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IC 6000
DEPOSITION CONTROLLER

JUNE 1979

INSTRUCTION MANUAL

INFICON
LEYBOLD-HERAEUS
6500 Fly Road, E. Syracuse, New York 13057, TWX: 710 541-0594, Tel: 315-437-0377

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PREFACE

The IC 6000 Instruction Manual contains information on installation, operation, and sensor maintenance and repair for the IC 6000 Deposition Controller. To be sure that you receive additional or updated technical information as it becomes available, we ask you to fill out the postage-paid reply letter in the front of the manual and return it to us.

The purpose and contents of each section of this manual are listed below. This information is also found at the beginning of each individually numbered section.

Section 1 — General Information — begins with a description of the IC 6000 deposition controller, and includes specifications both for the unit and the sensors. Instructions for unpacking and inspection are also found in this section.

Section 2 — IC 6000 Check Procedure — provides a description of the front panel displays, keyboard, and control switches and includes a test procedure which takes you step-by-step through programming and operating the film displays.

Section 3 — Installation and Programming the Executive and I/O Displays — contains instructions for installing the sensor and interfacing the unit with your vacuum system. A description of the back panel connections is included, as well as instructions for programming the multi-layer sequencing and the I/O configuration.

Section 4 — Programming the Film Displays — begins with a discussion of film and process sequencing. It includes a general listing of all film parameters, as well as specific information on determining some specific parameter values.

Section 5 — Sensor Maintenance and Repair — includes routine maintenance procedures for the standard, dual, bakeable and sputtering sensors, and a troubleshooting section to pinpoint malfunctions that can be corrected in the field.

Section 6 — Schematics — includes electrical schematics and outline drawings to assist in installation and maintenance.

Section 7 — Appendixes —
- A — Glossary of Programming and Operating Terms
- B — Status Messages
- C — IC 6000 Confidence Tests
- D — Measurement Theory

Section 8 — space for future additions to the manual. Please return reply card to receive these additions. RS232 Instruction Manual (074-026) + Sensor Shutter info

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Section 1 of the IC 6000 manual provides an overall description of the instrument design and function, including sensors and special features. In addition, there are tables of specifications that contain performance standards, limits, tolerances, and physical data for the unit and the sensors. Instructions for unpacking and inspection are also included in this section of the manual. The following areas are covered:

- General Description of the IC 6000
- IC 6000 Specifications
- Standard Sensor Specifications
- Dual Sensor Specifications
- Bakeable Sensor Specifications
- Sputtering Sensor Specifications
- Unpacking and Initial Inspection
- Inventory

Once you have inspected and inventoried the shipping cartons, we urge you to follow the test procedures outlined in Section 2. In this way, you will become familiar with the operation of the unit and will be sure it is working properly before you interface it with your vacuum system. Do not make any back panel connections until you have completed all the initial checks and have a thorough understanding of how the instrument works.

IC 6000 DEPOSITION CONTROLLER GENERAL DESCRIPTION

The IC 6000 is Inficon's latest contribution to the thin-film industry. Based on a resonating quartz crystal sensor, the IC 6000 deposition controller provides both accurate film measurement and total deposition control.

Crystal Switch® leads the list of the many new IC 6000 features. Two crystals and a pneumatically-operated shutter are combined in a small sensor package. This dual sensor, in conjunction with a stability-sensing algorithm, attacks the problem of crystal instability and failure.

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If the monitoring crystal becomes unstable or experiences total failure during a controlled deposition, the instrument may be programmed to automatically switch to a second crystal without process interruption or loss of process control. To protect against the possibility of both crystals failing, the IC 6000 may be programmed to complete on time-power with the microcomputer automatically computing the time and power required to complete deposition.

The IC 6000 incorporates unsurpassed programming capability, with six complete and independent film programs that each contain 37 programmable parameters. For automatic sequencing of multilayer processes, the unit may be programmed to automatically control a process of up to 32 layers, with each layer controlled by any one of the six film programs. For systems with multi-process requirements, the IC 6000 will store three separate process sequences, so that changing from one process to another is as simple as programming which process to run. External connections can link the three processes into a single process of up to 96 layers.

Several unique functions are included in this list of 37 film program parameters. Two rate ramps, for example, provide complete control of rate changes during each film deposition. Tighter rate control may be established on even the slowest responding sources, by programming the control parameters - gain, approach, and limiter. The "presoak enable" feature reduces cycle time by allowing a second source to presoak, while the unit is simultaneously controlling the first layer source. Special delete and edit functions can tailor each program to your process requirements, thereby reducing programs to their simplest forms.

Three new front panel functions have been provided for ease of operator control. A process sequence that has been interrupted may be continued (see START/CONT, p. 2-8) from the interrupted layer or can be reset (see RESET, p. 2-8) to its beginning layer with the push of a button. In addition, a film program can be reset (see RESET, p. 2-8) to its beginning without losing previous sequence information, or aborting an entire process.

Complete I/O programming simplifies interface of the instrument to your system. Input and output functions are designated by selecting and programming the required control parameters. In addition to programming I/O functions, you can also program contact type (normally open, normally closed, and pulsed).

The I/O program will remain valid even in the event of line power failures or long periods of instrument disuse, since the unit incorporates an electrically alterable memory that retains data without battery backup. Other programmable values are also retained for an indefinite period. An internal interlock prevents accidental modification of the I/O program, and a user-programmable lock code provides limited access to stored program data, if desired.

The IC 6000 Data display provides the user with process control information. This single display gives rate, thickness, power, process time, and crystal condition information, plus an analog record of the quality of rate control. A message area on the Data display describes system malfunctions, process status, and abort conditions when a process or film terminates.

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IC 6000 SPECIFICATIONS

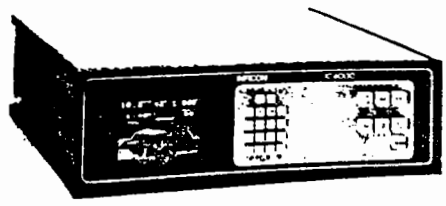


Fig. 1-1 IC 6000

Thickness Display Range	0 to 999.9 kÅ
Thickness Display Resolution (three automatic ranges)	1Å from 0 to 9.999 kÅ – 10Å from 10 to 99.99 kÅ – 100Å from 100 to 999.9 kÅ
Rate Display Range	0.0 to 999 Å/sec
Rate Display Resolution	0.1Å/sec at programmed rate of less than 25Å sec; 1 Å/sec at all other rates & auto ranging
Accuracy (Thickness and Rate Display)	± 1 count
Rate Contol Range	0.1 to 999.9 Å/sec
Measurement and Control Loop Update Period	200 milliseconds
Programmable Functions	
(6 film programs; 37 parameters)	
Density	0.8 to 99.99 gm/cc
Z-Ratio	0.1 to 3.999
Tooling	10 to 399%
Ramp Times (4 set points)	0 to 99:59 M:S
Soak Times (2 set points)	0 to 99:59 M:S
Soak Power (2 set points)	0 to 99%
Sensor	1 to 4
Source	1 to 4
Gain	1 to 99
Approach	0 to 99
Limiter	0.1 to 49.9%
Rate	0.0 to 999.9 Å/sec
Shutter Delay	0 to 99:59 M:S
Thickness Limit (2 set points)	0.000 to 999.9 kÅ
Feed Power	0 to 99%
Feed Time	0 to 99:59 M:S
Idle Power	0 to 99%
Max Power	0 to 99%
Crystal Switch® (2 parameters)	0 to 9 (each)
Time Limit	0 to 99:59 M:S
PreSoak Enable	
Rate Ramps	2 Ramps
Plot Dwell	1-99 measurements per display point
Rear Panel Plug-In Modules – Input/Output Modules	
4 External Control Inputs (Contact Closure or 15 to 36 Vac)	1 standard; 1 optional
4 Control Output Relays (contact rating 220 V max, 125 VA)	
Source/Sensor Modules	1 (or 2) standard; up to 4 optional modules
Source Control and crystal sensor input	Source Control, 0 to ±10 volts
IEEE 488-1975, RS-232-C	optional
Analog Output Rate or Thickness	0 to 10 volts; optional – 0-999 Å/sec (rate) – 0-1000Å (thickness)
Power Requirements	100/120/200/240V ±10%, 50-60 Hz 100 VA
Warm-Up Time	none necessary; 10 min. for maximum stability
Operating Temperature	0-50°C
Size	13.3 cm H (5.25") x 42.5 cm W (16.7") x 44.4 cm D (17.5") – Mountable in a 19" rack
Weight	10.88 kg (24 lbs)

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SPECIFICATIONS
REGULAR CRYSTAL SENSOR
IPN 007-206

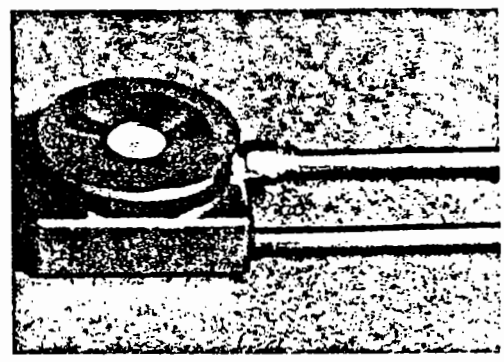


Fig. 1-2
Regular Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.063" (2.7 cm) x 2.35" (6 cm) x 0.60" (1.5 cm) high
Water line and coax length	Standard 30" (76 cm)
Crystal exchange	Front-loading, self-contained package for ease of exchange
Mounting	Two #4-40 tapped holes on the back of the sensor body

INSTALLATION

A. Feedthrough	a) 2 pass water with Microdot coax connector
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator designed to interface with deposition controller
C. Utilities	c) Water 150-200 cc min, 30°C max

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water lines	c) S-304, 0.125" (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) $>99\%$ Al_2O_3
F. Wire	f) Teflon insulated copper
G. Braze	g) Vacuum process high temperature Au-Ni alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat

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SPECIFICATIONS
DUAL (SWITCHABLE) CRYSTAL SENSOR
IPN 007-205

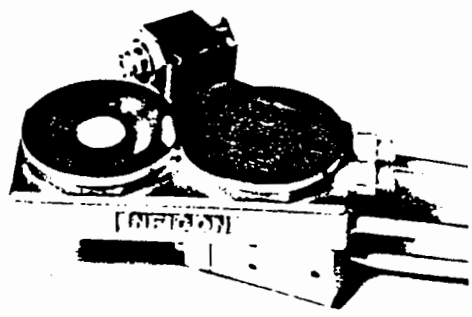


Fig. 1-3
Crystal Switch Sensor (Dual)

Maximum temperature	105°C
Size (maximum envelope)	1.45″ (3.7 cm) x 3.45″ (8.8 cm) x 1.70″ (4.3 cm) high
Water, air and coax length	Standard 30″ (76 cm)
Crystal exchange	Front-loading, self-contained packages for ease of exchange. Shutter flips up to ease access to the holders.
Mounting	Two #4-40 on the back of the sensor body

INSTALLATION

A. Feedthrough	a) Qty (1) 2¾″ Conflat® with 2 Microdot, 2 pass water and air or, Qty (2) 1″ bolt with 2 pass water and Microdot
B. Other	b) (1) Customer to provide vacuum tight braze joints or connectors for the water and air lines. (2) Valve assembly for air. (3) Two oscillators designed to interface with the deposition controller. (4) For automatic operation, the deposition process controller must be designed for the implementation of this feature.
C. Utilities	c) (1) Water 150-200 cc/min, 30°C max (2) Air, 80 psi (5.5 atmospheres) very low volume

MATERIALS

A. Body and Holders	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water and air lines	c) S-304, 0.125″
D. Connectors (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Other mechanical parts	g) 304 or 18-8 stainless steel
H. Braze	h) Vacuum process high temperature Au-Ni alloy
I. Crystal	i) 6.0 MHz, AT-cut plano-convex with Au overcoat

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SPECIFICATIONS
BAKEABLE CRYSTAL SENSOR
IPN 007-207, 208, or 209

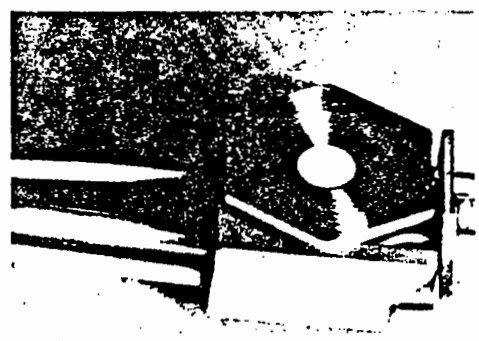


Fig. 1-4
Bakeable Crystal Sensor

Maximum temperature	450°C continuous (for bake only; waterflow recommended for actual deposition monitoring)
Size (maximum envelope)	1.35" (3.4 cm) x 1.38" (3.5 cm) x 0.94" (2.4 cm) high
Water line and coax length (from face of feedthrough to center of crystal)	a) standard (1) 30" (76 cm) IPN 007-209 (2) 20" (50.8 cm) IPN 007-208 (3) 12" (30.5 cm) IPN 007-207
Crystal exchange	Front-loading, self-contained package for ease of exchange. CAM type locking handle allows easy removal and good thermal contact.
Mounting	a) Standard — four #4-40 tapped holes on the back of the body b) Optional — right angle bracket

INSTALLATION

A. Feedthrough	a) 2¾" ConFlat®, integral with sensor head
B. Other	b) (1) Oscillator designed to interface with the deposition controller (2) Water and coax lines are semi-ridged, but easily formed.
C. Utilities	c) Water 150-200 cc min, 30°C max (Customer should provide means of easily disconnecting the ¼" water lines during bakeout)

