancillary circuits from the on-board power supply. These supplies remain active at all times. Not used in this application.

#### External Supplies

30 volts ac is used to supply the drive to the servo motors. This voltage is rectified on board to supply the d.c. voltage required to power the servo motor.

Y1 ENCLOSURE, CARD POSITION X12

#### Part No.

110742

#### Description

SERVO AMPLIFIER

#### Type

Euroamp/8 Servo motor Drive Card

#### Purpose

Provides Drive amplifier to the DC Servo motor of the "X" Camera Carriage. For this application the amplifier is used to convert the analog input voltage to a proportional output voltage and direction to drive the armature of the DC motor.

#### Indicators

Indicator lamps fitted to the edge of the board have the meanings set out in the Notes accompanying the illustration of the card Y1 X12.

#### Trimmers

All potentiometers are factory set and require no setting.

#### Selectable Jumper Links

Selectable Jumper links J1 through J4. Links have the following meaning:

J1 to J4 used to configure the amplifier as a velocity controller. Not used in this application.

J5 used to configure the output type for the error output signal.

#### Safety Stop

External Enable Input Pin 2z (controlled from Y1, X2 and detected by PCB40#4)

Enable (Pin 2z) provides immediate stop to drive motor (Enable is active low).

If Enable is left unconnected or connected to a voltage of between 5V to 12V, then the current loop of the amplifier is disabled and zero current is delivered to the motor.

#### Auxiliary Supplies

The amplifier card is able to supply ancillary circuits from the on-board power supply. These supplies remain active at all times. Not used in this application.

#### External Supplies

30 volts ac is used to supply the drive to the servo motors. This voltage is rectified on board to supply the d.c. voltage required to power the servo motor.

#### Y1 ENCLOSURE, CARD POSITION X13

#### Part No.

110742

#### Description

SERVO AMPLIFIER

#### Type

Euroamp/8 Servo motor Drive Card

#### Purpose

Provides Drive amplifier to the DC Servo motor of the "Y" Camera Carriage.

For this application the amplifier is used to convert the analog input voltage to a proportional output voltage and direction to drive the armature of the DC motor.

#### Indicators

Indicator lamps fitted to the edge of the board have the meanings set out in the Notes accompanying the illustration of the card Y1 X13.

#### Trimmers

All potentiometers are factory set and require no setting.

#### Selectable Jumper Links

Selectable Jumper links J1 through J4. Links have the following meaning:

J1 to J4 used to configure the amplifier as a velocity controller. Not used in this application.

J5 used to configure the output type for the error output signal.

#### Safety Stop

External Enable Input Pin 2z (controlled from Y1, X2 and detected by PCB40#4)

Enable (Pin 2z) provides immediate stop to drive motor (Enable is active low).

If Enable is left unconnected or connected to a voltage of between 5V to 12V, then the current loop of the amplifier is disabled and zero current is delivered to the motor.

#### Auxiliary Supplies

The amplifier card is able to supply ancillary circuits from the on-board power supply. These supplies remain active at all times. Not used in this application.

#### External Supplies

30 volts ac is used to supply the drive to the servo motors. This voltage is rectified on board to supply the d.c. voltage required to power the servo motor.

Y1 ENCLOSURE, CARD POSITION X14

#### Part No.

E6949

#### Description

SD2 STEPPER DRIVE

#### Type

Digiplan SD-2 Motor Drive Card

#### Purpose

Provides Drive for the step motor of the Front Squeegee

See Card x4 for controller.

Y1 ENCLOSURE, CARD POSITION X15

#### Type

Digiplan SD-2 Motor Drive Card

#### Part No.

E6949

#### Description

SD2 STEPPER DRIVE

#### Purpose

Provides Drive for the step motor of the Rear Squeegee.

See Card x4 for controller.

Y1 ENCLOSURE, CARD POSITION X16

#### Type

Digiplan SD-2 Motor Drive Card

#### Part No.

E6949

Description

SD2 STEPPER DRIVE

Purpose

Provides Drive for the step motor of the Moving Rail.

See Card x4 for controller details.

Y2 ENCLOSURE, CARD POSITION X1

Type

Arcom SCB34 Signal Conditioning Board

Part No.

107684

Description

BRIDGE DRIVER PCB

Purpose

Provides the processor with optically isolated fixed or variable output drives to various process functions.

Where the output function is single valued, either On/O the processor provides a signal at the ON input to the card. The card optically isolates the signal and switches the required full power to the output device.

If the output device requires variable output power, for example setting a required speed of a transfer belt. The processor signals the appropriate Channel SLOW input, and the card switches a pulse width modulated power output to the device.

The magnitude of the output power is determined by the setting of a Channel trimmer pot. The trimmer sets the gating of the output pulse train of an on-board oscillator. The resulting modulated train of pulses is then used to switch the output stage and the average power delivered to the device is in proportion to the pulse width.

Details of the adjustment to the trimmers is described in Chapter 7- Calibrations and Settings.

Functions controlled by Card Y2, X1:

RISING TABLE BRAKE

X CARRIAGE CLAMP

Y CARRIAGE CLAMP

SCREEN CLEAN PUMP

CLEANER HOME CLAMP

HEAD LATCH CLAMP

All functions listed are ON/OFF type ie the ON signal only is used.

Card Address Links (Group Address)

All cards in Enclosure Y2 are accessed by the Processor bus (a visible 50 way ribbon cable that links all cards

in the enclosure) Correct card identification is achieved by configuring each card to a unique address. The address is determined by the settings of the links on PL3, PL4, PL5, PL6. The required linking may be achieved either by removable links or by fitting a purpose-made connector with prepared wire wrapped linkages.

Links that define Group Address 1 G 0 (this card Y2 X1) are given in the accompanying illustration.

#### Reference Voltage

The on board Reference-supply generator is not used in this application, and therefore adjustment is not required.  
Y2 ENCLOSURE, CARD POSITION X2

#### Type

Arcom SCB34 Signal Conditioning Board

#### Part No.

107684

#### Description

BRIDGE DRIVER PCB

#### Purpose

Provides the processor with optically isolated fixed or variable output drives to various process functions.

Where the output function is single valued, either On/O the processor provides a signal at the ON input to the card. The card optically isolates the signal and switches the required full power to the output device.

If the output device requires variable output power, for example setting a required speed of a transfer belt. The processor signals the appropriate Channel SLOW input, and the card switches a pulse width modulated power output to the device.

The magnitude of the output power is determined by the setting of a Channel trimmer pot. The trimmer sets the gating of the output pulse train of an on-board oscillator. The resulting modulated train of pulses is then used to switch the output stage and the average power delivered to the device is in proportion to the pulse width.

Details of the adjustment to the trimmers is described in Chapter 7- Calibrations and Settings.

Functions controlled by Card Y2, X2:

VACUUM VALVE

TOOLING HEATERS

CARTRIDGE TILT MOTOR-

CARTRIDGE TILT MOTOR+

SCREEN DRIVE MOTOR-

SCREEN DRIVE MOTOR+

TOOLING PRESSURE SOLENOID

CHASE CLAMP

All functions listed are ON/OFF type ie the ON signal only is used.

#### Card Address Links (Group Address)

All cards in Enclosure Y2 are accessed by the Processor bus (a visible 50 way ribbon cable that links all cards in the enclosure) Correct card identification is achieved by configuring each card to a unique address. The address is determined by the settings of the links on PL3, PL4, PL5, PL6. The required linking may be achieved either by removable links or by fitting a purpose-made connector with prepared wire wrapped linkages.

Links that define Group Address 1 G 0 (this card Y2 X1) are given in the accompanying illustration.

#### Reference Voltage

The on board Reference-supply generator is not used in this application, and therefore adjustment is not required.  
Y2 ENCLOSURE, CARD POSITION X3

#### Type

Arcom SCB34 Signal Conditioning Board

#### Part No.

107684

#### Description

BRIDGE DRIVER PCB

#### Purpose

Provides the processor with optically isolated fixed or variable output drives to various process functions.

Where the output function is single valued, either On/O the processor provides a signal at the ON input to the card. The card optically isolates the signal and switches the required full power to the output device.

If the output device requires variable output power, for example setting a required speed of a transfer belt. The processor signals the appropriate Channel SLOW input, and the card switches a pulse width modulated power output to the device.

The magnitude of the output power is determined by the setting of a Channel trimmer pot. The trimmer sets the gating of the output pulse train of an on-board oscillator. The resulting modulated train of pulses is then used to switch the output stage and the average power delivered to the device is in proportion to the pulse width.

Details of the adjustment to the trimmers is described in Chapter 7- Calibrations and Settings.

Functions controlled by Card Y2, X3:

TRI COLOR BEACON RED

TRI COLOR BEACON AMBER

TRI COLOR BEACON GREEN

CLEANER PAPER FEED SOLENOID

TOP CAMERA SHUTTER SOLENOID

BOTTOM CAMERA SHUTTER SOLENOID

BOARD STOP SOLENOID  
SOFT EMERGENCY STOP

All functions listed are ON/OFF type ie the ON signal only is used.

Card Address Links (Group Address)

All cards in Enclosure Y2 are accessed by the Processor bus (a visible 50 way ribbon cable that links all cards in the enclosure) Correct card identification is achieved by configuring each card to a unique address. The address is determined by the settings of the links on PL3, PL4, PL5, PL6. The required linking may be achieved either by removable links or by fitting a purpose-made connector with prepared wire wrapped linkages.

Links that define Group Address 1 G 2 (this card Y2 X3) are given in the accompanying illustration.

Reference Voltage

The on board Reference-supply generator is not used in this application, and therefore adjustment is not required.  
Y2 ENCLOSURE, CARD POSITION X4

Type

Arcom SCB34 Signal Conditioning Board

Part No.

107684

Description

BRIDGE DRIVER PCB

Purpose

Provides the processor with optically isolated fixed or variable output drives to various process functions.

Where the output function is single valued, either On/O the processor provides a signal at the ON input to the card. The card optically isolates the signal and switches the required full power to the output device.

If the output device requires variable output power, for example setting a required speed of a transfer belt. The processor signals the appropriate Channel SLOW input, and the card switches a pulse width modulated power output to the device.

The magnitude of the output power is determined by the setting of a Channel trimmer pot. The trimmer sets the gating of the output pulse train of an on-board oscillator. The resulting modulated train of pulses is then used to switch the output stage and the average power delivered to the device is in proportion to the pulse width.

Details of the adjustment to the trimmers is described in Chapter 7- Calibrations and Settings.

Functions controlled by Card Y2, X4:

CARTRIDGE SEAL SOLENOID  
DISPENSE PRESSURE SOLENOID  
SCREEN DRIVE COUPLING RIGHT SOLENOID

SCREEN DRIVE COUPLING LEFT SOLENOID  
BOARD CLAMP SOLENOID  
SCREEN REAR STOP SOLENOID  
SCREEN FRONT STOP SOLENOID  
SCREEN CLAMP SOLENOID

All functions listed are ON/OFF type ie the ON signal only is used.

Card Address Links (Group Address)

All cards in Enclosure Y2 are accessed by the Processor bus (a visible 50 way ribbon cable that links all cards in the enclosure) Correct card identification is achieved by configuring each card to a unique address. The address is determined by the settings of the links on PL3, PL4, PL5, PL6. The required linking may be achieved either by removable links or by fitting a purpose-made connector with prepared wire wrapped linkages.

Links that define Group Address 1 G 3 (this card Y2 X4) are given in the accompanying illustration.

Reference Voltage

The on board Reference-supply generator is not used in this application, and therefore adjustment is not required.  
Y2 ENCLOSURE, CARD POSITION X5

Type

Arcom SCB34 Signal Conditioning Board

Part No.

107684

Description

BRIDGE DRIVER PCB

Purpose

Provides the processor with optically isolated fixed or variable output drives to various process functions.

Where the output function is single valued, either On/O the processor provides a signal at the ON input to the card. The card optically isolates the signal and switches the required full power to the output device.

If the output device requires variable output power, for example setting a required speed of a transfer belt. The processor signals the appropriate Channel SLOW input, and the card switches a pulse width modulated power output to the device.

The magnitude of the output power is determined by the setting of a Channel trimmer pot. The trimmer sets the gating of the output pulse train of an on-board oscillator. The resulting modulated train of pulses is then used to switch the output stage and the average power delivered to the device is in proportion to the pulse width.

Details of the adjustment to the trimmers is described in Chapter 7- Calibrations and Settings.

Functions controlled by Card Y2, X5:



HEAD LIFT DOWN (VR1)  
HEAD LIFT UP  
FRONT BELT MOTOR FORWARD (VR3)  
FRONT BELT MOTOR REVERSE (VR4)  
REAR BELT MOTOR FORWARD (VR5)  
REAR BELT MOTOR REVERSE (VR6)

Functions listed include those where a visible output is required. (Front/Rear belts). Remaining functions are ON/OFF type ie the ON signal only is used.

#### Card Address Links (Group Address)

All cards in Enclosure Y2 are accessed by the Processor bus (a visible 50 way ribbon cable that links all cards in the enclosure) Correct card identification is achieved by configuring each card to a unique address. The address is determined by the settings of the links on PL3, PL4, PL5, PL6. The required linking may be achieved either by removable links or by fitting a purpose-made connector with prepared wire wrapped linkages.

Links that define Group Address 2 G 0 (this card Y2 X5) are given in the accompanying illustration.

#### Reference Voltage

The on board Reference-supply generator is not used in this application, and therefore adjustment is not required.  
Y2 ENCLOSURE, CARD POSITION X6

#### Type

Arcom SCB9 Processor Input Signal Conditioning Board

#### Part No.

107686

#### Description

OPTO ISOLATOR I/P PCB

#### Purpose

Provides opto isolation of the process signals from Personality Card X8 to the processor.

#### Circuit

Inputs to the card are signals from the process, for this card these are the outputs from the Personality Card Y2, X8, are routed via this card for opto isolation prior to further routing to the processor.  
Noise filtering is available for conditioning each incoming signal.

Y2 ENCLOSURE, CARD POSITION X7

#### Type

Arcom SCB 40 Processor Output Signal Conditioning Board

#### Part No.

112389

#### Description

OPTO ISOLATOR O/P PCB

#### Purpose

Provides for the following:

1. Opto isolation of processor signals to the External Machine Interface Communications (Up-line/Down-line)
2. Opto isolation of processor signals to the Screen Changer.
3. Opto isolation of processor signals to the Personality Card.

#### Circuit

The accompanying illustration shows a simplified diagram of the circuit function. See the Arcrom System Manual for a fully detailed circuit diagram. Signals from the processor are routed via opto isolators to the process.

Y2 ENCLOSURE, CARD POSITION X8

#### Type

Interface Personality Card

#### Part No's.

112045- Base card

112165- SMPI/(Universal)

112166- SHEMA

112167- Fuji

113079- Fuji download only

112416- TDK

112417- Dynapert

112008- Sanyo

112418- Siemens

#### Description

INTERFACE PERSONALITY CARD

#### Purpose

Personality cards are interfacing boards configured to adapt the screen printer to function in cooperation with External Machines.

The screen printer requires to communicate using the interfacing standard of the EXTERNAL MACHINE. The machine is configured for specific interfaces using the relevant personality card, as listed above.

NOTE: Up and Downline interfaces must be of the same type

#### Features

This card provides the following features for configuring specified external Machine Interfaces:

#### 1. INTERFACING ADDRESSING

Each external machine interface type is assigned a unique coding by the setting of the bit link 1 to 4. For example the Sanyo link is recognized by the presence of a link at bit 2.

## 2. CURRENT LIMITING FOR 24V SYSTEMS

For Interfaces that require 24V signal lines, resistors can be fitted to the signal lines of the External machine Interface (Upline/Downline) and the Screen Changer Option to limit the signal current. Wire links would replace the resistors on the same signals for 12V systems where no current limiting is required.

## 3. ON BOARD 12V SUPPLY FOR EXTERNAL VLED ACTIVATION

The normal board supplies are +24V. On board +12V supplies are available for powering VLED (diode) in external opto diode cards, used for signal isolation within the interfacing process.

## 4. ISOLATED VOLT-FREE TRANSISTOR SWITCHING

Where the requirement is for volt-free transistor switch to the External Machine, provision has been made for up to four such switches (IC's 1 to 4). (This applies to the SMEMA interface).

Where such transistor switching is not required, IC 1 to 4 and the associated resistors RP 1 are not fitted. Wire links are fitted as illustrated to provide alternative linking when specified by the selected protocol.

## CHAPTER 7

### CALIBRATIONS AND SETTINGS

#### CALIBRATIONS

##### BELT SPEED

The front and rear belts are driven independently by two variable speed motors. It is necessary to calibrate these motors so that they drive at the same speeds in either direction.

The speed is measured using a tachometer on the center of the input or output pulley and should be adjusted to 300RPM by using four potentiometers on the SCB34 card in the electronics enclosure Y2, position X5.

The potentiometers and functions are listed below.

1. Select Diagnostics then the System module. Highlight the Display Digital Inputs module. A pop up window will be displayed listing the PCIB40's.

2. Select PCIB40#2 G1 to display a window containing the slow speed selection for the belt speed motors. Toggle each belt motor slow speed to ON. Exit from this window.

3. Select PCIB40#2 G0, and another window will be displayed showing the options of switching on/o the belt motors. Select the relevant motor to be adjusted and set the relevant potentiometer to achieve a factory setting of 300RPM (470mm/s). This setting can be adjusted to achieve specific customer requirements

- I) Front Belt Forward VR3
- ii) Front Belt Reverse VR4
- iii) Rear Belt Forward VR5
- iv) Rear Belt Reverse VR6

4. When motor settings have been achieved Exit from this module. This

completes the calibration, Exit from diagnostics or select another module.

## PRINT HEIGHT

This setting is used to maintain correct gap calibration after table sensor replacement or adjustment. As the table height also affects the pressure applied by the squeegee, pressure errors can be caused by the rising table height calibration. After this procedure reset the pressure reference height.

### NOTE

To set the printer reference height then a board must be used. Use the board which has the process parameters already set up. The key parameters, Board Thickness and Print Gap. The print gap should be set to 0mm.

1. Fit the screen.
2. Power up the machine and allow it to initialize.
3. Select 'Set-Up' followed by 'Edit Data'. Check and adjust if necessary, Board Thickness and Print Gap to 0mm.
4. Press Exit then Exit again. Select Maint then Diagnostics.
5. Select and run Rising Table and Home Rising Table.
6. Place the board on the rails and slide to a central position. Select and run Raise Table to Vision Height.
7. Select and run Table to Print Height.
8. Select and run 'Drive Table Using Jog Buttons'.
9. Using the jog buttons raise or lower the table until the top of the tooling clamps are just in contact with the screen.
10. Select and run 'Set Reference Print Height' and 'Confirm' the new height.

This completes the Print Height calibration. Stage 4 of the pressure calibration should now be carried out. Exit Diagnostics and initialize the machine, or select another diagnostic module, if required.

## SQUEEGEE PRESSURE

The pressure calibration is carried out in Stages 1-4 as detailed below. Prior to commencement of the calibration select the relevant stages from the calibration summary.

### NOTE

Ensure the rising table Print Reference Height is set correctly before commencing as Stage 4 of the calibration relies on accurate positioning to make a reference.

To calibrate the squeegee pressure a calibration kit is required.

### Calibration Summary

Stage 1 - Set up the amplifier card, +5V (RV3) for load cell excitation voltage, (use this stage if the load cell has been replaced or the amplifier card has been replaced).

Stage 2 - Setting of the transducer 'pre-load' set screw, (use this stage if the load cell has been replaced).

Stage 3 - Set the linearity of the amplifier card (RV2 Gain, RV4 O set), (use this stage if the amplifier card has been replaced)

Stage 4 - Set the squeegee reference height. This is a reference point from which the machine calculates how many steps it must drive to achieve the demanded pressure, (use this if the rising table sensors have been replaced or adjusted and if new squeegees have been fitted)

Select the necessary Stages to suit

#### Machine Preparation

1. Remove the screen if fitted.
2. Switch on the machine and allow to initialize.
3. Remove the cover from the printhead taking care to remove wires from the access cover safety switch.

#### Stage 1 - Load Cell Voltage (+5V)

1. On the pressure amplifier card monitor between +V and -V with a DVM, Figure 4 refers. This reading should be +5V dc +/-50mV. Adjust RV3 if necessary.

#### Stage 2 - Transducer Pre-Load Set Screw

1. Loosen the pre-load set screw locking nut. Place a 3.6 Kg load on top of the pressure assembly. Adjust the set screw so that there is a 1.0-1.5mm gap between the print carriage and the pressure assembly. Lock the set screw in this position. This will ensure that the load cell and set screw will not separate when the maximum squeegee weight is used.

2. Remove the load from the pressure assembly.

#### Stage 3 - Pressure Amplifier Setting (Linearity)

#### NOTE

Levelling the weights is a critical part of the operation as the machine uses the set step positions to calculate how many steps are required for a 1 Kg of pressure change (Pressure Factor).

1. Ensure that the rising table is clear of any support pins etc. Select MAINT then Calibrate Pressure.
2. Assemble the calibration fixture and the nosepiece on to the machine.  
Using the Incr/Decr button bring the nosepiece into contact with the balance.
3. Adjust the pressure amplifier O set so that the pressure display = 0.0Kg.
4. Select the 5 Kg option using the Next button. Place a 5Kg load onto the balance and using the Incr/Decr level the balance accurately (use a bubble level).
5. Adjust the pressure amplifier Gain (RV2) so that the pressure display = 5Kg +/-0.2Kg.
6. Remove the 5Kg load and select the Okg option using the Prev button
7. Adjust the pressure amplifier O set (RV4) so that the pressure display = 0.0Kg.
8. Select the 15Kg option using the Next button and place a 15Kg load

onto the balance. Using the Incr/Decr level the balance accurately.

9. Adjust the pressure amplifier Gain so that the pressure display = 15Kg +/-0.2Kg.

10. Remove the 15Kg load and select the 0Kg option using the Prev button.

11. Repeat steps 3 to 10. When the correct balance has been achieved continue on the next step.

12. Remove the nosepiece and calibration fixture.

13. Adjust pressure amplifier O set (clockwise) so that the pressure display = 3.6Kg +/-0.2Kg.

14. Check that a light downward force on the pressure mechanism decreases the pressure display. If not then repeat step 13 until this step is achieved.

15. Ensure that the rising table area is clear of any tools etc.  
and Press Exit. The Printer Configuration File will be updated.

#### Stage 4 - Squeegee reference height setting

1. Ensure the machine has initialized, if not then power off then on and allow machine to initialize.

2. Select Diagnostics and fit a screen to the chase and the standard squeegees to the front and rear carriers.

3. Select and run the Rising Table. Insert a board approximately in the center of the machine. Ensure there are board support pillars fitted.

4. Select and run Raise Table to Vision Height.

5. Select and run Raise Table to Print Height. Exit the Rising Table diagnostic.

6. Select and run Print Carriage diagnostics. Home the print carriage then position the carriage using Drive Carriage Using Jog Buttons, so that the squeegees are placed centrally about the board width. Right jog button moves the carriage towards the front. Exit the Print Carriage diagnostic.

7. Select and run the Squeegee diagnostic. Home the front and rear squeegees. Select Front Squeegee To Dwell Height and then select Rear Squeegee to Dwell Height.

8. Select and run Drive Rear Squeegee Using Jog Buttons. Right button will drive the squeegee downwards. Press and hold the right hand button until the squeegee stops driving. The message prompt bar will display 'Squeegee at Movement Limit'.

9. Select and run the Calibrate Rear Squeegee Print Height. Run Diagnostic and the Menu Bar will change to display Confirm. Pressing Confirm will update the Printer Configuration File. Select and run Home Rear Squeegee.

10. Repeat the steps 8 to 9 using the front squeegee options.

This completes the Pressure calibration. Exit Diagnostics and initialize the machine, or select another diagnostic module if required.

A trial run can be carried out by fitting the squeegees and a screen and running a board through the machine. Cycle the board checking to see if there are pressure errors reported. The error reported should only be once if at all, as the system is closed loop and therefore will compensate for any error discrepancy.

## VISION SYSTEM CALIBRATION

### Summary

For the vision alignment to function accurately a calibration of the system is required. This should be carried out by the maintenance personnel at the required period and at the installation of the machine.

The calibration of the vision system is carried out in three stages using a calibration screen, containing 25 equally spaced fiducials and a calibration board (plain copper clad).

The first stage, Calibrate O set is to compensate for any optical discrepancies between viewing up and down of the telecentric camera. This is achieved by printing the calibration screen and measuring the differences between the centroid of the screen fiducials and the centroid of the printed fiducials. The average of these differences are calculated and are recorded and used as part of the calibration data.

The second stage, Calibrate Vision, details the calibration of X, Y and Theta.

Calibration Video X, Y calculates the screen movement in pixel values. This is achieved by looking up at the calibration screen fiducials and moving the screen in the X and Y directions for each of the 25 fiducials by a fixed amount (2mm).

The movements are calculated for each fiducial and the mean taken. This average screen movement is recorded and used as part of the calibration data.

Calibration Theta calibrates the screen theta movement. The camera will select three screen fiducials and the screen will move in theta (using the two x axis implementing +2mm in x rear and -2mm in x forward to achieve the theta movement). The movements are calculated for each fiducial and the average taken. The data will be recorded and the calibration is complete.

### Calibration Procedure

The sequence of calibration is as follows:

- a) Select Set-Up and use Load Data and recall the CALIBRA.file.
- B) Insert the calibration screen and board and adjust if necessary the rough alignment of the screen to board.
- C) Adjust the print parameters so that a good print quality of the calibration fiducials is achieved.
- D) Use the Maint function and select the vision calibration modes.

These modes should be used in sequence and are as follows:

Stage 1 - Calibrate O set

Stage 2 - Calibrate Vision

Machine Preparation

Power up machine press green System button and allow to initialize. The Main Control Screen and the Main Menu Bar will be displayed. If the machine is already running and is in a different menu then press Exit repeatedly until the main Menu Bar is displayed.

Switch the diagnostic key ON (clockwise) so as to display the Maint function.

Stage 1- Calibrate O set

1. Press Set-Up button(F6) and the menu bar will change to show the functions available.
2. Push the Mode key until Auto is displayed on the Main Control Screen.
3. Press the Change Squeegee button to drive the print carriage rearwards and raise the squeegee mountings.
4. Raise the top access cover and fit the 535mm squeegees.
5. Press Change Screen. If there is no screen fitted then the message displayed in the screen will be 'Insert Screen'. If a screen is present then the machine will eject it, displaying the 'Remove Screen' in the Message Prompt Bar.
6. Lower the front access cover and insert the calibration screen so that the front edge of the screen frame is about flush with the panelling on the machine. Close the cover and press Change Screen and the screen will be automatically loaded into the machine.
7. Press Exit button and the Menu Bar will change to display the following.
8. A quantity of paste needs to be dispensed onto the screen so that the machine can print the 25 fiducials required to complete the Calibrate O set routine.

Paste can be applied by one of the two available methods:

- i) automatically from the paste cartridge using the Auto Dispens function.
- ii) manually onto the screen from the pot using the Manual Load function.

9. Press Paste Load to enter the paste application menu bar displayed below and using either method apply sufficient paste to the screen.

10. Press the Exit button, then the Set-Up key and the Menu Bar will change. Press the Load Data button and a pop-up window will be displayed on the Main Control Screen listing the Data Files currently stored on the hard disk. The Menu Bar will change to show the functions available.

11. Using the Left, Right, Up and Down buttons highlight the CALIBRA.data file. This data file contains the printing parameters and board information required by the vision calibration routine. The parameters contained within this file are set so that an initial print will be carried out with minimum user intervention.

Press the Load key and the data file will be transferred into the working parameters page.

12. Using the Next and Prev keys will highlight the parameter that is required for editing. The Incr and the Decr keys will cycle through fixed options or alter the highlighted parameter value.



If the settings are satisfactory then press the Exit button, if not then alter the settings so that the print parameters are adjusted to enable a print to be carried out on the blank calibration board. Press Save key to store the data file to hard disk, then press Exit button twice to return to the previous Menu Bar.

13. Press Change Tooling then Head. Raise the printhead under two button control. Press Board Width and position the rear rail using the two button control.

Equally space 25 support pillars about the 20" print area. Press Head and lower the printhead using two button control. Press Exit twice.

14. Insert the blank calibration board and support pillars into the machine. Press the Maint key and the Menu Bar will change to show the options available.

15. Press the Calibr O set key. The Menu Bar will change displaying the options available.

16. Press Set-Up OK key and the Menu Bar will change to show the options available.

17. Select the relevant camera axis using the Next/Prev keys. Using the Incr/Decr keys and viewing the vision monitor, position the screen fiducial so that it is placed centrally about the box displayed on the vision monitor. On completion of the positioning of the first fiducial, press Step and repeat the same exercise for the second and third fiducial. Press Step to continue.

The machine will continue and carry out the print cycle printing the 25 fiducials.

18. The camera will move sequentially around the printed area looking down at the printed fiducial and then looking up at the screen fiducial and measuring the difference. When the cycle has been completed remove the calibration board.

During the cycle, if at any time the printed fiducials are not satisfactory as they are viewed on the vision monitor then press Exit, the board will be ejected and start again.

#### NOTE

If for any reason the camera cannot locate the screen on board fiducial (except for poor prints) then press the Fiducial Set-Up key and re-learn the fiducial, (refer to Operator Manual, Chapter 5 New Product Set-Up, Stage 5A for details on setting up the Fiducial Recognition Strategy).

Press Retry and the sequence will continue and will not have any detrimental effect to the calibration.

#### Stage 2 - Calibrate Vision

At this point the screen will probably need cleaning due to solder paste.

1. Press Exit repeatedly until the main menu bar is displayed.

Press the Clean Screen button to initiate the screen cleaning cycle.

2. Press the Set-Up button and push the mode button until Auto is displayed on the main control screen, then press Exit button.

3. Press the Maint key then the Calibr Vision key and the Menu Bar will change showing the options available.

4. Press the Screen OK button and the camera will position itself on the first screen fiducial. The following sequence will be initiated:

a) The camera will view and locate the first of the 25 screen fiducials.

B) The screen will move +2mm in the X axis and then locate the screen fiducial.

c) The screen will then move +2mm in the Y axis and then locate the screen fiducial.

D) The camera will then move to the next fiducial and repeat the above sequence until all of the screen fiducials have been covered.

E) The camera will view and locate the first of 3 from the 25 screen fiducials.

F) The screen will move +2mm in the X forward axis, -2mm in the X rear axis (Theta movement) and then locate the screen fiducial.

G) The camera will then move to the next fiducial and repeat the above sequence until all three of the screen fiducials have been covered.

H) The camera will view and locate the fiducial 25 times without moving to check repeatability of capture.

This completes the Vision calibration

#### NOTE

If for any reason the camera cannot locate the screen on board fiducial (except for poor prints) then press the Fiducial Set-Up key and re-learn the fiducial, (refer to Operator Manual, Chapter 5 New Product Set-Up, Stage 5A for details on setting up the Fiducial Recognition Strategy).

Press Retry and the sequence will continue and will not have any detrimental effect to the calibration.

#### VISION HEIGHT

This setting is used to maintain correct vision focus for screen and board fiducials after camera maintenance, rising table sensor placement/adjustments.

#### NOTE

To set the vision reference height then a board must be used. Use the board which has the process parameters already set up. The key parameters are Board Thickness and Fiducial Positions.

This procedure is carried out in two stages. The first stage is used only if the camera optics need adjusting. If this stage is used then the vision needs to be calibrated.

Machine Preparation - Use this to start the procedure.

Screen Focus - Use this only if the camera focus for the screen needs adjusting (look up).

Board Focus - Use this only if adjustment or sensor replacement of the Rising Table has been made or the rail to the table height has been adjusted.

#### Machine Preparation

1. Fit a screen then power up the machine and allow it to initialize. Select Set-Up followed by Edit Data. Check and adjust if necessary, Board Thickness.
2. Press Exit then Exit again. Select Maint then Diagnostics.
3. Select 'Camera Axis' diagnostic.

#### Screen Focus

1. Home both X and Y Camera Axis.
2. Run 'Look Up' diagnostic.
3. Use the 'Move Camera X axis using Jog Buttons' and 'Move Camera Y Axis using Jog Buttons' until a feature is in the field of view of the camera (this feature can be seen on the monitor).
4. Loosen screw, (Figure 5 refers) and slide to adjust the focus on the camera lens until a clear picture is displayed on the monitor.

#### Board Focus

1. Select and run Rising Table diagnostics and Home Rising Table. Exit, select and run Camera Axis module.
2. Place the board on the rails and slide to a central position. Home both X and Y Camera Axis.
3. Select and run Camera to Fiducial 1 Position. Select and run Toggle Look Down. Exit this diagnostics and return to Rising Table diagnostics.
4. Select Raise Table to Vision Height and run this diagnostic.
5. Select and run 'Drive Table Using Jog Buttons'.
6. Using the left or right jog buttons, raise or lower the table until the fiducial is in focus. Ensure that the board stop does not foul the rails.
7. Select and run 'Set Reference Vision Height' and 'Confirm' the new height.

This completes the Vision Height calibration. Exit Diagnostics and initialize the machine, or select another diagnostic module if required.

#### HOME SETTINGS

#### X & Y CAMERA CARRIAGE

The X/Y camera carriage has to travel to its respective home positions upon machine initialization. Two limit switches are fitted to detect carriage overtravel.

#### NOTE:

Limit switches are fitted to machines manufactured prior to October '92. Machines after this date are devoid of limit switches and conditioning card.

Initial Setting of Y Direction Sensors (required only if sensors have been replaced)

1. The setting of the front limit hall effect is 125mm from the front edge of the machine.
2. The setting for the rear limit and home hall effect switches is 855mm from the front edge of the machine.
3. With the machine off, move the camera to the front and rear of the machine to ensure the vane does not foul any of the hall effect switches.

Initial Setting of X Direction Sensors (required only if sensors have been replaced)

The three hall effect switches in the X direction have no adjustment and so they only need to be mechanically set so as not to foul the vane which passes through them.

#### Testing of Sensors

Power up the machine with no motor power switched on. Connect a meter between the green lead (+) and black lead (-) of the X, Y Home hall effect in turn. Move the camera carriage by hand and ensure that each hall effect changes state (0-5v) as the vane passes through the slot. Disconnect and remove the meter.

Move the carriage in both axis so that the limit switches are made and check that the LED's on X9, Y1 (middle of the four) illuminate when the switches detect the vane.

#### X, Y Camera Home Positioning

1. Select Diagnostics and switch on motor power. Enter 'Camera System' diagnostic and Home both X and Y axis. The camera will move to the home hall effects and then reverse out until the first index pulse of the encoder is seen by the control card.
2. Release the Y servo motor from its drive belt. With motor pulley now disengaged, move the camera carriage by hand until a gap 28-30mm is measured between the camera carriage and the Y axis carriage support member.
3. Release the X direction left-hand pulley by slackening the sliding member screws and remove the belt from the pulleys. Re-position the camera carriage until a distance of 134-139mm is measured in the X direction from the board stop assembly to the Y axis carriage support member.
4. Carefully refit and tension the belts. Tighten the belt tensioning member and motor screw. Re-check dimensions and repeat if necessary.
5. Re-position the X and Y vanes so as to be just outside (1-2mm) of the home hall effects.
6. Home both X and Y axis. Check that the vanes stop within 2mm of leaving the hall effect and the home position is within 2mm of the required setting.

This completes the mechanical home set-up for the camera carriage.

## X, Y REFERENCE POSITIONS

The X y reference position needs to be set following any home adjustments, as follows:

1. Select Drive to Reference Position
2. Adjust the camera position by selecting Move Camera X or Y Axis using Jog Buttons so that it is placed centrally about the box displayed.
3. Select Set Reference Position then Confirm.

This completes the X, Y Camera Axis positioning. Exit Diagnostics and allow the machine to initialize.

## PASTE DISPENSER SENSORS

Three sensors are used on the dispenser. These are the horizontal and vertical positions for the dispenser and the home position for the carriage. The physical hard stops are set for true vertical and horizontal positions.

### Preparation

Ensure that there is no paste cartridge fitted. Enter Diagnostics and select Paste Dispense.

### Setting the Vertical Sensor

After setting the hard stop for a true vertical position place a 0.5mm feeler gauge between the stop and the adjuster. Set the vane so as to just trigger the hall effect by watching the appropriate sensor change state on the monitor. Lock the vane in this position, ensuring the vane does not foul the switch.

### Setting the Horizontal Sensor

After setting the hard stop for a true horizontal position place a 0.5mm feeler gauge between the stop and the adjuster. Set the vane so as to just trigger the hall effect by watching the appropriate sensor change state on the monitor. Lock the vane in this position, ensuring the vane does not foul the switch.

### Setting the Carriage Home Sensor

Press the Emergency stop button to disable the motor power, carefully slide the paste dispenser carriage by hand and set the lateral position of the hall effect to ensure no fouling of the vane as it passes through it.

Position the carriage (with the dispenser horizontal) so as the paste nozzle is in line with the sealing cap, and the cartridge empty sensor is looking through the slot in the carrier. Slide the hall effect into the vane so that the magnetic section on the hall effect is 3/4 covered. Lock the hall effect in this position ensuring the vane does not foul the switch.

Press the system button to enable the motor power, Home Dispense Carriage ensuring that the carriage stops in the correct position which is with the seal in the center of the nozzle and the 'Cartridge Empty Sensor' looking through the slot of the cartridge carrier. Reset the switch if necessary.

## PRINT CARRIAGE HOME SENSOR

The print carriage has to travel to its home position upon machine initialization.

### Machine Preparation

Remove the top access cover. Do not switch on the machine.

Position the sensor laterally to ensure the vane does not foul the hall effect switch as it passes through it. Position the vane in a central position along its adjustment slot.

1. Switch on the machine and select Diagnostics. Select the Print Carriage.
2. Press the 'HOME PRINT CARRIAGE' diagnostic. The print carriage will move into the hall effect and then reverse in slow speed until it just exits the sensor where it parks.
3. Measure the distance between the rear face of the 'O' ring support of the front rail and the face of the front squeegee holder, the correct setting is 512mm +/-0.5mm. Adjust the vane on the print carriage and re-run 'HOME PRINT CARRIAGE' until this measurement is achieved.

This completes the print carriage sensor set-up.

#### RAIL HEIGHT (Rail to Table Height)

A rail to table height adjustment is necessary to ensure that the board is supported correctly and evenly during printing.

The tool requirements to complete this procedure are:

a) one support pillar measured to be 81mm +/-0.02mm,(if autoflex if fitted 42.64mm +/-mm)

b) a board with approximate dimensions of 300 x 300mm.

c) 0.02mm(0.001") feeler gauge

1. Switch on machine, select Diagnostics then Rising Table module.
2. Home the Rising Table then Exit from this module.
3. Select the Print Head module and then Raise Printhead under Two Button Control. Exit this module.
4. Select Rail System module. Use Adjust in the Menu Bar and set the rail width according to the board being used. Select Drive Rail to Board Width.
5. Highlight Toggle Board Clamps and run this diagnostic. Place the board on the rails and slide to a central position. Toggle Board Clamps so that the board is held firmly. Exit this diagnostics and return to Rising Table diagnostics.
6. Select and run Raise Table to Vision Height. Place the support pillar (81mm for standard and 40mm if autoflex is fitted) close to the rail and under a corner of the board. Adjust the relevant adjuster so that the pillar is just touching the underneath of the board using a 0.02mm (0.001") feeler gauge. Repeat this setting for each of the four corners of the board.
7. After completion of all four corners then re-check all of them again to ensure that all four corners are adjusted correctly.
8. This completes the rail height setting.

On completion of this setting then the following procedures need to be carried out:

1. Print Height
2. Squeegee Reference Height

#### RAIL LIFTER SENSORS

Two through beam opto's are mounted either side of the rising table to detect premature lifting of the rear rail caused by incorrect positioning of the support pillars fitted to the table.

The opto vanes are height adjustable and should be set so that they are 0.5mm past when the opto beam broken by the vane (the LED on the opto on). This setting must be done with the table at the home position.

#### RAIL WIDTH HOME SENSOR

This sensor is used to find the home position of the moving rail. The rail is moved by a stepper motor towards the rear of the machine. When a vane, attached to the rail, enters the home through beam opto, the motor stops and reverses in slow speed until the vane just leaves the opto. This is the home position of the rail.

The vane is mounted on a sliding bracket which must be positioned so as to give a measurement of 508.5mm - 508.7mm, measured between the inside edges of the rails, when the moving rail is in the home position.

#### RISING TABLE SENSORS

##### Access

The sensors are located on the left-hand side of the rising table looking from the front of the machine. If the machine is standing alone then access is gained by removing the lower left panel of the machine. This can be done by pulling off the front panel and unscrewing/removing the rear panel. The left-hand panel retaining screws can now be released. If the machine is in-line then access is through the upline board entry aperture as an upline board loader will probably make side panel removal impossible.

##### Initial Setting

Using the top of the toolplate as the reference set the vane height as listed below.

##### Vane No.1

Vane Setting Position - Lower edge of bracket

Dimension - 171mm+/-0.5mm

##### Vane No.2

Vane Setting Position - Lower edge of vane tab

Dimension - 215mm+/-0.5mm

##### Vane No.3

Vane Setting Position - Lower edge of bracket

Dimension - 169mm+/-0.5mm

Vane No.4

Vane Setting Position - Upper edge of bracket

Dimension - 302mm+/-0.5mm

#### NOTE

With Autoflex tooling fitted an additional 40mm is to be added to each of the vane setting dimensions in the above table.

Fit a screen to the chase and set the distance from the underside of the screen to the top of the bracket supporting the table sensors to 373mm +/-0.5mm.

This completes the initial settings. It is now important to check the lateral positions of the vanes to ensure that they do not foul the sensors. This is achieved by entering the 'RISING TABLE' diagnostic followed by the 'DRIVE TABLE USING JOG BUTTONS' option. Carefully jog the table towards the lower limit but do not enter it, use an inspection mirror to observe the lateral position as necessary. Jog the table up towards the upper limit switch taking care not to enter the switch and check and reset the vane if necessary.

#### Final Setting

Home sensor initial setting

Enter the 'RISING TABLE' diagnostic. Run the 'HOME RISING TABLE' diagnostic to initialize the table. Check the table height to the screen is 208mm -0.00/+2.00mm, if this dimension is not achieved then reset the home sensor bracket by the required amount and re-run the 'HOME RISING TABLE' diagnostic. To check and readjust until correct dimension is achieved.

Home sensor setting repeatability check

Home the rising table 10 times, check that the dimension between the screen and table stays within 208mm -0.00/+2.00mm on each occasion, if a reading outside the specification is obtained lower the home hall effect switch bracket 1.5mm and re-test the home position a further 10 times to ensure repeatability. Check the dimension remains within the 208mm -0.00/+2.00mm specification.

#### NOTE:

Should the machine generate a 'RISING TABLE ERROR' during the set-up re-check the relative positions of the DATUM and DATUM INTERLOCK vanes.

This completes the mechanical setting of the rising table. It is now necessary to calibrate the vision height and the print height.

#### SCREEN ACTUATORS

There are three screen alignment actuators fitted to allow movement of the screen chase in X, Y and theta. Two actuators are mounted on the left-hand side of the printhead to give X movement if both driven in the same direction or theta movement if driven in opposite directions. The actuator at the rear is used to give a Y direction movement.

Stepper motors are used to drive the actuators as positional accuracy is important. One step of the motor equates to 4 micron screen movement. Two hall effect switches are fitted to each actuator to locate the home position. One is situated inside the actuator body, this is the coarse home position, the other is located on the end of the actuator



drive shaft, this is the fine home position.

Upon initialization the actuators travel to their home positions which places the screen in the central position. The way in which the actuators initialize is dependent upon whether they are in a positive or negative screen position upon power up. The machine control checks the coarse hall effect switch, if the vane is present the actuator is in a negative position and must drive in a positive direction to reach the home position. If the vane is not present the actuator is in a positive position and must drive in a negative direction to reach the home position.

Assuming the actuator is in a positive position the initialization sequence will now be described.

i) The actuator is driven at fast speed in the negative direction (clockwise) until the vane enters the coarse hall effect switch.

ii) The actuator is then driven in the positive direction at medium speed until the vane just leaves the coarse hall effect switch (anti-clockwise).

iii) The actuator is then driven in the positive direction at slow speed in a positive direction (anti-clockwise) until the vane on the shaft enters the fine home hall effect switch.

iv) Finally the actuator is driven in a negative direction (clockwise) at step speed until the vane just leaves the fine home hall effect switch. This is the home position.

#### X Screen Actuator Setting

1. Power up machine and allow to initialize. Insert and load a screen frame to the chase.
2. Enter Diagnostics and select Alignment System module.
3. Select Home X Forward and observe that the actuator runs and finds it's home position.
4. Select Home X Rear and observe that the actuator runs and finds it's home position.
5. Adjust the coarse sensor bracket position and remove the actuator to achieve a nominal dimension of 59mm +/-0.075mm for the actuator mounting face to the actuator ball contact.
6. Re-home the actuator and check the dimension.

#### Y Screen Actuator Setting

1. Set coarse home sensor to middle of it's travel.

Exit Diagnostics or select another module.

#### SCREEN CLEANER HOME

A hall effect switch is mounted beneath the left head clamp to detect when the cleaning unit is in the home position. When at home two electromagnets hold the cleaning unit in place, these are de-energised when the camera carriage collects the unit to clean the screen.

The hall effect vane is mounted on the cleaning unit carriage on a slotted bracket. To set the vane position use the following procedure.

1. Select 'Cleaner Clamp' from the 'Screen Cleaner' module in the 'Diagnostic' menu.
2. Ensure that the cleaning unit is at its home position. Turn the clamp on.
3. With the cleaning unit locked onto the electromagnet adjust the vane so as the Cleaner Home Sensor just toggles to on. Lock the vane in this position.
4. Toggle the clamp off. Move the cleaning unit by hand until the sensor changes. The clearance between the electro-magnets and plate should be less than 2mm.

## OPTO & SWITCH ADJUSTMENTS

### AIR PRESSURE SWITCH

An air pressure sensor is fitted to monitor the air pressure entering the distribution manifolds. The sensitivity of the switch is set to 3 bar by screwdriver adjustment on the sensor body.

### BOARD AT LEFT/RIGHT OPTO'S

These two sensors are used to detect a board at the input and output of the belt. As the machine is bi-directional the functions of these opto's are reversed when the pass through is changed.

### BOARD AT LEFT/RIGHT OPTO'S

These two sensors are used to detect a board at the input and output of the belt. As the machine is bi-directional the functions of these opto's are reversed when the pass through is changed.

The input sensor is used to start the transport belt on detection of a board. The board is transported into the machine and processed after which it is transferred to the output sensor where it stops and waits for the command to be passed onto the next machine in the line.

The sensors used are Keyence reflective opto's. These opto's are fitted with a red and green LED along with a sensitivity control. There is a small amount of positional adjustment in the bracket but generally it is not necessary to reset it as the footprint used by the reflective opto is large enough to cope with the holes in an average production board.

The sensitivity control should be adjusted to see a board when it is placed on the rails above it. Optimum setting:

1. Place a board on the rails covering the sensor.
2. Adjust the sensitivity so that the green lamp illuminates.

3. Re-adjust the sensitivity so that the green lamp just extinguishes.
4. Set the sensitivity control in the middle of this point and the maximum setting.

#### BOARD AT STOP SENSOR

This reflective opto is fitted to detect the board when it is at the stop. This Keyence opto is fitted with a red and green LED along with a sensitivity control. As a board approaches the stop it is detected by the opto and the green LED lights. This starts a timer which when elapsed stops the belts and clamps the board.

The sensitivity control should be adjusted to see a board when it is placed on the rails and is at vision height.

Optimum setting:

1. Place a board on the rails below the sensor and raise the rails to vision height.
2. Adjust the sensitivity so that the green lamp illuminates.
3. Re-adjust the sensitivity so that the green lamp just extinguishes.
4. Set the sensitivity control in the middle of this point and the maximum setting.

Optimum setting:

1. Place a board on the rails below the sensor and raise the rails to vision height.
2. Adjust the sensitivity so that the green lamp illuminates.
3. Re-adjust the sensitivity so that the green lamp just extinguishes.
4. Set the sensitivity control in the middle of this point and the maximum setting.

#### BOARD STOP LOWERED SENSOR

A through beam opto is fitted to ensure that the board stop is raised before any camera carriage movement is demanded.

This sensor is mounted on the camera carriage and has an LED mounted in its body which illuminates when the beam is broken. When the stop is home (raised) the LED is on as the beam is broken. The only adjustment is on the opto pillars which must be set to enable the beam of the opto to look through the slot of the vane giving definite up/down detection.

#### PASTE CARTRIDGE EMPTY SENSOR

The paste dispenser has a sensor fitted which detects when the solder paste runs low. The sensor used is a long throw through beam opto, which is driven from an interface card type PC046 mounted on the right-hand side of the rear printhead casting member.

The only adjustment for this sensor is the sensitivity control which can be found on the PC046 interface card. This must be set by fitting an empty cartridge to the dispenser at the home position and adjusting the sensitivity until the LED on the PC046 just lights. Remove the empty cartridge and fit a full cartridge, note that the LED goes on.

#### SCREEN AT FRONT/SCREEN AT REAR SENSORS

Two sensors are fitted in the chase to detect when the screen is at the front or rear of the chase. The screen at front sensor detects when a screen is in the chase but not fully home. The screen at rear detects when the screen is fully home. Both sensors are covered when the screen is home.

The sensors used are long throw through beam opto's which are driven from an interface card type PC046 mounted on the left-hand side of the rear printhead casting member.

The only adjustment for these sensors is the sensitivity control which can be found on the respective PC046 interface card. This must be set by removing any screen fitted and adjusting the sensitivity control until the LED on the PC046 just lights. Turn the sensitivity control one more complete run.

#### HEAD LIFT UP/DOWN SENSORS

The head lift sensors are magnetic reed switches mounted on slides along the body of the lift actuator. The switches are set to give the maximum amount of printhead lift while keeping the actuator within its own mechanical limits so as not to physically jam the mechanism.

##### Procedure For Setting the Actuator

1. Ensure that the printhead is fully down and remove the pivot pin from the head lift bar.
2. Ensure that Locknut 'B' is tight, and loosen Locknut 'A'. Rotate the Pivot Top so that Dimension 'A' is between 3 and 4mm. Tighten Locknut 'A' and insert the pivot pin into the head lift bar.
3. Set the Up/Down limit switches to the initial dimensions given.
4. Adjust the down limit switch so that the head lift bar has an over travel between 3-7mm. Use diagnostics, Printhead module and drive the print head up and down re-adjusting the down switch to achieve this.
5. Drive the printhead down. Make a note of the length of the actuator protruding. Adjust the Up limit switch so that when driving the printhead up that a stroke of 100mm is achieved.

##### Head Down Speed Setting

Potentiometer VR1 on Y2, X5 adjusts the speed of the printhead drive when lowering. Set this so that the printhead latches gently. The potentiometer initial setting is midway of its travel.

This completes the head lift actuator setting.

#### TIME AND DATE SETTING

## Time Setting

1. Switch on the machine and allow to initialize.
2. Insert the maintenance key and turn clockwise to enable the Maint. Option. Maint. Will be displayed on the Menu Bar.
3. Press Maint button and the menu bar will change to display the following.
4. Press Housekeeping button (F4) the menu bar will change to display the following.
5. Press Set Time button (F2) and a pop up window will be displayed showing the parameters available and the menu bar will change to display the following.
6. Using the Next and Previous keys selects the Year, Date or Month. Pressing the Incr. And Decr. Keys alters the setting of the selected parameter. Pressing the Set key sets the newly entered figure.
7. Press Exit three times to return to the main menu.

## Date Setting

1. Proceed as for Time setting as previously described in Paras 1-4.
2. Press Set Date button (F2) and a pop up window will be displayed showing the parameters available and the menu bar will change to display the following.
3. Using the Next and Previous keys selects the Year, Date or Month. Pressing the Incr. And Decr. Keys alters the setting of the selected parameter. Pressing the Set key sets the newly entered figure.
4. Press Exit three times to return to the main menu.

## HAPTER 8 SENSOR LISTING

### SENSOR NAME - SENSOR TYPE - SENSOR LOCATION

Air Pressure - Pressure Switch - Left hand manifold on rear of machine frame  
Board at Left - Reflective Opto - Front Rail, left side  
Board at Right - Reflective Opto - Front Rail, right side  
Board at Stop - Reflective Opto - Camera Body  
Board Stop in Position - Through Beam Opto - Mounted on Board Stop, Camera  
Camera Carriage X Limit Switch - Hall Effect - Far left and right of Camera Carriage  
Camera Carriage Y Limit Switch - Hall Effect - Front and Rear of Y Camera Carriage  
Camera X Home - Hall Effect - Second from left on X Camera Carriage  
Camera Y Home - Hall Effect - Second from left on Y Camera Carriage  
Cartridge Away - Hall Effect - Paste Dispenser Unit  
  
Cartridge Empty - Long Throw Opto - Mounted at Paste Dispenser Home Position

Cartridge Home - Hall Effect - Paste Dispenser Unit  
Cleaning Unit Home - Hall Effect - Front left hand side of printhead  
Diagnostic Key - Keyswitch - Control Console

Front Access Cover - Magnetic Reed Switch - Access Cover for Screen and Cleaning Unit  
Paste Dispenser Carriage Home - Hall Effect - Top of Printhead Casting, left hand side  
Print Carriage Home - Hall Effect - Rear and left of Printhead Casting  
Printhead Access Cover - Magnetic Reed Switch - Inside right of top access cover  
Printhead Down - Reed Switch - Upper Switch on Lift Actuator  
Printhead Up - Reed Switch - Lower Switch on Lift Actuator  
Rail at Rear - Through Beam Opto - Near rear Rail Motor  
Rail Lifted Left - Through Beam Opto - Left Side of Rising Table attached to Rear Rail  
Rail Lifted Right - Through Beam Opto - Right Side of Rising Table attached to Rear Rail  
Left Jog Button - Push Button Switch - Left Front Cover

Right Jog Button - Push Button Switch - Right Front Cover  
Screen at Front - Long Throw Opto - Front of Screen Chase  
Screen at Rear - Long Throw Opto - Rear of Screen Chase  
Screen Drive at Center - Hall Effect - Outer right hand side and center of Chase  
Screen Drive at Rear - Hall Effect - Outer right hand side of Chase at the Rear

Squeegee Front Home - Hall Effect - Inside Pressure Assembly  
Squeegee Rear Home - Hall Effect - Inside Pressure Assembly  
Table Datum - Hall Effect - Left side of Rising Table  
Table Home - Through Beam Opto - Left side of Rising Table  
Table Limit - Hall Effect - Left side of Rising Table

## CHAPTER 9

### PREVENTIVE MAINTENANCE

#### General

It cannot be stressed enough that cleanliness is the most important part of preventive maintenance. It is essential that operators take extreme care when redistributing paste, reloading the paste dispenser, removing squeegees and cleaning the dispenser drip tray.

Paste is the main cause of serious machine damage as the solvents can remove protective lubricants from bearing slides and, dry paste can damage seals followed by seizure of the bearings. Systematic checks and prescribed maintenance procedures are to be carried out at regular intervals which also contribute to smooth production runs.

The frequency with which the following checks and procedures are carried out are given as a guide only, this is based on machine run time of approximately 40 hours per week.

A useful aid to monitor the machine performance is a machine fault log which is filled in by the operator and enables the technician to see at a glance any problem areas that may require attention before a more serious machine fault occurs.

Personnel Classification

The check lists set out on the following pages are divided to suit two classifications of personnel, these are

-Operator

-Technician

#### Maintenance Kit

Part No. 112747, contains all the relevant tools to carry out calibrations and settings for preventative maintenance.

#### Lubricants

The recommended oils and greases to be used for the various servicings, described later in this chapter, are as follows:

Light Machine Oil - Turbine oil ISO VG 32-68

Light Grease - Lithium soap based Shell Alvina R2 DIN 51285 KP2K

#### Operator

Every 8 hours (per shift)

The following tasks must be carried out on a daily basis:

- 1) Vacuum clean and clear the rising table area of any paste.
- 2) Clean the machine surfaces of debris and paste.
- 3) Inspect the bearing slides of the print carriage, paste dispenser carriage, double squeegee carriage and camera carriage. If any paste is found call the maintenance technician who must remove the debris and re-lubricate the bearing slide.
- 4) Clean the surfaces which look upwards on the board at left and board at right sensors.
- 5) Clean out any paste in the dispenser drip tray.

#### Technician

Every 40 hours (Weekly)

The following tasks must be carried out on a weekly basis:

- 1) Check with the operators and the machine log for any abnormal conditions, investigate and make adjustments or repairs as necessary.
- 2) Empty the airline water trap if necessary.
- 3) Remove the front and rear panels and vacuum clean any debris from inside the machine
- 4) Inspect all the bearings slides, clean off any debris found and re-lubricate if necessary.

Every 1000 hours (6 Monthly)

The following tasks must be carried out on a 6 monthly basis:

- 1) Clean and lubricate with light machine oil the following:
  - i) Print carriage - bearing slides 2 o
  - ii) Double squeegee mechanism - bearing slides 2 o , leadscrews 4 o , and guide bars 4 o
  - iii) Camera carriage X and Y - bearing slide in X axis, and bearing slides in Y axis 2 o
  - iv) Rising Table - bearing slides, 2 o

v) Paste Dispenser - bearing slide

vi) Board stop - bearing slide

Warning - Do not move board stop by hand

vii) Rail System - bearing slides 6 o , and leadscrews 2 o

2) Clean and lubricate with light grease the moving rail transport height support bars

3) Inspect all the ribbon cables, flexible cables and tubing used by the print carriage, camera carriage, rising table and rails. Replace any damaged parts found being careful of the routing used so as to ensure no further damage.

4) Inspect the transport belts for wear. Replace if necessary.

5) Clean air supply filter. Replace if necessary.

6) Inspect all machine sensors. Clean the hall effect switches and opto's to ensure that the sensors are not fouled by their actuators, reposition if necessary.

7) Inspect the brushes of the print carriage, rising table and camera X, Y motors. Replace if necessary (half their original length).

8) Check the operation of the emergency stops. If fitted in-line, ensure that the up and down line machine emergency stops de-activate the machine.

9) Check the chase clamp clearance (10 thou). If out of specification reset.

10) Check the condition of the rail lifting pillars and hard stops, replace if necessary.

11) Check the rail to table height. Adjust if necessary.

12) Check the condition of the board clamps. Replace if necessary.

13) Clean the camera shutter mechanism.

14) Calibrate the pressure mechanism.

15) Calibrate the vision alignment system.

16) Calibrate the vision reference height.

17) Calibrate the print reference height.

#### Yearly

The following task must be carried out on a yearly basis.

Replace all the parts supplied in the service pack, SP265SER1.

#### 2 Yearly

The following task must be carried out on a 2 yearly basis.

Replace all the parts supplied in the consumable packS, SP265SER1 and SP265SER2

#### 5 Yearly

The following task must be carried out on a 5 yearly basis

Replace all the parts supplied in the consumable packS, SP265SER1 and SP265SER3

### CHAPTER 10

#### RECOMMENDED SPARES

### CHAPTER 11

#### REPLACEMENT PROCEDURES

#### Preparation



1. Switch on machine power and raise the printhead, switch on power.
2. To gain access to the camera for removal, move the camera forward and central over the table by turning the camera carriage drive shafts by hand.

#### Camera Removal

1. Disconnect the following items from the camera and optic body.
  - i) The co-axial cable and electrical supply lead from the left hand side of the camera body
  - ii) The upper and lower electrical connectors to the optic LED's (label connectors prior to removal for later identification)
  - iii) The electrical connector to the board stop lowered opto
  - iv) The three P clips securing the electrical and opto looms. Note the orientation of the P clips for later refitment.
2. Label the pneumatic tubing to the optic shutters for later identification, disconnect the two tubes from the optic lens
3. Remove the mounting plate grub screw from the upper face of the board stop assembly securing the camera mounting plate to the board stop assembly
4. Ease the looms rearwards to allow withdrawal of the camera. Withdraw the camera to the left of the machine, easing the camera and optic from the board stop assembly.

#### Optic Removal

1. Carefully grip the optic lens and body by hand, unscrew and withdraw the optic from the threaded ring and camera clamp.

#### NOTE

The optic body screw threads are secured to the threaded ring with Loctite Screwlock. Do not use any mechanical aid to unscrew the optic body, hand force will be sufficient.

#### Optic Replacement

Fitting existing optic to new camera

If the existing optic assembly is to be re-fitted to a new camera, set the focal length as follows.

1. Apply a minimal amount of Loctite 222e Screwlock in three positions on the threads of the optic body.
2. Screw the optic body fully into the threaded ring, (with the threaded ring still secured to the clamp by the securing screw).
3. Release the clamp securing screw and screw both the ring and the optic body into the camera until the ring abuts the camera body.
4. Unscrew the optic body and ring one full turn to set the focal length. If necessary, further unscrew the optic body and ring the amount required to ensure the optic lens is facing upwards and horizontal with the camera in its fitted orientation.

5. Secure the camera clamp in place with the securing screw.  
Fitting a new optic body and lens to the existing camera body.

If a new optic body and lens is to be fitted to an existing camera body the focal length will not require adjustment as it has been previously set, therefore proceed as follows:

6. Apply Loctite Screwlock to the threads of the optic body, as previously described, and screw the optic body fully into the threaded ring (with the threaded ring still secured to the clamp by the securing screw). Unscrew the optic body as necessary to set the prism (red LED's) facing upwards and horizontal.

#### Setting the Camera Bit Switches

##### NOTE

This operation may be carried out with the camera installed if preferred.

1. Remove the four screw and camera casing.
2. Set the camera bit switches as follows.

1- On

- 2- On
- 3- On
- 4- On
- 5- O
- 6- O

1- On

- 2- On
- 3- On
- 4- On
- 5- O
- 6- O

3. Replace the camera casing.

#### Camera Refitment

1. Fit the dovetail mounting plate to the camera mounting with four mounting screws as an initial setting, do not fully tighten at this stage.
2. Locate the camera body dovetail mounting plate into the board stop assembly, slide the camera in place until the edge of the mounting plate is flush with the board stop assembly.
3. Set the camera height and level in the X plane as follows:

l) Check the dimension between the optic body to screen height, this should be 20.5mm +/-0.5mm. Alternatively the camera height may be set by checking the dimension between the optic lens and the screen, this should be 9.5mm +/-0.5mm.

li) Remove the protective cover from the rising table surface, place a dial indicator beneath the optic and check

the level of the optic lens in the X plane, i.e. left to right, the lens and the screen should be level to 0.05mm.

