SUSS MA 45

MASK ALIGNER

Operator's Reference Manual

This Operator's Reference Manual is subject to review and/or revision.

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1186

Karl Suss

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1 GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

The SUSS MA 45 is a high precision mask aligner designed specifically for high resolution photolithography in thin film and hybrid applications in a laboratory or pilot production environment. The MA 45 offers unsurpassed flexibility in the handling of substrates of varying thicknesses as well as standard size wafers up to 100 mm in diameter. Operation of the aligner is easy to learn and provides the versatility needed in specialized processes.

Due to its modular construction and robust precision mechanics, the SUSS MA 45 is particularly easy to service. All functional groups are easily accessible and complete assemblies are quickly modified or replaced.

The general features of the MA 45 are outlined in Section 1 of this chapter. Section 2 briefly describes a typical operating procedure. In Section 3 you will find a description of the different exposure modes. In Section 4 you will learn to identify the discrete subassemblies of the machine. Section 5 describes the functions of the special features.

1.1 THE MA 45 MASK ALIGNER

The SUSS MA 45 (Figure 1-1) is equipped with a 350W lamphouse containing a relatively simple and yet comparatively high resolution optical system. A mercury short-arc lamp is used, giving primary exposure wavelengths from 350 to 450 nanometers. The aligner performs exposures in contact mode (mask and substrate in intimate contact) and proximity mode (distance between mask and substrate).

1.2 A BRIEF ORIENTATION

The operation of the SUSS MA 45 is straightforward and easy to learn. First, push the POWER button, illuminating the button and moving the lamphouse and microscope to the right. Press the START button, moving the lamphouse to the left. Remove the maskholder and place the mask (chrome or emulsion side up) onto it, toggling the VACUUM MASK switch on. Then slide the maskholder back into the machine and depress the MASKHOLDER button, illuminating it and clamping the maskholder in the stage. Next, load the substrate onto the chuck and depress the footswitch, moving the lamphouse to the right and inserting the chuck under the mask. When the chuck is under the mask, it will travel up into contact with the mask, performing wedge-error (parallelity) compensation and illuminating the CONTACT indicator.

Now take the microscope manipulator in your left hand, press the two brake release buttons with your fingers, and move the microscope to a suitable position for aligning. Set the black alignment separation distance thumbwheel to the desired value and

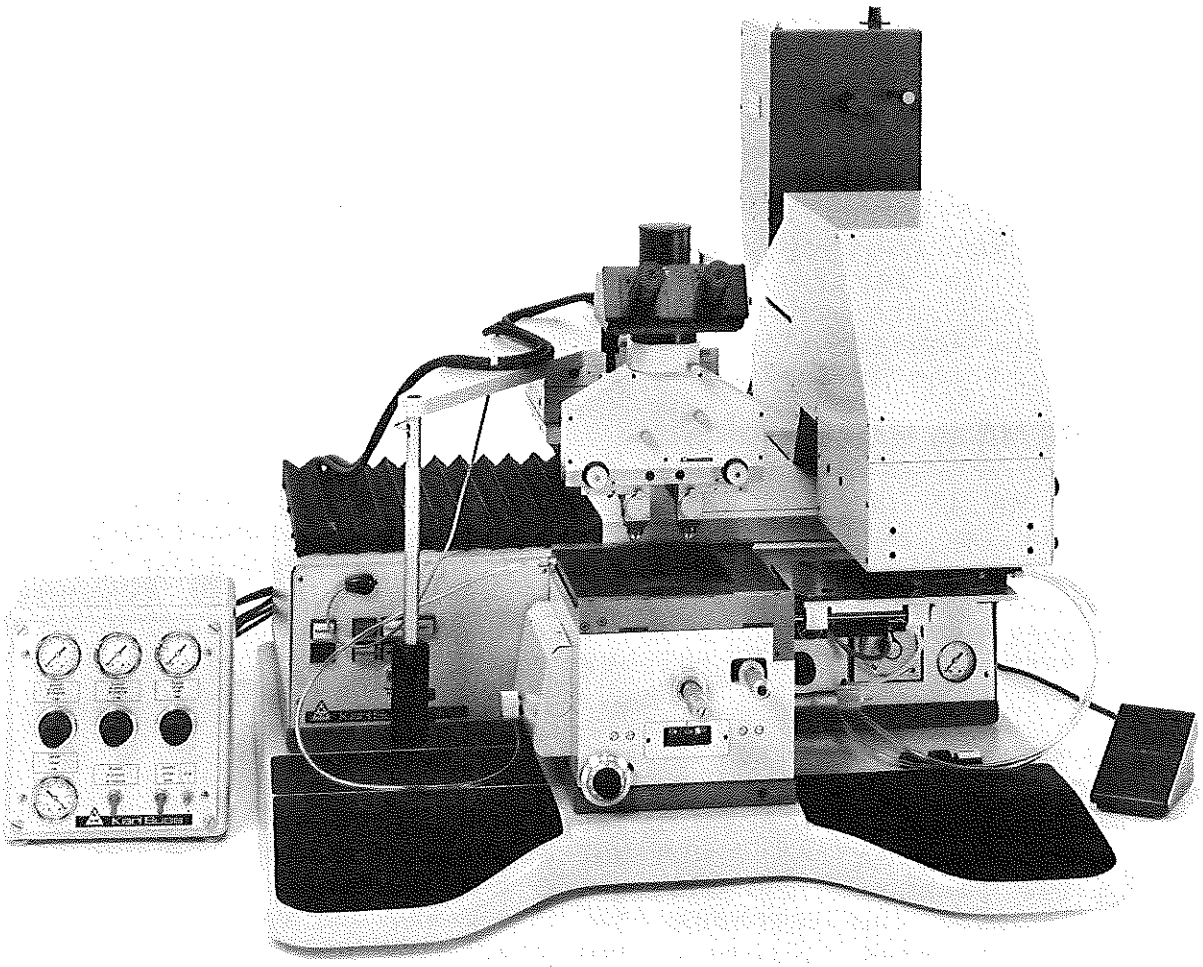


Figure 1-1 SUSS MA 45 Mask Aligner

press the SEPARATION button on the right side of the machine, illuminating it, extinguishing the CONTACT indicator and lowering the chuck to the separation distance.

Now align the substrate to the mask by turning the X-, Y- and Theta-micrometers. When alignment is satisfactory, press the SEPARATION button again, extinguishing it, illuminating the CONTACT indicator and moving the chuck into contact with the mask. After verifying good alignment, set the exposure timer and press EXPOSURE, illuminating this button and moving the lamphouse to the left. The shutter will now open, exposing the substrate. When the timer counts down to zero, the shutter closes and the substrate on the chuck moves to the right. The exposed substrate may now be removed.

1.3 EXPOSURE MODES

The SUSS MA 45 offers two exposure modes which may be selected by using the PROXIMITY button located on the left front panel of the machine. This button controls what takes place at the interface of the substrate and the mask during wedge-error compensation and/or exposure. If the PROXIMITY button is not illuminated, the contact mode is selected; if it is illuminated, the proximity mode is selected.

1.3.1 Contact Mode

In the contact mode, the substrate is raised until it contacts the mask, performing wedge-error (parallelity) compensation. When it is exposed, vacuum holds the substrate to the chuck while the substrate is in intimate contact with the mask.

1.3.2 Proximity Mode

In the proximity mode, the substrate never contacts the mask. Rather, the substrate is driven upward until it reaches a fixed distance from the mask. Alignment and exposure are performed at this distance.

1.4 THE SUBASSEMBLIES OF THE MA 45

The MA 45 is made up of discrete subassemblies (Figure 1-2). They are as follows:

1.4.1 Alignment Stage

The alignment stage is the heart of the MA 45, and consists of the pneumatics and mechanics for mask/substrate parallelity compensation, mask and substrate vacuum, maskholder (and maskholder clamping mechanism), Z-axis movement, alignment separation mechanism, X-, Y-, and Theta-micrometers, and variable thickness adjustment.

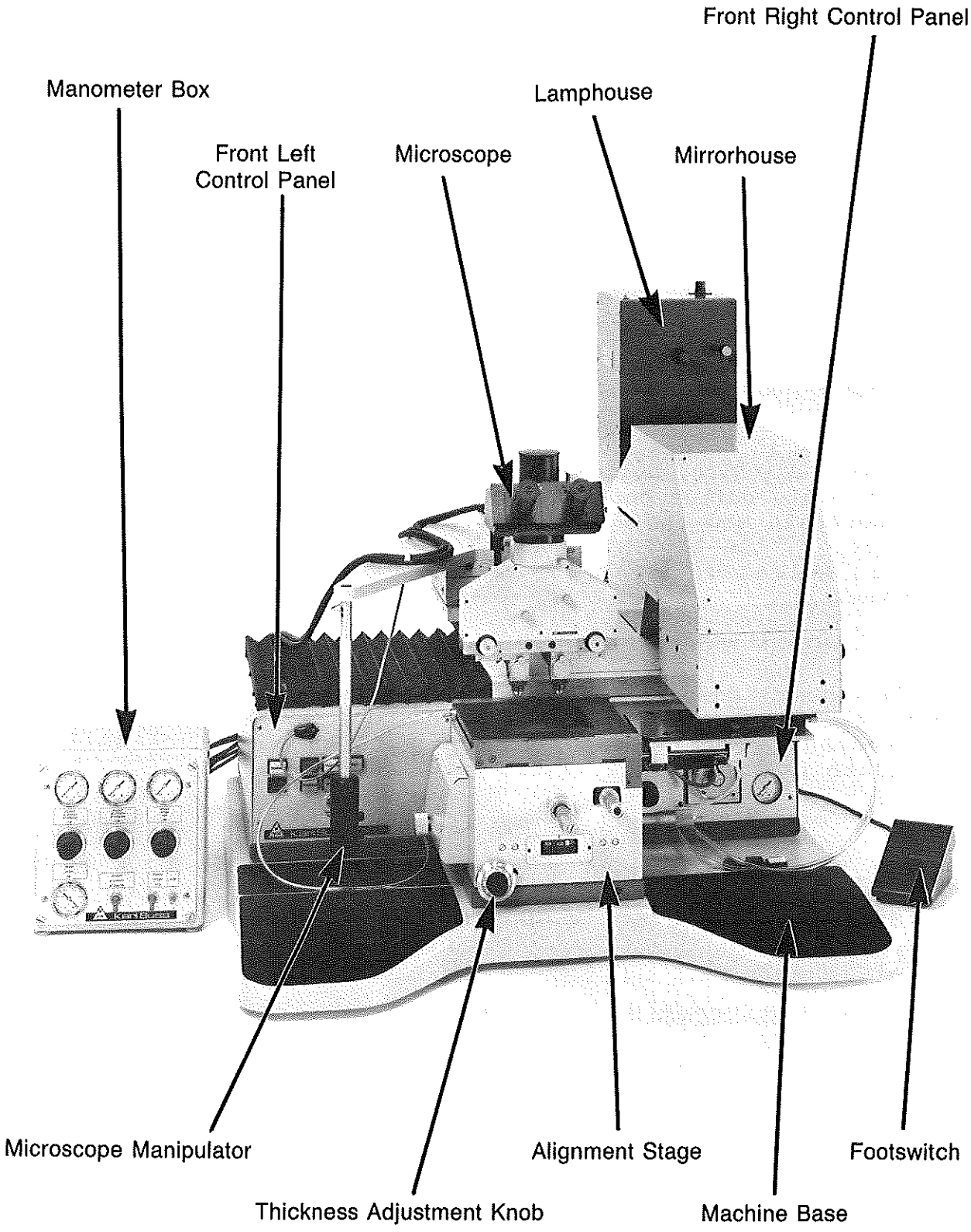


Figure 1-2 SUSS MA 45 Subassemblies

1.4.2 Machine Base

The base of the machine contains the relays, pneumatics, valves, and throttles which control the various machine functions.

1.4.3 Front Left Control Panel

The front left control panel (Figure 2-1) contains the indicators and operating controls, including the CONTACT indicator light, the MASKHOLDER, PROXIMITY, FIRST PRINT, MANUAL, POWER, and START buttons and the VACUUM MASK toggle switch. The function of each of these is described in Section 2.1.1.

1.4.4 Front Right Control Panel

The front right control panel (Figure 2-2) contains the air pressure regulator, the analog timer (or light integrator) and the pressure gauges. Below these are the connections for the chuck pre-vacuum and the compressed air. On the machine base below these are the SEPARATION button, the SUBSTRATE CLAMPING button and the EXPOSURE button. The function of each of these is described in Section 2.1.2.

1.4.5 Manometer Box

The manometer box (Figure 2-4) contains the regulators, throttles and gauges for adjustment of the compressed air, nitrogen and vacuum to the machine.

1.4.6 Microscope

The microscope assembly consists of the microscope adapter, microscope manipulator, and the microscope itself. Many microscope options are available, including objective revolvers with a variety of objectives, as well as brightfield, darkfield and interference contrast illumination.

The microscope manipulator is equipped with pneumatic brakes which are released by pressing the buttons on the manipulator handle. By pressing one or the other button, you can select an X-only or Y-only scan. If both buttons are pressed, you may scan the microscope in any direction.

1.4.7 Lamphouse and Mirrorhouse

The MA 45 is supplied with a lamphouse containing a 350W mercury vapor exposure lamp, an ellipsoidal mirror and a 45 degree cold light mirror. The cold light mirror reflects the desired short-wavelength ultraviolet light through a fly's eye lens and transmits the longer wavelengths to a heat sink located in the bottom of the lamphouse. Adjustment knobs for moving the lamp in X, Y, and Z directions are located in the upper section of the lamphouse (see Figure 5-2). The mirrorhouse contains a 45 degree

surface mirror and a front collimation lens. Diffraction reducing optics are also available for the MA 45. These optics provide extraordinarily high resolution over the entire area, resulting in steep edges and small diffraction effects.

1.5 SPECIAL FEATURES

Several special features are incorporated into the SUSS MA 45 in order to enhance flexibility and simplicity of operation.

1.5.1 First Print Exposure

Use the first print mode whenever there is no requirement for manually aligning the mask to the wafer. With the prealign chuck, the substrate is prealigned to an accuracy of ±2Ø microns. In this mode, one press of the foot pedal will prealign the substrate, center it under the mask, expose it, and remove the chuck and exposed substrate from under the mask.

1.5.2 Variable Thickness Adjustment

The SUSS MA 45 is equipped with a control to maintain constant contact pressure when processing substrates of various thicknesses. Alternatively, this control may be used to vary the contact pressure for a given substrate thickness. When the machine is installed, a reference mask and substrate are used to set the contact pressure between the mask and substrate. This setting may be varied using the thickness adjustment knob on the front of the machine (Figure 1-2). For a detailed description of how to set the contact pressure, please refer to Section 2.5.2.

2 OPERATING PROCEDURES

2.1 MACHINE CONTROLS

All of the machine controls are described below.

2.1.1 Front Left Control Panel (Please refer to Figure 2-1.)

a. MASKHOLDER Button - The MASKHOLDER button is used to clamp the maskholder into the maskholder frame.

b. CONTACT Indicator - The CONTACT indicator light illuminates when the substrate on the chuck is in contact with the mask.

c. PROXIMITY Button - The PROXIMITY button should be pressed whenever printing in the proximity mode is desired. If this button is illuminated, the substrate will be exposed at the proximity distance indicated on the black dial on the front of the stage. In this printing mode, the substrate never contacts the mask and substrate-to-wafer parallelity compensation is not performed.

d. START Button - Pressing the START button moves the lamphouse and the microscope to the left-most position, and moves the chuck out from under the photomask to its right-most position.

e. POWER Button - Pressing the POWER button activates the mask aligner and illuminates the POWER button.

f. FIRST PRINT Button - When the FIRST PRINT button is pressed, the lamphouse will stay in the exposure position and not allow for wafer-to-mask alignment. When this button is illuminated, pressing the foot pedal once will pre-align the substrate, center and expose it, and remove the chuck and substrate from under the mask.

g. MANUAL Button - The MANUAL button allows the operator to bring the substrate up to the mask manually. After the foot pedal has been pressed, bringing the substrate under the mask, the knurled knob on the left side of the stage may be turned to lift the substrate.

h. VACUUM MASK Toggle - Moving the VACUUM MASK toggle switch to the on position turns on the vacuum to the maskholder, thus clamping the mask to the maskholder. Conversely, moving the same switch to the off position turns off the vacuum, releasing the mask.

2.1.2 Front Right Control Panel (Please refer to Figure 2-2.)

The machine is equipped with either (a) an exposure timer, or (b) a light integrator.

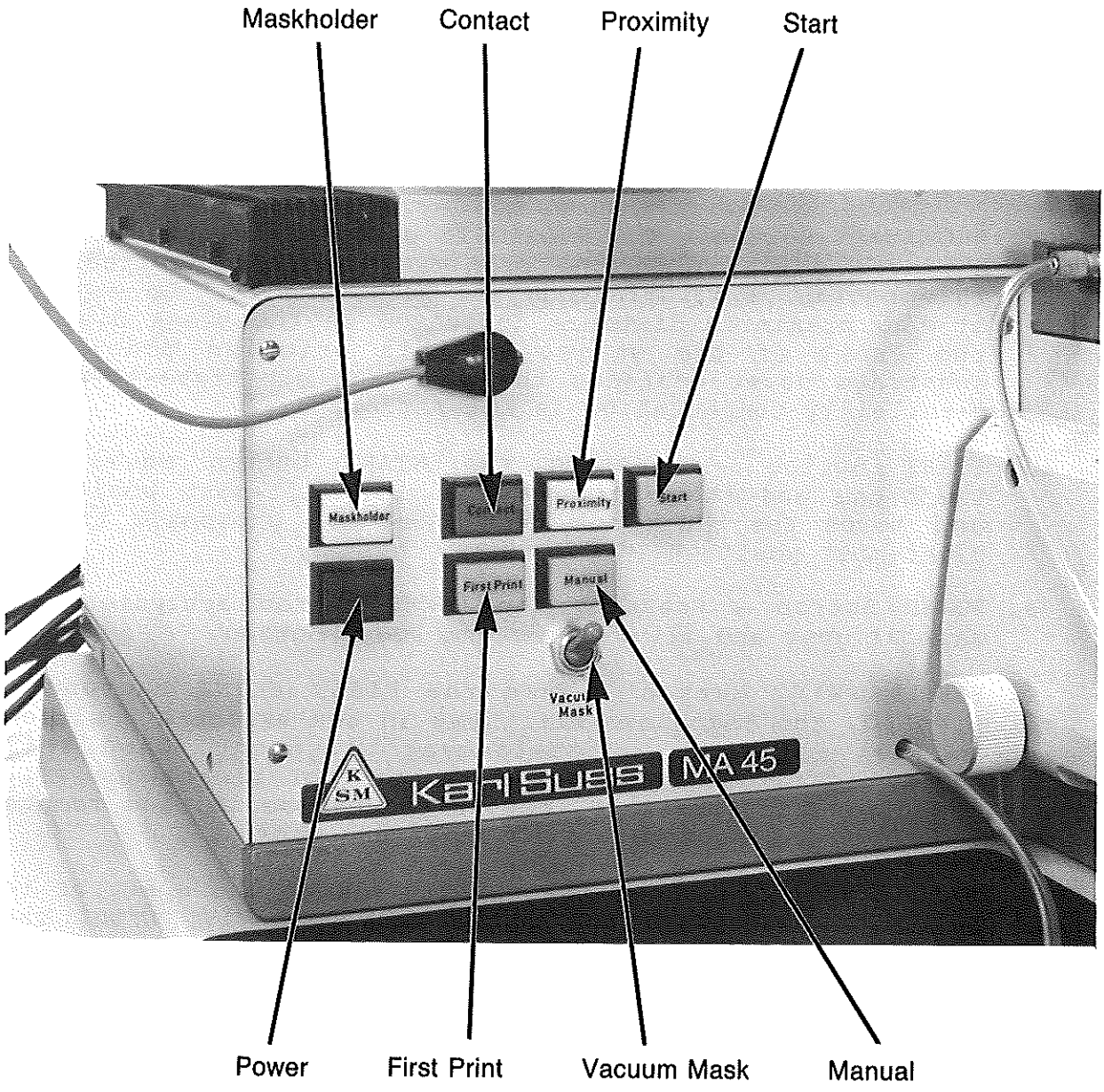


Figure 2-1 Front Left Control Panel

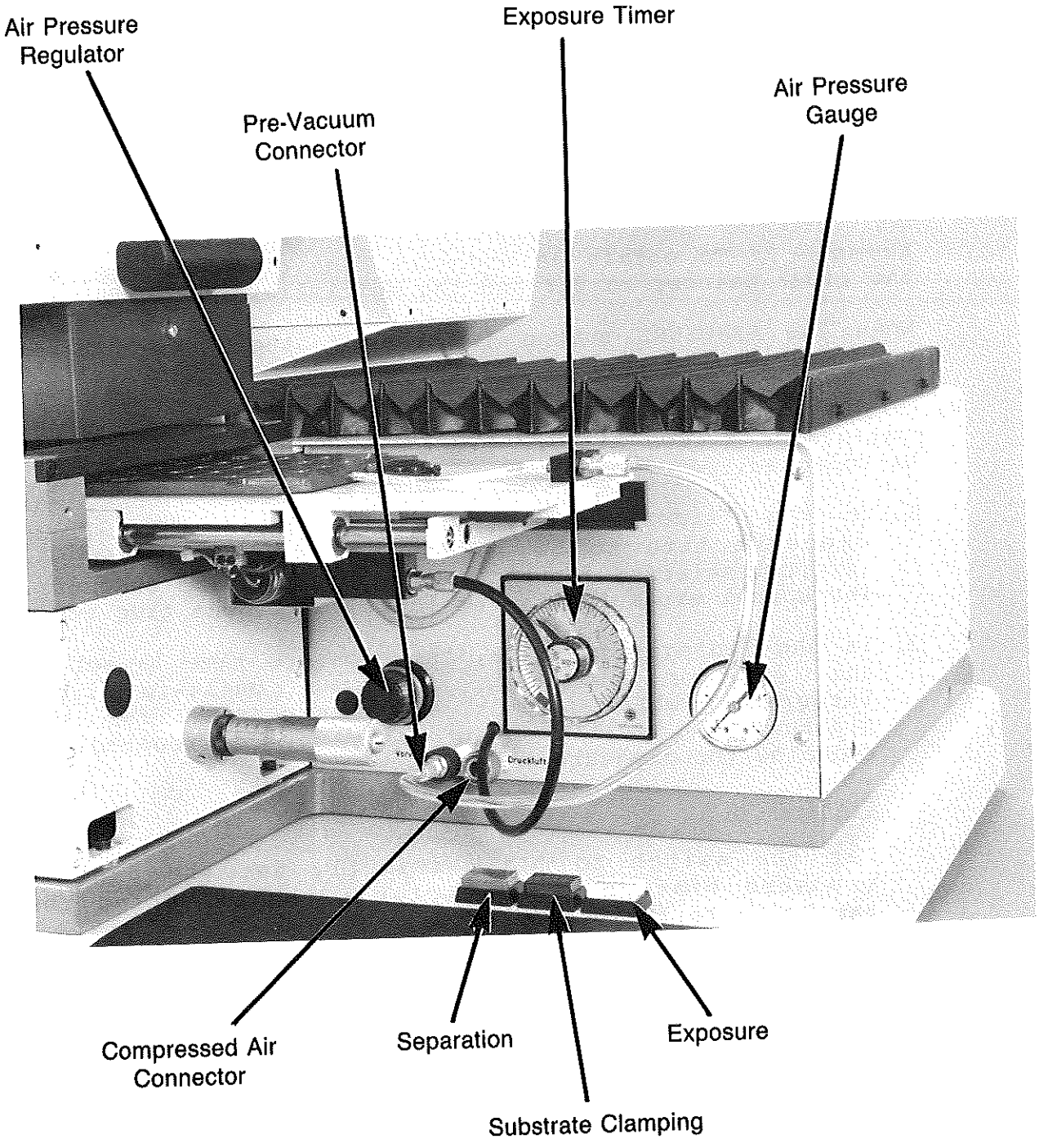


Figure 2-2 Front Right Control Panel

a. Exposure Timer - The exposure timer is used to control the exposure length. To set the timer, two controls are used:

-an inner knob marked "s","1Øs", "m", "1Øm", "h", and "1Øh" which is used to set the multiplier, and
-an outer ring which is used to move the timer pointer. The scale for the timer pointer is graduated from Ø to 3.

The exposure time is determined by multiplying the pointer setting by the multiplier set on the inner knob.

Example 1: To obtain an exposure time of 2 seconds, set the timer pointer to 2 and the multiplier to "s".

Example 2: To obtain an exposure time of 8 minutes, set the timer pointer to Ø.8 and the multiplier to "1Øm".

When the EXPOSURE button is pressed, the timer rotates counterclockwise to Ø during exposure.

b. Light Integrator - The small toggle switch on the light integrator allows either "timer" or "integrator" mode to be selected.

1. In the "timer" mode, the light integrator allows exposure time to be set on the selector switches (digital selector for times from Ø.1 to 999.9 seconds). The actual exposure time is identical to the time set.

2. In the "integrator" mode, the exposure time is set by the selector switches, but the built-in light integrator will automatically compensate for any fluctuation in light intensity by increasing or reducing the exposure time.