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Molybdenum & Inconel X-750
C. Water and coax lines	c) S-304, 0.125" (.3 cm) O.D. water 0.188" (.5 cm) O.D. coax
D. Other mechanical parts	d) 18-8 or 304 stainless
E. Insulators	e) > 99% Al_2O_3 in vacuum; other high density ceramics used elsewhere
F. Wire	f) (1) Ni (in vacuum) (2) Ni plated Cu (elsewhere)
G. Braze	g) Vacuum process high temperature Au-Ni alloy
H. Crystal	h) 6.0 MHz AT-cut plano-convex with Au overcoat

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SPECIFICATIONS
SPUTTERING CRYSTAL SENSOR
IPN 007-215

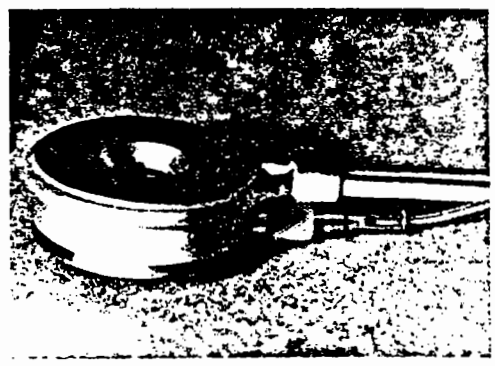


Fig. 1-5
Sputtering Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.36″ (3.45 cm) ϕ x 0.47″ (1.18 cm) high
Water line and coax length	Standard 30″ (76 cm)
Crystal exchange	Front-loading
Mounting	Customer supplied

INSTALLATION

A. Feedthrough	a) 2-pass water with Microdot coax connector 2¾″ — (IPN 002-043) 1″ — (IPN 002-042)
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator designed to interface with deposition controller
C. Utilities	c) Water 750 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) Au plated Be-Cu
B. Springs	b) Au plated Be-Cu
C. Water lines	c) Au plated Cu, 0.125″ (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Solder	g) Cadmium free silver and indium alloys
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Ag overcoat
I. Magnet	i) ALNICO 5

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UNPACKING AND INITIAL INSPECTION

Please unpack and inspect the IC 6000 as soon as you receive it,to detect any damage that may have occurred during shipment. This is especially important if there are signs of rough handling on the shipping boxes. If you do find damage, report it immediately to the carrier and to Inficon. Do not dispose of the packing material until you have taken inventory. Store spare crystals in their shipping containers for convenience and cleanliness.

WARNING: If you ordered a dual sensor, please read the air pressure warning label. Maximum design pressure for the pneumatic solenoid is 110 psi.

INVENTORY

At this time, you should make sure that you have received all the necessary equipment by checking the contents with the list provided below. If anything is missing, contact Inficon immediately.

-IC 6000 Control Unit, including one I/O module, one or two source/sensor module(s), power cord, and one hand-held power controller.

IPN 013-075	60 Hz	2 S/S Modules
IPN 013-083	50 Hz	2 S/S Modules
IPN 013-093	60 Hz	1 S/S Module
IPN 013-094	50 Hz	1 S/S Module

-Sensor (Standard, Dual, Bakeable or Sputtering)

a. Standard sensor with water lines
oscillator IPN 013-001
interconnecting cables IPN 013-067
crystal snatcher IPN 008-007
five spare crystals IPN 008-010
(Sensor Package IPN 007-206)

b. Dual sensor with shutter and water lines
oscillator IPN 013-001
interconnecting cables IPN 013-067
crystal snatcher IPN 008-007
five spare crystals IPN 008-010
(Sensor Package IPN 007-205)

c. Bakeable sensor with water lines
2 3/4" ConFlat® flange w/copper gasket
oscillator IPN 013-001
interconnecting cables IPN 013-067
crystal snatcher IPN 008-007
five spare crystals IPN 008-010
graphite IPN 009-175

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(Sensor Package IPN 007-207 [12"])
(Sensor Package IPN 007-208 [20"])
(Sensor Package IPN 007-209 [30"])

d. Sputtering sensor with water lines,
oscillator IPN 013-001
interconnecting cables IPN 013-067
crystal snatcher IPN 008-007
five spare crystals IPN 008-009
(Sensor Package IPN 007-215)

-Instrumentation Feedthrough

a. 2 3/4" ConFlat® with coaxial, two water lines, and one air line (IPN 002-080), for use with dual sensor,
b. 1" bolt with one coaxial and two water lines (IPN 002-042),
c. 2 3/4" ConFlat with 1 coaxial and two water lines (IPN 002-043), or
d. 2 3/4" Viton O-Ring Feedthrough (IPN 002-044)

-Instruction Manual (IPN 074-003)

In addition, you may have ordered one or more of the following options:

Crystals (gold contact) (IPN 008-010)
Crystals (silver contact) (IPN 008-009)
I/O Interface Module (IPN 013-044)
Source/Sensor Module (IPN 013-042)
IEEE 488-75 Interface Module (IPN 013-048)
Analog Output Rate or Thickness Module (IPN 013-043)

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SECTION 2
IC 6000 CHECK PROCEDURE

Section 2 of the IC 6000 manual contains procedures for checking the operation of the instrument prior to installation. It includes descriptions of the functional characteristics of the front panel as well as a program for testing the film displays. The following sections are included:

- IC 6000 Video Displays
- Front Panel Keyboard
- Front Panel Control Switches
- General Guidelines for Programming Film Displays
- Film Program Test Procedure

After you have familiarized yourself with the front panel controls and checked out the instrument, you are ready to install the sensors and interface the unit with your vacuum system. Do not, however, connect and program the I/O display until you have read Section 3.



Fig. 2-1 IC 6000 Front Panel

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IC 6000 VIDEO DISPLAYS

Introduction

Once you have inspected and inventoried the contents of the shipping boxes, you should become familiar with the functional characteristics of the instrument. Do not connect the sensors or oscillators until you understand how to program and operate the instrument. It will be helpful to follow all the procedures outlined in this section (including the test program) and to read the operating sections of the manual thoroughly before you begin to use the instrument. To begin, follow the instructions below:

1. Slide back the top cover of the unit. Directly in back of the front panel control buttons on the inside of the unit, you will see two small (red and white) toggle switches. Set these switches toward the front panel (if they are not already in this position), and slide the cover back on.

2. Plug the power cord into the unit and into a power source for which the unit was ordered.

3. Push the POWER switch. Both this button and the START/CONT button will be illuminated. After about 15 seconds, the Display Index will appear on the screen.

Note: If the ABORT switch is illuminated, indicating a memory failure, press RESET. The ABORT light will go off. Then press DSPL key; the display will change from Data to Display Index.

Display Index (Fig. 2-2)

The Display Index appears each time the DSPL key is pressed (unless the I/O is open; see p.3-13). The arrow near top of the display indicates which film is currently active. The numbers opposite Executive, Data, and I/O tell which digit is pressed to select those displays. Film programs are selected with digits 1 through 6. To enter test mode, press ↑ ; to exit from test, press ↓. (When the unit is in the test mode, ****TEST**** will appear on all the video displays.) Rate, power, and thickness data for the active film is shown at the bottom of the screen.

After you check the display, press digit 1,2,3,4,5, or 6 and the appropriate film program will appear.

Film Program Display (Fig. 2-3)

The IC 6000 contains six complete and independent film programs, each containing 37 programmable parameters. Each film program is contained in four display pages; each page is labeled with film number and program lock status. The program cursor is controlled by the arrowed scan keys on the keyboard, and may be single-stepped or fast-scanned, either up (↑) or down (↓). Display pages turn automatically as the cursor reaches the bottom (or top) of the page. As you delete parameters, the film program compresses, so that a typical program may become less than two full pages. Each page also contains rate, power, and thickness data on the active film. At this time, you should use the direction keys (↑,↓)

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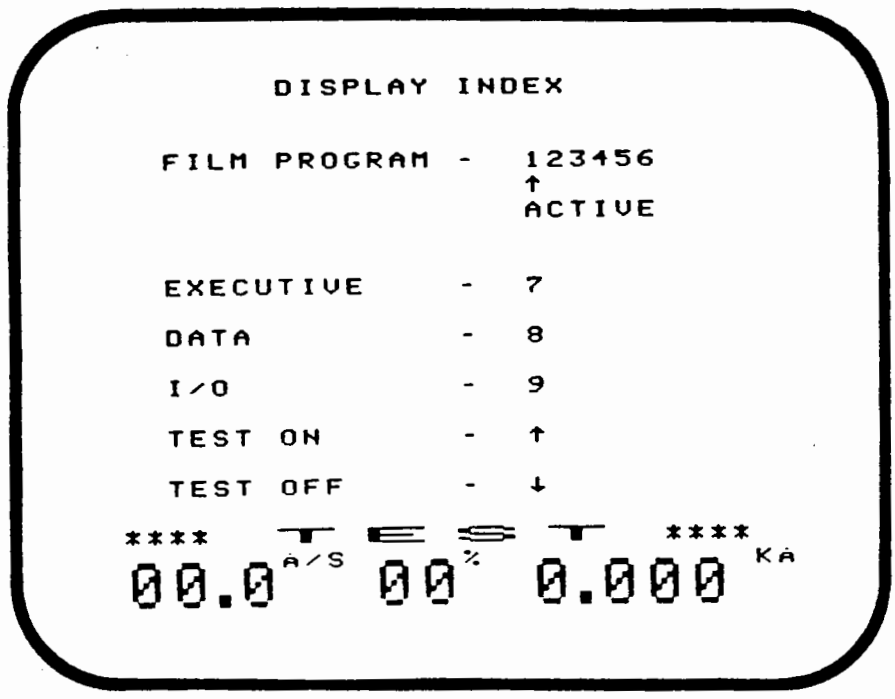


Fig. 2-2 Initial Display Index

to observe how they work in the film programs. Note that the direction keys work differently if the program is locked (see p. 2-7).

Press DSPL, then 7, to view the Executive Display.

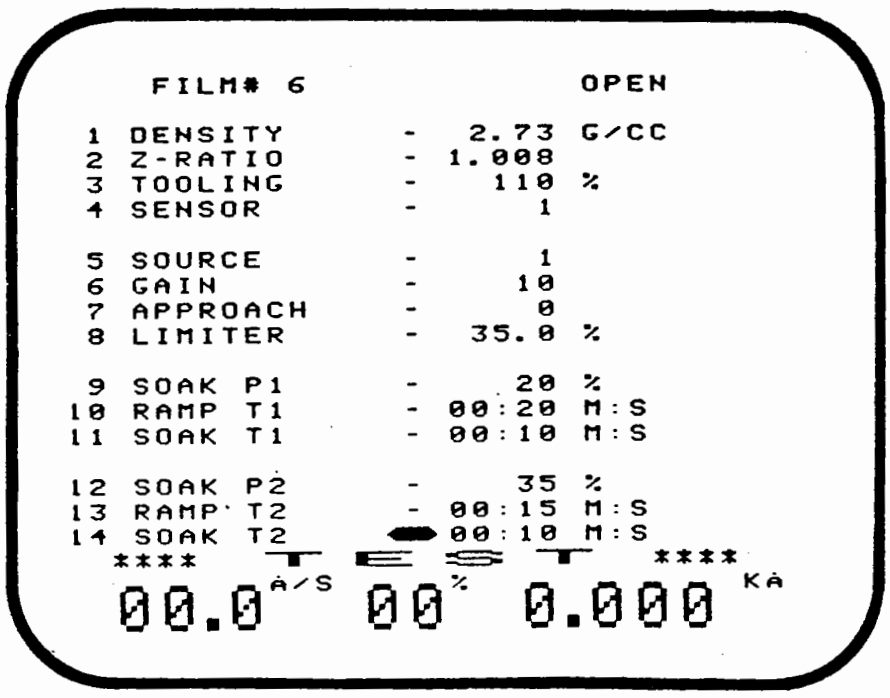


Fig. 2-3 Sample Film Program Display

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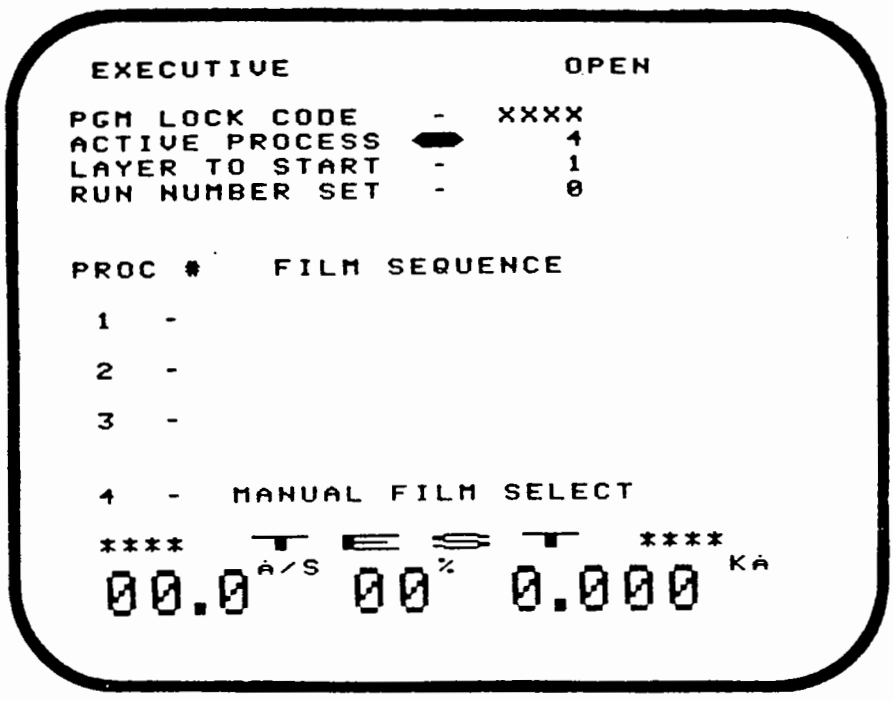