#### NOTE

To prevent damage to the table surface when checking the level of the optic lens, move the optic lens about the dial indicator, do not slide the dial indicator on the table.

iv) Adjustment for the optic height and level cannot be done with the camera fitted but will require removal of the camera and then adjustment to the camera dovetail mounting plate. Slacken the mounting plate screws and adjust the mounting plate to achieve the correct height and level. This part of the operation may require fitting and removing of the camera several times until the correct height and level is achieved.

4. When this has been achieved remove the camera and secure the mounting plate screws in place with Loctite 222e Screwlock, removing one screw at a time to prevent movement of the plate.

5. Refit the camera to the board stop assembly and ensure that the edge of the dovetail mounting plate is flush with the edge of the board stop. This will align the cut-away in the dovetail mounting plate to align with the grub screw.

6. Apply a minimal amount of Loctite 222e Screwlock to the grub screw and screw into the top surface of the board stop assembly.

7. Setting the level of the optic window in the Y plane is detailed in 'Calibrate Vision Height' at the rear of this procedure.

8. Reconnect the optic pneumatic tubes to their respective connectors on the optic shutters.

9. Reconnect the two electrical connectors to the upper and lower optic LED connectors. Reconnect the board stop opto connector.

10. Refit and secure the electrical and opto looms with P clips. Ensure correct orientation and fitment of P clips to prevent fouling.

#### Checks and Tests

1. Power up machine, turn the keyswitch on the main control unit, select Maint, select Diagnostics. Select Camera System diagnostic.

2. Select Initialize Vision and check the camera LED lighting.

3. Select Look Up and Look Down in turn and check the optic shutter operation.

4. Ensure all wires, looms and tubes are secure and clear of obstructions or snagging during the above operations.

5. Select Home Camera X Axis and Home Camera Y Axis in turn and check the camera X and Y home positions.

6. Exit and select Printhead module and then lower head. Exit and select Camera Axis module. Setting the Focus/Fixed Camera Height

1. Select and run both Home Camera X and Y axis
2. Run Look Up diagnostic
3. Fit a screen.
4. Use the Move Camera X Axis and Move Camera Y Axis until a feature is in the field of view of the camera (the feature can be seen on the monitor)
5. Adjust the optic focus adjusting screw, to obtain the clearest picture on the monitor.

## CHAPTER 12

### ELECTRICAL CIRCUIT LISTING

(Bhot's note: All electrical circuit diagram)

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## スクリーン印刷装置 2

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### SCREEN PRINTING MACHINE (BOOK 2)

#### INSTALLATION MANUAL

#### INTRODUCTION

##### General

To prevent damage to the machine while unpacking or during machine power-up it is essential to read and adhere to the procedures and sequences detailed in the Installation manual and to ensure the correct method of unpacking and assembly of the machine, machine preparation and power-up sequences are carried out prior to the normal running operations of the machine.

##### Manual Format

Chapter 1 Safety Features, describes the features on the machine that provides the operator safety while the machine is in operation.

Chapter 2 Services Required, describes the services needed for the machine to function correctly. A view of the service panel showing the external connections to the services and positioning of the circuit breakers is also shown. Chapter 3 Unpacking Instructions, describes the method of dismantling and unpacking the transit boxes, checking the machine, loose items and documentation. Checking the machine configuration against customer requirements, assembling the loose items to the machine and transportation of the machine to its designated area.

Chapter 4 Machine Preparation, describes the method of transporting the machine into position, removal of transit brackets, fitting the external services, adjusting the height and levelling the machine in preparation for machine power up.

Chapter 5 Power Up Sequence, describes the sequence of machine power up and checking of home sensor positions, system calibrations and settings, and new product set-up using a test board.

Chapter 6 External Machine Interface, describes the procedure for interfacing the screen printer to external machines (such as a placement machine) and ancillary equipment, and checking the functionality of the machine.

Chapter 7 Machine Performance, details the method of checking the machine performance with the customers board for print uniformity and accuracy.

Chapter 8 Machine Installation Acceptance, is a copy of the Machine Installation Document certifying acceptance of the machine and recording any outstanding issues, agreed and recorded by both the customer and installation engineer.

#### Installation Procedure

The procedure in this manual must be adhered to in the order that they are presented.

Problems encountered with the machine must be tackled and resolved before proceeding to the next step.

#### Anti-Static Handling

Standard precautions must be adhered to when handling electronic cards and configuring and inserting into the enclosures.

Anti-static precautions are necessary when connecting and disconnecting the signal cables from the Arcom PC to the Y1 and Y2 enclosures (and Y15 if fitted).

## CHAPTER 1

### SAFETY FEATURES

#### GENERAL

Safety features provides safe operating conditions for the machine.

The machine is fitted with an emergency safety shut-down press button switch. External modules in the line can be fitted for connection to a common cable loop line, that provides automatic shut down of all modules, if any single emergency switch is operated, or any frame cover is disturbed during normal operation of the line.

Covers fitted with safety interlock switches protect operating personnel from the moving mechanisms. Transparent plastic access covers are fitted over moving mechanisms of the machine and steel safety covers control access to the frame of the module.

#### PROTECTION FROM HIGH VOLTAGE

##### Mechanisms

Machine mechanisms are powered 24 V only and do not pose an electrical hazard to personnel.

##### 220/110 V

Where (210/110 V) incoming supply voltages are present, protection is a orded by controlling access to the enclosures that house the supply. The machine is fitted with an interlock isolator switch that cuts power to terminations down stream of the isolator, for example the isolator enclosure. Insulating shrouds o er protection at the isolator switch incoming power terminals.

### Hazard warning

Hazard warning labels "Danger High Voltage", are placed on the outside of enclosures where high voltage (220/110 V) terminations are present within and the enclosure is not fitted with a safety interlock. Inadvertent access to such enclosures is prevented by the presence of the frame covers.

### EMERGENCY SHUT-DOWN

The machine is fitted with an Emergency shut-down push button switch located on the right hand side of the front cover. An additional push button is located on the left hand side of the head cover, this is an optional extra. Pressing either of these push-buttons (or removing a steel frame cover) cuts power to the 24V supply to mechanisms of all modules connected into the emergency loop line. A warning of this condition is reported on the VDU. The E-stop system is described in detail onwards.

### EMERGENCY-STOP LOOP

Stand-alone operation of module requires the end-of line plug/socket to be fitted.

The E-stop system is a low voltage powered loop that interconnects selected modules in the line and provides automatic shut-down of any powered mechanisms of the line during an emergency shut-down. Breaking continuity of the E-stop loop provides an automatic safety shut-down procedure for modules. The connection loop comprises cable connections chained between upline and downline of modules selected.

### Recovery

When the normal working condition is restored, release the Emergency stop button and/or replace the cover that has been removed and press the green system button located on the control VDU.

### CLEAR ACCESS COVERS

Clear polycarbonate access covers are fitted to the machine to protect personnel from the mechanisms during normal line operations. Lifting a cover cuts power to the mechanism that the cover protects.

### STEEL FRAME COVERS

Frame covers are fitted with safety interlock switches are similarly connected to the emergency loop line. Removing the cover has the same effect as pressing the Emergency stop button, cutting 24 V power to the mechanisms of all modules connected into the loop line shuts-down. Indication that a cover has been removed (or the E-stop has been pressed) is given by an error message displayed on the control VDU.

### Recovery

When the cover is re-positioned, normal working condition is restored and the line may be restarted; pressing the green system button at the control VDU will enable the machines re-initialization procedure, where this is allowed by the control system.

### TWO BUTTON SAFETY SWITCHES

Located at the front of the machine, are the two button safety switches. The positioning of these buttons are needed to maintain maximum safety for the operator when operating a particular function. The two buttons have to be pressed simultaneously to become active.

The use of these buttons are dependent on the function selected at the VDU.

For example:

- Head Lift Up/Down
- Board Width
- Load Width

## PRINthead LIFT SUPPORT ASSEMBLY

### Function

For the protection of personnel when working beneath the printhead with the printhead raised, a Head Support Assembly, Part No 112975, is provided to mechanically secure the printhead in the raised position. The support should be used at all times that the printhead is raised and stowed by the machine when not in use.

The support assembly is colored red and incorporates an internal spring for ease of installation and removal. With the head raised the assembly is positioned to the front left hand side of the machine in the electro-magnetic sockets, ensure that the black end of the support is at the bottom and the silver end at the top.

### CAUTION

### IMPORTANT

The support assembly must be removed prior to selecting printhead lowered.

If an attempt is made to lower the printhead with the support assembly installed damage to the printhead, actuator and drive card may occur.

## CHAPTER 2

### SERVICES REQUIRED

#### GENERAL

In order for the machine to function correctly the following services must be available.

The services must be stable and clean.

#### MACHINE CONSUMPTION

Pneumatic supply

4 Bars at 250 Liters per Minute

Electrical supply

220V / 110V ac 50/60 Hz

2KVA

The above machine consumption show the required continuous supply needed.

For the Pneumatic supply the Air should be clean, non-lubricated and should range between 4 and 8 Bars.

For the Electrical supply the power should be greater than what is consumed to allow for power surges on initial power up. Therefore, the supply should be 3KVA or greater.

#### CIRCUIT BREAKERS

The external services panel has 9 circuit breakers fitted and arranged into 3 banks. The circuit breaker listing is as follows:

CCT Breaker Position - Amperage (A) - CCT Breaker Description

1. Mains - 6 - Machine Supply
2. 30V ac - 16 - Servo Motor Power
3. 30V ac - 16 - Rising Table Power
4. 24V ac - 10 - General Motor Power
5. 12V dc - 10 - Small Motor Power
6. 220V ac - 6 - Secondary of Isolating Transformer
7. 220V ac - 6 - Vacuum
8. Spare
9. Spare

## CHAPTER 3

### UNPACKING INSTRUCTIONS

#### General

To ensure the machine is not damaged during transportation certain machine components are removed from the machine prior to dispatch, wrapped and secured separately in the boxes. The printhead cover, machine side skirt panels, calibration board and screen, and the machine mounting feet accompany the machine all other items are located in the smaller box.

The machine mounting feet are removed at dispatch and replaced with transportation studs, the machine is then secured to the base of the transportation box with nuts and washers.

The studs, nuts and washers are replaced on machine assembly by the mounting feet.

#### Unpacking

The lids of both transportation boxes are secured with screws, the sides are nailed to the base. Remove both the box lids and the sides of the large box only.

Remove all loose items from the boxes. Remove the wrapping from around the machine, remove the loose items from their bags or wrappings.

#### CAUTION:

Do not remove the red transit brackets attached to the machine until the machine has been moved to it's designated position.

#### Machine Components

Ensure the following machine components, removed for transportation, are complete and correct:

Item

Machine mounting feet

Printhead cover

Paste dispense nozzle

Paste dispense tray

E-Stop plugs



Squeegees  
Under screen clean unit  
Twin monitor assembly  
Keyboard  
Tri-color beacon  
Pneumatic supply fitting  
Panel skirts  
Magnetic tooling pins  
Maintenance key  
Manifold (if TCU ordered)  
Miscellaneous Items  
Ensure the following additional equipment is complete and correct.

Item

Calibration screen  
Calibration board  
FMI leads  
Printhead safety prop  
Camera ring illuminator kit  
Spare bulb for vertical illuminator  
Spares kit (if ordered)

Documentation

Ensure the following machine documentation is complete and correct:

Item

Machine Operator Manual  
Machine Installation Manual  
Machine Technical Reference Manual  
Arcom manual  
DOS Packages  
Acceptance procedure  
Alignment data  
Software installation disk  
DEK delivery questionnaire

Inspection

Visually inspect the machine, all components and equipment for completeness, damage and condition.

Machine Configuration

A list of possible machine configurations, depending on customer requirements, are listed as follows:

Item

Voltage

Tooling  
Squeegee Style  
Squeegee Width  
Squeegee durometer  
Flood Bar Width  
Interface (FMI)

Host Comms  
Environmental Control  
Auto Screen Change  
Auto Screen Stacker  
Bar Code  
Screen Clean-Wet  
Label  
Color  
Screen Adapter  
Inventory

Check the machine against the customer 'Machine Configuration', 'Machine Components', 'Miscellaneous Items' and 'Documentation' as previously listed.

If damage or deficiencies are found they should be recorded on the 'Installation Acceptance Document' contained in Chapter 8 of this manual.

#### Machine Assembly

Assemble the machine components and assemblies removed for transportation, as listed in 'Machine Components', to the machine.

#### Transportation

Remove the four nuts and washers securing the machine to the transportation box base using a 36mm spanner (Wrench).

Raise the machine on the base using a fork lift truck or similar machine, locating the arms of the fork lift under the machine base to support the machine on the frame cross members.

CAUTION: Do not raise the machine using a lifting strop.

Fit the four mounting feet, adjust the height of each to approximately the same height, secure in place with nuts.

The machine is now ready for transportation to its designated area.

## CHAPTER 4

### MACHINE PREPARATION

#### GENERAL

Prior to machine power-up it is essential to follow the preparation in this chapter to ensure correct operation of the machine and prevent any possible damage occurring to the machine or personnel.

## TRANSPORTATION

Having successfully completed the unpacking instructions, detailed in Chapter 3, machine may now be transported to its designated area.

With the aid of a fork lift truck or similar machine, locate the arms under the machine so that the weight of the machine is taken fully on the machine frame, not on the side skirt panels. Transport the machine into position. Lower the machine and adjust the mounting feet to the approximate height required, see 'Machine Levelling' later in this chapter.

## TRANSIT BRACKETS

### CAUTION

Before any power is applied to the machine all transit brackets must be removed from the machine, failure to do so will result in machine damage.

These bracket are easily identified by their color red.

### Locations

Three transit brackets are fitted to the machine, prior to dispatch, to prevent the various machine assemblies moving during transit, these are:

- Squeegee Assembly
- Printhead Carriage
- Screen Chase
- Printhead Lift
- Paste Dispense
- Camera Carriage

The largest of the three brackets lays across the printhead carriage rails, locating on the two front screw positions of the rails and secures the following assemblies:

1. The two center studs of the transit bracket locate into two threaded holes in the rear squeegee mounting plate, preventing any movement of the squeegee assembly.
2. Two studs in the transit bracket locate in two threaded holes in the front face of the print carriage, preventing any forward or rearward movement of the printhead carriage.
3. Two studs in the transit bracket screw down on the screen chase, securing the front of the screen chase in position.
4. The longest studs in the transit bracket locate into two threaded holes in the machine frame, clamping the printhead to the machine frame, preventing the printhead from opening.
5. The single stud located through the lug on the left of the transit bracket screws against the paste dispense unit preventing any lateral movement of the unit along the carriage.

The second bracket locates at the rear of the printhead, upper surfaces, and secures the following assembly.

6. Two screws mount the transit bracket to the rear of the printhead frame and a single stud screws down onto the screen chase, securing the rear of the screen chase in position.

The third bracket is attached on the left hand printhead lift stud, securing movement of the following assembly:

7. A single screw secures the camera carriage and timing belt to the bracket, preventing any movement of the carriage or camera.

#### Removal Procedure

To remove the three transit brackets from the machine, proceed as follows:

1. From the main transit bracket, release the studs securing the following assemblies.

A) On the squeegee assembly securing studs, loosen the nuts and washers either side of the bracket, unscrew the studs from the rear squeegee mounting plate.

B) On the printhead carriage securing studs, loosen the nuts and washers either side of the transit bracket, loosen the nuts securing the studs to the carriage, unscrew the studs from the printhead carriage.

C) On the screen chase securing studs, loosen the nuts and washers either side of the bracket to release the screen chase.

D) On the printhead lift securing studs, loosen the nuts and washers either side of the bracket, loosen the nuts and washers securing the stud to the machine frame, unscrew the studs from the machine frame.

E) On the paste dispense stud, loosen the nuts and washers either side of the bracket to free the paste dispense unit.

2. From the rear transit bracket securing the rear of the screen chase to the printhead, loosen the nuts and washers either side of the transit bracket to release the screen chase, remove the two screws securing the bracket to the printhead, remove the bracket from the machine.

3. From the lower transit bracket securing the camera carriage to the left hand stud of the printhead lift stud, loosen the nuts and washers either side of the bracket securing the bracket to the stud, remove the screw securing the bracket to the camera carriage.

Carefully remove the main transit bracket and studs from the machine.

Fit dustcaps to the printhead carriage rail front screw positions.

#### Machine Re-location

The following procedure is given for installation of the transit brackets in the event that the machine may have to be re-located.

## Installation Procedure

To install the three transit brackets to the machine, proceed as follows:

1. Check that the camera transit bracket is fitted to the main transit bracket (ie. On the left hand stud of printhead lift studs). Check that all nuts and washers are fitted to the bracket studs.
2. Remove the dust caps from the printhead carriage rail front screw positions.
3. Position the main transit bracket across the printhead carriage rails, locating the bracket spigots into the front screw positions, and the bracket mounting feet resting on the front of the printhead frame.
4. Move the chase forward by hand and temporarily hold in position, locate and screw the printhead lift studs into the machine frame and secure in place using locknuts and washers. Secure the studs to the bracket with nuts and washers.
5. Ensure the screen chase is not in contact with the head lift studs. Screw down the studs until in contact with the chase to secure it in position, do not overtighten. Secure the bracket to the stud with the nuts and washers.
6. Fit rear transit bracket to the printhead with two screws and washers. Screw down the stud until it comes in contact with the screen chase, do not overtighten. Secure the bracket to the stud with the nuts and washers.
7. Move the printhead carriage forward by turning the drive shaft until there is a gap of approximately 1mm between the front squeegee mounting and the transit bracket.  
Remove the squeegee assembly pressure housing cover plate to gain access to the squeegee timing belts. Wind the front squeegee mounting down (rear timing belt) so the squeegee mount is clear of the transit bracket.

Adjust the rear squeegee mounting (front timing belt) until the holes in the mounting plate align with the transit bracket studs (protective tubing should be fitted to the studs to prevent rubbing against the front squeegee mounting). Locate and screw the studs through the slots in the rear squeegee mounting into the two threaded holes in the rear squeegee mounting plate, secure the studs to the bracket with the nuts and washers.

Wind the front squeegee up to abut the studs to secure the front squeegee mounting in place, refit the housing cover plate.

8. Locate and screw the printhead carriage studs into the threaded holes of the printhead carriage and secure in place using nuts and washers. Secure the studs to the bracket with nuts and washers.
9. Move the camera to its limit (ie. Fully left), to prevent the camera striking the screen clean unit when the carriage is moved forward. Move the camera carriage forward by hand to position the transit bracket over the camera carriage and timing belt, secure the bracket to the carriage using the screw and washer, do not overtighten. Secure the bracket to the stud with nuts and washers.

Note: The camera carriage fits over the timing belt to clamp the belt, preventing camera movement.

### PRE INSTALLATION CHECKS

Having removed the transit brackets and located the machine in position, prepare to install the machine, as follows:

1. Connect the pneumatic supply to the connection on the external services panel.
2. Connect the electrical supply to the external services panel.
3. Check that the E-Stop loop is connected, either to the external machines, in which case these machines must be powered up and operational in order for the loop to be closed, or if the external E-Stop loop is not required then the dummy plugs supplied with the machine must be connected.
4. Check that all circuit breakers are in the On position.
5. Ensure that all access covers and removable panels are closed and are in place.
6. Ensure that the Maintenance key is removed from the monitor.
7. Ensure that the E-Stop button is in the fully out position. To check this, push the E-Stop button until it latches. Twist the button clockwise to release it.
8. Check that all of the cables for the Control Monitors are connected.
9. Re-seat the control and drive cards of Y1, Y2 and Y3 enclosures by withdrawing the card approximately 3cm and refitting.

#### CAUTION:

Ensure that Anti-Static Precautions are adhered to when handling the electronic cards.

## MACHINE LEVELLING

### General

The machine must be installed at the correct height and then levelled before operation.

### Machine Height

The height of the machine will be governed by the external machines that is to be connected to and ranges from 840mm to 980mm, (depending if the feet extensions are fitted)

The height is measured from the floor to the top of the transport belts.

### Initial Levelling

Once the height of the machine has been ascertained then the four feet should be adjusted so that the decided height is achieved.

Place a machine level on the Tooling Base Plate facing East-West or North-South.

By adjusting each of the four feet individually by small amounts level the machine so that in each direction (East-West & North-South) 0.004" per foot (0.32mm/meter) is achieved. Lock the feet using the lock nuts on the adjusters.

Check that the height has not been disturbed. If so, then repeat

the two steps until the correct height and level is achieved.

## CHAPTER 5 MACHINE POWER-UP SEQUENCE

### GENERAL

Before the machine is powered up, a final check is required to ensure proper installation.

When fully satisfied that all instructions and preparation has been carried out as detailed in Chapter 4- Machine Preparation proceed with the power-up checks detailed in this chapter.

### ELECTRICAL SERVICES

Check the following electrical services are available:

Customer/Factory electrical supply

Check machine transformer is correctly configured for customer supply.

Check power supplies settings (12V, 5V & 24V)

### MACHINE POWER-UP SEQUENCE

When all of the above checks have been carried out then read the following procedure before continuing with the sequence.

1. Turn the Mains Isolation Switch clockwise, this will apply Main Power to the machine.
2. Wait until the Control Monitors are visually displayed.
3. The Main Control Screen will display a message, Press "System" Button to Proceed, in the Message Prompt Bar.
4. Press the green System button. (If the button fails to illuminate then the 'E' stop loop is open. Check all panels are closed and that the upline and downline connectors are fitted and that the Emergency push button is fully released). The machine will carry out an initialization procedure. This should be a quiet sequence with no more than a few servo motors running. If the machine appears to show excessive mechanical noise, then press the Emergency stop button then power the machine down.

Carry out the Check List in Chapter 4 'Installation', also ensure that every transit bracket has been removed.

Repeat the full procedure. If the problem remains then call the DEK Service personnel.

5. If the machine reports the error "MOTOR COMMS FAILURE" in the Message Prompt Bar when the machine has attempted to initialize, then the program resident on the Control cards is corrupt. For the machine to operate, the Mint program will have to be re-installed.

### FUNCTIONAL TEST

Diagnostic Entry

Check that all servos/stepper axis home to the correct dimensions, as follows:

1. With the machine initialized insert and turn the maintenance key to On to enter the maintenance function, the menu bar will display the following:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

2. Press the Main button and the menu bar will change displaying the Diagnostic function.

Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

3. Pressing Diagnostic will enter into the main diagnostic menu. If a password exists a window will display the message 'Diagnostic Password'. If the password is incorrect control will display the message 'Invalid password entered' and return to the previous menu. If the correct password is entered or no password exists a pop up window will display the following:

System

Print Head

Print Carriage

Squeegee

Camera Axis

Rail System

Paste Dispense System

Screen Alignment

Screen Change

Screen Cleaner

Rising Table

Foreign Machine Interface

Autoflex Tooling

Next/Prev keys will move the highlight bar up down the list of modules that can be selected.

Select Module key will open a new window displaying the diagnostic functions available for the selected module.

Exit will return operation to the start of initialization.

NOTE

Before any diagnostic function is used in any of the modules they must be homed first or they will not be able to initiate a command.

Highlight the module required using the Next/Prev keys, press Select Module.

Select Module, Next, Prev, System Enable, System Disable, Exit

Proceed with checking the home settings for the Print Carriage, Rising Table, X Axis Camera Carriage, Y Axis Camera Carriage and Paste Dispense, as detailed in the following pages. Adjustments for all sensor settings are detailed in the Technical Reference Manual.



## HOME MODULE SETTINGS

Print Carriage Home Position

Check dimension 'A' is 65mm +/- 0.5mm

For sensor setting refer to Technical Reference Manual

Rising Table Home Position

Check dimension 'A' is 208mm-0.00mm + 2.00mm

With Autoflex fitted dimension 'A' to be 168mm -0 +2mm

For sensor setting refer to Technical Reference Manual

X Axis Camera Carriage Home Position

Check dimension 'A' is 136 - 138mm. Ensure that the vane clears the magnet of the sensor 1-2mm.

For sensor setting refer to Technical Reference Manual

Y Axis Camera Carriage Home Position

Check dimension 'A' is 28 - 30mm. Ensure that the vane clears the magnet of the sensor 1-2mm.

For sensor setting refer to Technical Reference Manual

Paste Dispense Home Position

Check dimension 'A' is 15-17 mm from bearing to end stop dowel.

For sensor setting refer to Technical Reference Manual

## CALIBRATIONS AND SETTINGS

Complete the Calibration and Settings as stated below, refer to Technical Reference Manual Chapter 7 'Calibrations and Settings' for full detail.

Rail to Table Height

Print Reference Height

Vision Calibration

Board at Left/Right Optos

Board at Stop Sensor

Paste Cartridge Empty Sensor

## PRODUCT SET-UP

Carry out the basic product set-up for the test board, as detailed

in the Operator Manual, Chapter 5 - 'New Product Set-up'

## CHAPTER 6

### EXTERNAL MACHINE INTERFACE

#### INTRODUCTION

For the screen printer to be able to communicate to an upline external machine and a downline external machine the interface protocol has to be established.

The options for interface protocol are selected from the maintenance set preferences page.

In addition to changing the protocol in software, a personality interface card will have to be configured and installed into the machine for the relevant external interface to function correctly.

The protocol for interfacing external equipment is as follows:

SMPI- The upline and downline machines can be connected to either upline and downline connectors irrespective of machine positioning.

SMEME, SANYO, FUJI, & DYNAPERT - The upline machine must be connected to the upline connector and downline machine must be connected to the downline connector.

With the cables supplied connect the upline and downline machines to the screen printer.

2. Press the Maint button (F8), the Menu bar will change to the following:

Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

3. Press the Set Prefers button (or F5)

4. Using the Next and Prev keys highlight the Transfer protocol function. Use the Incr and Decr keys and change the protocol to what is required.

At this step, if required, change the Display Units, Transfer Mode etc. When completed Press Exit button (F8). This will save the revised printer configuration and the Menu Bar will change back to the following:

Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

5. Press the Exit button (F8) and the Menu Bar will change to the following:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

6. Press Set-Up button (F6). The Menu Bar will change to the following:

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

7. Press the Mode (F1) button until the mode displayed in the Main Control Screen changes to No-Print.

8. Press the Exit button (F8) and the menu bar will display the following:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

Ensure that the Upline and Downline Machines are connected and are powered up. (E-Stop loop connected if necessary).

Press the Run button (F1). This function key will change, to read Stop.

The screen printer will request a board from the upline machine and pass it through the machine. The board will stop at the sensor on the conveyor. On request from the downline machine the board will pass onto the external conveyor. When the sensor is clear the screen printer will request another board from the upline machine and the sequence will repeat.

Pressing the Stop will cease the sequence, changing the Stop key back to the Run key.

This will show that the interface is working between the screen printer and the external machines.

#### VISION ALIGNMENT TEST (SPC DATA)

##### Detail

Delete TEST.DAT from the PRINTER directory, (using the Housekeeping function-'Delete Date', Technical Reference Manual, Chapter 5 refers)

Set machine to run with Customer Board

Run 300 cycles

Copy all .DAT and .TXT files to diskette (using the Housekeeping function-'Copy to Disk', Technical Reference Manual, Chapter 5 refers)

Using Lotus spreadsheet DRY\_ALIN, input data and print out results.

#### PRINT TEST

##### Detail

Test print 10 boards to work paste

Using the test board, produce three consecutive prints and check for print uniformity, as follows:

Record 5 points on each of the three boards. Record the min. and max. figure from the 15 readings.

The total variation across the 15 readings should be equal to, or less than 50 microns.

## BOARD TEST FOR PRINT ACCURACY

### Detail

Print 10 boards to work paste.

Using the Test Board-Issue A, print 30 consecutive boards and measure the 8 points, paste to pad, using the LSM, (using Width mode) and record on the Print Alignment Table overleaf, (if available, download the details into spreadsheet using lap top p.c.)

Using suitable measurement equipment, load data into Lotus spreadsheet WET\_ALIN and print results.

## MACHINE INSTALLATION ACCEPTANCE DOCUMENT

### General

This chapter contains a copy of the standard Machine Installation Acceptance Document as an example. The service engineer/agent provides a working copy for signatures and recording purposes on machine installation. The acceptance document is designed to cater for all instances on machine installation where the customer is:

Part A Fully satisfied with the machines condition and performance in all respects.

Part B Satisfied that the machine is fully operational in all respects but has minor shortfalls.

Part C Is unsatisfied with the performance and condition of the machine.

In each instance the Engineer/Agent and Customer representative will complete the relevant Part of the document, retain a copy of the signed document and forward to the personnel stated at the end of each part to address given at the front of this manual.

### PART A

#### MACHINE INSTALLATION ACCEPTANCE DOCUMENT

##### FULL ACCEPTANCE

(SAMPLE)

MACHINE MODEL:

MACHINE SERIAL NUMBER:

CUSTOMER:

ADDRESS:

AGENT (if applicable)

### DECLARATION

I HAVE EXAMINED THE ABOVE MACHINE AND FOUND IT TO BE IN COMPLETE ACCORDANCE WITH THE DESCRIPTION, IN GOOD ORDER AND CONDITION AND FIT FOR THE PURPOSES FOR WHICH IT IS INTENDED.

CUSTOMER REPRESENTATIVE

NAME(Print):  
POSITION:  
SIGNATURE:  
DATE:  
DEK REPRESENTATIVE

NAME(Print):  
POSITION:  
SIGNATURE:

PART B  
MACHINE INSTALLATION ACCEPTANCE DOCUMENT  
CONDITIONAL ACCEPTANCE  
(SAMPLE)

MACHINE MODEL:  
MACHINE SERIAL NUMBER:  
CUSTOMER:  
ADDRESS:  
AGENT (if applicable)  
DECLARATION

I HAVE EXAMINED THE ABOVE MACHINE AND FOUND IT TO BE IN COMPLETE ACCORDANCE WITH THE DESCRIPTION SAVE THE CONDITIONS OVERLEAF. THESE CONDITIONS DO NOT IMPAIR THE USE OF THE MACHINE FOR THE PURPOSES FOR WHICH IT IS INTENDED.

CUSTOMER REPRESENTATIVE

NAME(Print):  
POSITION:  
SIGNATURE:  
DATE:

DEK REPRESENTATIVE

NAME(Print):  
POSITION:  
SIGNATURE:

OUTSTANDING ISSUES  
ITEM DESCRIPTION ACTION DATE RESOLVED

THE ABOVE ISSUES HAVE BEEN CORRECTED TO MY SATISFACTION

NAME(Print):  
POSITION:  
SIGNATURE:

DATE:

CUSTOMER TO RETAIN COPY

FORWARD COPY TO: MACHINE HISTORY FILE, DEK ACCOUNTS, SERVICE DEPARTMENT

PART C

MACHINE INSTALLATION ACCEPTANCE DOCUMENT

NON ACCEPTANCE OF MACHINE

MACHINE MODEL:

MACHINE SERIAL NUMBER:

CUSTOMER:

ADDRESS:

AGENT(if applicable)

DECLARATION

I HAVE EXAMINED THE ABOVE MACHINE AND FOUND IT NOT TO BE IN ACCORDANCE WITH THE DESCRIPTION FOR REASON OF THE CONDITIONS LISTED OVERLEAF.

CUSTOMER REPRESENTATIVE

NAME(Print):

POSITION:

SIGNATURE:

DATE:

DEK REPRESENTATIVE

NAME(Print):

POSITION:

SIGNATURE:

OUTSTANDING ISSUES

ITEM	DESCRIPTION	ACTION	DATE RESOLVED
------	-------------	--------	---------------

THE ABOVE ISSUES HAVE BEEN CORRECTED TO MY SATISFACTION

NAME(Print):

POSITION:

SIGNATURE:

DATE:

CUSTOMER TO RETAIN COPY

FORWARD COPY TO: MACHINE HISTORY FILE, DEK ACCOUNTS, SERVICE DEPARTMENT

SCREEN PRINTING MACHINE ( BOOK 3)

## OPERATOR MANUAL

### INTRODUCTION

It is advisable to read the Operator Guide first and familiarize yourself with the machine by checking the Machine Overview chapter with the machine.

The Operators manual is divided into 11 chapters.

Chapter 1 Safety Features, describes the features on the machine that provides operator safety while the machine is in operation.

Chapter 2 Machine Overview, is a diagram showing the position of various functions on and around the machine including the removable front panel which has a panel safety switch fitted to it.

Chapter 3 Production of screens, shows the positioning of an image on the screen.

Chapter 4 Vision Alignment System, describes how the vision system operates and what is involved in creating a fiducial strategy.

Chapter 5 Setting Up For a New Product, shows a procedure of how to program the relevant parameters to enable the machine to accept a new product.

Chapter 6 Retrieving A New Product, shows a procedure of how to retrieve a previously programmed product parameter file so that the machine can be changed from one product to another in minimal time.

Chapter 7 Paste Dispenser, describes the functions and settings of this programmable unit.

Chapter 8 Under Screen Cleaner, describes the functions and settings of this programmable unit.

Chapter 9 Fitting Of Squeegees, will describe the process operation of a squeegee and how to select and fit the correct type.

Chapter 10 SMT Print Quality, describes in depth the process and problems associated with basic and fine pitch printing.

Chapter 11 Error Messages, list and advises on the recovery of each error message reported on the machine.

### GENERAL

This screen printing machine is designed to be a versatile printer which can be operated as a stand alone or as part of an automatic in-line system. The screen printer is microcomputer controlled and can communicate with an outside host computer for parameters and management information.

The high standard of manufacture, and assembly, of this robust printer allows great accuracy and repeatability of performance. All operations are controlled by the microcomputer, which also records and maintains the print parameters for multiple products and machine

management, including machine run time; wait time; down time; faults and selected events.

A feature of this machine is the speed, and ease with which the printer may be re-configured to accept a new set of parameter values, or a change to a completely different product. The microcomputer can save and load multiple product information from hard disk storage to achieve a high speed set-up.

The machine printer provides complete flexibility in the use of long print runs, or small batch production, making this screen printer the Automatic choice.

All Parameter values are set via the VDU using a row of eight function keys placed directly below, coinciding with Menu Bar on the screen so as to make, machine to operator interface, quick and simple. There is also a pull out keyboard for use of direct communication to the microcomputer.

#### OPERATOR VDU INTERFACE

The Menu Bar that is shown across the bottom of the screen will show an array of functions that can be enabled by pressing the coinciding function key below the menu bar. These functions will initiate the selected action or change to a new Screen and/or Menu Bar, making further options available for action or data entry.

#### MACHINE SPECIFICATION

##### Board Handling

##### PARAMETER    DETAIL

Minimum size    100 x 50mm

Maximum size    510 x 508mm

Size tolerance    +/-0.3mm

Thickness        0.6 - 6.4mm

Warpage                1% of board diagonally up to 8mm max. (including board thickness)

Underside component clearance    Max. 19mm

Transport feed    Min 3.5mm to board edge

Feed direction    Pass thru, single-ended from left or right

Interface Option    SMPI, SHEMA, FUJI, DYNAPERT, SANYO, SIEMENS, PANASONIC, or others with adaptors

Interface Height    840mm - 980mm

Width Adjustment        Fixed front rail, motorized rear rail 50 - 508mm

Tooling                 Magnetic support pillars/ Autoflex

Registration              Vision

##### Print Parameters

##### PARAMETER    DETAIL

Screen frame        736 x 736mm external, 660 x 660mm internal

Print area            510 x 498mm

Print stroke         Automatic

Print speed          10-150mm/sec



Print pressure 0-20Kg  
 Print gap 0-6mm  
 Print modes Print/print,flood/print and print/flood  
 Squeegee types Single trailing/diamond, double trailing/diamond  
 Screen change-over Motorized  
 Screen adjustment X/Y +/-10mm, Theta +/-2 degree  
 Paste dispense 10-100mm/sec dispense speed, rate 0-100  
 Screen cleaning 0-100 cycles dry or solvent option

#### PARAMETER MENU PAGE

Programming the machine for Setting-Up and Process is listed as shown below on the parameter menu page:

#### Set-Up

##### PARAMETER DETAIL

Product Name File name (Max. of 250 board files), standard DOS format

Screen Adaptor None; 255; Sanyo; Heraeus

Board Width Rail Width, 49.5-508mm in increments of 0.1mm

Board Length Sets board stop default, 100-510mm in increments of 0.1mm

Board Thickness 0.5-6.0mm in increments of 0.1mm

Board 1 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Board 2 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Screen 1 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Screen 2 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Fiducial 1 X Distance of first fiducial from left edge of board, 0-510mm in increments of 0.1mm

Fiducial 1 Y Distance of first fiducial from front edge of board, 0-508mm in increments of 0.1mm

Fiducial 2 X Distance of second fiducial from left edge of board, 0-510mm in increments of 0.1mm

Fiducial 2 Y Distance of second fiducial from front edge of board, 0-508mm in increments of 0.1mm

Tooling Type Magnetic support pillars; Vacuum; Autoflex

Fiducial 1 X O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to left of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 1 Y O set Programmable o set of centroids of screen to board fiducials. += Screen o set to rear of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 2 X O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to left of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 2 Y O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to rear of board, -1mm to +1mm, in increments of 0.4mm

Screen X Forward } Actual Screen Position

Screen X Rear } XF & XR, -20 to +20mm in increments of 0.004mm

Screen Y Axis } Y, -10 to +10mm in increments of 0.004mm

Alignment Weighting Assigned Alignment to fiducial 0-100%, in increments of 1%

Board Stop X Distance from centerline of machine to stop position, 50 - 255mm, in increments of 0.1m

Board Stop Y Distance from front rail to stop position, 10-498mm, in increments of 0.1mm

Process

#### PARAMETER DETAIL

Print Speed 10-150mm/Sec in increments of 1mm

Flood Speed 10-150mm/Sec in increments of 1mm

Front Pressure 0-20Kg, in increments of 0.2mm

Rear Pressure 0-20Kg, in increments of 0.2mm

Flood Height Set height for the flood blade above the screen, 0-5mm in increments of 0.02mm

Print Gap Screen to board gap, 0-6mm, in increments of 0.025mm

Separation Speed Speed at which the first 3mm of board from screen separates 0.1mm - 100mm/Sec in increments of 0.1mm/Sec

Print Mode Print/Print;Print/Flood; Flood/Print.

Print Deposits 1;2;3

Paste Dispense Rate Number of print cycles between dispense cycles 0 -100 (o ) in increments of 1

Paste Dispense Speed Speed of paste dispense carriage, 10-100mm/Sec in increments of 1mm/Sec

Screen Clean Rate Number of print cycles between screen cleaner cycle, 0-100 (o ) in increments of 1

Screen Clean Mode 1-Dry; 2-Dry; 1-Wet/1-Dry; 1-Wet/2-Dry; 2-Wet/1-Dry; 2-Wet/2-Dry

Paste Dispense Rate Number of print cycles between dispense cycles 0 -100 (o ) in increments of 1

Paste Dispense Speed Speed of paste dispense carriage, 10-100mm/Sec in increments of 1mm/Sec

Screen Clean Rate Number of print cycles between screen cleaner cycle, 0-100 (o ) in increments of 1

Screen Clean Mode 1-Dry; 2-Dry; 1-Wet/1-Dry; 1-Wet/2-Dry; 2-Wet/1-Dry; 2-Wet/2-Dry

Paste Start Distance from the centerline of machine to dispense start, -255 to -255mm, in increments of 1mm

Paste Stop Distance from the centerline of machine to dispense start, -255 to -255mm, in increments of 1mm

#### GENERAL

Safety features provides safe operating conditions for both the operator and the machine.

The machine is fitted with an emergency safety shut-down press button switch. External modules in the line can be fitted for connection to a common cable loop line, that provides automatic shut-down of all modules, if any single emergency switch is operated, or any frame cover is disturbed during normal operation of the line.

Covers fitted with safety interlock switches protect operating personnel from the moving mechanisms. Transparent plastic access covers are fitted over moving mechanisms of the machine and steel safety covers control access to the frame of the module.

#### PROTECTION FROM HIGH VOLTAGE

##### Mechanisms

Machine mechanisms are powered 24 V only and do not pose an electrical hazard to personnel.

220/110 V

Where (220/110 V) incoming supply voltages are present, protection is afforded by controlling access to the enclosures that house the supply. The machine is fitted with an interlock isolator switch that cuts power to terminations downstream of the isolator, for example the isolator enclosure. Insulating shrouds offer protection at the isolator switch incoming power terminals.

#### Hazard warning

Hazard warning labels 'Danger High Voltage', are placed on the outside of enclosures where high voltage (220/110 V) terminations are present within and the enclosure is not fitted with a safety interlock. Inadvertent access to such enclosures is prevented by the presence of the frame covers.

#### EMERGENCY SHUT-DOWN

The machine is fitted with an Emergency shut-down push button switch located on the right hand side of the machine front cover. An additional push button is located on the left hand side of the head cover, this button is an optional extra. Pressing either of these push-buttons (or removing a steel frame cover) cuts power to the 24 V supply to mechanisms of all modules connected into the emergency loop line. A warning of this condition is reported on the VDU. The E-stop system is described in detail below.

#### EMERGENCY-STOP LOOP

Stand-alone operation of module requires the end-of line plug/socket to be fitted.

The E-Stop system is a low voltage powered loop that interconnects selected modules in the line and provides automatic shut-down of any powered mechanisms of the line during an emergency shut-down. Breaking continuity of the E-Stop loop provides an automatic safety shut-down procedure for modules. The connection loop comprises cable connections chained between upline and downline of modules selected.

#### Recovery

When the normal working condition is restored, release the Emergency stop button and/or replace the cover that has been removed and press the green system button located on the control VDU.

#### CLEAR ACCESS COVERS

Clear polycarbonate access covers are fitted to the machine to protect personnel from the mechanisms during normal line operations. Lifting a cover disables power to the mechanism that the cover protects.

#### Recovery

When the normal working condition is restored, and the relevant cover is closed when the machine will carry on and complete the cycle.

#### STEEL FRAME COVERS

Frame covers are fitted with safety interlock switches which are also connected to the emergency loop line. Removing the cover has the same effect as pressing the Emergency stop button, cutting 24 V power to the mechanisms of all modules connected into the loop. Indication that a cover has been removed (or the E-stop has been pressed) is given by an error message displayed on the control VDU.

#### Recovery

When the cover is re-positioned, normal working condition is restored and the line may be restarted; pressing the

green system button at the control VDU will enable the machines re-initialization procedure, where this is allowed by the control system.

#### TWO BUTTON SAFETY SWITCHES

Located at the front of the machine, are the two button safety switches. The positioning of these buttons are needed to maintain maximum safety for the operator when operating a particular function. The two buttons have to be pressed simultaneously to become active.

The use of these buttons are dependent on the function selected at the VDU.

For example:

-Head Lift Up/Down

-Board Width

-Load Width

#### PRINthead LIFT SUPPORT ASSEMBLY

##### Function

For the protection of personnel when working beneath the printhead with the printhead raised, a Head Support Assembly, Part No 112975, is provided to mechanically secure the printhead in the raised position. The support should be used at all times that the printhead is raised and stowed by the machine when not in use.

The support assembly is colored red and incorporates an internal spring for ease of installation and removal. With the head raised the assembly is positioned to the front left hand side of the machine in the electro-magnetic sockets, ensure that the black end of the support is at the bottom and the silver end at the top.

#### CAUTION

##### IMPORTANT

The lower support assembly must be removed prior to selecting printhead lowered.

If an attempt is made to lower the printhead with the support assembly installed damage to the printhead, actuator and drive card may occur.

#### CHAPTER 2

##### MACHINE OVERVIEW

(Bhot's Note: Illustration only)

#### CHAPTER 3

##### PRODUCTION OF SCREENS

##### INTRODUCTION

This chapter describes the production procedure of screens to suit the positional requirements determined by the design of the screen printer.

##### IMAGE POSITIONING

In order for the screen printer to be set-up consistently, it is important that the image position in the screen frame be accurately placed to the correct dimensions.

To help in positioning the image onto the screen the following diagrams will show the required dimensions.

#### Note

The front rail on the machine is fixed. Therefore, the position of the board front edge will also be fixed with respect to the position of the screen.

#### 'Y' AXIS POSITIONING

The important dimension to adhere to is the position of the artwork in the 'Y' direction. This dimension shows the position of the fixed front rail relative to the outer edge of the screen frame when the screen parameters are set to zero.

On most artwork there are usually corner alignment marks showing the board outline. These can be used to specify the positioning of the artwork relative to the outer edge of the screen frame.

Positioning of the artwork in the 'Y' axis is a simple process consisting of measuring from a point on the artwork to the front edge of the board, add this dimension to the fixed offset dimension (front rail to outer screen frame position). This will give a dimension whereby the screen manufacturer can accurately place the image in the 'Y' axis.

This dimension should be specified to 1mm

It is actual practice to measure from the nearest pad to edge of the board and to specify which pad the dimension has been measured.

#### 'X' AXIS POSITIONING

Usually the artwork is positioned centrally on the board therefore positioning of the artwork in the 'X' direction is achieved by placing the center of the image about the center of the screen frame.

This position should be specified to 1mm.

Occasionally the artwork is offset on the board therefore it is sometimes advisable to place the image of the artwork about the center of the screen frame so that the squeegee will apply equal pressure across the printing area. If the image is to be placed central in the screen frame then it is important to offset the position the board stop when setting up the parameters of the product.

The position of the screen artwork should be kept within the limits specified. To position the screen artwork, firstly determine the dimension, in mm, of the artwork from the front edge of the pcb. Subtract this dimension from 622mm. This will position the artwork in the 'Y' direction and must be kept within the 1mm.

The position of the artwork in the 'X' direction of the screen frame should be set so that the centerline of the board is placed equally around the centerline of the machine within 1mm.

#### NOTE

It is of the utmost importance that the image is placed squarely in the screen frame within the given dimensions.

#### SCREEN FIDUCIAL MAINTENANCE

General

As the vision system relies on good contrast between fiducial and the screen material(brass or stainless etc) it is required to maintain this contrast so as to enable good consistent fiducial location. The contrast will deteriorate each time the screen is cleaned depending on the type of solvent used and the type of screen used. To reduce this deterioration then periodic maintenance of the screen will be required and would only need burnishing.

If the fiducial has eroded over a period of time then a fiducial fill and screen burnishing will be required.

To determine the maintenance period and or fiducial erosion then the contrast has to be evaluated. This can be achieved by using the Vision Evaluation Table in Chapter 4, aiming for greater than 40 threshold separation.

The main objective is to establish a contrast deterioration to screen wash cycle rate.

#### CAUTION

If using an aqueous washing system with a saponifier the PH level must not rise above 11 or the fiducials will deteriorate rapidly due to corrosive action.

#### Fiducial Filling

1. Remove carefully any existing filler from the fiducials. This can be done using a pin and a magnifying glass.

#### CAUTION

As the screens are extremely delicate and that the fiducial is half etched, any excessive force will cause damage to the screen by creating a pip on the top side. Also ensure that no damage to the fiducial perimeter occurs.

2. Remove any debris from the fiducial recess using clean moisture-free air supply. Do not use any type of solvent to clean this area as a residue may be left inside causing poor adhesion of the filter.

3. Fill the Fiducial recess with the filler using the applicator. Due to the nature of the filler, complete all filling as the filter compound may set in the applicator. Spray on the activator and allow to cure for 2-3 minutes.

4. Dispose of applicator with care and recap filler bottle immediately after use.

5. Using a sharp blade remove the excess filler so that it is flush with the screen surface.

CAUTION: Care must be taken no to SCORE(scratch-Bhot) the screen surface.

6. Place the shield over the fiducial area and gently rub the screen surface with the course eraser. Do not rub aggressively. The objective is to remove any minute excess of the filler and to create the contrast between the screen and the fiducial.

7. With the shield still in place rub gently with the soft eraser to give the screen a bright finish. This will enhance the screen to fiducial contrast.

After the predetermined maintenance period has lapsed then the fiducial to screen contrast will require a touch up, therefore a screen BURNISH(to make or become shiny by rubbing, a gloss or polish-Bhot) is required. If fiducial erosion is occurring then the fiducial fill procedure will be required.

#### Burnishing

Carry out the following burnishing procedure for brass stencils:

1. Place the shield over the fiducial area and gently rub the screen surface with the course eraser. Do not rub aggressively. The objective is to remove any tarnishing to create the contrast between the screen and fiducial.
2. With the shield still in place rub gently with the soft eraser to give the screen a bright finish. This will enhance the screen to fiducial contrast.

#### Materials

- Filler & activator - Black Tak from Loctite type
- Eraser - course type as used for typing correction
- Eraser - soft type as used for drafting film
- Applicator - green, available from Loctite Part No. 1993323
- Blade - scalpel type Swan-Morton No 11. + holder
- Shield - thin metal type with various shapes and sizes ie circles squares etc

## CHAPTER 4

### VISION SYSTEM

#### INTRODUCTION

This chapter describes the concept behind the vision alignment method used on the screen printer. The screen printer contains an automatic vision alignment system designed to command a servo controlled screen movement to align the screen image to board image accurately and consistently.

The automatic screen adjustment occurs each and every print cycle, thereby insuring an accurately registered print.

The system of operation for vision alignment makes use of a single roving telecentric camera. This type of camera can view the underside of the screen and board fiducial by opening and closing the relevant shutters.

The alignment of screen to board is achieved by looking down and locating the position of the board fiducials and then looking up, locating the screen fiducials and then correcting the difference.

The roving camera houses the mechanical board stop allowing ease of setting up and speeding up cycle times.

The vision system samples light intensity from the scene within the field of view of the camera using arrays of photo-sensitive elements. Each of these elements transmits an output to the computer which is proportional to the intensity of the light reflected back from the scene being viewed.

This output is recorded as one of 256 shades of gray at each location in a grid of points known as pixels. Each pixel has a specific location within the image as determined by its co-ordinates. The output from each location is transmitted to the computer as an analog voltage. These voltages are converted to a digital signal (digitized) of values 0 to 255.

#### FIDUCIAL RECOGNITION STRATEGY

This section describes the information required by the vision alignment system to accurately locate the board and screen fiducials repeatedly.

A fiducial is an alignment mark, positioned on the board as part of the artwork. Using this fiducial pattern the vision recognition system can determine accurately the position of the board. This will enable the vision system to be able to determine the necessary screen correction needed for perfect screen to board alignment.

The vision system requires certain data in order to be able to locate a fiducial. This data can be generated by two methods, boundary tracking or correlation. A comparison of the two techniques are given below.

Boundary Tracking	Correlation
Can only locate isolated fiducials or features as an alignment mark	Any part of a feature can be used as an alignment mark
Fast to learn and locate when working with a board	Slow to learn and locate with certain features
Less tolerant to lighting changes and board variations	More tolerant to lighting changes and board variations

Either Boundary Tracking or Correlation are available for board alignment as individual techniques or, the recommended method, Boundary Tracking followed by Correlation should Boundary Tracking fail.

Each technique is used to report the position of a point on the board or the screen. For accurate alignment this point must be positioned in the same place on the board as it is on the matching area of the screen. Boundary tracking reports the centroid of the learnt fiducial which is used as the reference point when aligning.

Using correlation, this reference point must be defined. The recommended method of alignment, employing both techniques, intends that the correlation reference point is always set to the centroid position, determined by learning using boundary tracking.

If correlation is selected alone as the feature recognition technique then it is recommended that the fiducial is learnt first using boundary tracking to use the centroid as a reference point. If the feature used is a part feature then the reference point must be entered manually. Manual entry of reference points should be avoided. Each technique uses different working information and is therefore described separately.

## BOUNDARY TRACKING

From the digitized values, information regarding the scene being viewed is extracted. Based upon this information, the first task required of the vision system is to separate object from each other. The method of separation used is called binary thresholding, wherein each pixel in the scene is adjusted to either black or white, based upon a selected gray scale value.

Every pixel with a gray scale value equal to or greater than the selected threshold is white. The selection of particular threshold value can therefore be used as a means to eliminate certain features from a scene, leaving only those which are significant.



To be able to locate the fiducials either in the screen or on the board a Fiducial Recognition Strategy needs to be created.

- Box Height

- Box Width

- Perimeter

- Area

- Fiducial to background relationship

- Reflectiveness of fiducial

With this information the vision alignment can recognize the learnt Fiducial and determine the centroid accurately. Globally this known as the Fiducial Recognition Strategy. All this information is partly determined by the vision processor and partly by the user. The user will have to set up certain parameters so that the fiducial can be consistently recognized by the vision system.

It is therefore of the utmost importance that the strategy be correctly created so that the alignment accuracy of the screen to board can be achieved.

The vision system, when searching for the desired fiducial will start its search in a spiral, clockwise pattern, from the last position that a fiducial had been recognized. This will speed up the search time since that a fiducial's position changes very little due to the mechanical positioning of the board in the machine. The vision system will search for the edge of the fiducial and trace the outline.

Once the trace is complete the processor will check the shape, perimeter, area etc and compare it with the original learnt fiducial. If the shape that has been traced does not compare with the original then it is rejected and the search will continue until the whole field of view has been covered and the fiducial has been found. If however the fiducial has not been found then the system will display an error message telling the user that the fiducial is missing.

For the Fiducial Recognition Strategy to be created correctly an understanding of the parameter make up of the fiducial strategy is required.

#### Background

This can be changed to Light or Dark/

The vision system needs to know what the relationship is between the fiducial and the board. To determine this the user needs to judge whether or not the fiducial is lighter in contrast compared with the board. It is quite common to see the fiducial tinned therefore it will reflect more light than the board making it a Dark background. To help the users decision the Video Threshold can be displayed.

#### Video Threshold

The video THRESHOLD(beginning point-Bhot) is used as a decision line so that the vision system can convert the image into pure black and white. To the left of the line everything will be set to black and to the right of the line everything will be set to white.

To determine this threshold setting the use of a histogram showing the reflectiveness of the area in the field of view is required.

Displaying the Video Threshold will change the live image on the vision monitor into a black and to the right of the line everything will be set to white.

The ideal setting setting is to change the threshold so that the fiducial outline just starts to break up and to make a note of the value. Change the threshold setting so that the fiducial starts to merge into the background and make a note of the setting.

Place the threshold in the middle of these two values.

Example:

-Decreasing the threshold will make the display whiter.

Therefore Increasing the threshold will make the display darker.

-Decrease the threshold until the fiducial just starts to merge with the background. This number, for example is 80.

-Increase the threshold until the outline of the fiducial starts to break up. This number, for example, is 120.

-The difference is 40. Divide by 2 and add to the lowest number, which is 80, and the optimum setting for the threshold is 100.

Gain and Offset

The gain and offset adjustments are used to obtain a proper processing balance for the vision system. This balance will aid in obtaining accurate results for the Threshold operation when difficult imaging conditions are present.

Due to boards and fiducials varying from board to board or from batch to batch the reflected image will move the histogram up and down the gray scale. To achieve a correct balance of sensitivity the Gain setting should be set so that there is good separation between board and fiducial. This separation cannot be too small due to the Threshold setting being fixed.

The histogram will move up and down the scale varying with the different types of board and fiducials, therefore if the separation is too small then the Threshold setting will encroach into one of the two peaks distorting the image. If the separation is too large then the histogram will move off of the scale giving either a saturated image or an image that is too dark.

The Gain setting can be related to the contrast control on a television set. The Offset being the brightness control.

It is through histograms that the proper setting of the gain and offset are obtained.

To set the Gain the ultimate goal is to adjust the histograms such that the separation between the center of the two peaks (fiducial and background) is approximately 80 on the scale.

The Offset is adjusted so that the two peaks are positioned about the center of the scale.

Histogram

The histogram is the tool that is used to evaluate how much the contrast has improved for a change in lighting or optical filtering.

The histogram displays a bar graph representing the distribution of gray scale values bounded within the field of view of the camera. The graph illustrates the contrast within the field of view, providing an accurate method

of selecting Thresholds and improving the illumination of the fiducials using the Gain and O set adjustments.

The graph is arranged with the gray scale values 0-254 located on the horizontal axis, such that 0 corresponds to a pure black pixel and 254 corresponds to a pure white pixel. The vertical axis displays the number of pixels or occurrences at that specific gray scale level, within the field of view.

The objective of contrast enhancement is to attempt to separate the color of the background from the fiducial. The more separated the more contrast.

#### Search Box

Search box is actually a programmable field of view of the camera which is stored as part of the fiducial strategy. The search box consists of, search box left(0), search box right(511), search box top(0) and search box bottom(479). The figures given in the parentheses will display maximum field of view. Altering these parameters individually will enable the field of view to be reduced in size.

The search box is used in two ways. The first being to enclose a fiducial so that the histogram can analyze the scene and display the result. Encasing the fiducial with the search box will allow the histogram to display the fiducial characteristics with respect to the background so that the gain and o set parameters can be easily set.

With a full field of view the ratio between the background and fiducial is usually quite vast, therefore, the histogram representation will only display the background peak and the fiducial peak will not be displayed.

Ensure that the search box is set to maximum before learning the fiducial and before saving this data.

The second use of the search box is to isolate the fiducial when there is a similar characteristic mark or hole in the field of view. This is likely to happen on rare occasions.

#### CORRELATION (or template matching)

The vision system, when working with correlation, requires the following information in order to locate a fiducial:

- Feature box
- Reference point
- Fiducial or Feature description
- Acceptance Tolerance
- Rejection Tolerance

With this information, the vision alignment can recognize a learnt feature and hence determine the reference point accurately. This information is partly determined by the vision processor and partly by the user.

The user will have to set up certain parameters so that the feature can be found most effectively and not be mistaken for another feature.

It is therefore important that the feature description is formed accurately and that the working levels for location are set correctly so that alignment accuracy of the screen to the board can be achieved.

The vision system, when searching for a feature, moves a small rectangular template containing the feature around the camera image comparing the feature with the image.

The vision system derives a percentage of match found between the search feature and any part of the image. The feature is located when the match exceeds a set level. The location that is reported can be any defined point within the template (reference point). Each time the vision system locates a feature, the starting point for the next search is updated, to speed up the search time.

#### Correlation, First or Best

Location may be set up to work in one of two ways: Correlation First or Correlation Best. Using Correlation First, the vision system, will search until the first match is found which exceeds a set level. Using Correlation Best, the vision system will search until the best match is found which exceeds a set level. Where the location method of boundary tracking followed by correlation is selected, correlation will work using correlation first.

For the feature recognition strategy to be set-up correctly an understanding of the working parameters is required.

#### Background

This parameter is not relevant to correlation.

#### Video Threshold

This parameter is not relevant to correlation.

#### Gain and O set

The gain and o set must be set in exactly the same way that it is set using boundary tracking.

#### Histogram

The histogram may be used to evaluate how much the contrast has improved for a change in lighting or optical filtering as described in the boundary tracking section.

#### Search Box

The search box is a programmable field of view as described in the boundary tracking section.

Ensure that the search box is at full size before learning a feature and before saving this data.

#### Feature Box

The feature box is a second programmable field of view which forms the walls of the search template. The feature may be surrounded by moving each of the walls. After a successful learn using boundary tracking, the feature box walls will be set automatically and that is how they should be set unless the feature used is a part feature, and learning with boundary tracking is not possible.

The size of the feature box should not be large enough for changes in the board's position to cause the sort feature to slip out of the field of view.

When setting feature box, it is recommended to create a unique feature within the search area, this will enable correlation first to be used, increasing the speed of location versus correlation best.

#### Reference X and Y

The two parameters reference X and reference Y move the cross wires in the X and Y direction around the inside of the feature box in the field of view. When the vision system locates a feature, the location reported by it is marked by the cross wires with respect to the feature.

After a successful learn using boundary tracking, the reference X and Y values will be set automatically and that is how they should be set unless the feature is a part feature. Part features require fine attention to the reference point, to ensure the same point is marked on both the board and screen feature pair. Errors in positioning of the screen, as a result of a poor reference position must be rectified by examining the printed boards and adjusting the fiducial offsets in the parameters menu.

#### Acceptance Tolerance

The accept tolerance is used when locating, to define the percentage of match that must occur between the template and the image to be a successful location. The learning process updates and accept tolerance to a level midway between the best and second best match.

#### Rejection Tolerance

During location, the vision system steps the template around the search area, initially looking for a position where the match exceeds the reject tolerance. When such a match is found, the feature is examined in detail to determine if it is the edge of a position that exceeds the accept tolerance.

During learning, the rejection tolerance is used to determine the search step size. If the rejection Tolerance is set too high, the search step size will be set very small and therefore a large number of positions will have to be checked to cover the complete search area. If the rejection tolerance is set too low, a larger number of initial positions are likely to require more detailed examination.

#### Result Matrix

As a result of learning, the result matrix is populated with values. Each row shows the location (X and Y) of a found match. The percentage of match is also given for each location.

The position of each location may be seen on the camera image by highlighting the row to be viewed. Once a row is highlighted, the feature box will move to the location where that particular match was found.

If, after learning, the result matrix displays more than one match, then to avoid locating on the wrong match the accept tolerance must be set above the second best match.

### LIGHTING

#### General

The heart of any vision system is the light source. The lighting will not only illuminate the area in which the camera is viewing but also creates contrast between the board surface (background) and the fiducial itself.

The performance of the illuminators is dependent on the fact that when a beam of light strikes a fiducial, it is partially reflected and partly dispersed.

The range of materials and surface finishes on printed circuit boards is now such that to optimize fiducial capture two lighting options available.

The vertical illuminator is ideal for most finishes eg. Plain copper, tinned copper and highly reflective hot levelled finishes. The ring illuminator apertures contrast when using domed or resist covered fiducials.

#### Screen Illuminator

The type of lighting that illuminates the screen fiducials is visible red led's with inner and outer adjustments. When viewing the screen fiducial then the inner array set to maximum will be the general setting as it is unlikely to vary in its condition. It is likely there will be a slow degrading of the screen condition due to cleaning of the screen after production and will occur over a longer period of time. Occasional buffing of the fiducial surround on the screen will be required.

#### Vertical Illuminator

Light Source:	Midget flange lamp (T1 3/4), DEK Pt. No. 113568
Format:	Vertical via beam splitter
Power:	24 volt 80mA max.
Maintenance:	Replace lamp every 6 months
Fiducial Surface Flatness	+/- 15 degree max.
Fiducial Surface Dispersion:	+/- 15 degree max.

#### Recommended

Fiducials:	Hot air levelled, Tinned copper, Gold plated, Plain copper	er
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The vertical illuminator, fitted as standard, depends on light being reflected directly back into the camera, if the surface angle to the horizontal is too large, no light will be reflected into the camera and if dispersion is too large, insufficient light will enter the camera to give a good image.

#### Ring Illuminator

Light Source:	30 Infra-red LEDs
Format:	14mm & 22mm dia. Concentric rings
Power:	24 volt 150mA max.
Maintenance:	None required
Fiducial Surface Dispersion:	+/- 10 degree min.
Recommended Fiducials:	Resist covered and domed.

The ring illuminator depends on the light being dispersed from the surface entering from the camera, if the surface is shiny very little is dispersed and if it is also flat, insufficient light will enter the camera to give a good image.