Timer Mode

Set the switch to TIMER (right). Set the desired exposure time on the selector switches. Bring the lamphouse to the exposure position (see Sections 2.3.3 to 2.3.5), and when the shutter opens, use the potentiometer to zero the meter. Clockwise rotation will shift the meter needle to the right and vice versa.

Integrator Mode

Set the desired exposure time and balance the meter as described above. Set the switch to INTEGR. (left). When the meter reads zero, exposure will be identical to the time set. Any fluctuations in intensity will be compensated automatically. Should the fluctuations amount to more than four scale divisions, zero the meter once more.

c. Air Pressure Regulator - This regulator controls the air pressure to the wedge error compensation bladder. Adjust this regulator until air pressure gauge indicates 2.0 bar.

d. Air Pressure Gauge - This gauge indicates the pressure to the wedge error compensation bladder and should read 2.0 bar.

e. Pre-Vacuum Connector - This connection provides vacuum to the chuck for substrate clamping during transport. A vacuum line should connect this fitting to the transport slide.

f. Compressed Air Connector - This connection provides compressed air to the chuck for substrate pre-alignment. An air line should connect this fitting to the transport slide (pre-align chuck only).

g. SEPARATION Button - Pressing the SEPARATION button when the substrate is in contact with the mask moves the substrate to the alignment distance set by the Separation Control Wheel. When this button is pressed, it is illuminated and the CONTACT indicator is extinguished. Pressing the button again lifts the substrate back into contact with the mask, illuminating the CONTACT indicator and extinguishing the SEPARATION button.

h. SUBSTRATE CLAMPING Button - Pressing this button will activate the pre-alignment mechanism of the chuck (pre-align chuck only) and will turn on the vacuum under the substrate.

i. EXPOSURE Button - When the EXPOSURE button is pressed, the lamphouse of the machine moves to the left, the shutter opens, and the timer begins to time down. When the timer reaches zero, the shutter closes, the timer resets, and the exposed substrate and chuck are removed from the stage.

2.1.3 Alignment Stage (Please refer to Figure 2-3.)

a. Transport Slide - The transport slide is located near the top of the stage at the right hand side and is used to transport the chuck and substrate from the loading position into the stage.

b. Alignment Micrometers (X, Y, and Theta) - The Y and Theta micrometers are located on the front of the alignment stage while the X micrometer is mounted on the right side. They are used during alignment to move the substrate in relation to the mask. The range of adjustment in X and Y is $\pm$15.0 mm, with the micrometers having graduations of 1.0 microns. The range of adjustment in Theta is $\pm$3 degrees.

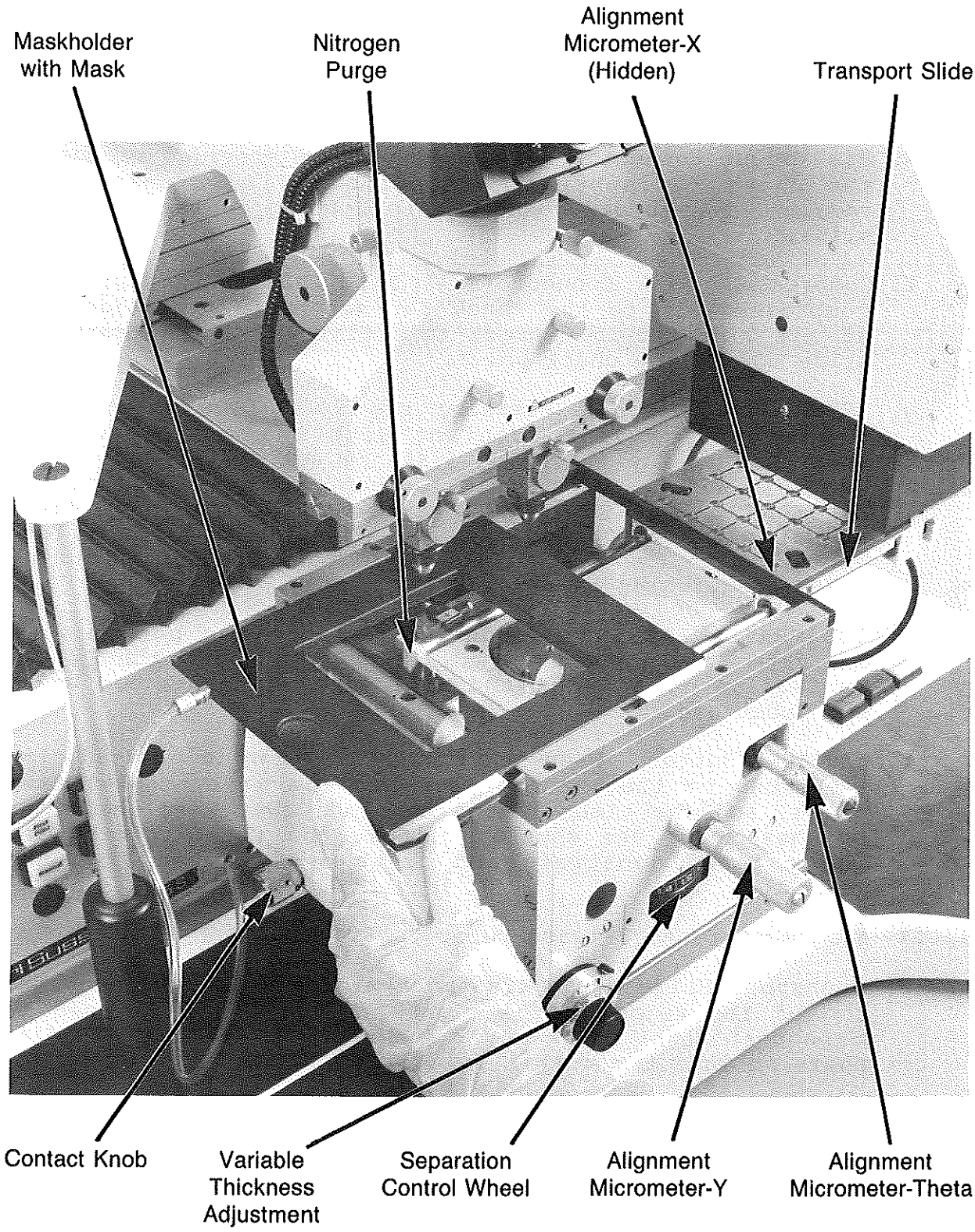


Figure 2-3 Alignment Stage

c. Wedge-Error Compensation Knob - The knurled wedge-error compensation knob is only used when the machine is in the manual mode with the MANUAL button illuminated. In this mode, the knob may be turned either counterclockwise by hand to bring the substrate and chuck into contact with the mask, or clockwise to lower the substrate and chuck from the mask.

d. Separation Control Wheel - The black separation control wheel sets the distance between the mask and the substrate. In the contact mode (PROXIMITY button extinguished), the substrate will be lowered this distance for alignment when the SEPARATION button is illuminated. In the proximity mode (PROXIMITY button illuminated), the substrate is separated by this distance from the mask during both alignment and exposure. The setting on this wheel can only be changed when the machine is in contact (CONTACT indicator illuminated) or when the chuck is not inserted into the stage. The Separation Control Wheel is graduated in millimeters. In other words, when the wheel is set to Ø.Ø4, the distance will be Ø.Ø4 millimeters or 4Ø microns.

e. Maskholder - The maskholder is removed and inserted from the left side of the stage. It is securely clamped in the maskholder frame when the MASKHOLDER button is pressed and illuminated.

f. Thickness Adjustment Knob - The thickness adjustment knob is located on the lower left corner on the front of the stage and is adjusted using a reference substrate and mask. If substrates or masks of different thicknesses are to be used, this thickness difference must be compensated for by using the variable thickness adjustment. This procedure is described in Sections 2.5.1. and 2.5.2.

g. Nitrogen Purge - For work with negative resists, the stage is equipped with a purge which flushes the wafer and mask area with nitrogen to reduce the "oxygen effect". The purge volume is adjusted using the throttle on the manometer box.

2.1.4 Microscope

2.1.4.1 Microscope Manipulator

The microscope manipulator which controls the movement of the microscope over the alignment stage is located on the left side of the machine. The microscope itself rides on X-Y slides which are equipped with pneumatic brakes. Two buttons located on the manipulator handle are used to unlock either or both brakes, thereby enabling the microscope to be moved in either the X or Y directions exclusively, or both directions simultaneously.

The microscope focus control incorporates a combined coarse-fine adjustment. This allows rapid and convenient focusing of the microscope image. If the focus adjustment is turned in one direction, the noticeable limits of the fine adjustment are reached and the coarse focusing motion will be effective. The fine adjustment is automatically re-engaged as soon as the slightest turn is made in the opposite direction.

2.1.4.2 Microscope Options with the MA 45

A number of microscope options are offered with the SUSS MA 45 in both normalfield and splitfield types. The three basic configurations are described below. A detailed description of the microscope supplied with your aligner may be found in the Appendix (Chapter 8). Since these microscopes are used in a number of SUSS products, the photographs which are used for identification may show the microscope mounted on equipment other than the MA 45.

a. Normalfield Microscope (SUSS M400) (Figure 8-1) - The M400 microscope consists of the microscope head (either binocular or trinocular), eyepieces, microscope body, illuminator, objective turret, and objectives. The microscope may be equipped with either a 3-objective or 4-objective revolver depending on the range of magnification desired. The SUSS M400 is offered in two versions: brightfield only, and a brightfield/darkfield/interference contrast combination. Interference contrast illumination is obtained (using an interference contrast objective) by inserting the analyzer and the polarizer into the illumination path. Darkfield illumination is obtained (using a darkfield objective) by inserting the darkfield stop into the light path.

b. Splitfield Microscope (SUSS M200) (Figure 8-3) - The M200 microscope consists of the microscope head (either binocular or trinocular), eyepiece, microscope body, illuminator, and one pair of objectives. The choice of eyepieces and objectives depends on the magnification desired. The objective separation distance is adjusted using the two combination objective separation knobs which also adjust the fine focus. The small knobs on the body of the microscope are used to select either singlefield or splitfield operation.

c. Splitfield Revolver Microscope (SUSS M230) (Figure 8-4) The M230 microscope is similar to the M200 splitfield microscope except that it is supplied with three pairs of objectives. The objectives are mounted on two 3x revolvers. Locking screws are supplied in the revolver mount dovetail to allow the revolver to be rotated without changing the objective separation distance.

2.1.5 Manometer Box

The manometer box (Figure 2-4) contains the gauges and regulators used to control the machine pneumatics. There are three pressure gauges labelled AIR PRESSURE, AIR PRESSURE, and NITROGEN. These should be set at 4 bar (60 psi), 3 bar (45 psi), and 1 bar (15 psi) respectively (unless otherwise noted), using the regulator located under each gauge.

With the exception of parallelity compensation, the left Air Pressure regulator controls the pressure used for all machine functions controlled by air pressure (mirrorhouse movement, microscope lift and manipulator brakes, lamphouse heat sink cooling, etc.).

The right Air Pressure regulator controls the pressure in the bladder ring located under the parallelity (wedge error) compensation plate, and thereby regulates the wedge-error compensation pressure.

The Nitrogen regulator controls nitrogen pressure; nitrogen is used for lamp base cooling in the lamphouse, the nitrogen purge function, and for releasing the vacuum in the vacuum chamber in vacuum chamber exposure mode (if so equipped). Two pneumatic toggle switches controlling the compressed air and nitrogen supplies are located below the gauges and regulators, along with a throttle controlling the nitrogen purge to the wafer stage for work with negative resist. A gauge located at the bottom left of the manometer box indicates the vacuum supplied to the machine.

2.2 START UP PROCEDURE

2.2.1 Pre-Operation Check List

Before starting the MA 45, it is important to:

a. Switch on the nitrogen and compressed air (manometer box) and adjust the regulators to the proper setting.

b. Switch on the vacuum to the machine.

c. Check all connections to and from the MA 45, including electrical and pneumatic lines.

2.2.2 Exposure Lamp Ignition

The lamp ignition sequence is as follows:

a. Check that the machine is turned off.

b. Please refer to the power supply manual in the Appendix and follow lamp ignition sequence as outlined.

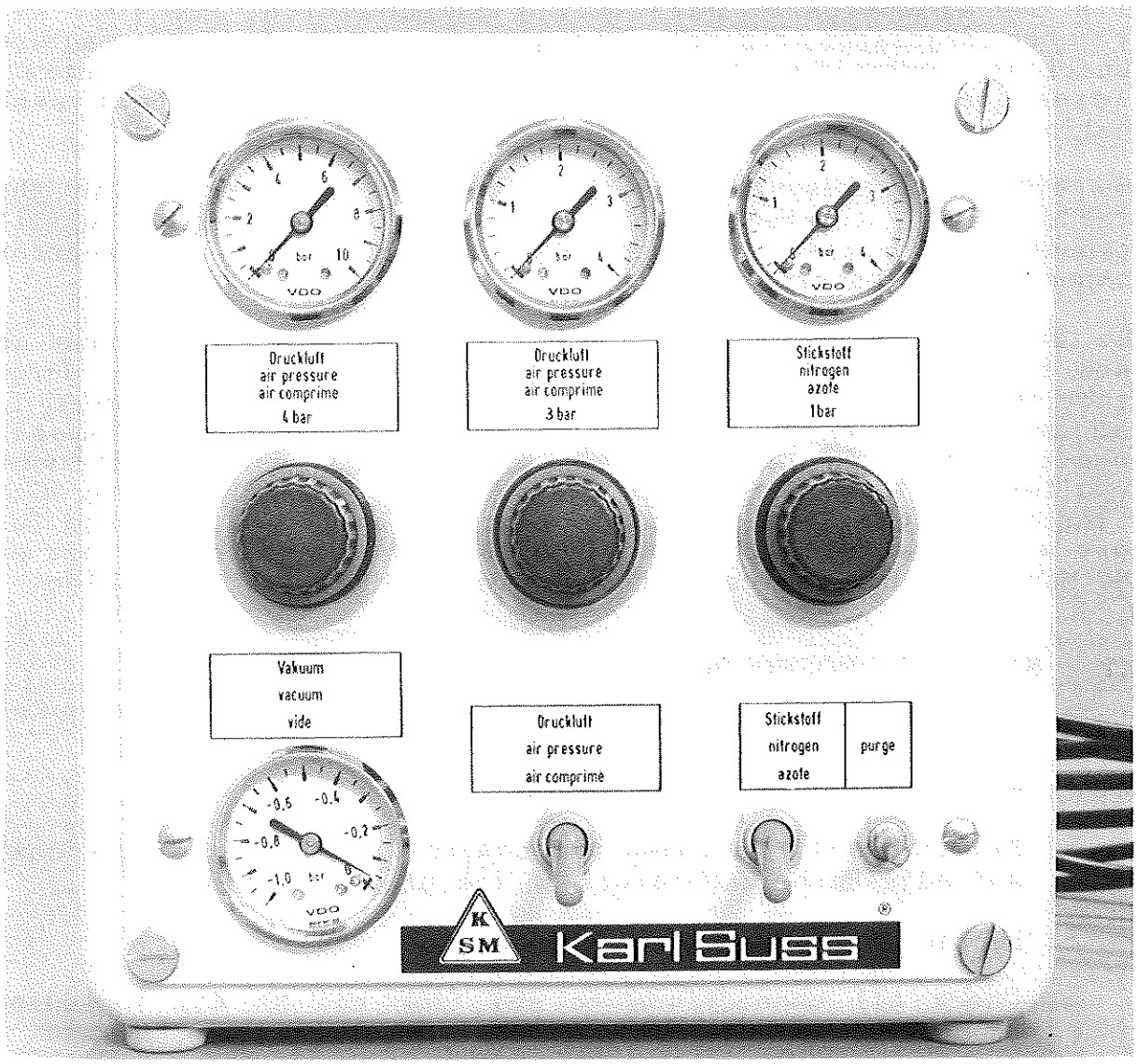


Figure 2-4 Manometer Box

2.2.3 Power Up

Turn the machine on by pressing the POWER button. The POWER button will illuminate.

2.3 OPERATION

2.3.1 Loading the Mask (Please refer to Figures 2-5 and 2-6.)

To load a mask into the machine, first press the START button, moving the lamphouse and microscope to the left and removing the chuck from the stage. Check that the MASKHOLDER button is extinguished. Remove the maskholder from the stage and place it on a flat surface, vacuum groove up.

> NOTE: It is very important to avoid scratching chucks and maskholders.

Check that the VACUUM MASK toggle switch is off. Place the mask on the maskholder with the patterned side up and move the VACUUM MASK toggle to the on position. Check that the mask is securely held to the maskholder by vacuum. Now invert the maskholder and reinsert it into the stage. Press the MASKHOLDER button, illuminating it and locking the maskholder into position.

2.3.2 Selecting an Exposure Mode

The SUSS MA 45 offers two exposure modes which you may select using the PROXIMITY button located on the left front panel of the machine. This button controls what takes place at the interface of the substrate and the mask during wedge-error compensation and exposure. If the PROXIMITY button is not illuminated, the contact mode is selected; if it is illuminated, the proximity mode is selected.

a. Contact Mode - In the contact mode, the substrate is raised upward until it contacts the mask, performing wedge-error compensation. During exposure, vacuum holds the substrate to the chuck while the substrate is in intimate contact with the mask.

b. Proximity Mode - In the proximity mode, the substrate never contacts the mask. Rather, the substrate is raised until it reaches a fixed distance from the mask. Alignment and exposure are performed at this distance.

Press the PROXIMITY button to select one of these exposure modes.

Next, turn the Separation Control Wheel to the desired distance for alignment (and exposure in "Proximity" mode). This wheel is graduated in millimeters (mm). In other words, if the wheel is set to Ø.Ø4, this distance will be Ø.Ø4 mm or 4Ø microns (µm).

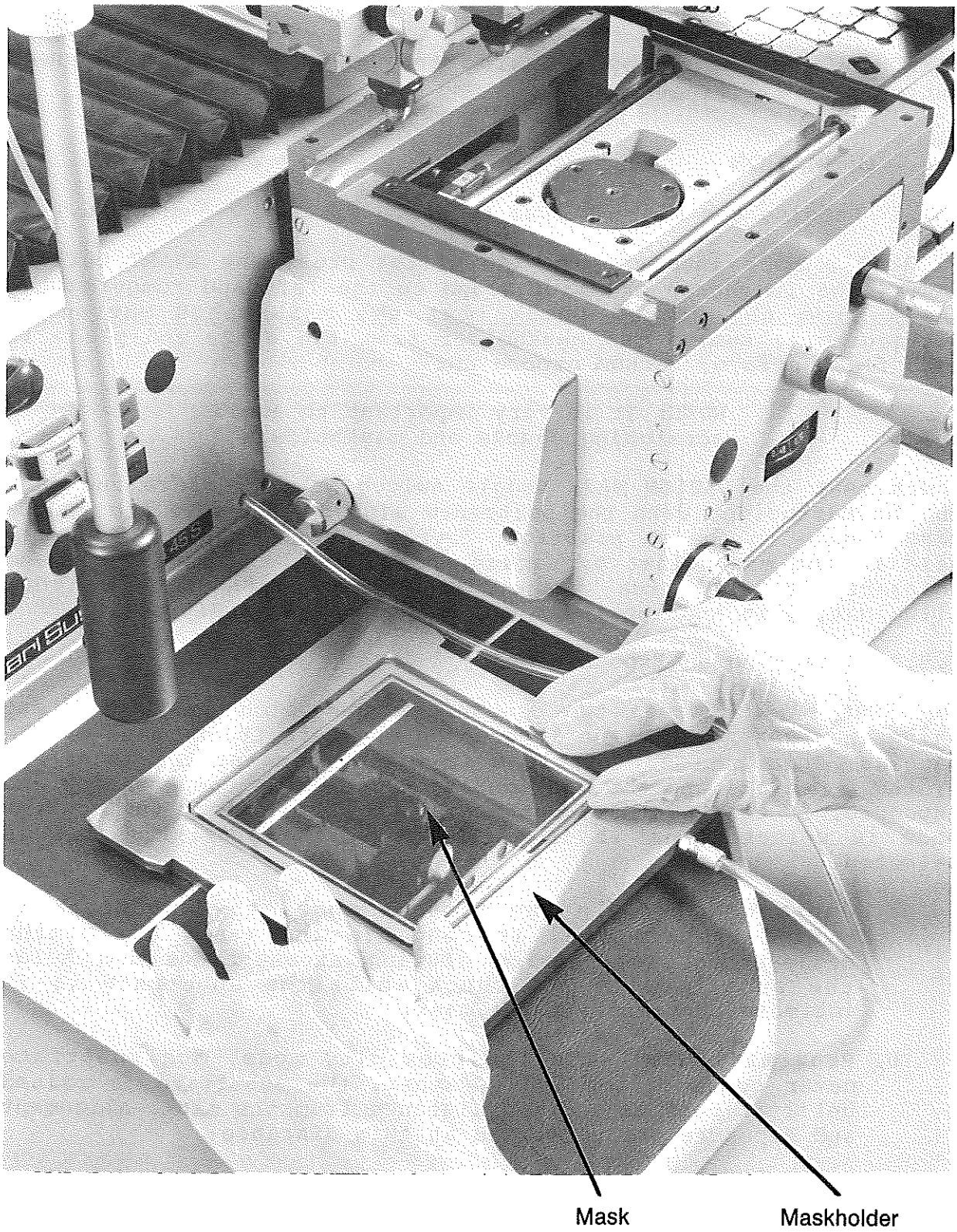


Figure 2-5 Loading Mask on Maskholder

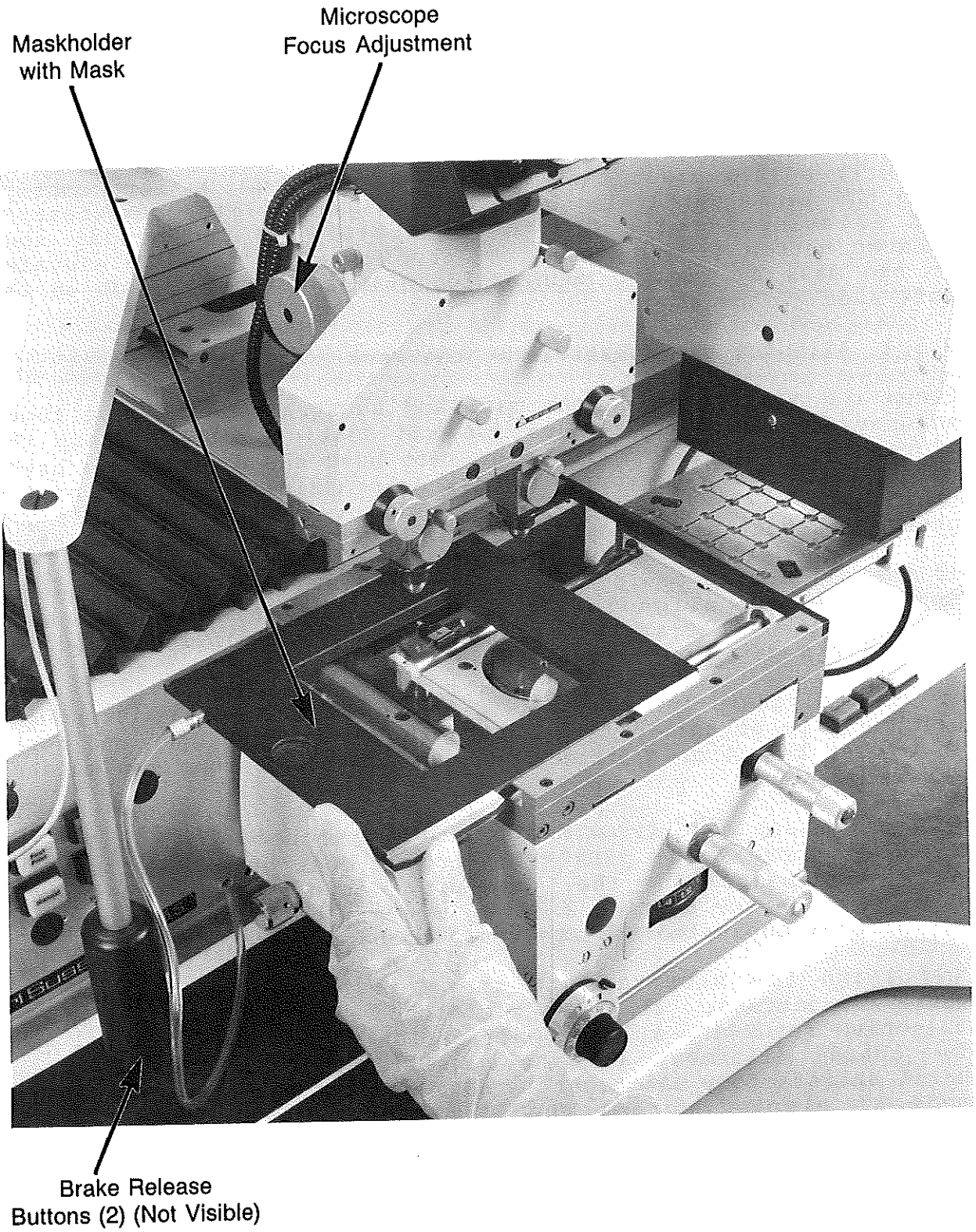


Figure 2-6 Loading Maskholder Into Stage

2.3.3 Loading the Substrate (Please refer to Figure 2-7.)

Place the substrate onto the chuck, ensuring that it covers all vacuum holes. Depress the footswitch once, pre-aligning the substrate (pre-align chuck only), clamping the substrate to the chuck, moving the lamphouse and microscope to the right and inserting the chuck and substrate under the mask. In the automatic mode (MANUAL button extinguished), after the chuck is properly seated under the mask, it will travel up into contact with the mask, performing wedge-error (parallelity) compensation and illuminating the CONTACT indicator. In the manual mode (MANUAL button illuminated), the chuck must be manually elevated to the mask by turning counterclockwise the knurled knob on the left side of the stage.

