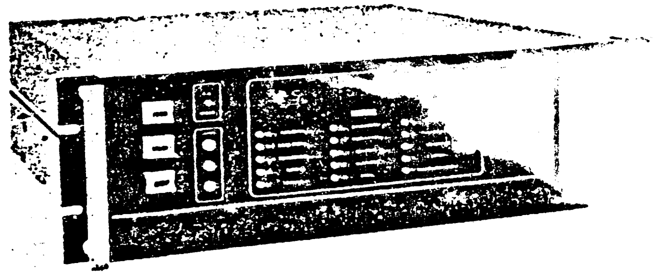
0101-8901-0

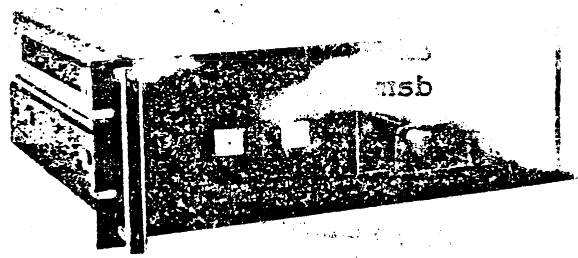
HSD Engineering, Inc.
6919 Snake Road
Oakland, CA 94611

THIN FILM DEPOSITION CONTROLLER



MODELS XMS-1 & XMS-3

TAPE READER



MODEL TR-1

INSTRUCTION MANUAL

INFICON INC. 5 ADLER DRIVE, EAST SYRACUSE, NEW YORK 13057 TWX: 710 541-0594 TEL: (315) 463-3377

WARNING

The XMS uses MOS devices in its memory circuits which may be damaged if exposed to large static discharges. If at any time it is necessary to remove the XMS-310 printed circuit board, first touch chassis. Removal and handling should be executed touching only the outside edge of the board.

WARRANTY

All Inficon instruments are warranted against defects in materials and workmanship for one year from date of shipment. Sensor heads, oscillators, and the TR-1 tape head are warranted for ninety days from date of shipment.

Inficon will repair or replace at its option products, which prove to be defective during the warranty period, provided they are returned to Inficon, Inc. No other warranty is expressed or implied. Inficon is not liable for consequential damages.

Contact Inficon for return authorization. All items to be returned to Inficon must be properly packaged, insured and shipped transportation charges prepaid.

No claim will be allowed for defects caused by purchaser's modification, abuse, misuse, excessive ambient temperatures or other abnormal conditions of operation. Failure of MOS circuits due to static discharge caused by improper handling is not covered.

Note: These instructions do not provide for every contingency that may arise in connection with the installation, operation or maintenance of this equipment. Should further assistance be required, please contact Inficon, Inc.

INSTRUCTION MANUAL

PART I

XMS-1 and XMS-3
THIN FILM DEPOSITION CONTROLLER

PART II

TR-1
TAPE READER

April 1975

Reprinted by
Airco Temescal
January 1976

Part No. 006-040

INFICON, INC., 5 Adler Drive, East Syracuse, New York 13057

TABLE OF CONTENTS

		Page
Part I - XMS 1 and XMS-3		
1.0	General Information	1-1
1.1	Receiving, Handling and Storage	1-1
1.2	Specifications	1-1
1.2.1	Physical Data	1-3
1.2.2	Accessories and Parts	1-3
2.0	General Description	2-1
2.1	Front Panel	2-1
2.2	Rear Panel Connections	2-6
2.3	Thickness Sensor	2-9
3.0	Preliminary Checkout	3-1
3.1	Initial Setup and Programming	3-1
3.2	Test Procedure	3-5
3.3	Manual Power Controls	3-6
4.0	Installation	4-1
4.1	Installation in Coating System	4-1
4.2	Rear Panel Connections	4-1
4.2.1	Interface (J6)	4-1
4.2.2	Source Power (J8)	4-5
4.2.3	Sensor 1, 2, 3	4-5
4.3	Installation of Sensor Head	4-5
4.3.1	Replacing the Crystal	4-7
4.4	Final Programming	4-8
5.0	Calibration	5-1
5.1	Theory of Operation	5-1
5.2	Thickness Readout Calibration	5-3
5.2.1	Density	5-3
5.2.2	Z-ratio	5-4
5.2.3	Tooling	5-5
5.3	Output Calibrations	5-5
5.3.1	Control Output, XMS-330	5-5
5.3.2	D/A Option, XMS-340	5-6

6.0	Repair and Maintenance		6-1
	6.1	General Circuit Description	6-1
	6.1.1	Measurement, XMS-320	6-1
	6.1.2	Control Output, XMS-330	6-1
	6.1.3	D/A Option, XMS-340	6-7
	6.1.4	Output Interface, XMS-350	6-7
	6.1.5	Front Panel, XMS-200	6-7
	6.1.6	Power Supply, XMS-400	6-12
	6.2	Service	6-12
	6.2.1	Case Removal	6-14
	6.2.2	Test Mode	6-14
	6.2.3	Troubleshooting - XMS	6-16
	6.2.4	Troubleshooting - Sensor Head	6-19
	6.2.4.1	Regular Sensor Head and Sensing Crystals	6-19
	6.2.4.2	Sputtering Sensor Head and Sensing Crystals	6-21
7.0	Parts List		7-1

Part II - TR-1

1.0	General Information		1-1
	1.1	Receiving, Handling and Storage	1-1
	1.2	Specifications	1-1
2.0	General Description		2-1
	2.1	Front Panel	2-1
	2.2	Rear Panel	2-1
3.0	Preliminary Checkout		3-1
4.0	Installation		4-1
	4.1	Manual Mode	4-1
	4.2	External or Automatic Mode	4-1
	4.3	Tape Preparation	4-3
	4.4	Loading Tape	4-5
5.0	Maintenance		5-1
	5.1	Preventive Maintenance	5-1
6.0	Parts List		6-1

LIST OF ILLUSTRATIONS

Figure		Page
Part I - XMS-1 and XMS-3		
2-1	XMS-3 Front Panel	2-2
2-2	XMS-3 Rear Panel	2-7
2-3	Exploded View of Sensor	2-10
3-1	Sample Deposition Run	3-4
4-1	Typical Installation	4-2
4-2	J6 System Interface	4-3
4-3	Interface Circuits	4-4
4-4	J8 Source Power	4-6
6-1	XMS-3 Block Diagram	6-2
6-2	XMS-3 Circuit Diagram	6-3
6-3	Interior View of XMS-3	6-4
6-4	Measurement, XMS-320	6-5
6-5	Control Output, XMS-330	6-6
6-6	D/A Option, XMS-340	6-8
6-7	Output Interface, XMS-350	6-9
6-8	Circuit Diagram, XMS-350	6-10
6-9	Front Panel, XMS-200	6-11
6-10	Circuit Diagram, XMS-400	6-13
6-11	Front Panel, Component View	6-15

Figure		Page
Part II - TR-1		
2-1	TR-1 Front Panel	2-2
2-2	TR-1 Rear Panel	2-3
4-1	TR-1 System Interface	4-2
5-1	TR-1 Circuit Diagram	5-2

LIST OF TABLES

Table		Page
Part I - XMS-1 and XMS-3		
5-1	Z Values for Common Materials	5-4
Part II - TR-1		
4-1	ASCII Code for XMS Function and Controls	4-4

PART I

XMS-1 and XMS-3
THIN FILM DEPOSITION CONTROLLER

1.0 GENERAL INFORMATION

The Inficon Model XMS Thin Film Deposition Controller series consists of the following items:

a. Thin Film Deposition Controller (XMS-1: 006-045; XMS-3: 006-046)
b. Standard water-cooled sensor head (Part No. 321-20; 007-030); includes oscillator cable and five spare crystals
c. Mating connectors (XMS-1: 006-053; XMS-3: 006-054)
d. Hand-held power control (006-016)
e. Instruction manual (006-040)
f. Power cord (068-002).

This publication covers the installation and operation of the XMS-1 and XMS-3. Specifications which are pertinent to one model are noted.

1.1 Receiving, Handling and Storage

Upon receipt of the Thin Film Deposition Controller, examine it immediately for any damage that may have occurred in transit. Immediate examination is especially important if rough handling is evident. If damage is found, a claim should be filed with the transportation company immediately, and Inficon should be promptly notified.

Spare crystals should be stored in their shipping containers.

1.2 Specifications

Thickness Measurement Range (three automatic ranges)	0 to 999.9 kÅ
Thickness Limits (two set points)	0 to 999.9 kÅ
Rate Control Range	0 to 999 Å/second
Thickness Display Resolution	1Å from 1 to 9.999Å 10Å from 10 to 99.99 kÅ 100Å from 100 to 999.9 kÅ
Rate Display and Control Resolution	1Å/second
Rise Time	0.1 to 99.9 minutes

Tooling	20 to 499%
Soak Time (two set points)	0.1 to 99.9 minutes
Soak Power	0 to 99%
Maximum Power	0 to 99%
Idle Power	0 to 99%
Gain	0 to 99
Density	0.80 to 99.99 gm/cc
Z-ratio	0.100 to 1.999
Control Voltage Out (XMS-3 three source outputs)	0 to -10 Vdc @ 20 mA
Power (either unit)	± 10%, 115/230 Vac, 50-60 Hz, 70 watts
Battery	Maintains memory for 16 hours if the line power is interrupted
Operating Temperature	
Instrument	0 to 50°C
Sensor Head	-20 to 105°C
External Control Inputs Start Zero Stop Crystal Fail Enable Soak Hold Maximum Power Enable	All require 60 to 135 Vac rms
Control Outputs Rise, Soak, Deposit or Crystal Fail (internally selectable) Thickness 1 Thickness 2 Abort Shutter 1 Shutter 2 (XMS-3 only) Shutter 3 (XMS-3 only)	Solid state relays; maximum 135 Vac rms, rated at 3 amps

1.2.1 Physical Data

XMS-1 and XMS-3	Weight: 25 lbs; 5-1/4" H x 16-3/4" W x 17-1/2" D; rack mountable
Oscillator	Weight: 9 oz; 7/8" H x 1/8" W x 2-1/4" L; includes 3" coax terminated in BNC for connection to vacuum feedthrough and 10' multiconductor cable for connection to XMS.
Sensor	Weight: 4 oz; 1-3/8" diameter x 5/16" thick; supplied with 30" of 1/8" OD copper water-cooling lines and 30" coax terminated in Microdot 132-0112 connector.

1.2.2 Accessories and Parts

	Part No.
Sensor Head for thermal deposition systems. Complete with oscillator (321-40), interconnecting cables, water lines and five (5) spare crystals (321-25).	321-20
Sputtering Thickness Sensor for sputtering and thermal deposition systems. Complete with oscillator (321-40), interconnecting cables, integral water lines and five (5) spare crystals (321-55).	321-50
Bakeable Sensor Head for temperatures up to 450°C. Includes integral 2-3/4" diameter flange (copper gasket) with 30" water lines. oscillator (321-40), interconnecting cables and five (5) spare crystals (321-25).	321-72
Sensor Crystals (package of 5)	321-25
Sputtering Sensor Crystals (package of 5)	321-55
Instrument Feedthrough for baseplate mounting in 1" bolt hole, single coaxial, double water line.	321-201

	Part No.
Instrument Feedthrough, single coaxial, double water line, 2-3/4" diameter flange (copper gasket).	321-202
Instrument Feedthrough, single coaxial, double water line, 2-3/4" diameter flange (Viton O-ring).	321-205
Recorder Output for Thickness and Rate (0 to 10 Vdc)	XMS-340

TR-1 Tape Reader used only with XMS-3. The TR-1 is capable of entering into XMS-3 a total program for each of N layers or changing particular process parameters during a deposition.

2.0 GENERAL DESCRIPTION

2.1 Front Panel (Figure 2-1)

The following is a description of operational characteristics of all switches and indicators located on the front panel:

a. Zero

Depressing resets accumulated thickness and establishes a new reference for the unit. Elapsed time of soak or deposition is also zeroed with this button. If the source output exceeds the maximum power set point, this indicator will light and flash.

b. Start

Depressing initiates a programmed run. If the unit is in the stop mode (stop lamp on), pressing this switch once resets the stop mode, lights the start button and selects layer 1. This readies unit to start with a second push of the start button.

c. Stop

Pressing places unit into stop mode. That is, all source control outputs return to zero and the XMS can not be restarted until start reset has been initiated. Any time the unit is in the stop mode, the switch will be lit.

d. T/X

Pressing (orange pushbutton) allows operator to view in the displays elapsed time from start of deposition (Group 1), percent of crystal life used (Group 2) and total accumulated frequency shift referenced to new crystal (Group 3). Percent is based on 1.5 MHz = 100%. Failure of the sensor crystal is indicated by the flashing of this lamp.

e. Layer (XMS-3 only)

The XMS-3 will control three sources from three sensors in any combination. The small switches labeled 1, 2 and 3 indicate, when lit, which layer is being programmed or operated. Pressing any one of these switches allows the operator to manually select desired layer. Active layer can not be changed after a layer is started. Any layer can be programmed at any time by first going to THE PROGRAM MODE, THEN SELECTING LAYER.

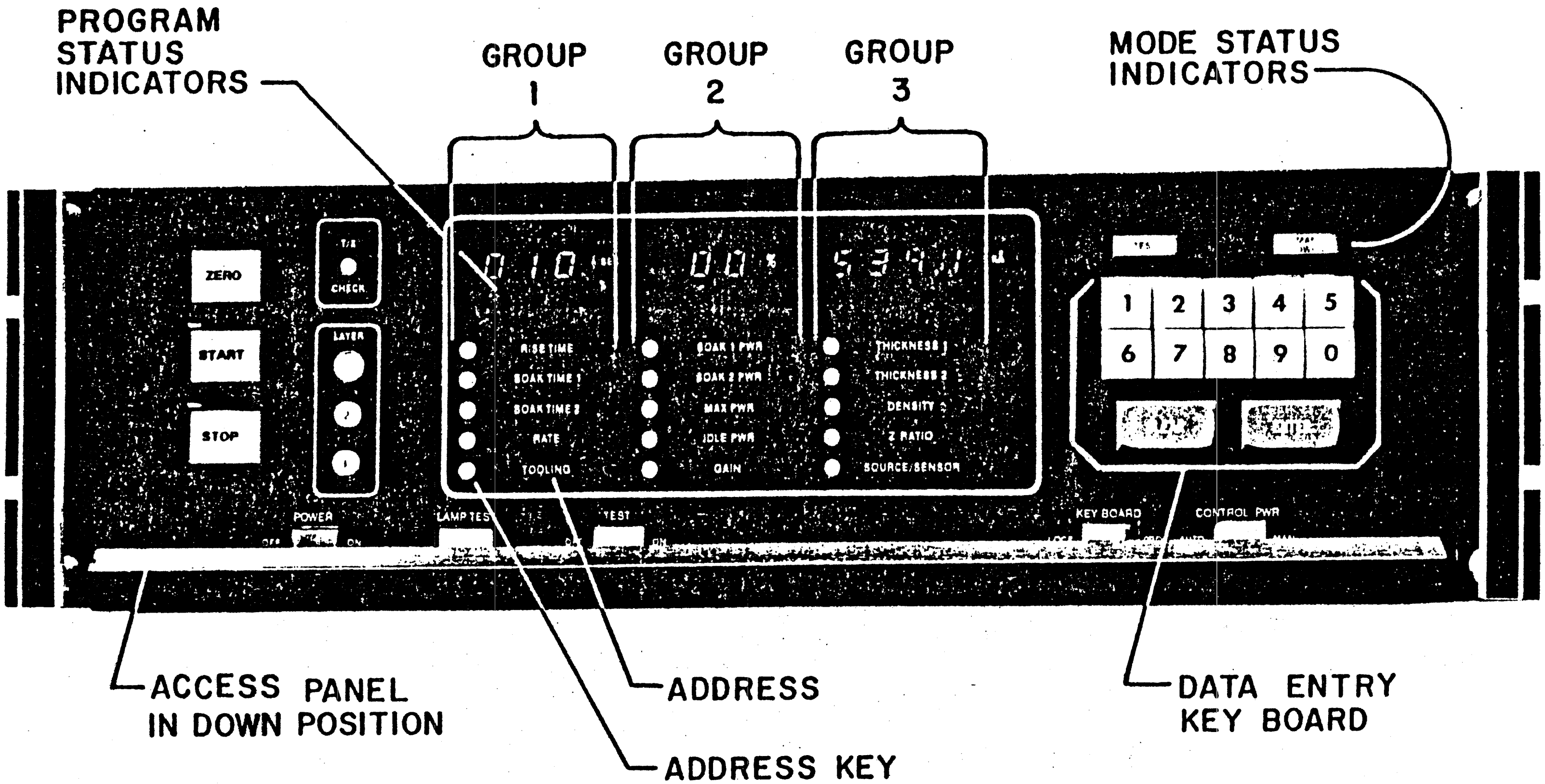


Figure 2-1 XMS-3 Front Panel

the program mode, then selecting layer. Leaving the program mode automatically returns layer selection to the active layer.

f. Display and Programmable Functions

The numerical displays, data address and address keys are presented in three groups. When program data are being displayed, one address and the corresponding display will be illuminated. The keys located adjacent to the individual addresses provide (a) access to programmed data during a normal run and (b) address selection when in program mode.