The light source used to illuminate the board is infra red and cannot be seen by the naked eye. The inner and outer ring can be individually adjusted to give maximum contrast between the fiducial and board.

The outer ring has been designed to give a different angle of lighting and is used mainly for fiducials coated in solder resist. Solder resist will reflect the lighting without allowing the fiducial image to be captured, this is known as SATURATION. The outer ring will penetrate the solder resist allowing the fiducial to reflect the light, thereby, displaying the fiducial image. The setting of this array should be maximum.

For domed fiducials optimum results can be obtained by using both the inner and outer arrays, setting them to maximum.

#### Interchangeability

Both units use the same mechanical and electrical fixing making removal and replacement simple and quick.

#### Adjustment of Lighting

Below are tables showing the basic settings that will generally give good results. However, there will be certain cases that may cause difficulty in fiducial location. To aid in lighting adjustment a description of the need for inner and outer lighting rings is required.

The main objective is to achieve good contrast between fiducial and background. This is known as separation. As a rule, the more intense the lighting, the better the separation.

The tables given below are only guidelines as to the lighting, gain and offset settings for different types of fiducial. The need for further experimentation may arise due to the characteristics of background and fiducials.

LIGHTING TYPE	FIDUCIAL TYPE	INNER ARRAY	OUTER ARRAY	VIDEO OFFSET	VIDEO GAIN
Vertical	Most types and/or initial	Maximum	Minimum		
100 Set for best	Hot air leveled	Maximum	Maximum		separation
Vertical	Hot air leveled	Maximum	Maximum		
100 Set for best	tinned copper				separation
	gold plated				
Ring	Solder resist	Minimum			
Maximum	255 Set for best		covered fiducial		separation
Ring	Domed fiducial	Maximum	Maximum		
255 Set for best					separation
SCREEN TYPE	INNER ARRAY	OUTER ARRAY	VIDEO OFFSET	VIDEO GAIN	
Brass Stencil	Maximum	Minimum	150		Set for best separation
Stainless Steel	Maximum	Maximum	150		Set for best separation

Setting the Gain control will enhance the separation between the fiducial and background.

When setting the gain, ensure that the fiducial peak on the histogram does not run off of the scale.

#### Threshold Evaluation

The objective of using the tables below is to establish the best lighting setting and then the optimum threshold value.

If the product experiences difficulty in finding fiducials then it is likely that the separation is small and therefore will require fine tuning. If this is the case then the table will establish this and will show if the lighting does not give the separation required. There is an alternative light source available which should overcome this problem.

Randomly select 3 boards. Set machine to view a fiducial and use fiducial set-up. Adjust lighting and video gain for optimum contrast. Adjust threshold to min and max which will give actual separation.

If the fiducial has a separation between 20-40 then the following formula should be applied to give optimized setting of the threshold for consistent location. Less than 20 is too small a separation which shows that the fiducial to background contrast is merging.

$$S/3 + H = O$$

S- Separation

H- Highest value of minimum threshold

O- Optimum threshold setting

For example:

Best separation = 36

The highest value of the minimum threshold = 97

$(36/3) + 97 = 109$

Therefore the optimum threshold setting is 109.

## FIDUCIAL OFFSET

Fiducial o sets are a means of correcting the vision alignment when discrepancies arise in the following:

- a) Using correlation recognition software
- b) If the fiducial to artwork is incorrect

The reason for discrepancies in a) is that the alignment reference point is input manually by the operator giving a slight variation in the board to screen alignment.

The discrepancy in b) is that the fiducials are either placed on the screen after the main artwork has been generated or that the fiducials have been placed directly onto the screen after the screen has been manufactured.

To adjust the fiducial o sets several prints of the relevant board must be carried out. Measure the paste to pad o set and input those measurements into the fiducial o sets in the parameters page.

Note: The o set value for the paste to pad variation must be consistent.

Adjusting the fiducial o sets will re-align the screen, ie. A positive X value will o set the screen alignment to the left of the board, similarly a positive Y value will o set the screen alignment to the rear of the board.

## ALIGNMENT WEIGHTING

Alignment weighting is the facility to compensate for a pitch mis-match between the screen fiducials and board fiducials.

The error becomes apparent after printing where there is a pitch error in fiducials between screen and board.

Ideally a perfect match of the images should be obtained between screen and board, but due to variables in the manufacturing of the screens and boards, this is rarely obtained.

To obtain the best match between the screen and board the system will calculate the error between the screen and board then automatically assigns the errors equally between Fiducials 1 and 2.

However if a bias to one side of the board is desired ie. In the case of localized fine pitch, then adjustment of the weighting value can be made.

## CHAPTER 5



## NEW PRODUCT SET-UP

### INTRODUCTION

#### General

Before commencing with this procedure the Vision System Chapter should be read and understood.

This set-up procedure is used for pre-production, on an unknown product. When the procedure has been completed the product parameters can be recalled instantly by product name using the Retrieving Previous Product procedure Chapter 6.

The following procedure is carried out in Stages 1-5. Each stage must be completed before carrying on with the next stage. Each stage can be repeated if necessary.

#### Stage 1

Edit Parameters Menu for new product, i.e. product title, board edge dimensions and board fiducial positions.

#### Stage 2

Load/change new screen

#### Stage 3A

Add/Change magnetic support pillars

#### Stage 3B

Set-Up/Change Autoflex support pins

#### Stage 4

Rough Alignment, step board through and adjust to rough align screen

#### Stage 5A

Fiducial Set-Up BT - BT/CORR

#### Stage 5B

Fiducial Set-Up CORR Only

#### Stage 6

Paste load and squeegee fitment

### MACHINE MODES

The following modes are available, performing the functions described below:

#### Auto Mode

In Auto mode the print cycle will request boards as required from an upline machine, print and pass them on demand to a downline machine.

#### Single Mode

In Single mode the print cycle will print a single board and stop.

### Step Mode

In Step mode the selected cycle, Print, Paste Dispense or Clean Screen will be performed one functional step at a time, at each step access will be given to adjust the appropriate parameters.

### No Print Mode

In No print mode boards will be requested from an upline machine and passed on demand to a downline machine, without any action.

Auto Mode When running auto mode the following menu bar is displayed:

End Run, Stop Cycle, Paste Load, Clean Screen, Adjust

### End Run

When End Run is selected the current cycle will complete the full print cycle and return to the main menu bar.

### Stop Cycle

Pressing the Stop Cycle will halt all actions and the menu bar will display Continue and Abort options.

Pressing Continue will re-commence the print cycle from the point at which it halted.

Pressing Abort will purge the board from the rails, return the paste dispense cartridge, clean screen and camera carriages to their datum positions. The print cycle will return to the start position in single mode. Two board removal options are available, Auto and Manual.

Selecting Auto allows board removal from the board exit position, selecting Manual allows the printhead to be raised under two button control for board removal from within the machine.

### Paste Load

Selecting Paste Load will display Auto Dispens and Manual Load options.

Pressing Auto Dispens will automatically apply a quantity of paste to the screen from the paste cartridge.

Pressing the Manual Load will raise the squeegees clear of the screen and drive the print carriage rearwards to allow the operator to apply paste to the screen, see 'Paste Load' at the rear of this chapter.

### Clean Screen

Pressing Clean Screen will drive the screen cleaner unit to clean the lower surface of the screen. The clean screen mode parameters will set the option for combinations of wet and dry cycles, see 'Introduction - Process', at the front of this manual.

### Adjust

Pressing Adjust allows the operator to adjust any of the main process parameters displayed on the pop up window, see 'Introduction - Parameter Page', at the front of this manual for parameter listing.

### PARAMETER MENU PAGE

Only the following parameters need to be adjusted to enable the machine to be set up for a new product. The remainder of the parameters are used for process and are adjusted after product set-up to obtain the print quality.

## Set-Up

Product Name File name (Max. of 250 board files), standard DOS format

Product Barcode (If fitted and selected in the Set Preference Page)

Screen Adaptor None; 255; Sanyo; Heraeus

Board Width Rail Width, 49.5-508mm in increments of 0.1mm

Board Length Sets board stop default, 100-510mm in increments of 0.1mm

Board Thickness 0.5-6.0mm in increments of 0.1mm

Board 1 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Board 2 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Screen 1 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Screen 2 Fiducial Mode Boundary only; Corr First; Corr Best; Boundary/Corr

Fiducial 1 X Distance of first fiducial from left edge of board, 0-510mm in increments of 0.1mm

Fiducial 1 Y Distance of first fiducial from front edge of board, 0-508mm in increments of 0.1mm

Fiducial 2 X Distance of second fiducial from left edge of board, 0-510mm in increments of 0.1mm

Fiducial 2 Y Distance of second fiducial from front edge of board, 0-508mm in increments of 0.1mm

Tooling Type Magnetic support pillars; Vacuum; Autoflex

Fiducial 1 X O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to left of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 1 Y O set Programmable o set of centroids of screen to board fiducials. += Screen o set to rear of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 2 X O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to left of board, -1mm to +1mm, in increments of 0.4mm

Fiducial 2 Y O set Programmable o set of centroids of screen to board

fiducials. += Screen o set to rear of board, -1mm to +1mm, in increments of 0.4mm

Screen X Forward} Actual Screen Position

Screen X Rear } XF & XR, -20 to +20mm in increments of 0.004mm

Screen Y Axis } Y, -10 to +10mm in increments of 0.004mm

Alignment Weighting Assigned Alignment to fiducial 0-100%, in increments of 1%

Board Stop X Distance from centerline of machine to stop position, 50 - 255mm, in increments of 0.1m

Board Stop Y Distance from front rail to stop position, 10-498mm, in increments of 0.1mm

## PRODUCT SET-UP - QUICK REFERENCE

The following table details a summary of the various procedures contained in this chapter, in sequential order, with the paragraph references where applicable:

### PRODUCT SET-UP

1. Power Up & Initialize the Machine
2. Load Default File
3. Edit Parameters for Initial Product Set-Up
4. Insert/Change Screen
5. Board Support Set-Up

6. Use Step Mode:
7. Adjust Lighting Teach Fiducials
8. Load Paste Change Squeegee
9. Edit Process Parameters & Save

## STAGE 1 - EDIT PRODUCT PARAMETERS

Switch on the Main Isolator and wait until the Main Control Monitor is displaying. The Message Prompt Bar will display the message 'Press SYSTEM switch to Initialize Printer or select Diagnostics'.

Pressing the green System switch will apply power to the motors and the machine will carry out an initialization routine, setting all motors to their home position and checking all sensors to ensure that the machine is clear of any product that may have been left in the machine.

With the machine powered up and the machine initialized the Main Control Screen should be displayed showing the Printer Status Page and the Process Parameters Page.

### Notes

1. The eight push buttons on the right hand monitor, (positioned below the main control screen), relate to the corresponding message displayed immediately above on the Menu Bar of the main control screen. Therefore selection of the desired function, mode or parameter is achieved by depressing the push button directly below.

Alternatively, selection of the desired function, mode or parameter may also be achieved by use of the keyboard keys F1 to F8.

2. For keyboard operation the number of the function keys will be shown in parentheses, eg.(F1).

3. When editing large numeric parameter values press the forward slash(/) key on the keyboard to enable numeric entry instead of using the Incr and Decr keys. This key function will only be in operation in parameter edit pages. To show when this option is available the key will be shown in the margin next to the step procedure.

4. The Maint function will only be displayed when the maintenance key is switched on (clockwise).

With the machine initialized the Menu Bar will show the main menu as follows:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint.

1. Press the Set-Up button (or F6) and the Menu Bar will change to show the functions available.

Mode, Load Data, Edit, Change Squeegee, Change Screen, Change Tooling, Exit

2. Press the Load Data button (or F2), a pop-up window will display Load Data File and the menu bar will change to the following:

Load, Bar Code, Left, Right, Up, Down, Exit

3. Using the Up and Down keys select the required parameter file and press

the Load button (or F1), the menu bar will return to the following display:

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

4. Press Edit Data button (or F3) to enter password, (if not required, continue as detailed below), a pop-up window will display Edit Current Process Parameters and the menu bar will display the following:

Save, Next, Previous, Incr., Decr., Exit

5. Using the Next and Prev buttons (or F4 & F5) will highlight the parameter that is required for editing. The Incr and Decr (or F6 & F7) will cycle through fixed options or alter the highlighted parameter value.

6a. Highlight the Product Name parameter and press Incr or Decr to enable editing. Type in the name of the product, using the keyboard located under the monitor, that is about to be set-up. Follow the standard DOS format which is 8 characters long and no punctuations. Press return on the keyboard.

6b. If barcode is fitted and has been selected in the Set Preference page, then highlight Product Barcode option and press Incr or Decr to enable. Using the light pen swipe the barcode on the product swiftly, left to right or right to left, until the number of the product is displayed.

7. Move the highlight bar to Board Width. Use the Incr or Decr (of F6 & F7) to set the Dimensions, in mm or inches, so that it equals the width of the product plus a clearance. Ie. Product width is 200mm then the Board Width value should be 200.5mm. The 0.5mm tolerance is an example, therefore the tolerance that is to be added should allow for the maximum tolerance board size through the machine.

8. Move the highlight bar to the Board Length. Use the Incr or Decr (or F6 & F7) to set the dimensions, in mm or inches, so that the exact length of the product is entered.

9. The setting of the Board Width and the Board Length dimension will allow the machine to calculate the default settings of the following:

-Board Stop

-Paste Dispense stop and start

-Print Stroke Length

-Under Screen cleaner stroke length

10. Move the highlight bar to Board Thickness. Use the Incr and Decr keys and set the dimension, in mm or inches, to the actual board thickness. The nominal board thickness is 1.6mm.

If the Printing Parameters are known then move the highlight bar to the relevant parameter ie Print Speed, Print Pressure, Print Gap, Print Separation Speed, Paste Dispense Rate and the Paste Dispense Rate to 0 and adjust the Print Parameters after the machine has been set up.

11. Move the highlight bar to Board 1 Fid mode. Use Incr and Decr buttons to select the required fiducial location type.

12. Move the highlight bar to Board 2 Fid mode, Screen 1 Fid mode and Screen 2 Fid mode and select for each, using the fiducials location type.

13. Move the highlight bar to Fiducial 1 x co-ord. Use the Incr and Decr buttons and set the dimensions, in mm or inches, to where the distance of the first fiducial is (or feature area if Corr is selected) located in relation to the left edge of the board.

14. Move the highlight bar to Fiducial 1 y co-ord. Use the Incr and Decr buttons and set the dimensions, in mm or inches, to where the distance of the first fiducial is (or feature area if Corr is selected) located in relation to the front edge of the board.

15. Move the highlight bar to Fiducial 2 x co-ord. Use the Incr and Decr buttons and set the dimensions, in mm or inches, to where the distance of the second fiducial is (or feature area if Corr is selected) located in relation to the left edge of the board.

16. Move the highlight bar to Fiducial 2 y co-ord. Use the Incr and Decr buttons and set the dimensions, in mm or inches, to where the distance of the second fiducial is (or feature area if Corr is selected) located in relation to the front edge of the board.

17. Move the highlight bar to Tooling Type. Use the Incr and Decr buttons to select the type of tooling that is going to be used. The options are: Autoflex; Vacuum; Magnetic.

18. When all of the above parameters are set and are satisfactory then use the Save button (or F2) to store the current set of parameters to Hard Disk file using the Product Title as the filename. If not then highlight the particular parameter that needs to be changed and use the Incr or Decr buttons to edit the parameter then use the Save button.

The Message Prompt Bar will display the message 'Board data file saved'.

19. Press Exit button (or F8) twice, and the Menu Bar will change.

First exit:

Load, Left, Right, Up, Down, Exit

Second exit:

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

## STAGE 2 - LOAD NEW SCREEN

Raise the top access cover and fit squeegees.

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

1. Press the Change Screen button (or F5). Lower the front access cover and if there is no screen fitted then the message displayed on the screen will be 'Insert Screen & Retry'. If a screen is present then 'Remove Screen Under Two Button Control' will be displayed in the Message Prompt Bar on the VDU. Press the Two Button Safety Switches simultaneously until the screen is ejected.

2. Insert the screen and close the front access cover. Press the Change Screen

button (or F5) and the screen will automatically be loaded into the machine.

### STAGE 3A - BOARD SUPPORT SET-UP

#### Magnetic Support Pillars

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

1. Press Change Tooling button (or F6) and the Menu Bar will change to the following.

Adjust, Head, Home Stop, Board Stop, Full Width, Load Width, Board Width, Exit

2. Press Head button (or F2) and raise the printhead under the two button control.

3. Press Board Width button and using the two button control move rails to board width.

4. Place the board on top of the clamp central to the white reference mark.

5. Taking care not to move the board, position the support pillars.

To position the pillars for maximum board support it is advisable to position them remembering that the larger the board used the more support is required.

If the printed board appears to suffer uneven print quality then define where more support is needed and add the relevant pillars.

6. When the support pillars have been arranged then remove the board.

Press Head button and lower the head using the 2 button control.

7. Press Exit button twice to return to the main menu.

### STAGE 3B - BOARD SUPPORT SET-UP

#### Autoflex Tooling

1. Press Tooling Change button (or F6), the Menu Bar will change as shown below, and the screen will display 'Changing Tooling Parameters'.

#### Change Tooling Parameters

Board Width	152.8mm
Board Stop X	75.6mm
Board Stop Y	76.0mm

Adjust, Head, Home Stop, Board Stop, Full Width, Load Width, Board Width, Exit

2. Press Adjust button (or F1) and the Menu Bar will change as shown below and the screen will display the 'Change Tooling Parameters'. The parameters are highlighted, the adjustments are now active.

Change Autoflex, Save, Next, Prev, Incr, Decr, Exit

3. If changes to the board width or stop positions are required at this stage, adjust by using the Next/Prev buttons to select the parameter required, and the Incr/Decr buttons to adjust to the desired dimension.

4. Press Change Autoflex button (or F1), the Menu Bar will change and the screen will display the autoflex pin positions relative to the size of board previously set up.

Lower, Raise, Left, Right, Up, Down, Exit

5. Using the Left, Right, Up and Down (or F4, F5, F6 and F7) buttons positions the cursor over the pin desired to support the board. Using Lower and Raise buttons (or F1/F2) selects the pin position.

6. Press Exit button (F8) to exit Change Autoflex. Press Save button to save Autoflex pin position settings. Press Exit twice to return to main menu. The rail will tool to the board size, and the Autoflex pins selected will raise beneath the board.

#### STAGE 4 - ROUGH ALIGNMENT

Mode, Load Data, Edit Data, Change Squeegee, Change Screen, Change Tooling, Exit

1. Pressing the Mode button (or F1) will change the Mode displayed on the Main Control Screen.

Press until Step is displayed alongside Mode.

2. Press the Exit button (or F8) and the Menu Bar will change to the main menu bar. The machine will change to the new product set-up.

3. Place the board on the conveyor input, ensuring that the sensor is covered.

Press the Run button (or F1). The camera and board stop will be positioned.

Auto Board, Manual Board, Exit

4. Press the Auto Board button (or F1) and the board will be transported into the machine. The Menu Bar will change.

Step, Head, Fiducial Set-Up, Adjust, Single Exit

5. Push the Step button twice. This will raise the board to vision height, and the Menu Bar will change.

Depending on which fiducial recognition method is to be used, proceed to either Stage 5A or 5B, as applicable.

#### STAGE 5A - FIDUCIAL SET-UP BT-BT/CORR

1. A small window will be displayed centrally on the vision monitor. Press Adjust button (or F5) and a new menu bar will be displayed. Using Next and Previous highlight the relevant axis and use Incr or Decr to position the displayed fiducial about the center of the box.

Press the Exit button. The Menu Bar will change.



Step, Head, Fiducial Set-Up, Adjust, Single, Exit

2. Press the Fiducial Set-Up button (or F3) and the Menu Bar will change.

Learn Fiducial, Locate Fiducial, Next, Prev, Incr, Decr, Exit

The Main Control Screen will display a parameter window containing the temporary Fiducial Strategy Parameters and a gray scale histogram.

3. Using the Next and Prev keys, highlight the relevant parameter, and using the Incr and Decr keys, adjust accordingly in the following sequence.

BT - BT/CORR

1 Change background - change this to either light or dark

2 Close search box - encase the fiducial

3 Adjust lighting - adjust the lighting controls to suit fiducials

4 Adjust the O set to 255 for the board fiducial and 150 for the screen fiducial

5 Adjust the Gain to achieve maximum separation while ensuring that the fiducial peak does not run off the histogram scale

6 Adjust threshold - so that fiducial has unbroken outline and solid as possible, adjust between max and min to show the separation between board and fiducial.

7 Open search box - open to full size, left=10:right=511:top=0:bottom=479.

If the window raps around set so that -1 window is within 10 of max figures

Learn Fiducial, Locate Fiducial, Next, Prev, Incr, Decr, Exit

4. Press Learn Fiducial (or F1) the Menu Bar will change.

Learn BT, Learn Corr, Exit

5. Press the Learn BT button (or F1). The Menu Bar will change and a cross hair will appear on the Vision Monitor. Position the cross hair to the left and adjacent of the fiducial using the four keys, Left, Right, Up and Down.

Learn Fiducial, Left, Right, Up, Down, Exit

6. Press the Learn Fiducial button (or F1). An outline will be drawn around the Fiducial and the crosshair placed in the center of the fiducial. If not then re-position the crosshair closer to the fiducial and then press the Learn Fiducial button (or F1).

7. Press the Exit button (or F8) to return to the learn option Menu Bar.

Learn BT, Learn Corr, Exit

8. Press the Learn Corr button (or F2) and view the learn correlator menu bar. The vision monitor will

display the fiducial with the feature box around it and the cross hair at the correct reference position.

Learn, Display, Adjust, Exit

9. Press the Learn button (or F1). A prompt indicating the time of learning and tracking will be displayed and the Menu Bar will change.

Continue, Exit

10. Press the Continue button (F1) to learn the fiducial and wait while the vision system processes the information and a prompt "please wait" will be displayed.

When complete the machine will step into the result matrix menu and the menu bar will change. The highlighting cursor will highlight the best match entry in the result matrix window.

Next, Prev, Exit

11. If the vision system has populated only one row in the result matrix then that is the only match. Where there are more than one match displayed, Next and Prev may be used to view each match position on the monitor.

12. Press the Exit button (or F8) four times then Step, the Menu Bar will change.

Step, Head, Fiducial Set-Up, Adjust, Single, Exit

Repeat Steps 1-12 for Screen Fiducial 1, Board Fiducial 2 and Screen Fiducial 2.

13. Press the Step button, the Board Data will be saved and the Menu Bar will change.

Step, Single, Exit

14. Pressing the Single button will continue the board, continuously, through the print cycle until the board is ejected out of the system. If the Print Parameters were set and paste loaded, then a print would have taken place, therefore, print quality and alignment can be checked.

#### STAGE 5B - FIDUCIAL SET -UP CORR Only

1. A small window will be displayed centrally on the vision monitor. Press Adjust button (or F5) and a new menu bar will be displayed. Using Next and Previous highlight the relevant axis and use Incr or Decr to position the displayed fiducial about the center of the box.

Press the Exit button. The Menu Bar will change.

Step, Head, Fiducial Set-Up, Adjust, Single, Exit

2. Press the Fiducial Set-Up button (or F3) and the Menu Bar will change.

Learn Fiducial, Locate Fiducial, Next, Prev, Incr, Decr, Exit

The Main Control Screen will display a parameter window containing the temporary Fiducial Strategy Parameters and a gray scale histogram.

### 3. CORR Only

- a) Ensure that the search box is full size
- b) Adjust board lighting to max, screen lighting as per Screen Lighting Adjustment tables) Adjust Gain and O set to max.

Learn, Locate Fiducial, Next, Prev, Incr, Decr, Exit

4. Press Learn Fiducial (or F1) the Menu Bar will change.

Learn BT, Learn Corr, Exit

5. Press the Learn Corr button (or F2) and view the learn correlator menu bar. The vision monitor will display the feature box and the cross hair.

Learn, Display, Adjust, Exit

6. Press Adjust and the Menu Bar will change and a pop-up window will be displayed showing the parameters to be adjusted.

Next, Prev, Incr, Decr, Exit

7. Using the Next and Prev keys highlight the relevant parameter and adjust using the Incr and Decr keys.

8. Press Exit button (or F8) and the Menu Bar will change:

Learn, Display, Adjust, Exit

9. Press the Learn button (or F1). A prompt indicating the time of learning and tracking will be displayed and the Menu Bar will change.

Continue, Exit

10. Press the Continue button (F1) to learn the fiducial and wait while the vision system processes the information and a prompt "please wait" will be displayed.

When complete the machine will step into the result matrix menu and the menu bar will change. The highlighting cursor will highlight the best match entry in the result matrix window.

Next, Prev, Exit

11. If the vision system has populated only one row in the result matrix then that is the only match. Where there are more than one match displayed, Next and Prev may be used to view each match position on the monitor.

12. Press the Exit button (or F8) four times then Step, the Menu Bar will change.

Step, Head, Fiducial Set-Up, Adjust, Single, Exit

Repeat Steps 1 - 12 for Screen Feature 1, Board Feature 2 and Screen Feature 2.

13. Press the Step button, the Board Data will be saved and the Menu Bar will change.

Step, Single, Exit

14. Pressing the Single button will continue the board, continuously, through the print cycle until the board is ejected out of the system. If the Print Parameters were set and paste loaded, then a print would have taken place, therefore, print quality and alignment can be checked.

## STAGE 6 - PASTE LOAD AND SQUEEGEE FITMENT

### General

To enable the operator to apply paste to the screen or change a squeegee, Paste Load and Change Squeegee functions are available. Selection of either functions temporarily halt the print cycle while the operation is carried out.

### Paste Load

After the initial loading of paste to the screen, two options of loading paste are available for paste application:

- I) Automatically - using the Auto Dispense function where paste is applied from the paste dispenser to the screen.
- li) Manually - using the Manual Load function where the print carriage is driven rearwards allowing the operator access to apply paste from a pot on to the screen.

The following procedures detail the two methods of paste application:

### Auto Dispense

With the machine initialized the menu bar will display the main menu as follows:

Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint.

1. Press the Paste Load button (or F3) and the Menu Bar will change to show the functions available.

Auto Dispens, Manual Load, Exit

2. Press Auto Dispens button (or F1), the paste dispense cartridge will lower and traverse across the screen applying paste on to the screen.

3. Press the Exit button (or F8) to return to the main menu.

### Manual Load

1. Press the Paste Load button (or F3) and the menu bar will display the following:

Auto Dispens, Manual Load, Exit

SCREEN PRINTING MANUAL

## TECHNICAL REFERENCE MANUAL

### INTRODUCTION

#### Manual Format

It is advisable to read through the Technical Reference Manual first and be familiar with the machine by comparing the components, sensors and assemblies as shown on the machine overviews of Chapter 2 with the actual machine. The Technical Reference Manual is divided into 13 chapters.

Chapter 1 Safety Features, describes the features on the machine that provides the operator safety while the machine is in operation.

Chapter 2 Machine Overview, with diagrams showing the position of various functions, sensors and assemblies on and around the machine.

Chapter 3 Technical Description, describes in detail the sequence of operation of various modules on the machine.

Chapter 4 Error Messages, lists and advices on the recovery of each error message reported.

Chapter 5 Diagnostics, lists and describes the operation of individual diagnostic routines available on the machine.

Chapter 6 Electronic Enclosures, shows the electronic cards position in the enclosures and gives a description of the function and configuration of each individual card.

Chapter 7 Calibration and Settings, gives step by step guidance for calibrating and setting modules on the machine. This chapter will also give opto and switch adjustments necessary for correct machine operation.

Chapter 8 Sensor Listing, lists all sensors used on the machine and gives the part number and input ports displayed in the diagnostic menu.

Chapter 9 Preventive Maintenance Schedule, specifies the schedule for maintaining the machine periodically and shows personnel classification.

Chapter 10 Recommended Spares, lists the consumable packs required to maintain the machine throughout its life span.

Chapter 11 Replacement Procedures, details the procedures for removal, replacement and any subsequent checks and tests of components listed in the 1,2 and 5 year service packs.(Chapter 10 refers).

Chapter 12 Electrical Circuit Listing, lists the electrical circuits on the machine and gives description and drawing reference numbers.

Chapter 13 General Assembly Listing, lists the mechanical assemblies on the machine and gives description and drawing reference numbers.

## CHAPTER 1

Safety features provides safe operating conditions for the machine.

The machine if fitted with an emergency safety shut-down press button switch.

External modules in the line can be fitted for connection to a common cable loop line, that provides automatic shut down of all modules, if any single emergency switch is operated, or any frame cover is disturbed during normal operation of the line.

Covers fitted with safety interlock switches protect operating personnel from the moving mechanisms. Transparent plastic access covers are fitted over for moving mechanisms of the machine and steel safety covers control access to the frame of the module.

### PROTECTION FROM HIGH VOLTAGE

#### Mechanisms

Machine mechanisms are powered 24 V only and do not pose an electrical hazard to personnel.

#### 220/110 V

Where (220/110V) incoming supply voltages are present, protection is a orded by controlling access to the enclosures that house the supply. The machine is fitted with an interlock isolator switch that cuts power to terminations down stream of the isolator, for example the isolator enclosure. Insulating shrouds o er protection at the isolator switch incoming power terminals.

#### Hazard Warning

Hazard warning labels "Danger High Voltage", are placed on the outside of enclosures where high voltage (220/110V) terminations are present within and the enclosure is not fitted with a safety interlock. Inadvertent access to such enclosures is prevented by the presence of the frame covers.

### EMERGENCY SHUT-DOWN

The machine is fitted with an Emergency shut-down push button switch located on the right hand side of the machine front cover. An additional push button is located on the left-hand side of the head cover, this is an optional extra. Pressing either of these push buttons (or removing a steel frame cover) cuts power to the 24 V supply to mechanisms of all modules connected into the emergency loop line. A warning of this condition is reported on the VDU. The E-stop system is described in detail below.

### EMERGENCY E-STOP LOOP

Stand-alone operation of module requires the end-of-line plug/socket to be fitted.

The E-Stop system is a low voltage powered loop that interconnects selected modules in the line and provides automatic shut-down of any powered mechanisms of the line during an emergency shut-down. Breaking continuity of the E-Stop loop provides an automatic safety shut-down procedure for modules. The connection loop comprises cable connections chained between upline and downline of modules selected.

#### Recovery

When the normal working condition is restored, release the Emergency stop button and/or replace the cover that has been removed and press the green system button located on the control VDU.

### CLEAR ACCESS COVERS

Clear polycarbonate access covers are fitted to the machine to protect personnel from the mechanisms during normal line operations. Lifting a cover cuts power to the mechanism that the cover protects.

#### Recovery

When the normal working condition is restored, and the relevant cover is closed then the machine will carry on and complete the cycle.

### STEEL FRAME COVERS

Frame covers are fitted with safety interlock switches are similarly connected to the emergency loop line. Removing the cover has the same effect as pressing the Emergency stop button, cutting 24 V power to the mechanisms of all modules connected into heloop line shuts-down. Indication that a cover has been removed (or the E-stop has been pressed) is given by an error message displayed on the control VDU.

#### Recovery

When the cover is re-positioned, normal working condition is restored and the line may be restarted; pressing the green system button at the control VDU will enable the machines re-initialization procedure, where this is allowed by the control system.

### TWO BUTTON SAFETY SWITCHES

Located at the front of the machine, are the two button safety switches. The positioning of these buttons are needed to maintain maximum safety for the operator when operating a particular function. The two buttons have to be pressed simultaneously to become active. The use of these buttons are dependent on the function selected at the VDU.

For example:

- Head Lift Up/Down
- Board Width
- Load Width

### PRINthead LIFT SUPPORT ASSEMBLY

#### Function

For the protection of personnel when working beneath the printhead with the printhead raised, a Head Support Assembly, Part No 112975, is provided to mechanically secure the printhead in the raised position. The support should be used at all times that the printhead is raised and stowed by the machine when not in use. The support assembly is colored red and incorporates an internal spring for ease of installation and removal. With the head raised the assembly is positioned to the front left hand side of the machine in the electro-magnetic sockets, ensure that the black end of the support is at the bottom and the silver end at the top.

#### CAUTION

#### IMPORTANT

The support assembly must be removed prior to selecting printhead lowered. If an attempt is made to lower the printhead with the support assembly installed, damage to the printhead, actuator and drive card may occur.

CHAPTER 2 MACHINE OVERVIEWS (Note: all illust.-Bhot)

CHAPTER 3 TECHNICAL DESCRIPTION

## CAMERA CARRIAGE

The camera carriage can be divided into two sections, the 'X' movement and the 'Y' movement. The 'X' movement is defined by the feed direction as facing the front of the machine and the 'Y' movement is defined by the direction of the print stroke as facing the front of the machine.

The carriage is driven by a dc servo motor which has an encoder attached to the motor. The motor is driven from an optimize control card which is housed in the electronic enclosure Y1 position X2. Utilizing together, the dc servo motor and encoder, provides high positional accuracy.

The camera carriage houses the telecentric camera which also houses the board stop. The single roving camera allows speed and flexibility in locating fiducials during the print cycle.

The camera itself can view both the board fiducials and the screen fiducials by opening the relevant shutter. These shutters and the board stop are controlled pneumatically.

When the machine is first powered up, an initialization routine is implemented. This routine for the camera carriage consists of driving the camera in X and Y until the home sensors are detected. The carriage is then driven out of the sensor until the first index pulse of the encoder is detected then stops. This position then equates to zero counts on the encoder.

To insure against machine damage, limit sensors are fitted at either end of each carriage axis. These sensors detect an overrun on the carriage and if detected will report an error message, either Camera X-Axis error or Camera Y-Axis error.

For camera carriage to accurately calculate and position itself over the entire working area, a reference fiducial is positioned on the front rail. The home positions are only rough initial settings, therefore, a reference fiducial, positioned on the center of the front rail, is used so that the camera carriage can calculate the board stop and fiducial positions to a closer tolerance.

This function is carried out in diagnostics and is then stored as part of the printer configuration file on to hard disk. This diagnostic routine needs only to be initiated if the home sensor is replaced or the vane has been removed.

## PRINT CARRIAGE POSITIONING

The print carriage mechanism moves the pressure assembly along the print stroke length. The stroke length is automatically set when the board width parameter is set. When the initialization routine is initiated, the print carriage will move to its home position sensor(rear of the machine). When the sensor change has been detected, the motor will reverse its direction at slow speed until the sensor clears, at this point the motor will stop. This is defined as its start position or zero count for the encoder to position the carriage.

## MACHINE PRINT CYCLE

The routine of the following machine print cycle will be described for Step mode.

1. Press Run and the camera will position itself to the board stop co-ordinates.

The board stop will lower into position ready for the incoming board.

2. Press Auto Board and the board will be transported into the machine stopping at the board stop, the belts will stop running as soon as the board stop sensor detects the board.

3. The board clamp mechanism will be energized and the board stop will retract.

4. (a)The rising table will drive up to vision height at the same time the rail lift sensors will be monitored, causing a "Rail lifted error" if detected stopping the rising table.



- (b) The camera carriage will drive to the position determined by fiducial 1 X & Y co-ordinates. The board 1 fiducial strategy data will be used to detect the board fiducial. The vision monitor will display a small box so that the fiducial can be positioned correctly if necessary.
5. The X & Y camera carriage clamps are energized and fiducial 1 is located. The location of the fiducial is then copied to the Align Data structure. The camera shutters will change and then view screen fiducial 1.
  6. The screen fiducial 1 will be located and the location copied to the Align Data structure. The camera carriage clamps will be de-energized and the camera will be driven to board fiducial 2 X & Y co-ordinates. The camera shutters will change to view the board fiducial.
  7. The X & Y camera carriage clamps are energized and fiducial 2 is located. The location of the fiducial is then copied to the Align Data structure. The camera shutters will change and then view screen fiducial 2.
  8. The screen fiducial 2 will be located and the location copied to the Align Data structure. With the data recorded the screen correction is calculated and the X fwd, X rear and Y screen actuators will move to the new position.
  9. The camera carriage will drive to its home position and the Rising table will move up to the print height minus 3mm. When the screen has finished its correction then the chase clamps are energized and the Rising table will then drive up to the print height.
  10. The print carriage will move to the start of the print stroke and both squeegees will drive to their dwell height(5mm above the screen).
  11. Either the front or rear squeegee will drive down to the calculated pressure setting set in the board parameter menu.
  12. The print carriage will drive at the set speed in the board parameter menu. The pressure transducer will be read after 60mm of the start of the stroke and will cease reading when it is 25mm from the end of the print stroke. The average pressure is then calculated and if it differs from the set pressure by more than +/- KG will display a "Pressure error". From this data a new squeegee displacement will be calculated for the next print cycle on the particular squeegee.
  13. The squeegees will raise to their dwell heights.
  14. The board count will be incremented. The chase clamps will be de-energized and the Rising table will drive down at the speed set by the Print separation speed in the board parameter menu until 3mm clear of the screen. The Rising table will drive down to its datum height at full speed and de-energize the board clamps.
  15. The front and rear belts will drive until the board is detected at the output sensor. The cycle counts for the paste dispense and screen cleaner will be incremented and if either has reached the values set by the dispense rate or clean screen rate then the appropriate cycle will be performed.

#### RISING TABLE

The rising table is the mechanism which transports the board up to the vision height for vision correction and then up to the screen height ready for printing.

The positioning of the rising table is controlled in software utilizing a dc servo motor with a positional encoder fitted. For the rising table to be accurately positioned it must first start from a reference position. This achieved by making the datum sensor.

When the machine is first powered up, an initialization routine is called up which will insure that the rising table is positioned at the home sensor. If the sensor is not made then the rising table will be driven downwards at a reduced speed until the sensor has been made. The rising table will then inch upwards until the sensor has just been cleared. From this datum the rising table can then be positioned accurately according to the relevant position required.

The rising table has also a brake fitted so that stability is maintained during the print cycle.

To maintain machine safety there are limit sensors fitted to monitor the position of the rising table. These limit sensors if activated will report an error message "Rising Table error" on the Main Control Screen.

The limit sensors consists of Upper and Lower limit, and the reference sensors are the datum and datum interlock.

The upper and lower limit switches detect that the movement of the rising table has exceeded its travel. The upper limit detects that the rising table is pressing into the screen and the lower limit detects that the rising table has overdriven downwards. If these are detected then the machine will inhibit the power to the rising table motor. The letter 'L' will be displayed on card X1, of enclosure Y1 when the limit switches have been detected. The datum sensor detects when the rising table has reached its home reference position so that accurate positioning from this datum can be achieved. Due to the home position being critical there is a another sensor fitted to ensure that the datum is achieved. This is the datum interlock sensor. When the datum sensor has been made then the datum interlock sensor is checked to see if its vane is also in the sensor, if not then an error will be reported. The datum interlock sensor is checked by the Arcom PC and should be detected before the datum sensor.

#### SQUEEGEE PRESSURE MECHANISM

The squeegee pressure mechanism houses two independently driven squeegees and a single pressure transducer used to monitor the set pressure on both squeegees.

The front and rear squeegee pressure is set, checked and corrected independently of each other.

The calculation required for setting the pressure is initially stored as part of its calibration.

The calibration consists of setting the output voltage of the load cell to equal

160 mV/Kg. This is achieved by applying a precise known load to the squeegee

mechanisms and adjusting the electronic amplifier to achieve the required voltage slope.

When the load is applied to the balance which is used is leveled for each weight that is used. To be able to level the balance the squeegee has to be displaced by a number of steps. The steps required to level between 10kg and 15kg are used to calculate a pressure factor and is stored in the printer configuration file.

Also as part of the calibration the height of the squeegee from its home position to the top of the screen (virtual zero pressure) is calculated and stored in the printer configuration file.

With this information, the set pressure can be calculated as a pure displacement.

During the print stroke the pressure transducer is monitored 60mm from the start until 25mm short of the finish of the print stroke.

If for any reason the monitored pressure is outside the error window of +/-1Kg it will display the message "Pressure error" and will show the actual pressure reading against the set pressure.

Pressing continue will allow the machine to complete the cycle. This action will repeat for the opposite squeegee and will automatically correct the pressure difference for the relevant squeegee.

#### CHAPTER 4 ERROR MESSAGES

##### INTRODUCTION

If for any reason the machine does not complete a particular sequence in the time allowed for in software, then an error condition will arise. The relevant error message will be displayed on the Main Control Screen.

Machine Errors will be detected by sensors specifically designed for checking correct machine status (System Power, Pneumatic Power, etc.) or by functions failing to achieve their correct operation.

These latter errors are either detected by a limit sensor being operated or by setting a time limit for their completion. The time limits are set so they are 1.5 times the longest possible time taken for that particular operation, after which if not completed an error will be reported on the Main Control Screen.

When an error occurs the relevant message will be displayed on the Main Control Screen. The displayed error message will be accompanied by information regarding the possible causes and the corrective action to be taken.

The Tricolor beacon will change to red and will record the error in the Event Log file.

##### ERROR RECOVERY

If during an error recovery the same error is repeated a recovery will only be allowed if the action permits, otherwise

the message "Unable to recover" will be displayed. In the event of this happening call the Maintenance personnel. If any error message is displayed then the following options will be displayed on the Menu Bar.

#### Abort

Pressing this option will re-initialize the entire printer ejecting any product that may be in the printer, returning to the Main Control page.

#### Recover

Pressing this option will attempt to continue with any cycle that is in operation. This function will set modules (paste dispenser, print carriage, etc.) to their home position and then eject the board that is currently in the printer without re-initializing the machine. This option should be the first to be operated if there is an error reported.

#### Diagnostics

This will enable the diagnostics to be entered if necessary to clear the problem if it persists.

### ERROR MESSAGE LISTING AND INTERPRETATION

#### Board Stop stuck

This error is reporting that the board stop, which is housed in the camera assembly has failed to lower or retract.

#### Board stuck in Rails

This error is reporting that the board has failed to either reach the board stop or exit the machine after being printed.

#### Camera X Axis error

This error is reporting that the camera carriage has failed to reach its home position in the X axis.

#### Camera Y Axis error

This error is reporting that the camera carriage has failed to reach its home position in the Y axis.

#### Front Squeegee error

This error is reporting that the front squeegee has failed to reach its fully up position.

#### Front Squeegee Pressure error

When this error is detected then a new window will be displayed. The window will display the set pressure reading and the actual pressure reading.

#### Paste Carriage error

This error is reporting that the paste carriage has failed to reach its home position or that it has made the limit switch.

#### Paste Carriage Tilt error

This error is reporting that the paste cartridge mechanism has failed to either make its up or down limit switches.

#### Pneumatic Power down

This error message is reporting that the pneumatic supply is either too low or has been disconnected.

#### Print Carriage error

This error is reporting that the print carriage has failed to move or that it has reached the safety limit switches.

#### Rail Width error

This error is reporting that the motorized rail has either failed to move or that it has not moved to the correct width setting.

#### Rear Squeegee error

This error is reporting that the rear squeegee failed to reach its fully up position.

#### Rear Squeegee Pressure error

When this error is detected then a new window will be displayed. The window will display the set pressure reading and the actual pressure reading.

#### Rising Table error

This error is reporting that the rising table has either failed to reach its fully down position or that when attempting to reach the required height during the machine cycle did not achieve the positional accuracy.

#### Screen XF error

This error is reporting that the X forward screen actuator failed to initialize to its central datum.

#### Screen XR error

This error is reporting that the X rear screen actuator failed to initialize to its central datum.

#### Screen Y error

This error is reporting that the Y screen actuator failed to initialize to its central datum.

#### System Power down

This error is reporting that the 24V motor power has been switched off either by the Emergency Stop button being activated (including upline and downline external machines) or that the removable frame access cover has been removed.

#### Unable to find Fiducial

This error is reporting that the vision system is unable to locate the relevant screen or board fiducial.

## CHAPTER 5 MAINTENANCE

### General

With the machine initialized, insert and turn the maintenance key to On to enter the maintenance function, the menu bar will display the following:  
Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

### Maintenance

The maintenance function is a means by which the technician may calibrate the squeegee pressure and vision system, download data from hard disk to floppy disk, and set the various machine modes and options, as described as follows:

Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit

#### Calibrate Pressure

Selection of Calibrate Pressure will automatically configure the machine ready to accept the Calibration Rig (Pt No. 1141.06), for full details regarding Squeegee Pressure

Calibration refer to 'Squeegee Pressure', Chapter 7 - Calibrations, of this manual.

#### Calibrate O set

Calibrate O set compensates for any optical discrepancies between viewing up and down of the telecentric camera/

#### Calibrate Vision

Calibrate Vision compensates for any screen movement in the X, Y and Theta direction.

The combination of both calibrations encompasses calibration of the vision system complete full details of which are described in Chapter 7 - Vision System Calibration.

#### Housekeeping

The file management system is introduced to enable the user to download data from hard to floppy disk while remaining within the software environment, thus alleviating the requirement to use DOS.

Pressing the housekeeping button displays the menu bar with the following options:

Set Date, Set Time, Print Data, Copy to disk, Copy from disk, Delete Data, Exit

#### Set Date & Set Time

Selection of Set Date & Set Time options will each open a window displaying the current PC values and allow the operator to accept these values or change them. Refer to Chapter 7 of this manual for setting details.

Exit will return to the maintenance display and menu bar without any other action.

#### Print Data

On selection of Print Data button the menu bar will change the following:

Product Data, Event Log, Config Data, Manage Data, SPC Data, Exit

Exit will return to the housekeeping display without any other action.

Event Log will output the contents of the EVENT.DAT file to the printer port.

Config Data will output the contents of the CONFIG.TXT file to the printer port.

Manage Data will change the menu bar to give print to printer or print to file options, then the contents of the MANINF.DAT file will be output in text format to the selected device, if output to file is selected, it will be to A:(backslash)MANINF.PRN.

SPC Data will output the contents of the READINGS.DEK file to the printer port.

Product Data will display a window on screen containing the names of the Product Data files available on hard disk and change the menu bar to the following options:

Print Printer, Print File, Left, Right, Up, Down, Exit

The Left, Right, Up and Down keys will enable highlighting of the required product file.

Print Printer will output the contents of the selected Product Data file to the printer.

Print File will output the contents of the selected product data file, in text format, to the floppy disk, with the same filename but with a .PRN extension.

#### Copy to Disk

On selection of Copy to Disk button the menu bar will change to the following:

Product Data, Event Log, Test Data, SPC Data, Exit

Exit will return to the housekeeping display without any other action.

Event Log will copy the Event.dat file from the hard disk to the root directory of the floppy disk.

Test Data will copy all of the following files from the hard disk to the root directory of the floppy disk, Test.log; Test.dat; Fiducial.dat; O set.dat; Videoxy.dat; Theta.dat; Config.txt.

SPC Data will copy the Readings.dek file from the hard disk to the root directory of the floppy disk.

Product Data will display a window on the screen containing the names of the Product Data files available on the hard disk and change the menu bar to the following.

Copy File, Left, Right, Up, Down, Exit

The Left, Right, Up, Down keys will enable highlighting of the required product file.

Copy File will copy the selected product data file from the hard disk to the root directory of the floppy disk.

#### Copy from Disk

On selection of Copy from Disk a window will display the names of the Product Data files available in the root directory of the floppy disk, and the menu bar will change to display the following:

Copy File, Left, Right, Up, Down, Exit

The Left, Right, Up, Down keys will enable highlighting of the required product file.

Copy File will copy the selected product data file from the root directory of the floppy disk to the hard disk. It will then update the Barcode LUT.

#### Delete Data

On selection of Delete Data the menu bar will change to the following:

Product Data, Event Log, Test Data, SPC Data, Exit

Exit will return to the Housekeeping display and menu bar without any further action.

Test Data will display the prompt 'Confirm deletion of Test Data' and give a Yes/No option. If confirmed any Test.log and Test.dat files should be deleted from the hard disk.

SPC Data will display the prompt 'Confirm deletion of SPC Data' and give a Yes/No option. If confirmed the Readings.dek file should be deleted from the hard disk.

Event Log will change the menu bar to display the following:

Delete All, Delete Data, Delete Number, Exit

Delete All will display the prompt 'Confirm deletion of All Event Data' and give a Yes/No option. If confirmed copy the contents of the Event.dat file to an Event.bak file, overwriting any

previous file, delete all entries in the Event.dat file and then insert a 'New Event Log' entry.

#### Set Prefers

Calibr Pressure, Calibr O set, Calibr Vision, HouseKeeping, Set Prefers, Diagnost, Exit

Selection of Set Prefers button display a pop up window and changes the menu bar to display the following:

Next, Prev, Incr., Decr., Exit

Transport Mode

Machine Units

Transfer Protocol

Transfer Period

Comms Protocol

Event Recording

Tooling Hardware

Fiducial Reference

Barcode Hardware

Inspect Rate

SPC Data Mode

Next and Previous will move the highlight between the parameter values.

Increment and Decrement will alter the highlighted parameter value.

Transfer Mode

Sets input and output ends of the printer.

Left to Right; Right to Left; Left to Left; Right to Right;

(Default Left to Right)

Machine Units

Offers option of units:

Metric or Imperial units. (Default Metric)

Transfer Protocol

Set the protocol for transferring boards to adjacent machines:

No FMI; Sanyo; Sanyo Flowout; SMPI; SMEMA; Fuji; Dyna; Siemens; Panasonic: (Default SMPI)

Transfer Period

A programmable time period used by certain transfer protocols:

Min 0 sec.

Max 99 sec.

Increments 1 sec.

Period of Transfer Time- This is the period of time which the 265 allows a transfer of a board before displaying a 'Board Transfer Error' for Upline or Downline

Period of Waiting Time- This is the period of time which the 265 allows when waiting for the Upline or Downline machine to request a board for transfer displaying a message of 'Waiting for Upline/Downline'

## Comms Protocol

The communications protocol to be used for serial communications to host computer:  
SECS II; BSC

## Warning

Do not select SEC II Protocol without having the Host Comms package fitted. This will result machine lock-out.  
If this is inadvertently selected, call DEK Service for advice.

## Event Recording

Sets whether all or majority events only are recorded in the Event log file:

Major events only; All events

Major events- Refers to displayed error messages.

All Events- Refers to every other event generated within the machine.

## Tooling Hardware

Set whether Autoflex tooling is fitted:

Autoflex; Plain

## Fiducial Reference

Sets whether the fiducial co-ordinates are specified relative to the front/left or front/right corner of the board:  
Left; Right

## Barcode Hardware

Sets whether or not barcode reader is fitted:

Fitted; Not Fitted

## Inspect Rate

Sets the number of print cycles between Inspection cycles, set to zero for no inspectionMin 0(o )

Max 100

Increments 1

This will enable a Post-Print Inspection of a fiducial alignment  
directing this data to file according to SPC Data destination.

## SPC Data

Sets the destination of the SPC data generated during an inspection cycle

Serial; Disc.

Serial- Outputs to serial port.

NOTE: If Host Comms is connected currently this option cannot be used.

Discs- Outputs to a READINGS.DEK file on hard disk.

This data can then be accessed from disk via housekeeping.

## Diagnostics

This function is described in detail in the following section

## DIAGNOSTICS

## INTRODUCTION



The diagnostic function is an aid to the user to allow individual access and control to motors and modules. It will allow the user to control the sequence of the machine so that a particular module can be exercised.

To enter the diagnostic mode the key switch on the Main Control Unit must be inserted and turned clockwise. This will enable the Maint option to appear on the Menu Bar:  
Run, Head, Paste Load, Clean Screen, Adjust, Set-Up, Monitor, Maint

Press the Maint button and the Menu Bar will change displaying the Diagnostic option. Calibr Pressure, Calibr O set, Calibr Vision, House Keeping, Set Prefers, Diagnost, Exit  
Pressing Diagnostic will enter into the main diagnostic menu. If a password, exists a window will display the message 'Diagnostic Password'. If the password is incorrect control will display the message 'Invalid password entered' and return to the previous menu. If the correct password is entered or no password exists a pop up window will display the following:

System

Print Head

Print Carriage

Squeegee

Camera Axis

Rail System

Paste Dispense System

Screen Alignment

Screen Change

Screen Cleaner

Rising Table

Foreign Machine Interface

Autoflex Tooling

Next/Prev keys will move the highlight bar up down the list of modules that can be selected.

Select Module key will open a new window displaying the diagnostic functions available for the selected module.

Exit will return operation to the start of initialization

#### NOTE

Before any diagnostic function is used in any of the modules they must be homed first or they will not be able to initiate a command.

#### SYSTEM

The system diagnostic module contains the following:

- Display all Digital Inputs
- Display all Analog Inputs
- Toggle Red Beacon
- Toggle Amber Beacon
- Toggle Green Beacon
- Data Logging
- Run Alignment Test

- Run Production Test
- Change Edit Password
- Change Diagnostic Password
- Change DOS Password
- Terminate control and Return to DOS

#### Digital Input Status

Selecting this option, a new window will be displayed showing the relevant groups.

PCIB40's are the I/O cards that are housed in the Arcom PC. There are five PCIB40 cards and are numbered as such. Each card has up to five groups, G0-G4 and will monitor and control various drive and control cards in the Y1 and Y2 enclosure.

PCIB40's are divided into Inputs and Outputs.

Selecting each option will display another window displaying the functions that can be switched on or off.

#### Analog Input Status

Selecting this option will display a new window showing the analog output of the load cell amplifier card of the squeegee pressure mechanism.

#### Tri-Color Beacon

Selecting any one of the three colors will toggle them between on and off.

#### Data Logging

Selecting this function will alternately enable and disable data logging during diagnostic operations.

#### Run Alignment Test

Selecting this function will initiate the machine to run Dry Alignment accuracy test.

#### Run Production Test

This option is only used as a cycle test at the base factory and should not be run. In doing so the machine could result in damage.

#### Change Edit Password

Selection of this option will prompt the operator to enter a new password.

#### Change Diagnostic Password

Selecting this option will either allow a password to be inputted or change an existing password. This password protection inhibits unauthorized entry into diagnostics.

#### Change DOS Password

Selection this option will either allow a password to be inputted or change an existing password. This password protection inhibits unauthorized exit to DOS.

#### Terminate 265 Control and Return to DOS

Selecting this option will terminate the 265 and return to the DOS prompt.

#### PRINT HEAD

The Print Head diagnostic module contains the following:

#### Raised Head Under 2 Button Control

Selecting this option will allow the print head to be raised using the two button safety switches located on the front of the machine. These switches must be operated simultaneously.

#### Lower Head Under 2 Button Control

Selecting this option will allow the print head to be lowered using the two button safety switches located on the front of the machine. These switches must be operated simultaneously.

#### Toggle Head Latch

Selecting this option will alternately switch the print head magnetic latches on and off.

#### Head Up Sensor

This will display the head up sensor status.

#### Head Down Sensor

This will display the head down sensor status.

#### Left Jog Button

This will display the operation of the left button of the two button safety switches located on the front of the machine.

#### Right Jog Button

This will display the operation of the right button of the two button safety switches located on the front of the machine.

### PRINT CARRIAGE

The Print Carriage diagnostic module contains the following:

#### Home Print Carriage

Selecting this option will move the print carriage back to its home sensor position and stop. It is always advisable to home the print carriage before attempting to position it anywhere.

#### Drive Carriage to Front Position

Selecting this option will move the print carriage to a position that will clear the paste dispense unit if operated.

#### Drive Carriage to Rear Position

Selecting this option will move the print carriage to the end of the print stroke.

#### Drive Carriage Using Jog Buttons

Selecting this option will allow the user to position the print carriage anywhere between the front and rear position using either of the two button safety switches located on the front of the machine. The Left button will move the print carriage towards the rear and the Right button will move the print carriage towards the front.

#### Cycle Print Carriage

Selecting this option will start a continuous cycle of driving the print carriage between its front and rear limits pausing at each end for 2 seconds. The speed will be measured and displayed.

The cycle will be terminated if the Stop key is used or that the set cycle count is reached.

#### Actual Carriage Speed

This will display the actual speed during the Cycle Print Carriage option.

#### Cycle Count

Will display the count when the module is being cycled.

#### SQUEEGEE

The Squeegee diagnostic module contains the following:

##### Home Front Squeegee

Selecting this option will drive the front squeegee upwards to its home position as detected by its home sensor.

##### Home Rear Squeegee

Selecting this option will drive the rear squeegee upwards to its home position as detected by its home sensor.

##### Front Squeegee to Dwell Height

This option will drive the front squeegee to a position 10mm clear of the top of the screen.

##### Rear Squeegee to Dwell Height

This option will drive the rear squeegee to a position 10mm clear of the top of the screen.

##### Rear Squeegee Flood Height

This option will drive the rear squeegee to the height set by the flood reference height parameter.

##### Drive Front Squeegee Using Jog Buttons

Selecting this option will enable the right jog button to drive the front squeegee up at slow speed and the left jog button will drive it down, stopping immediately the button is released.

##### Drive Rear Squeegee Using Jog Buttons

Selecting this option will enable the right jog button to drive the rear squeegee up at slow speed and the left jog button will drive it down, stopping immediately the button is released.

##### Calibrate Front Squeegee Print Height

This option is used as part of the pressure calibration procedure. The function of this option is that the squeegee will be driven down until some pressure is applied. The Menu bar will change showing the option Confirm. Pressing Confirm will set the current height of the front squeegee minus the current pressure sensor reading multiplied by the pressure factor. This will be the front reference height parameter and will be stored as part of the printer configuration file.

##### Calibrate Rear Squeegee Print Height

This option is used as part of the pressure calibration procedure. The function of this option is that the squeegee will be driven down until some pressure is applied. The Menu bar will change showing the option Confirm. Pressing Confirm will set the current height of the rear squeegee minus the current pressure sensor reading multiplied by the pressure factor. This will be the rear reference height parameter and will be stored as part of the printer configuration file.

##### Calibrate Rear Squeegee Flood Height

The function of this option is that the rear squeegee fitted with a flood bar is driven down until the flood blade is

just touching this screen. Pressing the Confirm key will store this height as part of the printer configuration file.

#### Pressure Reading A/D...Kg

This is a live display showing the actual pressure being applied to the squeegee.

With no squeegee fitted the display should show a reading of approximately 3.6 Kg.

#### CAMERA AXIS

The camera system module contains the following:

##### Camera Axis Home

Selecting this option will drive the Camera X and Y carriages simultaneously to find their datum positions as determined by their home sensors.

##### Camera Axis to fiducial 1 position

Selecting this option will drive both X and Y carriages to the position set by the fiducial 1 x and y coord parameters.

##### Camera Axis to fiducial 2 position

Selecting this option will drive both X and Y carriages to the position set by the fiducial 2 x and y coord parameters.

##### Drive to reference position

Selecting this option will drive both X and Y carriages to the position set by the camera x and y reference parameters.

##### Set reference position

Selecting this option will alter the Printer Configuration file after the camera has been positioned so that it is viewing the fiducial on the front rail. On selection of this option the Menu Bar will display Confirm which on pressing this key will alter the printer configuration file. This is to be used in conjunction with Move camera x and y axis.

##### Move camera X axis using Jog buttons

Selecting this option will enable the Right Jog button to drive the X axis right at slow speed and the Left Jog button will drive it left, stopping immediately the button is released.

##### Move camera Y axis using Jog buttons

Selecting this option will enable the Right Jog button to drive the Y axis right at slow speed and the Left Jog button will drive it left, stopping immediately the button is released.

##### Initialize vision

Selecting this option will initialize the frame grabber board and will display a live image on the vision monitor.

##### Display reference box

Selecting this option will display a super imposed box on the vision monitor.

##### Toggle Look up on/o

Selecting this option will alternately energize the camera Down shutter, displaying On status and de-energizing it will display the o status.

##### Toggle Look down on/o

Selecting this option will alternately energize the camera Up shutter,

displaying On status and de-energizing it will display the o status.

#### Cycle camera system

Selecting this option will start a continuous cycle of driving the camera x and y carriages to each of the following positions in sequence, dwelling for 2 seconds at each point, locating the fiducial at each fiducial position, displaying the returned location and then repeating the cycle.

The cycle being the following:

1. Datum
2. Fiducial 1
3. Fiducial 2

If the data logging is enabled the fiducial co-ordinates will be appended to C:\backslashlashSANbackslashLOGbackslashCAMERA.DAT file. This continuous cycle will be terminated by selecting the stop key or when the set cycle count has been reached (50).

#### Cycle count

Will display the count when the module is being cycled.

### RAIL SYSTEM

The Rail System module will contain the following:

#### Home Rail Width

Selecting this option will increase the rail width motor to find its datum position as determined by its home sensor.

#### Drive Rail to Board Width

Selecting this option will drive the rail width motor to the width set by the board width parameter.

#### Drive Rail Width using two button control

Selecting this option will enable the right jog button to drive the rail width motor forward at a slow speed and the Left jog button drive it back, stopping immediately after the button is released.

#### Drive Belts Using two button control

Selecting this option will enable the Right Jog button to drive the belt motors to the right and the Left Jog button to drive them left, stopping immediately the button is released.

#### Toggle Board Clamp

Selecting this option will alternately energize the Board Clamp displaying On status and de-energize it, displaying O status.

#### Toggle Board Stop

Selecting the option will alternately lower and raise the board stop housed in the camera assembly, displaying On status when lowered and O status when raised.

#### Cycle Board on Belts

Selecting this option will start a continuous cycle of driving the belts to the right until the board reaches the right board sensor, dwelling for 2 seconds then driving the belts left until a board reaches the left board sensor, dwelling for 2 seconds and repeating the cycle until stop is pressed or the set cycle count is reached (50).

#### Cycle Board Clamp

Selecting this option will start a continuous cycle of clamping and unclamping the board clamps.

#### Board Stop in Position

Will continuously display the current status of the board stop lowered position.

#### Board at Stop

Will continuously display the current status of the board at stop sensor.

#### Board at Left

Will continuously display the current status of the left board sensor. On will be displayed if a board is detected on the rails at the left of the machine.

#### Board at Right

Will continuously display the current status of the right board sensor. On will be displayed if a board is detected on the rails at the right of the machine.

#### Cycle count

Will display the count when the module is being cycled.

### PASTE DISPENSER SYSTEM

The Paste Dispenser diagnostic module contains the following:

#### Carriage Home

Selecting this option will drive the dispense carriage left to find its datum position as determined by its datum sensor.

#### Drive Carriage to Start Position

Selecting this option will drive the paste carriage to the position set by the paste start parameter.

#### Drive Carriage to End Position

Selecting this option will drive the paste carriage to the position set by the paste stop parameter.

#### Drive Cartridge Down

Selecting this option will drive the cartridge tilt down until the cartridge down sensor is located.

#### Drive Cartridge Up

Selecting this option will drive the cartridge tilt up until the cartridge up sensor is detected.

#### Toggle Paste Dispense

Will alternately energize the paste dispense, displaying On status and de-energize will display O status.

#### Toggle Cartridge Seal

Will alternately energize the cartridge seal, displaying O status and de-energize will display On status.