Fig. 2-4 Sample Executive Display

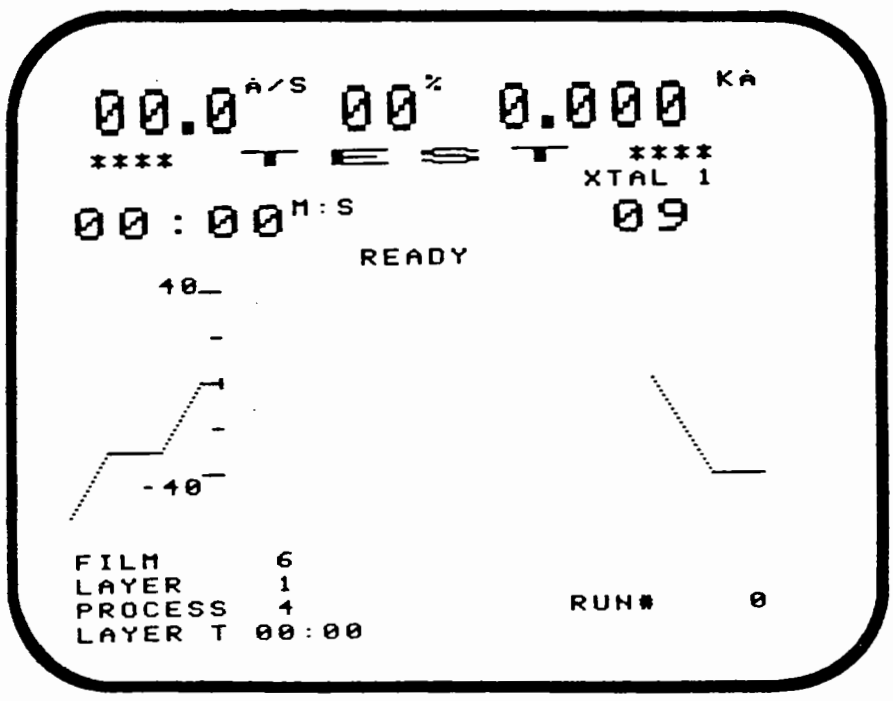


Fig. 2-5 Sample Data Display

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Executive Display (Fig. 2-4)

The Executive display provides the only entry to the Program Lock Code (see p.3-11 for programming). It tells which process is active (Active Process) and, for Processes 1,2, and 3, in which layer the unit will start (Layer to Start). "Run Number Set" allows the operator to keep track of runs (with each start of first layer of the process incrementing the run number by one). The film sequences of Processes 1 through 3 are programmed and recorded on the Executive display; Process 4, Manual Film Select, is also indicated. The lower portion of the display gives rate, power, and thickness information on the active film and indicates whether or not the unit is in the test mode.

Now press DSPL 8 to select the Data display.

Data Display (Fig. 2-5)

The Data display gives complete information for the deposition layer in progress, as well as the status of the crystal sensors and any other deposition sources used. The top of the display shows deposition rate (Å/s), power (%) and thickness (kÅ). Deposition rate is shown to the left. If the desired rate in a film program is under 25 Å/s, the resolution of the rate display will be .1 Å/s. If the programmed rate is higher than 25 Å/s, resolution will be 1 Å/s. The power display is a direct indication of the control voltage being applied to the active source (% of 10 volts). If <u>any</u> source (active or not) reaches or exceeds its programmed maximum power level, the % power indication flashes on the screen. Four digits of thickness are displayed. The units are Å and the floating decimal point gives 1, 10 or 100 Å resolution as the thickness increases from 0 to 999.9 kÅ. If the unit is in the test mode the word "TEST" appears just below the rate-power-thickness indication.

The next horizontal area of the display gives phase time, layer phase and crystal status. Phase timer shows the time remaining, or the elapsed time of the active layer phase in minutes and seconds. The active phase is indicated in the center portion of the display. The crystal status display is located under the thickness indication. In addition to indicating the sensor selected and its approximate frequency shift, a flashing indication ("XTAL") shows that a crystal failure has occurred. An alternate display of S & Q accumulators is available by pressing the decimal key (see p. 4-13). Changing to another display and returning to the Data display reestablishes the crystal life reading in this area.

Source status and rate deviation are found on the central portion of the CRT. If any source has a control voltage applied to it by the IC 6000, the appropriate source number is shown on the graphic representation of the deposition cycle. As the process phase changes, source numbers move across the CRT.

During the Rise and Soak periods, the active source is displayed above the power graph, and the source being presoaked is displayed below it. When a source reaches the deposition phase, the graphic display is changed to indicate the "rate deviation" from the desired or set rate of the active process. The vertical scale is ±40 Å/s, with 1 Å/s resolution. The horizontal time base of this deviation display is controlled by process parameter 37 (Plot Dwell). The horizontal scan rolls around on itself, erasing previous data if all measurement cannot be contained on a single scan. If

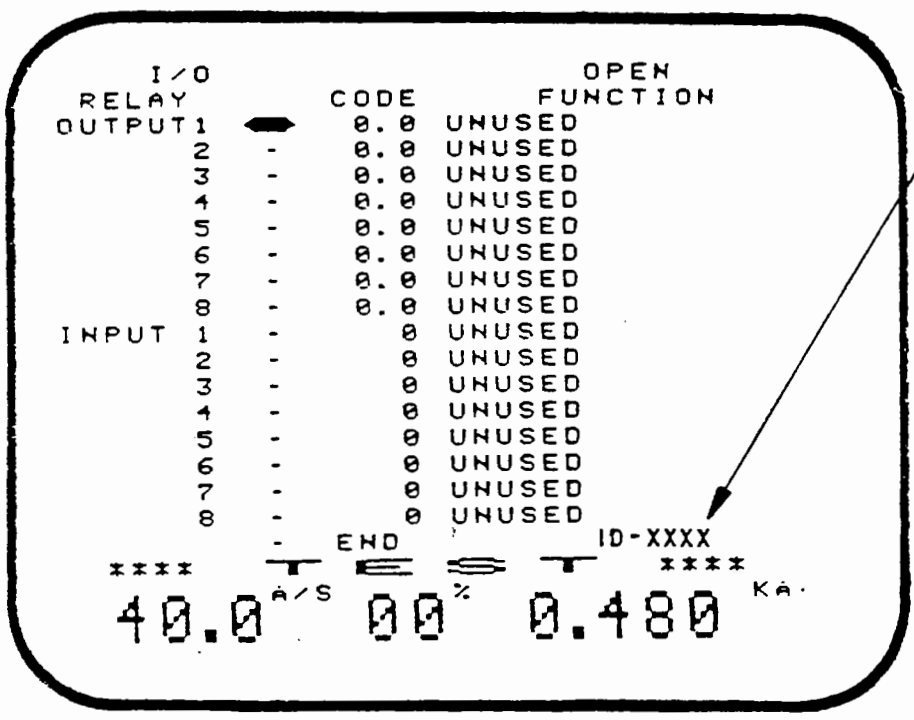
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the plot dwell is greater than one, additional rate deviations will be plotted in the same horizontal location, giving a "cloud formation" display of rate deviation. To obtain the average value of this "cloud," the operator changes to another display and then returns to the Data display. The information gathered prior to returning will be displayed as averaged data, with the "cloud" display continuing from the point of return. The lower left portion of the screen shows active film, active layer, active process and layer time. Run number is logged at the right. The lower portion of the screen also contains a space where flashing status messages are displayed (p. 7-2).

I/O Display (Fig. 2-6)

The Input/Output display is typically programmed only once, but may be viewed at any time. With one I/O module, the user can program four outputs and four inputs; the addition of a second module doubles that capacity. When the outputs and inputs are programmed, the message code appears on the display; any that are not programmed read "unused." Page 3-12 provides information on programming the I/O display. You can turn to this section and experiment with entering codes. Do not, however, make any back panel connections until you thoroughly understand how to program the I/O.

CAUTION: Once the I/O is programmed, the IC 6000 is interchangeable *only* with IC 6000 units which have identical I/O programs.



Note: To aid in diagnosing Field Service and application problems a 4-digit hex coded firmware ID is displayed in this area. This will change with firmware revisions and should be reported when requesting service or application assistance.

Fig. 2-6 Sample I/O Display

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DESCRIPTION OF KEYBOARD

In addition to the video display, the front panel also includes a keyboard. The function of the various keys is described below:

Front Panel Key	Function
Digits 0-9	Enter program data and call displays (when pressed after DSPL key).
•	Enters decimal point in program data, and (in Data display) calls up stability and quality factor information in place of crystal life.
↑ ↓	A momentary press of either of these keys moves the cursor one step up (↑) or down (↓); holding them down causes fast-scanning. In the Display Index, these keys designate test on (↑) or test off (↓). If the program is locked, pressing these keys turns the display pages.
C	Clears newly entered data at the cursor location and recalls old data. (In Executive display, this key also performs an editing function; see p.3-11.)
E	Enters displayed data at cursor location and steps cursor to next parameter.
EDIT	Moves cursor to a deleted parameter in the film program and displays it for entering data. Pressing it again moves the cursor to subsequent deleted parameters. (For function of EDIT key in Executive display, see p.3-11.)
FLM #	Used only in Data display to change the active film. In order to change the active film, the unit must be in a ready-to-start mode (START light on) and be programmed to process #4 (manual film selection). Pressing FLM #, then the appropriate digit (1-6) establishes the active film.
DSPL	Used for changing displays when followed by a digit key (1-9).

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FRONT PANEL CONTROL SWITCHES

Abort Switch

Pressing the ABORT switch terminates the deposition activities. The ABORT button lights, all source powers are reduced to zero, and in the Data display, a flashing status message appears, giving the reason for the abort (see p. 7-2). The abort and stop relays activate, if they have been programmed.

Start/Cont Switch

One of two functions is performed by this push button depending upon the status of the IC 6000 when the button is pressed.

1. START - If the unit is ready (START/CONT lighted), pressing will initiate a film program.

2. CONT (continue) - If unit is aborted or stopped (ABORT lighted), pressing the START/CONT button will place the unit in a ready-to-start condition (START/CONT lighted) for the same film program that was being executed when the abort or stop occurred. If the shutter was open at the time of the abort, any accumulated thickness and analog history will be retained until the film is completed. This function allows an aborted sequence of films to be continued with minimal operator action. If the continue feature is invoked while a remote "Final Thickness Trigger" input is active, the present active film will be skipped on the next start command.

Reset Switch

Two functions are performed by this push button, depending upon whether or not the IC 6000 is in an abort condition.

1. RESET (Process) - If the unit is aborted or stopped, (ABORT lighted), pressing RESET makes the unit ready-to-start, resets the layer counter to 1, and resets the active film to the film # determined by the Executive display (Layer to Start). Any accumulated thickness will be lost.

2. RESET (Film) - If the unit is not aborted, (ABORT not lighted), pressing RESET will remove any active film source power, and will reset the active film phase sequencing to the ready phase of this layer. If the shutter was open at the time the RESET button was pressed, any accumulated thickness and analog display history will be retained. Pressing START will reinitiate the active film program.

MAN Switch

The (MAN) manual switch overrides automatic sequencing and is used to go in and out of manual power control. When you press an unlighted MAN button, the button lights, the shutter opens for the active source, and (if you are in Data display) the word "manual" appears on the screen. Source powers are maintained until altered with the controller.

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Pressing the MAN button again takes the machine out of manual control. The light goes off and the unit proceeds to automatic control loop (deposit) for the active film. However, if the final thickness has been exceeded,the unit will sequence to the next viable phase, with accumulated thickness displayed.

XTAL SW

The lighted crystal switch (XTAL SW) button indicates that the crystal currently in use is not the one that has been programmed for that film. Pushing an unlighted XTAL SW button causes the crystal to switch from the primary to the alternate crystal and turns the light on. The thickness is retained from the first crystal and measurements begin to accrue from the new crystal. Pressing again returns the unit to the first crystal and turns the light out. The switch is also used to clear the relay and the operator indication for crystal failure.

ZERO THK SWITCH

Pressing this switch zeroes the thickness reading on the display.

GENERAL GUIDELINES FOR PROGRAMMING FILM DISPLAYS

The following general guidelines apply to programming any of the six IC 6000 film displays. Please note, however, that the program keys do not function as described below if the program is locked. For programming the Executive display, see p. 3-11 . For an explanation of the terms used in programming, see p. 7-1 .

1. The cursor is controlled by the arrowed keys (↑ ↓). One momentary press moves the cursor one step (parameter) up (↑) or down (↓). Holding the key down causes the cursor to fast-scan a page. When it reaches the bottom (or top) of a page, the page changes automatically. If the program is locked, the cursor will not move as indicated above, but will change the film program pages. (The parameters cannot be altered with the program locked.)

2. Entry is a two-stage operation using digits 0 through 9 and the E key. Numbers are placed on the display by pressing the most significant digit first. That is, to enter 12.3, press 1,2, . (decimal), then 3. (For time entries, see #6 below.) After checking the numbers and pressing the E key, the data is entered and the cursor steps to the next parameter.

3. Illegal entries (i.e., entries outside the parameter ranges listed on p. 4-5) will produce an "ERROR" message on the screen, and the cursor will not move. If this occurs, clear the illegal data by using the C key, and enter a correct number.