Group 1

Rise Time (0 to 99.9 minutes) - Time required to ramp power to soak power 1.

Soak Time 1 (0 to 99.9 minutes) - Time system remains at soak power 1.

Soak Time 2 (0 to 99.9 minutes) - For any selected time, system will divide it between rising to soak power 2 (50%) and time at soak power 2 (50%).

Rate (0 to 999Å/second) - Desired deposition rate when system is in automatic control.

Tooling (20.0 to 499%) - A programmable constant which allows instrument calibration for systems where there exists a geometric difference in the crystal sensor and substrate location.

Group 2

Soak Power 1 (0 to 99%) - Power level for preconditioning new melt.

Soak Power 2 (0 to 99%) - Power level selected to produce a deposition rate close to desired auto-control rate.

Maximum Power (0 to 99%) - Level which limits the maximum any output power can achieve.

Idle Power (0 to 99%) - When thickness 2 is reached, deposition power returns to this preselected level.

Gain (0 to 99) - Loop constant which is experimentally determined to achieve most stable automatic rate control.

Group 3

Thickness 1 (0 to 999.9 kÅ) - Provides a one second duration solid state relay closure when thickness equals preset value.

Thickness 2 (0 to 999.9 kÅ) - Terminates deposition cycle when thickness displayed equals preset value. Solid state relay closure for one second is also provided. Thickness 1 must be equaled or exceeded before thickness 2 becomes operative.

Density* (0.800 to 99.99 gm/cc) - Value determined by type of material being evaporated.

Z-ratio* (0.100 to 1.990) - Value determined by elastic properties of material being evaporated. Section 5.0 describes the concept of Z-match and lists values for some common materials.

Source/Sensor* (1-3/1-3 XMS-3 only) - Unit will accommodate three sources and three sensors with the ability to accept any source/sensor combination at all three layers of deposition.

g. Status Indicators

A group of indicators located directly below displays which give visual indication of state of the automatic run:

Rise
Soak 1
Soak 2
Deposition
Thickness 1
Thickness 2
Idle

---

*These quantities can not be entered or changed when the program is in any power control mode.

h. Data Entry Keyboard

The keyboard is activated by placing the unit into the program mode, depressing blue pushbutton behind door (program status lamp illuminated). Clear key clears displayed data only and does not effect data in memory. New data are entered via the enter key.

The following controls are located behind the hinged door at the bottom of the front panel:

a. Power On/Off Switch

When in the on position, this switch supplies ac line power to the unit and activates the auxiliary battery circuit. The battery is continually charging when the unit is on and line power is present. Ac power interruption places the unit on battery operation and will maintain program memory for 16 hours.

Caution: If the unit is turned off for extended period of time, be sure the power switch is in the off position or total discharge of the battery will occur.

b. Lamp Test

A momentary switch which allows testing of all lamps which do not operate with a front panel switch. Displays will show all 8's, zero flashing, T/X flashing and status lamps.

c. Test

Depressing test switch lights test indicator. A description of operation is contained in the preliminary checkout section.

d. Keyboard

Momentary switch which unlocks data entry keyboard shown by lit program indicator lamp. Depressing switch a second time returns unit to normal. When system is placed in program, data address rise time is lit, and only the displays above this address are on.

e. Control Power (Auto/Manual)

When switch is in the manual position, manual power indicator is on and the output power level remains at last value prior to switch change. Power level in manual mode may be controlled with hand-held controller. In automatic position deposition power is controlled at rate set point.

2.2 Rear Panel Connections (Figure 2-2)

a. System Interface J6

All inputs are optically isolated from internal circuitry and require 60 - 135 Vac signal between the common input (17, 18) and function input. Numbers in ( ) are pin connections.

Stop (14) - Momentary input terminates power to all sources and front panel stop lamp is illuminated.

Zero (5) - Momentary input zeros thickness reading and elapsed time upon removal of signal.

Start (10) - Momentary input initiates start of programmed cycle. Constant input will automatically cycle XMS-3 through three layer deposition.

Note: Stop, zero or start inputs can be simultaneously activated. The occurrence of any two is treated as a stop. Momentary inputs to these controls should be a minimum of 1.0 second duration.

Crystal Fail Enable (13) - With this input activated, crystal failure will initiate an abort (stop) condition returning all source power control to zero. In a normal state crystal failure holds source power at the value existing just prior to failure.

Soak Hold (9) - A constant input will prevent program from proceeding beyond soak 1 power.

Maximum Power Enable (6) - When the input is activated, the XMS will stop when deposition power exceeds programmed maximum power level for a period in excess of 6 seconds. Deposition power is limited to maximum power setting when input to this function is inactive.

Common (17,18) - Circuit common to above inputs.

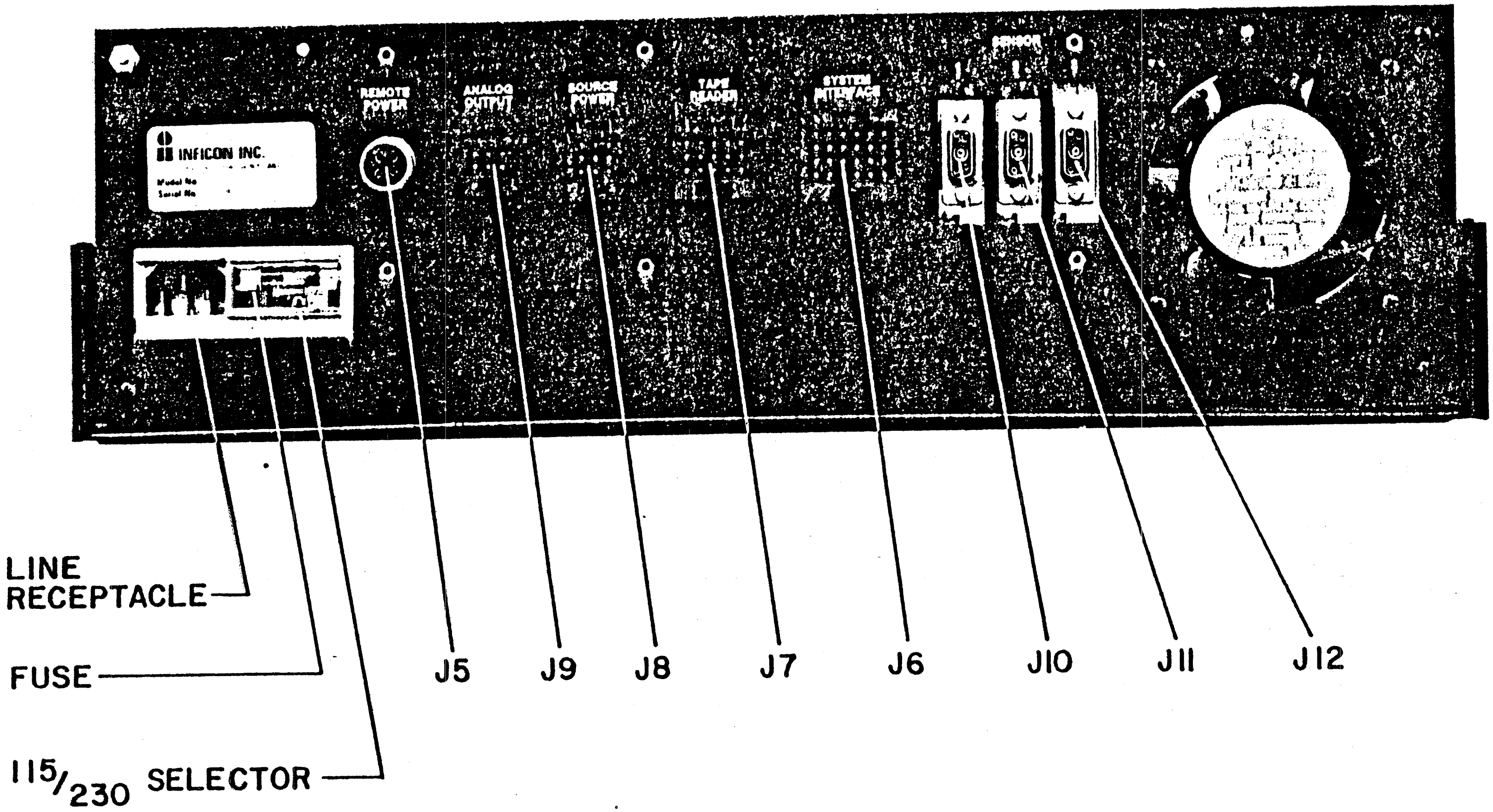


Figure 2-2 XMS-3 Rear Panel

All outputs are rated at 135 Vac, 3 amp rms maximum. Numbers in ( ) are pin connections.

Cycle Triac (3,4) - This output may be internally wired to provide a circuit closure during any of the following programmed functions. The diodes to be connected are located on board XMS-350.

Rise	CR-39
Soak 1	CR-41
Soak 2	CR-38
Deposit	CR-40 (Factory Wired)
Crystal Fail	CR-42

Abort (19,20) - Triac opens whenever maximum power is exceeded for greater than 6 seconds or system experiences crystal failure (see Maximum Power Abort Enable and Crystal Fail Abort Enable above).

Thickness 1 (1,2) - Circuit closure for 1.0 second when actual thickness reading equals preprogrammed thickness 1 while in automatic deposition.

Thickness 2 (23,24) - Circuit closure for 1.0 second when actual thickness reading equals preprogrammed thickness 2, while in automatic deposition. Thickness 1 must be equaled or exceeded before thickness 2 becomes operative.

Shutter 1 deposition (7,8); Shutter 2 deposition (11,12); Shutter 3 deposition (15,16) - Triac closes at beginning of deposition and opens at thickness 2 of the specified layer. These outputs are intended for shutter control in a multiple shutter system. For control of a single shutter the cycle triac can be used if uncommitted. If cycle triac is being used, shutter 1, 2 and 3 should be paralleled for single shutter operation. Shutter 2 and shutter 3 outputs are provided on XMS-3 only.

b. Source Power J8

The XMS-3 is capable of delivering three independent source control voltages with a range of 0 to -10 volts (0 - 100%) at a maximum current 20 mA. All three outputs are referenced to Pin 7 on the connector.

Control Source A	- Pin 5
Control Source B	- Pin 4 (XMS-3)
Control Source C	- Pin 1 (XMS-3)
Reference	- Pin 7

c. Sensor 1, 2, 3 (J10, 11, 12)

Signals from crystal sensor are connected to the XMS through these plugs. J11, 12 are installed in the XMS-3 only.

d. Remote Power (J5)

The hand-held power controller (P/N 006-016) is connected to this jack when manual control of source power is desired.

e. Main Power

This assembly contains a male connector for line power input, line fuse and a selector switch for 115 or 230 Vac input operation. Unit is shipped with switch in 115 Vac position.

2.3 Thickness Sensor

Inficon's thin profile sensor head allows great flexibility in mounting in the vacuum chamber. The sensor head is designed for use in thermal evaporation.*

An exploded view of the thickness sensor is shown in Figure 2-3. The 6 MHz AT-cut quartz crystal is mounted in the cover and held in place with the crystal pressure assembly. This design simplifies the replacement of the sensor crystal in the vacuum system.

The design of the sensor is such that the crystal is edge mounted. This maintains high crystal activity and freedom from mode hopping even with large mass loading. Thermal stability is provided using a small aperture and efficient water cooling. The exposed surface of the crystal is grounded to eliminate the effects of electrical disturbances such as RF field interference and accumulation of charged particles.

*If using Inficon's Sputtering Sensor Head or Bakeable Sensor Head, refer to individual instruction booklet, or sheet, for usage instruction and assembly drawings.

A321-003

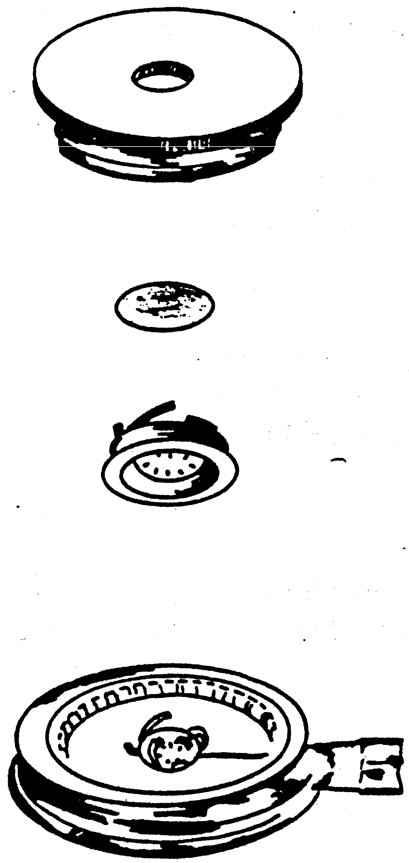


Figure 2-3 Exploded View of Sensor

3.0 PRELIMINARY CHECKOUT

This section is designed to help the new user of XMS to familiarize himself with the basic operation of the instrument. In addition, it provides an excellent method for determining whether or not the unit is functioning properly.

3.1 Initial Setup and Programming

Proceed through the following steps, referring to Section 2.0 if there are questions regarding the function of various programmable data.

a. Connections

The unit requires 115 Vac (for hookup to 230 Vac line, refer to Section 4.1) input power. In addition, connect the oscillator cable (321-40) supplied to input connector sensor 1 located at the rear of the instrument. The sensor head may now be connected to the oscillator cable by using the cable supplied with the head and a Microdot to BNC adaptor. If a vacuum feedthrough was purchased with the system, this can be used for the adaptor. The sensor head is shipped with a crystal installed. For instructions on proper vacuum installation and changing of crystal, refer to Section 4.3.1.

b. Initial Turn-on

When the instrument is initially turned on, the following indicators will be lit:

Start	Group 1 Displays (000)
Layer 1 (XMS-3 only)	Rise Time Address
Program	

Test and Manual Power may be lit depending on switch settings.