#### Paste Cartridge Empty

Will continuously display the current status of the cartridge empty sensor.

#### Cartridge in Down Position

Will continuously display the current status of the paste dispense down sensor.

#### Cartridge in Up Position

Will continuously display the current status of the paste dispense up sensor.

### SCREEN ALIGNMENT

The Screen Alignment module contains the following:

#### Home Actuator

Selecting this option will drive the X forward, X Rear and Y Axis actuators simultaneously to find their datum positions as determined by their datum sensors.

#### Drive X Forward Motor Using Jog Buttons

Selecting this option will enable the the right Jog button to drive the X forward actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Drive X Rear Motor Using Jog Buttons

Selecting this option will enable the right Jog button to drive the X rear actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Drive Y Motor Using Jog Buttons

Selecting this option will enable the right Jog button to drive the Y actuator right at slow speed and the left Jog button to drive it left, stopping immediately the button is released.

#### Toggle Chase Clamp

Selecting this option will alternately energize the Chase Clamp solenoid, displaying On status and de-energize it, displaying O status.

#### Cycle Alignment System

Selecting this option will start a continuous cycle of driving the screen actuators to each of the following positions in sequence, dwelling for 2 seconds at each point and then repeating the cycle.

### ----- 地震時の緊急対応 -----

#### Emergency Power Shut-O

To be fully prepared for an emergency you should know how to shut o the power supply to your house.

Immediately after an earthquake, or major disaster, do not turn lights on or o or use matches. Use flashlights and check for gas leaks. Sparks from lights or flames can cause an explosion or fire. If you have natural gas and hear or smell a gas leak, shut o the gas valve to your home and open doors and windows.

Locate your home ' s electrical circuit or fuse box. It is usually located outdoors in the rear or side of your house if it is not indoors in a hallway or closet. After an earthquake, if you hear sparking sounds, see or smell smoke, you should go to your electrical box and shut o your power. If you have any sub-panels adjacent to the main fuse, breaker panel, or in other parts of the house (in an emergency), be safe and shut them o too.

Shorts can sometimes develop to cause a circuit to bypass the breaker or fuse.

Electrical power should also be shut o at the circuit or fuse box if there is damage to the wiring in your house. Damaged appliances should be disconnected. If you have a power outage, you should also turn o all the



non-essential appliances and light fixtures in your home. Then turn on only one light to avoid an overload when your power is restored. Check your home's outside electrical connections. Check the power lines around your home. If there is damage to the connection from the power pole to your house, you should go to the electrical box and turn on the main switch or shut on the fuse switch. Finally, check for outdoor hazards, such as downed power lines. Beware of hidden hazards. Don't touch a chain link fence. There may be a power line down that is touching the fence somewhere beyond your sight. Determine whether the power is out only in your home or in the whole neighborhood. Report what you find to your local power company.

#### Pull-Out Cartridge Fuses

Your house may be equipped with fuses or circuit breakers. If your house has fuses, you will find a knife switch handle or pull-out fuse that should be marked "MAIN." If your house has circuit breakers, you may need to open the metal door of the breaker box to reveal the breakers (never remove the metal cover).

The main circuit breaker should be clearly marked showing on and off positions. Turn off all the small breakers first, then turn on the "MAIN" (see diagram top right).

#### MAIN Circuit Breaker

Prepared by the Peninsulas Emergency Preparedness Committee of Washington 11/00 (www.pep-c.org)

## ----- ドアの修復 -----

よくあるドアに関する問題を解決するには

When a hinged door fails to open and close smoothly, or when the lock or latch fails to snap shut after the door is closed, muttering under your breath and kicking the bottom of the door will seldom solve the problem--nine times out of ten it will only make matters worst.

蝶番式ドアがスムーズに開け閉めできない場合やロック式のカギや空錠式カギがドアを閉めた後にピシャッと閉まらない場合はひそひそ話（実際は小声でプツプツ言うの意だが、ここでは著者が冗談の意味を含めているのであえてひそひそ話しと訳し、日本人にじっくりいくように変更しました。）をするか、またはドアの下側を蹴飛ばすことによってまれにこの問題を解決することができます。ただし、術中八苦、物事をさらに悪くする結果となるでしょう。

上記のように、すべての文章を日本語に訳したいのですが、時間がないので役立つと思われる部分のみ翻訳していきます。

### DOORS THAT STICK OR BIND (サビ等で動きが悪くなったドア)

Most people think the **only real cure for a door** (ドアの唯一可能な修理方法) that sticks or binds is **to get out a plane or sanding machine** (カンナまたはサンダーを使って(手に入れ)) and **trim off the edges** (縁を削り取る).

While this maybe necessary if the edges of the door **have swollen from excessive humidity** (湿気を含み過ぎて膨れ上がる), or if the door frame has **"settled" or buckled out of alignment** (調整範囲以上に納まったか歪んだ), more often than not **these conditions** (これらの状態) are not what is causing the trouble.

In a high percentage of cases the problem is caused by hinge screws (蝶番のねじが原因である問題点) that **have worked loose** (ゆるんだ状態で動く), or by hinges that **were not properly installed in the first place** (最初の場所から取付けが悪かった) (a leaf (蝶番の薄い金属片をはめ込む部分) is **recessed** (溝をつける) either too deep into the wood or **not deep enough** (浅過ぎる)).

### Loose Hinge Screws (蝶番ねじのゆるみ)

Since this is probably **the most frequent reason why** (最も起きうる理由) a door suddenly starts to stick and

bind--and since ( ~なので ) it is probably the easiest problem to solve ( 解決が最も簡単な問題 ) --it makes sense to check the hinge screws first.

Swing the door wide open and test ( ドアの開け閉めをして ~ をテストする ) each screw with a large screwdriver whose blade fits snugly into the slot of each screw ( ドライバーの先をそれぞれのねじ穴にぴったり合せ ) so you can apply the degree of torque required ( 必要なトルクを与える ) .

If the screws' slot are clogged with paint ( ペンキで詰まる ) , use the point of a knife ( ナイフの先 ) or the edge of a putty knife ( パテ用ナイフの縁 ) to clean the slots out ( ねじ穴をきれいにする ) first.

Sometimes you will find that no amount of turning ( いくら回そうが ~ しなない ) tightens the screw because the wood is so chewed up ( 木材部分が噛み砕かれていて ) that the screw no longer holds ( その場に固定する ) .

The solution to this problem ( 問題の解決方法 ) is to remove the screw ( ねじを取り外す ) and then fill the hole with slivers of wood ( 長細の木片で穴をふさぐ ) (wooden toothpicks work fine). Keep packing wood in ( どんどん木片を詰め込んでいく ) until no more pieces will fit ( 入りきらなくなる ) then break each one off flush with the surface ( 表面と平らになるように ) .

If the hole seems to go all the way through ( 通り抜ける ) so that the slivers fall through on the inside ( 中で落ちてしまう ) , use wood plugs or small pieces of dowel ( ダボ ) instead.

Provide a snug fit inside the hole ( 穴にぴったり合わせる ) (whittle a piece to fit ( 削って一片を合わせる ) if necessary), then dip the plug or dowel in glue ( 栓またはダボを接着剤に浸す ) and tap it in ( 叩き入れる ) .

Allow the glue to harden ( 接着剤を固める ) before you trim off the plug flush at the surface ( 栓を削り取り表面と平行になるようにする ) .

After the hole has been packed with ( ~ で詰める ) wood sliver or a small plug, reinsert the screw and tighten securely. ( ねじを再度差し込み、外れないように締め込む ) (Make sure first that the old screw head is not badly chewed up ( 古いねじの頭がひどく壊れている ) ; if it is, don't try to reuse ( 再利用する ) it--throw the screw away ( ねじを捨てる ) and replace it with a new one of the same size. ( 同じ大きさの )

### Improperly Mounted Hinges ( 不適切に取り付けられた蝶番 )

If loose hinge screws are not the cause of the door's sticking or rubbing, then the next most frequent possibility is the way the hinges are mounted ( 蝶番が取り付けられている方法 ) .

The first step in checking for ( 何か不具合のものをチェックする。注意 : Check ~ と Check for の違い - Check for の後にはあってはならないものが目的語として入り、不定冠詞 ( a, an ) はつけない。特定の不良等を目的語にする場合は the が必要 ) this is to find out exactly ( 正確に見つけ出す ) where the rubbing or sticking occurs ( 起こる ) .

Look for ( 探す ) signs ( 兆候 ) of abrasion along the edges or close the door over a sheet of paper, then slide the paper along and note ( 気をつけて見る ) where it sticks it won't pull out easily.

When this happens ( 起こる ) along the closing edge near the top or bottom of the door, or along the top and bottom edges near the outside corners, chances are that the problem is being caused ( 引き起こされている ) by one of the hinges--it is set either too deep in the wood or not deep enough.

As you can see from ( ~ から分かるように ) studying the drawings, if a leaf on the top hinge has not been mortised

(ほぞがあげられる) sufficiently into the edge of the door or the doorjamb, the top corner of the door will project (突き出る) slightly farther from the jamb than it should, causing (引き起こす) the door to rub at point A or B in the drawing.

Rubbing may also occur (起きる) in these places if the lower hinge is set (取り付けられる) too deep into the wood, in which case the door is pulled in (引き入れられる) toward the hinge along the bottom when it closes.

If the reverse is true (逆の場合) --that is (つまり、すなわち), if the bottom hinge is not set into (入れ込まれない) the wood as deep as it should be--then the door may rub (こすれる) at point C or D.

Rubbing may also occur (起きる) at C or D if the top hinge is set too deep.

In all of these cases (これら全ての場合) you'll notice (気が付く) that you have a choice, an alternative method for solving the problem (問題解決の代替方法).

You can either set one hinge deeper (the one that is not deep enough) or you can shim out (詰め木等を入れて削って面一にする) the other hinge, the one that is set too deep. You do the latter (後者、後口) by placing (置く) pieces of cardboard behind the hinge leaf, thus bringing it out (外側に持ってくる) slightly to straighten (真っ直ぐにする) the door's vertical alignment.

Shimming out one hinge will have much the same effect (同様の効果がある) as recessing the other hinge slightly--the end result is that the door hangs straight (真っ直ぐに吊り下がる) without rubbing along the top or the bottom.

To determine (決める) which method you should use, swing the door wide open (ドアを揺らして広く開ける) and examine (調べる) the two hinges.

You should be able to tell if one hinge leaf is not set deep enough: It will not be quite flush with (完全に面一になる) the surface.

In a majority of cases (ほとんどの場合) this will not be the problem--the problem will be that one of the hinge leaves has been set too deep. To correct for this (これを補正するには), prop the door open (ドアを開けておく) by wedging (くさびの役目をさせる) a magazine under the outside corner, then remove the hinge screws that hold (保持している) that hinge leaf against the doorframe or doorjamb. Cut a piece of cardboard the same size as (と同じサイズに) the hinge leaf and slip (差し入れる) it behind the hinge, then replace (交換する) the screws and tighten securely.

Now try the door again. You may find (気が付く) that a single thickness of cardboard is not quite enough--the door closes better but still sticks or binds slightly. If so, add a second or even a third piece if necessary to build up the required thickness (必要な厚みを持たせる).

Shimming can be impractical (実用的でない) when there is not enough clearance (十分な隙間がない) between the lock edge of the door and the doorframe to allow for (～を許す) the added thickness of a cardboard shim behind the hinge.

You will be better off (うまくいく) in that case if you set the other hinge slightly deeper.

This is only feasible (実行可能であるばかりでなく), however, if the hinge is not already recessed (まだほぞが掘られていない) below the surface of the wood--that is, if it actually sits above (～の上に落ち着く) the surface of the wood.

To recess (ほぞを掘る) a hinge (これ蝶番自体を指すのではなく、蝶番の形を指す) more deeply on the edge of a

door, you will have to **remove** ( ~を外す ) the door from its hinges so that you can **prop it up** ( 立て掛ける ) on its other edge while you **work on** ( ~の作業をする ) the hinge mortises.

Removing the door is not very difficult.

With the door closed and latched, use a large screwdriver and a hammer to **drive** each of the hinge pins **upward** ( ~を上向きになるように動かす ) .

Remove the bottom hinge pin first, then the top one (if there are three hinges, **leave** ( 残しておく ) the middle one for last)

With all the hinge pins out you can **grasp the door by the knob** ( ドアのノブをつかむ ) , **unlatch** ( ラッチを外す ) it, and swing it open **while lifting slightly** ( ちょっと持ち上げながら ) .

The hinges will **come apart** ( 分離する ) quite easily, **allowing** ( 許す ) you to **lift** ( 持ち上げる ) the door and **lay it over on** ( それを ~の上に横たえる ) its edge.

To **support** ( 支える ) the door in this working position ( この作業位置に ) , you can either **clamp it** ( 押し付ける、クランプする ) against the side of another door or **wedge** ( 押し込む ) it into a corner of the room where two walls meet.

Of course, you do not have to **remove** ( 外す ) the door if the leaf you want to **work on** ( 作業する ) is the one that is **fastened to** ( 固定されている ) the doorframe--just prop the door wide open by wedging something under the free edge, then **unscrew** ( ~のねじを外す ) the hinge leaf on the frame and swing it out of the way so that you can use a chisel to **deepen** ( 深くする ) the mortise (recess) in which it **fits** ( 嵌合する ) .

**Deepening** ( 深くすること ) a Mortise

Cutting the existing mortise slightly deeper **calls for** ( 必要とする ) careful work with a very sharp chisel.

Since the hinge outline **is already cut out** ( 既に切り出してある ) , all you have to do is **cut within it** ( 中をほじくる ) .

Start by **tapping** ( コンコンと打つ ) the chisel around the **perimeter** ( 周囲 ) while **holding** ( 持つ ) the blade at **right angles** ( 直角に ) to the surface, then **make a series of light cuts** ( 続けて浅く削る ) across the recessed surface by tapping the chisel.

To actually **remove** ( 取り除く ) the **excess wood** ( 余分な木 ) you push the chisel **in** ( のみを押し込む ) with your hand ( 手で ) , along the grain, **shaving off** ( 削り取る ) only a little at a time ( 一回に ) until the mortise is deep enough. Push with a sideways shaving or slicing action ( 横を削り取るまたは横をはがし取るようにのみを押し込んでください。 ) , using the **thumb of one hand** ( 片方の手の親指で ) and the **forefinger of your other** ( もう一方の手の人差し指で ) to **guide** ( ~に沿わせる ) the cutting edge.

Use a hammer or mallet if you must, but if possible **avoid** ( 避ける ) it.

You'll be **running the risk of** ( ~のリスクを負う ) taking off **too much wood** ( 木をはがし取り過ぎ ) or **splitting** ( 裂く ) the edge of the door.

**DOORS THAT BIND** ( さびたりして動かなくなる ) , OR **SPRING OPEN** ( バネの力で開いたままになる )

Up till now ( ここまでは ) we have been talking about ( ~について話してきました ) doors that **swing closed easily** ( 簡

単に戻って閉じてしまう) until the edge of the door comes in contact with (接触する、当たる) the doorframe and starts to rub or stick.

There is another problem that occurs almost as often: A door resists closing (閉じようとしな) and seems to spring open when you swing it shut (それをバタンと閉める).

Nine times out of ten (10回に9回は、術中八苦) this is also a hinge problem--at least one of the hinges has been recessed too deeply, either into the edge of the door or into the doorframe.

You can check this out (これを調べ上げる) by watching the hinges carefully (蝶番を注意して観察することによって) while someone else swings the door closed. Probably you will notice that as the edge of the door starts to make contact with (当たる、接触する) the doorframe the hinges are still not fully closed. Then, in the effort to close the door the rest of the way (残りを), the hinges seem to spring or bend (曲がる) slightly (the hinge leaves cannot meet (ずれる)).

This condition (この状態) is usually caused by the hinges having been improperly set.

Either they were recessed too deeply, or they were not recessed uniformly (the pin edge of the hinge leaf was set deeper than the inside edge of the same hinge leaf).

In the first case (最初の場合は) -- when the whole hinge has been set too deep--it's simply a question of the door meeting (～に当たる) the frame before the hinge closes fully.

In the second case (二番目の場合は) -- when only the pin side of the hinge is deeper than the rest of the hinge come together before the door is fully closed.

In both cases (両方の場合) the door will tend to (～しがちである) spring open before it latches (カチッと閉まる).

Either the problem is solved (解決される) by installing (取り付け) shims behind the hinges.

If the full hinge has been recessed too deep, you install (取り付け) one or more cardboard shims.

If only the pin edge of the hinge leaf has been set too deep, you still install shims behind the hinge leaf, but in this case (この場合) you use narrow pieces of cardboard that are only about one-third the width (～の幅の約3分の1だけ) of the hinge leaf.

These go behind (裏側に行く) the pin edge of the hinge so that they cause (引き起こす、～の原因となる) the hinge to swing around slightly (少し回り込む) (more into the door opening).

This should eliminate (取り除く) the springy, last-minute resistance to closing (閉じようとする最後の抵抗) that can cause binding when the hinge edge is set too deep near the pin.

To install full-size shims you'll have to remove all the hinge screws so you can swing the leaf out of the way.

However, for narrow shims that only have to fit behind (～の後ろに納まる) the pin edge of the hinge, you need to loosen (ゆるめる) the screws, then slide (滑らせる) the strip of cardboard into place.

WHEN ALL ELSE FAILS (どうしてもだめなら) -- GET OUT THE PLANE (平行にするのはあきらめて)

There are, of course, cases where shimming alone simply will not solve the problem (問題を解決する) --for

example, if the door sticks along its entire length (長さ方向全体に渡り動きが止まる (にぶい)), or if it is rubbing or sticking in several different places (いろいろな個所でこすれたり、動きが止まる) along the top and bottom. Chances then are that some planing (平滑化) or sanding (やすりがけ) will be required (必要です) to trim off extra wood along those edges where the rubbing occurs (発生する).

If only a slight amount of trimming is required (必要) you may be able to do (やれるかもしれない) it without actually taking the door down (ドアを外す (解体する)), particularly if the rubbing occurs along the lock edge (as long as it is not right near the lock itself) or along the top edge.

Prop the door open by wedging (差し込んで支える) a book or magazine under the bottom, then use a small block plane or wood to rasp (ガリガリとこする) to trim (削り取る) the edge where the rubbing occurs.

Take off (取り除く) only a little at a time and keep (続ける) testing by swinging the door shut to make sure (確認する) that you're not taking off more than is necessary (必要以上に).

When finished (終わった場合、終了した時), sand the edge smooth (縁をやすりでなめらかにする), then touch up with (仕上げをする) paint, shellac, or varnish to seal out moisture (湿気が入らないようにする).

The door was stuck. (ドアが開かなかった) (たまたま CNN ニュースでこの表現があったので、ここに載せておきました。)

Working on the door within its frame is impractical when wood must be trimmed away along the full length of the door (ドアの長さ全体に渡って), and it won't work when wood must be removed next to the lock itself.

Obviously you cannot plane (かんなをかける) past the lock (カギを越えて) without removing (取り外す) the lock and then resetting (再度取り付け) it—a tricky job even for an experienced carpenter.

Under these circumstances (この状況下では) it is best to take the door down and trim the needed amount off the hinge edge, rather than along the lock edge.

The hinge leaves are easy to remove (取り除く), and after the necessary planing has been completed (終了した) they can easily be reset (元に戻す) by chiseling out (のみで削り取る) the mortise slightly deeper until the hinge leaves are once again flush with (～と面一になる) the edge of the door.

Since you will be working on (～の作業をしている) the edge opposite the lock (where the rubbing actually occurs), you'll have to approximate (～に近づける) the amount that has to be trimmed off, then hang the door back (ドアを掛け戻す) on its hinges temporarily to see if (～かどうか確認する) you have removed enough.

If trimming is required (～が必要である) on the top or bottom edge of the door, make sure you plane from the corners in toward the center, never out toward the corners.

Running the plane (かんなをかけること) past the edge of a corner is almost certain to cause splintering (裂け).

With the door lying on (横たわる) one of its long edges, this will mean (意味する) planing downward for about half the width of the door (ドアの約半分の幅), then turning the door over (ドアをひっくり返す) so that it rests on (～の上に横たわる) the opposite long edge and planing the other half of the door's width (ドアの幅のもう一方の半分), again in a downward motion.

After you have removed the required amount of wood, replace the hinge leaves in the mortise to see (確認する) how much deeper the mortises will have to be in order for the face of the hinge leaf to once again sit flush with (～と面一に横たわる) the edge of the door, then trim the mortise to the required depth (必要な深さまで) as

previously described.

### WHEN THE LOCK WON'T LATCH (カギがカチット閉まらない場合)

This is another annoying door problem--the door closes easily without sticking or binding, but it won't **stay closed** (閉まったままの状態を保つ) or **snap shut** (ビシャッと閉まる) because the latch bolt on the door lock is **not quite in line with** ( ~とびったり合わない) the opening in the strike plate on the door frame.

You can almost always **correct a condition** (状態を正す) of this kind by **moving** ( ~を動かすこと) the strike plate slightly in order to **line up its opening with the latch bolt** (ラッチボルトとその穴をびったり合わせる) when the door is fully closed.

The trick is finding **which way to move** (どっちに動かしたら良いか) it.

You **start** (開始する) by closing the door slowly while your eye is **level with** (同じ高さにある) the strike plate.

**Have someone else stand on** (他の人に ~の上に立たせる) the other side of the door, **shining a bright light on the latch bolt** (ラッチボルトに明りを当て) so that you can **watch** (見る) the action of the bolt as it **slides** (滑走する) across the curved part of the strike plate and tries to **slip into** ( ~にすべり込む) the opening.

**In this way** (このようにして) you should be able to tell whether the opening in the plate is too high or too low to **line up with** ( ~と並びを合わせる) the latch bolt.

**Depending on** ( ~によって) exactly how much out of line it is, you have two options: (1) You can **remove** (取り外す) the strike plate and **reinstall** (再度取り付ける) it slightly higher or lower to **compensate for** (補正する) the misalignment; or (2)having removed the plate, you can use a metal file to **elongate** (広げる) the opening slightly at the top or bottom(depending on whether the strike plate was sitting too low or too high) and reinstall it in the same position.

Generally, if the distance the plate must be moved is 1/8 inch or less, it is easier to **file** (やすりをかける) the opening to **compensate** (補正する) the misalignment. If the plate is more than 1/8 inch out of line, however, it is better to **remount** (再度取り付ける) the plate in a higher or lower position. (あたかも俺は取り付けると言う用語を一杯知っているのだと言いたいように、一つのマニュアルの中で Install、Mount、Attach、Mantle、Assemble、Remove、Detach、Unscrew、Dismantle、Uninstall、Take out 等を連発していますが、外国では同じ単語を繰り返し使うのを嫌います。日本はどうしても統一したくなる場所ですね。)

You **remove** (取り外す) the plate by taking out (取り外す) the two screws that **hold** (保持する) it in place (対象物があるべき所での意: あえて翻訳する必要はありません) .

Then fill the old screw holes by **jamming in** (ごちゃごちゃ突っ込む) as many wood slivers (pieces of wood toothpick work fine) as you can. (as many ~ as you can 出来るだけ多くの)

**Break** each piece o **flush** at the surface.(折って平らにする)

**Hold** (保持する) the plate in its new position, then **drill** (穴等を空ける) pilot holes for the screws and **mount** (取り付ける) the plate in its new location.

You may have to **chisel away** (のみで取り除く) a little extra wood to **permit** (許す) recessing (凹部をつける) the strike plate **flush with** ( ~と面一になるように) the wood, and you may have to **enlarge** (広げる、大きくする) the opening in the wood slightly so the latch bolt can **slide all the way in** (ずっと奥まで入り込む) .

Sometimes the problem is horizontal rather than vertical alignment. The strike plate may **be too close to** ( ~ に近過ぎる ) the stop molding (against which the door closes) so that the door **hits** ( 当たる、ぶつかる ) the stop molding before the latch bolt can **slip into** ( 滑り込む ) the strike plate's opening.

To **cure** ( 直す ) a condition of this kind you again have two choices: (1) You can **remount** ( 再度取り付ける ) the strike plate **slightly farther away from** ( ~ から多少遠ざけて ) the stop molding; or (2) you can **pull** the stop molding **o** ( pull o : 引き抜く ) and **move** ( 移動する ) it slightly farther away from the strike plate (so the door can **swing a little more into its opening** ( もう少し開く ) when fully closed).

Sometimes a door will close easily enough, and then will **rattle** ( ガタガタ音を出す ) to **show** ( 示す ) that it **isn't snug** ( ぴったりしていない ) , even when closed all the way.

In this case the stop molding **is too far away from** ( ~ から遠すぎる ) the door when the door is fully closed-or, to put it another way, the strike plate is too far away from the stop molding.

Again, two options: (1) You can **remount** ( 再度取り付ける ) the strike plate **slightly closer to** ( 少し ~ に近づけて ) the molding; or (2) you can **pry o** ( 引き抜く : テコの応用で ) the stop molding and **renail** ( 再度くぎで固定する ) it slightly closer to the door (with the door closed and the latch bolt engaged in the strike plate, you **renail** the molding so that its edge just **makes contact with** ( 接する ) the face of the door).

There is also another simple solution that will **work** ( 作用する ) when only a slight amount of "play" **needs to be taken up** ( 遊びをなくす必要があります。 ) : **Place** ( 着ける ) a strip of foam-type self-adhesive weatherstripping on the inside of the stop molding to **take up the slack** ( ゆるみをなくす ) .

This will not only **eliminate** ( なくす ) the rattle, it will also **cut down on** ( 削減する、なくす ) sound transmission. ( 同じ動詞の繰り返しを避けている例 )

## **SOLVING** ( 解決すること ) DOOR LOCK PROBLEMS

An interior keyless door lock **is normally referred to as** ( 通常 ~ と呼ばれる ) a knob set or knob-and-latch set.

The most popular type is the cylindrical or tubular set, which **is installed by** ( ~ によって取り付けられている ) **boring** ( 穴等を空ける ) two holes in the door--a large one through the door and a smaller one into the edge of the door.

The small one **intersects** ( ~ と相い交わる ) the larger hole so that the latch bolt assembly (which **fits into** ( ぴったりはまる ) this hole) can **engage** ( かみ合わせる ) the main lock mechanism.

In older homes, there may be mortised locksets or knob sets that have the whole mechanism **recessed into** ( ~ に隠された ) the edge of the door.

This is done by drilling a series of vertically aligned holes in the door edge and then using a chisel to **hollow out** ( えぐって空ける、くり抜く ) a rectangular-shaped mortise or recess in which to fit the lock.

**From the description above** ( 上に述べたように ) you can see that there are several different types of locks used on residential doors, so this would be a good time to **explain** ( ~ を説明する ) the principal types and how they **differ** ( 異なる ) .

**Broadly speaking** ( 大まかに言うと ) , all home door locks **fall into** ( fall into categories: 分類される ) one of four categories: tubular locks, cylindrical locks, mortise locks, and rim locks (often called night latches or auxiliary locks).



Tubular locks and cylindrical locks **are similar in that** ( **be similar in that** 主語 + 動詞 = ~ の点で似ています ) both are easily installed merely by boring two holes through the door.

Cylindrical locks are generally more **rugged** ( 丈夫にできている ) and **are designed** ( 設計されている ) for use on exterior doors for which security is a prime consideration, and when a key is needed to **lock** ( ロックする ) the door from the outside (a knob or pushbutton is used on the inside in most cases to lock and **unlock** ( ロックを解除する ) without a key).

The sentences are **justified**. ( 文は左右端が並んでいます。 ) The sentences are **rugged**. ( 文は左づめになっています。 ) 等と使用します。

Tubular locks are used only on interior doors. Most do not have a key, although they often have a locking mechanism that is activated ( 動作させられる ) by pushing a knob or turning a button on one side (you can unlock on the other side **in an emergency** ( 緊急時に ) by pushing a heavy piece of wire or long nail into a hole in the knob or directly under it).

All door locks have moving parts, so occasional lubrication **is required** ( ~ が必要です ) to **keep** ( 保つ ) them operating smoothly.

Often this is the only thing wrong with a balky lock, or a knob set that isn't working smoothly. Powdered graphite is the best lubricant to **correct such a condition** ( そのような状態を正す ) .

It **comes** ( 入っている ) in plastic squeeze tubes with a narrow nozzle that **enables** ( できるようにする ) you to **pu** ( 吹き付ける ) the powdered lubricant into a lock, through the latch bolt opening.

Never use ordinary oil, which can **cake up** ( 覆い固める ) and **gum** ( ゴム状にくっつき固める ) the mechanism (there are some lubricating liquids that **contain** ( ~ を含んでいる ) graphite and, used like oil, also work well on locks).

**Squirt** ( 吹きかける ( ジェット状に ) ) the graphite in around the latch bolt while turning the knob **back and forth** ( 前後に ) , then remove the knob and squirt some more alongside the knob stem while turning the knob on the other side back and forth.

It may also **help** ( 補助する ) to **rub** ( こすりつける ) a little paste wax on the face of the strike plate, or **spray** ( 吹きかける ( 霧状に ) ) a small amount of silicone lubricant onto the plate and the sloping face of the latch bolt, which should then **slide in** ( 滑り込む ( 自動詞 ) ) more easily when the door **is slammed shut** ( バタンと勢いよく閉める ) .

Lubrication is especially important on outside door locks--not only because they **are exposed to** ( ~ にさらされている ) the weather, possibly causing oxidation or corrosion of the metal parts, but also because lubrication is your best protection against the lock freezing up when **wind-driven rain or snow gets inside** ( 風にあおられて雨や雪が入り込む ) .

(When a lock does **freeze up** ( 氷固まる ) , the easiest way to **thaw it out** ( それを解かず、解凍する ) is to **heat** ( 温める ) the key with a match or cigarette lighter, then **work** ( 動くように働かせる ) the heated key gradually into the cylinder until the ice on the inside **melts** ( 解ける ) .

You may **find** ( 分かる ) at first that the key only **goes partway in** ( 少しだけ回る ) ; **keep** ( ~ し続ける ) heating the key and **reinserting** ( 再挿入する ) it until it goes all the way in ( 回りきるまで ) and the lock turns smoothly.

Never **force** ( 無理に ~ する : この場合は無理にキーを差し込むの意 ) the key in, and never **use** ( 使う ) a pair of

pliers or similar tool to **turn** ( 回す ) the key when you can't turn it **with your fingers**( 指で ) .

**As a rule** ( 通常 ) , when a tubular or cylindrical lockset (sometimes **referred to as** ( ~ と呼ばれる ) a bored lockset because it **is installed**( 取り付けられている ) by just boring two holes) starts ( 開始する ) to **act up**( 異常に作動する、変な動きをする ) , the simplest solution is to **replace it with a new one** ( それを新しいものと交換する ) .

**Replacement locks** ( 交換用のかぎ ) are widely **available** ( 入手できる ) in all hardware stores and home centers, and they **come complete with** ( ~ が添付されている : この **complete** は強調で使用されているので訳す必要はない ) installation instructions and templates for boring the necessary holes (for installation in a new door).

Most of these locks **are designed to** ( ~ するように設計されている ) fit holes of the same size **spaced the same distance** ( 同じ間隔で並んでいる ) from the edge, but some do **vary** ( 変化する : ここでは多種多様であるとも訳せばよい ) .

So to **play safe** ( 間違わないようにする ) when buying a new lock, either **bring** ( 持っていく ) your old one with you or **measure** ( 測る ) the size of the holes and the distance from the edge for the larger hole.

**That way** ( そうすることによって ) you will **be sure** ( 確実となる ) the new lock will **fit** ( 合う ) the original holes in the door.

To **take the old lock off** ( 古い錠前を取り外す ) , you first have to **remove** ( 取り外す ) the knobs.

In cylindrical locks, and some of the better tubular ones, these knobs **are usually threaded onto** ( ~ に通常取り付けられている )( **thread** はテープなどを通す場合やこのようにノブをねじ込むような場合に使用します。 ) the shaft and will have a setscrew to **lock them on** ( それらを固定する ) .

After this screw **is loosened** ( ゆるめる ) , the whole knob can **be unscrewed** ( ネジ込まれた状態から取り外す ) .

In tubular locks the knob **is usually attached to**( 通常 ~ に取り付けられている ) the decorative escutcheon plate--or **rose** ( 花びらのような口 ) , as it is sometimes called--so that loosening the two screws or bolts that **go through**( 貫通する ) it will **enable** ( できるようにする ) you to pull the whole thing out of the door, the knob **with the spindle attached** ( 主軸を取り付けた状態で ) .

In a cylindrical lock, the rose is a separate plate **fastened to** ( ~ に固定されている ) the door **with** ( ~ を使って ) two screws; once the knob is removed, the plate can **be slid off** ( スルッと抜ける ) .

You then **take out** ( 取り出す ) the two screws that **hold** ( 固定している ) the latch bolt mechanism in place against the edge of the door and **pull out** ( 引き出す ) the latch bolt and face-plate.

This **frees up** ( 完全に働かないようにする、自由にする、自由化する ) the lock mechanism so that you can pull the whole assembly out.

In the case of a tubular-type lock, you cannot pull out the latch bolt mechanism until you have pulled out the knob with stem attached, since the stem **goes through**( 通り抜ける ) a square hole inside the latch bolt assembly.

Mortise locks are long, **rectangular-shaped**( 長方形の ) units that have to be **mortised**( ほぞ穴を空ける ) or **recessed**( 凹所をつける ) into the edge of the door.

Mortise locks are not widely used on interior doors nowadays, but they are excellent for entrance doors for which

maximum security is desired ( 望まれている ) , since they are especially hard to force ( 特に押し入るのが難しい ) .

Many older houses still have mortise locks on interior doors, and when one of these acts up ( act up は普通でない動きをする ; 気ままな [ 荒々しい ] 行動をとる , あばれる ; 人目をひくようなふるまいをする , かっこよく見せる ; いたずらをする , ふざける、機械など 異常に作動する , 調子が狂う、病気・傷など 再び悪化する , 再発する、などがあります、ここでは“ 異常に作動する ”が一番ふさわしいでしょう ) your best bet is to replace the lock entirely ( すべて ) with one of the newer tubular or cylindrical types.

To cover up ( 塞ぐ ) the holes left ( 後に残った穴 ) by the old knobs on the mortise lock, you can buy ( 買う、購入する ) special modernization kits that include ( 含む ) oversize escutcheon plates.

These will not only cover the old holes in the door, they also ( 前の not only との慣用表現で通常は not only ~ but also ~ の構文をとり、~ばかりでなく、~もの意味。最近では but は省略する傾向があります。 ) allow for holes to be bored ( 空ける ) that accept ( 受け入れる ) the knob handles and latch ( 掛け金をかける ) bolt mechanisms of the new lockset.

### CURING ( ~ を修復する ) A WARPED DOOR

A door that is warped ( 反っている ) or twisted ( ねじまがっている ) will be difficult to close, or will tend to ( ~ する傾向がある、~しがちである ) rattle and vibrate when it is closed.

If the door is bowed ( 弓なりに曲がる ) or warped ( 反り返る ) along the hinged edge, then the best method for curing may be to install ( 取り付ける ) a third hinge in the middle.

Attach ( 取り付ける ) the hinge to the edge of the door first, then have someone press ( 誰かに押させる ) as hard as possible on the curved side of the door to force it straight ( 無理やり真っ直ぐにする ) while you mark ( ~ に印を付ける ) the location for that hinge on the doorframe.

Now mount ( 取り付ける ) that hinge leaf against the doorframe or jamb ( 押し込む ) ( ちょっと古い英語で現在は jam を使う ) in the position marked, then push the door straight ( ドアを真っ直ぐに押す ) to force the hinge leaves together ( 蝶番のプレートを無理に合わせる ) and slide ( 滑り込ませる ) the pin home.

If the door is bowed or too warped for this correction, your best bet is to remove ( 取り外す ) the door and try to straighten ( 真っ直ぐにする ) it with weights.

Place the door flat ( ドアを平らになるように置く ) across two sawhorses or similar rigid supports, with the bowed side facing up ( 曲がった側を上向きにして ) .

Place ( 置く ) heavy weights over the highest point of the bulge or warp, using bricks, large rocks, or pails filled with ( ~ を満たした ) water or sand.

You may not be able to place enough weight on the door to straighten it immediately, but the idea is to leave ( そのままにしておく ) the door with the weights on it for at least 24 to 48 hours.

The continuous pressure should gradually straighten ( 真っ直ぐにする ) the warp.

For best results, leave the weights on long enough ( and make sure ( 確実にする ) they are heavy enough ) to give the door a slight reverse bend ( ドアを少しだけ逆に曲げる ) .

This "overcorrection" should result in ( 結果として ~ になる ) a straight door when the pressure is removed ( 取り除く ) .

If the edges of the door, including the top and bottom, are not painted ( ペンキを塗る ) , make sure they are painted

as soon as the door has been straightened.

This will **prevent** (防ぐ) further absorption of moisture.

If the door is twisted or warped diagonally, you can use the same method of applying weights, but you'll have to **put** (置く) extra blocks or bricks under the corners to **correct for** (～を修復する) the propellerlike twist in the door.

When a door is only slightly warped, so that the top or bottom corner of the door **touches** (当たる) the stop molding before the rest of the door, it is sometimes simpler to **leave** (ほおって置く) the door alone and simply **renail** (釘を打ち直す) the stop molding so it **matches** (合う) the slight curve in the door.

You'll have to **pry it o** (それをこじあけて離す) along the lock edge and then renail it, starting from the top so that its **inside face** (内側の面) just **touches** (接する) the door along its full length--even if this **means** (～を意味する) curving the molding slightly as you **nail** (釘で固定する) it into place.

### HANGING (吊るす) A NEW DOOR

Replacing an old interior door with a new one (古い屋内ドアを新しいものと交換すること) is a carpentry job any home handyman can **tackle** (取り組む) with **ease and assurance** (簡単及び確実に).

You can find **a door in the style and size you want** (好みのスタイルとサイズのドア) at most any local lumberyard, or your local dealer **can order** (注文して取り寄せる) whatever you want (some **yards** (製作所) also make them to order).

After you get the door home (ドアを家で受け取った後), your first step is to **trim** (かななどで削り取る) it to the **proper height** (適切な高さ) to.

If the door has **projecting ends on the vertical stiles** (縦がまち, 縦棧の飛び出た部分) (建築用語で新しいドアの上下にドアが痛まないようにわざと余分な部分をつけておく) at each side, **saw these o** (それらをノコギリで切り落とす) to **make the ends flush with the top and bottom rails** (先を上下の横木と面一になるように), then trim the door to height.

There should be about 1/8-inch **clearance** (隙間) at the top and about 1/4-inch clearance at the bottom when the door **is in place** (嵌められた、はめた) inside the frame.

If at least 1/4 inch of wood is to **be taken o** (～から取り除く) the top or bottom, use a saw.

If less than 1/4 inch is to be removed, use a bench plane or jack plane. Make sure you **plane** (かなかけする) from the edge **in toward** (内側に～に向けて) the center from each side, and **never allow** (決して～させるな) the plane to **run o** **past** (～を通り過ぎる) the end of the door, as this will almost certainly result in **splintering** (裂け).

For doors that **swing into** (回転して～に入り込む) a **carpeted** (カーペットの敷いてある) room, **remember** (覚えておいてください) to **allow for** (～の余地を残す) the thickness of the carper.

Usually, an additional clearance of 3/4 inch to 1 inch at the bottom will **su ce** (足りる).

The next step is trimming the edges, usually by planing, to **ensure** (確実に得る) approximately 1/8 inch of clearance on each side -- in other words, the total width of the new door should be approximately 1/4 inch less than

the width of the opening into which it must **fit** ( 勘合する ) .

To install the hinges, **prop** ( 立て掛ける ) the door in place in its opening, using 1/4-inch wedges (scrap pieces of plywood or hardboard **work well** ( ~でも良い ) ) along the bottom to **raise** ( 持ち上げる ) the door to the height at which it will actually **hang** ( 吊り下がる ) .

**Wedge** ( 押し込む ) additional pieces along each side to center the door in its opening, then use a sharp knife or chisel to **mark the location** ( 位置の印をつける ) of the hinges on both the door and its frame.

If the door **is being hung** ( 吊ってある状態にある ) in an opening where originally there was a door of the same size, then the hinge mortises will have already been cut in the door frame; use these as a guide to mark the top and bottom of each mortise to be cut in the edge of the door.

If, on the other hand, you **are hanging** ( 吊るしている ) a new door **where there was none before** ( 以前に何もなかった所に ) , **locate** ( 位置決めする ) the hinges so the upper one is about 7 inches down from the top and the lower one about 10 inches up from the bottom.

After marking the location for each hinge, **take the door down** ( ドアを下ろす ) and **prop it** ( それを立て掛ける ) on its lock edge so you can **chisel out** ( のみで削りだす ) the mortises.

**Use** ( 使う ) the hinge leaf as a pattern to mark the outline of the new mortise, then **score** ( 印をつける ) around this outline by **tapping lightly** ( 軽くたたく ) with a sharp chisel.

To chisel out the mortise, **start** ( 始めてください ) by **making a series of shallow cuts** ( 一連の浅い切り目をつける ) across the surface, along the grain, then remove the excess wood **tapping the chisel in from the side** ( 横からノミを内側に打ち込んで ) while **holding the blade horizontal** ( 刃を平行に保ちながら ) .

**Remove** ( 取り除く ) a little bit of wood at a time to **avoid digging too deep** ( 彫り過ぎないように ) ; cut the mortise just deep enough so the face of the hinge leaf will **be flush with** ( 面一となる ) the surrounding wood.

Now **hang** ( 吊り下げる ) the door by **interlocking** ( 組み合わせる ) the hinge leaves and **tap** ( コツコツとたたく ) the hinge pins **into place** ( 正しい場所に ) .

The final step is to **install** ( 取り付ける ) the door lock or knobset.

Use one of the tubular or cylindrical models.

These locks **come with** ( ~を備えている ) special templates that **help** ( 役立つ ) you **locate** ( 位置決めする ) ( **locate**: どこに穴を掘ったら良いか穴の場所を決める、**position**: ~を動かして~の位置を決める; この場合は穴自体は動かすことができませんので **locate** を使っています。この点は非常に重要で “ 位置決め ” に **locate** を使うべきか、**position** を使うべきかをはっきり区別しなければなりません。マニュアルの中に間違った使い方が多く見られます。 ) the holes that must be bored through the door, along with other **detailed** ( 詳細な ) installation instructions.

Your dealer may also have a jig for rent which can **make** ( ~にする ) the job even easier.

These are metal guides that **clamp** ( ~に固定する ) to the edge of the door and have openings to **guide** ( 導く、助ける ) you in drilling holes exactly **where needed** ( 必要な場所に ) .

## SLIDING DOORS

Sliding closet doors are generally suspended ( 通常 ~ から吊るされている ) from an overhead track by means of ( ~ の手段で ) small wheeled hangers or roller brackets that ride on ( ~ の上に乗っている ) channels fastened ( 固定されている ) across the top of the door opening.

In some cases the doors are bypassing ( すれ違う ) --that is, there are two doors that bypass ( すれ違う ) each other and can slide full-length ( 全長をすべる ) in either direction.

Each door rides on a separate track ( 別々の溝に乗る ) (ここで separate tracks としていないのは、最初の Each の後は単数扱いという文法上の規則により、それに関連する名詞 ( 群 ) も単数にすることに注意) on the overhead channel, so they can pass ( 通過する ) each other easily.

A single sliding door (used between rooms, for example) will slide into ( 滑り込む ) a hollow pocket or cavity inside the wall, and the overhead track will have only a single channel or track for the roller brackets.

In either case ( いずれの場合でも ) there are guides on the floor (little plastic clips) that serve ( ~ の役目を果たす ) to keep ( 防ぐ ) the doors from swinging in or out as they move ( 動く ) .

In some installations the sliding doors also fold ( 折りたたまる ) (these are usually called bifolding ( 互い違いに折りたたまる ) doors).

They are suspended ( 吊るされている ) like regular ( 普通の ) sliding doors from overhead tracks with pivot guides or roller guides fastened to ( ~ に固定してある ) the top of each door or section.

These guides may be attached ( 取り付けられている ) either to the inner face ( 内側 ) of the door or to the top edge, and they move inside a track or channel attached to ( ~ に取り付けられている ) the top of the doorframe of doorjamb.

All sliding or bifolding doors that ride on overhead tracks have ( 有する ) some type of adjustment ( 調整機能 ) that permits ( 許す ) slightly raising ( 高くする ) or lowering ( 低くする ) the individual hangers, in order to compensate for ( 補正する ) minor misalignments of the door or its frame, and for the fact that many doorframes and floors are not exactly level ( 正確に平行になっていない ) .

In some cases the hangers or brackets are mounted with screws ( ネジで取り付けられている ) that run through ( 通り抜ける ) slotted holes; loosening ( ゆるめる ) these screws allows ( 許す ) one to raise ( ~ の位置を高くする ) the bracket or lower ( ~ の位置を低くする ) it, even to move ( 動かす ) it sideways slightly.

In other cases there is a threaded shaft with a nut on it that permits ( 許す、可能にする ) similar adjustments.

Directions furnished with ( ~ を備えている ) the hardware, or close study of one of the brackets, should indicate ( 示す ) how it can be adjusted ( 調整される ) , in either case.

When a sliding door tends ( ~ しがちである ) to jump ( 飛び越える ) its track, or seems ( ~ と思われる ) to bind ( 引っかかる ) at some point, the first thing you should check ( チェックする、確認する ) is the condition of the hangers or brackets at the top of the door.

Should they be ( = If they should be ) bent out of alignment or otherwise damaged ( 損傷を受けている、損傷している ) , they may need replacing, though in most cases it is simply a matter of readjusting them to correct for a slight misalignment.

( 余談 : “ Never been kissed, never been touched, but totally damaged ” という冗談があります。これは “ 今まで私はキスされたこともないし、触られたこともないけど、完全にボロボロ ” との意です。女性が使う冗談ですが、とてもおもしろいです。説明は難しいですが、キスもされたことがない純白を訴えているのですが、完全にウソだと分かる

表現です。外国的な発想ができないと、英語の冗談はとてつもらなく思われますが、外国の感覚が理解できる方は英語の冗談がとってもおもしろいことに気が付くでしょう。自分を訓練するつもりで、テクライトの英語サイトの冗談集で実力を試してください。笑い転げたら合格、首をかしげたらまだまだ修行が足りませんぞ！)

Such a readjustment can usually **be made** ( 行う ) without taking the door down, but if necessary the door can be **disengaged** ( 取り外す ) by **removing** ( 取り除く ) the floor guides at the bottom, swinging the door outward ( ドアを外に向けて揺らす ), and almost simultaneously **lifting it up** ( それを持ち上げる ) to **disengage** ( 取り外す ) the wheels from the overhead track.

**In the course of** ( ~する間に ) checking these brackets, also **inspect** ( 調べる ) the track to **see if** ( ~かどうかを見て確認する ) it has become **dented** ( へこみがある ) or **bent** ( 曲がっている ) .

If it has, **straighten** ( 真っ直ぐにする ) it by **tapping** ( たたく ) with a **hammer** ( ハンマーで ) and a block of wood, or by **bending** ( 曲げる ) it with a **large pair of pliers** ( 大きいヤットコで ) .

If necessary, take the track down and **replace with** ( ~と交換する ) a new length of the same style.

Do not **lubricate** ( ~に潤滑油を塗布する ) these tracks; oil or grease will **attract** ( 引きつける、寄せ付ける ) dirt.

The rollers or wheels **are usually made of** ( 通常~でできている ) self-lubricating nylon or similar plastic that **does not require** ( 必要としない ) further lubrication.

When doors **slide** ( すべる ) on tracks along the floor--the way most metal-framed glass patio doors work--problems with sticking, binding, or jamming usually **mean** ( ~を表している ) that this cottom track has been physically damaged or bent.

**In most cases** ( ほとんどの場合 ) you'll have to remove the door by lifting it up and then swinging the bottom out, but often there may be only one place along the track where this **works** ( 作用する ) .

**In others** ( その他の場合 ) the door can be lifted out at any point along its length.

To straighten the **bent** ( 曲がった ( 形容詞 ) ) track you simply tap with a hammer and a block of wood.

**Cut** ( 切り取る ) the piece of wood so it **forms** ( 形作る ) a snug fit inside the track, then **push it into** ( それを~に押し込む ) the track and **hammer** ( ハンマーで打ち込む ) against it from the outside.

### **Sliding** ( スライド式の ) Cabinet Doors

Small sliding doors such as those **used on** ( ~に使われている ) cabinets usually **ride on** ( ~に乗っかっている ) simple tracks **consisting merely of** ( 単に~でできている ) slotted strips of wood, or of grooved channels, either metal or plastic, along the top and bottom.

The track on the bottom **is not as deep as** ( ~ほど深くない ) the track along the top, so each door can be lifted enough to **clear** ( ~から出す ) the bottom track.

To **remove** ( 外す ) a door, you first raise it **as high as it will go** ( できるだけ高く ) , then swing the bottom edge out and **pull free** ( 引っ張って自由にする ) .

This type of arrangement is almost always **trouble-free** ( 故障しない ) , unless the door **warps** ( 反る ) or **swells** ( 膨張する ) , or dirt or some other **foreign matter** ( 異物 ) gets into ( 入り込む ) the track.

Use a **stiff brush** (固めのブラシ) or a vacuum cleaner to **remove** (取り除く) any such **obstruction** (障害物), and **spray** (噴霧する) with a silicone-type lubricant (never use oil) to **ease up** (滑らかにする) a set of doors that is (a set of doors を単数で受けていることに注意) **otherwise** (そうでない場合は) **difficult to move** (動かす).

If a door persistently **jumps out of** (～から外れる) its track when **slid back and forth** (前後に滑らす), chances are that something **is stuck inside** (～の中に挟まっている) the track, or that the track is bent.

The problem can also **occur** (発生する) when the doors are a little too short, or when the framework of the cabinet has warped slightly so that the tracks are now **a little farther apart than** (～からチョット遠くに離れている) they were originally.

Any of these defects will **result in** (結果として～になる) the door's **not extending** (届いていない) far enough into the upper track, so that the top **pops out** (飛び出る) when you **slide the door** (ドアを引く).

(余談：昔はやった漫画のポパイ (popeye) は **popped eye** (出目) から名づけられました。)

If a door persistently **jumps out of its track** (トラックから外れる) when **slid back and forth** (押したり、引いたりする), chances are that **something is stuck inside the track** (トラックに何かが引っ掛かっている), or that the track is bent.

The problem can also occur when the doors are a little too short, or when the framework of the cabinet **has warped slightly** (わずかに反っている) so that **the tracks are now a little farther apart than they were originally.** (トラックが元の位置から少しばかりずれてしまっている)

Any of these defects **will result in** (結果として～になる) the door's not extending far enough into the upper track, so that the top **pops out** (飛び出す) when you **slide the door** (ドアを引く).

**To correct this condition** (この状態を直すには), remove one of the tracks (the upper or the lower) and insert a thin strip of cardboard or plastic under it to **shim** (詰め木等をして持ち上げる) the track **up** and **bring the two slightly closer together** (二つをわずかに近づける).

The door should then **project** (突き出る) far enough into the upper track to **keep it from** (それを～から防ぐ) jumping out.

## ----- 窓の修復 -----

### REPAIRING WINDOWS

Windows are not only a means of allowing daylight to enter the house and people to see out during the day, they are also essential for ventilation in most homes. For this reason most windows are constructed so that they can be opened or closed when desired--and this is exactly what causes most window problems. A fixed pane of glass is fairly easy to seal, and there is nothing movable to get out of order. But windows that open and close are movable, so mechanical breakdowns can occur, and there is always the problem of maintaining a watertight, airtight seal that will not interfere with easy opening and closing.

With modern improvements in design, including the development of more efficient weatherstripping materials, a surprisingly good seal can be created around any hinged or sliding window. And because a single pane of glass is an extremely poor insulating material, adding storm windows, or using double-pane glass, is essential for those who want to minimize energy losses all year round (in the winter to keep heat in, and in the summer to keep it out).

Windows for the home will generally fall into one of categories: double-hung windows that slide up and down in separate channels in the window frame; sliding windows that operate from side to side so that one panel slides



behind the other; casement windows that swing open on hinges like a door; and awning windows that have sashes that are hinged along the top so that they swing out from the bottom, like awning. (Jalousie windows might be described as another version of the awning window, except that they consist of many narrow panes of glass that swing out together when the operating mechanism--either crank or a lever--is activated. There is no standardization of parts for these specialized windows, so repairs usually must be made by a professional dealer/installer.)

## REPAIRING DOUBLE-HUNG WINDOWS

Double-hung windows are far and away the most popular type of residential window in common use. Offering a choice of lowering the upper sash or raising the lower sash, they provide maximum flexibility for ventilation. They may be made of wood, metal, or vinyl plastic, or a combination of these materials, with wood still the most popular (some newer wood windows are vinyl-clad on the outside to eliminate the need for painting).

When a double-hung window starts to stick or bind, nine times out of ten the trouble is caused by dirt or paint clogging the channel in which the window sashes slide.

### Opening a Stuck Window

In most cases when a window is stuck shut--either because paint is caked around the edges or because the wood has swelled--unless the condition is really severe you should be able to free the sash by prying carefully around the edges with a stiff putty knife.

Force the blade in between the sash and the molding, using hammer if necessary, then wiggle or twist it back and forth to break the "seal" formed between the two. Work your way slowly up one side and then down the other side, twisting and wiggling the blade repeatedly in each spot before moving on to the next position. Then try opening the window again.

If it is still stuck, there is an additional step that sometimes works. Get a small block of wood, slightly narrower than the width of the window channel, and place it in position inside the channel just above the frozen sash frame. Rap this block sharply with a hammer two or three times. This will serve to spread the frame momentarily--just enough to break the sash loose so you can move it.

If you still cannot get the window open, your best bet is to pry the stop moldings off on each side of the window frame and remove the sash completely, then follow the directions on the pages that follow.

Assuming the window sash can be removed, even if it is with great difficulty, the first thing you should do is clean out the channel by scraping with a narrow putty knife, then scrubbing with a stiff brush. If paint has caked inside the channel or along the edges, use a small hook-type scraper to remove it, along with any dirt or other foreign matter that may have accumulated.

Pay particular attention to the edges of the stop molding where they come up against the face of the sash. This edge often becomes so caked with paint that moving the sash up or down becomes extremely difficult (sometimes impossible). Use a brush or vacuum to clean out dust and chips, then lubricate the channels by spraying with a silicone lubricant, or by rubbing a piece of paraffin or candle wax along the inside of each channel.

If none of these measures makes the window work any easier, it is possible that the wood has swollen. The way to cure this condition is to remove the stop moldings on each side so that you can take the bottom sash out and trim off the edges by sanding or planing.

Use a wide chisel or stiff putty knife to pry the stop moldings off, then use a scraper to clean excess hardened paint off the face of the sash. Once the stop moldings have been pried off, the lower sash will be easy to remove--just lift up slightly, then pull it toward you and up out of the window frame. The cords or chains that are attached to each side (and connected to the sash weights at the other end) can then be detached to let you get in with a small block

plane or a wood rasp to trim the edges.

If your window does not have sash weights but instead has spiral-type spring balances, you'll find that you won't have cords or chains to contend with, but you will have to unscrew the tubular balance from the window frame in order to get the sash out. You will then have to detach it from the sash at the bottom, so that you can get at the edge of the sash with a plane or rasp.

Although taking off the stop moldings on the inside will make it easy for you to remove the lower sash, it still will not enable you to remove the upper sash. This sash rides in a separate, outer channel which is separated from the inner channel by a strip of wood molding known as a parting strip. To get the upper sash frame out you will have to remove this parting strip, having first removed the lower sash and the stop moldings.

Start by lowering the upper sash as far as it will go. Then grasp the square parting strip near the top with a pair of heavy pliers. Pull straight out with a firm grip until the upper end comes free. Chances are that it won't come out easily, having over the years become virtually glued into place with layers of paint. But if you work carefully, prying along the edges with a sharp chisel or knife and pulling steadily with the pliers, you should be able to get it out in one piece (don't worry if you don't--a new parting strip can be bought readily at any lumberyard). As soon as the top of the parting strip starts to come loose, move your pliers down a few inches and start pulling again till you gradually get more of it loose.

There are two precautions to remember when you are trying to remove this parting strip: (1) Sometimes there are small nails or screws that hold it in place, so look carefully for any of these and pry them rather than between them. (2) In many instances you will find that the bottom rail of the lowered upper sash will overlap the parting strip; in that case you cannot pull it straight out along its full length, but will have to bend the top end out past the side of the window frame, then pull up and out while gripping hard in order to get the whole length out.

#### Repairing Broken or Jammed Sash Cords

Older windows have sash cords and weights, and these frequently present problems. When the upper sash keeps falling down, or when the lower one won't stay up after you raise it, chances are that the ropes connected to the sash weights are broken. These sash weights are on the inside of the window frame, riding up and down in concealed pockets on each side. Sometimes a window sash will jam or stick because the rope that goes over the pulley is jammed--the rope has "jumped the track" and come out of the pulley groove. When this happens the rope often gets caught between the edge of the pulley and the wood frame in which it is mounted, and the harder you pull, the tighter the rope gets jammed in. To correct this, raise the sash enough to give you some slack, then use a blunt screwdriver or the side of a dull putty knife to work the rope free by pushing it upward. If necessary, tap the tool with a hammer. When the rope is clear of the pulley's side, guide it over the top of the pulley and back into the groove where it belongs.

In most cases, however, the problem is not that simple. You will probably find that the rope going up and over the pulley is slack--or it will be missing entirely, because it has broken and the weighted end has fallen back down inside the window frame's pocket. To repair this properly, you will have to replace the broken rope with sash chain (sold in all hardware stores and lumberyards).

Start by removing the stop moldings on each side, then lift the sash frame completely out of the window and disconnect the cords from both edges of the sash. After the bottom sash has been removed, examine the window frame inside the channel on both sides. Along each, you should be able to discern the barest outline of a cut-out panel.

Called the pocket cover, this panel may be hard to see at first if the outline has been covered over many layers of paint. If you cannot find it, try tapping hard against the lower part of the channel with a hammer; this may cause the paint to crack around the panel and enable you to see its outline more easily.

In some cases the panel is held in place with two small screws, one at the top and one at the bottom of the panel, but in others it will just be a force fit. In still others the pocket cover may never have been completely cut out around the edge, so may have to use a keyhole saw to complete the rest of the cut. If the panel is partially covered

by the parting strip, then you will have to take this strip out first. After you have located the cut-out panel, either unscrew it or work a chisel carefully around the edges to pry it out. This will reveal an opening through which you can reach inside the pocket and find the sash weight.

If your window has no pocket cover or removable panel inside the channel--or if you just cannot find it on your window--then the only way to get at the sash weights inside the frame is to pry off the window trim around the inside. This will expose the hollow space where the sash weights are suspended.

After the pocket cover(or the inside window trim) has been removed, reach in and lift the sash weight--it will be sitting on the bottom if the cord is broken. Untie the old cord, then cut a new piece of sash chain the same length as the old cord. If you are not sure of the correct length, start with an extra-long piece of chain so that you can trim it off afterward.

Feed the new chain over the top of the pulley, starting at the outside. Let it fall down inside the pocket until you can reach through and grab the end as it comes down. Attach this end to the sash weight, using the small hooks or clips sold for this purpose, then set the sash weight back inside the pocket; make sure the free end of the chain (the end that will be attached to the sash) can't pull through by pushing a nail or large paper clip through one of the chain links on the other side of the pulley. Now install chain on the other side of the window frame in the same way.

Set the sash frame back into the window so that it rests on the sill, then pull down the free end of one chain until you have raised the weight up high enough (inside the pocket) so that it almost touches the pulley. Slide a small nail through one of the links in the chain to keep the weight from dropping (the nail will get caught in the pulley opening), then fasten the other end of the chain to the side of the sash frame in the same place where the old rope was fastened; use one or two small nails, or the clips provided on some windows.

Repeat this on the other side of the sash frame, then test by raising the sash as high as it will go--the weight should clear the bottom by at least a couple of inches.

Replacing the cords for the upper sash frame is done in much the same manner, except that you have to take the lower sash out first (even if only one cord is broken it's a good idea to renew all four cords while you are at it and have the window apart). You can then remove the parting strip on each side in order to get the upper sash out. Since this is harder than just replacing the cords on the lower sash, there is a temptation to do only the lower ones when the upper cords are not broken--but this is only delaying the day when you will have to do the whole job over again.

#### Replacing Sash Cords with Spring Tape Balances

Instead of replacing broken sash cords with chain, you can get rid of sash weights altogether--as well as the need for rope or chain--by taking out the pulleys at the top of the window frame on each side and replacing them with a half-round, drum-shaped device that has a spring-wound tape on the inside. Its outside dimensions are such that the housing will fit into the opening left when the old pulley is removed, using two small screws at the top and bottom to hold it in place.

Designed so that the unwinding metal tape builds up spring tension (to counterbalance the weight of the sash frame) as it pulled downward, these spring balances come in various sizes to match sash frames of different weights and sizes, so you have to be sure of your window measurements when buying them.

To install them you start by removing the stop molding and sash frames. Then disconnect and remove the old cords and weights. Pry out and remove the pulleys at the top of each side, then install the spring balances in the old pulley openings. A special metal bracket supplied with each balance is then attached to the side of the sash frame in the groove where the old rope originally fitted, and the free end of the spring-loaded tape is pulled down and clipped onto this bracket.

#### Repairing Windows with Tube-Type Spring Balances

Many windows installed over the past two or three decades have tubular-type spring balances, instead of the older sash weights and cords. Some of these spring balances permit some adjustment to increase tension as they

wear, but others cannot be adjusted at all and must be replaced when they start to lose tension.

If your windows are equipped with the adjustable type, here is how you can increase tension:

Hold the tube firmly with one hand and remove the screw holding it in place at the top. When the screw is out (keep holding the tube firmly because it will try to spin away from you) you can adjust the tension by turning the tube clockwise two or three turns.

If the spring is too tight (the window creeps up), then you want to decrease tension, and you do this by letting the spring unwind slowly after the screw at the top has been removed.

If the balance doesn't work at all, or is not the adjusting type, or if adjusting the tension doesn't solve the problem, you will have to replace the balance entirely. To do this you first raise the sash as high as it will go, then unscrew the brackets on the bottom of the sash frame which attach the spring balance to the sash. Now remove the stop moldings and lift the sash out of the window frame.

The new spring balances are installed simply by reversing the order--screw the upper end of the tube in place against the window channel, then replace the sash and attach the brackets that fasten the end of the spiral rod to the bottom of the sash. When buying a replacement unit, bring the old one along to make sure the new one will fit.