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4. Some parameters can be deleted from the film programs (see p.4-5). To remove them, enter a zero for that specific parameter by pressing 0, then E. Do not merely press E, or the cursor will step to the next parameter without deleting the previous one. Entering a zero removes the parameter from the display, and in some cases, automatically deletes other parameters from the group. For example, entering a 0 (zero) in (Rate Ramp 1) New Rate, will also cause Start Ramp and Ramp Time to be deleted.

5. The EDIT key is used to recall deleted parameters. The first press of the EDIT key advances the cursor and displays a previously deleted parameter and any others that may have been deleted from the group. Pressing it again recalls subsequent deleted parameters. If you press EDIT after the last deleted parameter in the program has been recalled, the cursor will step to the end of the program. Once the EDIT key has displayed the parameter of interest, you can enter a value which will then become part of the program. (For more information on the EDIT key function, see Test Program, step 26, p. 2-16.)

6. Time parameters can be entered in seconds or in minutes:seconds. If you want to enter minutes:seconds, both digits of the "second" notation must be entered. For example, to enter two minutes, press 2, . (decimal),0,0, and then the E key. To enter two and one-half minutes, press 2, . (decimal), 3,0, and then the E key.

   When entering seconds only, the number (if greater than 59) is automatically converted to minutes:seconds. For example, 125 seconds will appear as 2:05 on the display.

IC 6000 TEST PROGRAM

At this point, you are ready to enter a sample program and observe a test run of the instrument to make sure it is performing correctly. You may want to leave this sample program in Film #6 for future tests.

1. Slide the top cover back and set the two internal toggle switches (red and white) toward front of instrument. Plug the power cord into the unit and into the line source for which it was ordered.

2. Push the POWER switch. Check to see that the POWER and START/CONT switches remain illuminated.

3. After a 10-15 second warm-up, check to see that the Display Index appears (Fig. 2-2).

4. Press DSPL 6. Enter the parameters shown in Fig. 2-7 (a through d) into Film #6. Notice that you are entering 0 in some parameters, thereby deleting them (and, in some cases, others from their groups). Be sure to enter 0 (press 0 key followed by E key) if it appears; do not merely go on to the next parameter.

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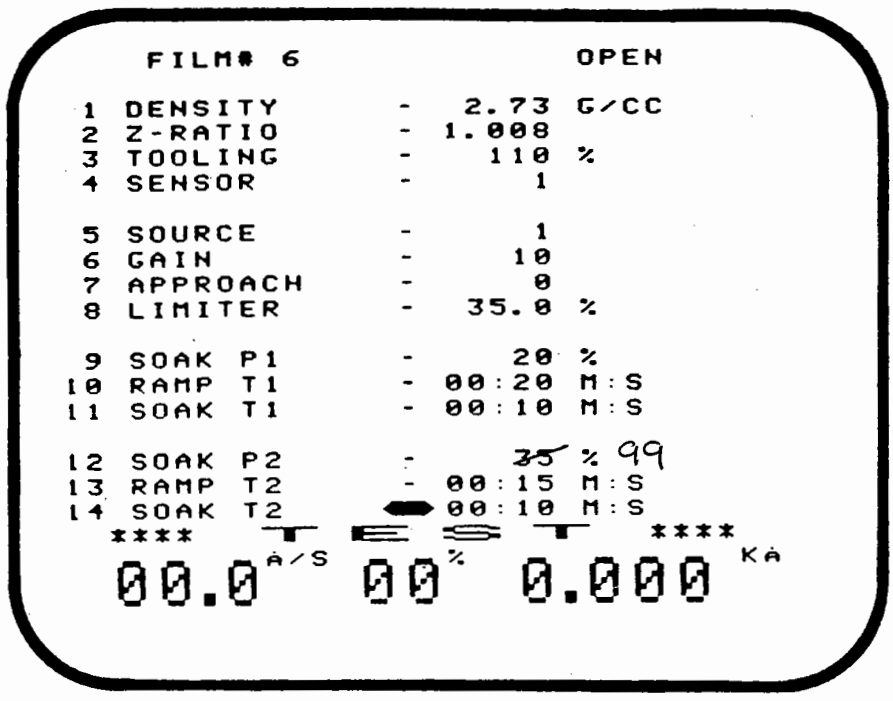


Fig. 2-7a IC 6000 Test Program Displays

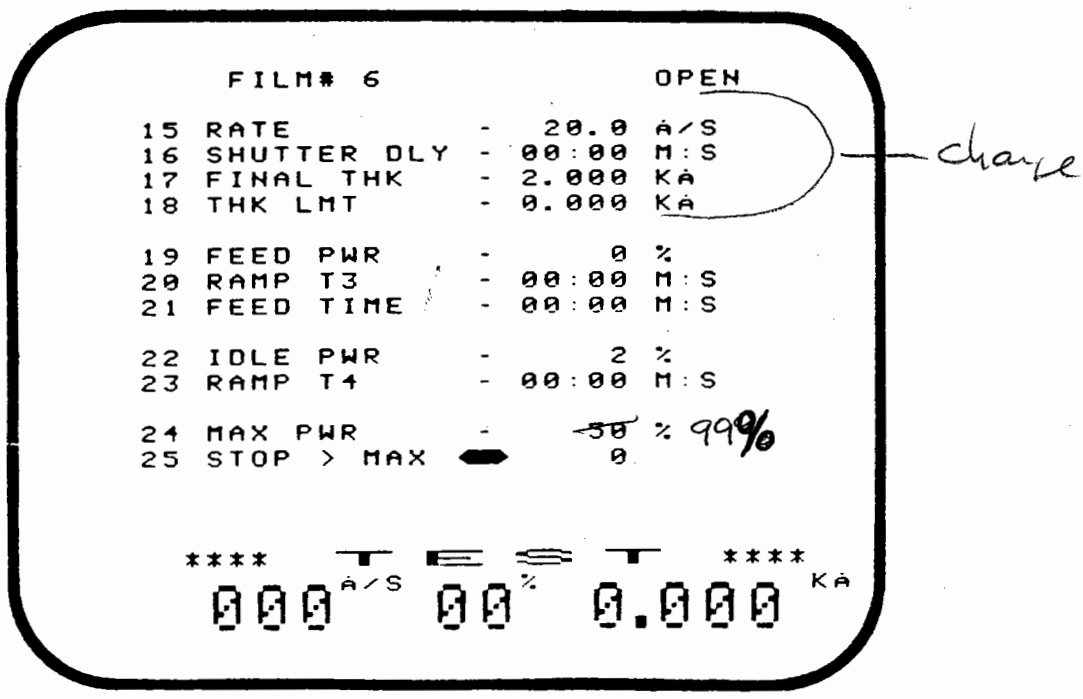


Fig. 2-7b

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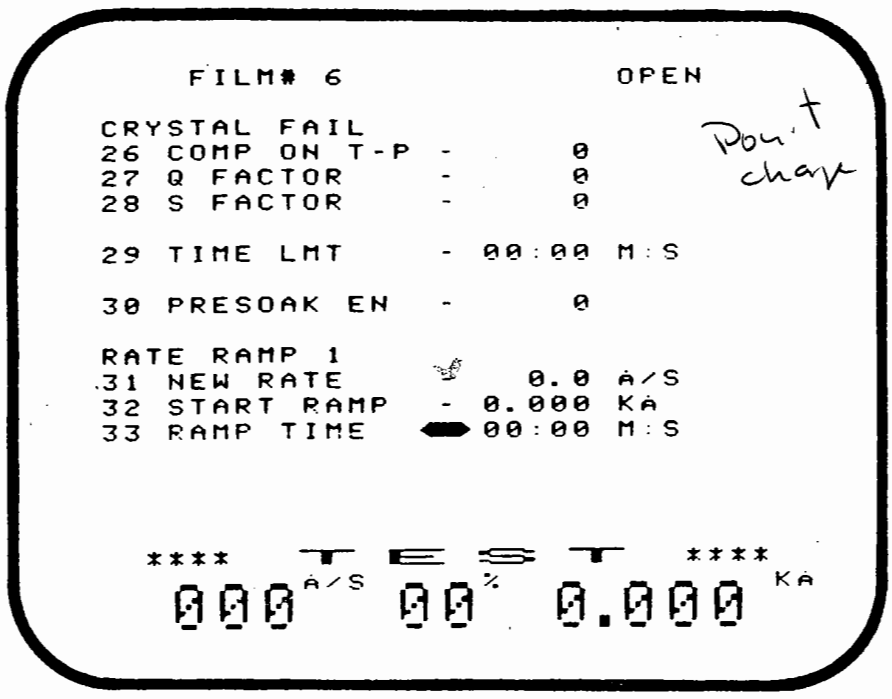


Fig. 2-7c

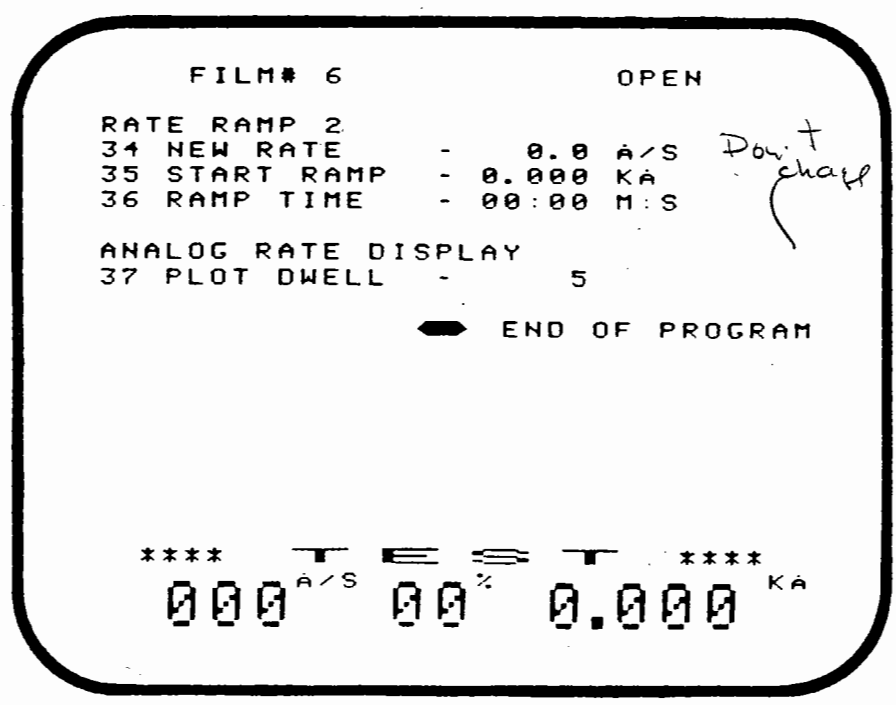


Fig. 2-7d

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5. After programming, go to the Executive display (DSPL 7); enter active process 4 (if it is not already entered), by pressing 4, then E. The display should appear as in Fig. 2-8.

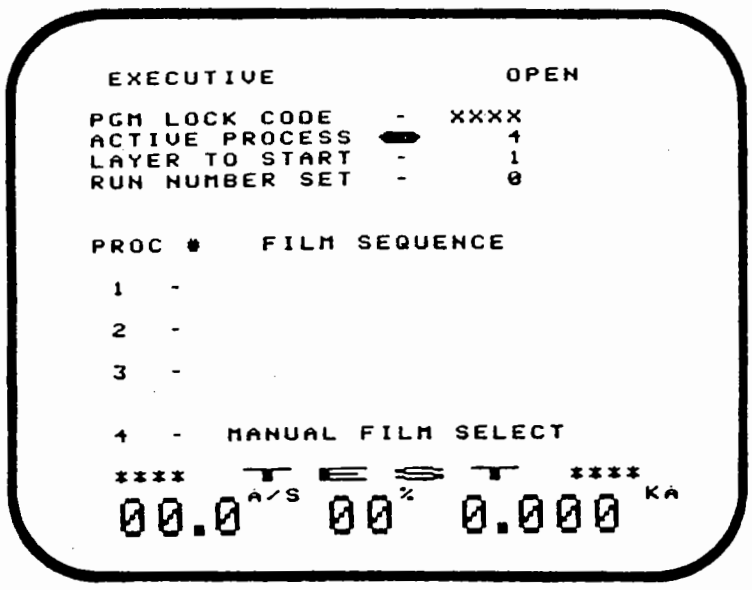


Fig. 2-8 Executive Display Program

6. Go to the Data display (#8). Check that the film number entered is 6; if it is not, enter 6. (Press FLM# 6.) The display should appear as in Fig. 2-9. (Note that the crystal life number will be random in a test program.)

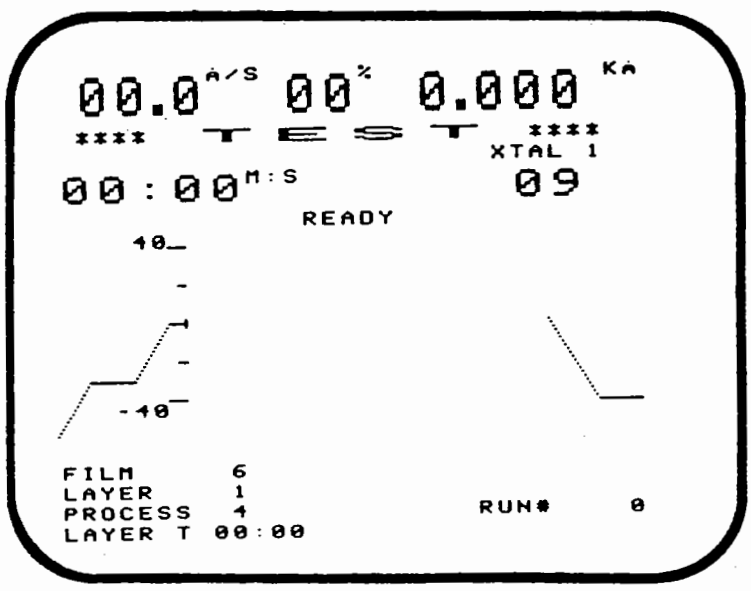


Fig. 2-9 Data Display before Test Run

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7. Push START to begin a test run. Observe the run indications on the Data display as shown in the series below (Fig. 2-10). Note that the power indication will flash when the unit reaches max power.