2.3.4 Aligning the Substrate to the Mask

Focus the microscope on the mask and substrate, using the focus adjustment knobs (see Figure 2-6 and Section 2.1.4). Grasp the microscope manipulator with your left hand and depress the brake release buttons with your fingers. By pressing one button or the other, you may select either an X-only or a Y-only scan. If you press both buttons, you may scan the microscope in any direction.

If the aligner is equipped with a splitfield microscope, the two objectives are aligned to two alignment features on opposite sides of the substrate using the microscope manipulator and the objective separation controls (see Section 2.1.4 b).

If the aligner is equipped with a normalfield microscope, alignment is performed by scanning the microscope back and forth in either the X or Y direction with the microscope manipulator described above.

In the contact mode (PROXIMITY button extinguished - see Section 2.3.2 a. above), the SEPARATION button must be pressed for the mask alignment. In the proximity mode (PROXIMITY button illuminated - see Section 2.3.2 b. above), the substrate and mask are already separated and are ready to be aligned.

Now align the substrate to the mask using the X-, Y-, and Theta-micrometers. If the microscope is equipped with an objective revolver, a low magnification objective should be used for coarse alignment and the magnification steadily increased until satisfactory alignment is obtained. If the contact exposure mode is elected, press the SEPARATION button to bring the substrate into contact with the mask. (SEPARATION button will be extinguished and CONTACT indicator illuminated.)

2.3.5 Exposure

The substrate is now ready for exposure. (Exposure mode should be selected before alignment. See Section 2.3.2) Set the exposure time on the timer or light integrator located at the right end of

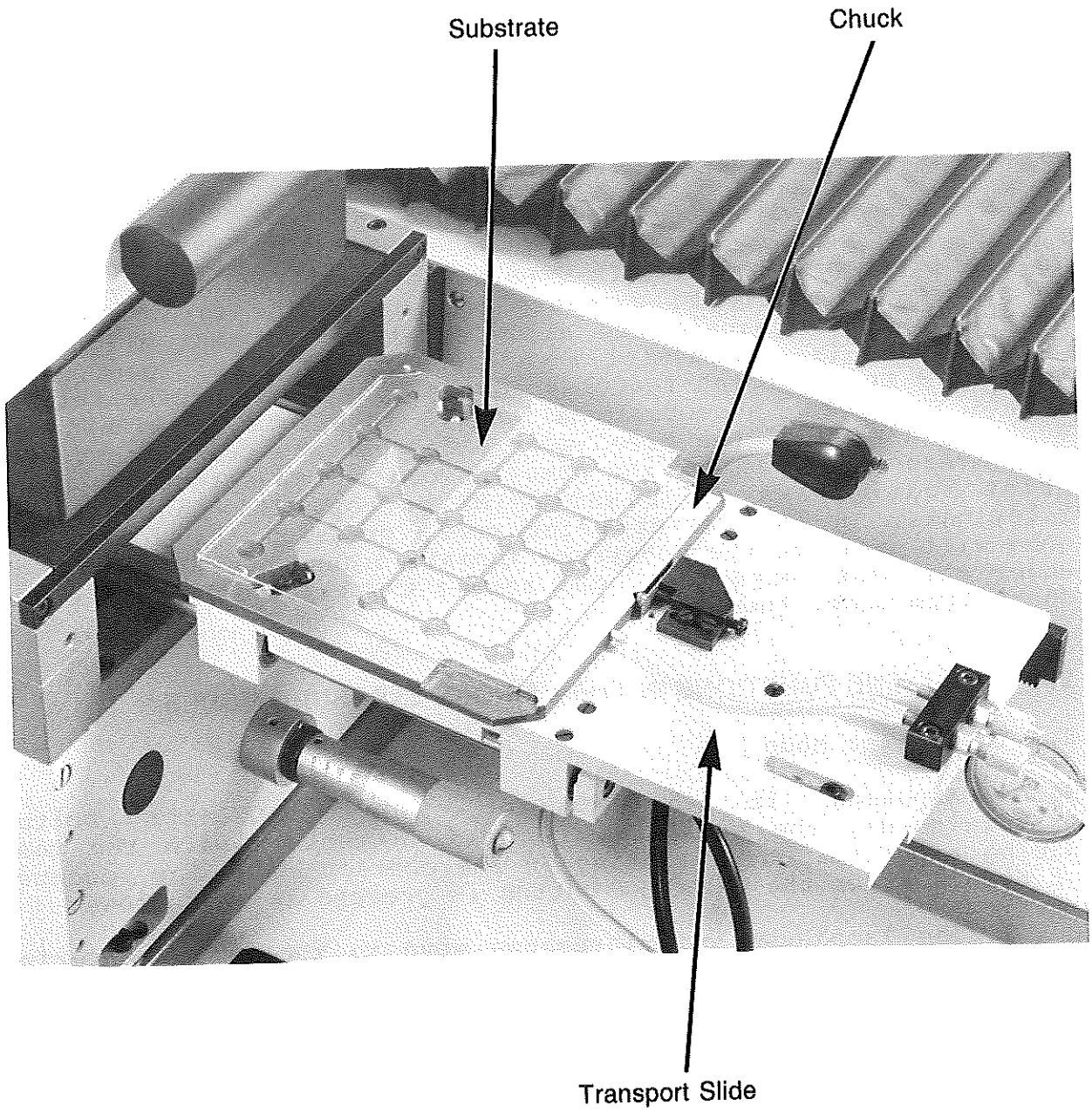


Figure 2-7 Loading the Substrate

the right front control panel. Sections 2.1.2 a. and b. contain complete instructions for setting the timer and integrator.

Press the EXPOSURE button. (With some microscopes, the microscope will be raised a sufficient amount to allow the objective or objectives to clear the maskholder.) The mirrorhouse now moves into position over the mask (see Figure 2-8). When the mirrorhouse reaches the correct position, the exposure shutter opens and exposure takes place for the amount of time set on the exposure timer or light integrator. After exposure, the shutter closes and the chuck and substrate are lowered from the mask and removed from the stage. The exposed substrate is now ready to be removed from the chuck.

2.3.6 Exposure without Alignment (FIRST PRINT)

In the first print mode (FIRST PRINT button illuminated), the MA 45 proceeds directly to exposure once the wafer is in exposure position without pausing to allow substrate to mask alignment. This feature is very useful when exposing the first level, when there are no alignment features on the substrate, or for further levels where the acceptable alignment tolerance is within the accuracy limits of the prealigner and substrate transport system (±2Ø microns or less for the prealign chuck). To select the first print mode, press the FIRST PRINT button. This button will illuminate. In this first print mode, pressing the foot pedal once will prealign the substrate (prealign chuck only), center it under the mask, expose it, and remove the exposed substrate and chuck from under the mask.

2.4 MACHINE FUNCTIONS IN THE VARIOUS EXPOSURE MODES

2.4.1 Contact Mode

When exposing in the Contact Mode (PROXIMITY button extinguished), the substrate is held in contact with the mask during exposure. When printing in the contact mode, the sequence of events after the EXPOSURE button is pressed is as follows:

1. The lamphouse and microscope move to the left, centering the exposure optics over the mask and substrate.

2. The shutter opens, exposure takes place for the length of time selected on the exposure timer, and the shutter closes, completing the exposure.

3. The substrate and chuck are lowered from the mask and move to the right.

2.4.2 Proximity Mode

When exposing in the PROXIMITY mode (PROXIMITY button illuminated), the substrate never makes contact with the mask.

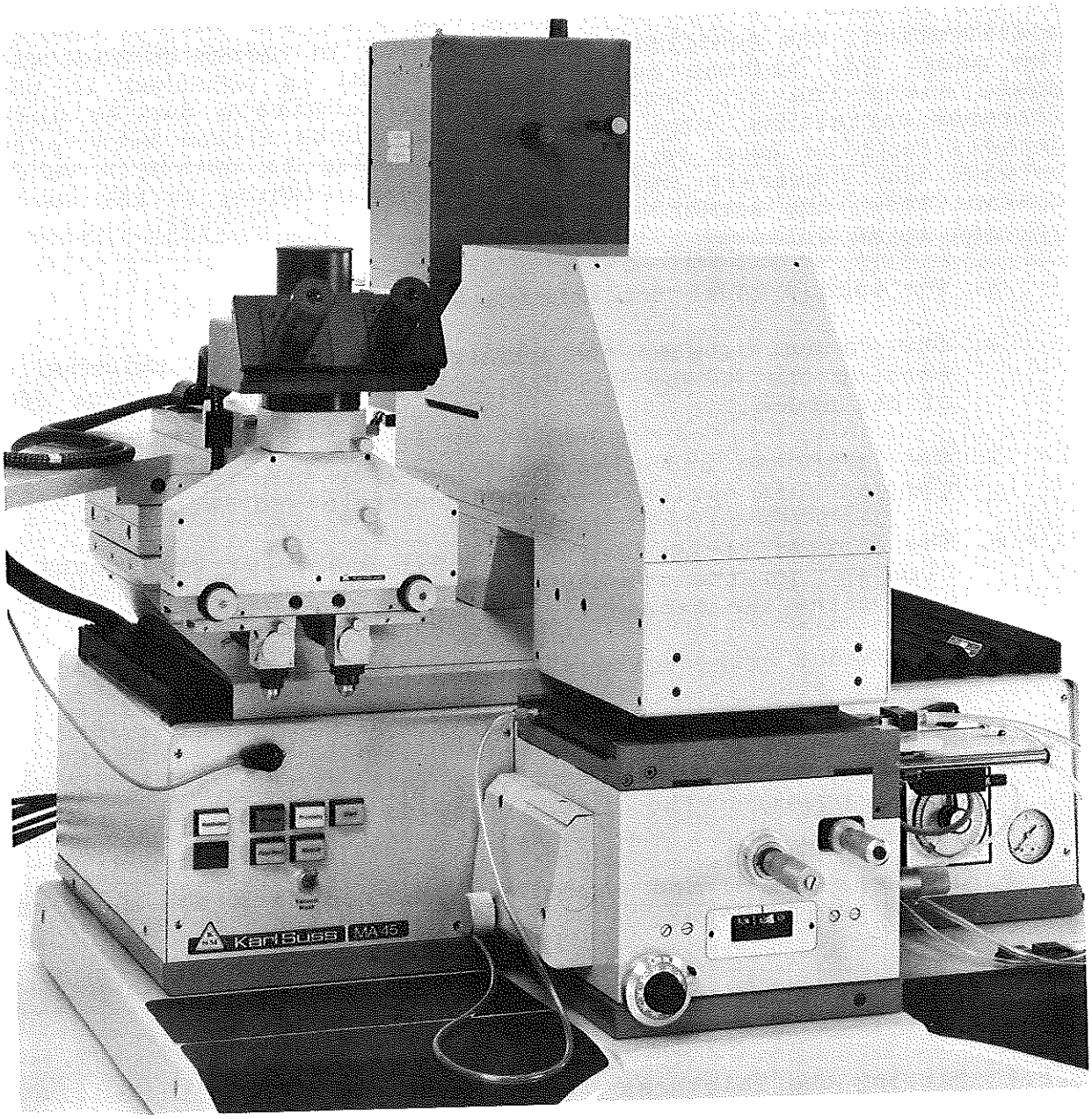


Figure 2-8 Mirrorhouse in Exposure Position

Rather, the substrate is aligned and exposed at the proximity gap indicated on the black thumbwheel. Otherwise, the sequence of events after the EXPOSURE button is pressed is described in Section 2.4.1.

2.4.3 Vacuum Contact Mode (Optional)

If the aligner is equipped with the optional vacuum chamber modification, the substrate can be exposed in vacuum contact with the mask. The highest possible resolution is obtained in this mode, since the gap between mask and substrate due to dust, flatness variations, etc. is minimized. Chucks fitted with vacuum gaskets must be used in this mode in order to obtain a vacuum between the substrate and the mask. When printing in the vacuum contact mode, the sequence of events after the EXPOSURE button is pressed is as follows:

1. The vacuum under the substrate is switched off.
2. The vacuum between the substrate and mask is switched on through the vacuum chamber hole located at the outer edge of the chuck.
3. The lamphouse and microscope move to the left, centering the exposure optics over the substrate and mask.
4. The shutter opens, exposure takes place for the length of time set on the exposure timer, and the shutter closes, completing the exposure.
5. The vacuum between the substrate and mask is switched off.
6. The vacuum under the substrate is switched on.
7. A nitrogen burst is introduced through the vacuum chamber hole, breaking the vacuum between the substrate and the mask.
8. The substrate and chuck are lowered from the mask and moved to the right.

2.5 ADJUSTMENT PROCEDURES

2.5.1 Setting the Thickness Adjustment

The MA 45 is equipped with a device to maintain constant contact pressure when processing substrates of various thicknesses. Alternatively, this device may be used to vary the contact pressure for a given wafer thicknesss.

When the equipment is set up, a reference mask and substrate are used to set the contact pressure between the mask and substrate.

This setting may be varied using the variable thickness adjustment knob located on the lower left front of the stage.

One revolution of the thickness adjustment knob corresponds to approximately 300 microns of substrate thickness or contact pressure. Rotate the knob clockwise to increase the contact pressure or subtract substrate thickness; rotate the knob counterclockwise to decrease contact pressure or add substrate thickness.

Examples: Assume that in each case a reference mask of 60 mils (about 1500 microns) thickness and a reference substrate of 20 mils (about 500 microns) thickness were used to set up the machine at installation. Further assume that a contact pressure of 500 microns was set and that this corresponds to a setting of 5.0 on the thickness adjustment knob.

Example 1: It is desired to process 14 mil (about 350 micron) thick substrates. Procedure: Rotate the thickness adjustment knob clockwise to a setting of 5.5 (500 microns - 350 microns = 150 microns = 0.5 revolution).

Example 2: Using 20 mil thick substrates, it is desired to decrease the contact pressure from 500 microns to 350 microns. Procedure: Rotate the thickness adjustment knob counterclockwise to a setting of 4.5 (150 microns = 0.5 revolution).

Example 3: Using 20 mil thick substrates, it is desired to use a mask of 63 mils thickness. Procedure: Rotate the thickness adjustment knob counterclockwise to a setting of 4.75 (63 mils - 60 mils = 3 mils = about 75 microns = 0.25 revolution).

2.5.2 Setting Contact Pressure Using the Dial Indicator Kit

2.5.2.a U.S. Version

To set the contact pressure, please refer to Figure 2-9A and proceed as follows:

1. Disconnect the microscope from the microscope adapter in the following manner. Remove any source of illumination to the microscope (such as the fiber optic guides). Loosen two knurled screws located on the left side of the microscope adapter behind the microscope. Slide the left and right objectives as far apart as possible. Lift the microscope up from the adaptor housing and set it on a clean, stable surface.

2. Press the START button, moving the lamphouse and the microscope to the leftmost position, and moving the chuck to the load position.

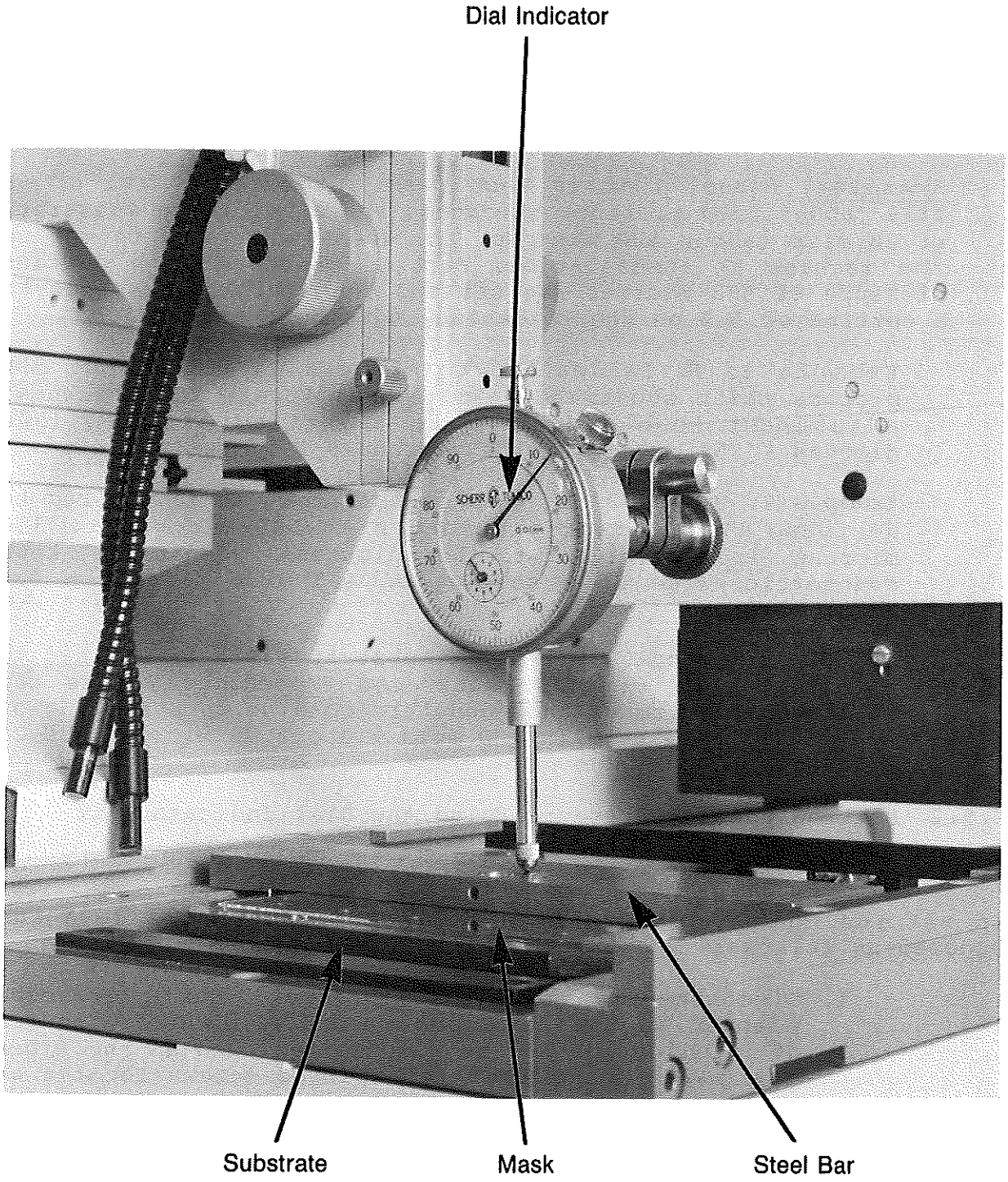


Figure 2-9A Dial Indicator Assembled in Machine (U.S. Version)

3. Remove the maskholder, mask and substrate from the machine.

4. Depress the MANUAL and MASKHOLDER buttons, illuminating them.

5. Load a representative substrate onto the chuck and press the footswitch, moving the chuck into the stage area.

6. Place a representative mask on top of the loaded substrate.

7. Assemble the dial indicator to the arms and dovetail supplied and slide the dovetail into the microscope mount dovetail. Tighten the lower knurled screw on microscope adaptor, securing dovetail in place.

8. Place the steel bar supplied over the center of the chuck on the maskholder rails with the notched side down and the flat side up.

9. Position the dial indicator over the bar and adjust the indicator downward (using the microscope focus adjustment) until the dial indicator arm contacts the bar and indicator deflection is obtained. Rotate the outer ring of the dial indicator to obtain a reference needle reading of zero.

10. Rotate the contact knob on the left side of the stage 180 degrees counterclockwise. The wafer and mask will contact the bar and move it upwards. The CONTACT indicator will illuminate, showing that contact has been made.

    The amount of vertical movement of the bar (measured from the zero reference) is the contact pressure. The amount of contact pressure is adjusted by rotating the thickness adjustment knob clockwise to increase it and counterclockwise to decrease it. One revolution of the knob corresponds to a 300 micron distance in Z direction. The last motion of the thickness adjustment knob should be in the clockwise direction. If a reduction in contact pressure is desired, turn the knob counterclockwise past the desired setting, then return it clockwise until the proper reading is obtained.

11. When the desired contact pressure has been achieved, lock the thickness adjustment knob using the locking lever. Record the substrate thickness, mask thickness, and the indication of the thickness adjustment knob. These values are used as the

reference when varying substrate thickness or contact pressure without the use of the dial indicator. (See Section 2.5.1)

12. Reinstall the microscope, reversing the procedures outlined in Step 1.

2.5.2.b International Version (Please refer to Figure 2-9B)

Basic Adjustment of the Measuring Device

- Your measuring device is adjusted according to the maskholder thickness. Should a readjustment be necessary, the procedure is very simple. First, place the maskholder face down on a very flat surface, for example, a granite or marble plate.

- Adjust the dial of the measuring device according to the thickness of the mask, and lock the measuring device with the magnet so that the dial gauge indicator is positioned in the hole of the maskholder and resting on the surface.

- Adjust both scales of the dial gauge by means of the "Z-shift" to zero.

To set the contact pressure, proceed as follows:

1. Place a representative substrate on the chuck, and insert maskholder without mask.

2. Fix the measuring device on the maskholder with the precision ball above the center of the substrate.

3. Rotate the contact lever 180 degrees counterclockwise as in normal operation, bringing the substrate into contact with the precision balls.

4. When in contact position, the small needle shows the value of the mask thickness and the large needle shows "0", the wedge error pressure is equal to "0".

5. Adjust the Z-axis to the desired contact pressure using the variable thickness adjustment knob. Lock the knob using the locking lever.

6. Record the substrate thickness, mask thickness, and the indication of the thickness adjustment knob. These values are used as the reference when varying substrate thickness, mask thickness, or contact pressure without the use of the measuring device. (See Section 2.5.1)

3 WARNINGS AND SAFETY HAZARDS

> **IMPORTANT:** This section contains information that the operator must know and understand to minimize the risk of injuries. This information is consistent with local and federal safety regulations.

KARL SUSS equipment is designed to protect the user against all possible hazards. After review by qualified safety personnel, the user should generate a specific safety procedure with regard to the particular application of the equipment and local codes.

3.1 ELECTRICAL PRECAUTIONS

When the covers are removed from the mask aligner, hazardous voltages may be exposed. When all of the covers are in place, there is no danger from these voltages.

Service of the electrical systems should be performed only be qualified personnel. Therefore, it should never be necessary for the operator to open the cover of the electrical portion of the mask aligner. If any problems occur with the power supply, switch off the machine and notify maintenance personnel immediately.

> **CAUTION:** Never open the housing while the power line is connected.

3.2 HIGH PRESSURE LAMPS

The light source for the concentrated ultraviolet illumination required to expose the wafer is a high pressure lamp. Special precautions must be taken when working with such lamps.

3.2.1 Electrical Hazards

The voltage and current required to run a high pressure lamp constitute a lethal combination. Starting ignition voltages are 30 KV and open circuit potentials range up to 180 VDC at currents between 5 and 50 amps.

When performing any maintenance on the exposure lamp power supply, lamp housing, or the lamp itself, ensure that the power line to the power supply is disconnected.

3.2.2 Lamp Explosion

These exposure lamps operate at extremely high pressure (50-70 atm). Explosion is therefore a possibility if they are handled or

operated improperly. They may fail due to improper cooling, improper setting of the power supply, usage outside the manufacturer's guidelines, etc. Additionally, some high pressure lamps, even when cold, are still above atmospheric pressure and should be handled with protective face shields and gloves.

> **NOTE:** Careful handling of the lamp and proper operation of the equipment will substantially reduce the possibility of lamp explosions.

The lamphouse is designed to minimize damage of the interior of the equipment and avoid any possible injury to the operator should a lamp explosion occur. All assemblies and protective covers must be in place during operation of the machine.

Some of these lamps contain hazardous elements, like mercury. If a lamp should break, take precautions to avoid touching the fragments and/or breathing the vapor.

3.2.3 Exhaust Requirements

High pressure lamps produce ozone due to the interaction of the radiation emitted below a wavelength of 250 nm with oxygen. Ozone attacks the mucous membranes of the respiratory system, producing symptoms similar to pneumonia. The effects are cumulative. The smaller wattage lamps, cadmium-xenon to 200 watts and mercury to 500 watts, should only be operated in a well ventilated area. Larger wattage lamps, such as 350 watt Cd-Xe and 500 watt Hg-Xe, must be exhausted from the room.

3.2.4 Eye and Skin Safety

The ultraviolet light produced by these lamps can cause erythema of the skin (similar to sunburn) and conjunctivitis. In addition, the large infrared output can cause retinal burns resulting in blindness.

Every SUSS mask aligner is equipped with light guards, and the high pressure lamp and exposure path are enclosed. The mask aligner should not be operated unless all of these protective covers and devices are in place.

3.3 BROKEN WAFERS

Since fragments of broken wafers and substrates can be very sharp, there is a risk of injury to the operator or maintenance personnel when trying to remove them from the machine. Extra care should be taken and proper tools, i.e. tweezers, should be used to minimize this risk.