In addition, the unit is preprogrammed in all three layers with the following data:

Rise	000
Soak Time 1	000
Soak Time 2	000
Rate	000
Tooling	100
Soak Power 1	00
Soak Power 2	00

Maximum Power	90
Gain	10
Thickness 1	0000
Thickness 2	0000
Density	1.00
Z-ratio	1.000
Source/Sensor	1/1 (XMS-3 only)

c. Programming

At this point the instrument is ready to accept the program data. The format and general rules for programming the XMS are listed below:

Data entry is a two-stage operation: i) enter data into displays and ii) enter data into memory.

Data existing in memory are not erased until new data are entered via the entry key.

Clear key clears display data only.

When entering new data, the first entry from the keyboard clears the displays and enters the depressed digit from the right. Therefore, new data may be entered into the displays directly without first clearing old data.

Successive digits are entered from the right as keyed.

Thickness 1 and thickness 2 incorporate auto-ranging. Full scale ranges are 9.999 kÅ, 99.99 kÅ and 999.9 kÅ. When entering data in these addresses, observe decimal shift if desired thickness is greater than 10 kÅ.

Data entered into the displays which are outside the boundary conditions specified for each function (see Section 2.1(f)) will not be accepted when the entry key is pressed.

When data are entered via entry key, unit automatically steps to next address.

Zeros may be entered in thickness 1 if this control is not required.

Thickness 2 is the controlling function in terminating deposition; therefore, data entered are always greater than zero. For normal operation thickness 2 must be greater than or equal to thickness 1.

Individual address selection is achieved by pressing key adjacent to address.

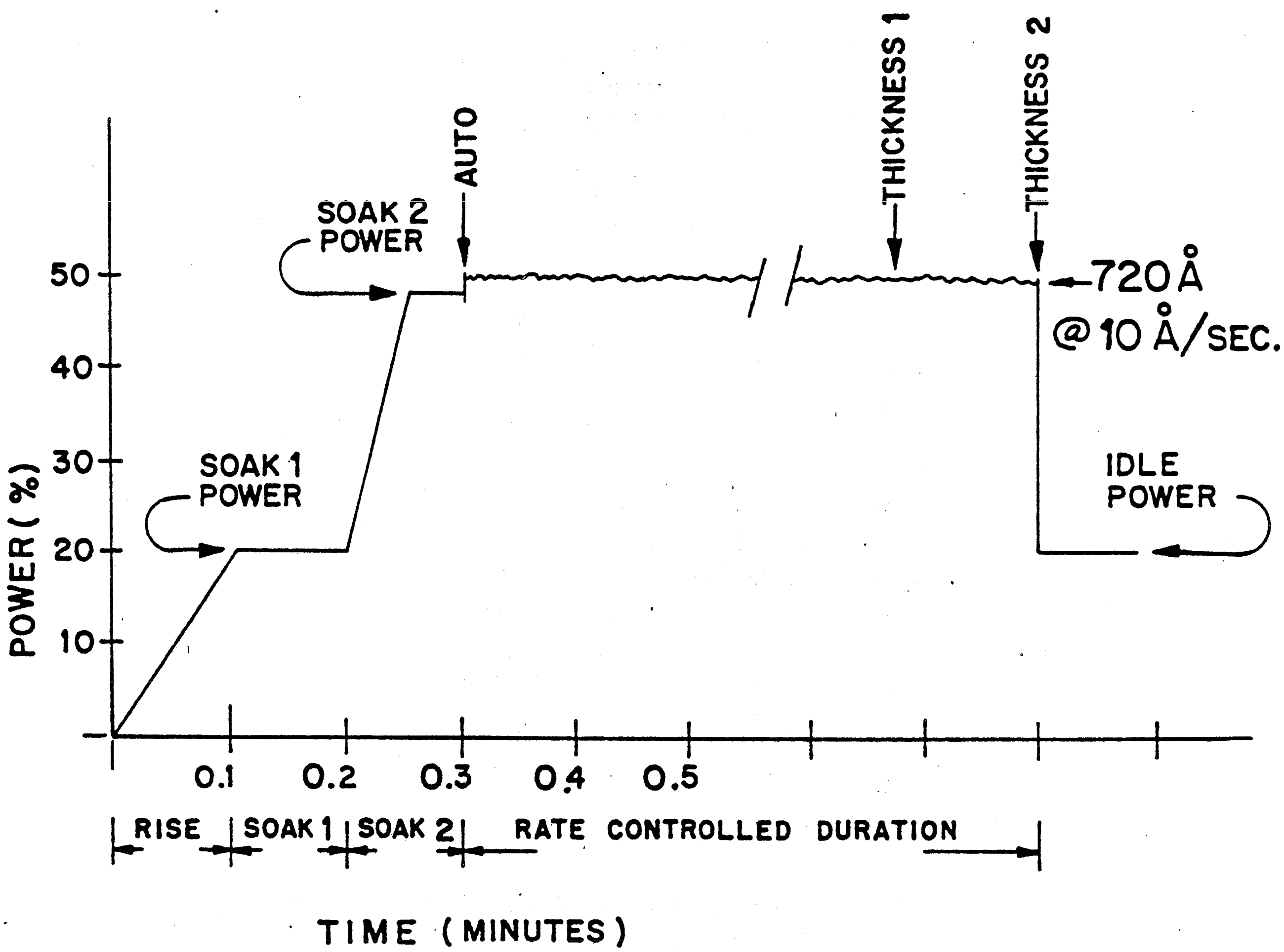
Value for percent tooling should be rounded off to nearest 1%. When entering data, last digit (i.e., digit used for decimal point shift) must be zero.

The sample program below will help demonstrate the proper procedure. Figure 3-1 is a graphic representation of a typical run.

Rise Time	00.1 minute
Soak Time 1	00.1 minute
Soak Time 2	00.1 minute
Rate	10Å/second
Tooling	100%
Soak Power 1	20%
Soak Power 2	50%
Maximum Power	60%
Idle Power	20%
Gain	40
Thickness 1	0.700 kÅ
Thickness 2	0.720 kÅ
Density	1.00 gm/cc
Z-ratio	1.000
Source/Sensor	1-1

The first data to be entered are rise time. This is executed by pressing #1 key on the data keyboard and observing 0.1 on the display. Depressing the enter key places these data in memory and automatically steps the unit to the next address, soak time 1. The above sequence is continued entering the above format until source/sensor address is reached at which time entering 1-1 into the memory steps the instrument to ready to program layer 2 rise time. If it is desired to test or run multilayers on a XMS-3, the procedure for programming layers 2 and 3 is exactly as above.

When using the XMS-3 in a multilayer coating system, the unit will automatically cycle through each layer. Starting with layer 1, a start command initiates the run; and when thickness 2 is achieved, the unit remains in layer 1 displaying final thickness and idle power. A second start command automatically shifts the unit to layer 2, and the



OTHER DEPOSITION PARAMETERS:

TOOLING 100%
MAX. POWER 60%
GAIN 40
1ST THICKNESS ... 700 Å

Figure 3-1 Sample Deposition Run

program proceeds through this layer. If it is desired to use the XMS-3 with a 1 or 2 layer system, enter zeros in the source/sensor of those layers to be omitted. For example, if the unit is to be used as a single layer system, zeros entered in source/sensor address layers 2 and 3 will insure that each start command will initiate a layer 1 deposition.

3.2 Test Procedure

After any or all data entries have been completed, the unit may be returned to the ready-to-start mode by depressing the momentary program switch. In this mode the following indicators should be lit:

Start
Layer 1
All numerical displays.

The internal test mode of operation in this instrument provides an excellent way to initially check out the unit prior to installing it into a system. Proceed with the steps listed below, noting the sequence of visual indicators:

a. Test switch on; press zero switch

Start lamp on
Layer 1 lamp on
Rate display 10Å/sec
Power display 00
Thickness display increasing in value

b. Press start

Start lamp off
Layer 1 lamp on
Rise time status lamp on
Power display increasing
Rate display 10Å/sec
Power equal to 20%; soak time 1 status lamp on
Rise time status lamp on for 50% of soak time 2
Soak time 2 status lamp on; soak power 2 rises to 50%
Thickness reading zeros; deposit status lamp on
Thickness reads 0.700 kÅ; thickness 1 status lamp on
Thickness equal to 0.720 kÅ; thickness 2 status lamp on; idle power status lamp on; power display reaches 20%
Thickness continues to increase
Start and layer 1 lamps on

c. Press T/X switch and elapsed time should read 1.2 minutes.

d. Return test switch to off position.

The internal test mode is designed to simulate a constant rate of 10Å/sec. It is easy, therefore, to validate the performance of rate control, density and tooling factors. The preceding test run displayed a rate of 10Å/sec and a fixed power level when in deposition. This was due to the values of the function rate = 10Å/sec, density = 1.00 and tooling = 100%. Make the following program change and note the effect on displayed rate and deposition power when a test run is initiated.

a.	Program	Rate = 20Å/sec Tooling = 100% Density = 1.000
	Effect	Rate Display = 10Å/sec Deposition power increasing, and zero key flashing when maximum power is reached
b.	Program	Rate = 10Å/sec Tooling = 400% Density = 1.000
	Effect	Rate Display = 40Å/sec Deposition power decreasing
c.	Program	Rate = 10Å/sec Tooling = 100% Density = 2.000
	Effect	Rate Display = 5Å/sec Deposition power increasing

In general while in test mode, any rate set point greater than displayed rate should increase power and rate set point less than displayed rate should decrease power.

3.3 Manual Power Controls

Because of the variations in types of coaters and control parameters, it is necessary to establish functions such as soak power 1 and soak power 2 by experimentation. The hand-held power controller will allow an operator to determine these power levels. The hand-held controller connector is located at the rear of the instrument, and the following steps outline the proper use:

a. The instrument in ready-to-start mode (start indicator lit)

b. Auto/manual switch in manual position (manual indicator lit)

c. Desired layer indicator lit (check for proper source selection by pressing source sensor)

d. The hand-held controller contains a three-way switch. All positions are momentary and will return to rest when released. Pushing the switch forward or aft will cause the output control voltage to increase or decrease as observed on the power displays. A downward pressure on the switch will immediately return power to zero (stop).

4.0 INSTALLATION

4.1 Installation in Coating System (Figure 4-1)

A few precautions should be taken when interfacing the XMS and the coating system:

a. When rack or cabinet mounting the XMS, insure there is adequate ventilation.

b. The cooling fan located at the rear of the instrument should be free of obstructions.

c. Provide a ground strap between lug (rear panel) on unit to the vacuum system's main ground point.

d. Ac line power should be removed from XMS whenever connections are being made.

e. At no time should the input or output ratings be exceeded.

f. The instrument is shipped for use with 115 Vac main power. If operation is required with 230 Vac, change position of selector switch (Figure 2.2). This is accomplished by removing fuse and sliding switch to extreme left position.

THIS DOES NOT CHANGE RATING ON EXTERNAL INPUT AND OUTPUTS. MAXIMUM 135 Vac.

4.2 Rear Panel Connections (Figure 2-2)

4.2.1 Interface (J6)

All control inputs and outputs are accessible at this connector. Utilizing the mating connector and pins supplied, interconnections between the XMS and coating system may be 20 gauge wire or smaller. Precaution should be taken when soldering the pins to insure that solder does not flow to the contact portion of the pins. Figure 4-2 shows functions together with their pin location. For functional description of inputs and outputs, refer to Section 2.2.

The inputs are optically coupled to the internal circuits of the XMS. This type of coupling gives excellent isolation between the coating system and the XMS without placing special restrictions on the driving circuitry. A simple contact closure (Figure 4-3) supplying a 50-60 Hz signal of 60 to 135

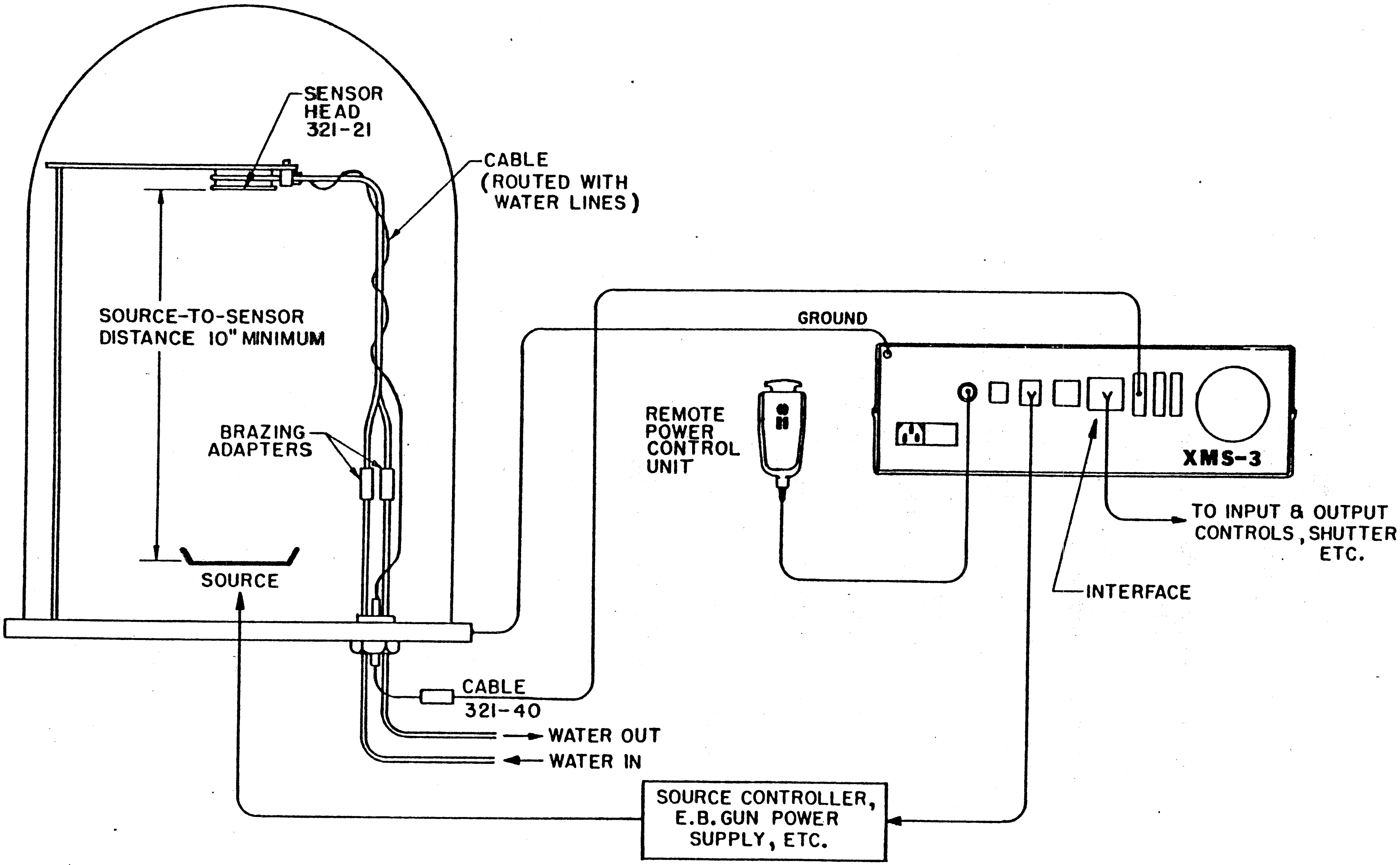


Figure 4-1 Typical Installation

Pin	Function
1,2	Thickness 1 Triac
23,24	Thickness 2 Triac
17,18	Common Input
19, 20	Abort Triac
7,8	Shutter 1 Triac
14	Stop Input
10	Start Input
11,12	Shutter 2 Triac (XMS-3)
15,16	Shutter 3 Triac (XMS-3)
5	Zero Input
9	Soak Hold Input
3,4	Cycle Triac
21	---
22	---
13	Crystal Fail Abort Enable
6	Maximum Power Abort Enable