### REPAIRING CASEMENT WINDOWS

Unlike sliding double-hung windows, casement windows are attached by hinges so that they can swing open and be closed much like an ordinary door. Made of wood or metal, they usually operate with a lever-type mechanism that is activated by a crank on the inside. Some older models do not have cranks, but rather a rod or lever that you merely push to open or pull to close. The rod slides through a pivot bearing that in turn slides in a track on the sill.

When a casement window starts to stick and bind, the trouble almost always has one of four causes: (1) The hinges that support the window need lubrication. (2) The window frame's edges are caked with paint and/or dirt. (3) The opening and closing mechanism--crank, rod, or tracks in which the guides slide--needs lubrication. (4) The rod or pivot lever that actually pushes the window open and pulls it closed has been bent.

Start by lubricating the hinges or pivoting supports on which the window swings, using a few drops of lightweight oil and working it in by opening and closing the window a few times. Next, lubricate the crank mechanism that activates the rod or lever that opens and closes the window. To do this you will have to take off the handle assembly (it is held in place by two screws), then clean out the gears and the inside of the case and repack with fresh grease.

If the window still doesn't work right, swing it all the way open and inspect the track along the bottom edge of the sash (on some wood casement windows this track will be on the inside face of the sash, not under the bottom). Use a wire brush to clean out dirt, paint, or encrusted grease, then rub a little fresh white grease (Vaseline works fine) along the track.

When a casement window swings open easily until the last inch or so, but then "gets stubborn", the first thing you should suspect is an accumulation of dirt and hardened paint along the edges of the sash frame, or inside the window frame itself where the sash contacts the casing. Use steel wool and a wire brush to clean off any such accumulation on metal frames, and a scraper and sandpaper for wooden frames.

If none of these steps makes the window work easily, the trouble is most likely either inside the crank mechanism, or in the actuating rod slide (where the end of the rod slides along the track on the bottom of the sash frame). If the rod or lever is bent, or if the part that slides along the track is sticking, you can try, in the first case, to straighten the rod, or, in the second, to unstick the sliding track and guide by cleaning and lubricating.

One sure way to make certain whether or not the problem lies with the crank mechanism, rather than with the slide or the rod as described above, is to disconnect the rod from the sash frame. You can usually do this by swinging the window open as far as it will go, then slipping the sliding guide out one end of the track (depending on its style, and on which way the window swings, the guide will come out of either the left or right end of the track).

After the rod or arm is disconnected, turn the crank handle to see if it works easily. If it does, you know the problem lies with the track or guide. If it doesn't, then you know the crank mechanism is the trouble. Take the whole thing off (it is held in place by two screws), then examine the gears or other moving parts are bent, or if the teeth are chipped and broken.

If everything looks okay, flush out the mechanism with kerosene or paint thinner, then squirt some fresh oil inside and try again. If the handle still does not work easily, your best bet is simply to replace the entire mechanism with a new unit. You can buy it at many large building supply outlets and home centers, or your local dealer should be able to tell you where you can order one. Bring the old one along to be certain you get a new one that will match.

Casement windows are often plagued with one other type of problem--drafts caused by the fact that the window doesn't shut tight enough. This is particularly true of metal casements, which have a lever-action handle with a hook-shaped lock on the outside that swings up through a slot to engage the sash frame. The mechanism is supposed to pull the sash up against the window frame and create a tight seal, but in some cases it does not pull tight enough. To correct this condition, remove the handle from the inside, then slide a shim or spacer made of cardboard or plastic behind it. The effect will be to move the handle slightly farther inward, and thereby apply greater closing pressure as the hook part swings inward.

#### Installing New Window Channels

One way to rejuvenate an old double-hung window with broken sash cords, or with poor weather stripping and hard-to-move sash, is to install replacement channels that eliminate the need for weights and cords--or balances of any kind.

Sold in home centers and lumberyards, these replacement channels come with permanent weatherstripping, as well as a friction-type channel that holds the sash in position regardless of where you leave it. They are available in various lengths to fit most standard-height windows.

You install them by first removing the stop moldings on either side, then taking out the lower sash and the upper sash, disconnecting the cords or chains attached to the sides of each. Taking out the upper sash will usually require removing the parting strip first. With both sashes out, the cord pulleys at the top of each channel are removed next, either by prying them out or simply by driving them into the hollow space behind the frame with a hammer. Don't worry about the holes that remain--these will be covered by the new channels.

Now use sandpaper to clean the edges of each sash and scrape off any ridges of paint that remain. Then, stand the two sashes up behind each other and place one channel on each side. Press everything firmly together and lift the whole assembly up and set it in place inside the window. Set the bottom ends of the channels in place first, then tip the upper ends into position. The channels are then fastened in place against the sides of the window frame with screws--first at the top, then at the bottom. The job is finished when you replace the stop moldings on each side (they are no longer needed to hold the sash in place, just to give the frame a finished look).

#### REPAIRING SLIDING WINDOWS

The most common cause of trouble with a horizontal sliding window--wood or metal--is dirt or paint inside the track, or on the edge of the sash frame. This is especially true in older houses with wood windows on which multiple layers of paint have built up over the years.

Sometimes you can correct the problem by cleaning out the track with a wire brush, or by scraping the edges of the movable sash frames with a narrow putty knife. In most cases, however, you will have to take the window sash out, then use a scraper and some sandpaper to remove the hardened paint from both the window frame and the sash frame. (Horizontal sliding windows can be removed by lifting up and swinging the bottom end out of the track, then pulling the top out.) Spray the track and the edges of the sash with silicone lubricant, then replace the sash.

Lubrication is also the answer on metal sliding windows--after tracks and sash edges have been thoroughly cleaned with fine steel wool and a wire brush. Use a silicone spray or rub with paraffin, but don't use oil in this case--it will only attract and hold dirt that will then cake up and cause more trouble.

If lubrication doesn't solve the problem, then the track is probably damaged or bent. Examine the inside of the track carefully to find the damaged section. If it is just bent in one place, you should be able to straighten it with a hammer and a small block of wood, or by using a pair heavy pliers. If it is bent in many places, or is cracked and broken, you should replace the entire window frame.

#### REPAIRING AWNING WINDOWS

These windows are practically the same as casement windows, except that they are hinged along the top and thus

swing out from the bottom, instead of from one side or the other. Most of the cleaning and lubricating techniques described above for casement windows will also apply to awning windows.

While most awning windows have crank mechanism similar to the ones used on casement windows, some have a scissors-type lever-arm action that helps support the opened window sash. Like the operating levers or rods that are used on a casement window, the pivot points on the operating mechanism should be lubricated regularly with a lightweight penetrating oil. Don't forget the pivoting arm at the side that rides up and down in a track as the window frame is hard to work, cleaning and lubricating the track in which the end of this arm rides is all you need to do.

## REPLACING BROKEN PANES OF GLASS

The hardest part of replacing a windowpane is, more often than not, getting the broken pieces of the old glass out and then removing the old hardened putty. For safety's sake, you should wear heavy work gloves to protect your hands, and when pulling the broken pieces of glass out of the frame, play safe and grab with an extra piece of cloth (in addition to the gloves) or with a pair of pliers before you start twisting or pulling.

After the broken pieces of glass have been removed, scrape out all of the old, hardened putty or glazing compound, using a narrow chisel or a sti putty knife. If you find the putty to be exceptionally hard and stubborn, you can make things easier by first applying heat to soften it, using either an electric heat lamp or a portable propane torch. An electric heat lamp will take longer, but it is safer and less likely to scorch the wood or the surrounding paint. Either way, it is a good idea to keep a bucket of water or a small fire extinguisher handy--just in case.

After the glazing compound has been removed, clean out the rabbet thoroughly (the rabbet is the groove or recess into which the glass fits), either scraping or rubbing with steel wool. Then coat the exposed wood inside the rabbet with boiled linseed oil, or with a thin coat of exterior primer. This seals the wood and helps to ensure a better bond (otherwise the wood will absorb the oil in the glazing compound, which then, in time, dries out excessively). If the window is metal, make sure you clean off all rust and corrosion and apply a coat of metal primer before glazing.

When measuring for the new pane of glass, make sure you allow for a slight amount of clearance on all sides--usually about 1/8 inch less around all four sides. Bring these measurements to your local dealer (be sure you tell him you have already made the needed allowance for extra clearance), and have him cut a new piece to size.

A word of caution here about the kind of glass to buy: If the window or door is in location where it can be easily broken (by children throwing balls, for example, or by accidental encounters with large packages or big dogs) you should buy safety glass or tempered glass, or instead of a glass get a clear plastic such as one of the break-resistant acrylics. In many communities there are laws or building codes that require such materials for hazardous locations.

Before installing a new pane of glass you should first apply a layer of glazing compound behind it to ensure a waterproof seal. Roll a wad of glazing compound into a long thin strip (about 1/8 inch in diameter), place it along the rabbet where the glass will go, then press the pane of glass into place, shoving in hard enough to squeeze the compound flat, with the excess oozing out around the edges.

Glazier's points--triangular-shaped bits of metal--are what actually hold the glass in place, not the glazing compound. Use about two points on each vertical side in smaller windowpanes, more on the larger ones. You install glazier points by pushing them in with the blade of a screwdriver or sti putty knife, or you can buy the kind that has a slight flange at one side and, very carefully, tap them in with a tack hammer.

The last and final step of window replacement is applying the glazing compound around all four sides to seal the edges of the glass with an airtight and watertight fit. The easiest way to do this is to roll the glazing compound into a long strip--a "bead" slightly thicker than a pencil--then press it firmly into place with your fingers. Knead it down so that it makes firm contact with both glass and frame. You are then ready to form a neat bevel with your putty knife, smoothing off any excess in the process.

Holding the blade at such an angle to the surface that only a corner of the blade contacts the glass, press down firmly while dragging the blade smoothly along the surface. This will shave off excess compound so that it can be peeled away with your other hand. The idea is to form a neat beveled edge that will be both flush with the wood on

the outside and tight against the glass on the inner side. If you have trouble getting the compound smooth because the knife tends to "drag" or crumple the surface, try heating the knife slightly--the warm blade will make the glazing compound easier to finish smoothly.

The glazing compound should come up just high enough on the glass to cover the wood that is visible through the glass, but not high enough so that you see the edge of the glazing compound from the inside.

Metal-frame windows are glazed in much the same manner as wood windows except that you don't use glazier's points to hold the glass in place. Instead, there are special clips that snap into the channel in the window where the glass fits. Some windows have plastic splines that hold the glass in place instead.

### Cutting Glass

Although all hardware stores and lumberyards will cut glass to size, there are times when you may want to cut your own--for example, when trimming down a large piece for a small pane, or when using scrap pieces for a picture frame. Fortunately, there are only two tools you'll need: a glass cutter and a straightedge. A pair of square jaw pliers may also come in handy if you have to break off small strips, though this is not always necessary.

Lay the piece of glass on a flat surface that you have covered with several layers of newspaper (to serve as padding). Then place the straight-edge along the line of cut and hold it down firmly with one hand. Now grip the glass cutter with your thumb and index finger, and dip the cutting wheel into a little kerosene or very light machine oil.

You make the cut by scoring the glass only once with a single stroke, bearing down with firm, steady pressure during the entire length of the stroke. Do not bear down hard--just press with moderate pressure and move the cutter along steadily. The idea is to score the surface of the glass with a single smooth stroke so that the cutter makes a crisp, crackling sound and leaves a uniform score mark without skipping and with no tiny chips flying off the surface. Going over the stroke almost always results in breaking or chipping the glass at some point. Now place a pencil, dower, or strip of wood under the glass so it is positioned directly under the score mark you've just made. Then press down on both sides of the glass, more smartly on the smaller piece. It should snap off neatly along the line of cut. If any narrow slivers remain, grasp these with a pair of pliers and snap off by twisting up or down.

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### ----- テーブルの組み立て -----

#### CAUTION

To ensure safety, do not attempt to assemble product without following instructions carefully. Proper and complete assembly, use, and supervision are essential for proper operation and to reduce risk of accident or injury. A high probability of serious injury exists if this billiard table is not installed, maintained, and operated properly.

This table is contained in to three separate cartons:

Carton #1

Carton #2

Carton #3

(master table carton): Contains set of aprons, set of rails, main frame, owner's manual, cloth kit also hardware kit and grout kit.

: Contains two pedestals.

: Contains set of slate with slate liner.

#### INSTRUCTIONS:

CAUTION!

NOTE:

See Fig.1.

Unpack master carton:

Put two side beams, two end beams and two cross beams top face down on flat floor, ( Top of frame identified by painted marks. Orient frame members accordingly.) Using sixteen hex head lag screws (#13) and sixteen washers (#14) attach two cross beams b lign with pre-drilled holes and notches. Attach end beams to side beams using pre-drilled holes.

SIDE BEAMS MAY HAVE EXTRA HOLES NOT NEEDED FOR THIS TABLE ASSEMBLY, PLEASE FOLLOW INSTRUCTION CAREFULLY.

1. etween two side beams. A

2.

Place seam line of laminate inward, See Fig.2.

3.

See Fig.2 and Fig.3.

4.

Clean slate and liner completely of dust and wood chips. Any dirt and debris will prevent center section and end sections from aligning properly.

NOTE: Be sure there are no gaps between center slate and end slates.

Unpack slate pack.

Position slate on top of main frame, Place center slates and liner on center of main frame, line up end slates on each end. Attach slate with liner follow by pre-drill holes on slate and liners.

5.

Fig.5

6.

(See Grout Kit and Instructions below.)

Shim and Grout slates with kits provided.

SHIMMING INSTRUCTIONS:

GENERAL RULES

STEP-BY-STEP SHIMMING PROCEDURE

Accomplish leveling of slate with as few shims as possible.

Slate is brittle. Do not tap with a hammer or tighten screws unreasonably. Slate will not be able to compress. most shim up to level. Shims are meant only to raise the low places at the seams and ends. Do not assume the floor is level. Most leveling can be accomplished by working with frame.

If power tools are used, be sure only enough torque is used to do the job.

Seams can best be checked by passing ones finger over seam joint and feeling if it is flush.

All screws must be tightened after shimming.

No two sets of slate are exactly alike. Some sets require more, or less, shimming that others.

Be sure table is set in its final location.

Table must be as level as possible before shimming. Large di erences in levelness must be corrected by raising or lowering frame with shim stock. DO NOT ASSUME FLOOR IS LEVEL!

Tighten down all slate mounting screws.

Check with a carpenter ' s level to determine which slate end is level, and use finger tips to locate uneven spots at seams. Loosen screws at these points and see if slate comes up to flush. If so, detach individual shims from sheet shipped with this table and place under these areas. Place shims next to screws.

Lay a straight edge across seams to be sure slate pieces are flat in relation to each other.

After top surface of slate is flat and level, all screws must be snugged down in tight position. DO NOT OVERTIGHTEN SCREWS! SLATE IS BRITTLE! Check these screws before beginning grouting.



#### GROUTING INSTRUCTIONS:

Clean top of slate with damp cloth. **DO NOT USE TOO MUCH WATER!**

Prepare Plaster of Paris furnished with this table. Add water sparingly. Do not mix all the powder at first; save some in case needed to thicken initial mixture. To mix: Pour 1/3 to 1/2 of grout into container; slowly add drops of water while stirring. Grout should be a thick paste when mixed (will not drip off putty knife). If grout is too thin, slowly add more powder.

Using a putty knife fills both seams and the four countersunk holes in the center playfield area. (Only the countersunk holes in center of table need to be filled since rails will cover other holes.) Do not use more plaster than necessary.

Let plaster dry. Read the rest of this manual while waiting!

Using medium grit sandpaper and sanding block, sand plastered areas smooth and flat. **RECHECK THESE AREAS TO MAKE SURE THEY ARE FLAT.** Re-plaster if low places are found at countersunk holes or seams.

Cloth bed and cushions. Attach with staples or tacks as required.

Complete rail assembly, mount two center castings and four corner castings using twelve Hex bolts (#1), twelve split lock washers (#2), twelve std. (#3) washers and twelve square nuts (#4) and using twelve screws (#19) for additional support.

Complete aprons assembly. Using sixteen screws (#7) and four #17

See "Murrey bed and cushion clothing instructions" inside cloth kit.

See Fig.6 For details.

See Fig.7

corner posts (attach two side aprons and two end aprons and attach aprons to rails using twelve 85 degree brackets (#8) with thirty-six screws (#7).

Attach rail assembly and apron assembly using Thirty-six wood screws (#7) and twelve 85 degree brackets (#8) See Fig.7 and Fig.8.

See Fig.8

Using eighteen flat washers (#6), eighteen lock washers (#2), and eighteen hex head bolts (#15), attach rails to slate and slate liner.

Measure play area. Left and right rail assemblies and end rails should be parallel and perpendicular to each other, respectively.

#### WARRANTY DURATION:

#### WARRANTY COVERAGE:

#### WARRANTY PERFORMANCE:

#### NOTE:

#### WARRANTY DISCLAIMERS:

#### LEGAL REMEDIES:

This Murrey billiard table is warranted to the original consumer purchase for a period of 2 years against workmanship defects in the cabinet. It also warrants a period of 90 days against workmanship defects in the cloth, rubber and pockets from the original purchase.

ESCALADE SPORTS warrants to the original Consumer Purchaser that any Product of its manufacture is free from defects in material and workmanship when used for the intended purpose under normal use and conditions.

**THIS WARRANTY IS VOID IF THE PRODUCT HAS BEEN DAMAGED BY ACCIDENT, UNREASONABLE USE, NEGLIGENCE, IMPROPER SERVICE, FAILURE TO FOLLOW INSTRUCTIONS PROVIDED WITH THE PRODUCT OR OTHER CAUSES NOT ARISING OUT OF DEFECTS IN MATERIAL AND WORKMANSHIP.**

During the above warranty period, ESCALADE SPORTS shall repair or replace with a comparable model, and/or product, or component thereof, for any product which may prove defective under normal use, proper care

and which our examination shall disclose to our satisfaction to be thus defective, please contact our Warranty Dept.

Or Write us at:

Or E-mail us at:

Other than shipping requirements no charge will be made for such repair or replacement of in-warranty Products.

ESCALADE® SPORTS strongly recommends that the Product is insured for value prior to mailing.

Manufacturer warrants for ten (10) years, Escalade Sports will repair the playing surface of this table, free of charge, if it fails to remain flat, within a tolerance of + or - 30/1000 of an inch, measuring from any flat plane within the playing surface. Cloth not included in warranty. Should this product become defective due to material or workmanship within period, contact the Customer Service Department.

This warranty is not transferable and does not cover normal wear and tear, or damage caused by improper handling, installation or use of this product. This warranty is also void if product is in any way abused, damaged, or modified from its original state, or if used for other than indoor residential use. This warranty gives the consumer specific legal rights, and may have other rights which may vary from state to state.

ANY IMPLIED WARRANTIES ARISING OUT OF THIS SALE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE WARRANTY PERIOD. ESCALADE® SPORTS SHALL NOT BE LIABLE FOR LOSS OF USE OF THE PRODUCT OR OTHER CONSEQUENTIAL OR INCIDENTAL COSTS, EXPENSES OR DAMAGES INCURRED BY THE CONSUMER OF ANY OTHER USE.

Some states do not allow the exclusion or limitation of implied warranties or consequential or incidental damages, so the above limitations or exclusions may not apply to you.

This warranty gives you specific legal rights and you may also have other rights, which may vary, from state to state.

The following sections provide information on functionality common to all ProEssentials objects.

## Exporting

All ProEssentials objects have access to the Export Dialog. See AllowExporting.

The export dialog allows the user to export:

----- ソフト関係 -----

### Format

Destination

### MetaFile

Clipboard, File, and Printer.

### Bitmap

Clipboard, and File.

JPEG

Clipboard, and File.

PNG

Clipboard, and File.

Text / Data

Clipboard, and File.

#### MetaFile Format

The MetaFile format is a good method to export the objects image. The metafile will be able to adapt to varying output resolutions. However, since the image has textual attributes, the image should not be stretched or squeezed. If so, the text will also be stretched or squeezed. If re-sizing, be sure to maintain the length to width aspect ratio.

#### Bitmap Format

The Bitmap format is the most common image export format, however, it uses a large amount of memory and doesn't necessarily take advantage of high resolution printers.

#### JPEG Format

Similar to the Bitmap format, the JPEG format is compressed to take less memory but still doesn't take advantage of high resolution printers. This format is widely used on web pages. This format is best suited for photographs because line art will be fuzzy due to compression. A better format is the PNG.

#### PNG Format

Similar to the Bitmap format, the PNG format is compressed to take less memory but still doesn't take advantage of high resolution printers. This format is gaining use on web pages and is most similar to the GIF format. This format will produce the best looking compressed raster images.

#### Text / Data Format

When the Text / Data Only format is selected and the user presses the Export button, a Text / Data Export Dialog is invoked.

The Text / Data Export Dialog allows the objects information to be exported in a variety of ways. The user selects the desired data and whether or not to include labels. The Data to Export section will change depending upon the object. The user then chooses either a Table or List style and output precision.

#### IMPORTANT TIP

The text export dialog is a useful tool for the developer as well as the end-user. If you are having trouble programmatically passing data into the object, you can use this export dialog to export the data into Notepad to verify what is currently inside the ProEssentials object. Its best to export in a List Style with Maximum Precision. This will usually shed light on the problem and allow you to adjust your logic to properly pass the data into ProEssentials. If you are having trouble passing data, please use this tip before calling for technical support. Our support staff will likely ask you to try this approach to resolve the problem.

#### Clipboard Destination

The Clipboard will be the most common destination. It provides a quick method of sharing information with other Windows applications.

#### File Destination

When exporting to a File, the user must supply a filename via a SaveAs File Dialog. It is not shown because it is a standard SaveAs Dialog.

#### Printer Destination

When the Printer destination is selected and the user presses the Print button, a Print Dialog is invoked.

The Print Dialog allows the user to select a printer, adjust printer setup, and if the object has a vertical scrollbar, allows the user to adjust Scrolling Subsets Print Options. The Scrolling Subsets Print Options enables the user to export multiple pages. The object is automatically scrolled one page at a time, and each page is in turn sent to the printer. This enables all the information of the object to be printed clearly and easily. See PEprintgraph.

#### Object Size Parameters

The Object Size section changes depending on the Format and Destination selected. When exporting a Bitmap, JPEG or PNG, the only unit size available is pixels. When exporting to the Printer, No Specific Size changes to Full Page. When exporting Text / Data, the Object Size section is hidden.

## Maximization

All ProEssentials objects have maximization capabilities. Maximization is the process of copying the object into a modal dialog box **enlarged** to fit the screen. When the user is finished working with the maximized version, they can click the title bar or press Esc to return to the normal sized object. See AllowMaximization.

### IMPORTANT NOTE

The Maximization mechanism creates a copy of the object and maximizes this copy. This allows the underlying control to still receive data in a real-time data monitoring application. However, this also means that there is no DataHotSpot feedback between the maximized object and your program. To maintain DataHotSpot feedback, you will have to maximize the actual object by adjusting the Width and Height properties for VB/Delphi developers or via the MoveWindow API if you are a C/C++ developer.

## Help

All ProEssentials Dialogs have Help buttons which access "PEGRAPHS.HLP". This help file contains end-user information about the use of ProEssentials objects. Its pretty basic but if needed, Gigasoft provides the help context IDs outputted so that you can integrate your own help. Or, you can set NoHelp to TRUE to disable all help menus and buttons.

The ProEssentials provide everything necessary to adjust the contents of "PEGRAPHS.HLP". This enables the developer to adjust the help text to target a particular audience.

The property HelpFileName allows the developer to change the file which gets opened when the user selects a ProEssentials Help button or menu item.

## Mouse Interface

ProEssentials objects respond to the mouse as follows.

Right-Button Single-Clicking invokes a popup menu.

Left-Button Double-Clicking will show the customization dialog. 3D Scientific Graph objects will auto-rotate upon Double-Clicking.

Left-Button Single-Clicking will give the object the input focus. If user clicks on a hot-spot, the corresponding event or notification message will be invoked.

Left-Button can be used to control scrollbars.

## Keyboard Interface

ProEssentials objects can also receive the following keyboard commands:

Key Stroke

Result

SPACEBAR

Shows the customization dialog.

Q

Shows a popup menu.

S

Switches between monochrome and color viewing styles.

T

Toggles between custom and original parameters.

X

Shows the export dialog.

M

Maximizes the object to fit the screen.

P

Shows the print dialog.

D

Shows the Text/Data export dialog.

ARROWS

Scrolls both vertical and horizontal scrollbars by one line.

PG-UP/PG-DOWN

Pages vertical scrollbar.

SHIFT+PG-UP

Pages horizontal scrollbar to the right.

SHIFT+PG-DOWN

Pages horizontal scrollbar to the left.

HOME

Moves vertical scrollbar to its first position.

END

Moves vertical scrollbar to its last position.

SHIFT+HOME

Moves horizontal scrollbar to its left-most position.

#### SHIFT+END

Moves horizontal scrollbar to its right-most position.

Version 5 adds much more control over the built-in user interface. All built-in menus and dialog tabs can be disabled if needed. There is also a new mechanism to add your own menu items if needed. See CustomMenuText. Also see Common Question 38. Within the demo, see example 127.

AllowUserInterface can be used to disable all mouse and keyboard interfaces or just the mouse or just the keyboard portions.

----- イラクの生物兵器計画の査察状況 -----

## STATUS OF VERIFICATION OF IRAQ'S BIOLOGICAL WARFARE PROGRAMME

### Executive Summary

1. Iraq did not acknowledge its proscribed Biological Warfare (BW) weapons programme until July 1995. From the first UNSCOM inspections in 1991 until 1995 Iraq denied it had a BW programme and has taken active steps to conceal it from the Special Commission. These steps included fraudulent statements, forged documents, misrepresentation of the roles of people and facilities, and other specific acts of deception.
2. Since its first revelations in July 1995, Iraq has submitted three "Full, Final and Complete Disclosures" (FFCDs) of its proscribed biological programme. The first of these, presented in August 1995, was declared null and void by Iraq itself. The second, submitted in June 1996, was subjected to intensive efforts to verify its accuracy and completeness through eight inspections and other technical discussions. In March 1997 an international panel of experts reviewed that FFCD and recommended its rejection because of the inadequacy of the material presented throughout the document.
3. In September 1997, Iraq submitted its third "final" FFCD since the July 1995 disclosures. This FFCD contained essentially no new significant information from the previous one that the Commission had rejected as incomplete. A panel of international experts reviewed it in September 1997 and considered it as deficient in all areas. Iraq however argued that it had not been given an adequate opportunity to present its case to the UNSCOM assembled experts and at Iraq's request, a Technical Evaluation Meeting (TEM) between Iraq and a Commission assembled panel of international experts convened in Vienna in March 1998. Iraq did not present any new information at that meeting and the experts therefore reviewed the same material for a third time.
4. The TEM team reviewed the entire FFCD, and concluded it was deficient in all areas. In summary:

**Weaponization** There is considerable uncertainty regarding weaponization. The Iraqi account of the Al-Hussein BW warheads cannot be reconciled with the physical evidence. On R-400 bombs, there are inconsistencies in the account and the experts had no confidence in the number filled or how many were filled with particular agents.

**Production** Bulk BW agent production appears to be consistently understated. There are discrepancies between production capacity and the amounts of bulk agent declared to have been produced. The lack of documentation

contributes to a low level of confidence in the Iraqi account of agent production quantities.

Acquisition The declaration on imports of raw materials and equipment is incomplete.

Planning All aspects of planning are omitted. This ranges from the circumstances surrounding the decision to commence the programme, the planning and the direction of the programme, the reasons for decisions and the individuals and organizations involved. The Commission considers that a knowledge of planning and decision-making is important because without it, determining the scale and the scope of the programme is not possible.

Research and Development (R&D) R&D is said to be unplanned, but the evidence shows that the programme was thoroughly planned.

History of Iraq's BW Programme Iraq provided a selected and incomplete history of the BW programme.

Organizations The FFCD generally lacks information concerning organizational information from the highest levels down. There is also a lack of information on the military (or intelligence) involvement in the programme in spite of the fact that the programme resulted in the deployment of weapons such as bombs and missiles.

Concealment and Deception Since its disclosures in 1995 Iraq has continued to deceive the Commission and conceal parts of its BW programme. This includes efforts to hide documents, media, equipment and operating locations.

5. At Iraq's request another review of the FFCD by a team of international experts was conducted in Baghdad in July 1998. By agreement with Iraq and the Special Commission this team focused on those elements directly related to the material balance: weapons, bulk agents and materials such as bacterial growth media. This team concluded:

Weapons On weapons the team concluded that the material balances and their sub-components (production, filling and destruction) declared in the FFCD for biological bombs (R-400) and Al-Hussein warheads, could not be verified. Furthermore the account in the FFCD on biological spray devices, modified drop tanks and the aerosol generator (Zubaidy device), could not be verified.

BW agents The material balances for bulk BW agents and their sub-components (production, filling, losses and destruction) for all declared agents (Clostridium botulinum toxin, Bacillus anthracis spores, aflatoxin Clostridium perfringens spores and wheat smut) could not be verified.

Media The media material balance and its sub-components (acquisition, consumption, losses and destruction) could not be verified.

FFCD Iraq's FFCD in its totality cannot be verified. The team also expressed the view that verification cannot be achieved in the present circumstances whilst the Commission has an incomplete understanding of the philosophy of the programme including the military and other (such as security service) requirements for biological weapons. Without such an understanding, the Commission has an inadequate basis on which to assess whether the Iraqi account is complete. Accordingly, the FFCD in its present form, is an inadequate document for verification purposes.

6. Both the Vienna TEM and the experts' review in Baghdad concluded that Iraq's biological FFCD is an inadequate document for verification purposes. The FFCD does not provide a coherent or comprehensive account of Iraq's BW programme and lacks any supporting framework such as descriptions of planning, objectives, policy and organizations involved. The experts found that much of the information collected by the Commission to verify the FFCD in fact contradicts statements therein, particularly the evidence regarding weaponization, the quantity of agents produced and the media balance. The hundreds of interviews that the Commission has conducted with Iraqi officials also fail to provide a comprehensive account and even allowing for errors of memory, often contradict the account in the FFCD.

7. Supporting documentation is generally lacking. Iraq explains that this was because a decision was made in 1991 that all documents relating to the BW programme were to be destroyed. After the departure of Lt. Gen. Hussein Kamel Hassan in August 1995, the Commission was told that some documents had however been saved and about 200 documents relating to the BW programme were recovered by the Commission from buildings at the Haidar Farm. Most of these documents related to research and did not add a great deal to the Commission's overall understanding of the programme. In addition to these documents, since 1995 and after much prompting by the Commission, Iraq has provided a number of additional documents of variable quality. Most of them are peripheral



to the verification process and are open to various assessments. Thus, except in some limited areas, documentation provided by Iraq is grossly inadequate for verification purposes.

8. On technical, industrial and scientific developments of Iraq's BW programme, it has not been possible to compile a comprehensive assessment because Iraq has not been transparent in its FFCD nor in its clarifications of the account of its BW programme.

9. The review also attempted to quantify levels of confidence in the accounting for the various elements of Iraq's BW programme. In reaching its assessment, the Commission has taken into consideration the quality of information in its possession; documentary, physical, and personal testimony provided by Iraq; and the correlation of this information with other information such as that provided by Iraq's former suppliers, from inspections or otherwise obtained by the Commission.

10. The Commission has a degree of confidence in the accounting for some proscribed items which Iraq presented for verification and disposal. This includes, for example: the destruction of buildings, and equipment at Al-Hakam, the destruction of large quantities of growth media acquired for the programme; and evidence that R-400 aerial bombs and Al-Hussein warheads contained BW agents and consequently that *Bacillus anthracis* spores and *Clostridium botulinum* toxin were indeed weaponized.

11. The Commission has far less confidence in the accounting for proscribed items declared by Iraq as having been unilaterally destroyed. These include, for example: the number and fill of R-400 aerial bombs destroyed at Al-Azziziyah; the number and fill of BW Al-Hussein warheads destroyed; and the fate of the biological warfare agent to be used with drop tanks.

12. The Commission has little or no confidence in Iraq's accounting for proscribed items for which physical evidence is lacking or inconclusive, documentation is sparse or nonexistent, and coherence and consistency is lacking. These include, for example: quantities and types of munitions available for BW filling; quantities and types of munitions filled with BW agents; quantities and type of bulk agents produced; quantities of bulk agents used in filling; quantities of bulk agents destroyed; quantities of growth media acquired for the programme; and quantities of growth media used/consumed. In addition the Commission has no confidence that all bulk agents have been destroyed; that no BW munitions or weapons remain in Iraq; and that a BW capability does not still exist in Iraq.

13. From 1987 onwards Iraq undertook pilot and industrial scale production of BW agents. Iraq denies any parallel activity to develop weapons capable of delivering the BW agents it was producing. During inspections, Iraq has stated that its policy was to evaluate weapons that had been developed for Chemical Warfare (CW) purposes, to establish whether they could be adapted for BW agents. It is difficult to accept that Iraq claims it had not initiated a BW-specific weapons programme in the late 80's, possibly in the MIC Naval and Aerial Bombs Section, in order that efficient and effective dissemination weapons be made available. It is not clear whether such weapons have been developed and are not disclosed, or have been partly developed, not reaching a stage where they could be manufactured.

14. Several other outstanding issues also remain to be resolved. These issues are related: to the scope and extent of R&D activities; the acquisition of supplies and equipment; the involvement of military and other agencies in the BW programme; and deception and concealment of the BW programme.

15. Iraq has not provided evidence concerning the termination of its offensive BW programme. The evidence collected by the Commission and the absence of information from Iraq, raises serious doubts about Iraq's assertion that the BW programme was truly "obliterated" in 1991 as it claims.

16. Abbreviations

Agent A.....Clostridium botulinum toxin

Agent B.....Bacillus anthracis spores

Agent C.....aflatoxin

Agent D.....Wheat Cover Smut

Agent G.....Clostridium perfringens spores

Al-Hakam.....Al-Hakam Factory for Production of BW agents

ATCC.....American Type Culture Collection

Bt.....Bacillus thuringiensis

BW.....Biological Warfare

CN.....1-Chloroacetophenone, riot control agent

CS.....o-Chlorobenzylidene Malononitrile, riot control agent

CW.....Chemical Warfare

DIALOG.....Computer Database

FFCD.....Full Final and Complete Disclosure

FMD.....Foot and Mouth Disease Vaccine Factory

Haidar Farm.....Storage site for documents of Iraq's weapons programmes

IAEA.....International Atomic Energy Agency

kg.....kilograms

km.....kilometres

Kimadia.....State Company for Drugs and Medical Appliances Marketing

LC.....Letter of Credit

MIC.....Military Industrial Commission

MOD.....Ministry of Defence

NMD.....National Monitoring Directorate

R&D.....Research and Development

SCP.....Single Cell Protein

SCR.....Security Council Resolution

SEHEE.....State Establishment for Heavy Engineering Equipment

SEPP.....State Establishment for Pesticides Production

SOTI.....State Organization for Technical Industries

TEM.....Technical Evaluation Meeting

TSMID.....Technical and Scientific Materials Import Division

TRC.....Technical Research Centre

UNSCOM.....United Nations Special Commission

VRL.....Veterinary Research Laboratories

#### Introduction

17. Iraq's offensive BW programme was among the most secretive of its programmes of weapons of mass destruction. Its existence was not acknowledged until July 1995. During the period from 1991 to 1995 Iraq categorically denied it had a biological weapons programme and it took active steps to conceal the programme from the Special Commission. These included fraudulent statements, false and forged documents, misrepresentation of the roles of people and facilities and other specific acts of deception. For example, Iraq claims to have destroyed much of the documentation and overt evidence of the programme. At the same time Iraq maintained other aspects of the programme such as the equipment, supplies (e.g., bacterial growth media), and personnel as an intact entity and facilities of the programme such as the Al-Hakam facility that produced BW agents.

18. In 1995, when Iraq was confronted with evidence collected by the Commission of imports of bacterial growth media in quantities that had no civilian utility within Iraq's limited biotechnology industry, it eventually, on 1 July 1995, acknowledged that it used this growth media to produce two BW agents in bulk, botulinum toxin and Bacillus anthracis spores, between 1988 and 1991. It was not, until August of 1995, however, that Iraq acknowledged that it had weaponized BW agents, and had undertaken weapon tests from 1987 onwards. This admission only occurred after Lt. Gen. Hussein Kamel Hassan departed. Shortly afterwards, Iraq released a considerable quantity of documents concerned with its weapons of mass destruction programmes. The documents relating to biology represented just 200 documents with some pages out of a total of more than a million pages. Many of the biological documents were scientific reprints from foreign journals. Clearly, they represent only a minor portion of a BW programme that ran from 1973 until at least 1991.

19. Since July 1995, the Commission has conducted 35 biological inspections directly or indirectly related to investigations of Iraq's proscribed BW programme. In addition, two inspections devoted to the destruction of sites, known to be integral components of the programme, have been undertaken. The past programme investigations have concentrated on issues that are directly related to disarmament and have attempted to validate these aspects of Iraq's Full Final and Complete Disclosure (FFCD), generally without success. This considerable effort has been negated by Iraq's intransigence and failure to provide cooperation concerning its biological weapons since January 1996.

20. After Iraq's acknowledgement of its BW weapons programme, Iraq has submitted three FFCDs of its BW programme. While the first of these FFCDs was declared void by Iraq itself in August 1995, the two latter FFCDs

were reviewed by panels of international experts on four occasions. In March 1997, an expert panel recommended the rejection of Iraq's June 1996 FFCD because of the inadequacy of the material presented throughout the document. In May 1997, the Commission presented formats to enable Iraq to clarify deficiencies in its biological FFCD. All areas of concern to the Commission were clearly identified and discussed with Iraq. It was expected that these issues would be seriously and comprehensively addressed by Iraq in its next FFCD. However, in September 1997, Iraq provided a new FFCD that contained essentially the same information, ignoring all advice provided to it by the Commission. As reported to the Council, an international expert panel reviewed Iraq's biological FFCD in September 1997, and considered it deficient in most aspects. In March 1998, a biological Technical Evaluation Meeting (TEM) between the Commission and Iraq took place in Vienna dealing with all aspects of the biological FFCD. The Commission's team comprised 18 experts from 15 countries.

21. On each occasion the experts unanimously considered Iraq's FFCD presented an inadequate, inaccurate account with deficiencies in all areas. Iraq's latest biological FFCD (submitted in September 1997) is not complete and fails to present a coherent, technically detailed, overall account. The shortcomings occurred not only in areas directly concerned with the material balance (e.g., weapons, bulk-agent products, and microbiological growth media), but also in all other areas (e.g., history, planning, acquisition, research and development). The TEM team also concluded that the FFCD had substantial deficiencies in all areas and Iraq's account of its BW programme could not be verified as a 'full and complete disclosure', as required by the Security Council. Iraq provided many explanations for the account in the FFCD but was unable to substantiate most of its disclosure, and was unwilling to add the missing components. In July 1998, another international team concluded the FFCD, in its present state, could not be verified as complete and accurate.

22. The Emergency Session of the Commission held in November 1997, concluded that the biological weapons file was the most serious area in which Iraq had consistently disregarded its obligations under SCR 687. The members of the Commission noted that the paucity of progress was largely attributable to Iraq's denial of the existence of any biological weapons programme until July 1995. The members of the Commission further noted that Iraq's FFCD of September 1997, was not substantially different from previous, unacceptable, versions, and it remained largely unsupported by evidence and documentation. The Security Council was urged to call upon Iraq to rectify the existing deficiencies.

23. In April 1998, the Commission's report to the Security Council (S/1998/332) listed the priority issues identified by the TEM. These included: history of the BW programme, organizations involved, acquisitions, research and development, production, weaponization and materials balance. In May 1998, Iraq provided clarifications of some issues arising from the TEM but has failed to resolve any of the key issues outstanding. Subsequently on 3 and 4 June 1998, the Commission provided a technical briefing to the Security Council. This gave an outline of the material balance and the main outstanding disarmament issues in each weapons area. In biology, this briefing highlighted the lack of verifiable details on virtually the entirety of the programme.

24. UNSOM presented to the Security Council outstanding issues and sought to establish a programme of work that would enable outstanding issues to be resolved. In biology the priority concerns were: the production of materials and equipment; agents; munitions, and their possible destruction. Additional requirements from Iraq were the provision of the information and materials identified by the TEM. The Commission subsequently met with the Deputy Prime Minister of Iraq in June and agreed on a schedule of work for the next two months. As part of the schedule of work it was agreed, at Iraq's request, to reconvene the international experts to discuss again, with a broad range of Iraqi experts the overall problems associated with the biological FFCD.

25. For these discussions, the Commission proposed that the approach should be "top down", that is focus primarily on weapons, in the belief that the many other important issues in biology might be more easily resolved if progress were made with respect to weapons. Accordingly, the discussions focussed on the provision of new material in the key area of the material balance of weapons, especially material not covered in the March TEM. Iraq did not provide any new information and the FFCD, presented to the Commission in 1997, was judged again to be

inadequate.

26. Iraq has recently pressed for the experts to make a "quality assessment," as to whether any biological weapons or agent remain in Iraq. This was emphatically stressed by Iraq during a meeting between him and the Commission's Chief Inspector in July 1998. Given the present information disclosed by Iraq, such an assessment could not be made.

27. To assess the quality of any biological agent over time requires knowledge and confidence in that knowledge. This includes the physical state of the agent, e.g., liquid or dried, with or without stabilizers; storage conditions of the filled weapons or bulk agent, e.g., temperature, humidity, containers, etc.; tests done on the agent before and after filling, and the results of such tests. None of this information on Iraqi weapons is available to the Commission. SCR 687 (1991) requires the elimination of BW weapons regardless of its "quality".

28. The FFCD presents a limited account that deals only with some components of the programme uncovered during the Commission's investigations. Iraq states that it 'obliterated' the BW programme in 1991, claiming that this involved the destruction of all its BW weapons and associated records and documents. This has greatly complicated the determination of the material balance, and thus hindered verification. The FFCD portrays a programme designed to culminate in January 1991, suggesting that no plans existed beyond that time. In reality the programme was a continuing one, with objectives stretching well into the future. The statement that the programme was 'obliterated' in 1991 is contradicted by later evidence of deception and concealment. This activity continued until 1995, at least, and one of the aims could have been the preservation of essential components of the BW programme. Indeed, Iraq, after 1991, retained suitable growth media, BW facilities, production equipment, teams of expert personnel, and the essential technical knowledge.

29. Iraq has not revealed the planning process. No mention is made of the role of the military and intelligence services in defining the requirements for the BW programme, or in the subsequent planning to meet that requirement. Iraq's doctrine of use of BW weapons is not covered in the FFCD. Consequently, the Commission can not determine the organization, scope and fate of the programme. Iraq has yet to present any formal renunciation of the termination of its BW programme.

30. This paper presents a status report on the investigation and the various attempts to verify Iraq's FFCD. Greater emphasis is placed on matters that affect the Material Balance (Part I), i.e., unfilled and filled weapons, bulk agent, and microbiological growth media. Part II presents the status of verification of other areas, including history, acquisition of supplies and equipment, research and development, sites and facilities, involvement of other organizations such as military and intelligence organs. Part III presents other issues that also relate directly to verification. These include: investigation and verification inspections; Iraq's documentary evidence; technical coherence of Iraq's stated programme; technological progress of the programme; termination of Iraq's programme; and concealment and deception.

## STATUS OF VERIFICATION CONCERNING THE MATERIAL BALANCE OF IRAQ'S BIOLOGICAL WARFARE PROGRAMME

### Weapons Systems

31. To assess whether Iraq has met its obligations under Security Council Resolution 687 (1991), obtaining a full understanding of all aspects of Iraq's BW weapons is essential. Iraq's FFCD does not contain the required detail for such an assessment. It must include numbers, types, markings and a detailed account of individual weapon systems, supported by documents and physical evidence. The term 'weapons' in this paper refers to filled munitions, empty munitions, and bulk BW agents.

### Al-Hussein Missile Warheads

32. In August 1995 Iraq declared that it had filled 25 Al-Hussein missile warheads with BW agents. This figure is not supported by conclusive evidence. In its FFCD Iraq has declared that five warheads were filled with Bacillus anthracis spores, 16 with botulinum toxin and four with aflatoxin. Ten warheads containing botulinum toxin were deployed to an abandoned railway tunnel at Al-Mansuriyah. The remainder was stored on the banks of the Tigris canal. No credible evidence has been presented to support this account of BW agent filling and subsequent weapon deployment.

33. Iraq claims that the Al-Hussein warheads were not specifically developed for BW; instead the Chemical Warfare (CW) warheads were filled with BW agents. Although static and dynamic trials were undertaken with CW agents, Iraq denies that there were any BW trials. Most of the CW warheads had aluminium containers. According to Iraq, later CW, and all BW, warheads had stainless steel containers to be filled with CBW agents. The substitution of aluminium containers with stainless steel containers is explained as a response to difficulties in welding aluminium. It is not attributed to the needs of the payload. Thus this BW weapon was filled and operationally deployed without any field tests.

34. Iraq asserts that all 25 BW warheads were unilaterally destroyed at specific locations at Al-Nibai desert in July 1991. To verify the FFCD, the Commission in 1998 took samples from the remnants of agent warhead containers excavated from various locations at Al-Nibai. The results of the analyses do not support the statements made in Iraq's FFCD. Traces of Bacillus anthracis spores have been identified on remnants of containers from at least seven distinct missile warheads as opposed to the five declared. There are discrepancies between the Iraqi account of where groups of warheads containing particular BW agents were destroyed and the results of the analyses. This throws doubt on the accounts of weapons filling, deployment and subsequent destruction.

35. In response to this evidence, in July 1998, Iraq changed its account of BW warhead and other munitions filling. It stated to an Commission team that, instead of the declared five Bacillus anthracis spores and 16 botulinum toxin warheads, there had been in fact 16 Bacillus anthracis spores and five botulinum toxin missile warheads. Iraq insisted that this change in disclosure would not affect Iraq's declaration on the total quantity of BW agents produced and weaponized. These changes also included alterations to the numbers of R-400 aerial bombs filled with Bacillus anthracis spores and botulinum toxin. Iraq did not present any supporting documents or other specific evidence to substantiate the new statement. In the original account, Iraq emphatically asserted that all ten weapons in the Al-Mansuriyah railway tunnel were filled with Bacillus anthracis spores and only later was this adjusted to botulinum toxin.

36. This new explanation contradicts many aspects of the accounts of the unilateral destruction of special warheads, including those filled with BW agents. Further, it is inconsistent with the accounts provided during the preceding three years by Iraqi personnel directly involved in warhead filling and destruction activities. The new statement does not fit the physical evidence available of the unilateral destruction of biological warheads.

37. The account of Iraq's Al-Hussein BW warheads has changed frequently over the past few years. In July 1998, even in the space of a few weeks, Iraq made 'suggestions' changing the numbers of warheads filled with particular BW agents and their deployment and destruction. The physical evidence from the destruction area and the analyses of the remnants contradicts the account contained in the FFCD. Thus the FFCD account is inaccurate and is not validated.

38. This table provides a summary of Iraq's declarations concerning Al-Hussein missile warheads.

FFCD UNSCOM Assessment Comments  
Al-Hussein Missile Warheads Produced for the BW Programme,  
Produced

25

There is no conclusive evidence that only 25 warheads were produced for BW use. The number cannot be ascertained. No evidence has been offered by Iraq, nor can UNSCOM find any, to indicate the numbers of BW warhead containers produced. Iraq acknowledges this lack of evidence.

Al-Hussein Missile Warheads Filled with BW Agents

Total filled

25

The evidence is circumstantial. The sole supporting document does not clearly refer to BW warheads. There is no credible evidence that only 25 were filled. This number is based solely on a document that refers to the "integration" of 25 warheads and mentions the presence of an officer connected with the BW programme.

Filled with botulinum

toxin

16

The figure of 16 appears to be derived solely by deduction; there is no supporting information. The number is inconsistent with evidence available. In September 1995, Iraq stated that 15 warheads had been filled with botulinum toxin; later this number was changed to 13. Later still the number was adjusted to 16. In July 1998, an Iraqi official suggested that only five may have been filled with botulinum toxin. According to Amer Rashid, this last figure was based on mathematical reasoning coupled with the results of the analysis of warheads recently excavated at Al-Nibai.

Filled with

Bacillus anthracis spores

5

The figure of five appears to be derived solely by deduction; there is no supporting information. The number is inconsistent with the evidence available, which suggests that more than five warheads contained Bacillus anthracis spores. In September 1995, Iraq stated that 10 warheads had been filled with Bacillus anthracis spores; later this number was changed to five. In July 1998, an Iraqi official suggested that 16 may have been filled with Bacillus anthracis spores. According to Amer Rashid, this last figure was based on mathematical reasoning coupled with the results of the analysis of warheads excavated at Al-Nibai.

Filled with

aflatoxin

4

The figure of four appears to be derived solely by deduction; there is no supporting information. In the original declaration of the contents of the Al-Hussein missile warheads, in September 1995, no mention was made of aflatoxin. Later Iraq stated that two had been filled with aflatoxin. Finally this number was adjusted to four.

Other

0

Documents presented by Iraq indicate that 16 warheads were filled with an agent that had a "time to effect" of greater than one week. This implies that the agent mentioned would not cause significant casualties until more than a week had passed following exposure. This raises the possibility of an agent other than Bacillus anthracis spores and Clostridium botulinum toxin which have a time to effect less than one week. Aerosol exposure to Clostridium perfringens spores fit this description. Iraq has declared the production of 340 litres of this agent but denied weaponization. Iraq has failed to account for very large quantities of a growth component, i.e., peptone, that could have been used to produce more than 7,500 litres of this BW agent. The description could apply also to aflatoxin, however, the amount of aflatoxin produced by Iraq's account, was insufficient to fill 16 warheads.

## Al-Hussein Missile Warheads for BW Destroyed Destroyed

25

Remnants excavated from Al-Nibai, the site of their declared unilateral destruction, include sufficient stainless-steel agent containers to account for declared quantities of BW and possible CW warheads, however the locations of the remnants are inconsistent with the FFCD account. Iraq declares that 25 warheads containing deactivated BW agent were destroyed.

## R-400 Aerial Bombs

39. Iraq has declared, that 200 R-400 aerial bombs were manufactured for BW purposes. However, Iraq acknowledges that the numbers of bombs filled with particular BW agents are "guesses".

40. Iraq's accounts concerning the development of the R-400 bomb for BW purposes have changed since 1995. In 1995 when the personnel who conducted the programme were explaining the programme, they described it in considerable detail. There was a series of field trials using a total of six R-400 bombs, two each charged with Clostridium botulinum toxin, Bacillus subtilis and aflatoxin. Many animals were said to have been used. These field trials were reflected in the June 1996 FFCD. Subsequently, Iraq has denied that any such trials were conducted. It is very difficult to reconcile this change with very specific accounts of R-400 trials given by scientists, the attendant veterinary surgeon and workers, at what was said to be the site, namely Al-Mohammediyat. There was also a trial in August 1990 to determine the size of 'booster charge' charge required to disperse the agent. All attempts by Iraq to locate the exact site at Al-Hakam and find any evidence have failed.

41. Iraq initially claimed that 166 R-400 bombs were filled with BW agents. It was stated that three agents were used: agent 'A' (Clostridium botulinum toxin), agent 'B' (Bacillus anthracis spores), and agent 'C' (aflatoxin). Subsequently, to accommodate a document provided by Iraq that suggested that 157 R-400 bombs were destroyed, the figures were adjusted by a new claim by Iraq that only seven, and not 16 R-400 bombs were filled with aflatoxin.

42. Evidence of the destruction of three botulinum toxin filled R-400 bombs was found in 1997 when and remnants of another 20 R-400 bombs in the same area were identified. Remnants of another 25 R-400 bombs were also found in 1991, by a Commission inspection team, at a time when Iraq was declaring a total of only 40 R-400 bombs (stated to be all CW) at Al-Azziziyah. It cannot be determined whether all these weapons had ever been filled. The figure of "157" R-400 bombs is based on a document provided by Iraq that suggests that 157 were destroyed. There is no evidence to support that these were in fact biological bombs.

43. A review by international experts of all information available to the Commission demonstrated that the account of R-400 bombs in the 1997 biological FFCD is both incomplete and inaccurate. The FFCD provides no documented account of filling. This means that a material balance for the weapons and the BW agents incorporated within them cannot be established. There is no confident upper limit on the number of bombs filled for BW purposes. There is no authenticated account of the destruction of the BW agent contained in the weapons. The possibility that such weapons remain in Iraq, cannot be precluded or that agent produced for such weapons exists in bulk storage.

44. The 1997 biological FFCD omits, or does not substantiate, many aspects of the R-400 programme, such as quantitative aspects of filling weapons, location and timing of filling, storage, deployment and destruction of weapons and military deployment or use. Photographic evidence shows that biological R-400 bombs were at an undisclosed site in October 1991, which is after Iraq claims that the BW programme had been "obliterated". This is of particular concern as it affects the credence of the account of R-400 weapons in the FFCD. The total number of R-400 bombs that would have been available for filling is not known.



45. The account of Iraq's R-400 aerial bombs has been changed several times since 1991. Even in July 1998 Iraq has made 'suggestions' changing the numbers of bombs filled with particular BW agents. The inconsistency between the FFCD account and the physical evidence means that the Iraqi account cannot be confirmed. Thus, the FFCD account is not verified.

46. The frequent changes in the Iraqi account of the Al-Hussein missile warheads and the R-400 aerial bombs are more than adjustments of detail. They cast doubt on the entire Iraqi declaration on weaponization.

47. The table provides a summary of Iraq's declarations concerning R-400 aerial bombs.

#### FFCD UNSCOM Assessment Comments

##### R-400 Aerial Bombs Produced

###### Produced

200

The number of R-400A bombs produced cannot be established. From production documents it is evident, that more than 200 bombs were available for BW. Senior Iraqi officials stated that the numbers given in the FFCD are only estimates. Partly coated bombs both with and without black stripes have been found by UNSCOM that is inconsistent with Iraq's account. Initially, Iraq ordered 200 R-400A bombs for the BW programme, externally marked with two longitudinal black stripes and with an internal protective coating. Iraq claims that, because of time constraints, a decision was made to produce only 175 R-400A bombs and another 25 without the epoxy coating or black stripes.

##### R-400 Aerial Bombs Filled with BW Agents

###### Total filled

157

The figure 157 is based solely on an extract from a diary that states 157 R-400 bombs were destroyed. However, it is unclear if the items destroyed were associated with BW agents. In 1991 Iraq claimed that only 40 R-400 bombs were destroyed at Al-Azziziyah. In September 1995 Iraq declared that 166 bombs were filled. After presenting a diary that indicated 157 R-400 bombs were destroyed at Al-Azziziyah, the number was changed to only 157 filled. Filled with botulinum toxin 100 Iraq did not present any evidence in support of its claims. Evidence of botulinum toxin was found by UNSCOM in two destroyed R-400A bombs at Al-Azziziyah. However, botulinum toxin was also found in one recovered R-400 bomb. In 1991, empty R-400 bombs bearing markings consistent with botulinum toxin fill were presented as chemical weapons to a UNSCOM team. Iraq states that 100 R-400A but no R-400 bombs were filled with botulinum toxin. A senior Iraqi official suggested in July 1998 that many more than 100 contained botulinum toxin. According to Iraq, the numbers are only estimates.

###### Filled with

##### Bacillus anthracis spores 50

The account is not supported by documents. No evidence of Bacillus anthracis spores has been found among the remnants recovered at the destruction site. Iraq states that 50 R-400A but no R-400 bombs were filled with Bacillus anthracis spores. A senior Iraqi official in July 1998 suggested that probably fewer than 50 contained Bacillus anthracis spores. According to Iraq, the numbers filled are only estimates.

Filled with aflatoxin 7 Iraq has not provided any documents to support the filling of R-400s with aflatoxin. No evidence of aflatoxin has been found among the remnants recovered at the destruction site. Iraq initially stated that 16 uncoated R-400 but no R-400A bombs were filled with aflatoxin. Later the number was reduced to seven to correspond to the decrease in total numbers of bombs filled. According to Iraq, numbers filled are only estimates.

##### Other

0

There is no complete account of the agents to fill R-400 weapons. An analysis of all the available evidence does not rule out the possibility that another BW agent was filled into some weapons, either in addition to those declared,

or substituting one already declared. The inconsistencies in markings indicating agent type on the R-400 bombs coupled with the lack of evidence on filling, the presence at Al-Walid Airbase of two undeclared R-400A weapons and the frequently changing accounts of Iraqi personnel make it impossible to confirm the BW agents deployed or used for filling purposes.

#### R-400 Aerial Bombs Destroyed

Empty bombs destroyed 43 Video tape and still photographs of destruction activity are the basis for this number. Not all bombs were visible. Iraq states that none of these bombs was ever filled. Based on the markings on the weapons and other circumstantial evidence this cannot be confirmed. Iraq states that a total of 37 R-400 bombs "intended" for filling with BW agents were destroyed at Al-Muthanna under UNSCOM supervision (26 black-striped and 11 non black-striped). An additional six were claimed to be defective and not filled. These were recovered from the River Euphrates in December 1994.

Filled bombs destroyed 157 Evidence of the destruction of BW bombs was found at Al-Azziziyah. The total numbers destroyed could not be determined from the remains at Al-Azziziyah. In addition there is evidence that R-400A bombs carrying BW markings were present at an airfield where no BW weapons were declared. Iraq states, based on a diary, reporting the events, that 157 BW-filled bombs were destroyed at Al-Azziziyah in July 1991. Evidence that all were indeed BW-filled was not presented.

#### Aircraft Drop Tanks

48. In September 1995, Iraq declared the existence of two projects concerning the use of aircraft drop-tanks to disseminate BW agents. One employed a Mirage F-1 aircraft, the other a MiG 21. The Mirage F-1 drop-tank project was said to have commenced in November 1990 when a prototype, made from a modified drop-tank, was manufactured and a series of trials undertaken. Following the last trial, just before the Gulf war, the Mirage with the prototype tank attached was left in a shelter at Abou Obeydi Airbase, near Al-Kut. Iraq states the shelter was bombed and the Mirage F-1 and its drop-tank were said to have been destroyed by fire. Three further drop-tanks were modified. This work, which appears to have been straightforward, requiring only a few days' efforts, continued throughout the period of the war at several establishments. The weapons were completed in March 1991. It is stated that these items were destroyed in summer 1991. The remains of three such tanks have been inspected. Iraq's plan was for the modification of 12 tanks in total. Iraq states that only the scarcity of a key component, an electric fuel cock, limited the number to three.

49. The drop-tank project appears to have been pursued with the utmost vigour by Iraq. It seems to have been the only BW weapon system that continued in development after the start of the Gulf war. Two mobile tanks for bulk BW agents, each with a capacity of 1000 litres, were found buried at the Al-Azziziyah outstation of Abou Obeydi. This raises questions about the state of readiness of this weapon system. Iraq will not discuss the details of concepts of use and flatly refuses to acknowledge the plan for this project.

50. Iraq has claimed for two years that the drop tanks were intended to deliver Bacillus anthracis spores. Bacillus subtilis spores were used as simulant in a test with this intent. In the Vienna TEM Lt. Gen. Amer Al-Saadi reversed this statement by claiming that botulinum toxin was the agent to be used. His technical experts were unable to provide technical information in support of this claim. The availability of agent, and its nature, greatly influence an assessment of the material balance. Four drop tanks would require 8000 litres of agent. The FFCD fails to state which agent was intended to be used.

51. There is no evidence that the prototype weapon and aircraft were destroyed, nor is there sufficient documentary evidence concerning this weapon and its components. The FFCD account is not validated.

#### Pilotless Aircraft Project

52. The concept was to produce a MIG-21 aircraft that could take off and fly on a preset flight path without a pilot

on board. The plane would carry a drop-tank containing BW agent. After a preset time the valves on the tank would open and disseminate the agent. The aircraft would continue to fly until it ran out of fuel. One experiment was undertaken on 10 January 1991 at the Iraqi Air Force Al-Rasheed Airbase. The reason given for dropping the project was the intervention of the 1991 war, expressed as "the situation at that time".

53. Apart from one letter, thanking the project workers, all the information on this matter stems from interviews. However, there is a lack of evidence. The accounts given of the project are credible, when dealing with its technical aspects. When the management of the project, its place in the BW programme and the concepts of use of the weapon are considered, the accounts are contradictory and have changed between 1995 and the summer 1998. The FFCD gives abbreviated details of this project. No mention is made of the intended use of the pilotless aircraft for the dissemination of BW agent.

54. The FFCD account is too brief, considering the apparent intended use of this equipment. There is no clear evidence of the termination of the development of pilotless aircraft for BW dispersal. It is known that such work continues, although for a different stated purpose (targets for anti-aircraft artillery). The attempts to dissociate the MIG-21 project from the development of aircraft spray tanks has not been convincingly explained. The FFCD account is not validated.

55. This table provides a summary of Iraq's declarations concerning fixed wing aircraft spray systems:

#### FFCD UNSCOM Assessment Comments

##### Modification of F-1 Drop-Tanks

###### Drop-tanks produced

4

There is no evidence to corroborate that only four were produced. Interviews indicate that 12 tanks were to be modified. Iraq declares that one Mirage F-1 drop-tank was modified for dissemination of BW agent by 15 January 1991. Subsequently three more were similarly modified during the period of the Gulf war.

###### F-1 Drop-Tanks Destroyed

###### Drop-tanks destroyed

4

The original prototype drop-tank is said to have been destroyed by bombing. There is no physical evidence to support this. The remains of the other three drop-tanks were inspected by the Commission. There are extensive piles of damaged aircraft at Abou-Obeydi, however, the remains of the prototype drop-tank and Mirage F-1 fighter carrying it have not been identified among the debris.

###### Pilotless Aircraft Development

##### Pilotless MiG 21

1

Interviews generally support the statements on the development of a pilotless MIG-21. It is unclear whether the MIG-21 was intended to carry BW or CW weapons. Interviews suggest that the drop-tank and its delivery aircraft were being developed for both CW and BW. There is no evidence to confirm that the project was dropped before completion. The letter offered as evidence that the project terminated provides no such confirmation.

##### Aerosol Generators/Helicopter Spray System ("The Zubaidy Device")

56. An aerosol generator for the dispersal of biological warfare agents or toxins was developed by the Technical Research Centre at Salman Pak by modification of helicopter-borne commercial chemical insecticide disseminators.

These modified aerosol generators are assessed as suitable for the dissemination of BW agents from helicopters or slow moving fixed-wing aircraft and are referred to as Zubaidy devices. A description was included in the June 1996 FFCD. It did not however cite the number of devices produced nor account for their final disposition. In the current FFCD, the devices are only briefly mentioned. A document has also been submitted by Iraq reporting the successful field-testing of these devices in August 1988 to spray *Bacillus subtilis* spores. However it was stated at the Vienna biological TEM in March 1998, that Iraq now considers these devices to be inconsequential.