3.4 MOVING PARTS

The operator should take care to keep loose clothing, long hair, etc. from getting caught in the machine.

See-through covers are provided in certain cases to allow the operator to observe the operation of the machine. These covers should not be removed, as they prevent the operator from reaching into the moving equipment.

4 QUALITY STANDARDS

This chapter briefly describes some of the quality standards which we recommend you follow to help you obtain the best possible results from your SUSS equipment. KARL SUSS manufactures precision instruments that cannot be expected to function properly unless they are correctly adjusted and maintained, and precautions are taken to ensure a clean environment.

We assume that you have a comprehensive quality control program which has been developed to suit your particular application. These comments are only intended as a reminder that quality standards are an essential part of good business practices.

4.1 ENVIRONMENT

A mask aligner is intended for use in a well managed, professionally supervised clean room.

Mask dimensions are usually on the order of several microns, and frequently fall into the submicron range. At this level of precision, almost everything in a normal production environment would be judged too "dirty" to make semiconductor devices.

The cleanliness requirement is particularly stringent in the photomasking area. Not only are all of the critical dimensions produced here, but the frequent chemical operations present many opportunities for accidental contamination. Any type of contamination will affect fabrication yield and circuit reliability.

The exposure quality obtained from a mask aligner is a function of many variables in addition to clean room conditions. The quality of the mask used, wafer flatness, specifications and quality of the photoresist, and the condition of the resist spinner all play important roles.

To ensure the best possible results, the user must take appropriate steps to provide a clean environment and maintain consistent and effective quality standards for all aspects of the photomasking process.

4.2 MACHINE CHECKS AND ADJUSTMENTS

A mask aligner should be checked on a regular basis to ensure that the machine is still adjusted to optimum performance conditions.

4.2.1 Light Intensity

The light intensity measured at the wafer plane compared with the power input to the lamp gives an indication of any existing or pending failure of the exposure lamp. Towards the end of

the lamp's life, the bulb begins to darken. This is an indication of an increased possibility of a lamp explosion.

You should record the power input to the exposure lamp on a daily basis. Do not exceed the limit specified by the manufacturer of the exposure lamp.

Figure 4-1 shows a setup which can be used to measure light intensity and uniformity.

4.2.2 Light Uniformity

As part of your standard routine, you should measure the light intensity at different points of the wafer plane, for example at the 12, 3, 6, and 9 o'clock positions, and at the center.

By comparing these measurements, you can calculate and monitor the light uniformity.

4.2.3 Chucks and Maskholders

Chucks and maskholders are manufactured to very fine tolerances. Your standard routine as part of your attention to quality standards should include inspection of chucks and maskholders for cleanliness, mechanical integrity, and evidence of residues of any kind, including photoresist. The use of chucks or maskholders that have scratches or show signs of abuse will result in poor equipment performance.

A visual inspection is usually all that is required.

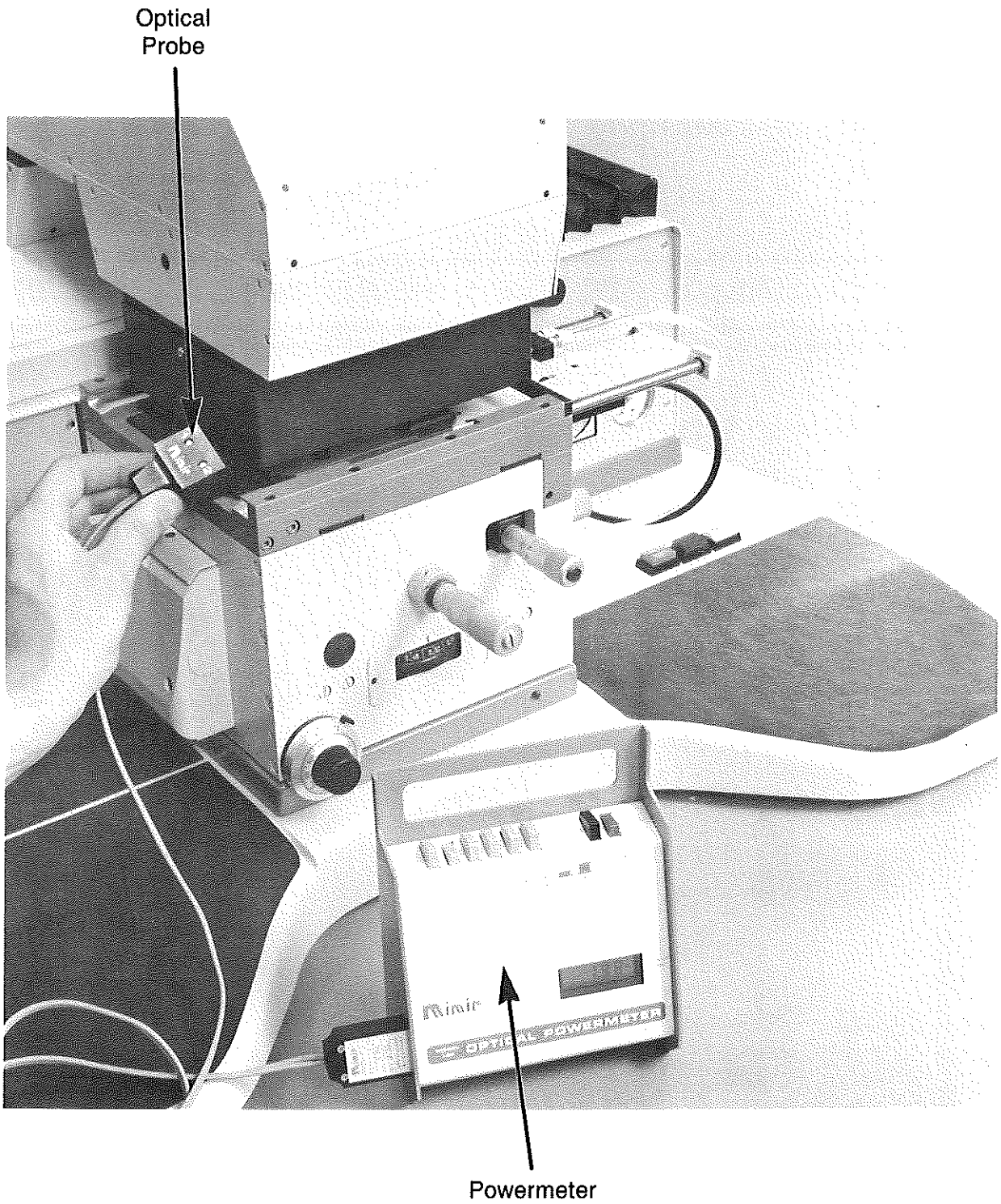


Figure 4-1 Measuring Light Intensity

5 MAINTENANCE

Your mask aligner was carefully designed and solidly built to exacting standards in order to provide many years of reliable performance. There are, in fact, KARL SUSS mask aligners still in daily use in the field after more than fifteen years of service. To ensure the highest quality performance and longest life from your unit, proper maintenance and care is an absolute must.

This chapter will acquaint you with the general maintenance requirements. It also covers the procedures for periodic maintenance such as lamp replacement, intensity and uniformity checks, and power supply calibration.

5.1 GENERAL MAINTENANCE

The few minutes spent performing the following checks and tests will greatly improve the overall performance of the mask aligner. In addition to these procedures, you should be alert to any unusual machine noises or behavior. These may indicate a condition that could lead to damage to the mask aligner if left uncorrected.

5.1.1 Visual Checks

A thorough visual check is the primary requirement of the daily maintenance program. Key areas include chucks, maskholders, and the microscope. These parts should be free of dust and residues, especially photoresist. The parts should also be inspected for scratches and other signs of wear. The use of scratched or damaged chucks and maskholders will result in poor equipment performance.

5.2 REPLACEMENT AND ADJUSTMENT OF EXPOSURE LAMP

The procedure for the replacement and the adjustment of the exposure lamp for the 350W lamphouse is described below.

> **CAUTION:** Under no circumstances should you touch the quartz bulb of the exposure lamp with your fingers. Clean inadvertently touched spots immediately with alcohol and a soft lintfree cloth.

The operator should have no trouble replacing and adjusting the lamp. If there are any questions, please free to contact your KARL SUSS service representative.

5.2.1 Lamp Replacement

1. Switch off the exposure lamp power supply and disconnect the main power cord.

2. Switch off the mask aligner. Do not attempt to open the lamphouse until the lamp has been switched off for at least 20 minutes.

3. Unscrew the screw securing the lamphouse and carefully swing it open on its hinges. Please refer to Figure 5-1.

4. Examine the cold light mirror and clean it if necessary. In order to clean the cold light mirror properly, it must be removed from the lamphouse. **Handle the mirror with care!** Clean under hot running water using a soft sponge and liquid soap. Rinse thoroughly, carefully blow off the mirror with nitrogen, and reinstall it in the lamphouse. The orientation of cold light mirrors 1 and 2 on the holder is not critical, since both sides of the mirror are coated. However, cold light mirrors 7, 8, and 11 are coated only on one side. This side is indicated by an arrow on one edge of the mirror. The mirror must be mounted on the holder so the coated side faces the lamp.

> **CAUTION:** Never touch the quartz bulb with your fingers! Handle the lamp only by its metal ends.

5. Remove the nut from the free end of the lamp and remove the lead wire. **Keep the nut - you will reuse it!**

6. Carefully unscrew the lamp from the socket. Should an adapter come with the lamp, remove it and install it on the corresponding terminal of the new lamp.

7. Take the new lamp from its box and remove the knurled nuts which are no longer needed. Do not use the knurled nuts which are supplied with the new lamp!

8. Install the new Hg lamp, and adapter if necessary, in the lamphouse socket, inserting the negative terminal through the ellipsoid mirror and carefully screwing it into the socket.

9. Secure the lead wire to the free end of the lamp with the hexagon nut. If one of the lead wires appears to be damaged or very blackened, replace the wire.

10. Check the position of the cooling tube so that it is directed towards the metal base of the free end of the lamp.

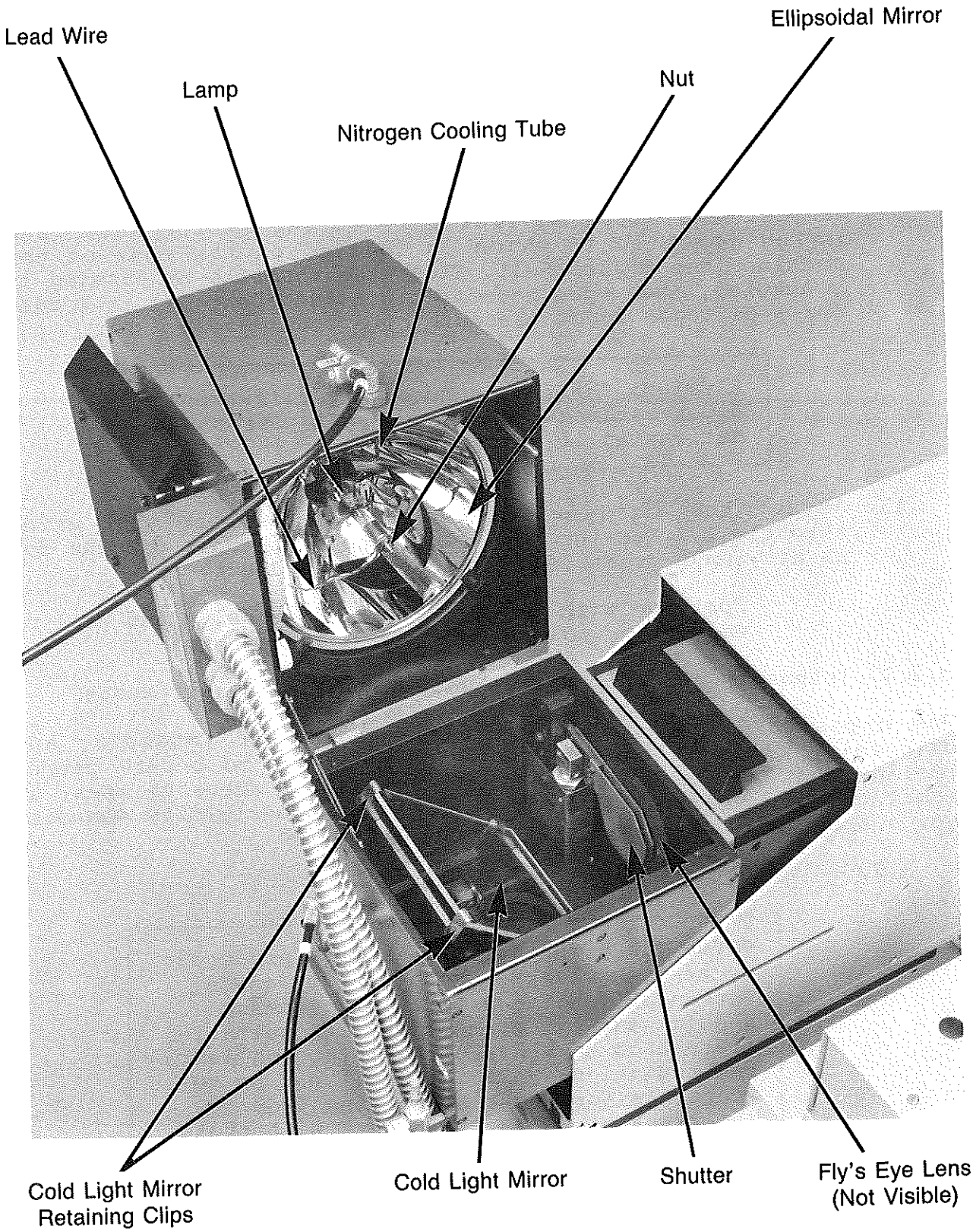


Figure 5-1 Lamphouse (Interior)

Continue with Section 5.2.2, "Lamphouse Reassembly and Pneumatic Adjustment"

5.2.2 Lamphouse Reassembly and Pneumatic Adjustments

11. Close the lamphouse and secure it with its screw.

12. Adjust the nitrogen flow for cooling of the lamp base using throttle 15 which is located on the rear of the machine (see Figure 5-2). Close the throttle by turning it clockwise, then open counter clockwise about 1/2 to 1 turn for a nitrogen input pressure of approximately 2 bar.

> **CAUTION:** Throttle numbers may differ on older machines. Please consult your pneumatic plan if in doubt.

13. Adjust the air flow for cooling of the heat sink using throttle 17. The throttle should be open about 5 turns for an air input pressure of approximately 4 bar.

Continue with Section 5.2.3, "Intensity and Uniformity Adjustments and Measurements"

5.2.3 Intensity and Uniformity Adjustments and Measurements

The exposure lamp must always be adjusted for intensity and uniformity after it has been changed in order to ensure proper cooling and uniform exposure across the entire exposure area. In addition, you should check the intensity and uniformity whenever you suspect wafers are not being evenly exposed.

5.2.3.1 Adjusting the Exposure Lamp

> **NOTE:** The high intensity energy produced by exposure lamps can cause eye damage. Personnel working with this equipment should wear eye protection with suitable filtration to block ultraviolet and infrared radiation. KARL SUSS will not be responsible for injuries arising from incorrect or unprotected work with these systems.

All exposure lamp adjustments are done with the exposure lamp power supply in idle mode. In order to perform the adjustments, you will need an intensity meter and the appropriate optical probes (365 nm, 405 nm, 320 nm, 254 nm, or 220 nm wavelength). Follow these step by step instructions:

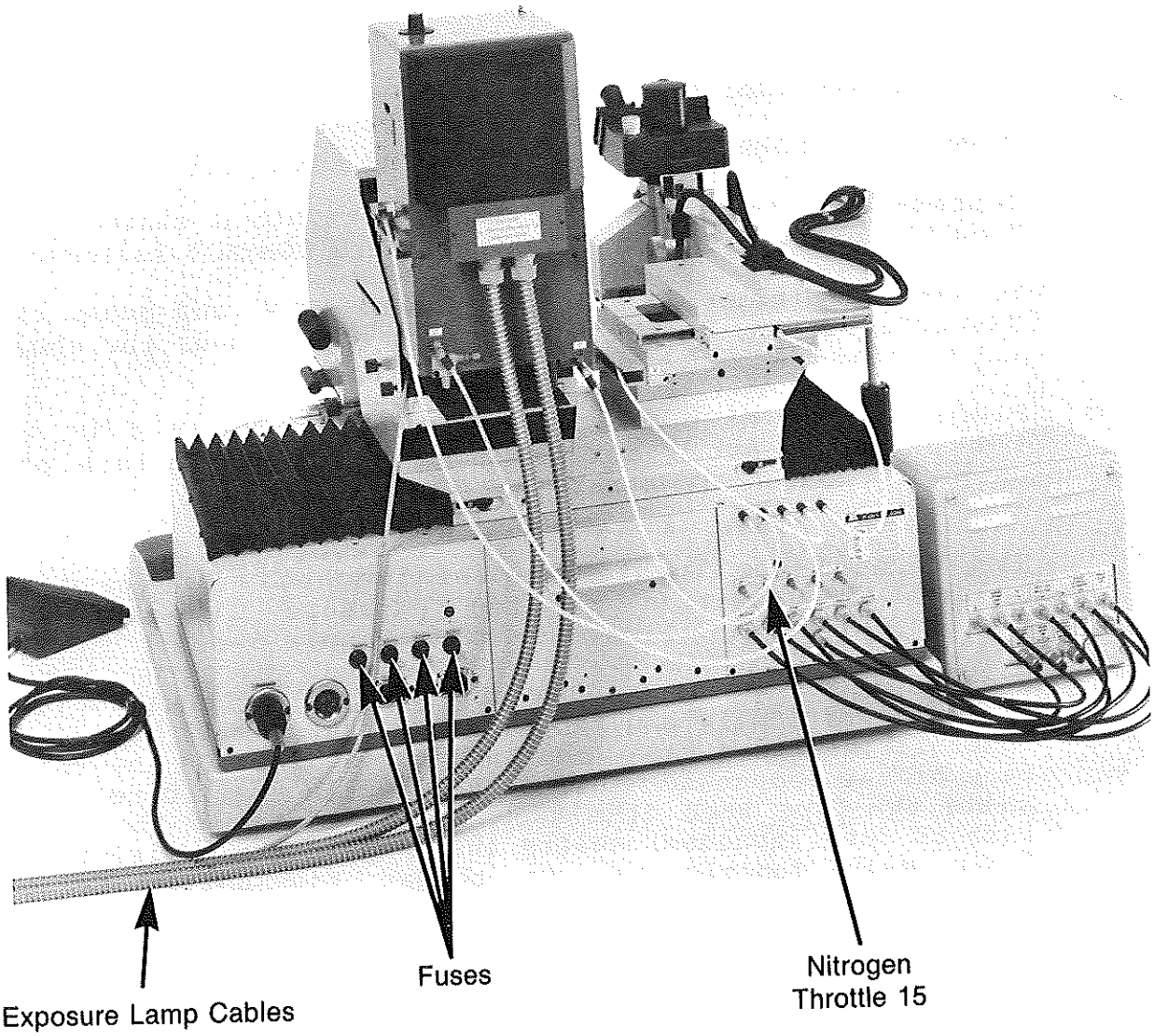


Figure 5-2 Back Side of Machine

1. Switch on the nitrogen and compressed air sources, which provide cooling for the lamphouse. Adjust the regulations to the proper settings.

2. Ensure that the mask aligner power switch is in the off position.

3. Switch on the exposure lamp power supply and ignite the exposure lamp by pressing the LAMP start button. Be certain that the power supply is set for idle mode (the CONTROL switch in the "out" position). Allow the lamp to stabilize for 10 - 15 minutes.

4. Depress POWER switch, activating machine.

5. Remove maskholder from machine.

6. Press MASKHOLDER switch, illuminating it.

7. Depress foot switch, moving the chuck into a contact (or "touch") position which illuminates the CONTACT indicator.

8. Set exposure timer to a long exposure time, and press the EXPOSURE button, centering exposure optics over the chuck and opening the shutter.

9. Place a piece of black paper, approximately 5" X 5", on the chuck to avoid scratching its surface. Place the optical probe on the paper (see Figure 4-1).

* * * *

The three knobs located on the lamphouse are used to adjust the position of the exposure lamp in the ellipsoidal mirror. Please refer to Figure 5-3.

The red knob (on the top surface of the lamphouse) shifts the lamp vertically and functions as the primary intensity control. The green knob (the knob to the left on the front face of the lamphouse) shifts the lamp in the Y direction, while the blue knob (the knob to the right on the front face of the lamphouse) shifts the lamp in the X direction. Their main function is to adjust the uniformity of illumination.

* * * *

10. Maximize the reading on the power meter by first shifting the lamp vertically using the red (top) knob. Then do the same in the Y and X directions using the green (left) and blue (right) knobs.

11. Alternately placing the probe at the front and rear edges of the illuminated area, use the green knob to shift the lamp in the Y direction until the meter gives the same reading at both locations.

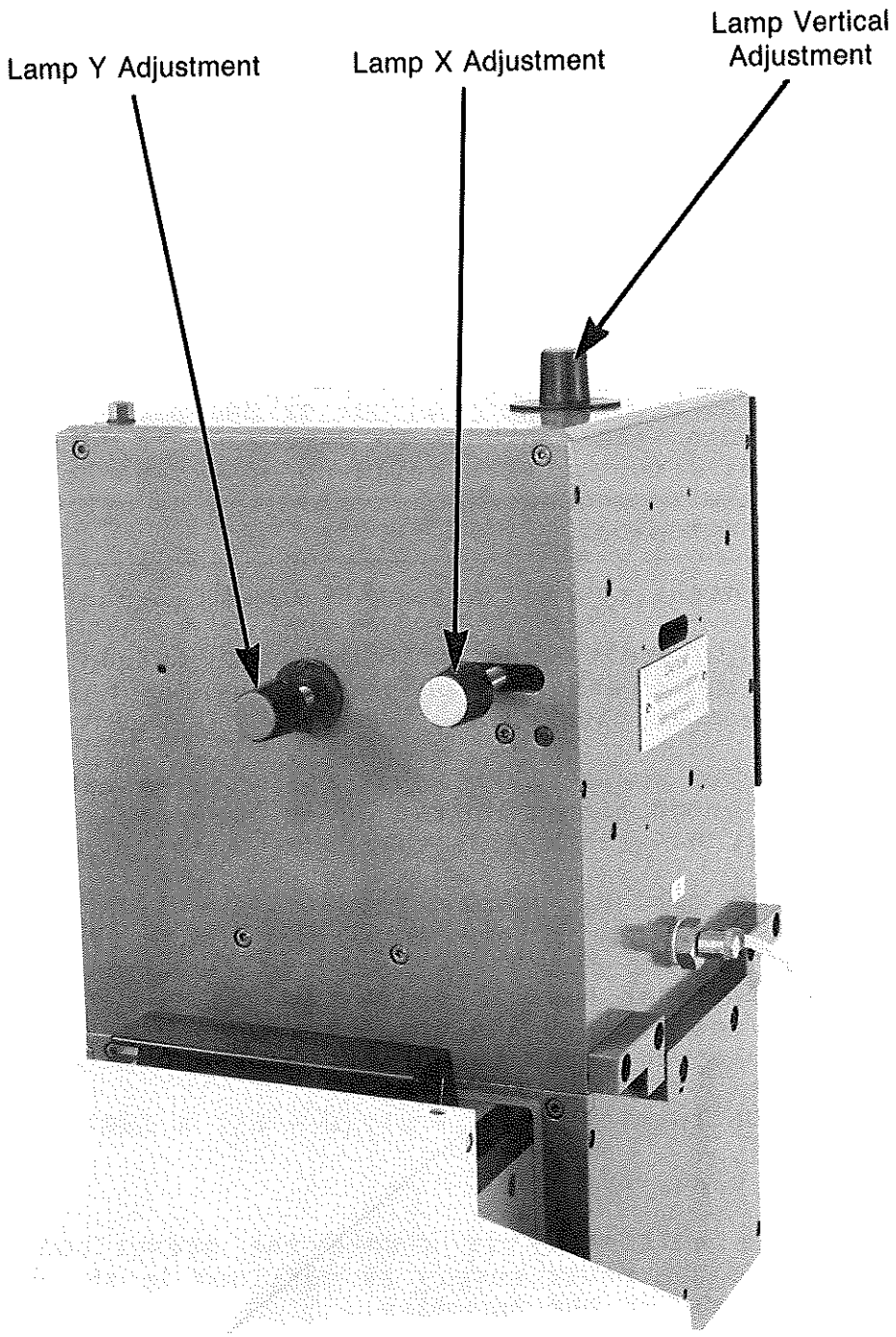


Figure 5-3 Lamphouse (Exterior)

12. Alternately placing the probe at the left and right hand edges of the illuminated area, use the blue knob to shift the lamp in the X direction until the meter gives the same reading at both locations.

13. Re-check the vertical adjustment (red knob).

> **CAUTION:** The red knob on the lamphouse must **only** be used to maximize the intensity of the exposure lamp. If you wish to adjust the intensity for process purposes, either adjust the power supply output or use proper filters. Using the red knob to decrease the intensity will result in a build-up of excess heat in the lamphouse which could lead to a lamp explosion.