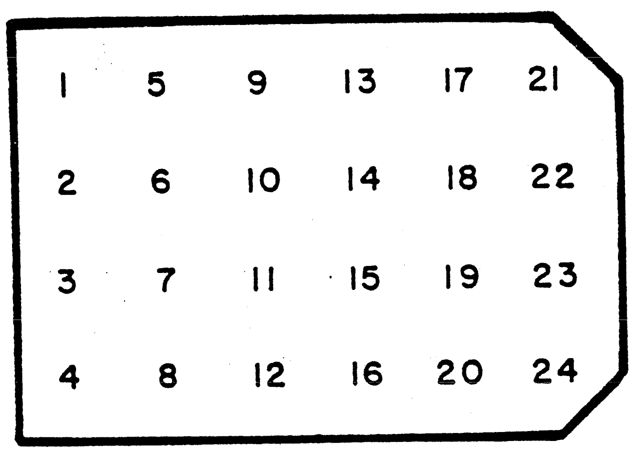


Figure 4-2 J6 System Interface

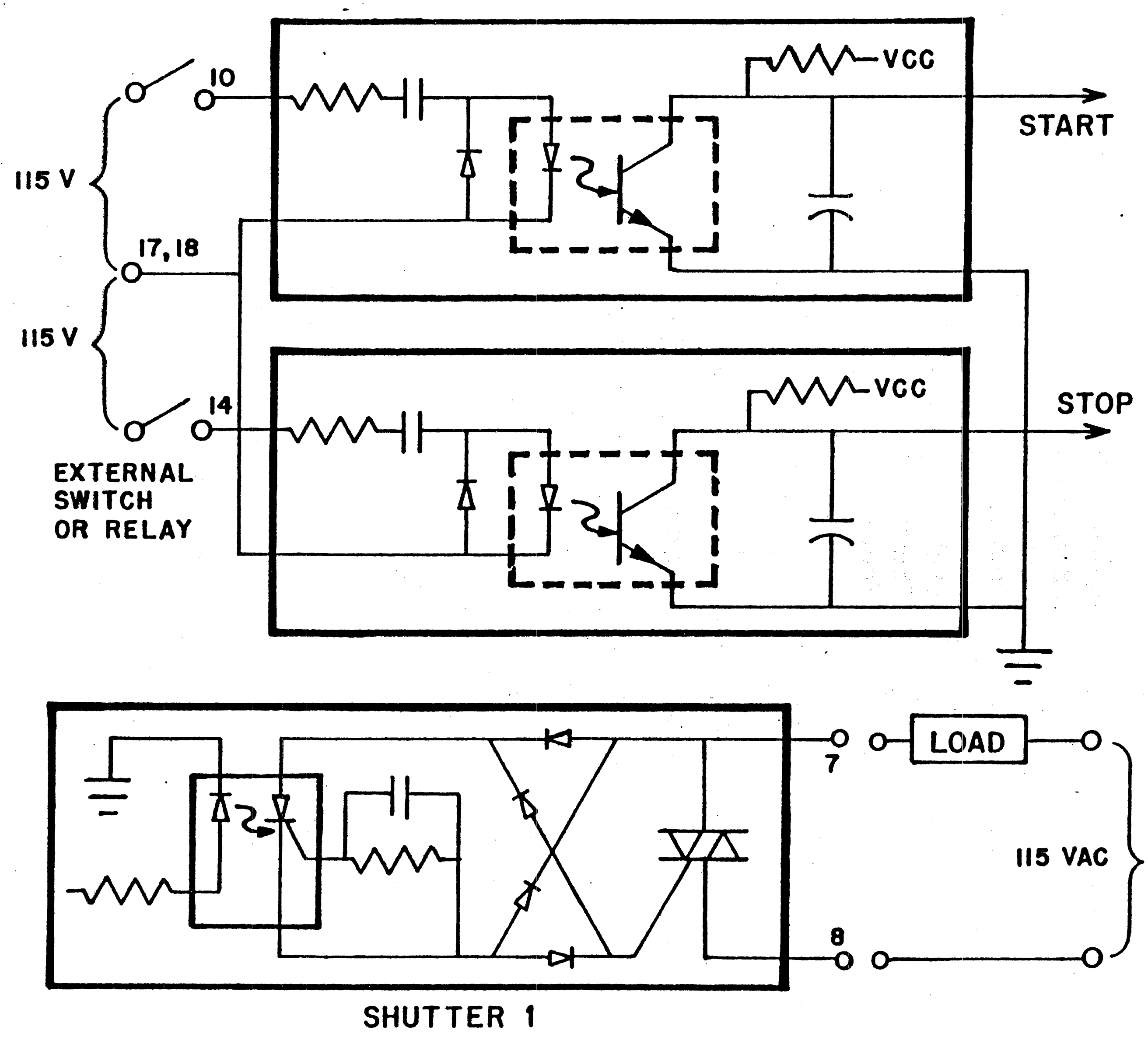


Figure 4-3 Interface Circuits

volt rms will activate these inputs. Current requirements are less than 50 mA rms when using 135 volt input.

CAUTION: Due to the common input (17,18), it is necessary to maintain ac line identity when interfacing the instrument to the coating system.

The outputs are also optically isolated with each circuit being independent (Figure 4-3). The triacs providing circuit closure are rated at 135 volts, 3 amps, and to insure reliability this rating should never be exceeded.

4.2.2 Source Power (J8)

Three separate control voltage outputs (XMS-3) are supplied at the connector (Figure 4-4). The output ranges from 0 to -10 volts and is capable of driving a load current of 20 mA. These outputs are driven by optical isolators in order to effectively decouple the unit from external noise. It is possible, however, to bypass the optical couplers with a simple wire change on the XMS-330 circuit board (see Section 6.0). This is not a recommended mode of operation and should only be considered for special applications.

4.2.3 Sensor 1, 2, 3

The 321-40 oscillator cable, supplied with the XMS, is connected to these inputs. Each input is a separate circuit, and input selection is determined when programming the unit. The normally supplied length of the oscillator cable is 10 feet, and longer lengths are available by special order. Only sensor 1 input is provided on XMS-1.

4.3 Installation of Sensor Head

The sensor head can be installed in any appropriate location in the vacuum chamber. It can be supported by the two 4-40 screws on the mounting bracket or by the water cooling tube alone. The cable length from the sensor head to the feedthrough should not exceed 40 inches. The water cooling tube should be cut to proper length and connected to the feedthrough by brazing or by using vacuum couplings. Shield the sensor cable from the radiation heat which comes from the evaporation sources or the substrate heater. If process allows, simply wrap aluminum foil around cable and water lines. This will extend the useful life of these components.

Pin	Function
5	Control Source A
4	Control Source B (XMS-3)
1	Control Source C (XMS-3)
7	Control Reference
2	---
6	---
3	---
8	---
9	---

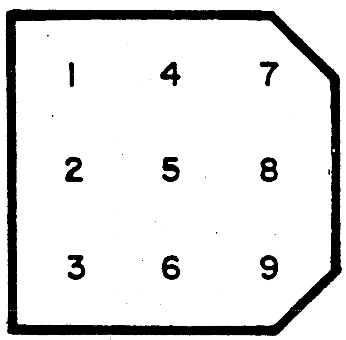


Figure 4-4 J8 Source Power

In installing the sensor head, the following precautions should be observed:

a. Water cooling is always recommended except for short depositions at low temperatures. For best stability the head temperature should not be allowed to exceed 100°C during operation. Approximately 0.2 gpm water flow should provide sufficient cooling for most applications.

b. Place the sensor head as far as possible from the evaporation source, preferably more than 10 inches. For complete system calibration, see Section 5.0.

c. If the evaporating material spatters during deposition and a small droplet of molten material hits the crystal, damage to the crystal may result causing the oscillation to cease. Use a shutter to shield the sensor head during the initial soak period which will help alleviate the problem.

4.3.1 Replacing the Crystal

Grip the sensor head cap with fingers and pull it straight out by squeezing finger tips in between the lip of the cap and the water cooling tube. Enclosed with each sensor head is a crystal snatcher (P/N 007-035). As shown in Figure 4-5, the crystal snatcher is inserted into the ceramic retainer (A) and a small amount of pressure applied. This tends to lock the retainer to the snatcher and allows the retainer to be pulled straight out (B). Once the crystal has been changed, the retainer may be inserted into the sensor cover and a slight side-to-side motion will release the crystal snatcher. Snap the cap onto the body of the sensor head.

Observe the following precautions in handling and using the crystals:

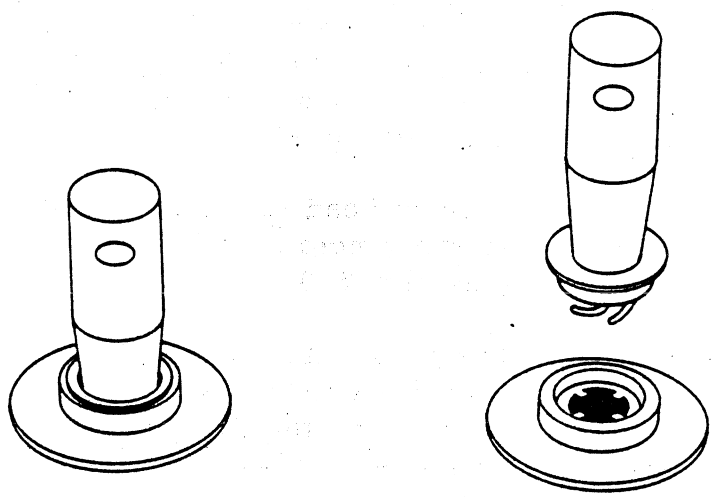
a. Always use clean lab gloves or plastic tweezers for handling the crystal to keep it free from contamination.

b. Observe crystal polarity (Figure 4-5).

c. Do not rotate the ceramic retainer assembly after it is seated as this will cause scratching of the electrode on the crystal and may result in intermittent or poor contact.

d. Certain materials, especially dielectrics, may not adhere strongly to the crystal surface and cause erratic readings.

e. It is normal for thick deposits of certain materials, such as SiO and Si to peel off the crystal when exposed to air. This is due to the change of film stress by gas absorption.



(A) (B)

Figure 4-5 Crystal Replacement

4.4 Final Programming

Refer to Section 3.0 for programming procedures. Several parameters in the final program must be determined by actual deposition:

Soak Power 1
Soak Power 2
Tooling Factor
Gain

It is suggested that a value of 10 be programmed for gain in the initial run. Adjustment of this parameter can be made during a controlled deposition, optimizing the value to achieve shortest acquisition time of desired rate and stable overall control. Soak power 2 should be set to a level which will achieve desired rate. This condition will also help in reducing the time required for establishing desired rate control. For calibration of tooling factor, density and Z-ratio, refer to Section 5.0.

CAUTION: If a test mode run is desired to check the unit out, the control voltage output signal exits at source power (J8) connector.

5.0 CALIBRATION

5.1 Theory of Operation

The evolution of commercial quartz-crystal film thickness monitors can be divided into three stages:

a. Frequency Measurement Techniques

The use of quartz-crystal resonator to measure deposited film thickness was first explored by Sauerbrey* in 1959 and later developed into a commercial unit. The thickness frequency equation used is given by

$$T_f = -(N_q d_q / d_f f_q^2) \quad (f_c - f_q) \qquad (1)$$

where

T_f = film thickness (cm)

d_q = density of quartz (g/cm^3)

d_f = density of film (g/cm^3)

N_q = $f_q l_q$ = frequency constant for AT-cut quartz crystal (Hz/cm)

l_q = thickness of quartz crystal (cm)

f_q = resonant frequency of unplated crystal (Hz)

f_c = resonant frequency of loaded crystal (Hz).

Extensive theoretical studies were made to derive Eq (1) with the assumption that the deposited mass is much smaller than the mass of the quartz crystal, or $(f_c - f_q) << f_q$. Experimentally, it was found that in order to keep the thickness measurement within a reasonable accuracy, the maximum frequency shift allowable by this technique is limited to about 2% of f_q.

b. Period Measurement Technique

The second generation quartz-crystal thickness monitors used the following equation for thickness computations:

*Sauerbrey, G.Z., Physik 155, 206 (1959).

$$T_f = (N_q d_q/d_f)\ (t_c - t_q) \qquad (2)$$

where $t_c = 1/f_c$ and $t_q = 1/f_q$ are the period of oscillation for the loaded and original crystals, respectively. It is apparent that for a small frequency shift Eq (1) becomes a good approximation of Eq (2). Although it has been experimentally demonstrated that Eq (2) is reasonably accurate for selected materials with frequency shifts of up to 10% of f_q, the theoretical justification of using Eq (2) for thickness computation was lacking. In addition, recent tests on validity of Eq (2) indicated that significant errors begin to appear for a majority of materials with crystal frequency shift as small as 5% of f_q. When the quartz crystal monitor is used to measure the rate of deposition, the errors in indicated rate become even more serious because the thickness error is a time varying function and rate is the derivative of thickness with respect to time.

c. Z-match Technique

Recent advances in crystal design and improved driving circuitry allow the quartz crystal to keep oscillating even with very large amounts of deposited material on it. In many cases frequency shifts of more than 20% of f_q can be achieved. Also, complex and precise mathematical calculations can be easily performed with modern digital circuitry. Therefore, if an exact thickness frequency equation can be found, an instrument can be developed which does not have to be a compromise between accuracy and crystal life.

Miller and Bolef* were the first to treat the quartz-film composite as a one dimensional compound acoustical resonator. Their results indicated that the elastic properties of the deposited film should be related to the frequency shift. A further study on their original solution resulted in a simpler thickness frequency equation in the form of

$$T_f = (N_q d_q/\pi d_f f_c Z) \tan^{-1} (Z \tan [\pi (f_q - f_c)/f_q]) \qquad (3)$$

where

$$Z = (d_q \mu_q/d_f \mu_f)^{1/2}$$

is the acoustic impedance ratio with μ_f and μ_q the shear moduli of deposited film and quartz crystal, respectively. Eq (3) shows that materials with different elastic properties will obey different thickness frequency relations. This phenomenon has been verified experimentally in our laboratory for a number of materials.

*Miller, J.G. and D.I. Bolef, J Applied Phys 39, 4589 and 5815 (1968).

The experimental results demonstrated that if the density and Z value of the deposited material are known, the film thickness can be determined to a remarkable accuracy by using Eq (3).

Another significance of Eq (3) is that for the first time the validity of "period measurement" technique, or Eq (2), can be explained from a theoretical point of view. Through a simple algebraic exercise, one can easily show that Eq (2) is a special case of Eq (3) with Z = 1, or quartz on quartz.

The Inficon XMS uses the concept of a microcomputer and incorporates an approximated form of Eq (3) for thickness computation. The acoustic impedance ratio Z can be entered into the instrument as a separate material constant. A reproducibility of better than 2% for both thickness and rate can thus be achieved with no restrictions on the allowable frequency shift of the crystal.

5.2 Thickness Readout Calibration

5.2.1 Density

Place a substrate with proper masking for film thickness measurement adjacent to the sensor head so that the same thickness will be accumulated on the crystal and this substrate. Set density to the bulk value of the film material or to an approximate value, Z-ratio to 1.000 and tooling to 100%. Place a new crystal in the sensor head and make a short deposition (1000-5000Å) by using the manual control. After deposition remove the test substrate and measure the film thickness with either a multiple beam interferometer or a stylus type profilometer. A new density value can be determined using the relationship:

$$\text{Density (g/cm}^3) = D_1 \frac{T_x}{T_{M_x}}$$

where

D_1 = Initial density setting

T_x = Thickness reading on XMS

T_{M_x} = Measured thickness.