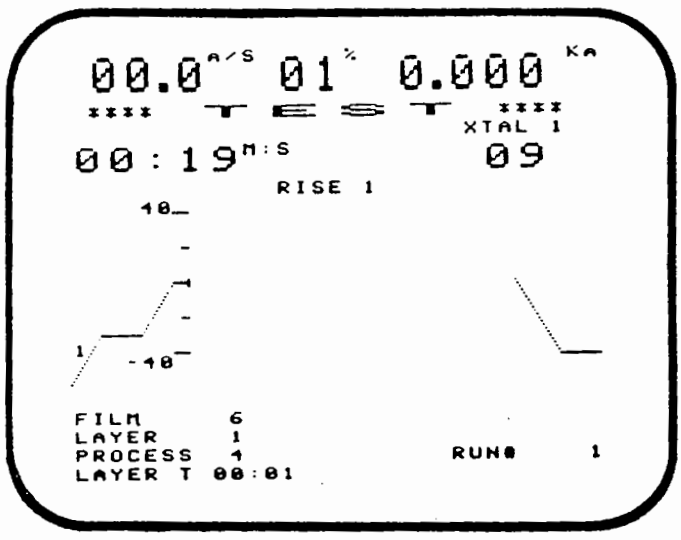


Fig. 2-10a Test Run Display

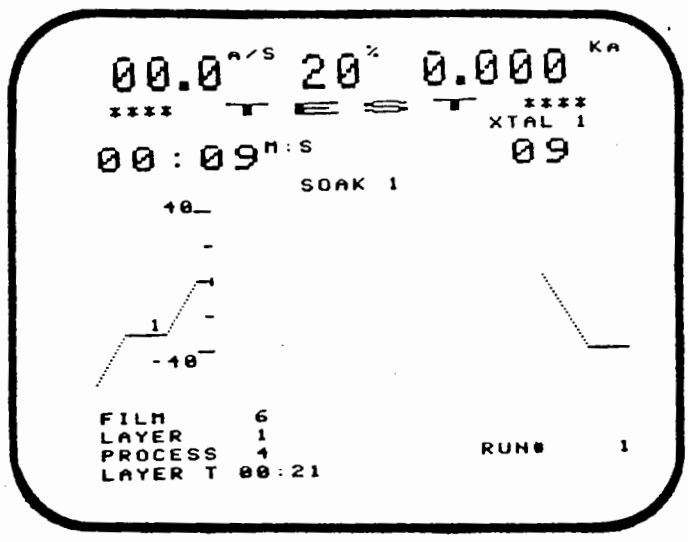


Fig. 2-10b

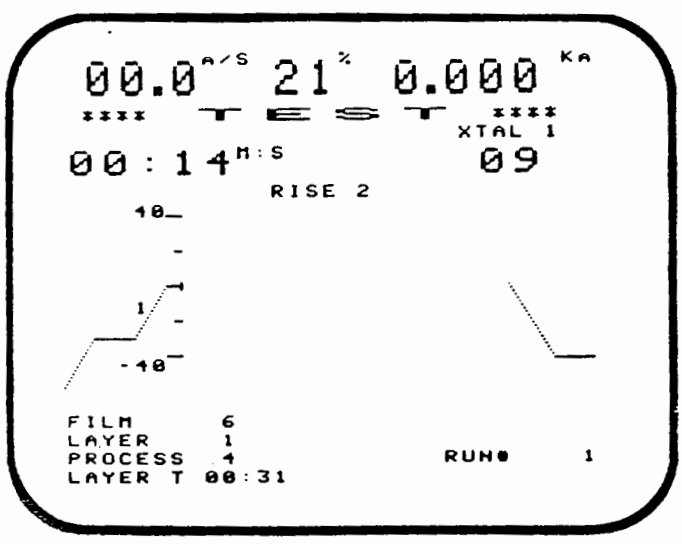


Fig. 2-10c

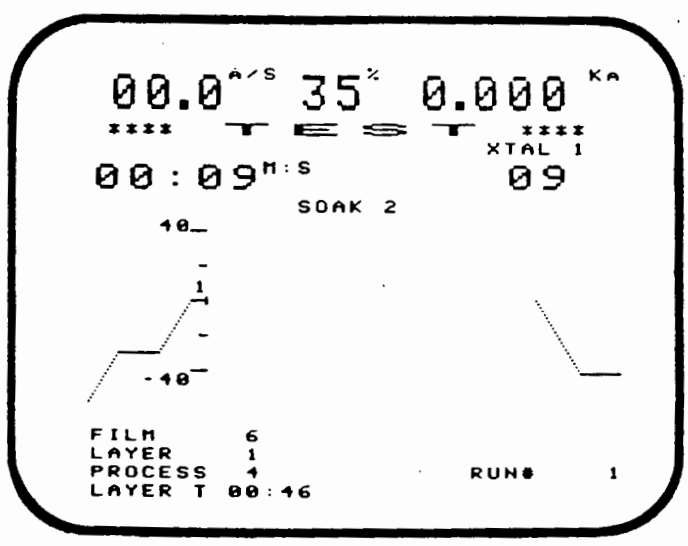


Fig. 2-10d

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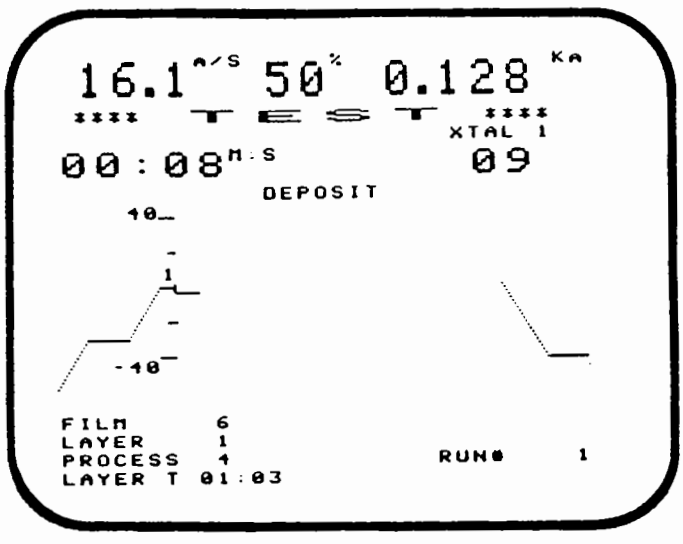


Fig. 2-10e

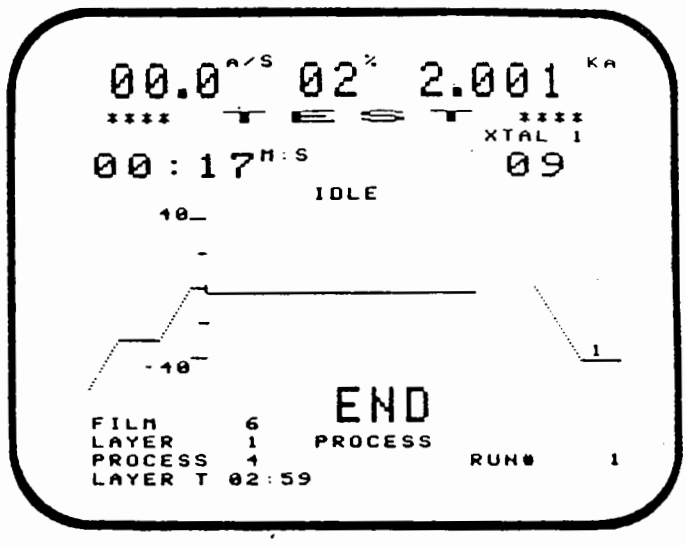


Fig. 2-10f

8. After the test run is completed, go back to film program #6 (push DSPL 6).

9. Using the cursors (↓) (↑) to scan the pages, observe that the film program has been compressed to two pages as shown below (Fig. 2-11).

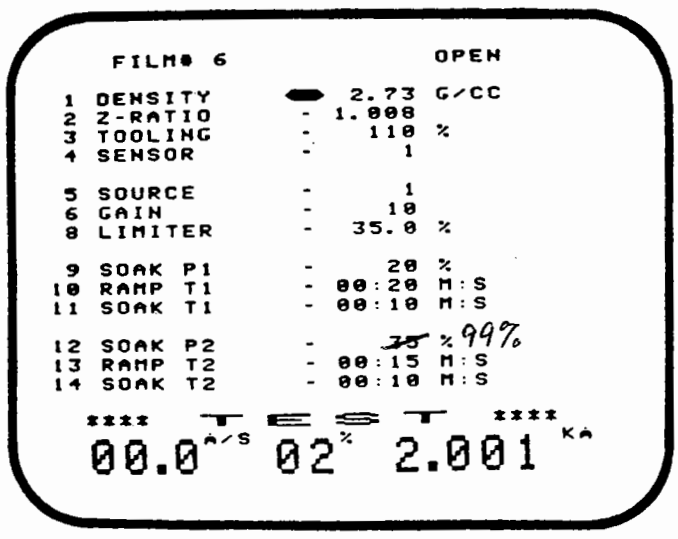


Fig. 2-11a Compressed Film Program

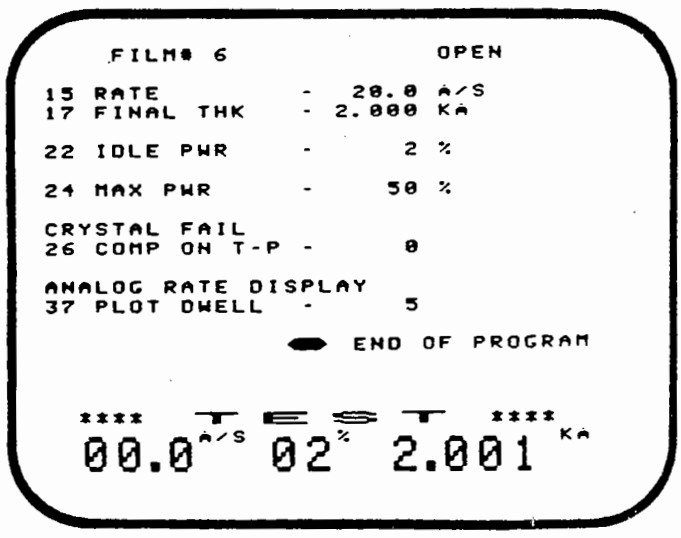


Fig. 2-11b

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10. Use the cursor (↑) to return to the Density parameter (#1) on page one (or press DSPL 6 again).

11. Press EDIT to return to deleted parameters. With the first press, the cursor will return Approach. Leave at 0 at this point. (Do not re-enter.)

12. Press EDIT. The cursor will return the Shutter Dly parameter. Enter 15 seconds.

13. Press EDIT. Cursor will return Thk Lmt. Leave at 0 at this point. (Do not re-enter.)

14. Press EDIT. Cursor will return Feed Pwr. Enter 25%.

15. After entering Feed Pwr, cursor will step to Ramp T3. Enter 10 seconds in Ramp T3.

16. After entering Ramp T3, cursor will step to Feed Time. Enter 10 seconds.

17. Press EDIT. Cursor will return Ramp T4. Enter 10 seconds.

18. Press EDIT. Cursor will return Stop>Max. Leave at 0 at this time. (Do not re-enter.)

19. Press EDIT. Cursor will return Q-Factor. Leave at 0. (Do not re-enter.)

20. Press EDIT. Cursor will return S-Factor. Leave at 0. (Do not re-enter.)

21. Press EDIT. Cursor will return Time Lmt. Leave at 0. (Do not re-enter.)

22. Press EDIT. Cursor will return Presoak En. Leave at 0. (Do not re-enter.)

23. Press EDIT. Cursor will return (Rate Ramp 1) New Rate. Enter 5.

24. After entering New Rate, the cursor will step to Start Ramp. Enter .5.

25. After entering Start Ramp, the cursor will step to Ramp Time. Enter 20 seconds.

26. After entering Ramp Time, the cursor steps to Plot Dwell. To return to Rate Ramp 2, use (↑) cursor to step to Ramp Time (parameter #33); press EDIT. Cursor will return to (Rate Ramp 2) New Rate. Enter 30.

27. Cursor will step to Start Ramp. Enter 1.5.

28. Cursor will step to Ramp Time. Enter 20 seconds.

29. Leave Plot Dwell at 5.

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30. Press DSPL 8 (Data); push START; watch a test run with some deleted parameters added.

Note: With Rate Ramp 1, the unit will first experience a decrease in power (approaching 0). Rate Ramp 2 will force power to max power and a flashing indication will appear on the screen surrounding the power number.

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INFICON
LEYBOLD-HERAEUS

SECTION 3
INSTALLATION AND PROGRAMMING THE EXECUTIVE AND I/O DISPLAYS

Section 3 of the IC 6000 manual contains instructions for installing the sensors, connecting the back panel modules, and programming the Executive and I/O displays. Please read the instructions carefully before you proceed. The following topics are included in this section:

- Pre-Installation and Grounding Instructions
- Installing the Sensors
- Installation of Shutter Control Valve Assembly
- Back Panel Connections
- Programming the Executive Display
- Programming the I/O Display
- Programming the Option Prom

Before you actually begin using the instrument, you should read Section 4, which gives detailed information on programming the film displays.