5.2.3.2 Intensity and Uniformity Measurements

If the intensity and uniformity adjustments in Section 5.2.3.1 were performed properly, the light intensity will be uniform at this point.

In order to ensure that exposures will be satisfactory for uniform production results, it is important that the light intensity be within ±10% tolerance.

With the optical probe, measure the light intensity at different points of the wafer plane (see Figure 4-1), for example at the 12, 3, 6, and 9 o'clock positions, at the center, and at several points in between. Using the high and low readings (H and L), determine that the uniformity, as calculated by the formula:

$$\text{Uniformity} = [(H - L)/(H + L)] \times 100\%$$

is less than ±10%.

Once the uniformity is within the prescribed tolerance, calibrate the power supply as outlined in the power supply manual found in the Appendix.

5.2.4 Power Supply Calibration

5.2.4.1 Constant Intensity Controller

After the new exposure lamp has been installed and adjusted for intensity and uniformity, the exposure lamp power supply must be recalibrated.

First, it is necessary to calibrate the supply to the measurement obtained on the power meter with the optical probe in the center of the exposure field. Then the power

supply is adjusted to the desired intensity output. Once calibrated, the reading on the power meter should track the reading on the power supply. To perform these calibrations, please refer to the power supply manual which may be found in the Appendix.

5.2.4.2 Constant Power Controller

Input power of the lamp should not exceed the manufacturer's specification; normally this information is packed with each lamp. To adjust the power supply, please refer to the power supply manual in the Appendix.

5.3 EXPOSURE OPTICAL SYSTEM

The exposure optics consist of an exposure lamp, ellipsoidal mirror, cold light mirror, fly's eye lens, condenser lenses (optional), diffraction reducing lens plate (optional), surface mirror and front lens (see Figure 5-4).

A detailed description of the optical system follows in Section 5.3.1. Section 5.3.2 outlines the components which differ from one wavelength range to another. Sections 5.3.3 and 5.3.4 detail the procedures for changing from one wavelength range to another.

5.3.1 Optical System Components

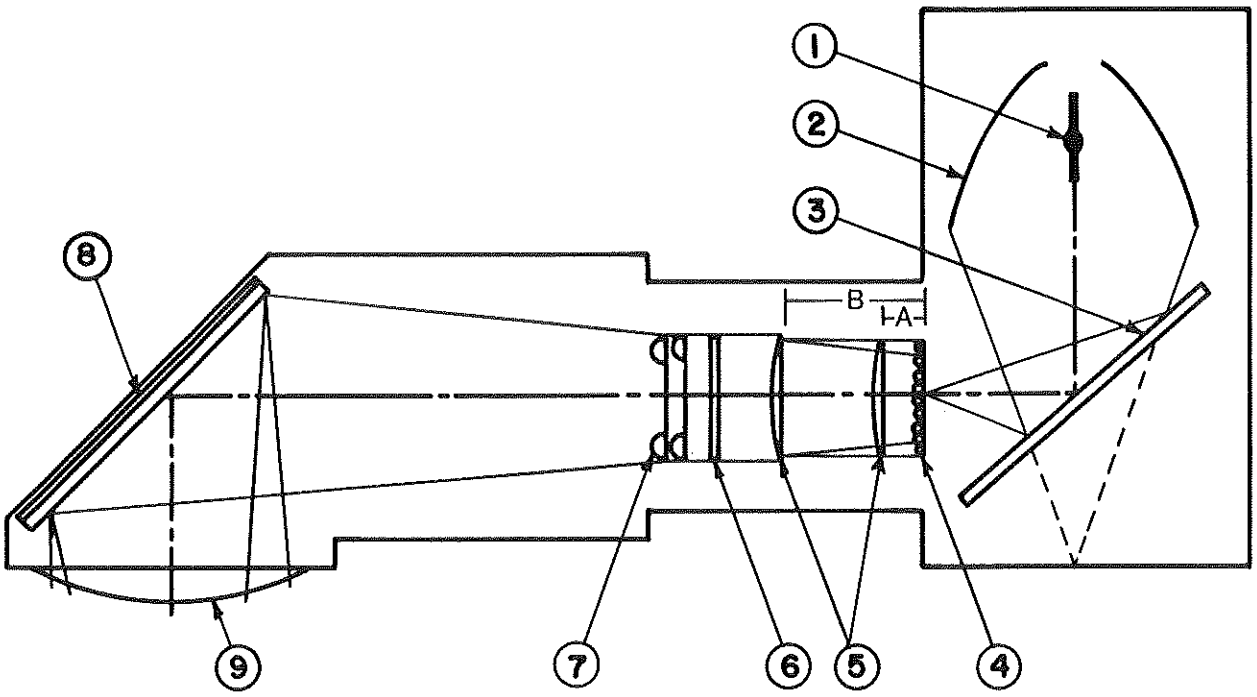
a. Exposure Lamp - The exposure lamp is a 350W super pressure mercury short-arc lamp. The spectral lines emitted by the lamp which are of interest here are those at 436 nm, 405 nm, 365 nm, 335 nm, and 313 nm.

b. Ellipsoidal Mirror - The exposure lamp is mounted in an ellipsoidal collecting mirror, at one focus of the ellipsoid. The ellipsoidal mirror collects the radiation emitted by the lamp and focuses it at the second focus of the mirror.

c. Cold Light Mirror - The cold light mirror transmits the unwanted longer wavelength radiation to the heat sink located at the second focus of the ellipsoidal mirror under the cold light mirror, and reflects the shorter wavelength radiation (cold light) to the fly's eye lens. The cold light mirror is specific to each wavelength range.

d. Fly's Eye Lens - The fly's eye lens disperses the light uniformly and directs it to the condenser lenses. The fly's eye lens is made of Herasil.

e. Condenser Lenses (optional) - The condenser lenses collimate the exposure light. The position of the condenser lenses in the mirrorhouse tube affects intensity



1. Lamp
2. Ellipsoidal Mirror
3. Coldlight Mirror
4. Fly's Eye Lens
5. Condenser Lenses - Optional
6. Frame for Filters - Optional
7. Diffraction Reducing Lens Plate - Optional
8. Surface Mirror
9. Front Lens

A = 10 mm (typical)

B = 55 mm (typical)

Figure 5-4 Exposure Optical System, MA 45

and uniformity. A scale is mounted on the right side of the mirrorhouse tube. (See Figure 5-4 for recommended position of the components in the optical path.) The position of the condenser lenses may be adjusted if necessary to obtain better uniformity. Like the fly's eye lens, the condenser lenses are made of Herasil.

f. Filter Holder (optional) - The filter holder is located between the condenser lenses (optional) and the diffraction reducing lens plate (optional). It may be used to mount filters of various types for work with negative resist or to reduce intensity (neutral density filters). In the UV300 system, a 365 nm interference filter is mounted in the holder.

g. Lens Plate (optional) - The purpose of the lens plate is to reduce diffraction effects in the printed image. The position of the lens plate, like that of the condenser lenses, affects intensity and uniformity. The recommended position of the lens plate is 85 mm from the lamphouse (position of the clamping screw). The lens plate is specific to each wavelength range.

h. Surface Mirror - The surface mirror changes the direction of the exposure beam from horizontal to vertical. It is important that the metallized side of the mirror face the beam.

i. Front Lens - The front lens provides final collimation and uniformity of the exposure beam.

5.3.2 Optical Components by Model

As described in Section 5.3.1, the fly's eye lens and condenser lenses are fabricated of Herasil.

5.3.2.1 Model UV400 Optical Components

- o Exposure Lamp: 350 watt Hg with adapter.
- o Cold Light Mirror: #1 or #7. The number of the cold light mirror is marked on one corner. Cold light mirror #1 is specific to UV400, while cold light mirror #7 may be used for UV400 and UV300.
- o Lens Plate (optional): 12 double lenses arranged in a triangle configuration, fabricated of Herasil.
- o Front Lens: Transparent.

5.3.2.2 Model UV300 Optical Components

- o Exposure Lamp: 350 watt Hg with adapter.

- o Cold Light Mirror: #2 or #7. The number of the cold light mirror is marked on one corner. Cold light mirror #2 is specific to UV300, while cold light mirror #7 may be used for UV300 and UV400.

- o Interference Filter: 60 mm diameter round filter (365nm)

- o Lens Plate (optional): 12 single lenses arranged in a triangle configuration, fabricated of Herasil.

- o Front Lens: Black.

5.4 SPARE PARTS (U.S. MARKET ONLY)

Parts included in the spare parts kits may vary due to machine changes or customer feedback. The parts included in your kit may therefore be slightly different than what are listed.

5.4.1 Basic Spare Parts Kit

A list of parts (light bulbs, grease, etc.) which comprise the basic spare parts kit supplied with the equipment may be found in Chapter 8.

5.4.2 Maintenance Kit

A maintenance kit is available from KARL SUSS. With this kit, you can perform the required periodic maintenance procedures outlined in this manual. A list of the parts in the maintenance kit may be found in Chapter 8.

CHECKLIST FOR MACHINE INSTALLATION
(U.S. Market)

NAME _____

COMPANY _____

MODEL _____

SERIAL # _____

EST. SHIP DATE _____

SPECIAL NOTES _____

_____

Your organization will soon be receiving this high performance SUSS Mask Aligner. In order to ensure a smooth installation, the following need to be available prior to the arrival of the service engineer who will be setting up your machine:

1. Power meter to calibrate lamp and power supply. _____

2. Provided through 1/4" OD semi-rigid hose to machine location:

   a. 75 - 105 psi of filtered, dry air _____

   b. 30 - 45 psi of 99.9% grade dry nitrogen _____

   c. 24" Hg vacuum _____

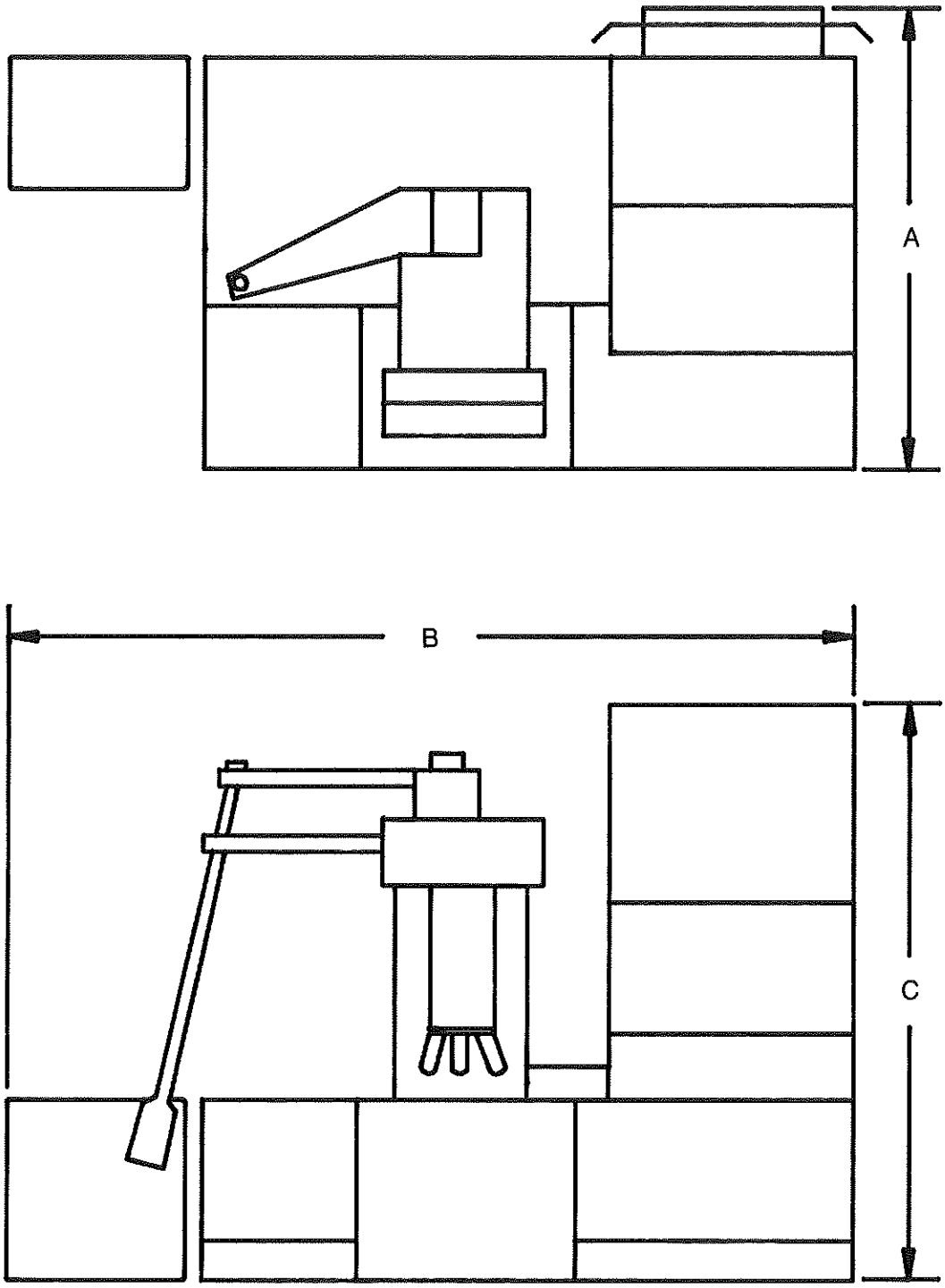
3. Two tees for 1/4" OD hose. _____

4. Two 110 VAC/60Hz/20A grounded outlets within 6 feet of machine location. _____

5. Test masks and coated, dehydrated wafers for use in verifying machine operation. _____

At time of installation, the lab should be set up to a point that test prints can be made and evaluated.

Figure 6-1 Checklist for Machine Installation



	Depth A	Width B	Height C
Dimensions:	760mm (30 in)	950mm (37.5 in)	700mm (27.6 in)

Figure 6-2 SUSS MA 45 Footprint

6 INSTALLATION

6.1 GENERAL

A few weeks prior to shipment of your equipment you will receive an installation package from KARL SUSS. Figure 6-1 is a checklist which should be used to ensure that installation of the equipment can be accomplished smoothly. Figure 6-2 is a machine "footprint" which may be used to determine space allocation.

6.2 RECEIVING THE SHIPMENT

KARL SUSS will give you an estimated date of arrival before shipping the mask aligner to your facility. If there are any special requirements at your site concerning shipment and receipt of large containers, please inform us immediately. Upon arrival of the shipment, the containers should be inspected for signs of damage. If any damage is apparent, immediately notify the shipping carrier and KARL SUSS.

6.3 INSTALLING THE EQUIPMENT

The mask aligner must be installed by a KARL SUSS service representative. The parts of the system, in their containers, may be transferred to the installation location if desired, but they should not be unpacked until the service representative arrives.

6.4 CLEARANCES REQUIRED FOR CRATE

The equipment is shipped in a crate 34 inches (87 cm) wide by 49 inches (125 cm) long by 37 inches (95 cm) high; it is accompanied by a large carton which contains accessories and miscellaneous hardware. The shipment weighs approximately 400 pounds (182 kg). The receiving doors should be wide enough to allow the crate to be moved inside the building for unpacking.

6.5 ENVIRONMENTAL REQUIREMENTS

The mask aligner should be located in a vibration-free area that is also as free as possible from dust and acid fumes. The area must be maintained at a room temperature between 66 F (19 C) and 75 F (24 C) and at a relative humidity of 45-50%.

The equipment may be affected by static electricity from the operator. Therefore, it should be installed in an area where the floor covering does not generate a static charge.

Please refer to Chapter 4 for other suggestions regarding environmental quality control.

The equipment must be installed at least three inches from the wall to allow for ventilation. In addition, all utilities are connected to the back of the unit. Although the machine can usually be serviced in place, in some cases it is necessary to move it 24 inches (60 cm) from the wall for access.

6.6 POWER REQUIREMENTS

6.6.1 U.S. Market Only

The unit requires two grounded (3 pronged) 110 V/60 Hz outlets:

- o one at 20 amps for the machine electronics.
- o one at 20 amps to power the isolation transformer which is connected to the lamp power supply.

6.6.2 International Market

The unit requires 220 V/50 Hz, 240 V/50 Hz, or 110 V/60 Hz AC.

- o power cord - grounded 3-wire cable; 1.5 m long.
- o power - 1.5 kW (MA45 and exposure lamp power supply).

6.7 OTHER UTILITY REQUIREMENTS

Requirements for nitrogen, vacuum, and compressed air are as follows:

- o Nitrogen: 30 - 45 psi or 2 - 3 bar; consumption = 17.5 scfh (0.5 m^3/h)
- o Vacuum: more than 24" of Hg or less than 200 mbar absolute (less than -0.8 bar gauge); flow rate = insignificant
- o Compressed air: 75 - 105 psi or 5 - 7 bar; consumption = 17.5 scfh (0.5 m^3/h)

It is important to use dry nitrogen and to eliminate any water in the compressed air lines.

For other than U.S. market - To connect vacuum, compressed air, and nitrogen to the machine, the shipment includes hoses (length about 3 m each) and connectors with 1/8" male pipe (gas) thread. Thus the customer should supply a sufficient number of connections with 1/8" female pipe (gas) threads. Optional SUSS pumps are supplied with appropriate connectors.

For U.S. market - Please refer to Figure 6-1 for requirements.

7 WARRANTY AND LIMITATIONS

In most cases, KARL SUSS mask aligners carry a six months warranty covering labor, material, and workmanship. This warranty may vary for different regions around the world. Please consult the specific warranty terms outlined in your quotation for the particulars pertaining to your machine.

7.1 LIMITATIONS

The warranty is limited to:

a. equipment unpacked and installed by KARL SUSS representatives.

b. equipment that is used and operated in accordance with the operator's manual.

c. equipment that is properly maintained on a regular basis as described in the operator's manual.

7.2 EXCLUSIONS

The warranty excludes:

a. damage while in shipment.

b. any items that are subject to wear during normal operation of the equipment, such as exposure lamps, maskholders, chucks, and the rubber lips for vacuum chucks.

7.3 EXPOSURE LAMP EXPLOSIONS

If an exposure lamp explosion should occur, please return the lamp socket and several of the glass fragments to KARL SUSS. We will contact the lamp manufacturer and try to determine the cause of the explosion. If the failure of the lamp is due to faulty workmanship or material, we will replace the lamp at no cost.

Consequential damage to the optics or lamphouse due to a lamp explosion is not covered by this warranty. It is important that you follow all lamp starting, adjustment, and cooling procedures, and that you do not exceed the recommended life of the lamp. We strongly suggest that you use exposure lamps provided by KARL SUSS only. Lamp explosions are nearly always caused by improper adjustment and/or operation of the exposure lamp.

8 APPENDIX

8.1 MICROSCOPE DESCRIPTIONS

8.1.1 SUSS Normalfield Microscope M400

The SUSS M400 microscope (Figure 8-1) consists of the microscope head (either binocular or trinocular), eyepieces, microscope body, illuminator, objective revolver, and objectives. The microscope is typically equipped with a 4-objective revolver to give a range of magnification. The SUSS M400 is offered in two versions: brightfield only and a brightfield/darkfield/interference contrast combination. Interference contrast and darkfield operation are only possible with certain objectives. (See Figure 8-2.)

8.1.1.1 Microscope Head and Eyepieces

A binocular or trinocular head is available. The eyepieces may be exchanged by simply removing one set from the eyepiece tubes and replacing them with another set. The choice of eyepieces is dependent on the magnification desired. (See Figure 8-2.) An image is obtained in the trino-tube by rotating the knurled knob located on the right side of the head.

8.1.1.2 Microscope Body

The microscope body contains a half mirror which reflects the microscope illumination onto the object and transmits the object image to the eyepiece image plane. In the brightfield/darkfield/interference contrast version, the microscope body also incorporates a slide containing the analyzer which is used for interference contrast illumination.

8.1.1.3 Objective Revolver

A 4-objective revolver is available with detents for each objective position. The revolver is rotated by grasping the revolver (not the objectives!) and turning it to the detent.

8.1.1.4 Illuminator

The illuminator utilizes a 15W lamp which is powered from an adjustable transformer. Please note that settings greater than "6" on the transformer should only be used for brief periods as this will drastically reduce the life of the lamp. An iris diaphragm is built into the body of the illuminator which can be used to obtain an optimum image.

In addition, on the brightfield/darkfield/interference contrast version, there are two slides built into the illuminator body. The first contains the polarizer plate which is used in conjunction with the analyzer to obtain interference contrast

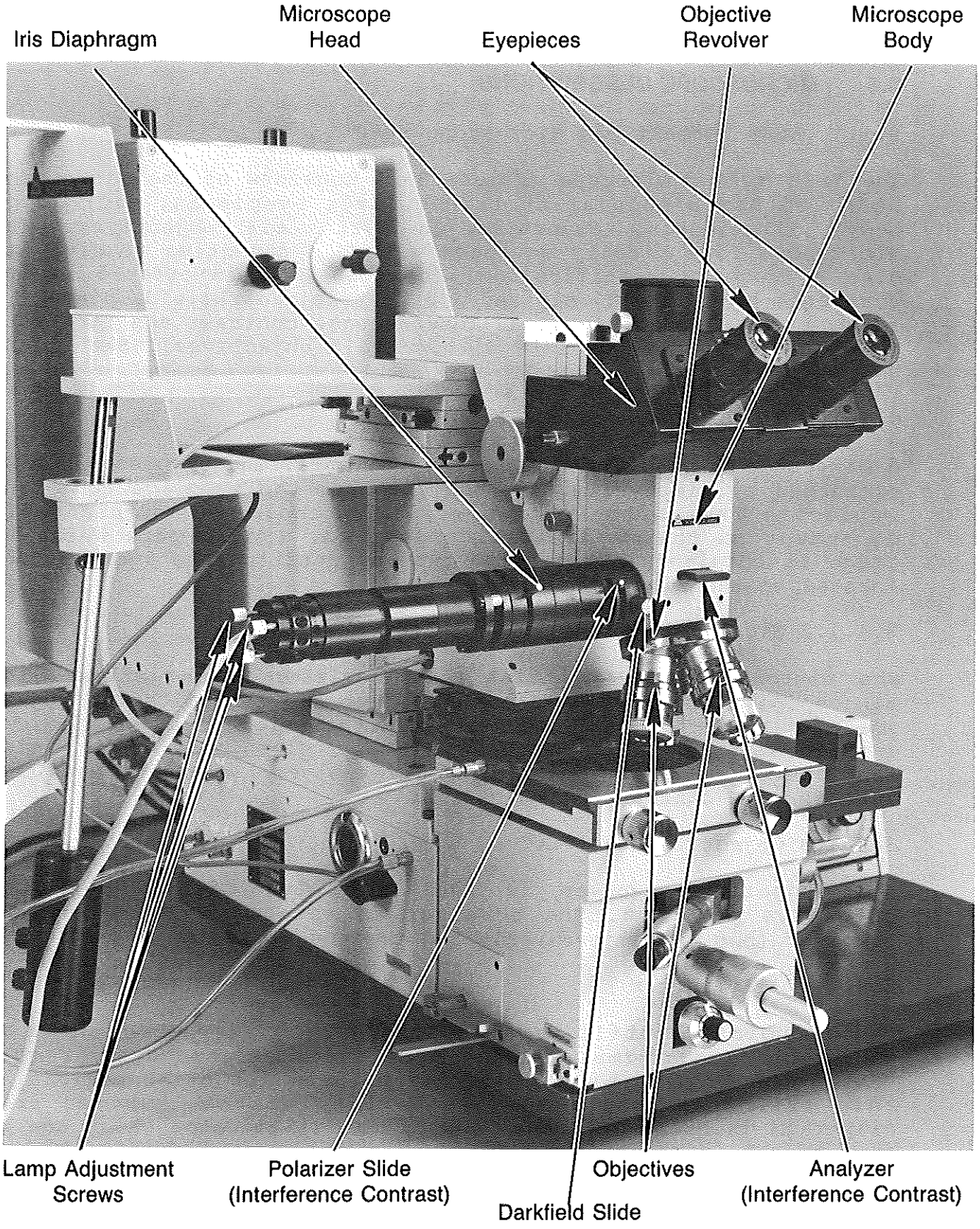


Figure 8-1 Normalfield Microscope, M400

(NOTE: MICROSCOPE NOT ATTACHED TO MA 45)

SUSS M400 Microscope																				
Objective	**3.2x**			**5x**			**5.5x**			**10x**			**LL 20x**			**H 20x**			**32x**		
Numerical Aperture	0.06			0.09			0.15			0.20			0.40			0.40			0.60		
Eyepiece (x)	6.3	10	16	6.3	10	16	6.3	10	16	6.3	10	16	6.3	10	16	6.3	10	16	6.3	10	16
Field of view 0 in mm	5.6	5.6	5.0	3.6	3.6	3.2	1.8	1.8	1.6	1.8	1.8	1.6	0.9	0.9	0.8	0.9	0.9	0.8	0.5	0.5	0.5
Total Magnification	20	30	50	30	50	80	55	90	140	63	100	160	126	200	320	126	200	320	200	320	510
Depth of focus (μm)	100	100	100	60	60	60	40	40	40	30	30	30	10	10	10	10	10	10	5	5	5
Working dist. in mm	12			12			13			14.2			10.1			8.2			5.8		
Brightfield	x			x			x			x			x			x			x		
Darkfield	-			-			x			-			-			-			-		
Interference Contrast	-			x			-			x			x			-			-		

Figure 8-2 Magnification and Optical Data, M400 Microscope

illumination. The polarizer may be rotated to obtain an optimum image using the lever. The second contains the darkfield stop which is inserted into the light path to obtain darkfield illumination.