Program the XMS with the new density value and observe that the displayed thickness is equal to the measured thickness. Slight adjustment of density may be necessary in order to achieve $T_x = T_{M_x}$.

5.2.2 Z-ratio

A list of Z values for commonly used materials in thin film technology are given in Table 5-1. For other materials Z can be calculated from the following formula:

$$Z = (d_q \mu_q / d_f \mu_f)^{1/2}$$

$$= 8.834 \times 10^5 \, (d_f \mu_f)^{-1/2}$$

where d_f and μ_f are the density (g/cm^3) and shear modulus ($dynes/cm^2$) of deposited film, respectively. The densities and shear moduli of many materials can be found in a number of handbooks.

Table 5-1
Z VALUES FOR COMMON MATERIALS

Material	Z
Pb	1.125
Al	1.077
S_iO_2 (amorphous)	1.066
Ti	0.627
Ag	0.529
Zn	0.511
Cu	0.437
Au	0.381
Ni	0.332
Pt	0.239

Results obtained in our laboratory indicated that the Z values of materials in thin film form are very close to the bulk values. However, for high stress producing materials, Z values of thin films are slightly smaller than those of the bulk materials. For those applications where more precise calibration is required, the following direct method is suggested.

Using the calibrated density and 100% tooling, make a deposition such that the percent crystal life display will read approximately 50% or near the end of crystal life for the particular material, whichever is smaller. Place a new substrate next to the sensor head and make a second short deposition (1000-5000Å). Determine the actual thickness on the substrate as suggested in density calibration. Adjust Z-ratio value in the XMS to bring thickness reading in agreement with actual thickness.

For multiple layer deposition, for example two layers, the Z value used for the second layer is determined by the relative thickness of the two layers. For most applications the following three rules will provide reasonable accuracies:

a. If the thickness of layer 1 is large compared to layer 2, use material 1 Z value for layer 2.

b. If the thickness of layer 1 is thin compared to layer 2, use material 2 Z value for layer 2.

c. If the thickness of both layers are similar, use a value for Z-ratio which is the weighted average of the two Z values for deposition of layer 2.

To achieve the ultimate in precision, a multiple sensor head arrangement with appropriate shuttering is necessary.

5.2.3 Tooling

Place a test substrate in the systems substrate holder. Make a short deposition and determine actual thickness. Calculate tooling from the relationship:

$$\text{Tooling (\%)} = 100 \times \frac{T_{M_s}}{T_x}$$

where T_{M_s} = Actual thickness at substrate holder

T_x = Thickness reading in XMS.

The percent Tooling should be rounded off to the nearest 1%. This value may be entered into the XMS program and $TM_s = T_x$ will be observed.

5.3 Output Calibrations

5.3.1 Control Output, XMS-330

There are two adjustment potentiometers per output located on this board. Only if a component in one of the outputs is changed will it be necessary to adjust the associated potentiometers. This adjustment can be performed by following these steps:

a. Select layer 1 (XMS-3 only)

b. Program source to be adjusted (1, 2 or 3 in XMS-3)

c. Depress stop switch and observe percent power equal to zero

d. Connect voltmeter to appropriate output and adjust zero pot for zero volt out (R4, 10 or 16)

e. Program maximum power equal to 99%

f. Place control power switch in manual position

g. Using hand-held power controller, adjust percent power reading equal to 99%

h. Adjust maximum potentiometer (R3, 9 or 15) for a reading of -10 volts on the voltmeter.

5.3.2 D/A Option, XMS-340

A simple means for calibrating a strip chart to the analog output is provided. For example, assume a rate recording on a strip chart with a full scale of 999 Å/second calibration.

a. Place the XMS in the program mode

b. Select rate address

c. Enter 500 Å/second into memory

d. Recall rate address

e. Adjust recorder sensitivity to achieve a half scale deflection

f. Enter 999 Å/second into memory

g. Recall rate address

h. Strip chart recorder should read full scale.

The above illustrates that by using the memory of the XMS as a source of rate and thickness display that it is a simple matter to calibrate the analog readout to the desired level of resolution prior to actual evaporation.

6.0 REPAIR AND MAINTENANCE

6.1 General Circuit Description

The objective of this section is to familiarize service personnel with the various PC boards in the XMS and the role they play in the overall operation of the unit. Each board is broken down into functional blocks, and a brief description is provided. Figures 6-1 and 6-2 show system block diagram and schematic. An interior view of the XMS-3 is shown in Figure 6-3.

The XMS-310 micro processor board has intentionally been omitted due to its complexity. Service hints in a later section will, however, provide a means for determining if a malfunction has occurred in this board.

6.1.1 Measurement, XMS-320 (Figure 6-4)

The initial thickness measurement is accomplished by determining the variation in the period of the sensor crystal's oscillation. Figure 6-4 is a block diagram of this basic computation.

A time gate (a) is generated by accumulating a constant number of pulses supplied by the sensor crystal and oscillator. The width of the time gate is therefore proportional to the period of these pulses. As material is deposited on the sensor crystal, its frequency decreases, in turn increasing the width of the time gate. This gate is nominally 0.5 seconds. The actual duration of the timing gate is determined by allowing this gate to control the sample time of a second counter (b). The input to the counter is provided by a 14.7 MHz crystal controlled oscillator.

At the beginning of each sample period, the counter (b) is preset to a number approximately equal to the frequency of a new sensor crystal. Thus at the end of each sample period, the coded number existing in the counter is proportional to the total accumulated thickness on the sensor crystal.

The remainder of this board contains a multiplexer which transfers the thickness information to the data bus. In addition, all external inputs are multiplexed through this unit to the same bus.

6.1.2 Control Output, XMS-330 (Figure 6-5)

This board contains three digital to analog converters when used in an XMS-3 and one when used with an XMS-1. The data input is supplied by an input bus, and this bus is multiplexed to the three D/A converters by a decoder. The final output is coupled through an optical isolator providing a high degree of decoupling between external noise and the internal circuits of the XMS.