PRE-INSTALLATION INSTRUCTIONS

When interfacing the IC 6000 with the coating system, please observe the following precautions:

WARNING: Remove ac line power whenever interface connections are being made.

CAUTION: Read the programming instructions on page 3-11 carefully, *before* you program the I/O display.

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In addition,

-Be sure that the cooling fan on the back of the IC 6000 is free from obstructions.

-Provide adequate ventilation when rack or cabinet mounting the unit.

-Check power requirements on page 1- 3.

-Connect a ground braid between the lug on the rear panel of the instrument and the vacuum system's main ground points, as well as a ground between the cable shield and the source/ sensor connector screw, as shown in Fig. 3-1.

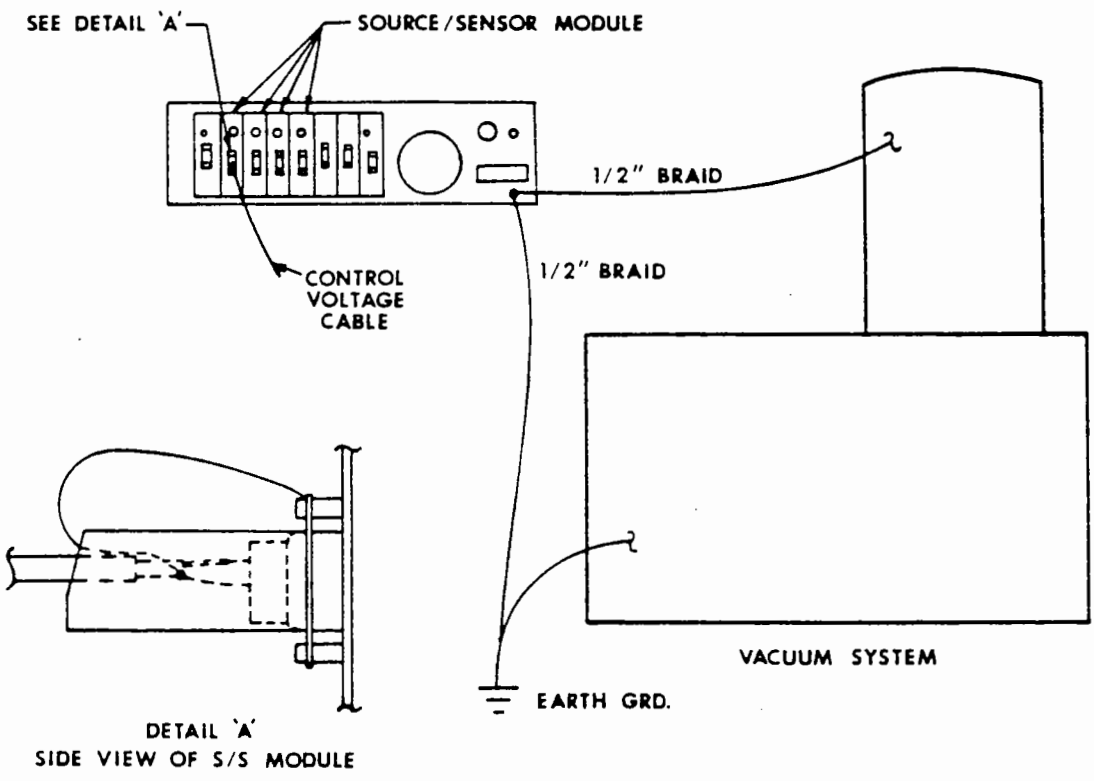


Fig. 3-1 Grounding Diagram

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INSTALLING THE SENSORS

Once you have tested the instrument to make sure it is running properly, you are ready to begin installation. The following general installation guidelines refer to the regular, dual, and bakeable sensors only. If you ordered a sputtering sensor, please refer to page 3-4.

- The sensor should generally be installed as far as possible from the evaporation source (a minimum of 10" or 25.4 cm.), while still being in a position to accumulate thickness at a rate which is proportional to accumulation on the substrate.

- Use a shutter to shield the sensor from spattering during the initial soak periods. If the crystal is hit with even a minute particle of molten material, it may be damaged and stop oscillating. Even in cases when it does not completely stop oscillating, it may become unstable.

Installation Procedure — Regular and Dual Sensors

The regular and dual sensors may be installed in any appropriate location within the vacuum system. Two tapped holes are provided on the back of the sensor body for attaching to the system. The cable length should not exceed 40 inches (101.6 cm.) from the sensor to the feedthrough. Cut the water cooling tubes and air lines to the proper length and connect them to the feedthrough by brazing or vacuum couplings. (Use a bending tool to form the tubes to the system.) Shield the coax cable from heat radiating from the evaporant source or substrate heater. You can do this very simply, if your process allows, by wrapping aluminum foil around the cable and water lines.

Installation Procedure — Bakeable Sensor

The bakeable sensor may be installed as described above, or with the clamps on the lines running to the sensor. The cable length and air lines are not adjustable. It will not be necessary to shield the cables. We do suggest, however, that you install a deposition shield to prevent accumulation of material on the cam mechanism. If the water and coax lines require bending, we suggest a minimum bend radius of ½". Always use a bending tool or form to avoid kinking.

Please refer to the specifications on pages 1-3 through 1-7 for other installation requirements, including maximum operating temperatures.

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Installing the Sputtering Sensor

The sputtering sensor can be installed in any position, and supported by the water-cooling tube. Cut the water-cooling tube to the proper length and connect it to the feedthrough with brazing adaptors or vacuum couplings. Avoid exposing the sensor cable to the glow discharge by wrapping the cable around the water-cooling tube and covering it with aluminum foil. Figure 3-2 shows several possible locations for the sensor in various sputtering systems.

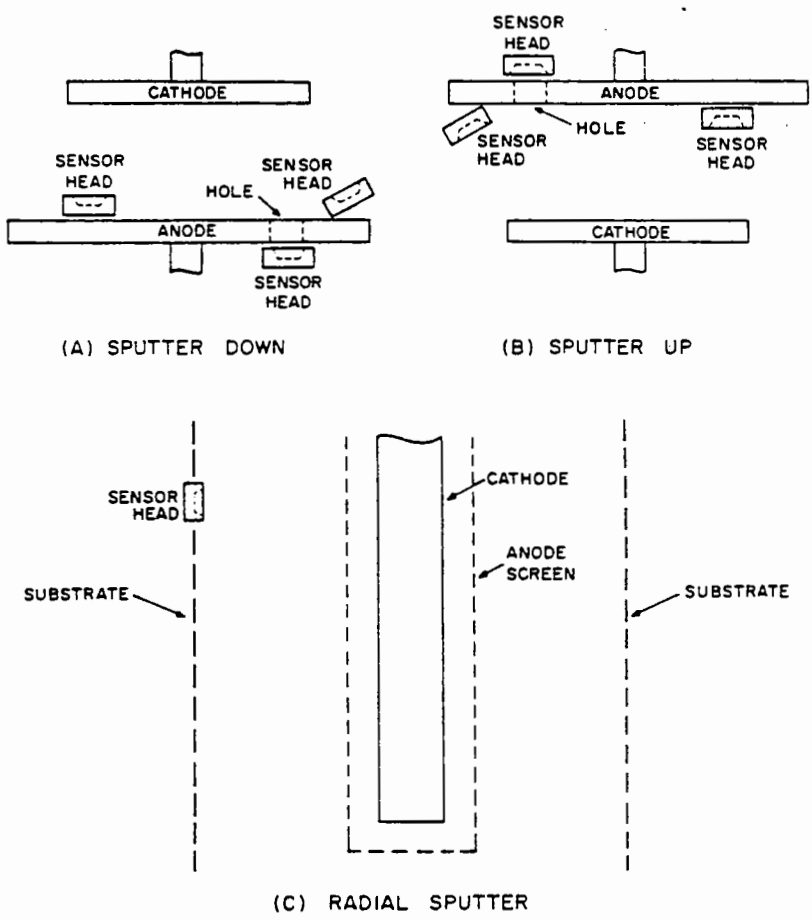


Fig. 3-2 Suggested Sensor Locations in Sputtering System

Because of geometric factors, variations in surface temperature, and differences in electrical potential, the crystal and substrates often do not receive the same amount of material. If you want the thickness indication on the unit to represent the thickness on the substrates, calibration is required to determine the tooling.

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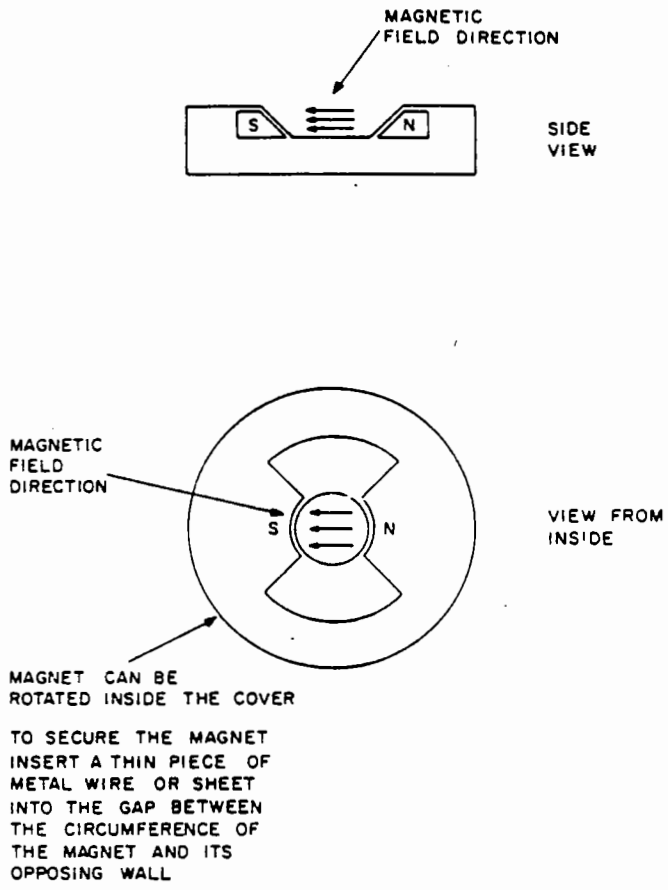


Fig. 3-3 Sensor Magnet & Field Configuration

The following precautions must be observed when installing the sputtering sensor:

1. Use water cooling during the sputtering process. Approximately 0.2 (750 cc/min) gpm water flow should be sufficient for most applications. Always check the water flow before starting the glow discharge.

2. In sputtering systems which use a substrate shutter, the sensor should be mounted in a location where it is always exposed to the glow discharge. If it is not, and the shutter is covering the sensor, there will be a small thickness jump when the shutter is opened, caused by thermal stress in the crystal.

3. The sensor contains a permanent magnet (Fig.3-3). If the sensor is to be installed in a sputtering system which employs external magnetic fields, make sure the magnetic field direction of the sensor is not opposing the external magnetic field (Fig. 3-4).

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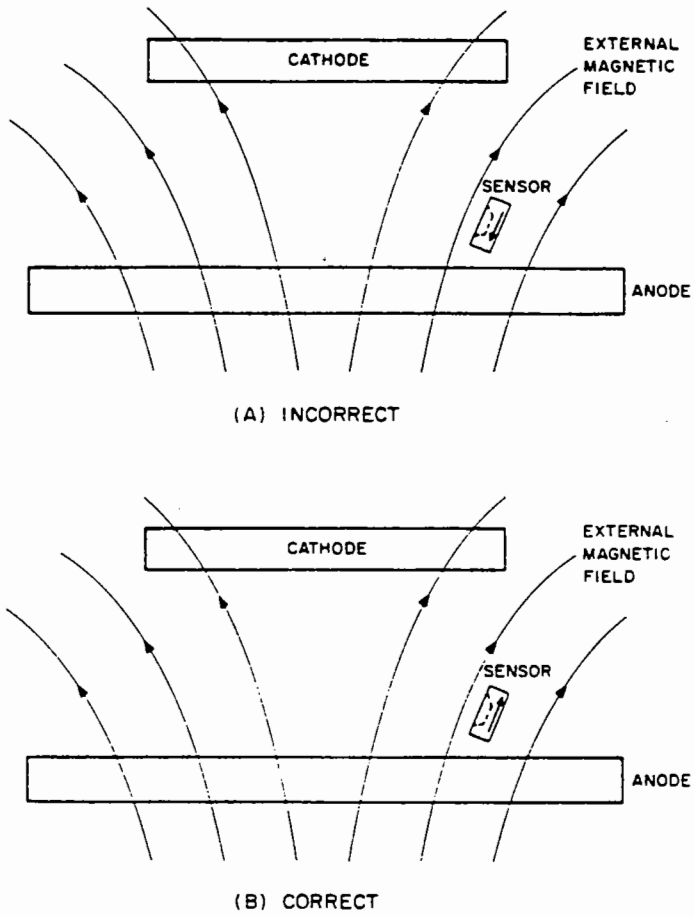


Fig. 3-4 Orientation of Sensor Magnetic Field in a Sputtering System Employing External Magnetic Field

The cancellation of magnetic fields near the sensing crystal may cause undesirable heating of the crystal. Use a small magnet to determine the field direction and rotate the magnet in the sensor to a desirable position. The sensor magnet can be held in position by inserting a small piece of thin non-magnetic metal wire or sheet into the gap between the circumference of the magnet and the opposing wall. The sensor's magnetic field is localized, and will not affect the external magnetic field to any extent.