57. The absence of a comprehensive account of the Zubaidy devices including their disposition and supporting evidence is an example of the incompleteness of the current biological FFCD.

58. The following table provides a summary of Iraq's declaration concerning the Aerosol Generators.

#### FFCD UNSCOM Assessment Comments

##### Aerosol Generators:

Numbers produced not stated in FFCD.

Iraq claims this device was not effective, but documentation provided by Iraq states that it was successfully field tested to spray bacteria. Experts assess this device as a most effective BW munition. Iraq turned over to UNSCOM developmental devices but not the final tested devices. These remain unaccounted for. From interviews Iraq has acknowledged 12 devices produced. None destroyed by UNSCOM.

59. The Commission has evidence of a parallel development by the Technical Research Centre (TRC) of a similar device, probably for delivery by drones. Iraq officially denies all knowledge about this second device but this denial is inconsistent with indications from interviews. It is unknown whether development of this second device continued to deployment but the possibility exists that it did and that such a weapon system still exists in Iraq.

##### Other Weapons Systems

60. Cluster Bombs: Iraq has been asked whether cluster munitions, which are inherently a more effective delivery system for BW agents than aerial bombs, were part of the BW programme. On one occasion, an Iraqi representative mentioned that, although cluster munitions were never used in the CW programme, they were part of the BW programme. He later retracted this remark formally. Since then Iraq has strenuously denied that cluster munitions played any part in the BW programme.

61. 122mm Rocket Warheads: The majority of the declared BW field trials carried out by Iraq involved the testing of 122mm rocket warheads. This part of the programme proceeded in an ordered and logical fashion, commencing with static tests of single warheads and culminating with salvoes of rockets charged with BW agent or simulant. There are documents, video tapes and interview information detailing this work. The Iraqi reports on these trials submitted to MIC, point out the success of the system and recommend adoption of this weapon for the delivery of Agents A, B, C and D. Despite the progress made over a period of years, the development of 122mm warheads was said to have been abandoned by August 1990. The 122mm warhead was considered unsuitable by Iraq "for the impending conflict". The full scope of this work, the rationale for the use of these weapons and the seemingly abrupt end of the project have never been satisfactorily explained.

62. Artillery Shells: A single 155mm artillery shell was found at Iraq's main BW production facility Al-Hakam, recovered from the River Euphrates. It was of the same type used for CW agents. It contained water. Another smaller calibre shell was also found. It had been detonated. These shells were said to have been for evaluation. Four similar shells were used in a trial for the dissemination of the BW agent Ricin. No further evidence has been found. It appears that these trials produced indifferent results, and that, apparently, these projects were not continued.

63. LD-250 Aerial Bomb: Static trials of LD-250 aerial bombs to disperse agents were conducted in 1988. It is likely

that further such trials were conducted. These tests were considered successful. Despite this, and the adoption of the weapon for CW agent delivery, it is claimed that no further development occurred.

64. Fragmentation Weapons: Experimental work on the sub-dermal introduction of *Clostridium perfringens* spores, applicable to fragmentation weapons, was acknowledged by a senior Iraqi worker in the field. He admitted that the work was relevant to fragmentation weapons that are designed to cause gas gangrene. Iraq denies carrying out any developmental work on weapons exploiting this research

65. Land Mines: When Iraq was considering which weapons to use for the dissemination of BW agent, land mines were considered. One of the scientists was sent to Al-Qa'a Qa'a, the explosives factory, to look for types of anti-personnel land mines that could be used for the purpose of filling. He found that there was nothing available suitable for filling with liquid BW agents.

66. 350mm and 1,000mm Calibre SuperGun Projectiles: The Iraqi SuperGun programme was developing long-range projectiles for both 350mm and 1,000mm calibre weapons. The drawings of various designs for the 350mm device, depict a projectile with a guidance and control section, control surfaces on the fins and a payload of around 20 kg. Plans existed for a 1,000mm calibre weapon that would have had a longer range, and a payload greater than 100 kg. Iraq denies that there was any connection between the BW programme and that of the SuperGun. This project, like the BW and CW programmes, was managed solely by MIC. Like the BW project, no objective or planning has been acknowledged. The development of this weapon system was well advanced, with several sites being used and plans prepared for new and more versatile weapons. The intended purpose of this weapon has not been revealed. A long range delivery system, with its guided projectile, capable of delivering relatively modest pay-loads suggests the use of very potent warheads, such as CW or BW agents, or even radioactive material. The range and payload delivery are of a similar order to those of the Al-Hussein. Without a more comprehensive disclosure by Iraq, the possibility that this weapon was being developed for the delivery of a BW payload cannot be ruled out.

#### BW Agents

67. Bulk warfare agent production appears to be considerably understated by Iraq. Production accounts are incompatible with resources available to Iraq's BW programme, including growth media and fermentor capacity. Production figures in the FFCD remain unsupported from 1987 to 1989 and 1991. The sole supporting document, for 1990, differs from information contained in the FFCD itself. Experts' calculations of possible agent production quantities, either by equipment capacity or by growth media amounts, far exceed Iraq's stated results. Significant periods when the fermentors were claimed not to be utilized are unexplained, especially for a period after August 1990, when Iraq's BW production facilities were ordered to operate at their maximum capacity. Stated low productivity of readily available equipment has not been adequately explained. The idle times for fermentor utilization and low productivity, which are technically not credible, cast doubt on the elemental credibility of the 1997 FFCD.

68. Quantities of each agent (and indeed what agents were placed) placed into munitions are unclear. Similarly, the quantities of bulk agents destroyed can not be verified. The quantities cited by Iraq are deduced and may have little relationship to actual quantities. The place and method of destruction is not established. There is no assurance that bulk agents were not recovered, in some instances, from weapons prior to destruction of the weapons.

69. Iraq has not reported all the known quantities of bacterial growth media that was imported for its BW programme, nor has it accounted credibly for all the media that it has reported. Iraq's declared failed batches are excessive and inconsistent in totality. In production of botulinum toxin, Iraq reported that thioglycollate broth when used at half strength of that recommended by the manufacturer produced acceptable toxin levels. These factors add to the quantity of BW agent that might have been produced by Iraq.

70. Fermentor usage: Iraq has calculated the quantity of agent produced by an assigned frequency and efficiency

of fermentor utilization as well as assumed numbers of failed batches of agent production. For the years 1987 to 1989 there are no records to support production and the frequency and efficiency of fermentor operation is inconsistent with the overall information. Additionally, fermentors appear to have been available earlier than stated. For example, the fermentation line acquired from the Veterinary Research Laboratories (VRL) at Abu Ghraib is stated to have been acquired only late in 1988 when it was moved and installed at Al-Hakam. However, documents provided by Iraq indicated consideration of its use in situ at the VRL and spare parts for this line were ordered by the BW programme beginning late May 1988.

71. Fermentor idle times: Relative to available resources, Iraq has declared less than expected production of bulk agents. Declared quantities are based on limited availability of capability such as fermentors and a shortage of specific bacterial growth components. As a proof for the limited production output Iraq claims, fermentors were not used for considerable periods of time. For example, Iraq claims lack of spare parts and a needed overhaul of some fermentors as an explanation for "idle periods". In fact, UNSCOM has evidence indicating spare parts were available. There is no corroborating documentation to support the less than optimal bulk agent production levels reported in the FFCD. The low production figures are particularly difficult to accept without supporting evidence during a period in mid-1990, when allegedly maximum production was ordered by Lt. Gen. Hussein Kamel Hassan.

72. Clostridium botulinum toxin, Agent A: It is not possible to verify the amount of Agent A produced, placed into munitions or otherwise consumed as presented in the 1997 FFCD. Various accounts of the destruction of bulk Agent A were made in both the FFCD and by independent Iraqi testimony. There is insufficient documentation to verify either the quantity of Agent A destroyed or whether remaining bulk agent in summer 1991 was destroyed. Methodology employed in destruction and location of destruction, similarly, can not be determined.

73. Bacillus anthracis spores, Agent B: It is not possible to verify the amount of Agent B placed into munitions or otherwise consumed as presented in the 1997 FFCD. UNSCOM cannot exclude the production of Agent B from facilities other than Al-Hakam based on analytical evidence of Bacillus anthracis spores in equipment (one fermentor and two tanks) located at the FMD facility at Daura. An Iraqi explanation for this finding presented during the inspection was not credible. Overall, bulk agent production quantities and the location of production of Agent B cannot be determined because of the lack of sufficient supporting documentation.

74. There are various accounts derived from both the FFCD and independent Iraqi testimony concerning the destruction of bulk Agent B. Laboratory analysis of samples obtained at Al-Hakam has demonstrated the presence of viable Bacillus anthracis spores at an alleged bulk agent disposal site. Iraqi experts cannot explain adequately how viable Bacillus anthracis spores could have been present at this site. The inactivation procedures described by Iraq for the "excess" bulk agent would preclude any live agents remaining following that inactivation procedure. The explanation provided by Iraq, i.e., endemic contamination is not credible. An alternative explanation proposed by Iraq that the viable organisms came from material discarded during agent production operations in prior years was contradicted by earlier information provided by Iraq. Further, that explanation, if true, would preclude verification of the destruction of bulk agents. There is insufficient documentation to verify either the quantity of Agent B destroyed or whether remaining bulk agent was destroyed. Methodology employed in destruction and location of destruction, similarly, can not be determined.

75. Aflatoxin, Agent C: Declared production of the BW agent aflatoxin could not have occurred using the process stated by Iraq. In its June 1996 FFCD, Iraq claimed that, in September 1990, it had zero balance on hand, having produced only 40 litres of aflatoxin that were nearly all consumed by weapons field trials. Assessments by the Commission show that the quantity produced would have been inadequate for the declared number of field trials. Iraq claimed to have produced 1,782 litres of aflatoxin for filling weapons from 1 October to 31 December 1990 and continued the production two weeks into January 1991 for an additional 119 litres. Taking into account the

technology, organization and production limitations including facilities, equipment, and personnel available, such large production volumes are doubtful. The impact on production of aflatoxin of mixing CS, CN, and smut spores with aflatoxin is not clear. A new account of aflatoxin production and weaponization is contained in the September 1997 FFCD, but the changes are not adequately explained or supported by documentary evidence. The new account is no more credible than the June 1996 version. Iraq has not offered any credible explanations to support its statements other than the 1990 Al-Hakam report that cites 2200 litres produced without the details of where and how it was produced. During an inspection in July 1998, Iraq tried to establish among themselves the figures of aflatoxin produced, indicative of Iraq's uncertainty with aflatoxin production quantities.

76. It is not possible to verify the amount of Agent C placed into munitions or warheads or otherwise consumed as presented in the 1997 FFCD. The question remains open regarding the aim and reasons of the choice of aflatoxin as an agent for BW. It is not clear what Iraq expected to obtain as a result of its use. One document refers to military requirements to produce liver cancer using aflatoxin and the efficacy against military and civilian targets. Understanding Iraq's concept of use for this agent may enhance the credibility of otherwise unsupported statements.

77. Iraq has indicated that the production data in the FFCD were based on recollection and back calculations due to a lack of production records.

78. Clostridium perfringens spores, Agent G: Stated amounts of Agent G produced, used, consumed or destroyed cannot be verified because of insufficient documentation. Iraq maintains that small quantities of Agent G, 340 litres, were produced because of limited availability of personnel and lack of critical growth media components. There is no documentation to support this, and the Commission has information which counters the allegation that growth media components represented a limitation. Iraq has not provided a credible material balance accounting for its known Peptone acquisitions by the BW programme. Peptone is a growth media component which appears to have been only used in the production of perfringens spores by the BW group.

79. Smut, Agent D: It is not possible to verify the amount of Agent D produced, used or consumed owing to a lack of sufficient documentation from Iraq.

80. Iraq had stated it produced smut coated with aflatoxin, but neither this statement, nor the destruction of bulk Agent D can be verified.

81. Bacillus subtilis spores, simulant for Bacillus anthracis spores dissemination: Stated amounts of Bacillus subtilis spores produced can not be verified. Stated quantities and time of production appear to be figures contrived to be compatible with the number and dates of field trials reported in the FFCD. Interview information and documentary evidence contradict Iraq's presentation of field trials conducted. Because of this artificial system for deriving production numbers, each additional trial that was not included in Iraq's arbitrary calculations, add to the disparity in quantities of simulant produced.

82. Bacillus thuringiensis spores, simulant for Bacillus anthracis spores drying: Iraq cites the production of 50 litres of Bacillus thuringiensis (Bt) spores in March 1990 for drying studies which are claimed not to have been done because of a failure to obtain a particular spray dryer. However, Bt spores were taken by Iraq to the supplier in December 1989 to test on the spray dryer it planned to acquire. The quantity of Bt spores produced can not be verified.

83. Ricin: Iraq asserts that 10 litres of ricin were produced from 100 kg of castor beans and that this quantity was used in a field trial using 155mm artillery shells in November 1990. Documents obtained during an inspection in 1997 indicate that far more than 100 kg of castor beans were collected and processed in October, November 1990. If the Commission had a clear understanding of Iraq's objective for including Ricin in its programme, then perhaps much of the uncertainties surrounding Ricin could be resolved.

84. Other agents produced: It is not possible to determine if bacterial or toxin agents other than those stated in the 1997 FFCD were produced. Seed stocks of other agents were actively sought for and obtained by Iraq's BW programme.

85. Drying of agent: It is not possible to determine if bacterial and toxin agents produced were dried to enhance storage stability or for reasons of dissemination. This issue is of significance because Iraq actively procured drying equipment and obtained training in the use of such equipment for key personnel. Drying studies on bacteria started in 1974.

The following table provides a summary of Iraq's declarations concerning the bulk agent production (as active agent), filling and destruction (unless stated otherwise).

#### FFCD UNSCOM Assessment Comments

Botulinum toxin produced (10 to 20-fold concentrated)

19180 litres

Insufficient documents to support quantities. Equipment and unaccounted for growth media do not support the figures. Quantities could be more at least double the stated amount. Iraq bases this estimate on 1990 "Al-Hakam" report with extrapolations into 1989 and earlier.

Botulinum toxin filled

10820 litres

Nothing to support statements. Iraq acknowledges numbers are estimates. Number of filled munitions could not be verified. See weapons tables. Figure is based on the alleged numbers of munitions filled; 100 R-400 bombs, each filled with 85 litres, and 16 Al-Hussein missile warheads, each filled with 145 litres.

Botulinum toxin used for field trials

499-569 litres

Stated field trials can not be verified as accurate, hence quantities of bulk agent consumed can not be verified. Quantities are based on unsupported number of field trials conducted.

Botulinum toxin wasted during handling

118 litres<sup>56</sup>

Nothing to support statements. Interviews differ with these estimates in ways that cast doubt in the account of filling. Quantities are estimates. There is no basis for assessment of wastage.

Botulinum toxin destroyed

7665 or 7735 litres

Nothing to support statements as to quantities destroyed and where and when destroyed. Interviews differ from official declaration. Quantities are contrived estimates. Stated as unilaterally destroyed in July 1991.

Bacillus anthracis spores produced (10-fold concentrated)

8445 litres

Insufficient documents to support quantities. Equipment and unaccounted for growth media does not support the figures. Quantities produced could be at least 3 times greater than stated. Iraq bases this estimate on 1990 "Al-Hakam" report with extrapolations into 1989 and earlier.

Bacillus anthracis spores filled

4975 litres

Nothing to support statements. Iraq acknowledges numbers are estimates. Number of filled munitions could not be verified. See weapons tables. Quantities are contrived estimates. Figure is based on the alleged numbers of



munitions filled;

5 Al-Hussein missile war-heads, each filled with 145 litres, and 50 R-400 bombs, each filled with 85 litres.

Bacillus anthracis spores used for field trials

None

No evidence has been presented to indicate whether or not Bacillus anthracis spores were ever tested. Iraq states that no field trials were conducted with Bacillus anthracis spores; only a simulant was used.

Bacillus anthracis spores wasted

52.5 litres<sup>58</sup>

Nothing to support statements. Interviews differ with these estimates in ways that cast doubt on the account of filling. Quantities are estimates.

Bacillus anthracis spores destroyed

3412 litres

Nothing to support statements as to quantities destroyed and where and when destroyed. Interviews differ from official declaration. Quantities are contrived estimates. Stated as unilaterally destroyed in 1991.

Aflatoxin produced

2200 litres

Facilities, equipment, and personnel do not support production statements. Experts assessments are that Iraq could not have produced the quantity of aflatoxin claimed, given the equipment, facilities and personnel stated by Iraq. Iraq bases the production of 2200 litres on the 1990 Al-Hakam report.

Aflatoxin filled

1120 litres

Nothing to support statements. Iraq acknowledges numbers are estimates. Number of filled munitions could not be verified. See weapons tables. Figure is based on the alleged numbers of munitions filled;

7 R-400 bombs, each filled with 80 litres and 4 Al-Hussein missile warheads, each filled with 140 litres.

Aflatoxin used for field trials

231-301 litres

Stated field trials can not be verified as accurate, hence quantities consumed can not be verified. Quantities are based on an unsubstantiated number of field trials conducted.

Aflatoxin wasted

30.5 litres<sup>59</sup>

Nothing to support statements. Interviews indicate wastage was much higher. Interviews differ with these estimates in ways that cast doubt on the account of filling. Quantities are estimates.

Aflatoxin destroyed

900 or 970 litres

Nothing to support statements as to quantities destroyed and where and when destroyed. Interviews differ from official declaration. Quantities are contrived. Stated as unilaterally destroyed in 1991.

Clostridium perfringens spores produced (10-fold concentrated)

340 litres

Insufficient documents to support quantities. Equipment and unaccounted for growth media does not support the figures. Quantities produced could be at least 15 times the quantity stated. Iraq bases the 340 litres estimate on 1990 Al-Hakam report.

Clostridium perfringens spores filled

None

Nothing to support statements. Stated quantities produced are insufficient for weaponization.

Clostridium perfringens spores wasted

None

Nothing to support statements. No filling, ergo no wastage.

Clostridium perfringens spores destroyed

338 litres

Nothing to support statements as to quantities destroyed and where and when destroyed. Quantities are estimates.

Ricin produced

10 litres

Documents and interviews do not support account. Based on an inaccurate account of Ricin activity.

Ricin used for field trials

10 litres

Nothing to support statements. Based on an inaccurate account of Ricin activity.

Wheat Cover Smut

Not quantifiable

Nothing to support statements. The total quantities remaining are claimed to have been destroyed in July 1991.

86. Mobile storage tanks. Eight mobile double-jacketed tanks were part of the VRL line transferred to Al Hakam. In addition, Iraq has acknowledged the production of an additional 39 mobile tanks by SEHEE. These tanks were used to transfer agent between production and filling or deployment sites and for storage of agent. Owing to their properties, they can be used for long-term storage of agent under controlled conditions or modified to function as fermentors suitable for the production of BW agent.

FFCD UNSCOM Assessment Comments

Mobile tanks acquired.

47

39 indigenously produced at SEHEE

8 from VRL

1990 Al-Hakam report refers to 70 being produced. Serial # 37 seen on remnants. 8 tanks are known to come from the VRL line. 39 tanks stated to have been manufactured by the Heavy Engineering establishment at Daura is based on a document in which SEHEE billed PC2/3 39ss vats (not specified) and 8 came from the VRL Vaccine line. The 1990 "Al Hakam" report cites 70 1m3 tanks.

Mobile tanks destroyed.

Unknown

Remnants of 2 tanks were found at Al-Azziziyah. Among other remnants turned over to UNSCOM, were the remains of approximately 22 tanks (4 tanks of the VRL line). The number has not been stated in the 1997 FFCD.

In the 1996 FFCD, 2 were said to have been destroyed at Al-Azziziyah, and 22 were cut-up and disposed at Iskanderiah. Thus 20+ tanks remain unaccounted for.

## Bacterial Growth Media

### Media Acquisition

87. In the early days of Iraq's BW programme based at Al-Muthanna and Salman Pak small quantities (in the order of tens of kilograms) of media of various types were purchased by Iraq through the State Establishment for Pesticide Production (SEPP) for research and pilot scale production for BW agent. . The media, some tens of kilograms, for the initial production runs of botulinum toxin at Taji in early 1988 is stated in the FFCD to have been acquired locally but the details are not provided and it is unknown whether the amounts declared represent the totality of the amount actually acquired. No supporting documentation is provided by Iraq for any of the acquisitions referred to above.

88. In late 1987 and early 1988, enquiries, and ultimately orders, were made for large purchases of media. Iraq acknowledges importing over 40 tons of media in 1988 and although no documentation is provided by Iraq. The Commission can confirm the four largest orders listed in the FFCD. However, the Commission has information that shows that the bulk media acquisitions as declared by Iraq are an incomplete listing and that further amounts in excess of 600 kg were imported and have not been declared. Furthermore, some of this undeclared media was received by Iraq prior to May 1988, suggesting that the statement in the FFCD that the Taji fermentor was shut down between April and July 1988 "due to the non availability of culture media", is incorrect.

89. Given the incompleteness of documentation regarding media acquisitions, particularly for local purchases, and evidence indicating that imports have been understated, the Commission cannot verify Iraq's declaration of media acquisition.

### Media Used In Production

90. The account in the FFCD of media consumed in the production of BW agent is acknowledged by Iraq to be a mathematical calculation based on a) the claimed quantity of agent produced and b) the estimate of failed production batches that would have also consumed media. In addition other quantities are said to have been discarded during the production process (Iraq has stated this to be due to spoilage). Other than the 1990 Al-Hakam report outlining agent production at Al-Hakam for that year, Iraq has provided no records or other documentation to support its estimates.

91. Iraq had stated that in June 1991, before the arrival of the first UNSCOM BW team, the media remaining at Al-Hakam was transferred to the State Company for Drugs and Medical Appliances Marketing (otherwise known as Kimadia) within the Ministry of Health. Iraq has explained that the role of Kimadia was to provide a cover story for media that had been consumed in the weapons programme. Subsequently documentation was drawn up to indicate that media consumed in the programme had been sent to hospitals in outlying regions where riots had occurred and hence would no longer be traceable.

92. Thus the difference between the quantity of media imported and that remaining in stock in 1991, i.e., the shortfall, accounted for by Kimadia, represents the media consumed in the Iraqi BW programme between 1988 and June 1991. This provides a snapshot in time immediately following the stated end of the BW programme and potentially is a figure that can be used in the verification of Iraq's FFCD. The picture however became confused in July 1998 when Iraq stated that not all the media left over from the programme was transferred to Kimadia, but certain amounts (undocumented) were retained at Al-Hakam. Thus the Kimadia "shortfall" figures would reflect media consumed in the programme plus any remaining at Al-Hakam in 1991. If this is the case then the Kimadia documents become less useful as a verification tool. Furthermore some of the data from the Kimadia documents

is in conflict with the FFCD. In discussions with Iraq during an inspection in December 1998, the issue of what quantity of media remained in 1991, became more unsettled. Iraq submitted "copies of documents" that casts further doubt on the usefulness of the "Kimadia documents" for verification. The "copies" provided during this inspection cast further doubt, however, may not be valid copies.

93. As noted above, Iraq has recently stated that in 1991 some of the media was transferred from Al-Hakam to Kimadia. What is unclear and has not been explained to the Commission is the basis for the retention of media at Al-Hakam. Peptone, for example, which had been used for the production of Agent G had no apparent role at Al-Hakam in 1991 if the BW programme had been abandoned. Also Kimadia had "covered" for all the media remaining in 1991 and therefore any media remaining at Al-Hakam had been written off and was untraceable. It is not clear why this media was not accountable in the Iraqi system if indeed Al-Hakam had been converted to legitimate purposes in 1991.

94. In summary the figures presented in the FFCD for media consumed in the production of BW agent are a theoretical calculation, have little supporting evidence and do not account for all media acquired. This current account therefore can not be verified.

#### Media Lost, Damaged or Destroyed

95. The FFCD identifies two losses of media prior to the first UNSCOM BW inspection. The first was said to have occurred during the evacuation of Al-Hakam and the relocation of its headquarters to Al-Asma'a school about 30 km away. It is stated that equipment important to the functioning of departments was relocated to the school on 22-23 January 1991. Included was an unknown quantity of media of various, but unidentified, types. At some time before the return to Al-Hakam in May 1991, Iraq claims the school was broken into and some items stolen and damaged including some of the media.

96. Iraq states that no investigation of the loss occurred and that the amounts and types of media cannot now be recalled. The figures in the material balance table of the FFCD indicate that over 900 kg of media were "lost" including over 700 kg of peptone which is relevant to *Clostridium perfringens* (Agent G) production. There would appear to be no basis for these figures other than a calculation designed to account for all the media i.e. so that the material balance equals zero.

97. The Commission has reason to believe that no media was stored at the schoolhouse and that none was stolen.

98. A second loss of media is stated to have occurred during the clean up of Al-Hakam prior to UNSCOM's arrival in 1991. This was said to be an unquantified amount of media damaged during the evacuation and it is stated to have been burnt and buried at a site adjacent to Al-Hakam. This site was visited by the Commission's inspection team in 1995 and it was confirmed that media was burnt and buried there but the types and quantities are not known. During the inspection in December 1998, Iraq presented several improbable accounts of media lost, damaged and stolen that defies credibility. In conclusion therefore, the Iraqi account of lost media cannot be verified and in the case of the school house media, it is probably not true.

99. During the destruction of Al-Hakam in 1996, 22 tons of media were collected from several facilities and destroyed under the Commission supervision. However some of the 22 tons (unquantifiable) probably came from sources external to the BW programme i.e. some of the media from the original orders is still unaccounted for. It is also uncertain whether all the media acquired for the programme has been identified. Thus there is little confidence that all the media associated with the programme has been located and destroyed.

#### Material Balance

100. The following tables provides a summary of Iraq's material balance declarations for growth media acquisition, usage, consumption and disposal by four key media types: casein, thioglycollate broth, yeast extract and peptone.

#### FFCD UNSCOM Assessment Comments

##### Casein

Casein acquired.\*

17554kg

Fails to include several smaller but significant orders acquired for the BW programme. Derived principally from 3 large orders in 1988.

Casein used for botulinum toxin production.

7074 kg

Production quantities are estimates and consequently media consumption figures are estimates that are based on estimates. No supporting data other than the production figures for 1990.

Casein lost and wasted.\*\*

145 kg

Not confirmed but represents 2% of that stated as used and does not therefore seem unreasonable. Unsupported statement.

Casein remaining in 1991.

10335 kg

The 10335 kg figure appears to be based on a 1995 inventory made by Iraq and may have little relation to the actual amount in 1991. Unconfirmed. Iraq also states 970kg remained unused in 1991 at Hakam. No supporting evidence for this

Casein destroyed in 1996.

Not specifically stated: implied 10335kg

Iraq and UNSCOM inventories differ, but for casein, in general agreement. Destroyed under UNSCOM's supervision.

##### Thioglycollate Broth

Thioglycollate broth acquired.\*

6036 kg

Fails to account for additional smaller but significant orders acquired for the BW programme. Derived principally from 1 large order in 1988.

Thioglycollate used for botulinum toxin production.

4130 kg

Production quantities are estimates and consequently media consumption figures are estimates that are based on estimates. No supporting data, other than the production figures for 1990.

Thioglycollate lost and wasted\*\*

58 kg

Not confirmed, but about 1% of total stated to be used and therefore not unreasonable. Unsupported statement.

Thioglycollate remaining in 1991.

1848 kg

The 1848 kg figure appears to be based on a 1995 inventory and may have little relation to the actual amount remaining in 1991. Unconfirmed. No supporting documentation

Thioglycollate destroyed in 1996. Not specifically stated: implied 1848 kg Iraq's and UNSCOM's inventories in 1995 di er, but for Thioglycollate, in general agreement. Destroyed under UNSCOM's supervision.

#### Yeast Extract

Yeast Extract acquired.\*

7070 kg

Fails to include additional smaller but significant orders acquired for the BW programme. Based on 3 large orders and 70 kg from an unidentified internal source.

Yeast extract used for agent production.

#### Botulinum toxin

1768 kg

#### Bacillus anthracis spores

185 kg

#### Perfringens

11 kg

Production quantities are estimates and consequently media consumption figures are estimates that are based on estimates. No supporting data other than the production figures for 1990. Iraq also stated 185 kg used in SCP production post 1991.

Yeast extract lost and wasted\*\*.

15kg

Represents less than 1% of stated usage and not unreasonable. Unsupported statement

Yeast extract remaining in 1991.

5090kg

The 5090 kg figure appears to be based on a 1995 inventory and may have little relation to the actual amount in 1991. Iraq has also stated (unconfirmed) that 4000 kg was retained at Al-Hakam in 1991 and 1807 kg sent to Kimadia, total 5807 kg: this is inconsistent with the FFCD. No supporting evidence for the quantity retained at Al-Hakam in 1991.

Yeast extract destroyed in 1996.

Not specifically stated: implied 4942 kg

Iraq's and UNSCOM's inventories in 1995 di er greatly for yeast extract. The majority of containers had been opened and the inventory was complicated by mis-labelled media, other sources of media possibly being added and duplicate labels.

Destroyed under UNSCOM's supervision.

#### Peptone

Peptone acquired.

1500 kg

Does not include several smaller but significant orders including one for 100 kg peptone. Quantity is based on a single large order.

Peptone used for Clostridium perfringens production.

45 kg

Production quantities are estimates and consequently media consumption figures are estimates that are based on estimates. No supporting data other than the production figures for 1990. Iraq also stated 125 kg used for civilian work post 1991.

Peptone lost and wasted\*\*.

705 kg

The basis for the figure appears to be a calculation designed to bring the material balance to zero. Unsupported by evidence. The bulk of the 705 kg has been presented as having been stolen from an evacuation site. UNSCOM has reason to believe this is untrue.

Peptone remaining in 1991.

750 kg.

The 750 kg figure appears to be based on a 1995 inventory and appears to have little relation to the actual amount remaining in 1991. Unconfirmed. Additional quantities of peptone were acquired after 1991 from the "local market". Peptone destroyed in 1996.

Not specifically stated: implied 625 kg

Iraq's and UNSCOM's inventories in 1995 differ greatly for peptone. The majority of containers had been opened and the inventory was complicated by mis-labelled media, other sources of media possibly being added and duplicate labels. Destroyed under UNSCOM's supervision.

101. \* Iraq has not reported all the media including casein, Thioglycollate broth, yeast extract, and peptone known by the Commission to have been imported for the BW programme. In response Iraq has suggested that the Commission must be confusing media ordered for the Forensic Laboratory with that ordered for the BW programme since both organizations used the same procurement system. If this is so, it implies that Forensic Laboratory had large quantities of media. However the purpose for this and its present whereabouts have not been declared.

102. \*\* The "lost" media cited in the FFCD includes media that was wasted during production or handling e.g., by spoilage, and media said to have been lost or stolen during the relocation of the headquarters. There is no further breakdown of these figures so that it is not possible to establish, for example, what media may have been lost through handling errors and what may have been stolen.

#### Assessment of Material Balance for Bacterial Growth Media

103. The material balance pertaining to media cannot be established. There are several factors which introduce uncertainty. On imports, Iraq's declaration understates the amount by at least 600 kg. Furthermore there is no documentation for the quantities of media said to have been acquired locally, nor any evidence whether this was the total amount. On media consumed, Iraq acknowledges that the figures it presents are derived from estimates of the quantity of agent produced. Since there is little supporting documentation relating to the quantities of agents produced, the amount of each type of media consumed carries similar uncertainties. On losses, Iraq's account of substantial amounts of media said to be lost during the evacuation of Al-Hakam cannot be quantified and furthermore the account of the theft of media from the school house, is probably untrue. The only fixed point in the material balance equation for bacterial growth media is the amount of imported media. Some more data can be derived from the amount of media destroyed by the Commission in 1996. However in relation to yeast extract and peptone there is considerable uncertainty in the destruction of the media. The majority of containers had been previously opened by Iraq and the Commission's assessment of their contents was complicated by mis-labelled media, other sources of media possibly being added and duplicate labels. In particular for peptone, the Commission's assessment of the media destroyed varies between 200 and 470 kg depending on the assumptions made with regard

to labelling. This compares with 625 kg implied in the FFCD as having been destroyed. For all the above reasons, the material balance for bacterial growth media cannot be verified.

104. Although a material balance cannot be established, an estimate can be made of minimum amounts of media still unaccounted for. As discussed above, the Commission is aware of additional quantities imported by Iraq. If the quantity of media declared by Iraq to have been consumed and lost is added to the amount of media destroyed by the Commission, and then this addition compared with the amount imported, a minimum figure for media unaccounted for can be derived. This will be a minimum figure because there may be additional quantities of media imported of which the Commission is unaware, and it also relies on the estimates in Iraq's declaration some of which are not accurate.

105. The following table gives the Commission's estimate of key media types unaccounted for.

#### Media

Minimum unaccounted for (kg)

Remarks

Casein 460 Sufficient for the production of 1200 litres of concentrated botulinum toxin (depending on availability of other components including yeast extract). This would represent an additional 6% of that which has already been declared by Iraq.

Thioglycollate broth 80 A relatively small discrepancy but the estimate depends on the reliability of Iraqi estimates of quantity consumed or lost during the production of botulinum toxin.

Yeast Extract 520 This minimum estimate is uncertain and is likely to be much higher. It is based on a liberal assessment of the contents of many opened and irregularly marked containers. However this minimum figure is sufficient to produce 26000 litres of Bacillus anthracis spores or over 3 times the amount declared by Iraq.

Peptone 1100 Iraq states that about 700 kg of peptone was stolen. UNSCOM has reason to believe this is not true and therefore the estimate includes the entire amount not adequately accounted for. It is sufficient to produce 5500 litres of concentrated perfringens agent or about 16 times the amount declared by Iraq.

106. As evident from the tables the greatest concern is with unaccounted amounts yeast extract and peptone. Although the expiry date for this media would have passed, advice from the manufacturers is that given appropriate storage conditions, particularly away from moisture, the media would still be usable today. The Commission has no information regarding its fate, whether it was retained or used to produce additional undeclared BW agent. The amounts that are "missing" however are significant and would be sufficient to produce quantities of agent comparable to that already declared by Iraq.

#### Material Balance

107. The most important elements of the FFCD are those related to material balance. That is weapons, filling of munitions, production of munitions, production of types and quantities of BW agents, acquisitions of growth media, supplies, equipment, and other material for the programme; bulk agents, munition and weapon destruction.

108. Establishing a material balance consists of determining the input materials and the output materials. In the case of biological weapons, the input materials are the bulk agents and munitions and the output material are the filled BW weapons. In turn, the input materials for bulk agents are the growth media components and the output materials are the bulk agents.

109. The quantities of bulk agent filled into munitions and allocation of munitions to agents, either by type or number for R-400 bombs or for Al-Hussein warheads cannot be determined from the information provided by Iraq.



The munitions available for the BW programme cannot be verified. The lack of adequate documentation prevent the verification of the munitions available for the BW programme.

110. There is no documentation to indicate the number of munitions filled with BW agents. Nor, is there any adequate documentation to support the account of the destruction of the weapons, unfilled munitions and bulk agent.

111. Bulk BW agent must be considered to be a weapon. In addition to the munitions, Iraq developed two types of aerosol dissemination devices that would use bulk agents - the modified drop tank and the aerosol device for slow moving aircraft. There are no production records or production documents to support the stated bulk agent production. The input material for this production is the respective growth media, which is not accurately reported. Production quantities of bulk agent are acknowledged to be estimates and stated media consumption are estimates, based on these estimates. Production quantities of the four types of agents declared by Iraq as produced in bulk cannot be verified.

112. As a result of the above for each of the critical elements of the material balance, Iraq's current account in the FFCD cannot be verified.

113. Determining the number of weapons destroyed is very important but, without knowing the quantity of munitions produced and allocated to BW, determining the quantity destroyed does little to help verify that all weapons have been destroyed, for which documentation has not been provided.

114. In July 1998 international biological experts reviewed with Iraq, at the request of ist Deputy Prime Minister, its biological FFCD, specifically addressing material balance as outlined above. On the material balances for weapons, agents and media the team came to the following conclusions:

#### Weapons

None of the subcomponents of the material balance for R-400 bombs (production, filling, destruction of filled and unfilled bombs) could be verified.

None of the subcomponents of the material balance for Al-Hussein warheads (production, filling, destruction of warheads) could be verified.

The account in the FFCD on modified drop tanks and the Zubaidy spray device could not be verified.

#### Agents

None of the subcomponents of the Clostridium botulinum toxin material balance (production, filling, losses and destruction) could be verified.

None of the subcomponents of the Bacillus anthracis spores material balance (production, filling, losses and destruction) could be verified.

None of the subcomponents of the aflatoxin material balance (production, filling, losses and destruction) could be verified.

None of the subcomponents of the *Clostridium perfringens* spores material balance (production, losses and destruction) could be verified.

None of the subcomponents of the wheat smut material balance (production, losses and destruction) could be verified.

Media

None of the subcomponents of the media material balance (acquisition, consumption, losses and destruction) could be verified.

115. In its accounting for various BW weapons-programme-related elements, the Commission has achieved various levels of confidence, depending on the quality of information; documentary, physical, and personal testimony provided by Iraq; and the correlation of this information with other information derived from Iraq, information provided by its former suppliers, or otherwise obtained by the Commission.

116. The Commission has a degree of confidence in the accounting for some proscribed items which were presented by Iraq for verification and disposal. This includes, for example: the destruction of buildings, and equipment at Al-Hakam, the destruction of large quantities of growth media acquired for the programme; and evidence that R-400 aerial bombs and Al-Hussein warheads contained BW agents and consequently that *Bacillus anthracis* spores and botulinum toxin were indeed weaponized.

117. The Commission has less confidence in the accounting for proscribed items declared by Iraq as having been unilaterally destroyed. These include, for example: the number and fill of R-400 aerial bombs destroyed at Al-Azziziyah; the number and fill of BW Al-Hussein warheads destroyed; and the fate of the agent to be used with drop tanks.

118. The Commission has little or no confidence in the accounting for proscribed items for which physical evidence is lacking or inconclusive, documentation is sparse or non-existent, and coherence and consistency is lacking. These include, for example: quantities and types of munitions available for BW filling; quantities and types of munitions filled with BW agents; quantities and type of bulk agents produced; quantities of bulk agents used in filling; quantities of bulk agents destroyed; quantities of growth media acquired for the programme; quantities of growth media used/consumed; and when or whether the programme ended. In addition the Commission has no confidence that all bulk agents have been destroyed; that no BW munitions or weapons remain in Iraq; and that a BW capability does not exist in Iraq.

119. Several other outstanding issues also remain. These issues are related: to the scope and extent of R&D activities; the acquisition of supplies and equipment; the involvement of military and other agencies in the BW programme; and deception associated with the concealment of the BW programme.

#### STATUS OF VERIFICATION IN THE AREA OF OTHER COMPONENTS OF IRAQ'S BIOLOGICAL WARFARE PROGRAMME

120. Iraq, under SCR 687 (1991), is required to declare the locations, amounts and types of all biological weapons and all stocks of agents and all related subsystems and components and all research, development, support and

manufacturing facilities. In SCR 707 (1991) this requirement was reaffirmed and the Council demanded that Iraq provide a full, final and complete disclosure on all areas related to its BW programme. Part I of this status report reviews those elements of the FFCD that are directly relevant to a material balance. Part II reviews additional elements of the FFCD. The biological TEM conducted in Vienna in 1998 indicated the significance of those issues and it was stated in the expert report: "The FFCD also does not provide a clear understanding of the current status of the BW programme or whether, or when, it was terminated." In April 1998, the Commission's report to the Security Council (S/1998/223) further underlined the significance of these issues by listing the history, the organization, acquisition and research and development among the priority issues to be resolved with regard to the proscribed biological weapons programme.

#### Other Acquisition

121. Iraq has failed to include in its FFCD all the acquisitions of munitions, equipment, media and agents acquired for or used in its BW programme. Iraq has not included all its acquisition of growth media for production purposes which for the four principal components are covered in this report under Part I, para 3. Iraq has not acknowledged all its acquisition of media used in R&D as well as that used in the seed fermenters during production of bulk agents. Neither has Iraq reported all its acquisition of equipment and micro-organisms, nor has Iraq declared all the agencies and individuals involved in that process. Iraq has not provided an adequate account of materials and equipment acquisition. Further, Iraq has failed to provide adequate answers regarding its BW procurement network including the Arabian Trading Company, and other front companies. A complete understanding of acquisition is essential to defining a material balance for Iraq's BW programme.

122. The FFCD does not contain all imports for Iraq's BW programme known to the Commission, although Iraq claims that all imports for the BW programme were reported. The basis which Iraq claims it used in the FFCD for determining what imports by Iraq to include or exclude among the declared acquisitions was shown not to be sound. Thus acquisitions, as measured by the number of orders including Letters of Credit (LCs) and cash deals through attaches at Iraq's Embassies overseas, are substantially under-reported. Without a complete accounting of all BW programme acquisitions, a material balance is not possible.

123. LCs and cash deals for such items as rotary evaporators, glassware, oven sterilizers, and Petrie dishes, are omitted from items attributed to the programme.

124. Not all strains of micro-organisms that were acquired by Iraq are included nor are all attempted acquisitions of strains included. The FFCD contains only the Vollum strain of *Bacillus anthracis* spores to be obtained by TSMID, in 1989, but in 1988 an Iraqi scientist involved in the BW programme had tried to obtain known BW and other virulent *Bacillus anthracis* spores strains from outside Iraq. All local acquisitions of strains are not included in the FFCD. Further, the fungal and viral strains acquired are not reported in the FFCD.

125. The media listing is incomplete in that Iraq fails to consider several Letters of Credit and cash deals related to media imports; some of these orders relate to media or media components used in production but other orders relate to media used in R&D and for seed fermenters used during the production process. Media acquisition during the time of the BW programme at Al-Muthanna are understated as well.

126. There is inadequate or in some cases no supportive evidence for munitions acquisition, both for weaponization and for field trials. Although the account of the acquisition of materials for the aerosol generator (Zubaidy device) was incomplete in the 1996 FFCD, much of the information presented in that version has been intentionally omitted in the 1997 FFCD.

#### History of Iraq's BW Programme

127. Iraq is required to provide a comprehensive account of the history of its BW programme. This may appear

peripheral to disarmament and to material balance issues. But lacking documentary or physical evidence to establish a material balance, other elements of the Iraqi BW programme become essential as tools for verification. The history of the Iraqi BW programme is certainly an element of the FFCD, which, if correctly declared, would facilitate verification.

128. The introduction and chronology presentation of Iraq's BW programme encompasses only a part of the programme, is inaccurate with respect to dates and fails to provide an insight into the decision making process which facilitated its evolution. The account misleads because it presents the programme as an entity which came to fruition in 1990 whereas in reality it was a programme planned to reach maturity some time in the mid/late 1990s. The account also fails to provide any perspective to the programme merely listing a miscellany of chronological events linked only by time rather than requirement, strategic planning, or military utility. As such there is no continuity to the account which limits the Commission's understanding of the BW programme.

129. Iraq claims that the programme started in 1974 by Presidential decree and by the establishment of the Al-Hazen Institute. Interview evidence shows that consideration of a programme was earlier, as evidenced by the establishment of a functional purpose-built scientific research complex by mid 1974. Planning, design and construction of such a complex would had to have started at least in 1973 with concepts developed earlier. The affiliation of the Institute is not defined other than to a "State Security Organization".

130. The Al-Hazen Institute terminated on 16 January 1979 not 1978, as declared, because of fraud by the Chairman (Major Ghazan Ibrahim, not stated in the FFCD) and some senior staff, not for reasons of inadequacy of the facility, nor inability to make scientific progress as claimed by Iraq.

131. Before the apparent "resurrection" of the programme in 1985 work continued at Al-Salman to create resource for biological purposes including buildings established for the Institute including an animal house. Prof. Nasser Hindawi submitted a proposal for BW research in the early 1980s. The date on which the Director of Al-Muthanna Establishment (Gen. Nizar Attar) formally requested the addition of a BW research is not indicated.

132. It is stated by Iraq that no plans were elaborated for the large scale production, weaponization and storage of BW agents which is contrary to the statement of Gen. Nizar Attar who stated in 1995 that a plan was formulated in 1986 to achieve weaponization within 5 years (which is precisely what happened). The evolution of the programme over the next five years appears to follow a well defined course implemented with urgency, authority, and great secrecy demonstrating considerable planning.

133. Research and Development at Al-Muthanna is claimed to have been restricted to consideration of just Clostridium botulinum and Bacillus anthracis spores whereas it is known that Clostridium perfringens was received on 10 November 1986 and that "DIALOG" database searches were undertaken for Clostridium perfringens on 13 May 1985 and 10 July 1985. Consultations were undertaken with Prof. Nasser Hindawi when at Mustansiriyah University in 1986.

134. In reality the Commission assesses that the transfer of the BW work from Al-Muthanna to Al-Salman (TRC) was to preserve secrecy. Al-Muthanna still had a requirement for the agents produced at Al-Taji and subsequently at Al-Hakam for field tests. Al-Muthanna continued to collaborate on both laboratory and field experiments from 1987 to 1991.

135. The establishment of the BW research group at Al-Salman in 1987 is accepted as stated although the means by which it was established and managed is far from clear. The relationship of the programme within TRC to other organizations is unclear. The responsibility and management for the expansion of the programme to include mycotoxins in 1987/88 and viruses and genetic engineering in 1990 has not been defined adequately.

136. The establishment of the BW agents production factory at Al-Hakam has not been related to a military

requirement or a weapons testing and procurement requirement. The extent of the capability there has not been justified.

137. Field tests of BW agents started in late 1987/early 1988. The extent of such testing has not been revealed and some previously acknowledged tests are now stated not to have taken place.

138. The activities undertaken in 1989 and 1990 - field testing aerial bombs, rockets and other munitions; the expansion of the programme in terms of research and agent production, and acquisition of additional facilities remain ill defined and as such a confident determination of the extent and scope of the programme cannot be made.

139. Since the FFCD falsely states that the BW programme was obliterated in July 1991 no credible account is given of the preservation and concealment of the programme until 1995.

#### FFCD UNSCOM Assessment Commentary

1974 - Initiation BW Programme by Government decree. Establishment of Al-Hazen required planning in earlier years. No decree provided. Al-Hazen Institute established.

1978 - Liquidation of the Al-Hazen Institute. Formally ceased activity on 16/1/79. Biological work continued at Al-Salman from 1979 to 1985. Legal reports confirming financial fraud by senior staff provided.

1983 - BW was introduced in Al-Muthanna objectives. This is probably correct. Date probably 1983 from testimony of Lt. Gen. Nizar Attar. No documents to support statement. Statement by Head Al-Muthanna that BW added to CW programme was made in interview testimony.

1985 - Start Al-Muthanna BW research. This is probably correct. Documentary evidence for the appointment of BW staff. Others were already engaged at Al-Muthanna. Requirement and assessment not provided.

1986 - No formal plans for BW. Planning was an integral and essential part of establishing the BW programme for the military. Contrary to statements of Gen. Nizar Attar and Haidar Farm documents.

1987 - Transfer BW research to Al-Salman under TRC. It is accepted that this occurred in 1987. Documents support the transfer of personnel. No realistic justification or rationale provided for the move.

End of 1987 - Production botulinum toxin for weapons tests. Acquisition Al-Taji was Aug 1987 and indicates prior planning for weapons. No documentary evidence of output of botulinum toxin. Acquisition Al-Taji supported by documents.

1988 - Start planning weapons tests. Weapons were considered from 1986 when Gen. Nizar Attar planned BW programme. Detailed planning started in 1987. No documents provided.

1988 - Expansion BW activities. It is accepted that this occurred although the extent and scope cannot be assessed. Recruitment of personnel and documented activity confirm this.

1988 - Establishment of Al-Hakam Factory for the production of BW agent. Plans laid 1987; no justification provided; relation of scale to military requirement not explained. Gen. Nizar Attar started formulating plans in 1986. Acquisition of site on 24 March 1988 documented.

1988 - Start aflatoxin research. 22nd May 1988 is accepted as the start date. No coherent account of initiation of work has been presented.

1989 - Start Ricin research. Ricin considered CW agent. The origin of and extent of programme unclear. Started in 1988. No coherent account of initiation of work has been presented.

1989 - Start Botulinum toxin production on an industrial scale. This is accepted. Consistent with evidence of construction and equipping Al-Hakam.

1990 - Botulinum toxin production continues on an industrial scale. Scale not consistent with admitted weaponization activities. Undertaken at Al-Hakam and Al-Manal.

September 1990 - Start of Bacillus anthracis spore production on an industrial scale. In response to August order of Lt. Gen. Hussein Kamel Hassan. Production does not make maximum utility of equipment available. Evidence of Bacillus anthracis spore production at Al-Manal. Al-Hakam 1990 report supports Bacillus anthracis spore production at Al-Hakam.

July 1990 - Start of virus research programme. Appears to be correct, at least for Dr. Hazem Ali's work. Role of Dr. Hazem Ali, a virologist, in programme unclear. Al-Hakam 1990 report supports this.

March 1990 - Start of genetic engineering programme. Appears to be correct. No clear objectives provided for this. Location of activity unclear. 1990 Al-Hakam report confirms start.

August 1990 - Decision to produce biological weapons for war. Accepted that the programme changed and was enhanced. No documents provided in support. Presented as a unilateral decision by Lt. Gen. Hussein Kamel Hassan.

August 1990 - Enhanced production of BW agents. Accepted that the programme changed and was enhanced. No documents provided in support. Presented as unilateral decision by Lt. Gen. Hussein Kamel Hassan.

[September 1990 - R-400 tests at Al-Mohammediyat.] Tests probably were undertaken with agents deployed.

Statement withdrawn by Iraq despite discussion of tests with weapons staff at Al-Mohammediyat which provided clear accounts of the trials.

September 1990 - Al-Manal established at FMDV facility Daura to produce botulinum toxin for weapons. Evidence that Al-Manal was also used for Bacillus anthracis spores - denied by Iraq. Bacillus anthracis spore genes were found on a fermentor and storage vessels. Documentary evidence that facility was acquired and 5000 litres botulinum toxin were produced.

January 1990 - Production of aflatoxin at Al-Fudhaliyah (Al-Safa'ah). No technically coherent account for production given. Testimony indicates September 1990 for start. 1990 Al-Hakam report states 2200 litres aflatoxin produced, but location not identified.

December 1990 and January 1991 - Weaponization of BW agents. The ordering and timing of weapons filling and deployment remains unclear. Timings of activities still not precise. It is unclear what the range of weapons used actually was. R-400 bomb and Al-Hussein missile warhead remnants confirm that BW agents were used with these weapons.

January - July 1991 - Deployment of weapons. Ambiguities remain on numbers and location of weapons deployed. Iraqi accounts of the deployment of weapons continue to change.

July 1991 - Destruction of weapons. Destruction of totality of BW weapons can not be verified. Physical evidence of destruction of some R-400 and missile warhead weapons confirming in part the statement.

June 1991 - Destruction of bulk BW agent. It is possible that bulk agent remains available to Iraq. No physical or documentary evidence of this. Interview testimony supports agent destruction although there are inconsistencies in account.

## Research and Development

140. Research is a fundamental cornerstone of Iraq's BW programme. It provides a scientific and technical basis for all aspects of the final developed programme. Although not all aspects investigated at the research level will lead to weapons development, the scope of the research programme is an index of the concept, strategy, and extent of the programme. No account whatsoever is given of review, concept, or theoretical projects undertaken by the research staff throughout the programme.

141. The Commission's understanding of the early years of Iraq's BW programme at the Al-Hazen Institute in the 1970s is poor. It is not credible that a single individual is portrayed as being solely responsible for initiating and planning the research programme. A military input is also denied, although it is acknowledged that officers from the Chemical Corps were members of the staff. A clear definition of the success, or possibly lack of it, is necessary because both outcomes would influence future development of the programme. A full account of the extent of the Al-Hazen programme has not been presented in the FFCD although this programme was offensive in nature. Subsequent clarification (12 May, 1998) provides some further background information but still fails to indicate the strategic planning that initiated a BW programme within Iraq.

142. The period of 1979 to 1984 remains a void in the Commission's understanding although there is considerable evidence of biological activities during that period - continuation of a building programme originally for the Al-Hazen Institute, retention of Al-Hazen staff at Al-Salman, Prof. Nasser Hindawi's submission for a research programme, acquisition of dual capable equipment, and placement of staff abroad for training. In other words the programme seems to have continued albeit with different objectives, emphasis, management, and resources.

143. The resurgence of the BW programme is attributed to Gen. Nizar Attar, the State Organization for Technical Industries (SOTI) and MOD, and the appointment of Dr. Rihab Taha as an investigator in early 1985. This resulted in an initial programme of work at Al-Muthanna where *Bacillus anthracis* spores and *Clostridium botulinum* are acknowledged to be the cores of the activities. However, according to Iraq, under Gen. Nizar Attar's direction a plan was formulated in 1985 to develop biological weapons which included at least one additional agent, *Clostridium perfringens*. Iraq states, that basic studies on cultivation, identification, and pathogenicity of only *Bacillus anthracis* spores and *Clostridium botulinum* were undertaken. Nevertheless, there are indications that a broader survey of agents was undertaken as evidenced by the range of BW agents and simulants obtained in 1986 together with literature surveys undertaken by Iraq's scientists.

144. In mid 1987 a group of biology researchers left Al-Muthanna to continue to undertake research within TRC at Al-Salman and to support biological weapons tests. The full circumstance of this transfer has not been presented. In addition it is stated that formal research on *Clostridium perfringens* started in 1988; aflatoxin, trichothecene and ricin work started, with the recruitment of further experts; and offensive work with *Tilletia* spp. (Wheat cover smut or bunt of wheat) continued at an increased level of activity. Additional research studies on the dissemination of BW agents using both liquid and dried BW agents was undertaken although the full depths of this work remains to be presented by Iraq. The extent of these studies has not yet been determined but documentation indicates a greater understanding of dissemination than revealed to the Commission.

145. At Al-Salman some fundamental research work on the enhancement of the toxicity and virulence of agents was also undertaken, some in conjunction with Al-Muthanna. Research on the scale up of agent production was undertaken and the searches for cheap efficient growth materials were undertaken, not all of which have been disclosed in the FFCD although both testimony by Iraq's experts and documents indicate activity undertaken. Studies on the storage and preservation of both seed stocks and bulk agents were undertaken. The effects of *Clostridium botulinum* and *Clostridium perfringens* spores were also determined. The rationale for this is not presented in the FFCD and no one accepts responsibility for the scientific and technical basis for this expansion other than Dr. Ahmed Murthada who by his own acknowledgement merely administered the programme. The relationship of the parent organization to Al-Muthanna, the Scientific Research Council, the University of Baghdad, the Iraqi Atomic Energy Agency and the Central Library of Iraq have not been defined. The extent of the research programme remains to be presented. In 1985, 1986, and 1988 a range of defined seed stocks of BW agents were acquired, some of which are not recorded as being a component of the BW programme.

146. In 1989 much of the research group and its attendant research was transferred to Al-Hakam where experiments on weapons materials compatibility was undertaken as well as quality control on BW agents produced at the industrial scale. The scale of the research work was further extended. In 1990 additional research locations were obtained at the Foot and Mouth Disease Vaccine Institute at Daura and apparently the Agriculture and Water Resources Centre at Fudhaliyah. Research on viruses was started by Dr. Hazem Ali and genetic engineering with Dr. Ali Nuria Abdel Hussein. The logic and intent for the selection of camelpox virus, infectious haemorrhagic conjunctivitis virus, and rotavirus are not stated in the FFCD. The objectives for the genetic engineering unit are not elaborated upon although testimony of Dr. Rihab Taha has indicated initially antibiotic resistant strains of *Bacillus anthracis* spores were to have been derived. Any relationship with that of the genetic engineering section of Al-Muthanna housed at the Serum and Vaccine Institute at Amiriyah under the direction of Dr. Al-Za'ag is denied.

147. Iraq's failure to identify and to present technically and scientifically competent staff who will accept intellectual and management responsibilities for the balance and emphasis of the research programme, the planning and development of the research programme makes the determination of the overall extent of the programme difficult. There is a denial that individuals from academia (other than Prof. Nasser Hindawi and Dr. Al-Akidi) or other Ministries (with one exception) contributed to the programme in a consultative or advisory role. There is also Iraq's

denial that any coordinating or supervisory committees existed which is unlikely.

148. Documents concerning the research activities have been provided to the Commission. In August 1991 some ten papers concerning the research of Dr. Rihab Taha were presented to the Commission. These focussed on the three agents *Bacillus anthracis*, *Botulinum toxin* and *Clostridium perfringens*. In 1995 additional information was obtained by the Commission from the Haidar Farm, including research papers that indicated that papers released in 1991 were carefully edited to mislead the Commission. No documentation concerning research on mycotoxins, smut, viruses, plant toxins and genetic engineering were included in the documents. In 1998 eight documents concerning research, apparently involuntarily provided by Prof. Nasser Hindawi, were provided to the Commission. The documents essentially confirmed earlier papers, although one three-page document which personally reviews Prof. Nasser Hindawi's contribution to the programme, bearing the date 1989, is given great credence by Iraq as defining the scope of the programme.

149. Iraq claims that research is one of the best documented areas of the FFCD. The account fails to give confidence that the full extent of the research programme has been described and that all achievements have been presented. This is partly because of a lack of documentation in areas of activity outside bacteriological warfare agents and partly inconsistent and reluctant oral accounts of such activities. No indication is given of weapons research which logically would have run in parallel with agent production activities.

#### FFCD UNSCOM Assessment Commentary

1974 - Initial research efforts to achieve a BW capability at Al-Hazen Ibn Al-Haithem Institute. Overall correct but earlier start, probably 1973, based on the requirement to plan the building programme. No documentation of substance provided in support. The account is partially supported by interviews.

1974 - 1978 - Al-Hazen Programme. The FFCD states that the biological part of Al-Hazen was "research on microorganisms for military purposes". It included antibiotic and environmental resistance, means of production, and agent preservation. The scope can not be defined but broadly the range of research is accepted although the true objectives of the work and the relationship to military requirement is lacking. *Clostridium botulinum*, *Bacillus anthracis* spores, *Shigella* spp., *Vibrio cholerae* and viruses were among organisms studied. Interview testimony supports much of the statement although accounts vary in terms of the success and outcome of the research.

1978 - Liquidation of Al-Hazen Institute. Records of imprisonment of senior personnel is cited as evidence. Scientific fraud is asserted. BW Research stated as ending. Formal termination of programme of Al-Hazen Institute occurred allegedly in January 1979 but work continued. Evidence supports formal end of Al-Hazen, but in January 1979. It is probably a temporary end of part of the BW programme; work continued on biological issues. Court documents indicate financial not scientific fraud.

1979-1984 - Activities - not acknowledged. Work continued at Al-Salman and planning for enhanced programme started. Iraq states no BW activities occurred during this period. Evidence of further work at Al-Salman and other locations. Planning at Al-Muthanna for integration into CW programme. Ba'ath party receptive to research ideas.

1985 - A new start to BW research. The actual year of initiation of work is not clear. Generally accepted that actual laboratory work of Dr. Taha's group started in late 1985. In February 1985 BW research started at Al-Muthanna involving Dr. Rihab Taha. Documents citing her transfer from the University of Baghdad to Al-Muthanna. Research plans are denied. No theoretical or concept development acknowledged. UNSCOM has evidence of plans. Plans were presumably laid before 1985, Iraq's stated starting point.

1985 to 1987 - Al-Muthanna research was a basic programme for *Bacillus anthracis* spores and botulinum toxin only. Restricted to laboratory production, characterization and storage. The time frame of research is accepted but the extent of the research is not determined. No supportive evidence submitted. Such studies were conducted. Not possible to verify that research was as limited as declared. Aerosol studies were conducted. Forged research papers produced in 1991 and presented to UNSCOM in support of these activities.

1985 - Acquisition of BW agents and simulants. In 1985, 1986, and 1988 a range of agents required to support programme were acquired, or attempted to be acquired, from a number of foreign sources including from ATCC and Institute Pasteur. Local acquisition also occurred. Documents support overseas sources, but many strains were also obtained from local sources; these are not cited. The rationale for the extensive range is not provided. The 12



May, 1998 declaration provides the year of import using the University of Baghdad as a cover.

1984 - Smut research at Al-Salman. Smut research started at Salman Pak in 1984 and continued throughout the 1980s. Initially a civilian study, subsequently from 1987 offensive in nature. Partially supported by interviews which also indicate an offensive side of the studies. Origin of offensive work unclear.

1987 - Transfer of "Biology Group" to Al-Salman. The Al-Muthanna group was transferred to Al Salman from May to July 1987. Various reasons cited. Evidence exists to generally support the time frame. Rationale for the transfer not convincing and conflicts with evidence.

1987 - Continuation of Bacillus anthracis spores and botulinum toxin research. Advanced research including determination of pilot scale production and storage begun in 1988. Evidence indicates earlier advancement to this stage. FFCD does not include all aspects indicated by interview testimony

1987 - Aerosol dissemination studies. Aerosol work undertaken at Al-Muthanna in 1987, with small animals, and at Al-Salman, 1987, latterly with a variety of agents. Both dry and liquid forms of agents were evaluated. No documents to support statements. Monkeys exposed at Al-Muthanna. Limited disclosure of this activity provided.

April 1988 - Clostridium perfringens research starts. Start date of work unclear. The objectives and scope of the work greater than acknowledged. Not all aspects indicated by interview are covered in the FFCD. Start cited as after hiring of a specific individual in 1988 and concentrating on the infectivity of spores, not toxin(s). Toxigenic strains selected. Documentary evidence of earlier interest and research.

1988 - Additional acquisition of BW agents and simulants Procurement activity greater than disclosed. In 1988, a range of additional agents required to support the programme were obtained.

1988 - Aflatoxin work started. Work initiated because of ease of production of aflatoxin. Accepted that work started in 1988 with the appointment of Dr. Emad. Origins and extent of this programme still uncertain. No documents concerning research other than weapons research.

1988 - Production technology. Pilot scale production of Bacillus anthracis spores, botulinum toxin, and simulants undertaken in 1988/89; processing and storage parameters evaluated. Agent drying process under-reported. No documents to support statements. Limited acknowledgement of production and downstream processing provided. Some work started much earlier than acknowledged. Drying know-how was greater than stated by Iraq.

1989 - Ricin work was initiated at Salman Pak. Research began in 1988 (or earlier) at the request of an Internal Security Officer. Origins and extent of this programme still uncertain. No documentary evidence. Even after Lt. Gen. Hussein Kamel Hassan's departure in 1995, documents were altered to conceal origins and organizations associated with this effort.

1990 - Trichothecene work starts in March. Work began in 1987 by someone other than Dr Emad. Account for trichothecene work conflicting and under reported. Documents indicate 1987 start to work.