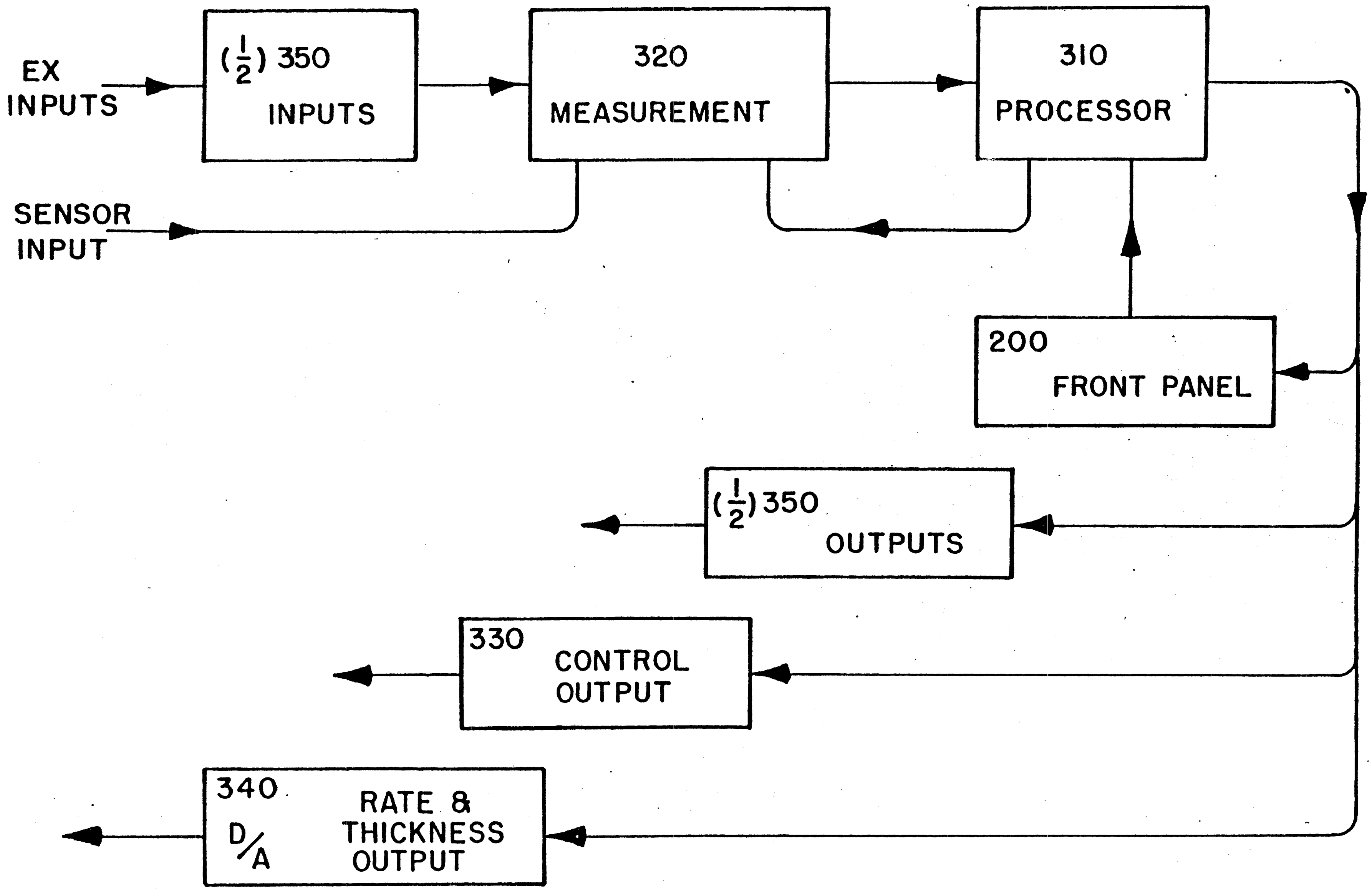


Figure 6-1 XMS-3 Block Diagram

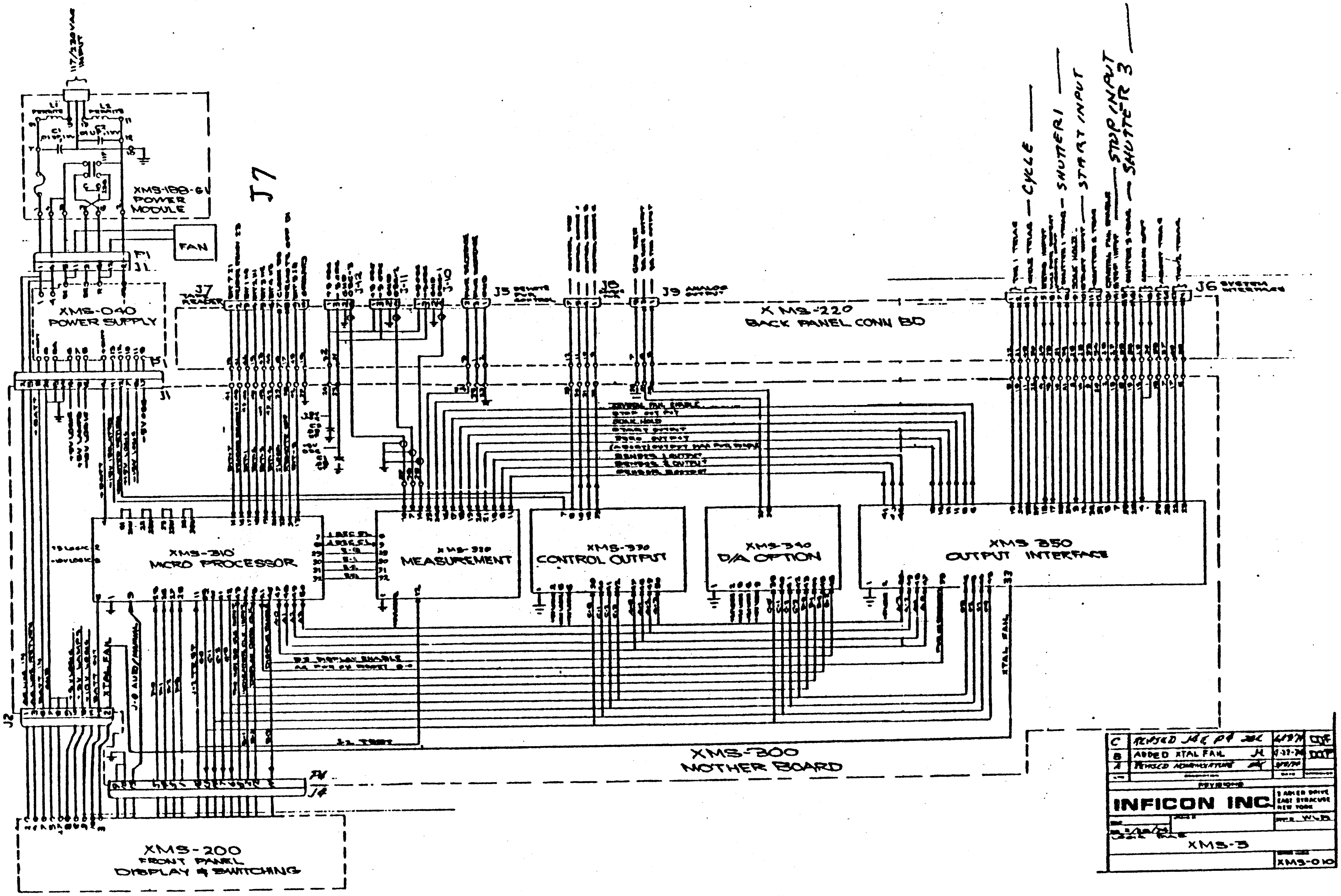


Figure 6-2 XMS-3 Circuit Diagram

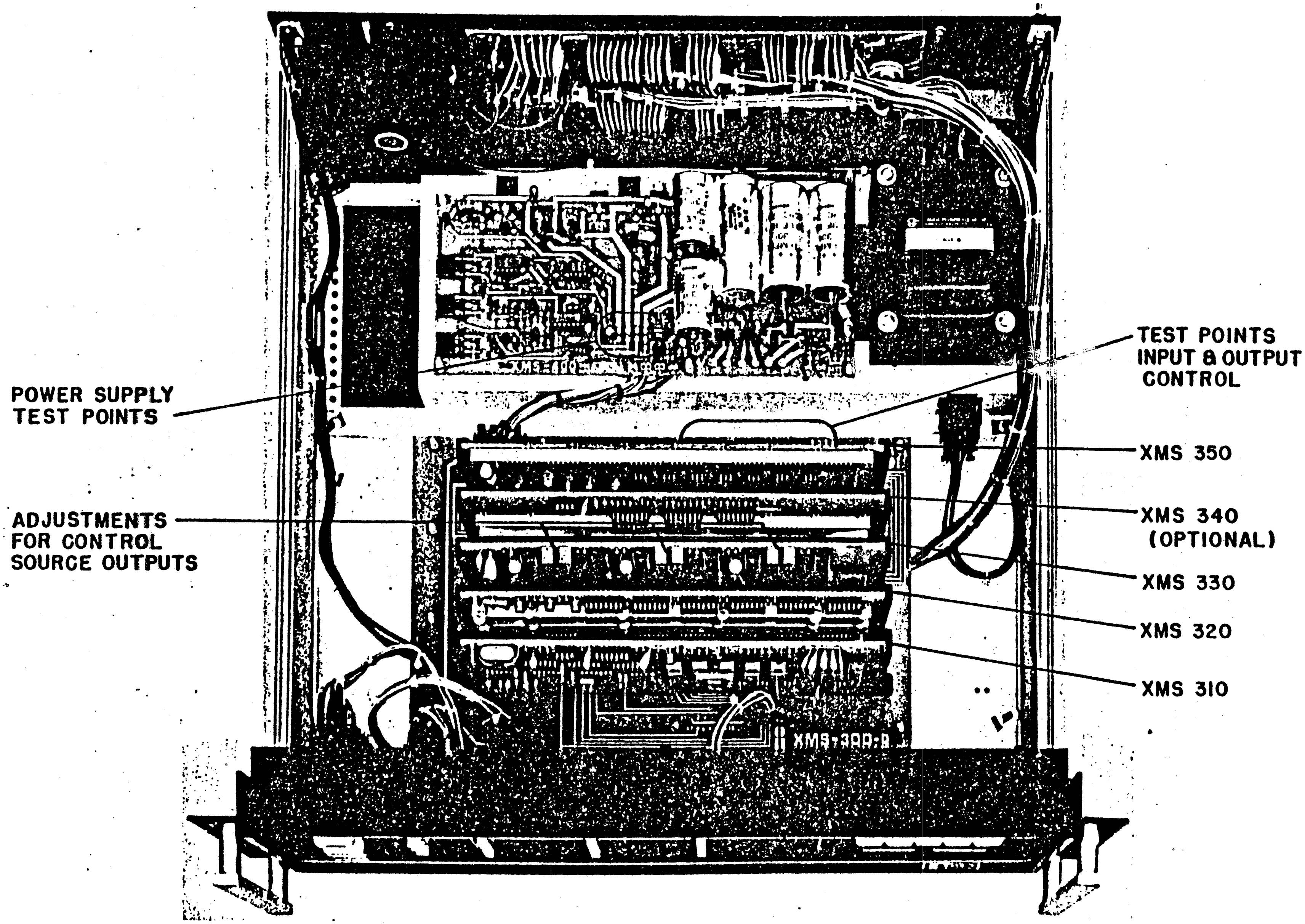


Figure 6-3 Interior View of XMS-3

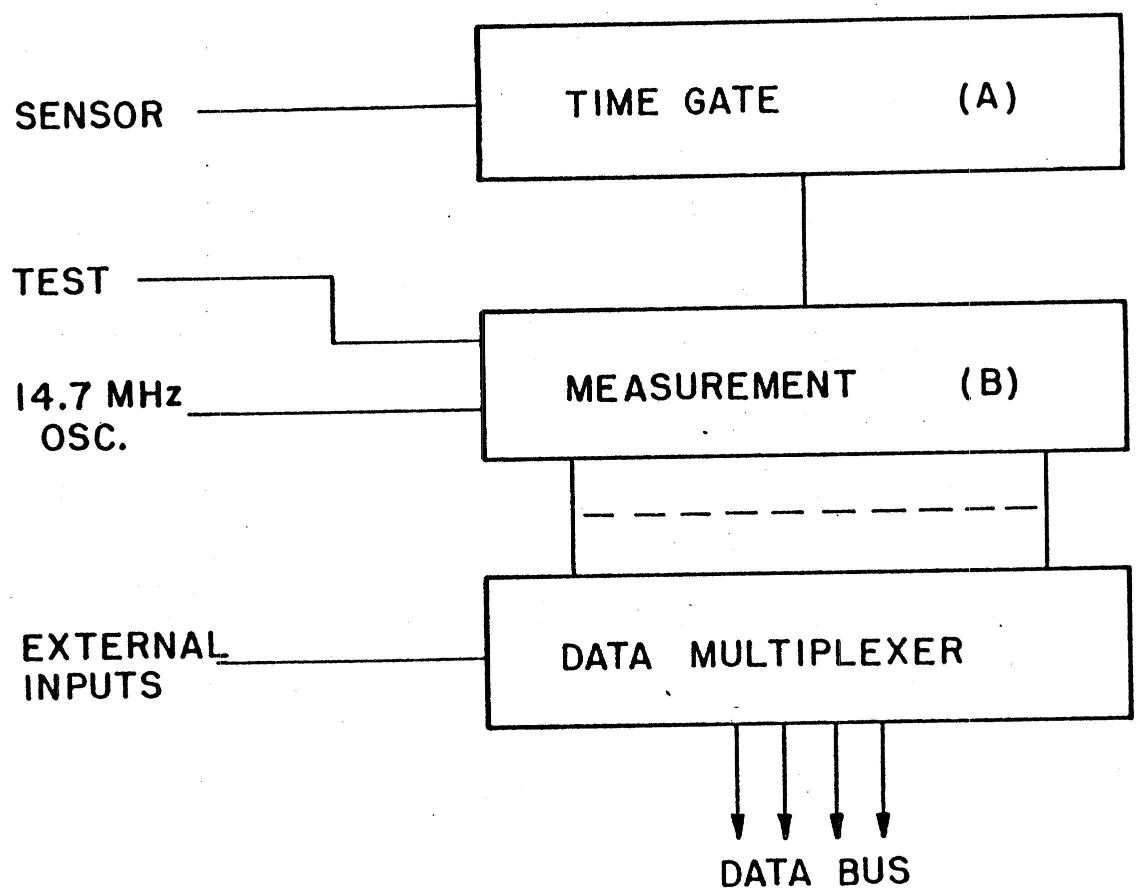


Figure 6-4 Measurement, XMS-320

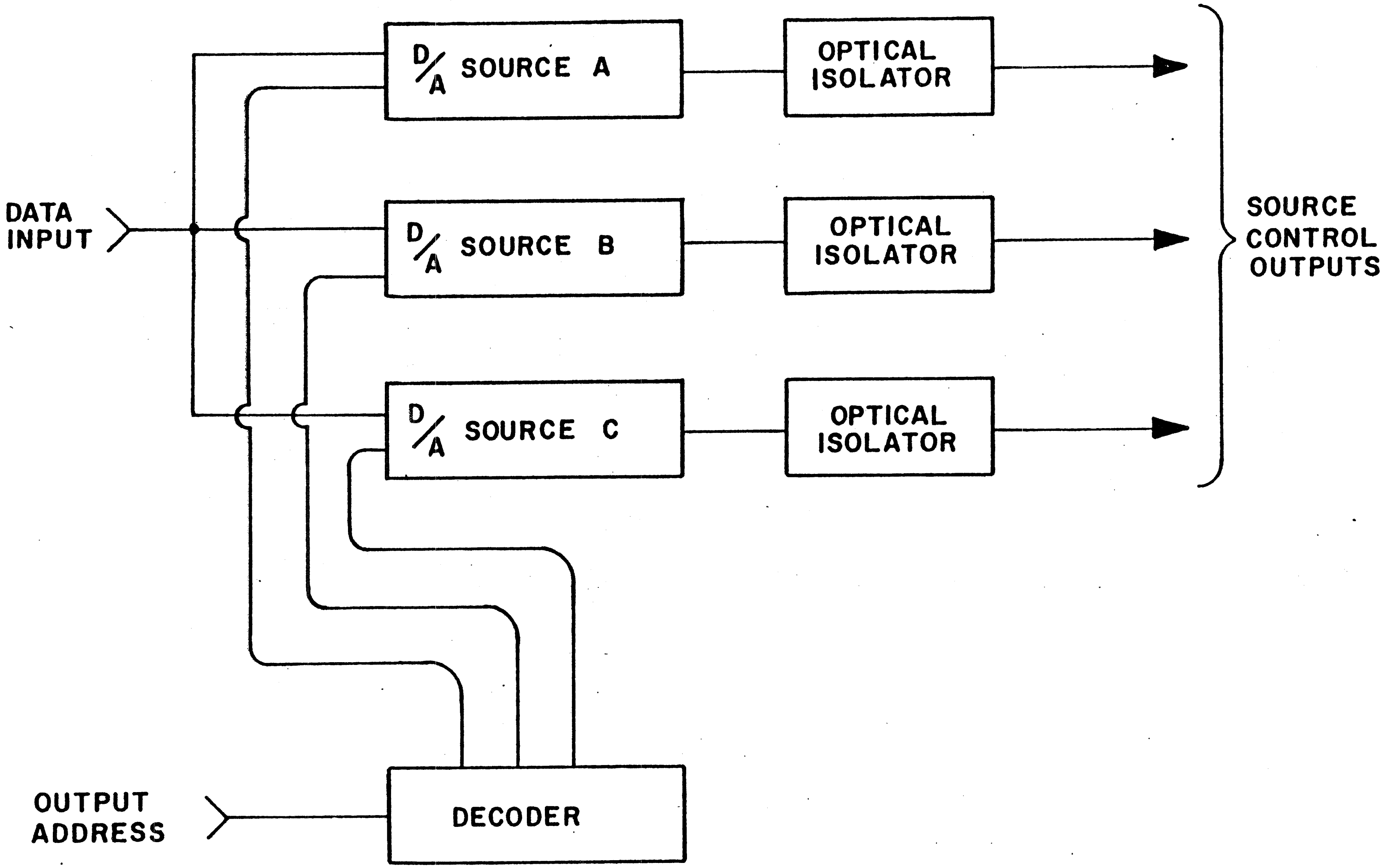


Figure 6-5 Control Output, XMS-330

6.1.3 D/A Option, XMS-340 (Figure 6-6)

Two analog outputs, both 0 to 10 volts, are provided. These outputs are proportional to the displayed rate and thickness. The rate output has a resolution of 10 mV corresponding to 1Å/second with a full scale of 10 volts equal to 1000 Å/second.

The thickness output is proportional to the three least significant digits displayed on the front panel. Therefore, as the ranges change on the display the full scale analog output (0 - 10 volts) representation also changes. These range changes effect the analog output in both resolution and full scale calibration.

Display Range	Output Resolution (10 mV)	Full Scale Output (10 V)
9.999 kÅ	1 Å	0.999 kÅ
99.99 kÅ	10 Å	9.99 kÅ
999.9 kÅ	100 Å	99.9 kÅ

As illustrated in Figure 6-6, starting at zero thickness the first 10 peaks represent an accumulated thickness of 1000 Å each. At this point the front panel display would change range to 100 kÅ full scale, and the analog output would shift to 10 volts equal to 10 kÅ. As above, a second range change would occur when 100 kÅ thickness is reached.

6.1.4 Output Interface, XMS-350 (Figures 6-7 and 6-8)

All inputs and outputs appearing at the interface connector (rear panel) are routed through this board. The outputs are controlled by data inputs from the processor board. The input data are addressed to appropriate latches by the decoder and the latches in turn drive the output optical isolators. The isolators together with their associated triacs provide normally open type control. The exception to this is the abort output which is normally closed. These circuits will only control ac signals.

The external inputs are coupled to the XMS via a second group of optical isolators located on this board. As in the case with the outputs, ac signals are required to successfully activate the inputs. Check Section 2.2 for input and output restrictions.

6.1.5 Front Panel, XMS-200 (Figure 6-9)

This board contains all the numerical displays, indicator lamps, display and indicator drivers and the majority of the pushbutton switches. Data are entered in this board periodically; keys and switches are sampled every 0.1 second, displays and indicators once a second.