4. The sensor is always at ground potential and cannot be made floating. In sputtering systems where the substrate holder (anode) is biased, the sensor should be located where it is electrically isolated from the substrate holder and where it does not affect the electric field near the substrates.
5. Be sure both the sensor and the vacuum system are adequately grounded.

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INSTALLATION OF SHUTTER CONTROL VALVE ASSEMBLY

The shutter control valve assembly (IPN 007-199) and the feedthrough should be installed at the same time. The same valve assembly is used for both the 1" and the (recommended) 2 3/4" feedthroughs. However, if the assembly is to be used with the 2 3/4" feedthrough, you will need to modify the valve bracket as follows:

1. Align the slot in the valve assembly over the edge of a table or other square edge.

2. Using pliers, grasp the part of the bracket extending over the edge and push down. The assembly will break along the slot. Use a file to smooth any rough edges which may be formed along the break.

Installation with 1" Bolts

You will need two 1" bolts. Use the first as is; on the second, one water line must be plugged, the other must have a fitting adapter (IPN 007-133) soldered to it. (This part is only available from Inficon.)

Now follow the steps below:

1. Insert 1" bolt
2. Add bracket
3. Add washer
4. Add nut
5. Tighten
6. Add the air fitting to the water line which has the fitting adapter installed
7. Connect 1/8" teflon air line
8. Install air line to 80 psi source.

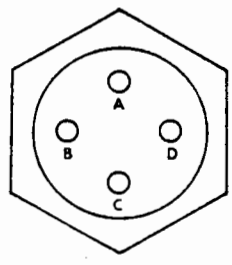
Installation with 2¾" Feedthrough

1. Install feedthrough
2. Add valve bracket (modified) to desired location
3. Tighten feedthrough bolts
4. Install air fitting to fitting adapter
5. Connect 1/8" teflon air line
6. Install air line to 80 psi source.

Note: Maximum assembly temperature is 105°C for bakeout and operation.

Pin Connections

To complete installation of the assembly, make connections for either 25 Vac or dc, using the diagram below.



Use pins D, B for dc;
pins A, C for ac.

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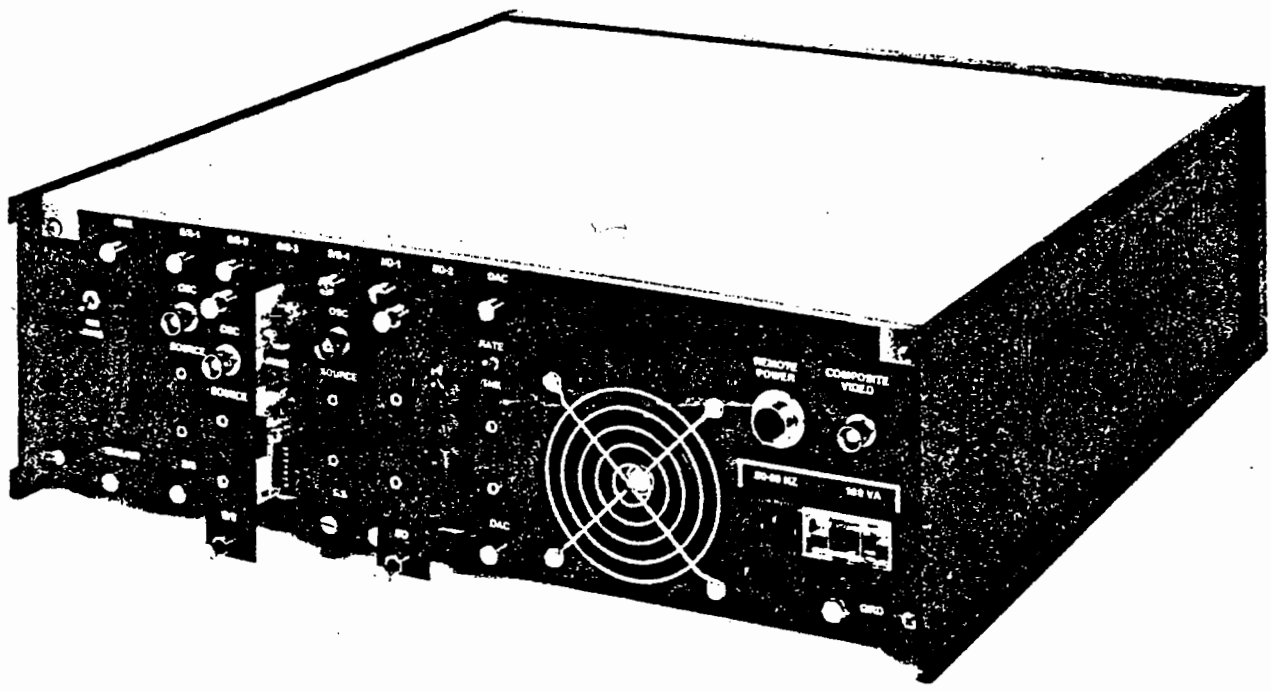


Fig. 3-5 IC 6000 Back Panel

BACK PANEL CONNECTIONS (FIG. 3-5)

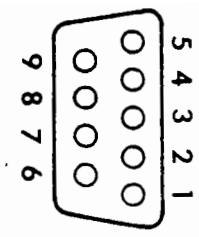
IEEE (488-75 bus interface)

Instructions for the IEEE bus will be included with shipment of that module.

S/S 1, S/S 2, S/S 3, S/S 4

The IC 6000 may utilize up to four (4) source output modules. Each module provides an optically isolated 0 to 10 volt control voltage that may be used to control a deposition power supply. All source outputs are independently isolated and may be referenced to the system ground in any manner the user desires, providing the 1000 Vdc common mode voltage between the output lines and the IC 6000 chassis is not exceeded. The control output lines are high-frequency bypassed to the chassis. All source output voltages are removed when the IC 6000 enters either the abort or stop mode, as indicated by the Data display status message area. Pins 3(-) and 4(+) of the 9-pin connector (J 1) supply the voltage. (The other pins are unused.) We recommend that the pin which establishes the ground reference be tied to the chassis (see p. 3-2). The diagram below shows pin locations on the source/sensor modules.

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J1 Pin Diagram
Source/Sensor Module

I/O-1, I/O-2

One I/O module is shipped with each unit; a second module is optional. Each module provides four optically isolated inputs and four output relays. The function of each I/O module is determined by programming the I/O display. (Refer to p. 3-12 for programming instructions.)

Pin connections for I/O-1 (outputs and inputs 1-4) and I/O-2 (outputs and inputs 5-8) are listed below. The function of each connection is programmed by the user (p. 3-12).

Outputs		J 1 Pin #'s
I/O 1	I/O 2	
1 or 5		6 & 7
2 or 6		1 & 2
3 or 7		8 & 13
4 or 8		3 & 12

Relay ratings: 250Vac (125 VA max)

Inputs		J 1 Pin #'s
I/O 1	I/O 2	
1 or 5		14
2 or 6		4
3 or 7		15
4 or 8		5
common		9
int. 24 Vac		10

With internally provided 24 Vac power source (100 mA max), one side common to J1-9, pin J1-10 can be directly utilized for input to pins 4, 5, 14, or 15.

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With an external power source, the allowable voltage range from J1-9 (common) to either pins 4,5,14, or 15 is from 15-36 Vac rms. The internal 24 Vac power supply is fused at 125 mA. This fuse can be replaced by removing the top cover. Fig. 3-6 shows pin locations on the I/O Module and a connection method showing the simultaneous use of both internal and external supplies.

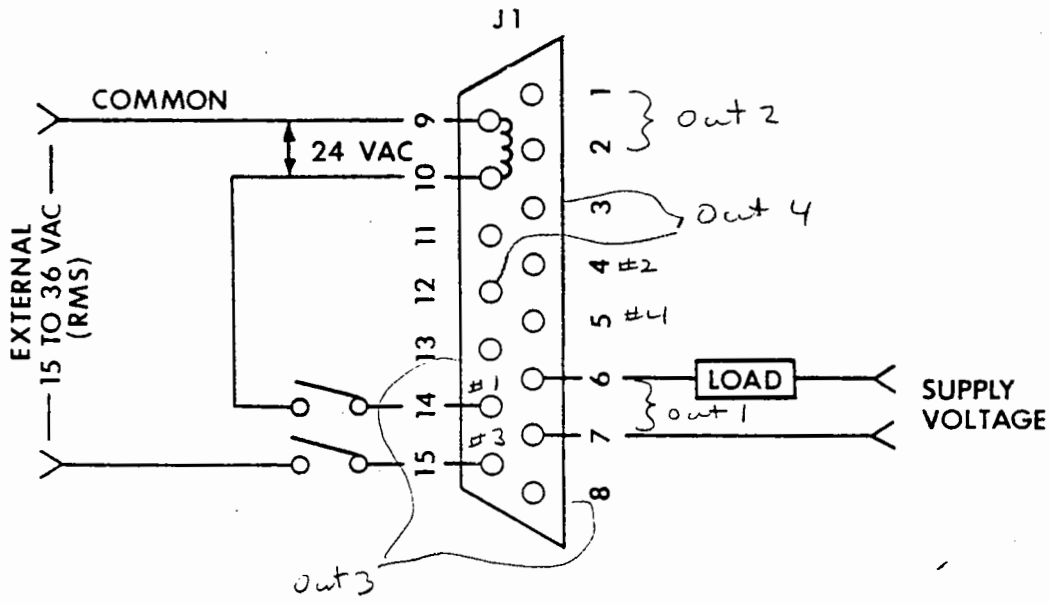


Fig. 3-6 I/O Pin Connections

DAC (digital-to-analog converter)

The toggle switch on the DAC module selects the analog signal which represents either rate (up) or thickness (down). Interfaced with a strip chart recorder, this optional module provides the user with permanent recordings of rate or thickness history. Output voltage is 10 V isolated.

Remote Power Connection (IPN 006-016)

The remote power connection allows the user to control power with a hand-held controller when the unit is in manual mode. The controller contains a three-way switch. All positions are momentary and will return to rest when released. Pushing the switch to the edges causes the output control voltage to increase or decrease. Downward pressure places the IC 6000 in an abort (remote) mode.

Composite Video Output

This BNC connection allows the video display to be shown on a video monitor or reproduced on a hard copier. Standard 50 or 75 ohm coax cables should be used with this connection. The composite video output is a 1.5 volt peak-to-peak output, negative black.

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PROGRAMMING THE EXECUTIVE DISPLAY

Lock Code

To enter the program lock code, follow the instructions below:

1. Select any display mode except the Executive display.

2. Slide the top of the unit back to expose the (red and white) internal toggle switches.

3. Place the white program lock switch in the low security position (toward the back of the unit).

4. Press DSPL 7 to go to Executive Display.

5. If the program data is currently locked, unlock the unit by entering the lock code.

6. If the program is unlocked, enter a four-digit number (1 to 9999) of your choice using digits 1 through 9 and the E key. A code of 0 equals "no lock."

7. Put the program lock switch in high security (toward the front of the unit). The code will be visible until you leave the Executive display, but thereafter will appear as xxxx.

8. To reprogram the lock code, follow the procedure above. If the code is forgotten, see the instructions on p. 4-2 for removing the code.

Active Process, Layer-to-Start, Run Number

For definitions of the above terms, see p. 4-2 . To enter numbers in these categories, the program must be unlocked. Then you may enter numbers, as in the film programs, using digits 1-9 and the E key. You can enter Active Process (1 through 4), Layer-to-Start (1 through 32), and Run Number (0-9999).

Film Sequence

To enter automatic film sequence numbers in Processes 1,2, or 3, use digits 1 through 6 on the keyboard. The square cursor on the display shows where data can currently be posted. Do not press the E key until the entire process has been displayed and checked.

If you make an error or wish to return to a number in the series, press the C key to move the square cursor backward or the EDIT key to move it forward in the line. To clear any number or terminate the sequence, press the 0 key (numbers will be cleared from that point to the end of the series). Layers before the zero will be retained; layers after the zero will be deleted when the sequence is entered.

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PROGRAMMING THE I/O DISPLAY

The IC 6000 is shipped with one standard I/O module installed in the back panel. A second module is optional. Each of these modules contains four optically isolated inputs and four output relays; the function of each is determined by programming the I/O display (DSPL 9). The illustration below shows a sample I/O program (Fig. 3-7).

CAUTION: The I/O display is typically programmed only once, at the time of interface with the coating system. Once the I/O is programmed, the IC 6000 unit is interchangeable only with other identically programmed IC 6000 units.