8.1.1.5 Darkfield Illumination (if equipped)

To obtain darkfield illumination, proceed as follows:

1. Rotate the revolver to bring the darkfield objective (5.5X) to the observation position.

2. Insert the darkfield stop into the illuminator light path by pulling the slide toward the operator.

3. Ensure that the polarizer and analyzer are not in the light path. (See "Interference Contrast Illumination".)

8.1.1.6 Interference Contrast Illumination (if equipped)

1. Rotate the revolver to bring an interference contrast objective (5xIC, 10xIC, or 20xIC) to the observation position.

2. Insert the analyzer into the light path by pulling the analyzer slide out of the microscope body toward the operator.

3. Insert the polarizer into the illumination light path by pulling the polarizer slide toward the operator.

4. Ensure that the darkfield stop is not in the light path. (See "Darkfield Illumination".)

5. Rotate the polarizer using the lever to obtain an optimum image.

8.1.1.7 Objectives

Objectives may be of the brightfield, interference contrast or darkfield type. (See Figure 8-2.) The higher magnification objectives have a restricted depth of focus which allows observation of the mask and wafer only in contact position or at a small separation distance. Please note that the positions of the interference contrast objectives or the darkfield objectives should not be exchanged in the revolver.

8.1.2 SUSS Splitfield Microscope M200

The SUSS M200 microscope (Figure 8-3) consists of the microscope head (either binocular or trinocular), eyepieces, microscope body, illuminator, and objectives. The choice of eyepieces and objectives depends on the magnification desired. The SUSS M200 is offered in three versions: brightfield only,

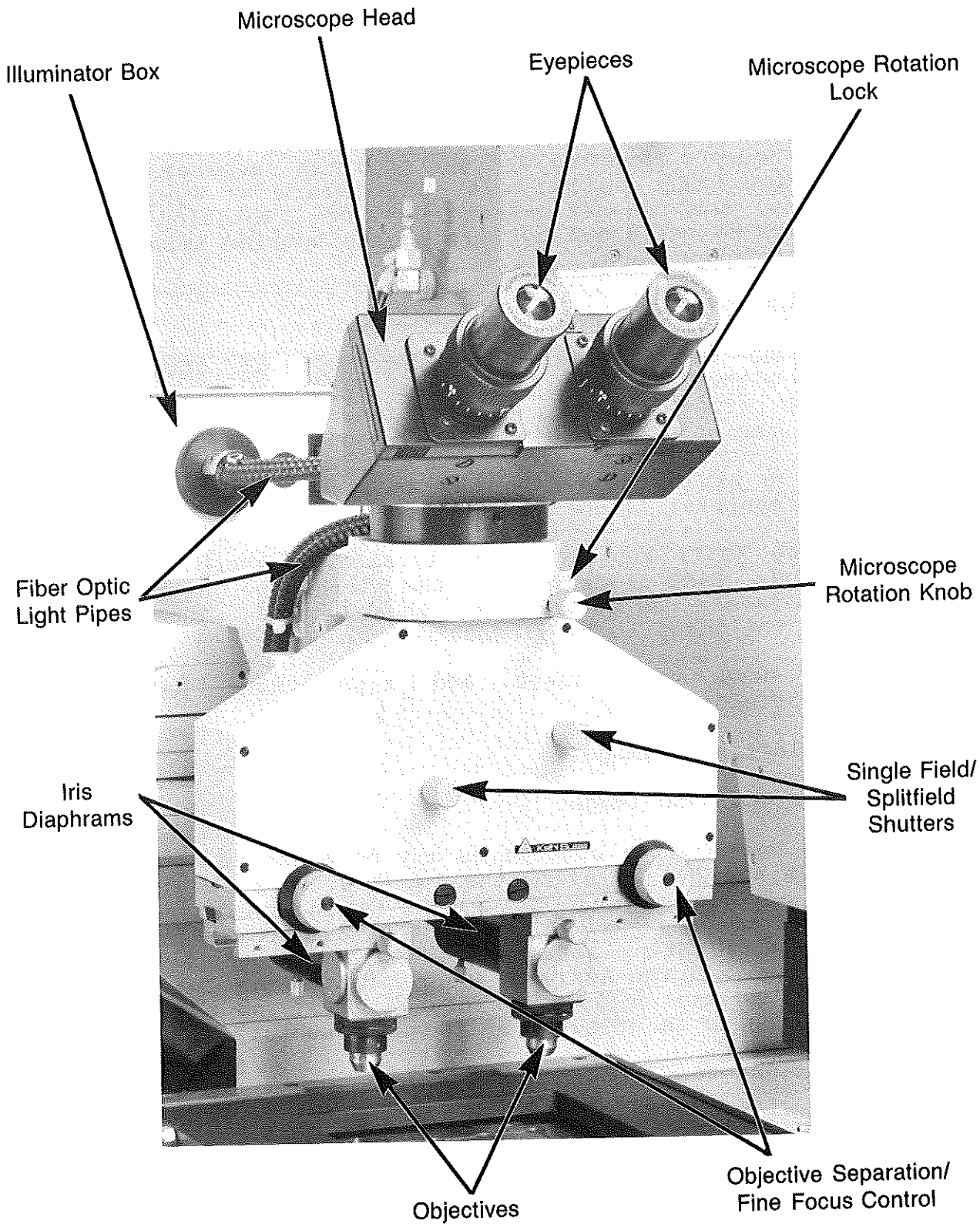


Figure 8-3 Splitfield Microscope, M200

brightfield/darkfield, and brightfield/interference contrast. Darkfield and interference contrast operation are only possible with certain objectives. (See Figure 8-5.)

8.1.2.1 Microscope Head and Eyepieces

A binocular or trinocular head is available. The eyepieces may be exchanged by simply removing one set from the eyepiece tubes and replacing them with another set. The choice of eyepieces is dependent on the magnification desired. Rotation of the microscope may be performed by turning the knurled screw located under the microscope head.

8.1.2.2 Microscope Body

The microscope body contains prisms, optical shutters for selection of either singlefield or splitfield operation, and half mirrors which reflect the microscope illumination onto the object and transmit the object image to the eyepiece image plane. In the interference contrast verion, the microscope body also incorporates a slide containing the analyzer which is used for interference contrast illumination.

There are two small knurled knobs located on the front of the microscope body. Each light path of the microscope incorporates a shutter separately adjustable by these knobs. These permit selection of the image to be viewed:

1. Left hand half image and right hand half image (Splitfield).

2. Full left hand image.

3. Full right hand image.

The distance between the objectives may be adjusted continuously between 26 mm and 100 mm using the two knurled knobs located on the bottom of the microscope body. In addition, a minimum distance of 14 mm or a maximum distance of 120 mm can be attained by two optional pivoting attachments. Both the sharpness of the microscope image and the scale of magnification are retained when changing the distance between the objectives. Fine adjustment of the image sharpness is effected by the same knobs.

8.1.2.3 Illuminators

Two type of illuminators are available. For brightfield operation only, two fiber-optic light guides connected to a lamphouse are normally used. In both cases, the brightness is controlled by an adjustable transformer. Two iris diaphragms are built into the body of the illuminators which can be used to obtain an optimum image.

To exchange the illumination lamps of the direct illuminators,

slide the lamp socket out from the illuminator body. Exchange the lamp and re-insert the lamp socket into the illuminator body. The three screws on the lamp socket may be used to center the lamp filament. All three screws should be positioned so that approximately 5 mm of thread is exposed.

The illumination lamp of the fiber optic illuminator is easily replaced by removing the lamphouse cover.

8.1.2.4 Darkfield Illumination (if equipped)

To obtain darkfield illumination, adapters with pivotable central stops are inserted into the illuminator light path. The normal objectives are replaced by brightfield/darkfield objectives (5.5X) with concentric condensers. Conversion from the brightfield to the darkfield mode and vice versa is effected by swinging the central stops in or out of the light path respectively.

8.1.2.5 Interference Contrast Illumination (if equipped)

For interference contrast illumination, the unit is equipped with revolvable polarizers, objectives with Wollaston prisms, and an analyzer built into the microscope body. To obtain interference contrast illumination, proceed as follows:

1. Insert the analyzer into the light path by pulling the analyzer slide out of the microscope body towards the operator.

2. Insert the polarizers into the illuminator light path by pulling the polarizer slides toward the operator.

3. Rotate the polarizers using the levers to obtain an optimum image.

8.1.2.6 Objectives

Objectives may be of the brightfield, interference contrast, or darkfield type. (See Figure 8-5.) Please note that each set of objectives is individually adjusted to the microscope. Therefore, their positions should not be exchanged. Replacement of a set of brightfield objectives with another set of higher magnification is possible, however, replacement with another set of lower magnification may result in some deterioration in image quality. In this case, the microscope should be returned to KARL SUSS for readjustment.

8.1.3 SUSS Splitfield Revolver Microscope M23Ø

The SUSS M23Ø Microscope (Figure 8-4) consists of the microscope head (either binocular or trinocular), eyepieces, microscope body, illuminator, two objective revolvers, and six objectives. The eyepiece and objective combinations result in a range of

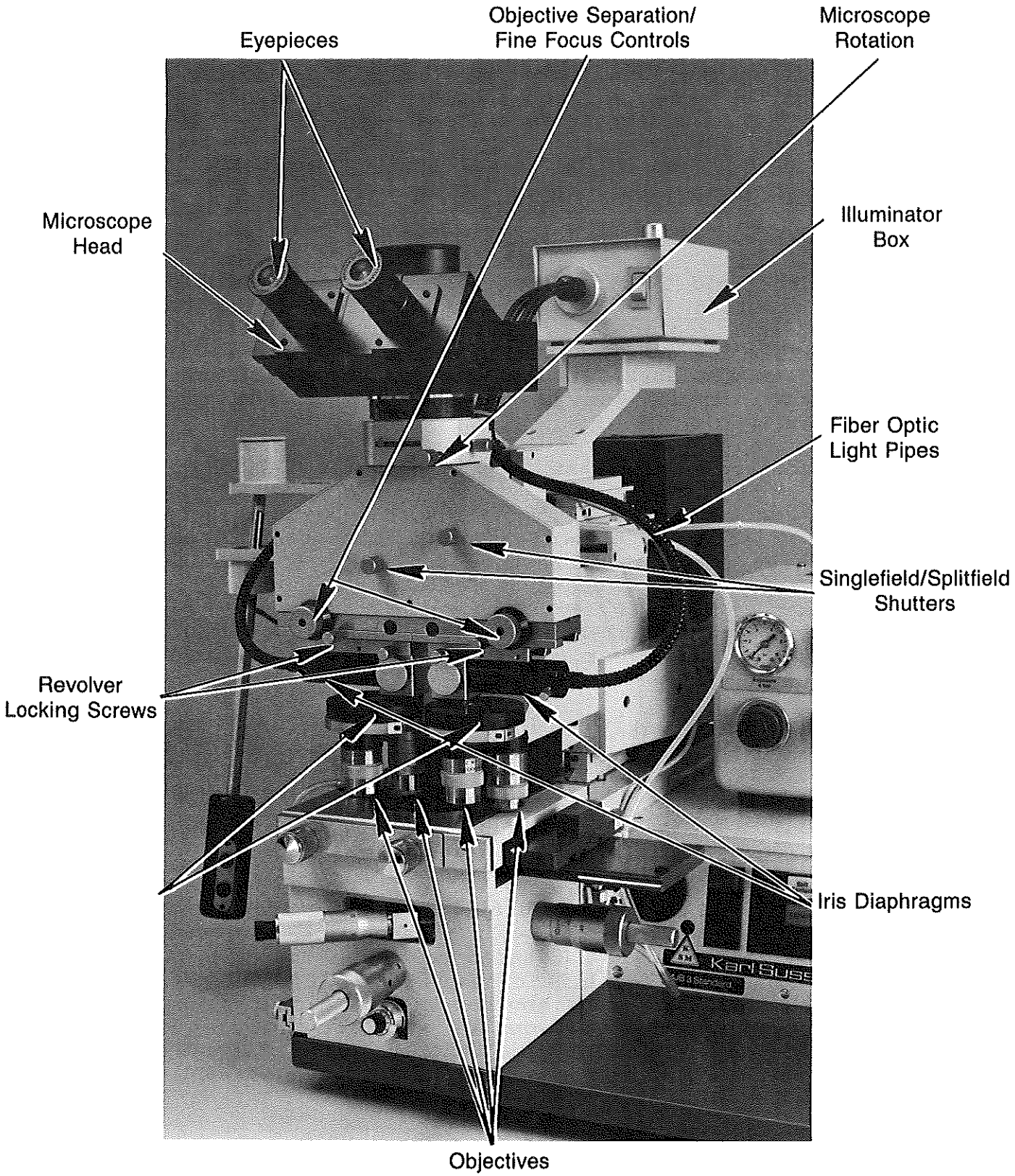


Figure 8-4 Splitfield Revolver Microscope, M230

(NOTE: MICROSCOPE NOT ATTACHED TO MA 45)

magnification of 80-260X (See table.) The SUSS M230 is available only in a brightfield version.

8.1.3.1 Microscope Head and Eyepieces

A binocular or trinocular head is available. The eyepieces may be exchanged by simply removing one set from the eyepiece tubes and replacing them with another set. The choice of eyepieces is dependent on the magnification desired. Rotation of the microscope may be performed by turning the knurled screw located under the microscope head.

8.1.3.2 Microscope Body

The microscope body contains prisms, optical shutters for selection of either singlefield or splitfield operation, and half mirrors which reflect the microscope illumination onto the object and transmit the object image to the eyepiece image plane.

There are two small knurled knobs located on the front of the microscope body. Each light path of the microscope incorporates a shutter separately adjustable by these knobs. These permit selection of the image to be viewed:

1. Left hand half image and right hand half image (Splitfield).

2. Full left hand image.

3. Full right hand image.

The distance between the objectives may be adjusted continuously between 26 mm and 100 mm using the two knurled knobs located on the bottom of the microscope body. There are also two locking screws which may be used to lock the position of each revolver, preventing the separation distance from changing when rotating the revolver.

Both the sharpness of the microscope image and the scale of magnification are retained when changing the distance between the objectives. Fine adjustment of the image sharpness is effected by the same knobs used to vary the separation distance.

8.1.3.3 Objective Revolvers

Each revolver incorporates detents for each objective position. The revolver is rotated by grasping the revolver (not the objectives!) and turning it to the detent.

8.1.3.4 Illuminators

Two fiber optic light guides connected to a lamphouse are used. The brightness is controlled by an adjustable transformer. Two iris diaphragms are built into the body of the illuminators which

can be used to obtain an optimum image.

The illumination lamp is easily replaced by removing the lamphouse cover.

8.1.3.5 Objectives

Three pairs of objectives are normally supplied: 6.5X, 9X, and 14X. The 14X objectives have a restricted depth of focus which allows observation of the mask and wafer only in contact position. Therefore, the 6.5X and 9X objectives should be used for alignment and the 14X objective for checking alignment. Please note that each objective is individually adjusted to the microscope. To retain parfocality of the objectives, they should not be removed from the revolvers. (See Figure 8-5.)

8.2 REMARKS REGARDING ALIGNMENT

Manual alignment is typically performed at an alignment gap which fully exploits the depth of focus of the microscope used. This ensures the least chance of damage to the mask or the substrate during alignment.

The depth of focus of a microscope is directly related to its magnification. For a typical alignment gap of about 20 microns, which is a reasonably safe distance between mask and wafer for most applications, the magnification is limited to about 180X, which may not be sufficient to obtain the level of alignment accuracy required. However, increasing the magnification to, say, 400X drastically reduces the depth of focus to about 3 microns. For all practical purposes, it is impossible to perform alignment at such a small gap.

The line and space resolution of an alignment microscope of the maximum practical magnification (180X) is about 1.5 microns. Fortunately, it is not necessary to recognize submicron features in order to achieve submicron alignment accuracy. Instead, we use a different approach.

The human eye has a remarkable ability to recognize symmetry. The challenge in designing appropriate alignment marks therfore consists of finding schemes where some kind of symmetry is apparent using high contrast patterns. The simplest example is placing a small cross inside a large cross. The line width of the small cross is not significant if both sides of the cross can be seen without excessive eye movement. The distance between the edge of the smaller line and the larger line when both crosses are aligned is critical, however. This distance must be larger than the minimum feature size for the given line and space resolution of the microscope, and at the same time, it has to be as small as possible.

SUSS M200 Splitfield Microscope													SUSS M230 Splitfield Microscope with Multiple Nosepiece					
Objective	**2x**		**3.5x**		**5x**		**5.5x**		**6.5x**		**10x**		**6.5x**		**9x**		**14x**	
Numerical Aperture	0.08		0.08		0.09		0.15		0.18		0.20		0.10		0.15		0.30	
Eyepiece (x)	6.3	10	6.3	10	6.3	10	6.3	10	6.3	10	6.3	10	6.3	10	6.3	10	6.3	10
Field of view 0 in mm	3.25	3.25	1.5	1.5	2.0	2.0	1.2	1.2	1.1	1.1	1.0	1.0	1.4	1.4	1.1	1.1	0.7	0.7
Total Magnification	35	55	75	120	50	90	90	150	100	160	120	190	80	120	100	160	160	260
Depth of focus (μm)	60	60	60	60	70	70	50	50	30	30	25	25	60	60	30	30	15	15
Working distance in mm	29		13.5		20		14.5		14.5		17.5		21.5		13		10.5	
Brightfield	x		x		x		x		x		x		x		x		x	
Darkfield	x		-		-		x		-		-		-		-		-	
Interference Contrast	-		-		x		-		-		x		-		-		-	

Figure 8-5 Magnification and Optical Data, M200/M230 Microscopes

The absolute minimum distance is about 2 microns, typical values being between 3 and 5 microns, depending on contrast and edge quality. If the distance between the small line and the large line is 3 microns, a Ø.5 micron misalignment will result in a 3.5/2.5 intensity ratio as read by the eye. This is a significant amount, the larger gap being 40% brighter than the smaller gap.

In proximity printing, the alignment gap and exposure gap are of the same order of magnitude, and so are usually handled with the same objective/eyepiece combination. In contact printing, however, since the exposure gap is considerable smaller than the alignment gap, an objective/eyepiece combination with a small depth of focus can be used to verify the alignment at exposure position before the exposure takes place. A revolver microscope using at least two different objectives is the ideal tool for this purpose.

In this case, a second adjustment key with smaller dimensions (for example, a 1 micron distance between the smaller and the larger lines) can be employed if desired, to make checking the alignment in exposure position easier. For the highest alignment accuracy, it is likely that the operator will have to alternate repeatedly between the separation and contact positions, even if the aligner itself has no shift.

Regrettably, there is no simple way around the problem of performing alignment with insufficient magnification.

8.3 SPARE PARTS (U.S. MARKET ONLY)

Parts which you receive as part of the basic spare parts kit or the maintenance kit may vary from time to time in designation or appearance from the part originally supplied in the equipment or included in the lists of kit contents which follow.

8.3.1 Basic Spare Parts Kit

Part No. 250SPØØ5

- -1.6A Fuse (3 each)
- -6.3A Fuse (3 each)
- -S35ZN Microswitch
- -2341 24-3ØV 1W Panel Lamp (2 each)
- -41Ø Grease

8.3.2 Maintenance Kit

Part No. 250SPØØ7

- -1.6A Fuse (3 each)
- -6.3A Fuse (3 each)
- -S35ZN Microswitch
- -83/141/55/B3Y MA55 Microswitch

-410 200 ON/OFF Switch
-410 300 ON/OFF Switch
-2341 24-30V 1W Panel Lamp (3 each)
-Hardware Kit MA56
-Nickel Anode Wire Assembly for Mercury Lamp
-410 Grease
-310 Grease
-340 Grease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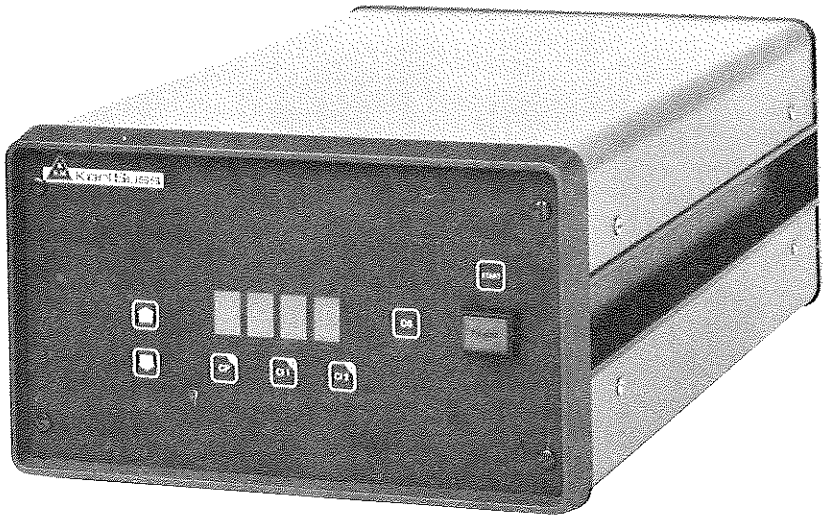
CONSTANT INTENSITY CONTROLLER

Operator's Reference Manual



This Operator's Reference Manual is subject to review and/or revision.

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Karl Suss

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1 GENERAL DESCRIPTION AND PRINCIPLES OF OPERATION

1.1 The Short Arc Lamp System

1.1.1 Arc Lamps

Mercury, mercury-xenon, and cadmium-xenon arc lamps operate at very high pressure, producing extremely bright concentrated sources of light. The spectral distribution consists of resonant lines superimposed on a thermal radiation continuum from the heated incandescent plasma. Important characteristics common to most of these lamps are:

- A clear quartz bulb, either spherical or elliptical in shape, with extensions at opposite ends constituting the electrode terminals.
- A pair of electrodes with relatively close spacing, approximately 1 mm to 1 cm, depending upon the wattage rating (hence the term "short arc lamp").
- A filling gas or vapor through which the arc discharge takes place.
- Extreme electrical loading of the arc gap, which results in a very high luminance. This results in internal pressure of 50-70 atmospheres at bulb temperatures as high as 900 degrees C. These factors alone should indicate that precautions are necessary to protect people and adjacent equipment should the lamp experience catastrophic failure.
- The requirement for a momentary high-voltage ignition pulse and ballast or active circuit to limit current during operation.

Short arc lamps are efficient ultraviolet producers. Mercury produces an intense line spectrum from 230 to 400 nm. Xenon produces a UV continuum from 190 to 400 nm.

A mercury arc lamp will have a small pool of liquid mercury, when cold, in a bulb filled with a rare gas such as argon or krypton. The gas is necessary to start the lamp and establish the arc. The heat generated will then vaporize the mercury until, at operating temperature, all of the mercury is vaporized. Starting from near atmospheric pressure at room temperature, these lamps will approach 50-70 atmospheres when operating. Typically, five to fifteen minutes are required for them to warm up and reach their operating pressure.

The mercury-xenon and cadmium-xenon lamps have xenon as the starting gas. The xenon speeds warm up, increases stability, and lengthens the life of the lamp.

The average life of a short arc lamp is dependent on many factors. Average life is based on deriving a useful radiant output from the lamp. During operation, atoms of tungsten are boiled off the electrodes due to the electron bombardment and are deposited on the inside walls of the quartz envelope, thereby reducing the radiant output and increasing the effective arc gap. The lamp, therefore, requires a greater voltage between the electrodes to maintain the required electrical field.

1.1.2 Lamp Housing

The housing system should provide all of the electrical and mechanical requirements or the operation of high pressure arc lamps. These include mounting of the lamp for stress free expansion, explosion protection, high voltage electrical inputs and provisions for external adjustments of the lamp position and/or lens and mirrors. The housing should also include some means of cooling which will maintain the lamp at its optimum operating temperature, neither over or under cooled.

For the purpose of usefulness in photolithography, the housing should contain some means of collecting and projecting forward the desired spectral radiation from the lamp.

1.1.3 Power Supply

The power supply for an arc lamp must take into consideration the lamp's operating characteristics. Although the supply can drive the lamp over a large latitude of electrical input powers, it is the lamp characteristics alone which will dictate the actual value of voltage and current. A basic supply should have the following specifications:

- A low ripple regulated DC output.
- A high voltage starting circuit (15KV or higher).
- A ballast or active circuit to limit current to the lamp during the warmup period.
- A means to adjust the lamp power output.

1.1.4 Constant Intensity

The chemistry of a photoresist requires that a given amount of energy (Joules) be absorbed by the molecular structure over a finite period of time for a successful print.

It is also desirable that the process be repeatable. Since the output of a short arc lamp begins to deteriorate from the moment it is started, and the decline is accelerated as the lamp ages, one is faced with varying illuminating conditions. As the shutter opens and light is detected in the light path, the controller will electrically drive the lamp to a power which will produce a preset level of intensity (mW/cm^2) at the wafer plane.

During the interval while the shutter is closed, the lamp power will be returned to a value at or near its rating (Idle) for optimum life. It should be noted that lamp power in the control mode may be dependent on the selected set value of intensity, the efficiency of the lamp and associated optical systems, and the age of the lamp.