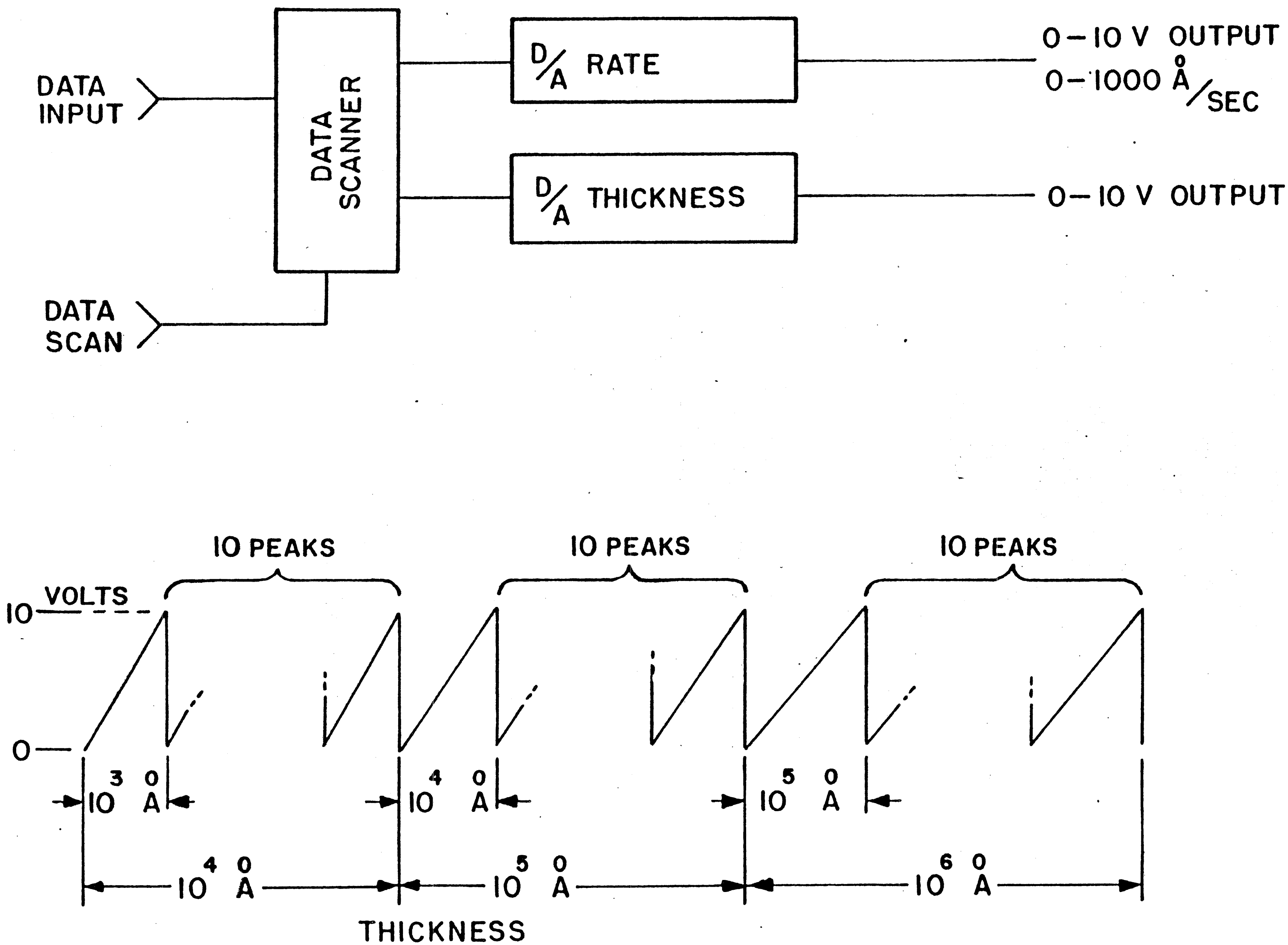


Figure 6-6 D/A Option, XMS-340

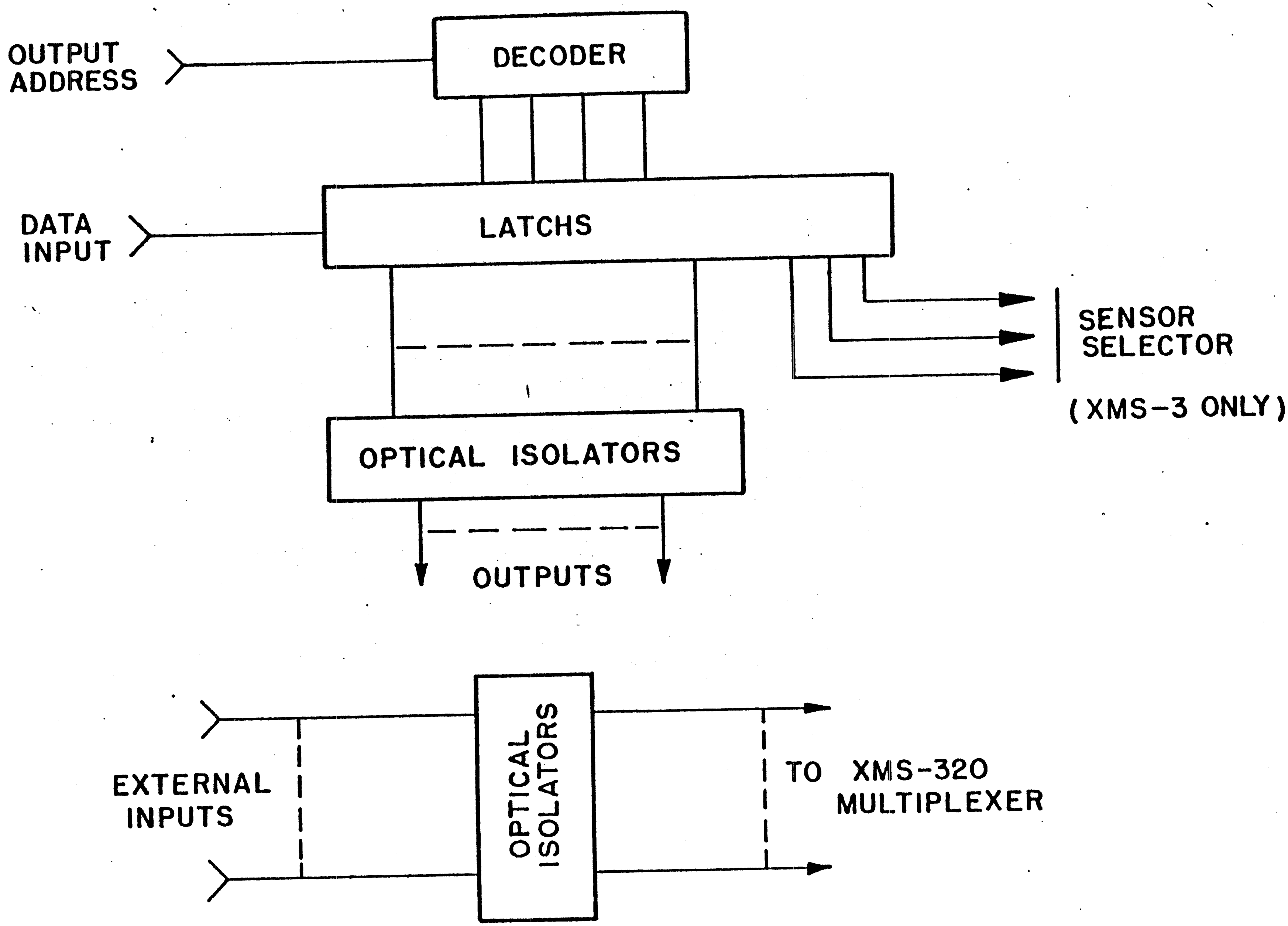


Figure 6-7 Output Interface, XMS-350

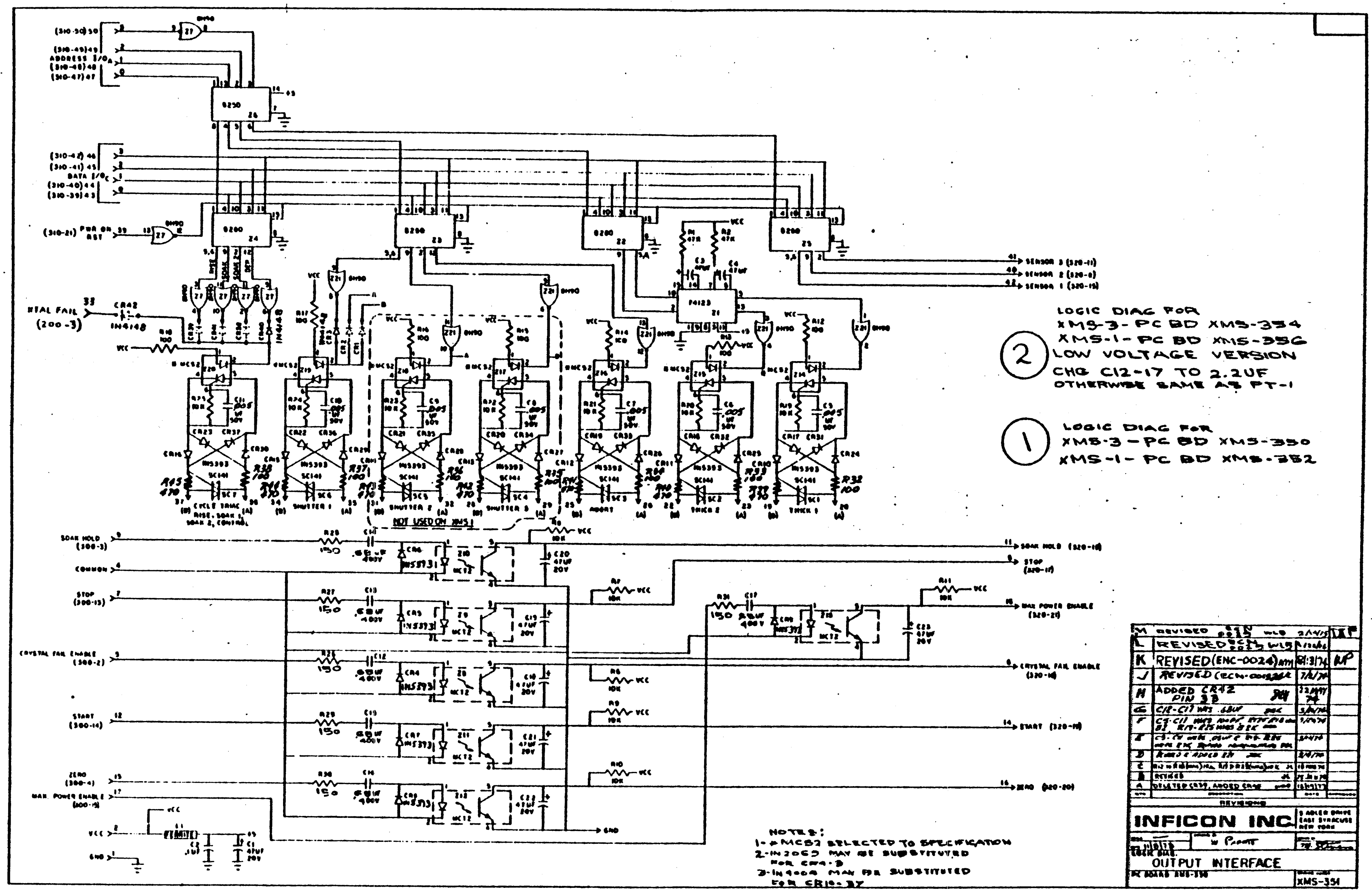


Figure 6-8 Circuit Diagram, XMS-350

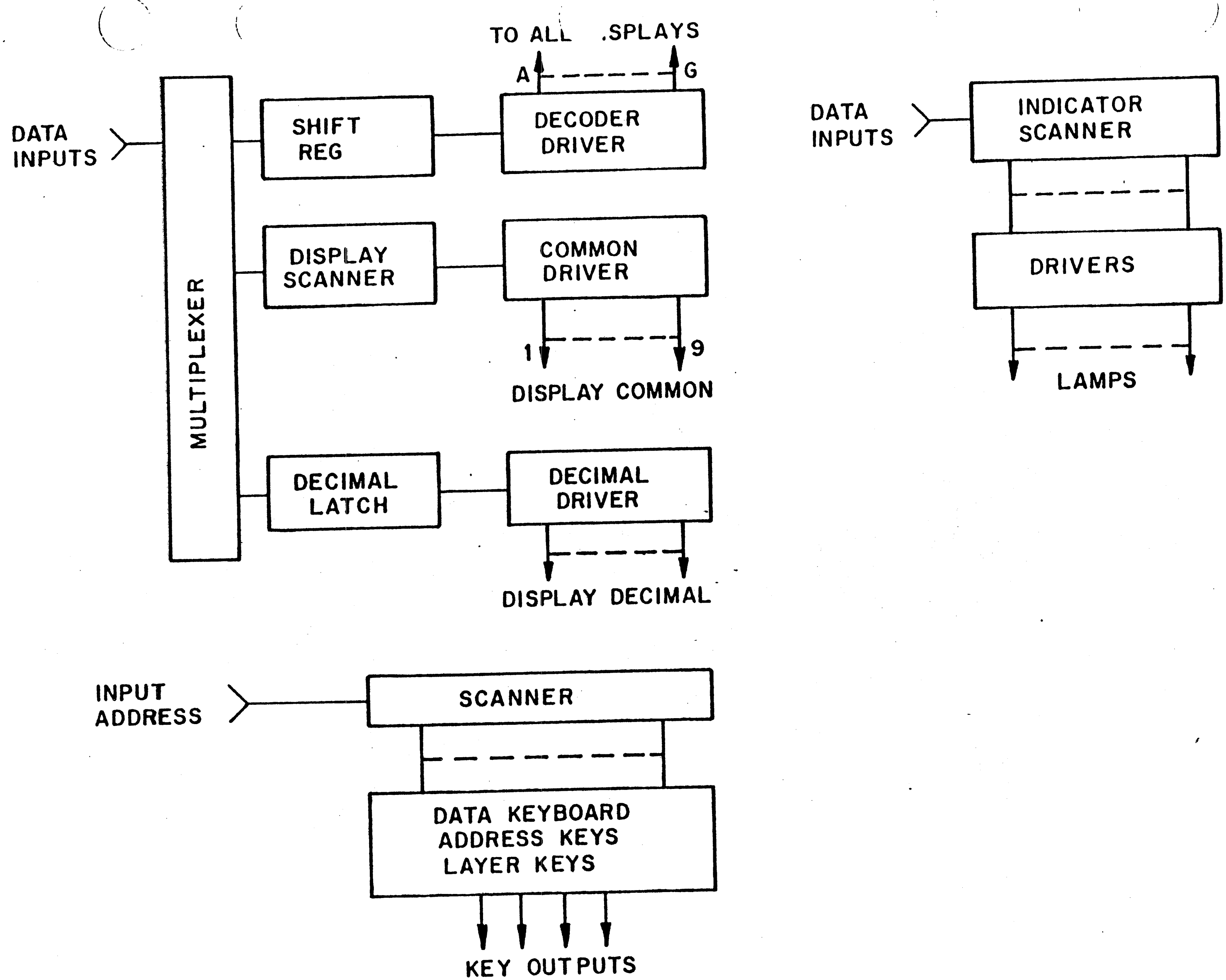


Figure 6-9 Front Panel, XMS-200

In the case of the displays, data for all nine digits are stored in registers, and by scanning these registers a single seven segment decoder sequentially supplies drive for all nine displays. The scanning rate is approximately 100 times a second.

Each indicator (status, mode, address, etc.) consists of two lamps with a single driving transistor. Data are entered into shift registers which activate the above transistors. Data keyboard, address key and layer keys are an integral part of a matrix. This matrix is periodically scanned, and the key outputs are fed to the XMS-310 for processing.

Because of the way the output data are handled, only one key or switch may be pressed at one time. If one key or switch is pressed, pressing a second will have no effect until the first is released.

6.1.6 Power Supply, XMS-400 (Figure 6-10)

This subassembly contains all the regulated voltage supplies for the XMS. The following is a list of voltages and the numbers in parentheses are test points located on the XMS-400 board (Figure 6-3). All voltages are in reference to circuit ground unless otherwise noted. Located on the right rear corner of the XMS-300 board is a Turret lug which is labeled Ground. This is a convenient reference point when measuring the following voltages:

+5 Vdc	(7)	
+5 Vdc	(6)	
+15 Vdc	(10)	
-15 Vdc	(11)	
-5 Vdc	(9)	
-15 Vdc	(13)	Isolated from circuit ground;
Common	(12)	-15 Vdc (13) measured with respect to Common

In addition to the above, this assembly contains one 12 volt and one 1.35 volt battery with an autocharging circuit.

6.2 Service

The XMS is designed in such a way as to make service relatively easy. With a little experience problems can be isolated to specific boards by observing the behavior of the various front panel displays and indicators. This section will concentrate on board substitution as a means of repair, with the exception of the XMS-200 where components such as LED display and lamps may be easily replaced without completely removing the board.

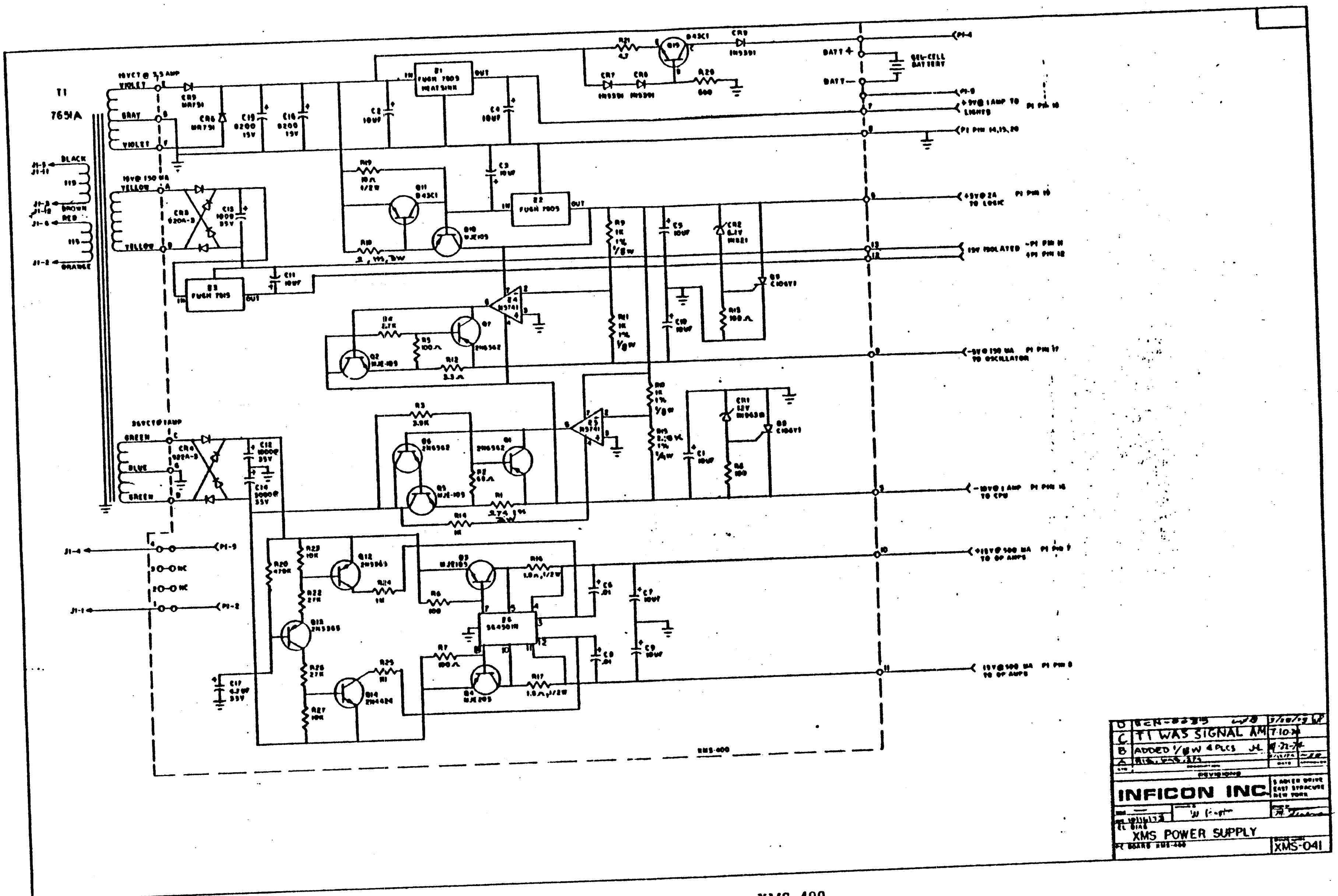


Figure 6-10 Circuit Diagram, XMS-400

6.2.1 Case Removal

To gain access to the PC boards, remove the two cover retaining screws located on the rear panel and lift top cover off. With the exception of the XMS-400 and XMS-200, all boards are plugged directly into the motherboard (XMS-300, Figure 6-2). Individual board locations are designated on the XMS-300, and each board is keyed eliminating the possibility of insertion error.