1990 - Initiation of genetic engineering. Began in 1990. Initiation of programme by acquisition of specific equipment and scientist. Attempted acquisition of equipment documented. Start of effort and other details are not given. The rationale for this work not given. Antibiotic resistance in Bacillus anthracis was the objective according to Iraqi testimony. Denial that Al-Muthanna Genetic Engineering Unit at Amiriyah contributed to the BW programme in 1990 and 1991.

1990 - Start of virus studies. Preliminary studies on growth and pathogenicity attempted in late summer 1990. Studies focussed on Camelpox, Infectious Haemorrhagic Conjunctivitis virus and rotavirus Partially documented. The rationale for this work not given. Other possible uses include incapacitating agents.

Al-Muthanna aflatoxin collaboration. In 1989 studies on augmenting aflatoxin with smut, CS, CN and mustard undertaken. Limited disclosure of this activity provided. The role of Al-Muthanna under-played.

Al-Muthanna ricin collaboration. Documents indicate collaboration was extensive in 1989. Al-Muthanna assisted in set-up for a field trial in November 1990. Role of Al-Muthanna under-played.

#### Sites and Buildings

150. There is a requirement for Iraq to provide the rationale, justification, and requirement for all sites including those for weapons tests, research and development, production, storage, weapons production and filling, deployment, and the destruction sites for weapons, documents and agents. Building diagrams must be provided where appropriate.

151. Such an account would correspond to one of the few tangible aspects of the programme which can be unambiguously presented - the actual buildings created and used. All that is provided in the FFCD is a physical description of some components. It does not relate activity undertaken or required to facilities available. Iraq has provided 23 site diagrams with little commentary after the Vienna Technical Evaluation Meeting (12 May, 1998) in response to the criticism.

152. The scale of a facility quite obviously relates to the scale of activities planned to be undertaken. In the case of a key facility within a BW programme it will accommodate the staff and resource required or projected to fulfill the objectives of the programme. The only sites that Iraq has acknowledged to be purpose built for BW purposes are the Al-Hazen Institute and Al-Hakam. It is conceivable that components of Al-Muthanna and Al-Salman were also designed with regard to biological weapons considering the common origin of the Chemical and Biological weapons programmes.

153. The Al-Hazen Institute was designed specifically for the start of the BW programme. In spite of this, few details have been provided by Iraq concerning the actual design and construction with regard to requirement. In addition the future requirements for Al-Hazen as evidenced by the construction of the "cube" and "L-shaped building" together with an animal house are not acknowledged.

154. The Al-Salman account describes the accommodation occupied by the staff associated with the biological programme but does not indicate how this matches requirement and utility. The additional buildings erected specifically to support the programme (animal house, fermentor building and incinerator building) have not been related to planning, construction and requirement.

155. The Al-Hakam Factory is acknowledged to have been built with the objectives of undertaking research and development together with industrial scale production of BW agents. Dr. Rihab Taha has also stated that weapons filling at Al Hakam was also considered for the future. Iraq states that weapons were filled for experimental field tests in 1990 at Al-Hakam and R-400 bombs were assembled at Al-Hakam in preparation for their subsequent filling (which apparently occurred at Al-Muthanna) and their subsequent deployment. Consideration of weapons assembly, filling and storage (empty and full) would have been a part of the consideration of Al-Hakam in 1987/88 as would the storage of bulk agent and the media required to produce such agents.

156. The biological agent was stored in a bunker and a warehouse at Al-Hakam. The hardened bunker was capable of housing some twenty 5000 litres containers. Just four are acknowledged to have been manufactured and two were placed in the bunker and two were placed in the warehouse. It is not clear how many more 5000 litre containers were made or planned to be fabricated. The containers were specifically designed for pathogen storage and subsequent sterilisation. Containers with a capacity of 1000 litres, which were wheeled and so mobile, were also manufactured. Although the precise number made is uncertain it appears that at least 39 were made in 1989 and 1990. Some 70 were planned to be fabricated. These would serve both as storage and transfer vessels. The total planned storage capability is difficult to ascertain but it is probably in the region of 80,000 to 100,000 litres of agent.

157. Al-Hakam was intended to accommodate, in 1988, three five-cubic metre fermentors in the first instance. According to a document provided by Iraq two such fermentors were planned to produce Agent A (botulinum toxin) and one for Agent B (Bacillus anthracis spores). This is described as industrial scale production and implicit is that it satisfied the minimum military requirement for Iraq. No account of this requirement has been made. In the event the fermentation line from the Al-Kindi Company was installed comprising seven 1480 litre fermentors and two 1850 litre fermentors (i.e., a total of 14060 litres) which is a similar overall volume confirming the operational scale requirement. Operating at a 5-day cycle about 820,000 litres of agent could be produced per year equivalent to 82000 litres of 10-fold concentrated agent. Assuming an annual replenishment of agent it would appear the

initial annual capacity of the factory would be about 80,000 litres. When both areas A and B of the large scale plant became functional the capacity would in essence double and remain at that level until the far larger capability in area D came on stream.

158. The site was used for the testing of weapons in 1990 and parts of the location lend themselves to experimental weapons tests away from the main production areas. As acknowledged the site is sufficiently remote to minimise contamination in the case of an accident and implicit is that it can be used for agent simulant testing.

159. This FFCD also omits any reference to mobile production facilities once considered, according to Lt. Gen. Amer Al-Saadi. It omits the rationale for the selection of the geographical location of Al-Hakam and consideration of other sites such as Basrah.

160. Since Iraq's overall account of sites is poor, and the FFCD fails to provide a coherent account of the overall military programme, it cannot yet be assessed whether the sites identified represent the entirety of the facilities used to support the programme. In the absence of a credible account of the overall planning and evolution of the programme some site related aspects cannot be fully evaluated.

161. Sites associated with Iraq's BW programme (the list of sites is not necessarily complete).

#### SITE Function UNSCOM Assessment Comments

Abou Obeydi Airbase, near Kut Test Site for drop tank dispersion tests Used to test drop tanks for BW dissemination. Description incomplete. Rationale for BW use of site not given. A poor quality incomplete site diagram is provided.

Agricultural & Water Research Station, Al-Fudhaliyah BW aflatoxin production claimed. Aflatoxin and genetic engineering research. No evidence, other than testimony, that site was used for this purpose. Partial rationale for site given provided, no site diagrams. Video evidence of MIC interest in site acquisition.

Agricultural Aviation Division, Khan Bani Sa'ad BW weapons development - Zubaidy device Used for purpose stated - supported by documents. Partial rationale provided on May 12, 1998. No site diagrams provided.

Airfield 37, near Ramadi BW Storage for BW R-400 bombs R-400 bombs at the site - no evidence of BW weapons at location Poor site diagram provided on May 12, 1998

House at Al-Amiriyah, Baghdad Preliminary R&D site, Al Hazen Institute. May be correct. No site diagram provided. Rationale not provided.

Diagrams provided May 12, 1998. Location not known.

Al-Adile Stores (Kimadia) Forged documents on growth media prepared at site Possible site for preparation of forged media documents Documents in UNSCOM possession. Forged documents acknowledged by Iraq  
Al-Azziziyah BW Storage and Destruction Site R-400 weapons destroyed at the site; weapons may have been deployed there. Rationale and site diagram provided in May 12, 1998 clarification.

Al-Dabash Stores, Baghdad Growth media storage Media from BW programme stored at site 1991-96. Iraq acknowledges role of site.

Al-Fao, Baghdad Design & Construction Center for Al-Hakam Evidence that it contributed to the design and construction of Al-Hakam. No information provided by Iraq.

Al-Faris Factory, Al-Amiriyah, Baghdad BW weapons development, drop-tanks No information provided. No information provided. Not acknowledged as a part of the programme.

Al-Hakam Factory BW agent production Accepted that it was one of Iraq's production plant. Justification and rationale inadequately presented. A selection of site diagrams provided but insufficient to provide a definitive account.

Al-Hazen Ibn Al-Haithem, Salman BW research Accepted that it was a site constructed for research activities. Rationale provided for first phase. Some diagrams provided on May 12, 1998.

Al-Kindi Company, Abu-Ghraib Training, TRC personnel on fermentation line. Source of fermentors for Al-Hakam. Explanation and rationale only partial.

Al-Manal, Daura, Baghdad BW Research & Production Stated role may be correct for botulinum toxin production and virus research but evidence of Bacillus anthracis spores work at this site. Explanation and rationale only partial. Al-Mansuriyah BW Missile Warhead Storage Role is not confirmed. Rationale only partly provided. A diagram and comments provided May 12, 1998 clarification.

Al-Meshada, Taji Storage surplus R-400 bombs. Stated role may be correct. No diagrams.

Al-Mohammediyat Test Site for weapons tests Stated role may be correct. Rationale only partially provided. No diagrams.

Al-Muthanna, Samara BW Research & Weapons filling Accepted that Al-Muthanna contributed to research and weapons, timing and detail of planning for activities unknown Rationale not totally credible emphasises CW aspects of building planning. Some diagrams provided. Description of buildings minimal.

Al-Nahrawan, near Baghdad Test site for prototype biological bombs. Site not positively located. Partial rationale. No site diagrams.

Al-Nibai BW missile warhead destruction. Missile destruction site still under investigation. No site diagrams. Partial account provided May 12, 1998 clarification.

Al-Numan Factory, Baghdad Fermentor component manufacture. Stated role may be correct. Rationale and site diagrams not provided.

Al-Qa'a Qa'a, Latifiyah Explosives. Role accepted. Rationale and site diagrams not provided.

Al-Rasheed Air Base, Baghdad Pilotless MiG 21 test for drop-tank. Stated role may be correct. Partial rationale provided. No diagrams.

Al-Taji BW Production. Stated role may be correct. Clear rationale not provided.

Asma School, Al-Hindaya Media, equipment, supplies, and records evacuation site. Stated role may be correct. However media aspect not supported by documentation. Diagrams not provided. Document supports that it served as an alternate site.

HQ Air Force Technical Depot, Taji Drop-tank storage, destruction. Stated role may be correct. Diagrams not provided.

Jarf Al-Sakr Test Site - 155mm shells and Ricin. Stated role may be correct. Diagrams not provided.

Jurf Al-Nadaf Aerosol chamber dump site. Role confirmed by inspection. Diagrams not provided.

Nasr State Establishment, Taji R-400 bomb manufacture. Stated role may be correct. Rationale for R-400s not provided. Diagram provided May 12, 1998 clarification.

Project 144, Taji BW weapons development - 122mm rockets and Al-Hussein warheads. Stated role may be correct. Rationale for warheads not provided. Inadequate diagrams provided.

Serum & Vaccine Institute, Amiriyah Storage BW seed stocks. Genetic engineering. Stated role may be correct. Rationale for Genetic Engineering not provided. Site diagram provided May 12, 1998 clarification.

Site 85, near Latifiyah BW deception site, acquisition. Stated role may be correct. Description and rationale inadequate.

State Enterprise for Heavy Engineering, Daura, Baghdad Mobile and Storage Tank Manufacture. Stated role may be correct. Rationale for mobile tanks not provided. May 12, 1998 clarification.

State Establishment for Mechanical Engineering, Iskanderiah Not acknowledged. Involvement in destruction of mobile tanks. Not acknowledged.

Store no 6, Misbah, Baghdad Growth media storage. Possible temporary media store. Iraq claims site to be temporary media store.

Technical Research Centre, Salman BW Research. Stated role may be correct. Rationale and diagrams provided. Destroyed by coalition bombing 1991.

Tigris Canal, near Fallujah BW missile warhead storage. The site may have been used for storage . Explanation and rationale changed over last two years.

University of Baghdad, Baghdad Procurement of BW equipment; BW agents procured for and used in the programme; deception. Stated role may be correct. Explanations, rationale, and diagrams not provided.

University of Technology, Baghdad Design & Construction Al-Hakam. No information provided by Iraq. Explanations, rationale, and diagrams not provided.

Military Industrial Commission, Baghdad Administrative Centre. No information provided by Iraq. No diagrams provided.

## Organization of Iraq's BW Programme

162. There is no comprehensive information about the organization of Iraq's BW programme, at all levels, and its relationship to other Iraqi bodies. This makes it impossible to determine the scope and nature of the programme. An understanding of the various relationships and interconnections between the diverse organizations that contributed to the BW programme is essential to gain a full appreciation of the programme and build confidence that the account provided is indeed full and complete. A variety of Government organizations would have contributed to the programme. Among these would have been the State Security and Intelligence, the Ministries of Agriculture, Health and Education, Ministry of Defence and some of its various branches, as well as the industrial and academic base in Iraq. The list of contributing organizations cited in the FFCD is incomplete compared to interview testimony and documentation. This can only be rectified by a full disclosure of relevant information supported by documents and details of funding.

163. Iraq claims that the Ministry of Defence provided no support to the BW programme. It is also stated that there was no representation on the Military High Command or the General Council of Ministers concerning any aspect of the BW programme. It is explained by Iraq that the Director-General of TRC reported directly to Lt. Gen. Hussein Kamel Hassan in his capacity of head of the State Security Organ, rather than as head of MIC. Despite this, Iraq forcefully denies any interaction between the BW programme and any Iraqi intelligence agencies.

164. Iraq claims that the BW programme was controlled from the bottom-up. Such a system would not account for the degree of coordination which became evident as the programme progressed.

165. In contrast with the Al-Hazen Institute, which had a formal personnel recruitment programme for its BW activities, the later BW programme had no such formal arrangements, according to Iraq. Promising people within the BW programme were sent abroad for higher education. It is claimed that no directive or directions to academic institutions existed to conduct research related to BW. The description of academic connections does not accord with the evidence.

## Military Involvement in Iraq's BW Programme

166. A clear description of the organizations driving, or influencing, the BW programme is critical to assess its dimension and significance. The lack of such descriptions reflects negatively on the credibility of accounts of R&D, production, and the selection and deployment of weapons. Without further physical or documentary evidence, the unclear explanations given, in these areas, make it impossible to confirm the information presented in the FFCD.

167. The account of military organizations involved in the BW programme is not seriously addressed in the FFCD. The contention that the MOD remained wholly unaware of Iraq's BW programme since 1987 is implausible. The programme started within the Al-Hazen Institute and was headed by a member of the Chemical Corps, Major Ibrahim Ghazim, and the biological component had two senior members recruited from the Chemical Corps. It is acknowledged that MOD was involved from 1983 to 1987 and that it endorsed the addition of BW to the remit of Al-Muthanna in 1983. Although, formally, the chain of command may have altered when the BW research and production component was transferred to TRC within MIC in 1987, it is unlikely that it was not visible to senior military personnel within the MOD. Programming for the formal adoption of BW would have been a factor in the strategic planning of Iraq's military development along with the foreseen nuclear and chemical capabilities.

168. Iraq would have developed a requirement for a militarily significant arsenal of biological weapons in 1987/88, or possibly earlier, based on strategic planning. This in turn would define the technical scope of the programme and the appropriate funding to ensure the eventual success of the programme.

169. According to Iraq's account, the involvement of MOD in the BW programme ceased with the transfer of the biology group from Al-Muthanna to TRC that was under the control of MIC. Iraq asserts this MOD link was only re-established specifically for the deployment of weapons in January 1991. The explanation given is that MIC had a higher status than the MOD and was a self-contained entity that could progress from initiation to deployment of weapons without external input. This has not been substantiated.

170. The BW weapons would have to have been integrated into Iraq's strategic arsenal. For these, military objectives, the concepts of use and the mechanisms for releasing these weapons must have been defined. This would have required extensive planning, which Iraq denies.

171. The FFCD portrays Lt. Gen. Hussein Kamel Hassan as the sole key decision-maker and controller of the BW programme after 1987. Links between Lt. Gen. Hussein Kamel Hassan, the MOD and other organizations are vehemently denied. It is assessed by the Commission that such links must have existed. Without such links, understanding how Iraq defined its military requirement and planned the use of its BW weapons, is difficult.

#### OTHER ISSUES RELEVANT TO VERIFICATION OF IRAQ'S BIOLOGICAL WARFARE PROGRAMME

172. In Parts I and II the status of verification of elements of Iraq's BW programme described to one extent or another in its FFCD is presented. However, a status report would not be complete without the inclusion of several other issues directly related to the verification of Iraq's BW programme. Iraq has attempted to portray the Commission as stalling in its verification efforts. As part of this effort, Iraq cites the numerous inspections and interviews conducted by biological experts as well as citing approximately 200 documents it has provided in support of its declaration. However, Iraq has failed to cite the obfuscation and deception by Iraq that has necessitated these multiple inspections. It has also not cited the type and nature of the documents provided. Quality is not measured solely on the number of documents or volume of material.

173. Other issues include the technological coherence of the programme. The less coherent the programme appears to be the greater the dependency for verification on documentation and physical evidence. Iraq tries to portray its BW programme as an inept programme without guidance or direction. The Commission's assessment of Iraq's level of technology does not support this contention. Iraq asserts that its BW programme was obliterated in 1991. There is little confidence that its programme has been ended. Throughout all of the issues in all three parts of this report is the pattern of concealment and deception employed by Iraq to prevent a true picture of its BW programme from emerging. These issues are addressed below.

#### Inspections 1991 to 1998

174. Over the past eight years the Commission has conducted some 70 inspections directly concerned with biological warfare activities undertaken by Iraq. In addition, six joint chemical and biological inspections have been undertaken, including one that included missile experts. Sixteen monitoring teams have followed biological activities in Iraq's industrial, agricultural, medical and academic facilities. More than twenty of these inspections were direct investigations of Iraq's proscribed BW programme and two were involved with destruction of facilities involved in the programme. The remainder included establishing protocols and procedures for monitoring, detailed audits of key facilities, determination of indigenous capability, and searches for documents. In addition two major meetings were held to exchange information, during August 1993, in New York, and March 1998, at the TEM in Vienna. On both occasions, Iraq produced no additional information to enable a true appreciation of its entire BW programme.

175. The past programme investigation consisted, essentially, of three phases. Firstly, the discovery inspections of 1991 and 1992, that showed that Iraq has not been forthcoming about the scale and scope of its programme. Second, from autumn 1994 to summer 1995, consisting of attempts to uncover the past weapons programme and to establish the credibility of statements being made by Iraq about its past programme and the claimed legitimate activities of sites assessed to have contributed to the programme. After the departure of Lt. Gen. Hussein Kamel

Hassan in August 1995, the Commission embarked on a third phase of investigation of the programme using, in part, information derived from the documents released by Iraq from the Haidar Farm. During the first and second phases, Iraq concealed from the Commission, the entirety of its programme. Iraq merely acknowledged a part of its research programme as a military research and development programme and falsely presenting its main BW agent production facility as a Single Cell Protein plant. During this period Iraq actively and deliberately concealed much of the research programme and the entirety of the remainder of the programme. This it achieved by outright lying, evasiveness, intimidation, forging of documents, misrepresentation of sites and personnel, the denial of access to individuals and the issue of successive FFCDs that were fraudulent. The account provided by Iraq wholly lacked credibility.

176. From September 1994 to July 1995 it became obvious that Iraq was failing to disclose a programme from the inconsistent, often conflicting and changing stories, presented without any substantiation. Eventually the failure of Iraq to account credibly for the vast amount of media imported between 1988 and 1990 led to the acknowledgment that Iraq, indeed, had produced industrial scale quantities of a significant military programme of two biological warfare agents (*Bacillus anthracis* spores and *Clostridium botulinum* toxin) although it was stated, incredibly, that this was done with no thought of weaponization.

177. Iraq has claimed that all documents concerned with its biological weapons programmes were destroyed in 1991. Lacking documents, other approaches have been adopted to investigate and verify Iraq's account of its programme. Interviewing personnel associated with the programme has been the main approach. Iraq has been reluctant to provide personnel to substantiate the details of its programme. Generally, only individuals identified from Haidar Farm documents and documents, otherwise recovered, have been presented. Technical assessments of the facilities and equipment acknowledged to be a part of the programme, sampling, and exploitation of recovered weapons and fragments have also contributed to the inspection process.

178. In August 1995 weaponization was acknowledged by Iraq including weapons trials and the prior deployment of weapons in January 1991.

179. From September 1995 the Commission investigated the full programme as revealed by Iraq. Initially the inspections undertaken in the latter part of 1995 were designed to understand and get and clarify information on Iraq's weapons programmes. Subsequently, attempts were made to verify the three succeeding FFCDs produced after August 1995. During these inspections it became obvious that the FFCDs were inaccurate and incomplete and so investigation of the programme was also begun again. The focus of the inspections was the issue of weapons and the production of BW agents, together with the acquisition of bacterial growth media, weapons, and production equipment. Others aspects such as research and development still await thorough examination. Many aspects have not been addressed because Iraq refused to cooperate. The Commission attempted to help Iraq recall further information about its programme by participating in a seminar in May 1996, which dealt with chemical and biological weapons, by submitting detailed questionnaires to Iraq (which were largely ignored, although later incorporated into the 1997 FFCD), and by organizing a TEM (Vienna, March 1998) for extensive evaluation of Iraq's declarations by a full range of international experts. From June 1998, following discussions between the Commission's Executive Chairman and Mr. Tariq Aziz, Deputy Prime Minister of Iraq it was decided to adopt a focussed programme of inspections following a "top down" approach concentrating on establishing a material balance for biological weapons themselves. This started with an inspection concerned with weapons that concentrated on biological R-400 weapons. The decision of Iraq on 5 August 1998 to cease cooperation with the Commission on the issue of verification has meant that verification of Iraq's biological warfare programme is now in abeyance.

180. Besides weapons related issues, inspections have been conducted to investigate planning, the military and intelligence contributions to the programme, and the acquisition of materiel. Concealment and deception, and the means by which this has been achieved has also been examined with no information of significance provided by Iraq.

181. Many aspects of the programme now included in the FFCD have been revealed because of the result of the Commission's inspections although it is acknowledged that other aspects have been revealed by Iraq without prompting. Ironically many issues and details discussed in the series of inspections conducted on the past programme are omitted from Iraq's official account directly showing that the FFCD is incomplete.

#### General Assessment of Iraq's Documentary Evidence

182. Notwithstanding the reticence with which Iraq has provided documents needed for verification, the quality of documentation provided by Iraq concerning its past BW programme has presented difficulties in providing a strong evidential base for the verification process. Problems with documentation quality reside in their relevance to the proscribed BW programme, as well as their completeness and finally, their authenticity. With respect to relevance, the bulk of documents provided by Iraq to the Special Commission tends to be removed one or more levels from the key issues central to the BW programme and can be best described as derivative, e.g, rather than presenting documents that unequivocally establish the identities of key personnel in the programme, Iraq has provided documents that track the departure of individuals from one place of employment to another. Alternatively, Iraq has provided documents that add nothing of relevance to its declaration by way of verification. With respect to completeness, Iraq has frequently provided fragmentary documentation which renders assessment and hence, verification, difficult because the lack of a full contextual basis. For example, the source of documentation for the 157 R-400 bombs unilaterally destroyed by Iraq, and which serves as a basis for Iraq's allegation that only this number of R-400 bombs were filled, was from a very few pages of a personal diary belonging to an Iraqi army officer apparently present at the time the bombs were destroyed. Finally, Iraq has "recreated" documents, such as the document on ricin production and research, that are at best questionable and may even hinder the verification process. Had Iraq provided appropriate documents of its BW programme dealing with the key elements of acquisition of materials, production of bulk agents, production of weapons, destruction of weapons, and destruction of bulk agents the verification process would have been better served.

#### Technical Coherence

183. One key factor in determining the veracity and credibility of Iraq's account of its biological weapons programme is the assessment of the coherence of the account. Any programme of activity will be managed to achieve set objectives within a specified, possibly flexible, time frame. Once the shape and coherence of the programme become apparent, verification can be achieved by selecting disclosures of appropriate components and determining that it is a faithful and authentic account. When these reference points are determined, other aspects will fall into place and need not be determined with such extensive rigour. Regrettably Iraq's account is not coherent, the first basic step.

184. Iraq fails on a number of levels to present a clear account of its programme. At the senior level there is no indication of the determination of a requirement for such weapons and planning for the acquisition and deployment of the weapons. At the management level there is no indication of how the requirement was to be met and how resources were acquired and utilized to fulfil the military need. In particular the scale and scope of the Al-Hakam Factory are not explained or justified; the inevitable weapons development programme to ensure effective BW agent dissemination is not presented at all. At the working level there is no rationale presented for research and development, or the industrial scale production of agent (especially before August 1990). The repeated statement by a senior Iraqi Government representative, that the programme was a minor programme, essentially run by unsupervised technicians who had an unrealistic programme of work, trivialises a serious programme of work and does nothing to help the Commission gain the appreciation of that programme. The denial of planning for the programme, contrary to the evidence, means that the basic coherence for the programme cannot be established.

185. A weapons programme by definition is a military programme yet apparently there was no military involvement in the claimed last four years of the programme. A philosophy for the programme should have been developed which would require the interaction of military, intelligence, industrial and academic sources. Iraq denies



any military committees or individuals contributed to the formulation of policy with regard to the acquisition and implementation of Iraq's BW programme.

186. The programme for biological weapons was immature in 1991. The failure of Iraq to account for its intended programme of work through 1991 and beyond also prevents the Commission from gaining a perspective of the interrelationships between the various components and so the coherence of the programme. This information will also be essential to determine if Iraq has indeed terminated its programme.

#### Technology Assessment

187. Iraq claims that the BW programme established was an immature programme that was ill considered and ineffectively executed. Further, Iraq claims that it lacked the industrial capability and expertise to manufacture equipment suitable for the production of BW agents and weapons. This is an argument frequently put forward by Lt. Gen. Amer Al-Saadi in his attempts to create the impression that Iraq does not pose a threat to its neighbours with regard to biological weapons.

188. The Commission could not make an accurate technical assessment of Iraq's scientific, industrial, and technical accomplishments because Iraq has not been transparent in its FFCD nor its clarifications about the BW programme. Since the programme has operated from 1973, it is reasonable to assume that Iraq attempted considerably more than has been revealed and that some components achieved success in areas not revealed to the Commission. Some 400 individuals are known to have contributed to the programme in various ways from research to weaponization. Civilians, civil servants, security, and military personnel were involved. Iraq has a record of denying and understating its weapons programmes. Iraq has preserved components of its BW programme since 1991, and much of the expertise remains in Iraq. The Commission has examined the indigenous capability existing in Iraq and has assessed in the course of inspection that Iraq is capable of manufacturing "dual use" equipment and munitions. The degree of sophistication of these systems may not meet so called "western" standards but none the less are quite capable of fulfilling the requirements.

189. Iraq has a broad based research community in Universities, Medical and Agricultural Institutes, and the Military Industrial Commission covering microbiology, biological processing, materials science, genetic engineering, pathology, biological production, munitions and weapons.

Iraq also has an industrial base capable of manufacturing fermentors and their ancillary requirements, spray driers, and storage vessels for agents. The industrial base will also sustain the engineering and manufacture of weapons.

#### The End of the Iraqi BW Programme?

190. In mid-1995 Iraq admitted that it had possessed a BW programme. Since then, Iraq has often stated that its BW programme was 'obliterated' in 1991. Officials cite, as proof of this, the unilateral demolition of the deployed BW weapons, deactivation of bulk BW agents and the destruction some documents associated with the programme. Despite these activities in 1991, Iraq retained the facilities, growth media, equipment and groupings of core technical personnel at Al-Hakam, while denying the very existence of any BW programme.

191. Although Iraq continues to insist that no elements of its BW programme have been preserved, the Government of Iraq has yet to offer evidence of the formal renunciation of its BW programme. It is explained that a decree was never issued because of a 1991 decision to conceal the BW programme. Again Iraq has produced no information on the decision to conceal the programme.

192. Iraq insists that all its BW weapons were destroyed in July 1991. The numbers, location and timing of weapon destruction and, indeed, whether all weapons were destroyed, remain in doubt. Iraq's account of the destruction of the BW-filled Al-Husseini warheads changed with virtually every inspection team that addresses the issue with Iraq.

No supporting evidence exists for the destruction of the bulk agent, also regarded by the Commission as weapons. Large quantities of bacterial growth media remain unaccounted for.

193. After 1991, Iraq maintained and expanded the purpose-built major BW production, research and development and storage facility, Al-Hakam. From that time, Iraq asserts that Al-Hakam was solely a single cell protein (SCP) production plant. However, no serious attempts to produce SCP ever occurred. SCP was only produced in insignificant quantities as a camouflage, principally by harvesting SCP from brewers waste rather than de novo production from petroleum products. Individuals, identified as key workers in Iraq's BW programme, continued as members of the staff of Al-Hakam. In the years after 1991, Iraq attempted to obtain dual-purpose equipment including industrial-scale fermentors from within the country and abroad.

194. In the years since 1995, the Commission's teams have continued to discover significant undisclosed dual-use equipment that could readily be used in a BW programme. In the six months period April to October 1998, some 150 undeclared items were found and tagged by biology monitoring teams. For example, many mobile tanks used in the BW programme are not accounted for. The significance of this lies in the fact that with only minor modifications these could be used as fermentors.

195. Although Iraq acknowledged its offensive BW programme in 1995, it has yet to make a full disclosure. One of the most obvious omissions is information concerning the termination of its offensive BW programme. The evidence collected by the Commission and the absence of information from Iraq, raises serious doubts about Iraq's assertion that the BW programme was truly obliterated in 1991.

#### Concealment and Deception

196. Verification is the basis of disarmament and arms control. Verification depends on serious cooperation between the parties concerned. It also depends on compliance, in principle. This includes the submission of comprehensive and accurate declarations which can be confirmed by supporting evidence. Without these, confidence in a verification regime as required under SCR 687 (1991) is limited, at best. Concealment of critical facts is a clear sign of non-compliance. It raises serious doubts in the efficiency of disarmament or any arms control work and unavoidably leads to speculations about the reasons motivating it. Concealment effectively precludes verification.

197. In April 1991, Iraq made a decision to conceal certain aspects of its weapons of mass destruction programmes from the world. With regard to its BW programme it decided to admit only a limited effort of research and development, that was restricted to a single location, never reached the level of production of agent or weaponization, and was terminated unilaterally in August 1990. Iraq maintained this position until in 1995, when the departure of the head of Iraq's weapons of mass destruction programs, resulted in additional aspects of these activities being released. Iraq admitted having had an offensive programme centred around a purpose built research and production facility and including large scale production of BW agents and weaponization and deployment of aerial bombs and long-range warheads.

198. A high-ranking Iraqi official, Lt. Gen. Amer Al-Saadi, stated in 1998, that Iraq offers no defence for the period of denial of its BW programme. He admitted it was a political decision to conceal both the programme and consequently its obliteration from the Special Commission. In fact, the attempts to conceal the programme caused and continue to cause serious doubts amongst the Commission's experts over Iraq's declarations. This and a lack of documentary or other physical evidence greatly hinders the process of verification of Iraq's disarmament efforts to which it is obligated by international law and its own acceptance of those terms.

199. A serious concern remaining is that the unilateral destruction of documents, agents and weapons in 1991 was linked to the concealment issue rather than the issue of obliteration of its programme. The difference being, that in the first case, only part of all assets may have been destroyed, purely to deceive the Commission and feign liquidation of the programme. Indeed, the Commission is aware that Iraq at least retained suitable growth media,

capable facilities, production equipment, teams of expert personnel, and the essential technical know-how. Until today, no credible declaration has been presented by Iraq as to if and when it obliterated its BW programme.

200. Since the disclosure of the BW programme in 1995, Iraq has released a number of documents to the Commission. Iraq has ascribed an inflated importance to certain of these documents and dismissed others. Indeed, some documents have been described as "first class", whilst on other occasions the same documents are described as unreliable or trivial. There is an attempt to disregard documentary evidence that contradicts the accounts of officials or material in the FFCD. It is apparent, that Iraq only releases documents and other information to address or respond to information the Commission had already become aware of.

201. The following tables detail events and actions taken by Iraq as a result and indicative of its decision to conceal the BW programme from the Commission. It portrays a systematic effort to deceive the Commission by a) false or incomplete declarations and b) removal or manipulation of evidence delineating the totality of its BW programme.

202. Concealment of Iraq's Biological Warfare Programme in its Declarations to the United Nations and its Bodies

#### Actions taken by Iraq Comments

8 April 1991 A letter presented by Iraq implied Ratification of the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction. Iraq later declared that in April 1991 it still had 157 biological bombs, 25 biological warheads and several thousand litres of unfilled biological agent in storage which would be a violation of the BWC. No article of implementation has been provided.

18 April 1991 Iraq declares to the Secretary General of the United Nations that it does not possess any biological weapons or related items as described in paragraph 8 of SCR 687 (1991). Iraq possessed at least the weapons acknowledged above on this date.

2 August 1991 Iraq declares to the first biological inspection team of the Special Commission a limited biological research programme for military purposes focussing on three bacterial agents. It was initiated at Salman Pak in 1986 and abandoned in August 1990 before it reached the stage of production or weaponization of biological agent. Iraq's current declaration of its BW programme describes an offensive military programme initiated in 1973 and abandoned in mid 1991. It comprised several research and production facilities and a variety of bacterial, fungal, viral and plant-derived agents were investigated and produced in large quantities. A number of delivery means were investigated and eventually utilized.

May 1992 Iraq submits an FFCD of its BW programme as demanded by S.C.R. 707 (1991). It details the activities outlined in its August 1991 declaration. It states that Al-Hakam, FMD facility and VRL were not related to any BW activities. Al-Hakam and FMD facilities were later declared as Iraq's main production sites for Bacillus anthracis spores and botulinum toxin used in their BW programme. Equipment of the VRL company was transferred to Al-Hakam and used in that process.

Early 1994 False site declarations are submitted on Salman Pak, Al-Hakam and the FMD facility. Salman Pak was described as the exclusive BW site undertaking limited research. Any involvement of Al-Hakam and FMD in the programme was denied.

March 1995 Iraq submits a second FFCD of its BW programme. It contained no significant additional information from the prior FFCD. The FFCD attempted to explain the import into Iraq in 1988 of 39 tons of growth media - a fact that was discovered by the Commission only in late 1994. Iraq declared that the media was imported for medical diagnostic purposes. Iraq presented documents in support of its declaration but later admitted that these were "recreated" from "originals" that were no longer available.

April 1995 Iraq declared during high-level talks in Baghdad that no further cooperation with regard to its BW programme could be expected by the Special Commission if the Chairman failed to report to the Security Council that the Missile and Chemical Files were closed and IAEA did not report the same in the nuclear area. No production or weaponization of biological agent was admitted.

July 1995 Iraq decides that it would cease all cooperation with the Special Commission on 31 August 1995 if there was no progress towards the lifting of sanctions. Iraq on 1 July 1995 in an oral presentation admitted to the

Chairman of the Special Commission the large-scale production of biological agent. It still denied weaponization of any biological agent. The quantity of Bacillus anthracis spores was considerably under reported. Production of aflatoxin and Clostridium perfringens spores was not acknowledged.

4 August 1995 Iraq submits a third FFCD of its BW programme. The large-scale production of two agents, Bacillus anthracis spores and botulinum toxin at Al-Hakam is admitted. Iraq denies any attempts to weaponize these agents. The FFCD was declared null and void on 17 August. This change was precipitated by the departure of Lt. Gen. Hussein Kamel Hassan, who over a considerable period of time was in charge of Iraq's weapons of mass destruction programme.

17 August 1995 Iraq presents additional information including weaponization of biological agents, research and production of additional agents and additional sites related to its BW programme. Iraq does not acknowledge weaponization of aflatoxin.

June 1996, September 1997 A fourth FFCD was submitted in June 1996 and a fifth FFCD in September 1997. Both were rejected by the Commission for reasons of a lack of comprehensiveness, accuracy and credibility.

### Concealment of Iraq's Biological Warfare Programme and Deception of the Special Commission

#### Actions taken by Iraq Comments

April 1991 Decision was taken to conceal BW programme from the Special Commission Details of this decision have not been provided to the Commission.

A Revolutionary Command Council Member under the supervision of the Deputy Prime Minister Mr. Tariq Aziz was responsible for the dealings with the Special Commission. Lt. Gen. Amer Al-Saadi, adviser to the Presidency, explained in 1998, that the decision makers were and still are a group of senior people including Deputy Prime Minister Tariq Aziz, Minister Mohammed Al Sahaf, Minister Lt. Gen. Rashid Amer, Minister Lt. Gen. Murthada and himself. Lt. Gen. Hussein Kamel Hassan was excluded from that group.

May 1991 Foundation of the Operations Section for the day-to-day dealings with UNSCOM. From this section, the National Monitoring Directorate (NMD) was established.

Removal of Evidence from Al-Muthanna. Traces of the BW programme were removed from the Toxicology Department and the filling station for Biological Weapons.

June 1991 Purported instruction by Lt. Gen. Hussein Kamel Hassan to destroy all documents, agent and weapons related to BW. Despite this clear order, an unknown amount of documents "survived". Iraq claims these were collected by Lt. Gen. Hussein Kamel Hassan in November 1991. UNSCOM inspections have repeatedly discovered documents related to issues defined under SCR 687 (1991).

Transfer of large amounts of bacterial growth media to Kimadia together with forged import documents. An inventory card indicating an arrival date for the media at Kimadia in 1989 was prepared later. In 1992, to explain the missing media that had been used for the production of BW agent, health departments were asked to sign fake receipts for that media for diagnostic purposes. Kimadia, operating under the Ministry of Health, was used as a front to explain the legitimacy of the import of the growth media.

July 1991 Iraq states that they unilaterally destroyed all biological weapons, bulk agent, related documents and some equipment. There is no documentation for this destruction process. A lack of related documents or physical evidence impedes direct verification of elimination of material as defined in paragraph 8 of SCR 687 (1991).

August 1991 Rehearsals of answers to expected questions by UNSCOM inspectors.

Al-Hakam is being systematically cleansed including all the equipment used in the BW programme to conceal any damning evidence

Preparations for the first UNSCOM Biological Weapons inspection.

Declaration of limited BW related research on three bacterial agents. A declaration was handed over to the first UNSCOM BW inspection on 2 August.

Submission of 10 research papers in support of their declaration. The papers were carefully edited to reveal only certain aspects of the programme.

September 1991 During inspection BW 2, Al Hakam is portrayed as a genuine civilian Single Cell Protein facility. A fake laboratory was presented. This account was maintained until July 1995. Prof. Nasser Hindawi, an expert in SCP, is presented to the team as the director of Al-Hakam. Prof. Nasser Hindawi later admitted that he was

not involved in a SCP project at the time of BW 2. He was appointed director of the Al-Hakam SCP project in November of 1991 and on 4 April 1992 director of Al-Hakam, only to be relieved from this post a few weeks later. Iraq declares to an UNSCOM team that 58 R-400 bombs located at Al-Muthanna were exclusively for Chemical Warfare (CW) purposes and were never filled. 56 of these bombs were destroyed under UNSCOM supervision and two removed for further study. Iraq later stated that about 36/37 of these bombs were in fact designated for biological purposes. Photo evidence of characteristic markings of the weapons supports this claim. November 1991 Instruction by Lt. Gen. Hussein Kamel Hassan claimed to have been given to collect all important remaining documents relevant for BW and hand them over to him. In 1995, following the departure of Lt. Gen. Hussein Kamel Hassan, these documents were handed over to the Special Commission and are referred to as the "Haidar

Chicken Farm" documents. Despite Iraq's claims, they are judged to be of low significance. The more significant documents, Iraq states to have collected in November 1991, have not been provided to the Commission, yet.

April 1992 Iraq presents to UNSCOM an account of the destruction of 40 CW R-400 bombs at Al-Azziziyah. Iraq states that 157 BW R-400 bombs were destroyed at Al-Azziziyah. No CW weapons are now stated to have been destroyed there.

Iraq presents an UNSCOM inspection team with the supposed remains of 45 CW warheads that had been unilaterally destroyed. UNSCOM inspectors counted 43 nosecones as indicators for the 45 destroyed warheads. Iraq later admitted that it seeded about 25 nosecones in the area of excavation to deceive the inspectors. Thus, only the remains of 20 CW warheads were in fact presented. The remaining 25 were biological warheads that were not ready to be disclosed in 1992.

August/ September 1993 During technical talks in New York, Iraq insisted that the BW programme comprised only limited research. This position was maintained until August 1995, when an offensive programme including agent weaponization was admitted. Since then, no further substantial information was presented to the Commission.

## Summary

203. Since the adoption of SCR 687 (1991), in April 1991, and until July 1995, Iraq denied that it had any proscribed BW activities. Despite Iraq's denial, the Commission, through its inspection and verification procedures, was able to determine that Iraq had not provided a full and comprehensive disclosure of its biological programme nor had it accounted for items and materials acquired for that programme. The Commission reported these findings to the Security Council in April 1995. On 1 July, 1995, Iraq acknowledged that it had had an offensive BW programme, but denied weaponization. Subsequently, in August 1995, after the departure of Lt. Gen. Hussein Kamel Hassan, Iraq admitted that it had weaponized BW agents and had deployed them for combat use. However, the Commission has a far from complete understanding of all aspects of Iraq's BW programme. The Biological FFCD neither contains the required detail, nor does it cover the full scope of Iraq's BW activities. In particular, a refusal to disclose, or even discuss, details of the military aspects of the BW programme is of concern.

204. Iraq has released information over the years very selectively. When Iraq is aware that the Commission has details of a particular event or circumstance, then a document will be released. Very little new information has been disclosed since 1995. There are many inconsistencies and contradictions in documents, personal testimony and physical evidence. However, the accumulation of inconsistencies creates patterns, which show that the FFCD is incorrect.

205. Iraq claims to have produced, filled, deployed and unilaterally destroyed 25 Al-Hussein missile warheads intended for BW use. No evidence exists to confirm the number of warheads produced as 25, or for a greater or lesser quantity. Confusion reigns, even among Iraqi officials, over how many warheads were filled with particular BW agents. There is no evidence of the proportions of weapons filled with particular types of agents. At Al-Nibai the numbers and locations of remnants of warhead stainless steel agent containers, some of which have traces of

Bacillus anthracis spores, contradict the account of the weapons' destruction in the FFCD.

206. The FFCD states that 200 R-400 aerial bombs were manufactured for the BW programme, and that 157 of these were filled with BW agents, deployed and unilaterally destroyed. The evidence available indicates that more than 200 were available for the BW programme. Iraq admits that the numbers filled with particular agents are guesses. Statements in 1998 by Iraq have further confused this matter. The physical evidence from the remnants, accounts for less than one third of those said to have been unilaterally destroyed.

207. From November 1990 until the cease-fire in 1991 Iraq worked to produce a system able to deliver large volumes of BW agent aerosol from high-performance aircraft. It is stated that four such drop-tank weapons were produced. The remains of three have been accounted for. There is no evidence to establish whether only four were produced nor have other details of this aspect been addressed by Iraq. In tandem with this work, Iraq attempted to develop, apparently unsuccessfully, a pilotless aircraft to carry the drop-tank weapon. Very little information exists on this latter project, and it is possible that it was intended for CW use or both BW and CW.

208. The first weapon system for delivering BW agent investigated by Iraq was a helicopter-borne aerosol generator. Successful trials led to the manufacture of 12 such items. There is no evidence of their destruction. Also the final, and presumably most effective, prototype of this aerosol generator has never been accounted for.

209. Besides the weapons that reached the production stage, several other potential delivery systems received some attention by Iraq. 122mm rocket warheads were extensively trialed with BW agent. Iraq claims to have abandoned this development. After briefly admitting that cluster munitions were part of the BW programme, Iraq withdrew the statement. Artillery shells filled with ricin were trialed. The LD-250 aerial bombs made by Al-Muthanna and used in early BW trials, were abandoned in favour of the more robust R-400 according to Iraq. Iraq investigated the use of gas gangrene relevant to application in fragmentation weapons.

210. A key determinant of the size and capability of the BW programme was the production of bulk agent. Apart from one document referring to a single year, no production records have been given to the Commission. All accounts and assessments are based on the capacities of the known production equipment, the amounts of growth media purportedly available and the time and personnel that could be used. The amounts of agent produced and declared by Iraq are unsubstantiated. Quantities far greater than those declared could have been produced without difficulty. Further to complicate this process, there are no records of storage, filling into munitions or destruction. As a result, experts have very little confidence in the production figures quoted in the FFCD.

211. The situation regarding bacterial growth media is similar to that of the production of bulk agent. There are disparities between Iraq's declared imports of media and information available to the Commission. The material balance of growth media is flawed. The absence of records of the use and discrepancies in the accountability of this material leaves open the possibility of significant undeclared production of bulk BW agent.

212. As in other areas of the BW programme there is a dearth of documentation relating to attempts (both successful and unsuccessful) to import the equipment and materials necessary to pursue the acquisition of a larger BW capability.

213. Research is a fundamental cornerstone of Iraq's BW programme. Although not all aspects investigated at the research level will lead directly to weapons development, the scope of the research programme is an index of the concept, strategy, and extent of the programme. No account whatever is given of review, concept, or theoretical projects undertaken by the research staff throughout the programme.

214. The account of the history of the BW programme, given by Iraq, encompasses only a part of the programme, it is inaccurate with respect to dates, and fails to provide insight into the decision making process that facilitated

its evolution. The account is misleading because it fails to present the underlying strategy and the long-term goals of the programme. Iraq's known concealment and deception activities cast doubts on its claim that the programme was obliterated in 1991.

215. Iraq is required to provide the rationale, justification, and requirement for all sites including those for weapons tests, research and development, production, storage, weapons production and filling, deployment, and the destruction sites for weapons, documents and agents. The FFCD account fails to state the scale and scope of the requirements for the programme. No information is provided on planning and true objectives. All that has been provided by Iraq is a physical description of some components. It fails to explain the rationale behind the selection of BW sites.

216. The absence of comprehensive information about the organization of Iraq's BW programme, at all levels, and its relationship to other Iraqi bodies, makes it impossible to determine the scope and nature of the programme. An understanding of the various relationships and interconnections between the diverse organizations that contributed to the BW programme is essential to gain a full appreciation of the programme and build confidence that the account provided is indeed full and complete. The list of contributing organizations cited in the FFCD is incomplete compared to interview testimony and documentation. This can be rectified by a full disclosure of relevant information supported by documents and details of funding.

217. A clear description of the organizations driving, influencing or otherwise participating in the BW programme is critical when assessing its dimension and significance. The lack of such descriptions reflects negatively on the credibility of accounts of research and development, production, and the selection and deployment of weapons. Further physical or documentary evidence in all these areas is needed to confirm the information presented in the FFCD.

218. Throughout the investigation of the programme there has been a systematic and comprehensive attempt by Iraq to conceal the programme and deceive the Commission. Until 1995 all aspects of the offensive BW programme were concealed and active measures taken to deceive the Commission. Since August 1995, Iraq has submitted a number of FFCDs of its declared BW programme. These declarations have been assessed by the Commission and by international experts as incomplete, inadequate and containing substantial deficiencies. They were not accepted as a full account of the scale and the scope of Iraq's BW programme. This refers in particular to weaponization of produced BW agents, bulk BW agent produced and acquisitions for the BW programme. Consistently Iraq has tried to understate the scale and importance of the BW programme as a whole, and the success of individual components.

219. In the Commission's view, Iraq has not complied with requirements of the relevant Security Council resolutions on the disclosure of its BW programme. A full, complete and verifiable disclosure of all its biological weapons activities needs to be presented by Iraq.

----- モバイル・ストレージ関係 -----

PersonalRAID: Mobile Storage for Distributed and Disconnected Computers 1

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Abstract:

This paper presents the design and implementation of a mobile storage system called a PersonalRAID.

PersonalRAID manages a number of disconnected storage devices. At the heart of a PersonalRAID system is a

mobile storage device that transparently propagates data to ensure eventual consistency. Using this mobile device, a PersonalRAID provides the abstraction of a single coherent storage name space that is available everywhere, and it ensures reliability by maintaining data redundancy on a number of storage devices. One central aspect of the PersonalRAID design is that the entire storage system consists solely of a collection of storage logs; the log-structured design not only provides an efficient means for update propagation, but also allows efficient direct I/O accesses to the logs without incurring unnecessary log replay delays. The PersonalRAID prototype demonstrates that the system provides the desired transparency and reliability functionalities without imposing any serious performance penalty on a mobile storage user.

## Introduction

As disk density continues to grow at a phenomenal annual rate of 100% [3], the cost, form factor, and capacity of stable storage continues to improve dramatically. One consequence of these dramatic technological advances is the emergence of highly compact secondary storage, which can be seamlessly integrated into devices of all shapes and forms. As technology continues to improve, as decentralization is carried to its logical next step, and as traditionally analog information is increasingly being turned into digital representations, it is not unreasonable to conjecture that such mobile storage may become a dominant form of storage in the near future, especially for personal user data, subsuming conventional disks enshrined in machine rooms.

Figure 1: An IBM Microdrive. On the left is a 1 GB Microdrive shown in its packaging. On the right is the same drive shown open with a U.S. quarter. (Courtesy of IBM. Unauthorized use not permitted.)

Unfortunately, as mobile storage flourishes, high-performance universal network connectivity may still not be available everywhere. At any instant, only a small number of devices may be connected to each other; and a mobile storage user cannot always count on an omnipresent high-quality connectivity to a centralized storage service. A mobile storage solution that does not rely solely on network connectivity for managing a collection of distributed (and possibly disconnected) devices needs to be found. We also share the belief that a user's attention is a precious resource that the system must carefully optimize for, and a central goal of the system is to ease the management of these disconnected devices.

We identify three important desirable features of such a mobile storage solution. (1) The availability of a single coherent name space. A user who owns a number of storage devices should not be burdened with the chore of hoarding needed data and propagating updates manually. Ideally, even when these devices are permanently disconnected, the user still sees a single coherent space of data regardless where she is and regardless which device she uses. The user should not have to modify her existing applications to enjoy these benefits. (2) Reliability. The view that only centralized servers provide reliability guarantees and mobile devices are inferior second-class citizens, whose data is expendable, is not always acceptable: the frequency and duration of periods where a mobile storage device is disconnected from a central server can be significant enough that one must have some degree of confidence over the reliability of data. (3) Acceptable performance. The provision of the transparency and reliability features listed above should not impose a significant overhead. Ideally, the user of the mobile storage system should always be able to enjoy a level of performance that is close to that of the local storage.

In this paper, as a first step, we describe a mobile storage system called a PersonalRAID that is designed to support a collection of disconnected and distributed personal computers. In addition to these end hosts, central to the PersonalRAID design is a portable storage device, such as the 1 GB IBM Microdrive (Figure 1) used in our prototype. We call this device the Virtual-A (VA). The VA is named so because: (1) it is analogous to a



conventional removable storage device (which is often named drive A on Windows PCs), and (2) it provides the illusion of a storage device whose capacity is far greater than the device's physical capacity. The VA allows the PersonalRAID system to achieve the three goals enumerated above: (1) The VA transparently propagates updates among disconnected hosts to ensure eventual consistency. It helps provide a single storage name space that is transparently available on all hosts. It supports existing file systems and applications without modification. (2) The VA provides temporary redundancy before data is propagated to multiple end hosts so that the PersonalRAID system can tolerate any single-device loss. (3) The PersonalRAID system intelligently chooses between a local disk and the VA device to satisfy I/O requests to mask propagation delays and minimize overhead.

The central aspect of PersonalRAID design is its use of a distributed log-structured design: the collection of distributed logs is the storage system: there is no other permanent structure hosting the data. This design not only allows PersonalRAID to propagate updates among the logs throughout the system efficiently, it also allows a user to satisfy her I/O requests directly from the logs without having to wait for propagations to complete. We have implemented a prototype PersonalRAID system. Our experiments demonstrate that the system achieves the transparency and reliability functional goals without imposing any serious performance penalty.

The rest of the paper is structured as follows. Section 2 describes the user experience and the main operations of a PersonalRAID system. Section 3 presents the rationale and the details of the log-structured design of the system. Section 4 describes our prototype PersonalRAID implementation. Section 5 details the experimental results. Section 6 compares PersonalRAID to a number of related systems. Section 7 concludes.

## Functionalities

The PersonalRAID system manages a number of disconnected storage devices where the mobile user desires a single name space on all of them. The mobile VA device is instrumental in bringing this about. It is generally not a good idea to rely exclusively on the mobile storage device alone due to its capacity, performance, and reliability limitations; instead, the device needs to be an integral part of a PersonalRAID system.

Figure 2: A usage scenario of PersonalRAID. The mobile user carries the Virtual-A device as the user travels among disconnected computers (such as a machine at home, a machine in the office, and a laptop on the go). The PersonalRAID system provides the illusion of a single name space, and it also ensures data reliability.

The VA accompanies the user wherever she goes (Figure 2). With current technology, a few gigabytes can be packaged in the form factor of a credit card (such as the Kingston 5 GB DataPak PC Card Type II Hard Drive) or a wrist watch (such as the IBM 1 GB Microdrive). The VA can communicate with a host computer via various forms of connectivity (such as PCMCIA, USB, or Bluetooth). As long as the VA is present, the user "sees" her up-to-date large home directory regardless where she is and which computer she is using. The user never needs to perform manual hoarding or manual propagation of data; and the loss or theft of any single device does not result in data loss. PersonalRAID mainly targets personal usage scenarios. (We address concurrent updates in Section 3.8.1.)

Figure 3: PersonalRAID operations. The roles of the home and office computer disks are reversed as the user creates new data at home, which must be propagated to the office.

Figure 3 depicts in greater detail the PersonalRAID operations that synchronize the contents of several host computer disks. (a) In this example, when in the office, the VA passively observes the I/Os performed to the office computer disk and incrementally records the newly written data. The office computer disk is called the source of this data. (b) When the user is about to leave the office and disconnects the VA, the system flushes some metadata so that an inventory of the VA's contents is placed on it. (c) The user then takes the VA home and connects the device to her home computer. The system reads the metadata, and file system operations can occur immediately following connection. (d) After connection, the system reads from either the VA or the home computer disk to satisfy user requests. We call the I/O events that have occurred between a pair of connection and disconnection events a session. (e) Possibly in the background, PersonalRAID synchronizes the contents of the disks by replaying some of the updates, which were recorded on the VA earlier in the office, to the home computer disk. The home computer disk is called the destination. Only after the latest updates are reflected on all the host disks do we remove the copy of the data from VA. (This invariant can be a problem if some hosts in the system are only infrequently visited by the user, and the VA device is not large enough to hold all the unpropagated data.) Note that it is not necessary to replay all the new data to a destination device in a single session--the user may choose to disconnect from the home computer at any time. As the user creates new data at home and the VA records it for later replaying to the office disk, the roles of the two end hosts are reversed: the home disk becomes the source and the office disk becomes the destination. Note that we are maintaining an invariant: a copy of any data resides on at least two devices. This invariant allows the system to recover from any single-device loss.

Our current implementation requires the VA device to be present when the file system is being accessed; this is consistent with the most common single-user case that PersonalRAID targets. We do not currently handle updates on a host that is disconnected from the VA. Such updates can be potentially conflicting. In Section 3.8.1, we discuss ways in which the current system could be extended to address these limitations. Another limitation is that the incorporation of a new host into the system requires a heavy-weight recovery operation, as discussed in Section 3.6.

For simplicity, our current system addresses only disconnected computers. We are researching extensions of the system that can exploit weak or intermittent network connectivity when it is present. We expect the mobile storage device and the weak connectivity to complement each other in such situations.

## Design

The design of the PersonalRAID should satisfy the following requirements:

Recording should not impose excessive overhead that may interfere with normal I/O operations.

During disconnection, the user should not be forced to wait for long before the VA can be safely removed.

During connection, the user should not be forced to wait for long before she is allowed to perform I/O operations.

Replaying should not impose excessive overhead that may interfere with normal I/O operations.

Replaying should proceed quickly so that the disk space on the VA can be quickly freed up for future I/Os.

## Naive Design Alternatives

A simple solution is the following. At the end of the work day in the office, for example, the system copies all the content that was updated during the day to the mobile disk. After the user reaches home, the system copies this content to the home computer disk. While relatively simple to implement, this approach has some serious

disadvantages: before leaving the office, the user is forced to wait for the entire set of newly modified data to be copied from the source to the mobile device; and after reaching home, the user must wait for the entire mobile device content to be copied to the destination before she is allowed to access the file system. With mobile storage devices that can store gigabytes of data, and with potentially lengthy intervals spent at one computer before moving onto another, the latency may become intolerable.

One possible improvement is to incrementally copy newly generated data from the source disk to the mobile disk in the background instead of allowing the new data to accumulate. This improves the disconnection time, but it does not address the long connection latency-the user still must wait for the entire propagation to complete before she can proceed to normal I/O activities.

To address these disadvantages, one realizes that the PersonalRAID needs to be a file system or storage system solution which can transparently decide which device to access for a particular piece of data: this is necessary, for example, if the user desires to access the data on the mobile device after connection but before it is propagated to the destination device. With this requirement in mind, let us consider a second alternative: during recording, the system mirrors a portion of the source device Unix File System (UFS) on the mobile device. After connection, while background replaying occurs, the user may transparently access the mirrored portion of the UFS on the mobile device.

While this second design alternative may improve the disconnection and connection latency, the choice of mirroring a portion of the UFS on the mobile device may not be a wise decision for best recording and replaying performance. First, during recording, UFS updates may incur a large number of small synchronous disk writes. The problem is made worse when the mobile storage devices typically do not possess the best latency characteristics so it is difficult to mask the extra latency by overlapping the I/Os to different devices. This situation is especially unfortunate when one realizes that the synchronous mirroring on the mobile device is unnecessary-data is already made persistent on the source device.

Second, replaying from a partial UFS mirror on the mobile device to the destination device UFS is also inefficient, because unnecessary disk head movement occurs. Slow replaying, in turn, has several negative repercussions: (1) slow replaying interferes with normal user I/O activity; (2) slow replaying may cause the mobile device to fill up; and (3) slow replaying prevents the user from taking advantage of the potentially faster destination device by forcing the user to continue to use the slower mobile device for reads.

### Log-Structured Organization

The analysis of the naive design alternatives shows that a good PersonalRAID design should have at least these two properties: (1) the mobile device should be an integral part of a storage or file system so that the user can transparently read/write the device without incurring long connection/disconnection latency; (2) the transfer of data onto/off the mobile device should take place in a fashion that avoids incurring the intrinsic latency bottleneck of disks.

One possible design that naturally satisfies these requirements is to have some variant of a log-structured file system (LFS) [12] on both the VA and the host disks. During recording, data is buffered in large memory segments; these memory buffers prevent overwritten data from ever reaching the disks and large segment-sized writes are efficient. Disconnection is analogous to a graceful LFS shutdown and connection is analogous to an LFS recovery, both of which mainly involve metadata operations that are relatively efficient. Note that disconnection must also flush any dirty data segments. Fast replaying is possible because the system transfers data at large segment-sized granularity that fully utilizes the VA and host disk bandwidth. Furthermore, during replaying, as the system reads live data from the VA and writes them to the destination device, large extents of empty segments are generated on both the VA and the destination device; therefore, replaying and segment cleaning in effect become an integral one.

## PersonalRAID Data Structures

Figure 4: Details of the main PersonalRAID data structures.

While it is possible to build a PersonalRAID system at the file system level by modifying an LFS to adapt to multiple storage devices, we have elected to construct the PersonalRAID by extending the design of a Log-Structured Logical Disk (LLD) [1]. A logical disk behaves just like a normal disk from the point of view of a file system: it allows the file system to read and write logical disk addresses. A particular implementer of a logical disk, however, can choose to map these logical addresses to physical addresses in a way that she sees fit. A log-structured logical disk maps logical addresses that are written together to consecutive physical addresses, effectively accomplishing the goals of an LFS. An LLD can support existing file systems with little or no modification and it is typically easier to implement an LLD than an LFS. The PersonalRAID system makes a single consistent logical disk available on all the participating hosts, despite the lack of any network connection between any of them.

The data structures on each device of a PersonalRAID are not unlike those of a conventional LLD. In a conventional LLD, the disk is structured as a segmented log. Data blocks are appended to the log as the LLD receives write requests from the file system. Each write request is assigned a unique time stamp from a monotonically-increasing global counter. Each segment contains a segment summary, which has the logical address and the time stamp of each data block in the segment. The segment summary aids crash recovery of the in-memory logical-to-physical (L-to-P) address mapping. The L-to-P mapping is checkpointed to the disk during graceful shutdown.

Figure 4 shows in greater detail the three main PersonalRAID data structures: the segment summary, the checkpoint, and the in-memory map. For each of the three data structures, there is one version for the host local disk and there is another version for the VA. The version for the local disk is essentially the same as that of a conventional LLD. The VA version is augmented with some additional information.

Each entry of the L-to-P mapping in the VA checkpoint is augmented with a bitmap: one bit (0) per host, and 1 if the block for this logical address needs to be propagated to host  $h$ . In a PersonalRAID system, the contents of the VA device are defined to be the set of data blocks that still need to be propagated to some host. Thus, a block is evicted from the VA device when it has reached each host in the system. In other words, the L-to-P entry for a particular logical address is marked null when the corresponding bitmap contains 0 in all positions. The VA checkpoint is also home to a global counter. All write operations in the system are assigned a unique time stamp from this counter.

Each entry of the VA in-memory map is augmented with a state field that consists of four bits (0000): this field is a summary of what needed to happen to this block at the beginning of the current session in terms of propagation (0), and what has happened to this block on this host in the current session in terms of replaying and recording (0).

When stored as a table, each L-to-P map consumes 4 bytes per logical address. Thus, assuming a block size of 4 KB, the L-to-P map needs 1 MB for each GB of logical address space. The total size of the bitmap fields in the VA checkpoint is  $bits$ , where  $N$  is the number of logical addresses and  $H$  is the number of hosts in the system. Thus, the bitmaps need 32KB of VA disk space per host for each GB of logical address space. The state fields in the in-memory data structure for the VA need 128KB for each GB of logical address space. Observe, however, that at any time, most L-to-P entries and the state and the bitmap fields for the VA will be null, since the size of the VA will typically be much smaller than the size of the logical address space. Thus, more compact representations of the VA data structures are possible.

We close this section by making the following observation about the PersonalRAID data structure design. Each device in a PersonalRAID is self-contained in that the physical addresses within the data structures for this device all point to locations within this device. If a logical data block is not found on this device, the pointer to it in the L-to-P mapping of this device is null; in this case, a corresponding pointer on a device that does contain the block points to a true location of the block. The union of all the valid pointers on all devices constitutes the whole logical-to-physical map.

## PersonalRAID Operations

In this section, we describe the various PersonalRAID operations in detail. Figure 3 also illustrates how these operations interact with the underlying log on each device.

### Recording

During recording (a), the system appends a newly created logical block to two logs: one on the source device and the other on the VA. The logical address of the newly created data is recorded in each of the two segment summaries along with the latest timestamp. The in-memory map of each device is also updated to reflect the latest locations of the data block. In addition, we set in the state field of the VA in-memory map to mark the creation event during this session.