There are limitations, however, as to the range that a lamp can be driven; too low and the arc will extinguish, while too high a value may result in an explosion of the bulb. These extremes are avoided by circuitry within the controller which set upper and lower values of power that the unit will deliver.

1.2 Principles of Operation

The basic circuit of the Constant Intensity Controller (CIC) is a switching power regulator which is controlled by a lamp voltage-ampere servo loop. The reference for this loop may either be a fixed value (idle or constant power) or a value derived from the optical control loop (constant intensity). Switching semiconductors are MOS transistors which are operated at a rate of 40 kHz. The output transistors are isolated from the low level drive and control circuitry by means of a high speed optoisolator device.

1.2.1 The Basic Regulator

A brief discussion which outlines the performance of a typical switching regulator is provided for controller users who would like to review the sequence of events.

Q is the MOS transistor whose only function is that of a switch; the device is either shorted and the voltage from the unregulated supply is applied through the inductor L to the lamp, or the device is off, and Q is effectively removed from the circuit. L serves as an energy storage reservoir, storing energy when Q is on and releasing energy to the lamp when Q is off. The diode D provides a current path for L in the discharge mode. Capacitor C, in conjunction with L, forms a low pass filter to smooth the output voltage. If the voltage at point B is monitored and used to control the output pulse width of the pulse modulator circuit, the following operating state exists:

$$\frac{V_{out} = V_{in}\,(T_{on})}{T}$$

Where:

V_{out} is the voltage applied to lamp.

V_{in} is the voltage supplied from the line.

T_{on} is the width, in seconds, of the switched voltage (Q is saturated).

T is the total period, in seconds, of the reference clock = 25 microseconds.

As an example: If the voltage of the supply was 100V and the desired output is 50V, the pulse-width modulator (PWM) would need to supply an "on" period of 12.5 microseconds or 50% duty cycle. By the same principle, an increase in the "on" time to 18.75 microseconds would give an output voltage of 75V and a decrease to 6.25 microseconds would result in 25V being delivered to the load. Note also that if point B was compared to an accurate internal reference voltage, the value of the unregulated supply could also vary and the output voltage would remain fixed due to the compensating action of the PWM circuit.

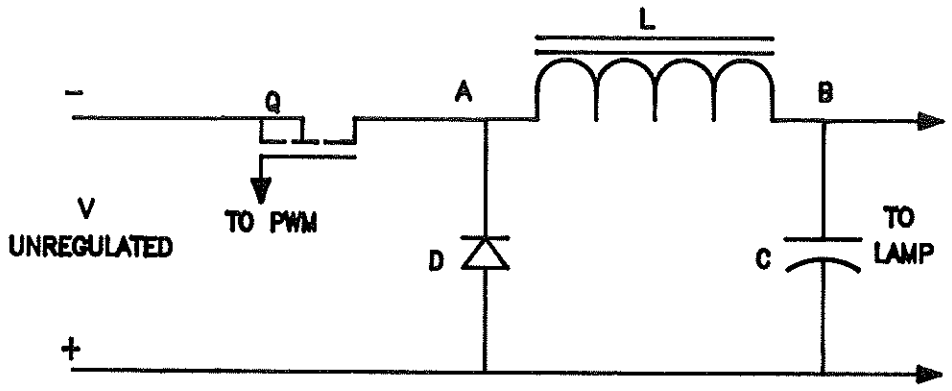


Figure PS-1 Block Diagram, Basic Regulator

1.2.2 Constant Power Control Loop

In addition to providing adequate output voltage stabilization against line voltage and load changes, the controller must provide immediate protection against overloads and equipment malfunction. Furthermore, a soft start is incorporated to prevent an excessive inrush of current due to the initial capacity load. Figure PS-2 illustrates the principle control loop of the CIC.

Both the output voltage and current to the lamp load are sensed. These signals are combined by means of a X-Y multiplier to produce a product of the function (watts).This signal is fed to the input of an error amplifier where it is compared with a reference voltage (V_{ref}) which is the desired power setting.

The output of this amplifier is connected to an input of the PWM IC. Another input of this modulator IC is used for a sawtooth oscillator signal. As a result of these two inputs, a rectangular waveform with the frequency of the oscillator emerges at the output of the PWM IC. The pulse-width of this waveform is determined by the output voltage of the error amplifier. Therefore, as the width of the pulse varies, the "on" time for the MOS transistor in the switching regulator will also vary and consequently the amount of energy taken from the input. Overvoltage and overcurrent protection is realized by circuit blocks which monitor these functions and activate appropriate inputs of the PWM IC and its associated output stage.

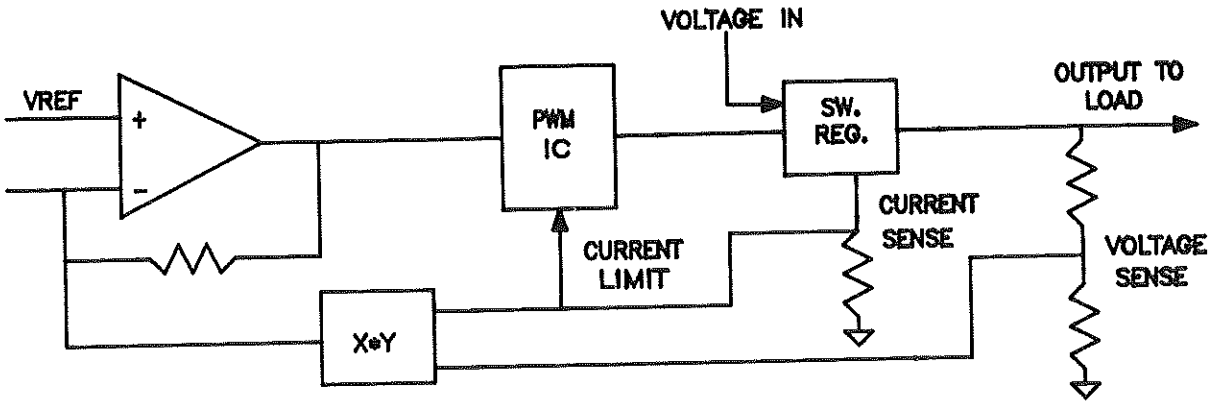


Figure PS-2 Constant Power Control Loop

1.2.3 Optical Control Loop

Incident light energy is converted into a proportional electrical current by means of a silicon photodetector. This current in turn is changed into a more usable voltage function by a current to voltage circuit. Calibration gain is performed by the microprocessor so that the resulting voltage output is proportional to input current and modified only by the loop gain required to bring the circuit into calibration.

The intensity voltage from the current to voltage converter is supplied to the microprocessor input. The output of the microprocessor is fed to the control loop (Section 1.2.2) where it replaces the reference (Idle) voltage. When so connected, the action of the overall system servo loop causes the lamp to be driven to a level which will prove an intensity equal to the value set by the reference voltage.

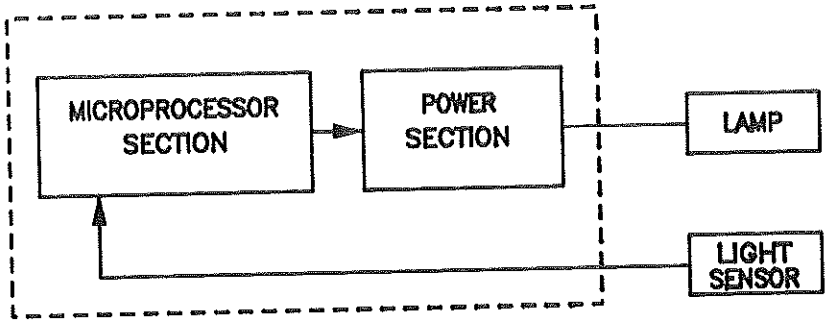


Figure PS-3 Block Diagram, Optical Control Loop

1.2.4 Optical Sensor

The photosensors used in the dual sensor assemblies are selected silicon photodiodes with enhanced efficiencies in the UV spectrum; thin film dielectric or selected glass absorption filters are used. Each of the sensors has an adjustment to make it easier to optimize the sensor to the particular installation.

1.3 Technical Specifications

CIC 500 Constant Intensity Controller

Operating Mode:	Single channel constant power. Independent dual channel constant intensity.
Output:	500 watts maximum continuous. 150 volts DC open circuit. 10 amperes active current limit.
Output Regulation:	±1% over selected mains input range.
Lamp Ignition:	30 KV start with automatic shutdown following ignition. Active current limit during warmup. Remote start unit.
Lamp Options:	350 watt Hg Lamp Idle power: 275 watts Maximum power: 400 watts Minimum power: 200 watts Maximum voltage: 80 volts 200 watt Hg Lamp Idle power: 195 watts Maximum power: 260 watts Minimum power: 135 watts Maximum voltage: 80 volts
Mains Input Options:	110 ±10% VAC 50/60 Hz 220 ±10% VAC 50/60/Hz
Optical Sensor:	Dual channel using silicon photodiodes with thin film dielectric or selected glass absorption filters.
Optical Control:	Autorange digital meter: 0 - 100mW/cm^2. Front panel channel selection. Front panel level set and calibration.
Size: (without remote start unit)	Depth: 419 mm (16.5 in) Width: 260 mm (10.25 in) Height: 152 mm (6.0 in)
Weight: (without remote start unit)	38.5 kg (17.5 lbs)

2 OPERATING PROCEDURES

The SUSS Constant Intensity Controllers (CIC 500 and CIC 1000) are designed to operate mercury, cadmium-xenon, and mercury-xenon short arc lamps.

CIC 500	CIC 1000
200 watt mercury	200 watt mercury
350 watt mercury	350 watt mercury
	350 watt cadmium-xenon
	500 watt mercury
	500 watt mercury-xenon
	1000 watt mercury

The CIC has three different operator selectable exposure modes; CP, and CI with two independent constant intensity channels.

a. Constant Power (CP) - In this mode, the controller supplies the lamp with a set power level selected by the operator. No attempt is made to monitor lamp intensity and compensate for variations in lamp output.

b. Constant Intensity 1 (CI-1) - In this mode, the controller monitors the lamp intensity and varies the power supplied to the lamp to maintain the intensity selected by the operator.

c. Constant Intensity 2 (CI-2) - Same as CI-1 but a separate channel.

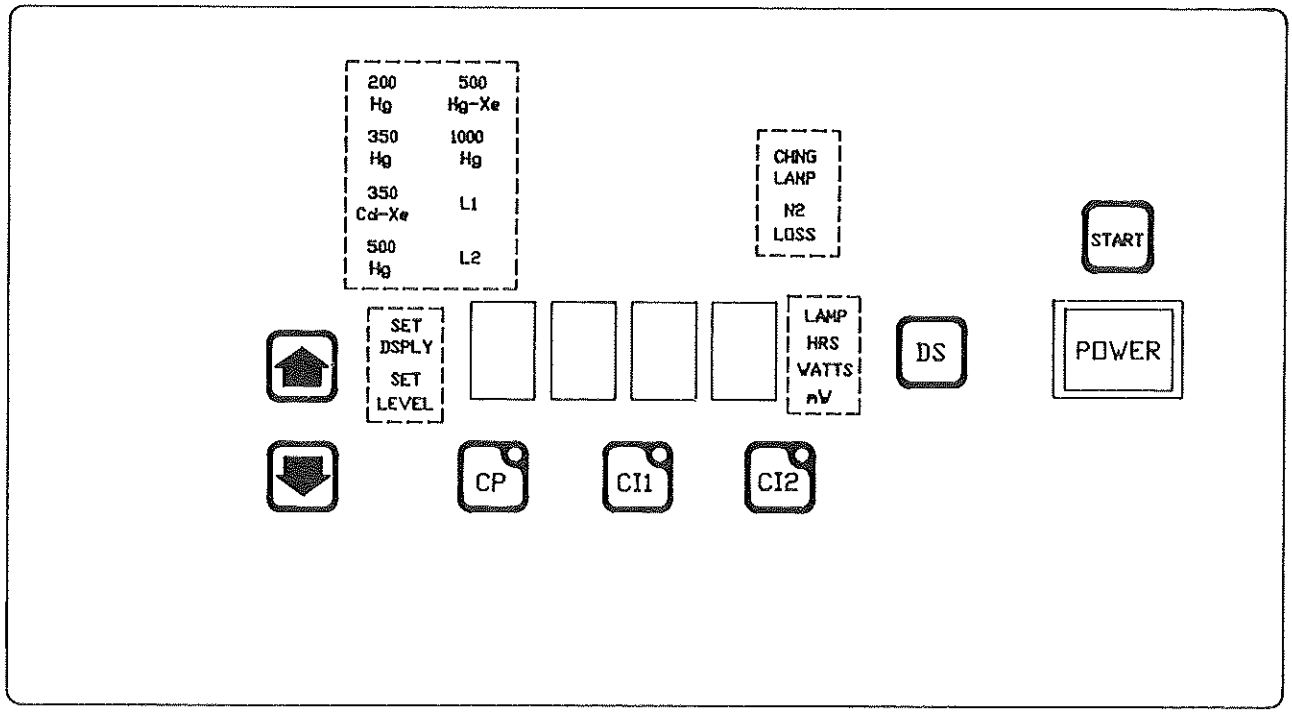
2.1 Front Panel Controls and Functions

(Please refer to Figure PS-4)

a. POWER switch - The pushbutton POWER switch applies main power to the CIC. Depress the button to apply power; if main power is present, pressing the button again to release it removes power.

b. START membrane key pad - Momentarily pressing the START key when the display indicates "rdy" will commence the lamp ignition sequence. Pressing the START key at any other time has no effect.

c. DS (Display Select) membrane key pad - The DS key performs different functions depending upon whether the controller is operating in the CP or CI mode.



NOTE - PANEL LEGENDS WITHIN DOTTED LINES NOT VISIBLE UNLESS FUNCTIONALLY ACTIVE AND ILLUMINATED.

NOTE - PANEL LEGENDS WITHIN DOTTED LINES NOT VISIBLE UNLESS FUNCTIONALLY ACTIVE AND ILLUMINATED.

Figure PS-4 Front Panel Controls

1. In CP mode, pressing DS key for less than 3 seconds:

- The CI1 key LED will flash.
- The display will indicate mW/cm^2.

If the DS key is pressed again, the same sequence will take place in CI-2. If the DS key is pressed for a third time, the display will revert to the original CP indication of watts.

In CI-1 or CI-2 mode, pressing DS key for less than 3 seconds:

Display will alternate between an indication of watts or mW/cm^2 for the channel (CI-1 or CI-2) in which the controller is operating.

2. In all modes, including pre-ignition "rdy" state, pressing DS key for more than 3 but less than 5seconds:

Pressing and holding the DS key for more than 3 but less than 5 seconds will cause the display to indicate total lamp hours. When lamp hours are being displayed, pressing the Down arrow will zero the lamp time counter. To exit from the lamp hour mode, press the DS key again to revert to the previous operating mode; if lamp is on, pressing CP, CI1, or CI2 keys will select that mode.

3. In all modes ,including pre-ignition "rdy" state, pressing DS key for more than 5 seconds:

Pressing and holding the DS key for more than 5 seconds will cause the display to indicate controller operating hours. The number which is shown on the display must be multiplied by ten (X10) to determine the total number of operating hours; this number cannot be reset. To exit from the total unit hours mode, press the DS key again to revert to the previous operating mode; if lamp is on, pressing CP, CI1, or CI2 keys will select that mode.

d. CP (Constant Power) membrane key pad - The CP key performs several different functions as follows:

1. Pressing CP key for less than 3 seconds:

Pressing and holding CP key for less than 3 seconds will cause the unit to go to the CP operating mode, and indicate watts on the display.

2. Pressing CP key for more than 3 seconds:

Pressing and holding the CP key for more than 3 seconds will cause the SET LEVEL indicator to illuminate, and the arrow keys will be activated.

By using the Up and Down arrow keys at this point, he operator can adjust the power supplied to the amp to any value desired within the operating range of the lamp (specified in Section 1.3). When the desired value is reached, press the CP key again to store the information.

e. CI1 or CI2 (Constant Intensity) membrane key pads - There are two independent constant intensity channels in the CIC with keys labelled CI1 and CI2. The functional description applies to either channel.

1. Pressing CI key for less than 3 seconds:

Pressing and holding the CI key for less than 3 seconds will cause the CIC to operate in the CI mode. The display will first indicate in mW/cm2; power in watts can be displayed by pressing the DS key.

2. Pressing CI key for more than 3 but less than 5 seconds:

Pressing and holding the CI key for more than 3 but less than 5 seconds will cause the SET LEVEL indicator to illuminate. The arrow keys will be activated, and the display will indicate in mW/cm^2.

By using the Up and Down arrow keys at this point, the operator can select the desired exposure intensity. When the desired value is reached, press the CI key again to store the information.

3. Pressing CI key for more than 5 seconds:

Pressing and holding the CI key for more than 5 seconds will cause the SET DSPLY indicator to illuminate. The arrow keys will be activated, and the display will indicate in mW/cm^2.

At this point, the controller can be calibrated to an external power meter. Use the Up and Down arrow keys to change the CIC display to match the display of the power meter; when the readings on the two meters are the same, press the CI key again to store the information.

Figure PS-6 which may be found at the end of this chapter is a chart which outlines the operating instructions in a condensed form. After you have read the manual and understand the operation of the equipment, the chart is particularly helpful as a quick reference.

2.1.1 Selecting the Operating Mode

The SUSS CIC Constant Intensity Controller is capable of operating in a constant power mode only, or an operator selectable constant power or constant intensity mode. For proper operation in the constant intensity mode, a SUSS optical sensor must be situated in the light path of the exposure optics of the mask aligner and attached to the rear of the controller.

a. To select Constant Power (CP) only operation:

Press and hold the Up arrow and CP keys while applying main power. In this mode, the CIC will operate only in the Constant Power mode; pressing the CI1 or CI2 keys will have no effect. When main power is applied, the display indicates "CP" for approximately one second and then commences the self test routine.

b. To select Constant Intensity (CI) operation:

Press and hold the Up arrow and CI1 while applying main power; this will select Constant Intensity operation. In this mode, the unit will function in either the constant power or constant intensity operating mode. After main power is applied, the display indicates "CI" for approximately one second and then commences the self test.

2.1.2 Lamp Selection

Pressing and holding the Down arrow and CI2 keys while applying main power will activate the Lamp Selection subprogram. By pressing the arrow keys, the unit will toggle among all applicable lamps, and the corresponding front panel annunciators will illuminate. When the desired lamp is indicated, pressing the CI2 key again will start the self test procedure. All parameters corresponding to the lamp selected will be automatically loaded from memory into the operating system.

2.1.3 Display Test

Pressing and holding the Down arrow and the DS keys while applying main power activates the Display Test subprogram. For ten seconds, all applicable annunciators and display signals will illuminate and the alarm will pulsate. After ten seconds, the self test routine will commence automatically.

2.1.4 Standby

Pressing and holding the Down arrow key for more than three seconds while operating in the CP mode will cause the unit to revert to the standby mode. The lamp will be operated at Idle power and the CP LED will flash. To exit from the standby mode, press the CP, CI1, or CI2 key to select that particular operating mode.

2.1.5 Alarm

The CIC is equipped with an audible alarm to indicate abnormal operating conditions. The alarm operates in two separate modes - either a continuous or a pulsating tone. The continuous tone is heard when either minimum or maximum lamp wattage is reached, or when an overtemperature condition has occurred. The pulsating tone is heard when an overvoltage condition has occurred and the power supply has automatically extinguished the exposure lamp; it also signals that the lamp cooling interface has been activated.

2.2 Rear Panel

(Please refer to Figure PS-5)

The rear panel of the CIC contains all connections required to operate the controller. These include the Lamp Ignition Inhibit Interface, the Lamp Cooling Interface, the Main Power, the Optical Sensor, and the Remote Start Unit.

For the controller to operate properly, electrical connections must be made between pins 3 and 4 of the Lamp Ignition Inhibit and pins 1 and 2 of the Lamp Cooling Interfaces. These connections can be made with either the connectors and attached jumpers which are supplied, or by connecting the controller to the appropriate areas of the mask aligner.

The rear panel of the unit also contains the cooling fan and a 5 volt regulator.

2.3 Starting the Lamp

Make sure that the cables are properly connected to the remote start box as defined in Section 6.3 and that the proper power cord has been connected to the main power connector. If all operating parameters have been previously selected on the lamp type, either constant power (CP) or constant intensity (CI) operating mode, then push in the red POWER switch on the front panel. The CIC will commence the self test and the status annunciators describing the lamp selected will be illuminated. When the display indicates "rdy", press the START key momentarily; the display will indicate "fire" and the unit will attempt to ignite the lamp. It will perform up to eight attempts at lamp ignition before resetting.

Once the lamp has been ignited, the high voltage start circuit will automatically shut down and the display will indicate "Cold" for approximately four minutes. This allows the lamp to properly warm up before aligner exposures. After the warm-up sequence has occurred, the previous operating mode will be indicated by an LED illuminating on either CP, CI1, or CI2. The previous wattage will be displayed on the display in watts in the constant power mode, or if in constant intensity and no exposure is occurring, the idle wattage will be displayed. It is possible, though, that radiant output from the lamp may continue to increase even after the proper wattage has been achieved. This is quite normal due to the functional characteristics of the lamp. The lamp can be extinguished by again pressing the power switch to remove main power from the controller.

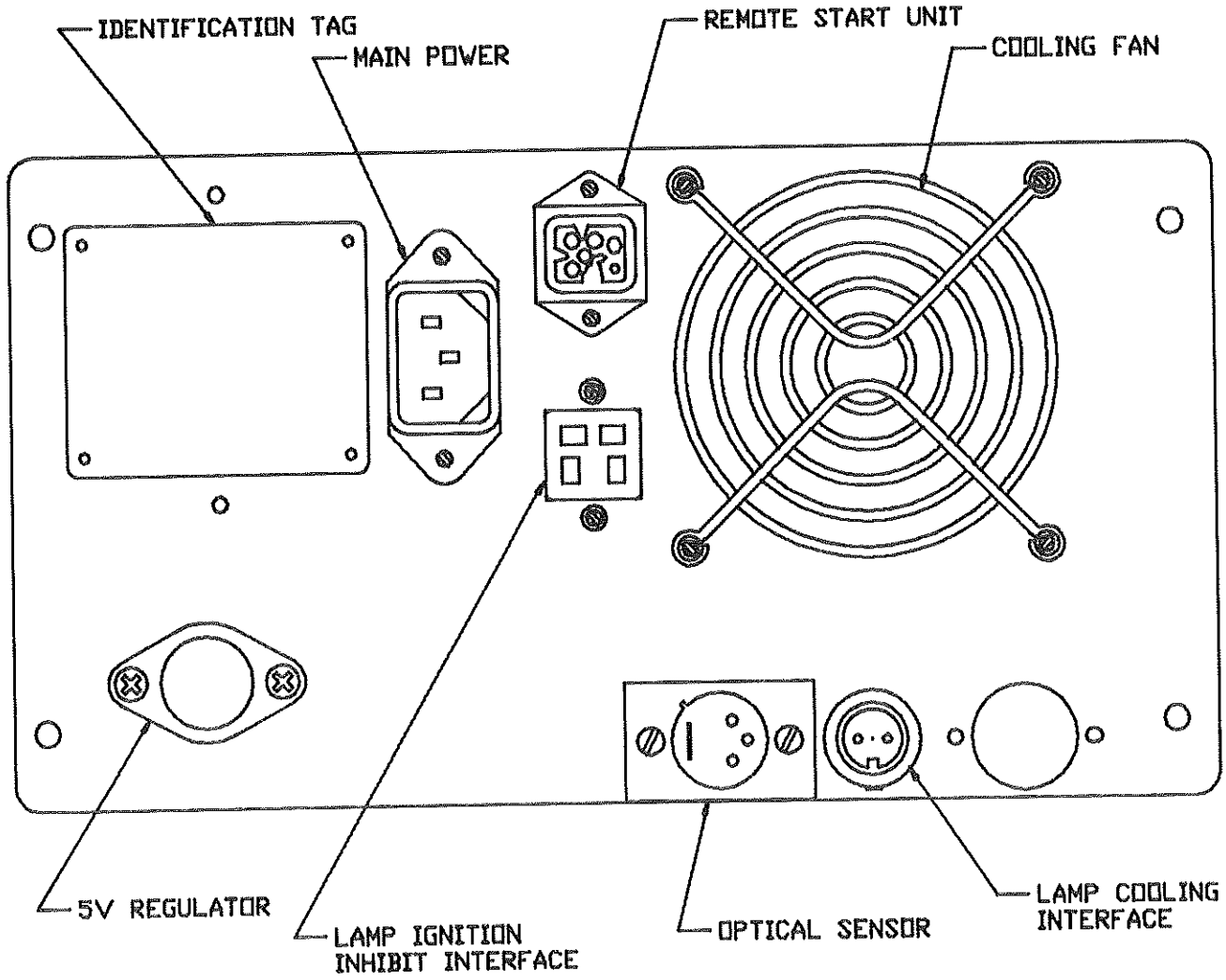


Figure PS-5 Rear Panel Connectors

2.4 Optical Sensor Calibration

The optical sensor is typically located somewhere off axis in the exposure energy optical path. The sensor is designed to operate properly when it is exposed to an energy level between 1% and 10% of the level of the main beam. To check sensor adjustment:

- o In CP mode, adjust power to maximum minus 20 watts.
- o Note mW value shown on the display in CI1.
- o Again adjust to maximum.
- o Note mW/cm^2 value shown on the display in CI1.