Removal of the main chassis from the outside case is required for the replacement of either the XMS-400 or XMS-200 assemblies. Six screws, located three on each side, release the chassis from the case. Lift chassis up slightly in the rear and pull towards rear of the case.

Access to the component side of XMS-200 front panel board (Figure 6-11) requires the following:

a. Remove three screws located in the top retainer bracket

b. Remove two screws located in outside corners of the bottom retainer bracket

c. Carefully slide the XMS-200 towards the rear of chassis. The clearance holes in the front panel for the address keys may require the removal of the yellow buttons prior to the removal of the XMS-200 board.

The XMS-400 power supply subassembly may be removed by:

a. Disconnect the two connectors located on the motherboard and XMS-400 support chassis

b. Remove four screws located one on each corner of chassis.

6.2.2 Test Mode

Approximately 95% of the internal circuitry of the XMS may be verified for proper operation by using the unit in the test mode. Section 3.2 provides a basis from which preliminary tests can be made. The following is presented in order to add some insights on this mode of operation and thereby increase its usefulness as a service tool.

Two problem areas usually encountered in attempting to test a thickness and/or rate monitor are:

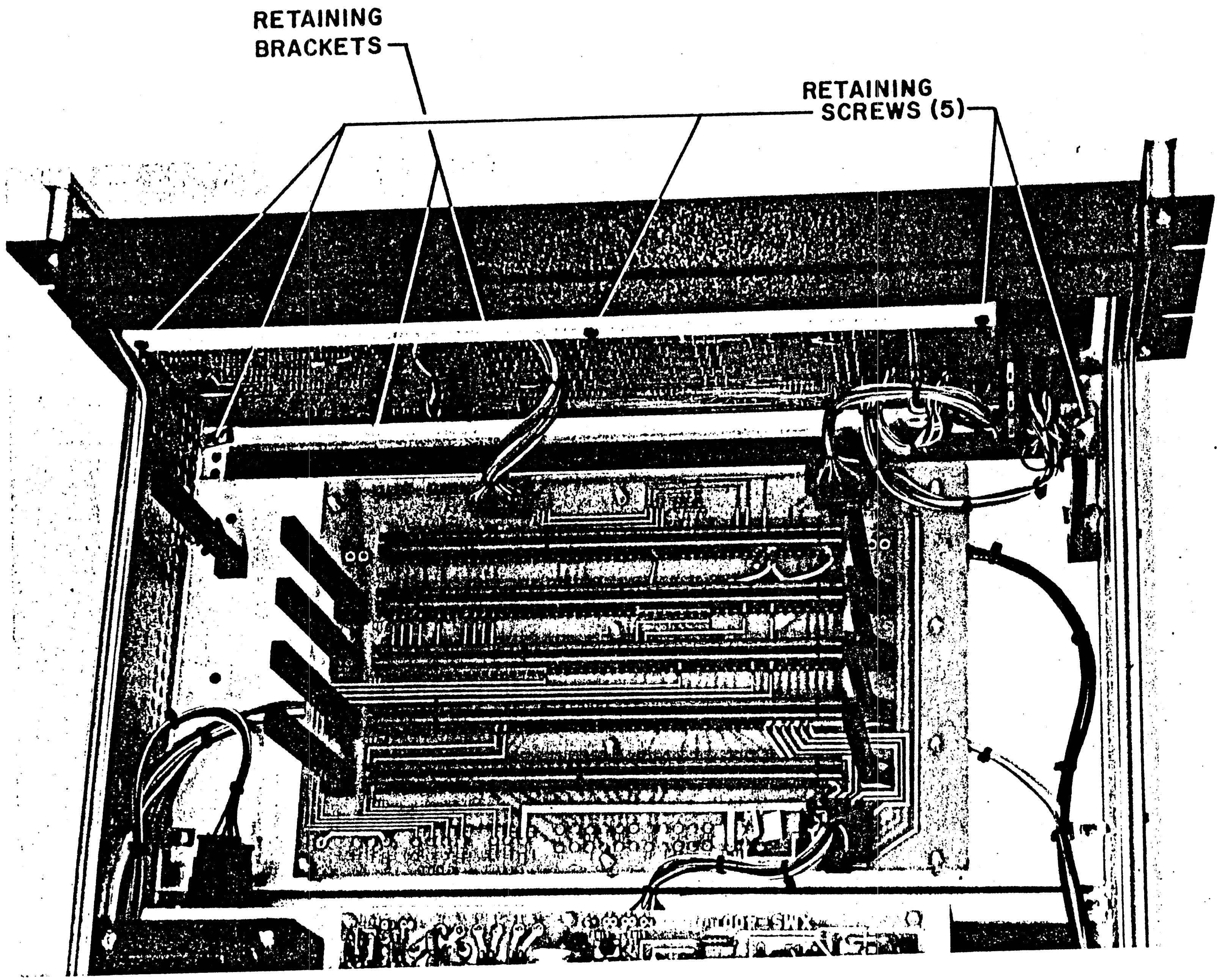


Figure 6-11 Front Panel, Component View

a. Validate thickness computation

b. Check rate display together with rate error determination for controlled operation.

In order to accomplish these tests, a stable internal 10 Hz clock is fed into the measurement counter (b) on the XMS-320 board (Figure 6-4). By allowing these pulses to accumulate, an apparent thickness buildup at a rate of 10Å/second will generate.

It can be seen from Figure 6-1 that by entering the 10 Hz clock at the 320 board a means is provided of checking all circuitry involved in thickness and rate computation with the exception of the time gate (Figure 6-4) and sensor input logic.

Refer to Section 3.2 for the method of validating density, tooling factor and Z-ratio.

6.2.3 Troubleshooting - XMS

CAUTION: Whenever it is necessary to handle the XMS-310, do so by the card edges. Static discharges may destroy some of the board's components.

Problem	Check
1. Front Panel remains dead with turn of Power switch.	a. Fuse located at rear of unit b. Remove top cover and check power supply outputs on XMS-400 test points. Replace supply assembly if determined bad.
2. Unit turns on but front panel indicators in state other than condition described in Section 3.0.	a. Remove the following boards: XMS-320, XMS-330, XMS-340 (optional), XMS-350. If condition persists, replace XMS-310.

Note: The majority of the time, if the XMS-310 experiences a malfunction, the problem will show itself as a discrepancy in the initial turn on condition. Exceptions to this rule and a more general indicator is the observation of several abnormalities in the instruments operation.

3.	Step 2 o.k.; that is, unit initializes correctly but unit is locked in that condition. Unable to program unit.	a. Check for key or switch stuck in the depressed state. b. One of the switches on the XMS-200 board is defective.
4.	Step 2 o.k.; <u>one</u> of the various indicators not functioning.	a. Loosen XMS-200 for access to component side. Replace indicator.
5.	Numeric displays on, except for one or two of the segments.	a. Press lamp test switch on front panel, determine faulty digit and replace.
6.	When lamp test switch depressed, identical segment in all displays will not light.	a. Replace Z7 (SCS-1001) on XMS-200.
7.	One numerical display totally black.	a. Replace display. b. Replace driver (MSP-6560).
8.	Unit normal except will not respond when various keys are pressed.	a. Check front panel switches for any which may not have returned to normal position (generally one of the address keys or data entry keys). b. If all keys appear to be clear, replace XMS-200.
9.	T/X lamp flashing with crystal and oscillator connected.	a. Check to which input oscillator cable is connected and verify XMS is programmed to same sensor input. b. Problem persists: place unit in the test mode; if T/X continues to flash, replace XMS-320. c. If T/X goes off, check continuity from center conductor of sensor head body assembly (321-20-1) to center conductor of BNC

			connector on vacuum feed-through. Check for shorts between center conductor and ground.
10.	Unit will respond to front panel controls (start, stop, etc.) but will not respond to external inputs.	a.	Replace XMS-350.
11.	Unit indicates normal sequence when running an auto-deposition, but various control outputs will not function (shutter, etc.).	a.	Replace XMS-350.
12.	Percent power reading normal on front panel but no source control voltage output.	a.	Be sure source connection (A, B or C) on rear panel coincides with programmed source (1, 2 or 3).

Note: In problems 10, 11 and 12, it is assumed the outputs are bad and XMS front panel indicators are functioning properly. A reversal of this (outputs operational, loss of front panel indicators) can usually be traced to the XMS-200.

13.	In test mode unit operates normally but gross error in thickness readings when compared to actual thickness being deposited.	a.	Check program values for tooling, density and Z-ratio.
14.	Loss of memory when power switch has been on and the power cord is disconnected.	a.	Check condition of batteries.
		b.	Check battery charger located on XMS-400.

6.2.4 Troubleshooting - Sensor Head

6.2.4.1 Regular Sensor Head and Sensing Crystals

Problem	
1. Large jumps of thickness reading during deposition.	Reasons: a. Mode hopping due to defective crystal. b. Crystal near the end of its life. c. Scratches or foreign particles on the crystal seating surface. Solutions: a. Replace crystal. b. Replace crystal. c. Clean or polish the crystal seating surface on the sensor cover.
2. Crystal ceases to oscillate during deposition before it reaches its normal life.	Reasons: a. The crystal is hit by small droplets of molten material from the evaporation source. b. Defective crystal. c. Material build-up at the edge of the opening hole making contacts to the crystal. Solutions: a. Use a shutter to shield the sensor head during initial period of evaporation. Move the sensor head further away from the evaporation source. b. Change crystal. c. Clean the sensor cover.
3. Crystal does not oscillate or oscillates intermittently (both in vacuum and in air).	Reasons: a. Defective or damaged crystal. b. Existence of electrical short or poor electrical contacts.

Solutions:

a. Replace crystal.

b. Check for electrical continuity and short in sensor cable, connector, contact springs and the connecting wire inside the sensor head.

4. Crystal oscillates in vacuum but stops oscillation after open to air.

Reasons:

a. Crystal was near the end of its life. Open to air causes stress change in the deposited film.

b. Excessive moisture accumulation on the crystal.

Solutions:

a. Replace crystal.

b. Turn off cooling water to sensor head before opening it to air.

5. Thermal instability: Large changes in thickness reading during source warm up (usually causes thickness reading to decrease) and after the termination of deposition (usually causes thickness reading to increase).

Reasons:

a. Crystal is not properly seated.

b. Excessive heat input to the crystal.

c. No cooling water.

Solutions:

a. Check and clean crystal seating surface.

b. If the crystal heating is due to radiation from the evaporation source, move the sensor head further away from the source and use sputtering crystals for better thermal stability. If the crystal heating is due to secondar electron bombardment from the electron beam source, change the regular sensor head to a sputtering sensor head.

c. Check cooling water flow rate (0.2 gpm at 20°C).

6. Poor thickness reproducibility.

Reasons:
a. Erratic source emission characteristics.
b. Material does not adhere to the crystal.

Solutions:
a. Move sensor head to a different location. Check the evaporation source for proper operating conditions.
b. Check the cleanness of the crystal surface. Evaporate a layer of proper material on the crystal to improve adhesion.

6.2.4.2 <u>Sputtering Sensor Head and Sensing Crystals</u>

<u>Problem</u>

1. Large jumps of thickness readings during sputtering.

Reasons:
a. Improper crystal seating.
b. Small pieces of material fell on the crystal (for crystal facing up situation).
c. Small pieces of magnetic material being attracted by the sensor magnet and contacting the sensing crystal.

Solutions:
a. Chèck and clean the crystal seating surface.
b. Check the crystal surface and blow it with clean air.
c. Check the sensor opening hole and remove any foreign material.

2. Thickness reading jumps back and forth and T/X Lamp flashing during sputtering.

Reason:
a. RF interference from the sputtering power supply.

Solution:
a. Check groundings. Remove the instrument and oscillator to a different location. Connect the instrument to a different power line.

3. Large drift of thickness reading (greater than 200 Å for density setting = 5.00 gm/cc) after the termination of sputtering.

Reasons:

a. Crystal heating due to poor thermal contact.

b. External magnetic field interferes with the sensor magnetic field.

c. Sensor magnet defective.

Solutions:

a. Check and clean the crystal seating surface.

b. Rotate the sensor magnet to a proper orientation with respect to the external magnetic field.

c. Check sensor magnet field strength. If a gaussmeter is available, the maximum field at the center of the opening hole should give a reading of 700 gauss or greater.

7.0 PARTS LIST

Parts lists are presented in this section for the XMS assembly. Group numbers G1 and G2 describe the parts for the XMS-3 and XMS-1, respectively.

Parts lists are shown only for completeness. It is not intended that field repairs be attempted, and such repairs may endanger the warranty.

TQ		Description	Part No.
-	X	Assembly, XMS-3	006-046
X	-	Assembly, XMS-1	006-045
-	1	Mother Board and Back Board, XMS-3	006-078
1	-	Mother Board and Back Board, XMS-1	006-077
-	1	Microprocessor, XMS-310	006-063
1	-	Microprocessor, XMS-312	006-070
1	1	Measurement, XMS-320	006-064
-	1	Control Output, XMS-330	006-065
1	-	Control Output, XMS-332	006-071
1	1	Option, XMS-340	006-061
-	1	Output Interface, XMS-350	006-066
1	-	Output Interface, XMS-352	006-072
1	1	Power Supply, XMS-400	006-067
1	1	Case, XMS-123	006-079
1	1	Front Display, XMS-200 Less XMS-210 and Layer Switch	006-068
1	1	Access Door, XMS-116	006-017
1	1	Mother Board Support, XMS-109	006-027
1	1	Top Support	006-080
1	1	Bottom Support	006-081
1	1	Power Module, Assembly, XMS-188	006-057
12	12	Standoff Nylon, TCBS-6N	020-069
1	1	Mounting Tape, Pressure Sensitive, 1/32" x 3/8" x 13.87 lg	070-073
1	1	Mounting Tape, Pressure Sensitive, 1/32" x 3/8" x 13.17 lg	070-073
9	9	Contact, Female	051-133
1	1	Fan, Pe Wee Boxer, IMC	006-036
-	1	Face Panel, XMS-101 P1	006-009
1	-	Face Panel, XMS-101 P2	006-002
1	1	Sub Panel, XMS-102	006-003
1	1	Back Panel, XMS-104	006-005
1	1	Support, Top Side, XMS-113	006-080
1	1	Support, Bottom Side, XMS-114	006-081
1	1	Connector, 10 Pin, Mod IV	051-123
1	1	Switch, Yellow Lens "Zero"	065-045
1	1	Switch, White Lens "Start"	065-046
1	1	Switch, Red Lens "Stop"	065-047
3	3	Bulb supplied with above	063-017
1	1	$1\frac{1}{4}$ amp Slo-Blo Fuse	062-013
1	1	Lamp, Layer Bulb 7333	063-005
1	1	Layer, Lens "1"	066-023
1	1	Layer, Lens "2"	066-024
1	1	Layer, Lens "3"	066-025
3	3	Bulb supplied with above	063-015

TQ		Description	Part No.
1	1	Battery, 12 volt	067-003
1	1	Battery, "C" cell	067-004
-	1	Connector Set, XMS-3	006-054
1	-	Connector Set, XMS-1	006-053