### Disconnection and Crash Recovery

During disconnection (b), first the file system on the PersonalRAID logical disk is unmounted. Unmounting flushes all the dirty file-system buffers to the PersonalRAID logical disk, and it also indicates to the user that the file system on the local host is unusable when the VA is not connected to it. Then, a graceful shutdown is performed on both the local disk and the VA. For the local disk, we simply write the in-memory map to its checkpoint region. (If the local host is not powering down after disconnection, then the system can choose to keep the map in memory--this optimization can reduce the connection time for the next session on this host. See Section 3.4.3.)

The VA checkpoint region contains the VA L-to-P map and the bitmap fields. Thus, for the VA, in addition to flushing the map, we must read the bitmap fields of the old checkpoint into memory, compute the new bitmap fields using the old bitmap fields and the state fields of the in-memory map, and write a new checkpoint back to the VA. If (written block), we set the bitmap to reflect the need of propagating this block to all other hosts in the system. Otherwise, if (propagated block), we clear the corresponding bit for this host in the bitmap but retain the values of the remaining bits. We also store the latest timestamp in the VA checkpoint; this timestamp marks the end of the current session and the beginning of the next session. To avoid corrupting the old checkpoint in case a crash occurs in the middle of a checkpoint operation, we maintain two checkpoint regions for each device and alternate between them.

A crash is a special case of disconnection. In a conventional LLD, the goal of crash recovery is to reconcile the contents of the segment summaries and the checkpoint to make them consistent with each other. In the PersonalRAID system, however, the crash recovery process also needs to make the local disk and the VA mutually consistent and to restore the PersonalRAID invariants. Note that the PersonalRAID system requires that the recovery process be completed at the crash site before the user moves to another host.

The first PersonalRAID invariant to restore is that all data blocks written in the past (unfinished) session must be

present on both the local disk and the VA disk. Because the flushes to the two disks are not synchronized, one of them might have fallen behind the other in terms of receiving the most recent writes. Thus, the crash recovery process might need to propagate data blocks from one disk to the other.

The other PersonalRAID invariant to restore is that the bitmaps in the VA checkpoint must correctly reflect the state of the system in terms of propagation of writes. Blocks written or propagated during the past session might have made the old bitmaps inconsistent. Such blocks can be identified by comparing the time stamps in the segment summaries with the time stamp in the old VA checkpoint. Having identified the written and propagated blocks, bitmaps are updated in the VA checkpoint as in the case of a normal disconnection described above. If all bits in a bitmap are clear, we must have performed all the necessary propagations and we can safely discard this block from the VA by nullifying the logical-to-physical mapping for this block on the VA. We also store the latest timestamp found during the segment summary scan in the VA checkpoint to mark the end of this session.

### Connection and Reading

During connection (c), the system needs to initialize the in-memory maps by reading the checkpoints. If the host that the VA is connecting to is powering up, the system needs to initialize the local disk in-memory map by reading the local disk checkpoint, just as LLD does. In a similar fashion, the system reads the VA checkpoint to initialize the VA in-memory map. The difference between the two maps is that the system also needs to calculate the state field of the in-memory map for the VA: `and` are set based on the bitmap stored in the checkpoint (`is` set equal to the current host's bit and `is` set to the inclusive OR of all other bits), while `and` are cleared. And if `,` the system concludes that the local disk contains an obsolete copy, and nullifies the logical-to-physical mapping in the local disk in-memory map. Finally, the system also reads the disconnection timestamp in the VA checkpoint to initialize the current timestamp.

As soon as connection completes, the system is ready to accept I/O requests. To service a read request (d), the PersonalRAID looks up the in-memory maps for valid logical-to-physical mappings to decide which device holds the most recent copy of a logical block. In the event that a fresh copy resides on multiple devices, the system is likely to favor the local disk, which is typically faster than the VA, although load-balancing opportunities exist. To service a write request, the PersonalRAID records the new block by appending it to both logs as described earlier.

### Replaying

Possibly in the background, the system performs replaying (e). A great deal of synergy exists between PersonalRAID and log-structured storage as replaying is integrated with segment cleaning on the VA device. The system checks the `bit` in the VA in-memory map to identify the live data on the VA that is yet to be propagated to the destination device. It then reads live data from the VA and appends it to the log on the destination device. The timestamp of the newly propagated block inherits that of the VA block, which the system reads from the corresponding VA segment summary. The `bit` is set in the state field. Next, the system checks `to` determine whether this block needs to be propagated to other hosts in the system. If `,` the data block must have been propagated to all hosts in the system and the block can be safely removed from the VA. If we attempt to populate a segment with blocks of identical propagation bitmaps, then we are likely to harvest free segments as their blocks are freed simultaneously. On the other hand, if `,` we must retain the block on the VA for further propagation to other hosts in the system and we have two options: we can either leave the blocks in place on the VA in the hope that they may be deleted in the future to render their cleaning unnecessary, or append them to the end of the VA log since we have already incurred the cost of reading them into memory. In the latter case, we have again accomplished segment cleaning on the VA as a byproduct of replaying.

In a conventional LLD, the segment cleaning algorithms mainly aim to maximize the number of free segments

generated per unit of cleaning I/O. This is typically achieved by cleaning segments that are relatively cold and have low utilization [12]. (Recall that a piece of data is said to be cold if it is unlikely to be overwritten in the near future, and utilization of a segment is a measure of the amount of live data in it.) In a PersonalRAID system, however, segment cleaning on the VA device becomes more complicated due to its integration with replaying. Instead of (or in addition to) coldness and utilization of segments, a good cleaning strategy might need to take into account the state of propagation of blocks. For example, at any time, a live block on the VA might need to be propagated (1) to the local host, but not to any remote host, or (2) to some remote host, but not to the local host, or (3) to the local host as well as some remote host. A cleaning strategy might prefer to clean one type of blocks before others depending on how aggressively it wants to replay blocks or generate free segments.

In this section, we examine the log operations during the recording, disconnection, connection, reading, and replaying phases of the PersonalRAID. We note two features of the PersonalRAID design. One feature is that the map information on each device is self-contained: all the valid pointers in a device point to locations within the same device. This feature allows data movement within one device or across a subset of the partially connected devices to be performed independently of other devices. The second feature of the PersonalRAID design is the potential for exploiting I/O parallelism: the recording, reading, and replaying phases can overlap I/Os to the VA and local disks to mask some of the I/O latency and balance load.

#### Recovering from Device Losses

We first discuss how to recover from the loss of a host computer disk. Then we discuss how to recover from the loss of the VA device itself.

##### Recovering from Host Disk Loss

This scenario is the simpler case to handle. We take the VA to a surviving host. The union of the contents of the local disk on this host and the VA gives the entire content of the PersonalRAID. First, we completely synchronize the local disk and the VA by replaying all those blocks whose latest versions are present on the VA but not on the local disk. Thus, at the end of this phase, the bit for this host in all the bitmaps is 0. Then, we create a physical mirror of the local disk onto a new disk (using a Unix utility like `dd`, for example). The new disk is brought to the accident site to replace the lost disk. The bitmaps on the VA are updated to reflect the fact that the restored disk now has all the PersonalRAID data.

##### Recovering from VA Device Loss

The more complex case is when the VA device itself is lost. There are two pieces to be reconstructed. The first piece is the metadata, which consists of the bitmaps and the current value of the global counter. The other is the set of actual data blocks that were lost with the VA device. Recall that the contents of the VA are defined to be the set of data blocks that must be propagated to some host in the system. Thus, to reconstruct the data part, we may need to visit all the hosts in the system.

A simple recovery method is this. We visit all the hosts in the system twice. The goal of the first tour is to construct the metadata part by scanning the segment summaries on each host and comparing time stamps. In the second tour, we simply visit each host to copy the required data blocks onto a new VA device. Note that this tour does not need to scan the segment summaries on the local disks--the L-to-P mapping is sufficient to locate the

required data.

An unpleasant aspect of this reconstruction approach is that it requires one to visit each host twice. To eliminate the first tour, we can make a copy of the bitmaps and the global counter on the local disk during the disconnection process. When the VA is lost, the user must retrieve the bitmaps and the value of the global counter from the host where she most recently disconnected. The bitmaps allow the system to identify the hosts on which the latest copy of a VA logical block is stored. The user now needs to complete only one tour to reconstruct the VA content. The price one pays for this simpler approach is the extra time and space spent during disconnection to write the bitmaps to the local disk, although it is likely that one should be able to overlap the bitmap flush time on the local disk with the slower VA checkpoint time, and the space consumed by the bitmaps is insignificant.

This VA reconstruction approach even works if one encounters a combination of a crash and the loss of the VA. In this unfortunate scenario, the user retrieves the old bitmaps from the computer that she visited last and then comes back to the crashed computer to complete the crash recovery process as described in Section 3.4.2. At the end of this crash recovery process, the system has recovered the lost bitmaps and she can start the reconstruction tour to reconstruct the lost VA data. To avoid having to go back to the computer that she visited last in this scenario, we can make a copy of the VA checkpoint bitmaps on the local disk during the connection process (as well as the disconnection process).

The VA reconstruction processes described so far require the user to complete at least one tour of all the hosts. To further reduce the number of hosts that one must visit after a VA loss, one can periodically replay some blocks to all the hosts to eliminate these blocks from the VA or periodically replay all VA content to some host. The latter technique is effectively the same as making a copy of the VA content on that host.

#### Reconfiguration

Reconfiguration of a PersonalRAID in the form of removing or adding hosts is relatively simple. To remove a host from the system, all the system has to do is to reformat the VA checkpoint to remove a bit from each bitmap. Recall that the bitmaps record which hosts in the system need to receive propagations. The checkpoint reformat allows the system to discard data from the VA, no longer propagating it to the removed host. To further simplify this process, the system can simply record at the beginning of the checkpoint which bits in the bitmaps are still considered active; so the non-active bits are not considered in the algorithm.

Adding a host to the PersonalRAID is essentially the same as recovering from the loss of a host disk. The only difference is the reformatting of the VA checkpoint to add a bit to each bitmap. Again, to further simplify the process, the system can simply activate a previously allocated bit. This bit is set to 0 in each bitmap since at the end of recovery (see Section 3.5.1), the recovered host has all the PersonalRAID data.

#### Virtual VAs

So far in our discussion, we seem to have assumed that the Virtual-A has to be a physical mobile storage device such as the IBM Microdrive. This assumption is not necessary: the Virtual-A can in fact be backed by a file, a local disk partition, or even a network connection. We call such a virtual backing device a Virtual Virtual-A (or a VVA or a VA).



One possible use for a local disk-based VVA is to use it instead of a mobile storage device to perform recording. Because mobile storage devices do not necessarily have the best performance characteristics, recording to a VVA can be more efficient. Of course, to transport the data, we still must copy the contents of a VVA to a mobile device-based VA (and sometimes, vice versa). One possible solution for avoiding the long copying latency is to allow asynchronous copying to the mobile device to occur in the background. Although the log-structured design of the VA organization allows the PersonalRAID to buffer a large amount of data in memory and delete overwritten data before it reaches the device, the amount of buffering is still limited by the available memory. A VVA that asynchronously copies to a VA essentially allows unlimited buffering. Another use of a VVA is to make a copy of the VA for the purpose of reconstructing a lost VA (as described in Section 3.5.2).

To efficiently implement a local disk-backed VVA, one in fact does not need to physically and separately store the data blocks that can already be found on the local disk of this host: the mapping information is all that is needed. Because we do not have to physically store separate copies for a VVA's data in this case, we call this a Virtual VVA (or a VA).

### Limitations and Extensions

In this section, we describe a number of limitations of the PersonalRAID system described so far. Some of these are the topics of our continued research and we discuss possible approaches of addressing them.

### Concurrent Updates

To simplify the discussion so far, we have made a conscious design decision of not addressing concurrent updates. We believe that this is an acceptable choice for the use cases that we are targeting: PersonalRAID, being "personal", is designed for a single user to control a number of distributed and disconnected personal storage devices; these storage devices do not receive updates concurrently simply because we do not allow the user to be at multiple sites simultaneously. There is, however, nothing intrinsic in the current PersonalRAID design that prohibits us from addressing concurrent updates.

Indeed, there are legitimate personal use cases where concurrent updates arise naturally. For example, a networked office computer can continue to receive email after the user has disconnected the VA and has gone on vacation, taking a copy of the mail file with her. As long as the user does not modify the same mail file during the trip, the current PersonalRAID design can be trivially extended to accommodate such concurrent but non-conflicting updates.

After the user disconnects the VA, as the office computer receives new updates, it records the updates in a VA on the local disk (as described in Section 3.7). When the user returns and connects the mobile VA device to the office computer, as long as there is no conflicting update, the system can merge the checkpoint of the VA with that of the VA to arrive at a consistent VA image as a result of propagating the VA updates to the VA. After the merging, the system operates as described previously.

If there are conflicting updates, application or user-level intervention is necessary. In this case, a more sophisticated extension to the current PersonalRAID design is necessary. The logical disk approach upon which the PersonalRAID design is based becomes a convenient and powerful vehicle to support file system versioning. At VA disconnection time, the content of the local disk L-to-P map is "frozen" to represent a version  $v$ . As updates are recorded in the local VA, none of the old blocks in  $v$  are overwritten. The union of  $v$  and the VA represents a new version  $v'$ . After the user returns and connects her VA device, which may contain conflicting updates, the union of  $v'$  and the VA represents yet another version  $v''$ . The user or an application must resolve conflicts to arrive at a

“consistent” new version. Upon conflict resolution, the old versions, , , and can be freed and a consistent VA image again emerges.

### Mobile Storage Limitations

Mobile storage technologies are likely to lag behind conventional ones in terms of performance and capacity. We believe that the performance disadvantages are addressed by the log-structured design of the PersonalRAID and the judicious use of the host disk in the forms such as the VA described in Section 3.7. Currently, we do not address the capacity constraint. We are currently researching ways that a weak network connection (when one is present) may complement the mobile storage device to address this limitation.

### Limitations of the Log-Structured Organization

The potential disadvantages of the log-structured organization are the possible destruction of read locality and the cost of segment cleaning (or disk garbage collection) [13,14]. PersonalRAID mainly targets personal computing workloads, which are often bursty and leave ample idle time for cleaning. The cleaning overhead can be further reduced by using techniques like freeblock scheduling [7], and by buying bigger disks and keeping the disk utilization low.

The base LLD design that we have borrowed has several potential disadvantages [1]. Keeping the entire logical-to-physical map in memory, the base LLD design consumes a large amount of memory and incurs some latency when reading this map from disk into memory at startup time. It is, however, possible to cache only a portion of the map in memory and demand it in gradually. We have not implemented this possible optimization.

### Implementation

In this section, we describe a Linux PersonalRAID implementation. As explained in Section 3, our system implements all the PersonalRAID functionalities at the logical disk level. The system consists of two main components: the PR Driver (PRD) and the PR Server (PRS) (shown in Figure 5). The PRD is a pseudo-block device driver that exports the interface of a disk. Upon receiving I/O requests, the PRD forwards them to the PRS via upcalls. The PRS is a user-space process that implements the LLD abstraction; it manages a partition on the local disk and the VA device in a log-structured manner as described in Section 3.

Most of the complexity in our system is concentrated in the PRS. Despite the upcall overhead, which is purely an implementation artifact, we chose this design for ease of programming, debugging and portability. Unfortunately, this decision also leads to some deadlock possibilities. A user process can cause the buffer cache to flush as a side effect of requesting system services (like dynamic memory allocation). The user process blocks till the flush is completed. If the PRS, which is just another user process, causes a flush to the PRD, the system enters a deadlock with the PRD waiting for the PRS to service the flush request. To prevent such deadlocks, our PRS is designed not to allocate memory dynamically during its life time. All memory used is allocated and locked at start-up time. Also, the PRS does raw I/O using the Linux /dev/raw/rawN interface, bypassing the buffer cache. Two additional changes are made in the kernel path used by the PRS to ensure that it never causes a PRD flush.

In addition to the in-memory map described in Section 3 (see Figure 4), the PRS maintains several main-memory segments for both the local disk and the VA device. These segments accumulate new block writes, just like the LLD system. Our implementation maintains more than one main-memory segment for each of the two devices. This

feature allows us to decouple the amount of write-behind buffering from the segment size, which may need to be based on other considerations such as segment-cleaning performance.

Figure 5: The PR Driver (PRD) and the PR Server (PRS) are the two main components of the PersonalRAID prototype. The PRD is implemented as a dynamically Loadable kernel module, whereas the PRS is a user-space process.

Segment cleaning is begun when the number of clean segments falls below a threshold. We use twice the number of main-memory segments as the threshold. Cleaning is invoked, if necessary, after flushes and stops once the threshold is reached. For simplicity, on the local device, like the LLD system, it chooses the segment with the minimum number of live blocks to clean. Live blocks are read into main memory and are copied with their old timestamps to the main-memory segments. Note that we mix the new block writes with the old blocks.

Segment cleaning for the VA device is a little more complex since replaying is integrated with cleaning. Our current cleaning policy adopts a simple heuristic to strike a balance between two goals: quickly generating empty segments on the VA and quickly propagating data. The cleaner gives higher preference to segments that have data blocks that need to be propagated. Among all such segments, a segment with the minimum number of such blocks is chosen. Among segments with no blocks that need to be propagated, we give preference to segments with fewer live blocks. To clean a VA device segment, live blocks are read into memory and if necessary, propagated to local disk. If the block still needs to be propagated to some other device, it is written back to the VA; otherwise, it is discarded. There is one subtlety in this algorithm. If a VA segment, while being cleaned, contributes new blocks to some main-memory segments of the local disk, then this VA segment cannot be reused until all those local disk segments are safely on the local disk. Otherwise, a crash may lead to a situation where the only copy of a data block is on a remote host, and recovering from such a crash would require visiting that remote host. Thus, before marking a set of segments cleaned in the current cleaning phase as free, we check for this condition and possibly flush the main-memory segments of the local disk.

Currently, the PRS performs request satisfaction, segment flushing, and cleaning sequentially. It is possible that performance can be improved by using multiple threads for some or each of these different tasks. The PRS is about 4000 lines of C code, including a substantial amount of debugging and testing code. The PRD is implemented as a dynamically loadable kernel module. It is about 700 lines of C code. All of the algorithms described above have been implemented with the exception of crash recovery, recovery from device loss, and reconfiguration.

## Experimental Results

In this section, we evaluate the performance of the prototype PersonalRAID system to demonstrate two conclusions: (1) PersonalRAID can achieve the transparency and reliability goals without imposing a significant performance penalty on a mobile storage user, and (2) the log-structured organization of the PersonalRAID is a sound design choice.

## Experimental Platform

Table 1: Host configuration. Model Dell Inspiron 4000 Notebook  
 Processor Pentium III, 800 MHz  
 Memory 256 MB  
 Operating System Red Hat Linux 6.2, Kernel 2.2.18

Table 2: Characteristics of the local disks and the VA used in the PersonalRAID prototype. The published sustained data rate of the Microdrive is 2.6 MB/s; while our best effort micro-benchmark on the drive yields 1.5 MB/s. Local

Disk VA  
 Maker IBM IBM  
 Model Travelstar 20GN 1 GB Microdrive  
 Interface ATA-4 PCMCIA  
 Capacity (GB) 10 1  
 RPM 4200 3600  
 Bandwidth (MB/s) 16.9 1.5  
 Avg. Latency (ms) 7.1 20.3

Table 3: Configuration parameters of our 2GB PersonalRAID server. Local Partition VA

Block Size (KB) 4 4  
 Seg. Size (MB) 0.5 1  
 Outstanding Segs 2 8  
 Size (GB) 3 1

Our experimental setup consists of two laptop end hosts (A & B) with an IBM 1GB Microdrive acting as the VA device. Table 1 shows the configuration of the laptops and Table 2 gives the characteristics of the laptops' internal local disks and the Microdrive. Note that the Microdrive's bandwidth is more than an order of magnitude worse than that of the internal disk. A challenge to the PersonalRAID system is to shield the user from this performance gap.

Table 3 shows the configuration parameters of the PR Server. The user "sees" a 2 GB PersonalRAID logical disk, which is larger than the VA capacity. The segment sizes and the numbers of outstanding segments are chosen so that the write-behind buffer of the local partition is smaller than that of the VA: the former is kept small so that the system limits the amount of data loss in case of a crash, while the latter is kept large to allow overwritten data to be deleted before it reaches the Microdrive and mask the higher latency. We must, however, remark that in our experiments, the large size of the VA buffers did not make a significant difference. The reason for this is that a Linux ext2 file system internally uses large buffers to absorb most of the overwrites. Thus, very few overwrites occur in the PersonalRAID buffers, which are at the logical disk level below the file system. In a system where the file system does less buffering, the impact of having large VA buffers might be significant.

## Benchmarks

We report results for two benchmarks. The first is an enhanced version of the "Modified Andrew Benchmark" [4,9], which we call "MMAB". (We modified the benchmark because the 1990 benchmark does not generate much I/O activity by today's standards.) MMAB has four phases. The first phase creates a directory tree of 50,000 directories, in which every non-leaf directory (with the exception of one) has ten subdirectories. The second phase creates one large file and many small files. The large file created has a size of 256 MB. Each of the small files is 4 KB. The benchmark creates five small files in each of the directories in the first five levels of the directory tree, resulting in a total of about 55,000 small files. The third phase performs file-attribute operations. During this phase, the benchmark first performs a recursive touch on all the directories and files in the directory tree; it then computes disk usage of the directory tree by invoking du. The fourth and final phase reads files. It first performs a grep on each file; it then reads all the files again by performing a wc on each file. We run the MMAB benchmark on laptop A and evaluate various options of gaining access to the resulting files on laptop B without the benefit of a network.

The second benchmark is a software development workload. We examine the cost of installing and compiling the Mozilla source code as a user moves between the two laptops. The benchmark has two phases. The first phase creates a development source tree from a compressed archive file (a .tar.gz file) stored on a local disk. The source tree consumes about 405 MB of total disk space. We refer to this phase as "MOZ1" in the subsequent sections. During the second phase, we compile the "layout" module within the Mozilla source tree, generating an additional 80 MB of data. We call this phase "MOZ2". To run this benchmark, we start with MOZ1 on laptop A. We then transport the data to the disconnected laptop B to continue with MOZ2.

## Recording Performance

Table 4: Detailed breakdown of recording performance for the MMAB benchmark. mkdir is the directory creation phase. lwrite creates a large file and swrite creates many small files. touch and du perform attribute operations. The touch phase reads directories and inodes, and writes inodes. The du phase generates write as well as read traffic because the recursive visit alters access times that are stored in the inodes. The metadata cache misses are the main contributor of this phase's latency. grep and wc read all the files. mkdir (s) lwrite (s) swrite (s) touch (s) du (s) grep (s) wc (s) total (s)

UFS-Local	156	20	398	806	6	142	368	1896
UFS-Upcalls	397	33	675	951	15	220	388	2679

LLD-Local	184	28	229	330	5	66	94	936
UFS-MD	398	320	725	1440	1200	535	880	5498
PR-VA	325	239	484	350	167	85	127	1777
PR-VVA	192	55	263	336	151	75	100	1172

Table 4 details the recording performance of the MMAB benchmark. "UFS-Local" is a Linux "ext2" file system created directly on the local disk partition. "UFS-Upcalls" is the same file system implemented with kernel upcalls into a user-level server. "LLD-Local" uses the same kernel upcall and user-level server mechanisms but it replaces the UFS with a log-structured logical disk organization. The results of these experiments are used to establish the base-line performance, to factor out the cost of using a user-level server, and to quantify the benefit of using an LLD for accessing the local disk. "UFS-MD" is an ext2 file system created directly on the Microdrive. "PR-VA" is an ext2 file system created on the logical disk exported by the PersonalRAID system where the Microdrive is used as the VA device. "PR-VVA" is similar to PR-VA except that it uses a partition on the local disk as the VA device. The PR-VVA performance is an indication of how well the PersonalRAID might perform if the VA device has much better performance than that of the Microdrive.

The Linux ext2 file system performs both metadata and data writes asynchronously to the buffer cache. The large memory filters out overwritten data before it reaches the disks and allows the surviving write requests to be intelligently scheduled. As a result, the additional benefit that the log-structured PersonalRAID derives from asynchronous writes is smaller than one might expect. During the MMAB and MOZ experiments, the segment cleaners in the PRS did not get invoked. Later in this section, we describe a separate experiment designed to measure the overhead of segment cleaning.

The results show that the PR-VA system is successful in masking the bandwidth difference between the local disk and the Microdrive: despite the fact that the PersonalRAID needs to write to two devices and that the system incurs the cost of kernel upcalls, the performance of PR-VA is close to or better than that of UFS-Local in most cases due to the relatively low overhead of log-structured recording. An exception is the large write (lwrite) performance, a case where the PersonalRAID recording performance is being limited by the Microdrive bandwidth. The read performance of the PR-VA is also excellent, since unlike the UFS-MD system which performs reads from the slower Microdrive, it satisfies reads from the faster local partition. Finally, the performance of PR-VVA indicates that the PersonalRAID system becomes even more attractive with a faster mobile storage technology.

Table 5 presents the recording performance of the MOZ benchmark, along with the cumulative totals from MMAB. Recall that MOZ1 is the source-unpacking phase run on laptop A and MOZ2 is the compiling phase run on laptop B. The former is more I/O intensive than the latter and it is much more difficult to mask the recording overhead during MOZ1 unless the VA device is faster. After we connect the VA device to laptop B, we have two options for PR-VA: we can run MOZ2 immediately after connection, in which case the system reads data from the slower Microdrive; or we can run MOZ2 after replaying the entire content of VA to the local partition, in which case the system reads data from the faster local disk. The workload being CPU-intensive, there is little difference between the 2 cases.

Table 5: Recording performance. MMAB total (s) MOZ1 (s) MOZ2 (s)

	post-replay	pre-replay		
UFS-Local	1896	75	476	--
UFS-Upcalls	2679	126	481	--
LLD-Local	936	66	464	--
UFS-MD	5498	404	640	--
PR-VA	1777	395	548	558
PR-VVA	1172	102	482	486

The next set of experiments (see Table 6) capture the effect of invoking the segment cleaner on recording performance. We repeatedly perform a series of recompilation steps where each compilation step is triggered by modifying the file attributes of a small randomly-chosen subset of source files. We perform the experiments on two configurations: a 1 GB VA partition and a 550 MB VA partition. The disk utilization of the first configuration is 50% and the cleaner is not triggered during compilation. The disk utilization of the second configuration is 96% and the cleaner must run to continuously generate clean segments to accommodate the new data generated by the compilation. A total of 231 MB of data is generated during the experiment. The cost attributed to the cleaner is low.

Table 6: Effect of cleaning on recording performance. Cleaner Cleaner  
not invoked (s) invoked (s)  
PR-VA 878 928  
PR-VVA 713 735

#### Disconnection and Connection Performance

Table 7: Disconnection performance. MMAB (s) MOZ1 (s) MOZ2 (s)  
PR-VA 7.3 7.3 7.3  
tar 1225 268 --  
hoard -- -- 62

Table 8: Connection performance. MMAB (s) MOZ1 (s) MOZ2 (s)

PR-VA	7.0	7.0	7.0
untar	411	225	--
unhoard	--	--	67

Table 7 and 8 compare the disconnection and connection latencies of several alternatives. To disconnect/connect the VA device from/to a host in PersonalRAID, all it takes is writing/reading the VA checkpoint. The checkpoint write may be preceded by the flushing of the remaining memory segments, which may add a few more seconds. The benchmarks that we used sync the disk at the end of each benchmark run so both the checkpoint write and read times are constants.

We examine two simpler alternatives to PersonalRAID. One is to use the Unix tar utility to create/unpack a Unix archive on the Microdrive at disconnection/connection times. tar writes less data to the Microdrive than PersonalRAID because it writes only enough information to allow it to recreate the directory structure without physically copying all the blocks, eliminating fragmentation costs. Unpacking time is much faster than packing time because unpacking is benefitting from the asynchronous writes of the Linux ext2 file system. Despite these optimizations, the latencies are not tolerable.

For MOZ2, tar alone would not have been adequate because we need to identify the files that have been changed, added, or deleted after compilation and act on just the changes. For this purpose, we use a pair of Unix scripts hoard/unhoard. Although these scripts are admittedly crude due to the liberal forking of some Unix processes, it is clear from the data that the resulting latencies of this approach are unlikely to be satisfactory.

To be fair, we note that the connection times for the simpler alternatives described above include the replay time. These times are less than the sum of connection and replay times for the PersonalRAID system (see the top rows in Tables 8 and 9), because the simpler alternatives write less data to the Microdrive than PersonalRAID, and write their data as a large, sequential file. Unlike PersonalRAID, however, these simpler alternatives do not allow normal operations to overlap the replay time and thus have a much greater impact on the user.

### Replaying Performance

Table 9: Replaying performance. MMAB (s) MOZ1 (s) MOZ2 (s)

VALFS	553	340	56
VAUFS	988	547	100
VVALFS	159	90	17



After a VA device is connected to a PersonalRAID host, background propagation (or replaying) starts. Table 9 shows the results of the experiments designed to analyze the impact of the log-structured organization on the replaying performance. "VALFS" refers to the PersonalRAID that replays from a log-structured VA to a log-structured local partition.

An alternative to this design is to use a UFS-style update-in-place organization on the local disk partition, while retaining the log-structured organization on the VA so that reads for replaying still occur at segment-sized granularity. To realize this alternative design, all we need to change is the L-to-P mapping for the local disk; we substitute it with an "identity mapping", which simply maps a logical address received from the file system to an identical physical address. The PR Server employs helper threads to perform asynchronous writes to the local partition and it limits the maximum number of outstanding writes to 20. Table 9 refers to this alternative as "VAUFS".

Finally, to evaluate the impact of a faster mobile storage device, we replay from a local partition-based VVA (as described in Section 3.7) to another local partition, both of which are log-structured. Table 9 refers to this last alternative as "VVALFS".

During these experiments, the cleaner on the log-structured local partition did not get invoked. Both cleaning and replaying are background activities that can result in synergistic benefits. We plan to investigate the performance impact of this integration in the near future. Furthermore, since all the storage devices in a PersonalRAID are self-contained, it is possible for end hosts to independently clean their local disks when they are not in use. Therefore, it is possible that large number of free segments are available before replaying starts.

Table 9 shows that despite the fact that both the VALFS and the VAUFS configurations are limited by the slow read performance of the Microdrive, the former can replay significantly faster than the latter, thanks in no small part to the former's log-structured organization. If the VA device could perform reads faster, the impact of the log-structured organization would have been even more dramatic as implied by the VVALFS performance numbers.

#### Related Work

Although PersonalRAID can be extended to deal with conflicting updates (as discussed in Section 3.8.1) and this is one of our ongoing research topics, the primary use cases targeted by PersonalRAID today are just that: personal usage scenarios where the availability of a single coherent name space and reliability are the primary concerns but conflict resolution is not. Conflicts are inherently file system-level or application-level events that must be addressed at these higher levels. PersonalRAID is a storage-level solution that can only provide mechanisms such as versioning that higher level systems may exploit. A number of research systems (including Ficus [11], Coda [6], and Bayou [10,15]) have focused on conflict resolution techniques that may provide insight on how to build and extend services running on top of PersonalRAID.

Many systems share PersonalRAID's goal of synchronizing the contents of a number of hosts; these systems include disconnected client/server systems such as Coda [6], distributed applications such as those built on top of Bayou [10,15], and replicated databases such as those provided by Oracle [8] and Sybase [2]. A common technique is to use an operations log that is recorded at the site that initiates the updates and is replayed at the various replicas. A variation of the theme is the use of "asynchronous RPCs" as those employed by Rover [5]. Before log replaying is complete, the access to a replica needs to be suspended if one does not want to expose stale data. We have determined that neither stale data nor the latency involved in log propagation may be tolerable for a PersonalRAID user. Thanks to its LFS roots, PersonalRAID inherits the absence of the notion of a separate operations log--the

collection of distributed logs is the storage system. As a result, the fresh updates carried in the VA device are always immediately accessible while replaying can occur in the background when convenient.

A VA device is similar to a disconnected Coda client in that it "hoards" data and buffers the latest changes [6]. It is different in that the VA device is not meant to support I/O operations on its own: the role of the VA in a PersonalRAID is two fold: (1) it acts as a transporter of all updates that are used to synchronize the contents of several disconnected end hosts, some of which may be mobile; and (2) it supports I/O operations only when it is coupled with a host local disk. There is no user involvement or guesswork involved in determining the content of the VA; and there is no danger of a "hoard miss."

The use of a mobile device to carry updates to other weakly connected hosts to bring about eventual consistency via pair-wise communications is similar to the approach taken by Bayou [10,15]. Bayou provides a framework for application-specific conflict resolution and applications must be re-programmed or developed from scratch to take advantage of the Bayou infrastructure. PersonalRAID, as a storage system, does not resolve conflicts in itself; as a result, it is possible for us to develop a general system, on top of which existing personal applications may run unmodified.

Existing mobile systems typically do not address data reliability on mobile hosts: these mobile hosts are typically considered inferior "second-class citizens" and their data is vulnerable until they are propagated to "first-class citizen" servers that are professionally managed and backed up occasionally. PersonalRAID provides protection against any single device loss at all times by leveraging the exact same mechanism that is needed to bring about eventual consistency of the system.

Finally, there are existing applications such as the Windows "Briefcase" that can synchronize the contents of multiple hosts. The two problems with these applications are exactly the problems that PersonalRAID is designed to address: (1) the inconvenience involved in manual movement of data, and (2) the poor performance in terms of both latency and throughput during synchronization events.

## Conclusion

As storage technology advances, a user is facing an increasing array of disconnected storage devices. Two of the important challenges a user must face is the lack of a single transparent storage space that is ubiquitously available and a certain degree of reliability assurance. PersonalRAID is a mobile storage management system that attacks these two problems. At the heart of a PersonalRAID is a mobile Virtual-A device that allows the user to transparently transport, replicate, and access data while interacting with a number of disconnected storage devices. By employing a distributed log-structured organization, the system is able to accomplish these tasks without imposing any serious performance penalty on the user.

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About this document ...

PersonalRAID: Mobile Storage for Distributed and Disconnected Computers 1

This document was generated using the LaTeX2HTML translator Version 99.1 release (March 30, 1999)

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The command line arguments were:

latex2html -split 0 pr.tex

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Footnotes

... Computers1

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Technical Program

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### . In Remembrance and Renewal

The closer we get to the anniversary of September 11, the less I am sure of my feelings. Do I want to pretend it never happened? Undoubtedly! Am I reluctant to relive the horror? Absolutely! Am I resisting the thought that this is not the last time the United States will suffer directly from terrorism? You bet I am! Am I feeling ambivalent about how we as a nation are responding to one of the greatest tragedies we've experienced? Yes indeed! Do I have the sense that justice has not yet been rendered? Unfortunately, I do!

Through this murky mix of feelings we recognize that at the most basic level our Christian faith calls us to remember and mourn the victims, support their loved ones, and continue our meager efforts to shape a more hopeful and less violent future. This is a goal that can bring all of us together, no matter what other feelings and convictions may be lurking in the background. Consequently your church staff would like you to know of the following opportunities (among many others) to observe the first anniversary of September 11.

A solemn service of remembrance, healing and hope to be held Wednesday, September 11, from 12 noon to 1 p.m. at First Congregational UCC, 945 G Street, NW, Washington, DC (202-628-4317). UCC President and General Minister John Thomas will be present, along with a combined choir representing Potomac Association churches. While this will be a Christian service, representatives of the Muslim and Jewish communities will participate.

- An interfaith gathering united for peace will take place Wednesday, September 11 at 7:00 at the George Mason University Center for the Arts Concert Hall. This service is sponsored by Fairfax County Faith Communities in Action and GMU. It will include interfaith readings, orchestra music, song, dance, and visual presentations.
- Our own sanctuary will be specially prepared for prayer and quiet reflection Monday through Friday, September 9-13, from 9:00 a.m. to 4:30 p.m. Those who stop by may light a candle, offer a written prayer or comment, or simply find respite in the beauty and silence.
- The quarterly Healing Service on Wednesday, September 4 at 7:30 a.m. offers an opportunity for a small group of participants to seek healing of mind, body, and spirit for themselves and others (and for our world), drawing upon some of the traditional rituals of the church including communion, the laying on of hands, and anointing with oil. We see this service as a way to reach out to the community, and we invite others to join us for this special observance.

However you choose to observe September 11, I hope that it will be meaningful and comforting, granting you a fuller sense of God's presence among us, and hope for the future.

Verne

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## Welcome New Members!

On August 25, Little River welcomed six friends into membership. Congratulations to Sam & Ginna Minasian Dalton, Esther Murphy, Barbara & William Kennedy, and Ulrich Wolf-Barnett. Look for introductions in the next Currents.

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### Fall Schedules

#### Worship

Our second service resumes Sunday, September 8 at 11:00. Care is available for children through age 7.

#### Office hours

The church office is once again open 9:00-4:30 Mondays-Fridays.

#### Currents deadlines

Biweekly deadlines resume September 12 at 4:30.

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### College (and Other) Addresses

By the time you read this, the office will be nearly ready to produce a new edition of the church membership directory. Please check your current information and let Jane Johnson know in writing of any changes or additions, including new e-mail addresses. Please [e-mail your changes](#) or use the form on the literature table in the narthex. And don't forget to include college students and nonresident family who are church members or friends.

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### Church School Registration

Church school begins Sunday, September 8! Register your children between 9:00 and 9:25 pick up and fill out a form for each child, and check their class assignments. Arrive early and avoid the crush; classes begin at 9:30!

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### Choir News

The Sanctuary Choir will begin rehearsing Thursday, August 29 at 7:30, and the Contemporary Choir on Sunday, September 1 at 12:15.

The Joyful Noise Choir is beginning a new year with a new format. All 7th-12th grade singers are invited to rehearsals on Sunday mornings from 10:45-11:15 a.m. in the Choir Room! We have had many young people interested in singing in the choir but their schedules were so busy on Thursdays. Our first rehearsal will be Sunday, September 8. We will be planning the music for Ginna's installation on September 22 as well as participation in a 9/11 commemoration at George Mason University. Join in the singing, fellowship, and fun!

The Salt of the Earth Choir will begin a new year of rehearsals Thursday, September 5 from 7 to 7:30. This year the choir will sing once each month. All youth in grades 2-6 are welcome. We sing, move, and enjoy Christian fellowship.

Director Jan McKee wants everyone to know she is looking forward to a wonderful year of singing God's praises with Little River's youth. If you have any questions about the youth choir program, please call her.

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#### September Hall Display

During September the hallway will feature our congregation members' interesting vacations and work trips. The Senior High youth will display memories of their Civil Rights Immersion in Memphis. Do you have pictures or souvenirs from your stay on a Normandy farm, a cruise to Denmark, camping in the Blue Ridge? Talk with [Dee Cardi](#) if you would be willing to share.

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#### Youth Group News

The 2002-03 Pilgrim Fellowship season kicks off Sunday, September 8. Ginna, our new pastor for youth, has a zillion ideas to share and is looking forward to spending Sunday evenings with you. Here's the new youth group lineup for the coming year:

4:00-6:00 Junior PF

5:00-6:00 Confirmation Class

6:00-6:30 Common dinner for all groups

6:30-8:00 Senior PF

It's going to be an awesome year, so plan on joining in on all the fun. See you on the 8th!

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#### Cyber Cafe, Anyone?

What if the Jr. High youth had a cyber cafe at church the first Friday of each month? Computers, food, friends sound interesting? If enough people think so, it can happen!

Please share your interest or questions with [Ginna](#) at church or [the Cardinals](#).

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#### Teacher Orientation

Orientation for church school teacher will be held Sunday, September 8 from 11:00 to 1:00 in Room 8. Brief introductions; a review of schedule, procedures, and resources; and lunch are on the agenda. Child care will be available.

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#### Dinner for Eight Signup

Sign up for this fall's Dinner for Eight program! Participants in this popular social event are divided into groups of about eight: singles, couples, age mixes, etc. Members of each group take turns hosting a dinner monthly in October (or the end of September) and the next three months. All provide a dish to share. Be sure to indicate if you prefer a daytime group, need a ride, or cannot host. Sign up after church Sundays September 8-29, or call the office.

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## Adult Fellowship

After summer vacations, adult members and friends of the Little River are invited to gather once again in fellowship Wednesday, September 11, at 11:00 for a bring-your-own picnic in the grove outside the church. Kathy Spaar will lead us through the labyrinth before lunch. Please join us for good fellowship, good conversation, and discussion of program ideas and projects for the coming year.

Carol Stolte

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## Fall Classes for Adults

Two Sunday morning Christian Education classes for adults will start September 15. At 9:30, John Moore and Kathy Spaar will lead a series on how the historical questionings of the Jesus Seminar affect our spirituality. At 11:00, guest speakers from the congregation will help participants discover their "spiritual type."

And on Monday mornings starting September 16, Richard Davidson will lead Christian Believers, a follow-up to the Disciple Bible study series. It explores how the beliefs, doctrines and practices of the Christian church have influenced the expression of Christian belief through words, images, and actions.

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## Confirmation Class

An introductory session of the 2002-03 Confirmation Class will be held Sunday, September 15 from 5:00-6:00 in the Conference Room. If you are in the ninth grade (or above) and have not received a letter of invitation, please contact the church office or speak to Verne. A meeting for parents will be held at 5:00 Sunday, September 8.

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## GINNA'S Installation

Mark your calendar for Sunday, September 22, when at 4:00 we will formally install Ginna Minasian Dalton as our Pastor for Christian Education, Youth and Evangelism. Watch Currents for details.

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## First Friday: Gearing Up!

First Friday is filled with fun this year! The season starts October 4 with a storyteller who gets lots of help from her audience, as they explore the legend of St. George and the dragon. Other programs include You're a Poet and Don't Know It, an enchanted evening in fairy-tale land, a puppet or two or three, and do you think there might be more encounters with critters?

First Friday is a cooperative parents-night-out program for the whole community. Children six months through sixth grade spend an evening of safe fun, good food, and new experiences for a very modest price. Parents get a free evening in return for volunteering for one session during the year. The season runs from October through April, with a break for the new year.

Important news for prior participants: every child must be newly registered for the coming season. Pick up a form at the office, or you can [register online](#). Please register early to help with planning.

Questions about First Friday? Visit the [First Friday web page](#) or talk with [Dee or Chuck Cardin](#).



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### Meet Our New CE Administrator

Hi, my name is Jackie Shafer and I'm the new Christian Education Administrator for Little River. So, you say, who is Jackie Shafer, and what is a CE administrator? Let me tell you.

My husband, Alan, my son, Eric, and I have been Little River members for six years. Eric is an active PF member (wouldn't miss PF for all the tea in China) and is entering tenth grade at Lake Braddock. Alan is a government employee and active church school teacher and member of the Stewardship Committee. I have been on the Board of Christian Education for four years and have served as chair the last twelve months. I love to laugh and joke around, love anything that sparkles (glitter! diamonds!!) and I absolutely adore working with kids.

The role of CE administrator is twofold: to run the day-to-day operations of the church school and to assist Ginna with anything else that affects Christian education and fellowship. I am looking forward to the start of the new school year and am delighted to be with Ginna. It's going to be a great school year!

Don't forget: Church school registration takes place September 15 (see article above). And make sure to pick up a new Adult Enrichment Opportunity brochure. Two new Sunday morning adult classes are being offered check them out!

Jackie

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### Mission of the Month: United College Ministries

"Changing Lives...Connecting People to God and to Each Other" is the motto of the United College Ministries in Northern Virginia (UCMNV). With beginnings in the mid-1960s, UCMNV has been an ecumenical and mutual ministry with two educational institutions George Mason University and the multiple campuses of Northern Virginia Community College seven denominations, interested individuals, and local congregations.

Through a ministry of presence and programming, UCMNV joins God's work of communicating the Christian message and acting it out in individual and campus life. Campus-wide events are organized on such topics as local and global hunger, international dialogue, prayer and spirituality, nonviolent conflict resolution, and drop-in spiritual retreats. The Listening Post provides a place to talk with one who will listen, respond, and provide non-judgmental companionship. Many diverse students compose these college campuses. Whether right out of high school, returning to school after a long absence, or learning to live in a new country and society, a student encounters an understanding response from UCMNV.

The UCMNV mission:

Our mission is to share God's universal love as revealed in Jesus Christ with campus communities of Northern Virginia; to encourage students and others in their intellectual and spiritual journey; to cultivate service to others as a way of life; to affirm the dignity of all people, foster reconciliation among those who are alienated, and nourish multi-cultural experiences of inclusive community; to advocate for peace with justice in personal, social, and international life; and to witness to the unity of the human family.

Little River supports this mission through the UCC Potomac Association, our benevolences budget, and members of our congregation who volunteer. If you would like to assist in this ministry by being a Listening Post volunteer, providing office help either weekly or five times a year when there are bulk mailings, being a host for international

students for a holiday meal, serving on the Governing Board, providing cookies or fruit at the Listening Post, or many other opportunities, please contact Claudia Newhart at [UCMNV](#). Further information can be found on [the UCMNV website](#).

Nancy Bowen

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Congratulations, Craig!

Washington National Cathedral 's quarterly magazine Cathedral Age, Craig Stapert, editor, won awards for photography, writing, design, and general excellence in April from two national professional organizations: the Associated Church Press and the Episcopal Communicators. The ACP 's award, for excellence in photography, was conferred for an article which includes pictures Craig took. A Cathedral [press release](#) has more details.

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Church Council Rescheduled

In observance of September 11, the Church Council meeting originally scheduled for that day has been moved to Tuesday, September 17, at 7:30.

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Read All About It in "Passages"

Pick up a printed copy of Currents to share the latest celebrations and concerns in our church family as well as the latest address, phone, and e-mail updates.

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Currents is published usually biweekly (and monthly in summer) for the members and friends of Little River UCC, Annandale, Virginia, and mailed third-class or by e-mail (to subscribe: e-mail your name to [getcurrents@lrucc.org](mailto:getcurrents@lrucc.org) from the address where you want Currents sent). Electric Currents, posted on the Little River UCC website every issue date, contains all material appropriate for public posting.

Submissions: Please include your name and phone number or e-mail (not for publication). Submit on paper or diskette (MS Word, MS Works, WordPerfect, or plain text) to church office, [e-mail to editor](#), or fax to editor (call first to arrange) or church (703-978-3372). Submit notices 3 weeks ahead of event if possible.

INVITATION TO ADVENTURE

FALL 2003

UNIT LEADER GUIDE

MINSI TRAILS COUNCIL  
BOY SCOUTS OF AMERICA  
(610) 264-8551

MINSI TRAILS COUCNIL

BOY SCOUTS OF AMERICA

INVITATION TO ADVENTURE  
UNIT FACT SHEET

1. INTRODUCTION

The Invitation to Adventure (ITA) Program is specifically designed to assist the Troops of the Minsi Trails Council in recruiting Boy Scouts. The program is structured to target units with 16 boys or less although any Troop may participate. ITA provides the opportunity to bring the new Scout immediately into the program by taking him to camp shortly after he is recruited.

2. ACTION PLAN FOR ITA 2003

August ITA promoted to all Boy Scout Troops. Recruiter postcards are mailed to all Boy Scouts in the Minsi Trails Council and ITA packets are mailed to all Scoutmasters, Committee Chairman, Unit Commissioners, Assistant District Commissioners, and the District Commissioners.

September ITA is promoted at all Roundtables. Boy talk dates are confirmed with each school.

October 1 All Troops wishing to participate in the ITA must have submitted their Unit Commitment Card by October 1 to the Boy Scout Office or the District Executive.

October (First Week) Interest Surveys are distributed to all schools not allowing a boy talk.

October 17, 18 All Interest Surveys are collected.

October 20, 21, 22 Phone A Thon inviting all boys who submitted an Interest Survey to the open house of the Troop closest to their home.

October 27 (Week of) All Boy Talks and Open Houses are conducted, and boys identified through boy talks are called and invited to Open Houses.

November 1 and 2 ITA Overnight campout is conducted at Trexler Scout Reservation. At least 2 Adults, and 1 Junior Leader and all new Scouts enjoy.

(NEXT)

### 3. SUMMARY

If conducted properly, the ITA program will add new Boy Scouts and Leaders to each Troop participating. Do the following steps and the Troop will qualify for the ITA Incentive Plan!

#### Troop Obligations for ITA Incentive Plan

1. Read ITA packet when mailed or given to you.
2. Confirm your participation in the ITA by submitting your Unit Commitment Card to the Scout Office or your District Executive by October 1<sup>st</sup>.
3. Explain to all current Scouts how the recruiter program works. (They will be receiving a recruiter postcard around the same time adults will receive this packet).
4. Provide one leader to assist with the phone a thon.
5. Schedule and conduct an Open House the week of October 27.
6. Keep record of all Scouts (to be turned in upon arrival at the ITA weekend) who earn the Recruiter patch.
7. Secure 2 Adults (or more) and a Junior Leader to attend the ITA Weekend.
8. Submit all new boy applications and money upon arrival at the ITA weekend.

Complete all of the above and the following is for your Troop

Recruit 3 youth Free Recruiter patches for all Scouts who had a friend join the Troop through the ITA Program, and have your Troop entered in a drawing to win a free cabin for a weekend at Trexler Scout Reservation. There will be one winner per district.

Recruit 5 youth Free Recruiter patches for all Scouts who had a friend join the Troop through the ITA Program, and have your troop entered in a drawing for FREE ADVANCEMENTS \*for the entire Troop for 1 year. There will be one winner per district.

\*Note. Badges included in Free Advancement are Merit Badges, Rank Advancements, and cards accompanying those advancements.

FREE JAMBO 2004 Recruit the highest percentage of youth in your district (in order to be fair for all Troop sizes, we are using a percentage instead of a straight number), and your Troop will be entered into the council grand prize drawing to have up to 20 registration fees waived for your Troops visit to JAMBO 2004. There will be one winner in the council.

PLEASE BE REMINDED THAT ALL YOUTH MUST BE NEWLY REGISTERED YOUTH THROUGH THE ITA PROGRAM. NO WEBELOS TRANSFERS OR TRANSFERS FROM OTHER TROOPS!

(NEXT)

MINSI TRAILS COUNCIL

BOY SCOUTS OF AMERICA

INVITATION TO ADVENTURE WEEKEND

DATE: Saturday and Sunday, November 1 and 2, 2003

LOCATION: Trexler Scout Reservation

ELIGIBILITY: All new Scouts registered as a result of the ITA Program.

COST: There is no cost for the boys or the Troop for the ITA Weekend.

\*\*\*\*\*

PROGRAM

Saturday, November 1, 2003

10:00 AM	11:00 AM	Arrive at camp, check in at Settlers Dining Hall, receive cabin assignments and weekend schedule.
11:00 AM	Noon	Lunch (Settlers Dining Hall)
12:15 PM	12:30 PM	Opening Ceremony (Buttress)
12:45 PM	1:30 PM	Round Robin # 1
1:45 PM	2:30 PM	Round Robin # 2
2:45 PM	3:30 PM	Round Robin # 3
3:45 PM	4:30 PM	Round Robin # 4
4:45 PM	5:30 PM	Individual Unit Time
5:45 PM	6:00 PM	Retreat (Buttress)
6:00 PM	7:45 PM	Dinner and Cleanup (Settlers Dining Hall)
8:00 PM	9:00 PM	Campfire (Settlers Camp Campfire Circle)
9:15 PM	9:45 PM	Cracker Barrel (Settlers Dining Hall)
10:00 PM	10:30 PM	Light ' s Out

Sunday, November 2, 2003

7:30 AM		Reveille
7:45 AM	8:00 AM	Morning Colors (Buttress)
8:00 AM	8:30 AM	Breakfast (Settlers Dining Hall)
8:40 AM	9:00 AM	Worship Service (Vespers area)
9:00 AM	9:30 AM	Pack Up / Clean Up Area
9:40 AM	10:00 AM	Closing Ceremony (Buttress)
10:00 AM		Leave to go home

Minsi Trails Council Obligations for ITA 2003

1. Mail Recruiter postcards and ITA info to Leaders.
2. Conduct Interest Surveys in all Schools not allowing boy talks.
3. Collect all Interest Surveys.
4. Schedule and coordinate the phone a thons during the week of October 20.
5. Schedule and conduct all boy talks the week of October 27.
6. Call all boys identified through boy talks and invite them to open houses.
7. Conduct and coordinate all programs, activities, and meals during the ITA Campout November 1st and 2<sup>nd</sup>.

8. Secure Incentive Plans and make sure all Troops qualifying for the ITA Incentive Plan are kept up to date on all drawings.

---

Due to the Boy Scout Office or your District Executive by October 1, 2003

INVITATION TO ADVENTURE 2003  
UNIT COMMITMENT CARD

\_\_\_\_\_ Yes, our Troop will participate in the ITA.

Troop # \_\_\_\_\_

District \_\_\_\_\_

Unit Leader Contact

Name \_\_\_\_\_

Address \_\_\_\_\_  
\_\_\_\_\_

Phone # \_\_\_\_\_

Email \_\_\_\_\_

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**Directors & Officers The ACE Report**

Issue No. 10 April 1993

The ACE Report is a periodic publication distributed to policyholders and other interested parties as a service by ACE. Its purpose is to address insurance concerns worldwide, as well as present timely information on current developments in liability issues surrounding directors and officers. The Editor of The ACE Report is Dan A. Bailey, a lawyer at Arter & Hadden in Columbus, Ohio, USA and a respected voice in the complex area of directors and officers liability.

Although prepared by professionals, this publication should not be utilized as a substitute for legal counseling in specific situations. Readers should not act upon the information contained herein without professional guidance.

**"PAPER" SETTLEMENTS: TOO GOOD TO BE TRUE?**

With increasing frequency, class action claims against directors and officers and their corporation are being settled through use of a so-called "paper" settlement, in which the corporation issues securities to the plaintiff class in settlement to the plaintiffs' claims. Such a settlement can provide substantial benefits to all parties involved in the

litigation and can constitute a "win-win" resolution of an otherwise problematic D&O lawsuit.

The plaintiff class is benefited to the extent the distributed securities have value. The plaintiff's lawyer can use that value to justify a fee award, which typically is paid with cash contributed by or on behalf to the defendants. The corporation and the defendant D&Os settle the litigation without incurring a loss for financial reporting purposes. Finally, the D&O insurer's coverage obligations are lessened.

Although the concept of using securities to settle class action lawsuits is not new, the willingness of plaintiff's counsel to agree to this type of settlement appears to have increased in the last year. A paper settlement is obviously advantageous when the defendants' ability to pay a large cash settlement is limited - whether because of the corporation's small liquidity or relatively low D&O insurance coverage. However, even large corporations with substantial liquidity and high D&O limits of liability have successfully used this form of settlement recently.

### Forms of Paper Settlement

The three alternative forms of paper settlement most frequently used are described below:

**Stock Distribution.** The corporation agrees to distribute to the class members treasury shares of common or preferred stock of the corporation. This is the simplest form of paper settlement to administer and value. Assuming an organized trading market exists for the stock being distributed, the value of that stock is simply determined by the market trading price as of the date of distribution.

In order to minimize the number of shares distributed (while maximizing the nominal settlement value to the plaintiff class for purposes of justifying a plaintiff attorney fee award), a stock distribution settlement frequently takes the form of a "claims made" settlement under which stock is distributed at a defined ratio only to those plaintiff class members who properly submit a proof of claim. The fewer proofs of claim submitted, the fewer shares actually distributed by the corporation. However, plaintiff's counsel, when justifying its fee award, assumes all members of the class will properly submit proofs of claim and therefore plaintiff's counsel uses the potential settlement value to the entire class as the proper benchmark for determining a fee award.

**Rights Distribution.** The corporation agrees to distribute to the class members rights to purchase shares of stock of the corporation at a defined discount price. Typically, these rights may be exercised for a period of 30 to 60 days after court approval of the settlement. If exercised, a plaintiff class member purchases a defined number of shares at a discount price determined either by a defined percentage of the stock trading price as of the end of the rights period or a defined amount per share below such trading price. For example, a "rights" settlement may permit a class member to purchase (for a period of 30 days following court approval of the settlement) 1 share of common stock for every 10 shares of stock purchased by that class member during the class period at a purchase price of 5% (or alternatively \$2.00) less than the stock's trading price at the end of the right's exercise period.

From the corporation's standpoint, this form of paper settlement is recently preferred over a simple distribution of stock because the corporation receives cash from the plaintiff class through the discounted purchase by class members of the shares of stock. Particularly for companies interested in raising additional capital, a "rights" settlement can be extremely attractive since the larger the settlement, the more capital is raised by the company. This type of settlement creates value to the plaintiff class to the extent the plaintiff's purchase shares at a discount and because the plaintiff's pay no brokerage commission in connection with the transaction.

If a corporation believes it already is fully capitalized and that further sale of shares would detrimentally over-capitalize the company, a "rights" settlement can be followed by an open market repurchase by the corporation of the same amount of shares as sold pursuant to the "rights" settlement.

Warrants Distribution. The corporation agrees to distribute to the class members warrants to purchase shares of the company at a defined purchase price over an extended period of time. Unlike a "rights" settlement, which permits the plaintiff class members to purchase shares at a discount over a relatively short period of time, a "warrants" settlement permits the class members to purchase at a defined price (typically not a discounted price) over an extended period of time (e.g. two or three years). The purchase price is typically determined by the average trading price of the company stock for the 30-day period immediately following court approval of the settlement.

A "warrants" settlement creates greater risk and higher potential benefits than does the "rights" settlement. With a "rights" settlement, the maximum value of the settlement is pre-determined by the defined discount price. Under a "warrants" settlement the ultimate value can range from zero to an unlimited amount, depending upon the market price of the company stock during the warrant period. As a result, warrants are more difficult to value. Recently-promulgated SEC regulations relating to disclosure of executive compensation include detailed rules with respect to the valuation of warrants issued to executives as compensation. Those regulations likely will be viewed by courts as persuasive authority in valuing a "warrants" settlement.

Notwithstanding these greater risks and valuation issues, plaintiff s' attorneys frequently prefer warrants over rights because the warrants arguably create greater potential benefit and thus justify a higher fee award for plaintiff s' counsel.

#### Securities Law Issues

In a rights or warrants type of settlement, the underlying stock ultimately issued to the plaintiff class members in a paper settlement typically must be fully tradeable by the plaintiff class immediately after issuance. If the shares must be newly registered with the SEC (which is an expensive and time-consuming process), the viability of a rights or warrants type settlement may be limited.

However, the securities distributed in exchange for the plaintiff s' release of their claims (i.e. shares of stock in a stock distribution type settlement or the rights or warrants) will likely be exempt from SEC registration under the federal securities laws. Section 3(a)(10) of the Securities Act of 1933 exempts from the registration requirements any securities (including rights or warrants) which are issued in exchange for the release of claims where the terms and conditions of such issuance and release are approved, after a hearing as to the fairness of the settlement, by a court. Thus, in most instances, the rights and warrants issued pursuant to a paper settlement likely are exempt from registration even though the underlying shares of stock issued upon exercise of the rights or warrants may need to be registered.

#### D&O Insurance Coverage Issues

Depending upon the form of the settlement, various D&O insurance issues may arise with respect to a paper settlement.

1. Is the value of the securities issues pursuant to a paper settlement considered covered loss incurred by the defendant D&Os? Issuers typically contend that the paper value is not covered under the policy. Since D&Os cannot personally issue corporate securities, the D&Os are not "legally obligated to pay" that value. The insureds, on the other hand, may argue that the securities distribution is in reality a form of corporate indemnification of the defendant D&Os since the securities distribution was in consideration for release of the D&O claims. In response, D&O insurers typically argue that corporate reimbursement coverage under the policy exists only to the extent the defendant D&Os are "legally obligated to pay" the loss and that since so such legal obligation exists to the D&Os under a paper settlement, no corporate reimbursement coverage exists. In addition, as explained below, the insurers may argue the paper distribution does not

constitute loss to the corporation.

2. Does the value of the securities issued pursuant to a paper settlement deplete and/or exhaust the applicable retention or deductible? Insureds may argue that even if the D&O insurer should not reimburse the corporation for the value of the securities issued, at a minimum such value should deplete or exhaust the corporate reimbursement retention or deductible. D&O insurers uniformly take the position that the D&O retention or deductible is depleted and/or exhausted only by loss otherwise covered by the D&O policy. If the value of the distributed securities does not constitute covered loss, such value does not deplete or exhaust the deductible.
3. Does the value of the securities issued pursuant to a paper settlement constitute the corporation's contribution to the settlement for allocation purposes? Insureds frequently argue that even if the value of the distributed securities is not covered loss, that value should be treated as the corporation's contribution towards settlement of the litigation for purposes of determining an allocation of loss between the corporation and the defendant D&Os. Insureds may argue that the D&O insurer should pay 100% of the cash component of the paper settlement since such a payment would result in the D&O insurer paying only a relatively small percentage of the total settlement value. The insureds thus contend that the D&O insurer is receiving an extremely favorable allocation - even though the insurer funds 100% of the cash component of the settlement.
4. D&O insurers typically contend that the loss to the corporation does not equal the value to the class members of the distributed securities. From an accounting standpoint, the corporation will not realize either a reduction in its assets or an increase in its liabilities as a result of the securities distribution. Although shareholders of the corporation may realize some loss because their interests are diluted by virtue of the securities distribution, that shareholder loss arguably does not constitute loss to the corporation. Accordingly, insurers argue that the value of the distributed securities should not be considered when determining a fair and reasonable allocation and that only the cash component of the settlement should be allocated between claims against the corporation and claims against covered D&Os.
5. Does the corporation's costs in repurchasing its stock in the open market following the securities distribution constitute loss either covered by the D&O policy or attributable to the corporation for allocation purposes? Insureds may argue that such stock repurchases would not have occurred but for the paper settlement and, therefore, the cost of such repurchases should be part of any coverage analysis. In response, D&O insurers argue: (1) the defendant D&Os are not "legally obligated to pay" such stock repurchase cost and therefore such costs are not covered, and (2) such costs are not incurred to settle the claims and therefore such costs are irrelevant in any allocation analysis. The D&O insurer's typical view is that those costs are incurred voluntarily by the corporation based on the corporation's business decision that it is in the best interests of the company and its shareholders to reduce the number of outstanding shares following consummation of the stock settlement.

Because paper settlements are increasing in frequency, D&O insurers and the insured may find it desirable to address these coverage issues through policy wording amendments. Although D&O insurers presumably would contend that the existing policy forms now adequately answer all of these coverage issues, it may be advantageous to explicitly address these issues with policy wording in order to avoid uncertainties and unrealistic expectations. In summary, paper settlements can be a cost-effective method for both insureds and D&O insurers to resolve D&O class action lawsuits. Although potentially troublesome coverage issues may arise, the position of the insureds and the D&O insurer is typically vastly improved in this type of settlement than in a standard cash settlement because

the serious coverage disputes usually involve only plaintiff's attorney fees and settlement administration costs (i.e. the cash portion of the paper settlement).