If the two intensity values vary when the power is increased, the sensor is adjusted properly. If the values do not differ, the sensor is exposed to too much energy. Adjust the shutter or light blocking screw on the sensor.

Perform the same test for CI2 and adjust the shutter or light blocking screw if necessary. On all SUSS optical sensors, the lower wavelength sensor is closest to the side where the cable enters the sensor housing.

2.5 Optical Calibration

For this discussion, we will assume that the lamp has started and has warmed to its Idle running temperature.

In order to obtain valid and repeatable results, it is necessary to use a calibrated UV powermeter whose optical bandpass filters are identical (within the range of $\pm$ 20 nm) to those of the optical sensor used with your controller. We recommend that you use the Model 100 Powermeter.

Optical calibration of the CIC is performed for both Constant Intensity 1 (CI-1) and Constant Intensity 2 (CI-2) channels. No optical calibration is required for Constant Power operation.

1. Perform the procedures in Section 4.2.3 to check for sensor saturation. This must be done whenever the exposure lamp position is changed or any optical components are moved or exchanged.
2. Select the channel (CI-1 or CI-2) to be calibrated.
3. Place the probe of the UV powermeter which corresponds to the channel that you are calibrating on the exposure chuck or mask holder of the mask aligner.

4. Open the light housing shutter so that light is incident on the probe. Note the value indicated on the powermeter.

5. Press and hold the CI key of the channel that you have selected until the display flashes and the SET DSPLY annunciator is illuminated. At this point, the mW/cm^{2}annunciator is also illuminated, and you have entered the Set Display subprogram.

6. Using the arrow keys, adjust the display on the CIC so that it matches the display on the powermeter. You have now calibrated the display section of the unit so that it correctly indicates exposure lamp intensity at the exposure point.

7. To revert to standard Constant Intensity operation,press the CI key again; the SET DSPLY annunciator will be extinguished.

The next series of steps is called the Set Level routine and is used to adjust the power to the lamp to provide the intensity you desire.

1. Press and hold the CI key until the SET LEVEL annunciator is illuminated. The mW/cm2 annunciator on the right side of the display will also be illuminated,and again the arrow keys will be activated.

2. The CIC has internally set minimum and maximum wattage ranges that will power any selected lamp. Use the arrow keys to select an intensity between these two limits.

3. Press the CI key again to revert to a normal operating mode after you have selected your desired exposure intensity.

   It is important to keep in mind when selecting an exposure intensity that the closer the lamp is being operated to its maximum limit, the shorter the lifetime of the lamp. Once you have selected the desired exposure intensity, it is always a good idea to go back to the Set Display subprogram and recheck the calibration. If necessary, readjust the CIC display to match that of the powermeter; also readjust the intensity level.

4. Once this has been completed for CI-1, repeat the steps for CI-2.

2.6 System Checkout

After optical calibration, you may want to verify the upper and lower power limits to which a lamp can be driven.

1. Press and hold one of the CI keys until the SET LEVEL annunciator is illuminated.

2. Press the Down arrow key while watching both the CIC and powermeter displays; both displays should track very closely.

3. Continue pressing the key until the minimum achievable power level has been reached. When the display stops decreasing and the alarm sounds, it indicates the lowest electrical power at which the lamp can be driven.

4. Now press and hold the Up arrow key. The CIC and powermeter displays should track as power to the lamp is increased, thereby increasing the intensity.

   Continued pressing of the Up arrow key will result in an audible alarm, indicating that the maximum achievable power level has been reached.

5. Press and hold the Down arrow key to return to the desired exposure intensity. The audible alarm will cease and power to the lamp will be reduced.

6. Close the shutter on the aligner. The intensity should drop to 0.00, and the lamp power should return to its Idle value.

SEQUENCE OF OPERATION / FUNCTION	PRESS MEMBRANE KEY PAD	FOR TIME IN SECONDS	USING KEY	DISPLAY SHOWS	TO STORE	TO RESET	ADDITIONAL COMMENTS
SETTING POWER CP	CP	T > 3	↑ or ↓	SET LEVEL	CP		
CALIBRATION CI-1 OR CI-2	CI-1 or CI-2	T> 5	↑ or ↓	SET DSPLY	CI-1,2		
SETTING INTENSITY CI	CI-1 or CI-2	3 < T < 5	↑ or ↓	SET LEVEL	CI-1,2		
IN CP MODE							
DISPLAY WATT	CP	T < 3		WATT			CI-1 FLASHES
DISPLAY mW/cm^2 CI-1 **	CP, DS	T < 3		mW/cm^2			CI-2 FLASHES; DEPRESSING DS AGAIN=WATT
DISPLAY mW/cm^2 CI-2 **	CP, 2 X DS	T < 3		mW/cm^2			
IN CI MODE							
DISPLAY mW/cm^2 CI-1 or CI-2	CI-1 or CI-2	T < 3		mW/cm^2			DEPRESSING DS AGAIN=mW/cm^2
DISPLAY WATT CI-1 or CI-2	CI-1 or CI-2	T < 3	DS	WATT			
TOTAL LAMP HOURS	DS	3 < T < 5				LAMP HOURS ↓ ONLY	Selected after RDY
TOTAL OPERATING HOURS	DS	T > 5					Selected after RDY; Multiplied by 10
CP ONLY	↑ (at same time) +CP+POWER						CI-1 or CI-2 No Effect
CP AND CI	↑ +CI-1+POWER						PS Must Switch Off First
DISPLAY TEST	↓ +DS+POWER						10 SECOND TEST
LAMP SELECTION	↓ +CI2+POWER		↑ or ↓		CI-2		
STANDBY IN CP	↓	T > 3				CP	PS Has to be in CP Mode; Lamp in Idle Power. CP Flashes.

** USED FOR SENSOR CALIBRATION (see Section 4.2.3)

FIGURE PS-6 Condensed Operating Instructions

3 WARNINGS AND SAFETY HAZARDS

3.1 Electrical

CAUTION:

Lethal voltages are present within the controller chassis. It is strongly suggested that you do not open the case and attempt repair.

Do not operate a 200 watt lamp with the controller set to the 350 watt setting.

The electrical requirements of voltage and current required to run a short arc lamp constitute a lethal combination. Starting ignition voltages are 30KV, and open circuit potentials range up to 150 VDC at currents between 8 and 50 amps. When performing any maintenance on the Constant Intensity Controller, lamp housing, or lamps, make certain that the power switch is in the Off position, the mask aligner is turned Off, and the CIC power cord is removed either from the wall power outlet or the controller.

3.2 Exhaust Requirements

All short arc lamps produce toxic ozone due to the radiation emitted below 200 nm. Ozone attacks the mucous membranes of the respiratory system, producing symptoms similar to pneumonia. The effects are cumulative. The small wattage lamps (xenon to 200 watts, and mercury to 500 watts) should be operated only in a well ventilated area. Large wattage lamps should be vented out of the room.

3.3 Lamp Explosion

The lamps operate at extremely high pressure (50-70 atm) and are therefore subject to explosion. They must be operated within a protective housing. Additionally, even cold mercury-xenon and cadmium-xenon lamps are still above atmospheric pressure and should be handled with protective face shields and gloves.

3.4 Eye and Skin Safety

The shortwave ultraviolet light produced by these lamps can cause erythema of the skin (similar to sunburn) and conjunctivitis. In addition, the large infrared output can cause retinal burns resulting in blindness. UV and IR absorbing goggles and protective clothing should be worn when working the vicinity of these emissions.

4 QUALITY STANDARDS

This chapter briefly describes some of the quality standards which we recommend you follow to help you obtain the best possible results from your SUSS equipment. KARL SUSS manufactures precision instruments that cannot be expected to function properly unless they are correctly adjusted and maintained, and precautions are taken to ensure a clean environment.

We assume that you have a comprehensive quality control program which has been developed to suit your particular applications. These comments are only intended as a reminder that quality standards are an essential part of good business practice.

4.1 Environment

KARL SUSS products are intended for use in a well managed, professionally supervised clean room.

Photomask dimensions are usually on the order of several microns, and frequently fall into the submicron range. At this level of precision, almost everything in a normal production environment would be judged too "dirty" to make semiconductor devices. The cleanliness requirement is particularly stringent in the photomasking area. Not only are all of the critical dimensions produced here, but the frequent chemical operations present many opportunities for accidental contamination. Any type of contamination may affect fabrication yield and circuit reliability.

The exposure quality obtained from a mask aligner is a function of many variables in addition to clean room conditions. The quality of the mask used, wafer flatness, specifications and quality of photoresist, and the condition of the resist spinner all play important roles.

To ensure the best possible results, the user must take appropriate steps to provide a clean environment and maintain consistent and effective quality standards for all aspects of the photomasking process.

4.2 Equipment Checks and Adjustments

The unit should be checked on a regular basis to make sure that it is still adjusted to optimum performance conditions.

4.2.1 Lamp Intensity

Output intensity from a short arc lamp will vary in direct proportion to the lamp input power. This input power, however, is limited by the physical characteristics of the lamp in operation. The efficiency of the lamp housing will also contribute to the actual amount of energy density which will be available. Considering these factors, it is apparent that both a maximum and a minimum amount of light intensity will exist for any set of conditions - lamp size, lamp housing, and required lamp safety limits.

In general, the higher the power at which the lamp is driven, the shorter the useful life of the lamp; "useful life" in this case is defined as the time required for the initial intensity to decay 50%. For optimum performance, the exposure intensity should be set at or below the value measured at Idle power. If you require a higher intensity, you should be aware of the tradeoffs involved.

4.2.2 Light Uniformity

Proper light uniformity is required for repeatability of exposure; tests and adjustments should be done periodically. Refer to the mask aligner manual for instructions on how to perform uniformity tests correctly.

5 MAINTENANCE AND SERVICE

This chapter describes the self test features, presents a comprehensive Troubleshooting Guide, gives step by step instructions on how to replace fuses and change main power, and provides guidance on how to receive further technical assistance.

5.1 Self Test Failure Conditions

The CIC performs a series of tests of the major functional sections of the unit every time the main power is applied. These are designated Test 1, Test 2, and Test 3.

Test 1 writes a sequence of test data to the unit RAM and then reads that information back. If the read data does not correlate with the written data, the test sequence terminates and the lamp ignition is inhibited. The display will alternate between "Fail" and "C 01".

Test 2 checks the unit's EEPROM where the following operational parameters have been stored: lamp type, previous operating mode, set point, display scaling, unit hours, and lamp hours. Test 2 is broken into four individual tests. (Please refer to Section 5.2 for specific details.) If the unit fails Test 2, lamp ignition is inhibited and the display alternates between "Fail" and "C 02".

Test 3 performs a check of the power section. Soft start of the power components is initiated and the detection circuitry for the voltage and current inputs is checked. If this test fails, lamp ignition is inhibited and the display alternates between "Fail" and "C 03". If the CIC passes all three tests, the display indicates "rdy" (Ready), and the START key is enabled.

5.2 Troubleshooting Guide

Symptom	Corrective Action
Display alternates between "Fail" and "C 01".	RAM failure; refer to Section 5.5 on how to receive technical assistance.
Display alternates between "Fail" and "C 2.1"	Press Up arrow to continue test. Re-enter either CP or CI exposure mode after lamp ignition.

Symptom	Corrective Action
Display alternates between "Fail" and "C 2.2"	Press Up arrow to continue test. Re-enter either CP or CI operating mode; re-enter SET LEVEL parameters after lamp ignition. (See Section 2.5)
Display alternates between "Fail" and "C 2.3"	Press Up arrow to continue test. Re-enter either CP or CI operating mode; re-enter SET LEVEL and SET DSPLY parameters after lamp ignition. (See Section 2.5)
Display alternates between "Fail" and "C 02"	EEPROM failure; refer to Section 5.5 on how to receive technical assistance.
Display alternates between "Fail" and "C 03"	Power section failure; refer to Section 5.5 on how to receive technical assistance.
Display indicates "OH" and lamp is extinguished.	Internal overheating; refer to Section 5.5 on how to receive technical assistance.
No display.	a. Bad fuse(s). Refer to Section 5.3.
Lamp will not start.	a. Connections between start box and lamp are loose, shorted, or have developed high resistance contacts; check all connections, especially those within the lamp housing. b. Connections between controller and start box are loose, shorted, or have developed ohmic contacts; check all connections at the back of the controller. c. Start interlock activated; see Section 6.3.3.
"Chng Lamp" annunciator illuminates.	a. Aged lamp causes overvoltage trip.
Lamp starts but controller shuts down after short time.	a. Lamp has been installed in reverse which results in rapid gap erosion; replace with new lamp and install correctly. b. Bad contacts in lamp housing; clean and check all connections. c. Defective lamp; replace. d. No cooling; N2 loss.

Symptom	Corrective Action
Lamp intensity is low; step changes in power - proceed slowly.	a. Lamp is overcooled; see Section 1.1.2 and reduce air flow past lamp. b. Lamp has developed a leak; replace. c. Reflective band on lamp has deteriorated due to age; replace.
Lamp intensity is low, but not over-cooled.	a. Improper alignment in lamp housing. b. Aged lamp with metal deposits on inside of bulb; replace. c. Optical coatings on surface deteriorated; replace.
Intensity display on control does not agree with that of external powermeter.	a. Measurement with external powermeter made at two different points in light beam. b. Measurement with external powermeter was made with a probe where spectral response differs from that of the controller. c. Change in optical properties or alignment of optical elements; recalibrate system. d. Incorrect calibration during original settings. e. Control settings of controller have been changed since original calibration. f. Insufficient light incident on optical sensor.
Intensity will not maintain present level in control.	a. Optical sensor not installed. b. Defective optical sensor assembly. c. No light on optical sensor.
mW/cm^2 display indicates no response.	a. Optical sensor not installed. b. Defective sensor assembly. c. No light on optical sensor.
Will not maintain correct Idle power.	a. Lamp is overcooled; refer to Section 1.1.2 and reduce N2 flow past lamp. b. Defective lamp; replace. c. Bad contacts in lamp housing; clean and check all connections.
"N2 Loss" annunciator illuminated.	a. Lamp cooling interface connector/ connection missing. b. Low/no lamp cooling.

5.3 Fuse Replacement

The incoming main power line has protective fuses on both legs which are rated at 7 amperes each. The internal 5 volt power supply has a 3 ampere fuse.

Follow these steps to replace a fuse:

1. Remove main power from the controller by detaching the power cord from the rear panel.

2. Take off the top cover by removing the four slotted screws holding it in place.

3. Locate the fuses which may be found in the right front section of the controller.

   The main power fuses are a 3 AG type, 1/4" in diameter by 1-1/4" long, and rated at 7 amp. The 5 volt power supply fuse is a metric type, 5 mm in diameter by 20 mm long, with a 3 amp rating.

4. To remove a fuse, simply pry it out of its snap-in type holder; set its replacement in place and snap it back in.

5. Replace and attach top cover with the four screws.

6. Examine all cables and connectors to try and determine reason for fuse failure.

7. If no apparent reason for failure, reattach power cord and restore main power to the controller. Should the fuse fail again, turn the unit off, remove power and refer to Section 5.5 of the manual for instructions on how to receive technical assistance.

5.4 Main Power Selection

The SUSS CIC units are designed to operate all applicable lamps over a wide variety of main input voltages. The controller is ordered in either 110V or 220V configuration; the voltage switch is set at the factory as specified in the purchase order.

The main power selection can be changed as follows:

1. Remove main power from the unit by detaching the power cord from the rear panel. Remove the four slotted head screws holding the cover in place.

2. Locate a two-position slide switch behind the main power switch; the positions are marked "110" and "220".

3. If main input voltage is between 90 and 130VAC, slide switch to "110" position.

   If main input voltage is between 200 and 260 VAC,slide switch to "220" position.

4. Replace the cover and reinstall the four screws. Ensure that the proper power cable has been connected to the rear of the controller.

5.5 Service Information

5.5.1 Technical Assistance

Should difficulties arise with the use or operation of your Constant Intensity Controller, and you are unable to resolve the problem by using the Troubleshooting Guide, you can receive further assistance as follows:

U.S., Canada, Central and South America - Call Customer Service at 802-244-7884 during normal working hours, Eastern time, or your regional KARL SUSS office.

International - The KARL SUSS office which processed your order or is currently handling your customer account can give you specific instructions on whom to contact to get additional help or answer any questions.

5.5.2 Factory Repairs

U.S., Canada, Central and South America

1. Call Customer Service at 802-244-7884 during normal working hours, Eastern time, or your regional KARL SUSS office.

2. Be prepared to furnish the following information (if available):

   a. Your company name, address, telephone number, and the name of the responsible individual whom we may contact if we have technical questions about the problem.

b. Model and serial number of the equipment.
c. A list of associated equipment and a description of the electrical connections.
d. A brief description of the problem.

3. Customer Service will provide you with an MRA (Material Return Authorization) number and instructions on where to ship the equipment. The MRA number must be shown on the outside of the return shipping container.

4. The repair charges for units not covered under warranty will be billed in accordance with the published price list in effect; a purchase order should be issued by your organization to cover the cost of repairs.

International

The KARL SUSS office which processed your original order or is currently handling your customer account can give you specific instructions on how to proceed to obtain repair of your unit.

6 INSTALLATION

6.1 Unpacking

6.1.1 Inspection

After removing the packing material, check to make sure that you have the following items and that your packing list agrees with the material which you have received.

a. SUSS Constant Intensity Controller
b. Dual Optical Sensor Assembly (used in CI configuration only) - may be installed on aligner.
c. Lamp cable and start box - may be installed on aligner.
d. Lamp cooling interface connector
e. Operator's Reference Manual

Upon application of main power to the CIC, the lamp selection which was set at the factory will be displayed on the front panel. A label on the mounting plate of the optical sensor specifies the optical wavelength for which the sensor is set.

6.1.2 Instructions in Case of Damage

If there is any indication of shipping damage to the instrument, notify both the common carrier who delivered the equipment and the Karl Suss office processing your order or contract. Claims for damage should be filed in accordance with standard procedures in your area.

6.2 Environmental Requirements

6.2.1 Utilities Required

The power requirements - voltage, line frequency, and maximum current - are shown on a label on the back of the unit. Each unit is capable of operating at voltages from 90 VAC to 260 VAC, and frequencies of 50/60 Hz. An internal switch will be set at the factory for the power option specified on your purchase order. See Section 5.4 for information on changing the main voltage.

6.2.2 Physical Environment

The Constant Intensity Controller is designed to operate continuously at ambient temperatures of 4 - 30C (40 - 86F) and to be stored or transported at temperatures up to 60C (140F).

The unit will perform best and provide an extended service life if it is stored and operated in a clean, dry, non-corrosive atmosphere.

6.2.3 Exhaust Requirements

Internal cooling is provided by a fan which pulls air through slots in the chassis behind the front panel and exhausts it through the rear panel. The unit does not require any clearance along the top and the sides, however the space on the bottom between the feet should not be obstructed in any way. In addition, a minimum clearance of 15 cm (6 in) between the rear panel and any obstruction should be maintained.

Although the exhaust of the CIC consists only of heated air, the lamp itself may produce toxic emissions. See Section 3.2 for details.

6.3 Coupling Procedures (refer to Figure PS-5)

6.3.1 Lamp Connections

The Constant Intensity Controllers incorporate remote starting units that can either be mounted to the back of the lamphouse or placed close to the exposure lamphouse. The remote starter has a cable which connects to the rear of the CIC and has connectors to attach the lamp cables. The cathode cable and connector are rated at 30KV; the cable insulation meets MIL-W-16878 and UL62 specifications. The white cable with the large black connector must go to the lamp cathode, and the cable with the red connector must go the the lamp anode.

If the remote start unit is attached to the back of the lamphouse, the connections are internal and connected at the factory.

The "stand alone" remote start unit should be placed as close as possible to the exposure lamphouse. Insert the 6-pin plug into the connector on the rear panel of the unit and secure with the locking lever. The connector is a Hirschman STAKIE-5.

Cathode - Rotate the connector so that the guide tab aligns with the mating slot, then push so the two units are aligned. Engage the locking ring on its thread and while applying forward pressure, rotate the ring until the units are fully mated and locked. This connector is an AMP type 853350-2.

Anode - Align the mating slots of the two units and press forward until a "snap" is heard and the units are fully mated. Install the two locking screws. This connector is an AMP type 53894-4.

To remove, reverse the procedures above.

6.3.2 Optical Sensor

If the unit has been ordered for use in the CI configuration and an optical sensor has been supplied, follow these steps to attach the optical sensor to the controller. Align the connector with its mating slot and push forward until the locking clip engages. To remove, press and hold the clip down while pulling firmly to the rear. Additionally, ensure that if an optical sensor is being used, the unit has been set to operate in the CI mode as described in Section 2.2.1.

6.3.3 Lamp Ignition Inhibit Interface

Provisions for two methods of inhibiting lamp start are made through a 4-pin Jones type jack on the rear panel.

The lamp ignition inhibit is used to prevent damage to connected equipment by the high voltage RF pulse used in starting the lamp. The usual requirement is that the associated equipment be powered down during the starting sequence. This is easily accomplished by connecting Pin 2 to the positive rail of the 24 VDC power supply in the associated equipment and Pin 1 to the ground rail. Whenever the aligner is activated, the internal start circuitry of the controller will be inhibited. Note that no other functions of the controller are modified by this condition. Additionally lamp ignition may be inhibited by the lack of electrical contact between Pins 3 and 4 of the Jones plug.

The mating plug is a Jones or equivalent type P-304-CCT.

6.3.4 Lamp Cooling Interface (N2 Loss)

A sensor which detects proper lamp cooling can be connected to the controller through a standard 2-pin connector on the rear of the unit. If lamp cooling is provided by a flow of air or nitrogen, a flow sensor may be installed in the cooling line. If this flow falls below a preset level, contact closure is broken.

Upon detection of loss of electrical contact at the Lamp Cooling Interface, the N2 Loss annunciator on the front panel will be illuminated. If the connection is restored within approximately three minutes, the N2 Loss annunciator will be extinguished and no further action will be taken.

If the connection is not restored, the controller will extinguish the lamp, the alarm will pulsate, and the N2 Loss annunciator will flash. Once the lamp has been extinguished and the Lamp Cooling Interface connection has been restored, the alarm will cease, the N2 Loss annunciator will go out, and the display will indicate "rdy". Lamp ignition can now be performed. If no flow sensor is used, the connector enclosed with the shipment must be used.

6.3.5 Isolating Difficulties

When you first install a CIC, we suggest that you also start with a new short arc lamp. Check and clean all electrical contacts within the lamp housing. Be especially critical of any crimp type contacts and replace them if there is evidence of corrosion or oxidation. Most of the apparent CIC malfunctions can be traced to faulty or incorrect electrical connections within the lamp housing, so a few minutes spent in scrutiny can prevent several hours of frustration, especially in tracing false symptoms due to intermittency. Improper mating of the cathode HV connector will also prevent the lamp from starting. Review Section 6.3.1 and ensure that the connector shaft is fully inserted and the locking ring engaged.

7 WARRANTY AND LIMITATIONS

7.1 Warranty Period

KARL SUSS products are warranted for a period of six months from the date of the original invoice.

7.2 Scope

This warranty covers all defects in material and workmanship on KARL SUSS products except as specified below:

1. Batteries
2. Voltage conversions.
3. Periodic checkups which do not disclose any defects covered by the warranty.
4. Units on which the serial number has been defaced, modified, or removed.
5. Damage or deterioration:
   a. Occurring to any external cabinet or case.
   b. Resulting from accident, misuse, abuse, neglect, unauthorized product modification, or failure to follow the instructions in the Operator's Manual.
   c. Resulting from repair or attempted repair by anyone not specifically authorized by KARL SUSS.
   d. Resulting from installation of parts or accessories that do not conform to the quality or specifications of the original parts or accessories.
   e. Occurring during shipment. (Claims must be presented to the carrier or as determined by local practice.)

KARL SUSS will pay for all labor and material costs to repair items under warranty except for shipping charges which are discussed in greater detail in Section 7.4.

All implied warranties, including warranties of merchantability and fitness for a particular purpose are limited in duration to the length of this warranty, unless otherwise provided by state law.

The liability of KARL SUSS is limited to the repair or replacement, at our option, of any defective product and shall in no event include incidental or consequential commercial damages of any kind.

7.3 Who is Protected

This warranty is offered only to the original purchaser of the equipment.

7.4 How to Receive Warranty Service

U.S., Canada, Central and South America

1. Call Customer Service at 802-244-7884 during normal working hours, Eastern time, or your regional KARL SUSS office.

2. Be prepared to furnish the following information (if available):

   a. Your company name, address, and telephone number with the name and telephone number of the individual whom we may contact for further technical information regarding the problem if necessary.
   b. Model and serial number of the equipment.
   c. A description of the electrical connections to associated equipment and a list of this equipment.
   d. A brief description of the problem.

3. Customer Service will provide you with a MRA (Material Return Authorization) number and instructions on where to ship the equipment. The MRA number must be shown on the outside of the return shipping container. It is important to remember that a unit will not be accepted for repair unless an MRA has been issued.

4. Although you must pay the shipping charges if it is necessary to ship the equipment, we will pay the return shipping charges if the product is covered under warranty.

International

The KARL SUSS office which processed your original order or currently handles your customer account can give you specific instructions about how to obtain warranty service.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