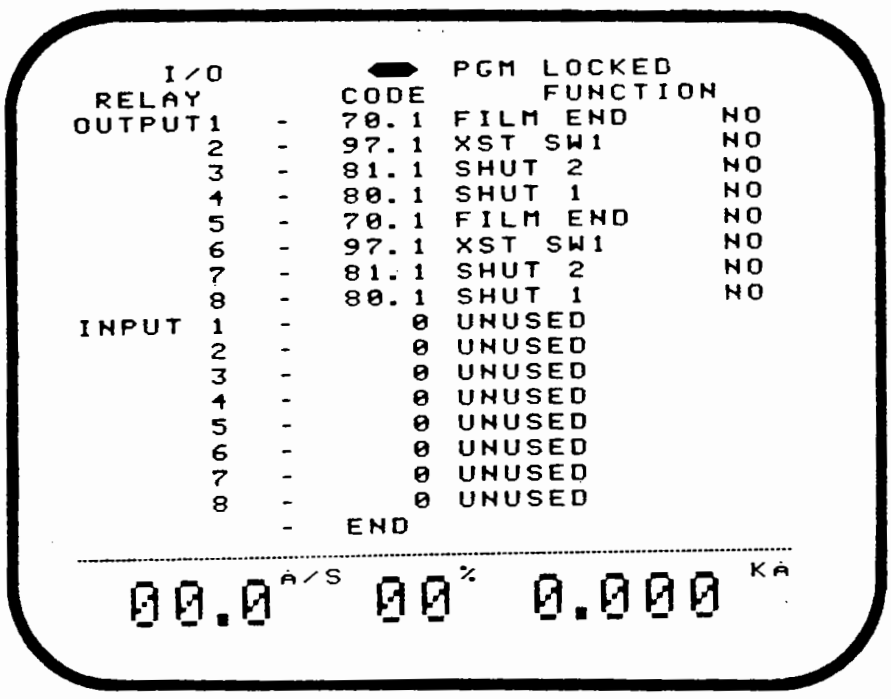


Fig. 3-7 Typical I/O Program

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I/O Lock

To provide security for the I/O program, the IC 6000 incorporates an I/O lock, accessed through the red toggle switch on the inside front of the unit (near the control switch circuit board). When the switch is set toward the front of the unit, the program is in high security position; when it is set toward the back of the unit, it is in the low security position.

I/O Programming

To program the I/O, set the red I/O switch to low security (back). This forces the instrument to the I/O display, and disables the DSPL switch. In order to leave I/O display, the red switch must be placed in high security (toward front). When the switch is set to high security, the Data display appears, operation may be resumed, and no alterations can take place in the I/O program until you once again place the switch back to reprogram the display.

Note:

If the unit has a programmed option prom, it will reprogram the I/O display based on prom memory, when the unit is powered up with the switch in the low security position. (See p. 3-17 for programming instructions.)

Outputs

Listed below are the command codes used in programming the output relay functions. Any relay not used may be programmed to 0 and the display will read "unused." There are two formats used in programming. In the first, XY.Z (relay functions 0-69), X is the film group number, Y is the function, and Z is the contact type. For example, 23.1 (XY.Z) indicates a normally open relay (Z = 1) when film #2 (X = 2) reaches Soak 2 (Y = 3). Once the correct number code is entered, the appropriate message will appear on the display.

NOTE: If at any time you encounter problems with the relay structure of the I/O program, we suggest that you substitute or exchange another module and program it in the same way. By doing this, you may be able to isolate the problem to the I/O module and simply replace the module.

Film Group — (X) (Used with function group number and contact type number.)

0 = all films
1 = film 1
2 = film 2
3 = film 3
4 = film 4
5 = film 5
6 = film 6

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Function Group — (Y) (Used with film group and contact type code number.)

0 = Ramp 1
1 = Soak 1
2 = Ramp 2
3 = Soak 2
4 = Rate Ramp 1
5 = Rate Ramp 2
6 = Wire feed

Zero - 6 remain active throughout phase.

7 = Time Limit
8 = Thickness Limit
9 = Final Thickness

Seven - 9 remain active until condition changes or next film starts.

Contact Type — (Z) (Both code formats use contact type number.)

0 = relay not used
1 = normally open (NO)
2 = normally closed (NC)
3 = pulses closed (PC) approx 1 sec
4 = pulses open (PO) approx 1 sec

The second format used in programming, XY.Z (relay functions 70 - 99), requires a number from the group tables, XY, (below) combined with a contact type number, Z. For example, 75.2 indicates a normally closed relay, opening at the end of film #5.

Relay 7 Group Table (Used with contact type number. X = 7, Y = 0 → 9, Z = contact type)

70 = end all films

Active when unit is ready to start

71 = end film 1
72 = end film 2
73 = end film 3
74 = end film 4
75 = end film 5
76 = end film 6

Seventy-one - 76 are active when film (sequence) reaches idle.

77 = abort

Active when front panel or remote external abort occurs.

78 = last film

Activates at start of last film in process and remains active until start of next process.

79 = time power

Activates at start of time power and remains active until start of next film.

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Relay 8 Group Table (Used with contact type number. X = 8, Y = 0 → 9, Z = contact type)

80 = shutter 1 81 = shutter 2 82 = shutter 3 83 = shutter 4	Eighty - 83 are active for sources 1-4 when the unit is in manual mode or deposit phases (including rate ramps or time power). When shutter delay is used, relays activate at the end of shutter delay.
84 = film 1 85 = film 2 86 = film 3 87 = film 4 88 = film 5 89 = film 6	Eighty-four - 89 are active from start of one specified film to start of next film.

Relay 9 Group Table (Used with contact type number as given above. X = 9, Y = 0 → 9, Z = contact type)

90 = stop all films	Activates when film stops or aborts.
91 = active process 1 92 = active process 2 93 = active process 3	Ninety-one - 93 are active as long as the associated process is active.
94 = shut open	General shutter open (see relays 80-83).
95 = max pwr	Activates when any source reaches max power for that source.
96 = xtal fail	Activates when any crystal fails, and is reset by operating the front panel or remote crystal switch.
97 = xtal switch 1	Activates when the non-programmed crystal is in use (sensors 1 & 2).
98 = xtal switch 2	Activates when the non-programmed crystal is in use (sensors 3 & 4).
99 = end of process	Activates at the end of process.

Inputs

In addition to the relay outputs, the IC 6000 has eight possible input ports which can be programmed to cause a number of logical conditions. A list of these input codes follows:

10 - remote start	-	Duplicates start function of front panel START/CONT button (see p.2-8).

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11 - select active process 1 12 - select active process 2 13 - select active process 3		Inputs 11, 12, and 13 are used to remotely select active process.
14 - film reset	-	Duplicates the film reset function of front panel reset button (see p. 2-8).
15 - stop	-	Similar to front panel abort function, but causes a stop rather than an abort (see p. 7-2).
16 - crystal fail inhibit	-	When activated, prevents a crystal failure from stopping the unit.
17 - next layer start	-	Starts a next layer presoak cycle if presoak enable (26) is also present.
20 - abort	-	Duplicates function of front panel abort (p. 2-8).
21 - abort reset	-	Duplicates function of front panel abort reset (p. 2-8).
22 - continue	-	Duplicates function of front panel continue (p. 2-8).
23 - zero thickness	-	Duplicates same front panel function (p. 2-9).
24 - final thickness trigger	-	Causes same effect as reaching final thickness in film program, or when active during a "continue" from abort operation will cause the present active layer to be skipped on the next start command.
25 - soak hold	-	If active at end of Soak 1, the soak is extended indefinitely until the signal is removed.
26 - presoak enable	-	If active at start of layer, determines that the next layer will presoak (p. 4-17).
27 - crystal switch	-	Duplicates front panel crystal switch function (p. 2-9).

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I/O OPTION PROM

Introduction

If you want to guarantee the interchangeability of the IC 6000 chassis, without making sure the I/O programs are identical, you can use the I/O definition option prom in all of your similar IC 6000 systems. The I/O option prom is a fusable link memory that is programmed by the user with the desired I/O configuration. This nonvolatile memory, containing the user I/O program, will be read into the IC 6000 whenever the instrument is powered up with the (red) internal I/O security switch in the low security position (see p. 4-2), or if after a power interruption the instrument determines it has not successfully saved all data ("Fault").

The I/O program can be modified, if necessary, since it now acts exactly as if it were entered via the front panel keyboard. These changes will be lost however, if the I/O security switch is placed in the low security position and power is again applied with the option prom in place.

These fusable link memories are available both programmed and unprogrammed from many electronics distributors. The following list of parts may be used:

Signetics	N82S123
National	DM8578
TI	SN 74S288
Harris	HM7603
Intersil	IM5601
MMI	6331

I/O Prom Programming Instructions

1. All sixteen (16) output words (which represent the eight output relays), and eight (8) input words must be defined, even if only one I/O module is present in the system. Unused inputs and outputs are programmed 0 (unused).

2. An option identification code must be programmed at the I/O definition prom address (01) so that its presence is sensed by the IC 6000 software. This code is (A5) HEX, (1010-0101).

3. Only I/O program codes that are valid when entered from the front panel may be used in the option prom.

The option prom contains 32 programmable word locations (bytes), each containing 8 bits of data. The 8 bits are programmed with two BCD (binary coded decimal) numbers, one occupying the high order 4 bits of the prom word, and the second occupying the lower order 4 bits. For example, the BCD number (97) would appear in the 8 bit prom data word as the bit pattern (1001-0111) and would be specified as the hexidecimal word (97) or (97H). The actual BCD values selected are the same as the (XY.Z) I/O program codes explained in detail on page 3-2 . The data

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location for the (XY.Z) codes is detailed in the following memory map of the option prom:

MEMORY MAP OF PROM DATA LOCATIONS

Prom Address		I/O Card Function	HEX DATA Code
Decimal	Hex		
00	0	None	FF
01	1	Option Ident	A5
02	2	None	FF
03	3	None	FF
04	4	None	FF
05	5	None	FF
06	6	None	FF
07	7	None	FF
08	8	Relay Output 1	XY
09	9	Relay Output 2	XY
10	A	Relay Output 3	XY
11	B	Relay Output 4	XY
12	C	Relay Output 5	XY
13	D	Relay Output 6	XY
14	E	Relay Output 7	XY
15	F	Relay Output 8	XY
16	10	Remote Input 1	XY
17	11	Remote Input 2	XY
18	12	Remote Input 3	XY
19	13	Remote Input 4	XY
20	14	Remote Input 5	XY
21	15	Remote Input 6	XY
22	16	Remote Input 7	XY
23	17	Remote Input 8	XY
24	18	Contact Type RLY 1	0Z
25	19	Contact Type RLY 2	0Z
26	1A	Contact Type RLY 3	0Z
27	1B	Contact Type RLY 4	0Z
28	1C	Contact Type RLY 5	0Z
29	1D	Contact Type RLY 6	0Z
30	1E	Contact Type RLY 7	0Z
31	1F	Contact Type RLY 8	0Z

Example: Outputs Desired
Relay 1 = ABORT/normally closed
X = 7, Y = 7, Z = 2
Relay 2 = Final Thk Film 1/Pulse closed
X = 1, Y = 9, Z = 3
Relay 3 = End of Process/Norm open
X = 9, Y = 9, Z = 1

Inputs Desired
Input 1 = Start
XY = 10
Input 2 = ABORT
XY = 20

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Prom Data Required
All I/O addresses contain the hexidecimal data (00) with the exception of the following:

ADDRESS		DATA
Decimal	Hex	
01		01 = A5H (Prom Identification Code)
08		08 = 77H (Relay 1 Function) abort
09		09 = 19H (Relay 2 Function) final thickness film 1
10		0A = 99H (Relay 3 Function) end of process
16		10 = 10H (Input 1 Function) remote start
17		11 = 20H (Input 2 Function) remote abort
24		18 = 02H (Relay 1 Contact Type) normally open
25		19 = 03H (Relay 2 Contact Type) pulse closed
26		1A = 02H (Relay 3 Contact Type) normally open

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INFICON
LEYBOLD-HERAEUS

SECTION 4
PROGRAMMING THE FILM DISPLAYS

Section 4 of the IC 6000 manual provides detailed instructions for programming the film displays. The List of Film Parameters is a general description of the programmable variables available in all film programs. Following this list is a more detailed explanation of many of these parameters, which should be helpful in determining values for your specific program. You will also find information on film and process sequencing in this section. (Please refer to p. 2-9 for general programming guidelines.) The following topics are included in this section:

- Explanation of Film Program Lock
- Process Sequencing
- Film Sequencing
- List of Film Parameters
- Thickness Readout Calibration
    - Density
    - Z-Ratio
    - Tooling
- Crystal Switch Functions
    - Q-Factor
    - S-Factor
- Determining S & Q Values
- Rate Ramps
- Presoak Enable
- Shutter Delay
- Adjustment of the Control Loop to a Source
    - Gain
    - Approach
    - Limiter

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EXPLANATION OF PROGRAM LOCK

In order to prevent unauthorized alterations in the film programs, the IC 6000 incorporates a program lock consisting of a four-digit code entered from the front panel. The (white) toggle switch for access to the program lock is on the inside front of the unit near the control switch circuit board. When this switch is set toward the back of the unit, the program lock is in low security; when it is set toward the front, it is in high security.

In the low security position (switch back), the operator may go to the Executive display and program in a 4-digit code number (see p. 3-11 for programming instructions). When he enters the Data display, the program will be locked from that point on; persons not knowing the code number will be unable to alter parameters or any data in the Film or Executive programs.

If the lock code is known, parameters may be changed by going to a film display, and entering the code in the program lock space at the top of the page. Parameters can then be altered and the program will remain unlocked until the operator goes to the Data display.

When the switch is set forward (high security) the operator is able to access and alter the Film and Executive programs, if the code is known, but is unable to reprogram the lock code. If he goes to the Executive display while in this mode, he will notice that the cursor skips the lock status line and goes to the active process line.

If the code is forgotten, place the white switch in low security (back), turn the instrument off, then turn it back on. The code will be removed, the program unlocked, and a new code can be entered. (This procedure also affects the data in the film programs since the deleted parameters are returned to the display.)

PROCESS SEQUENCING

The following paragraphs describe the method of sequencing from one film in a process to another. Processes 1,2, and 3, are defined and designated "active process" by programming the Executive Display (see p. 3-11. When the unit is in a ready-to-start condition (START/CONT button illuminated),a start command from either the front panel (START/CONT) switch or from a remote input will initiate the active process.

Each film in a process sequence is assigned a layer number by its position in the sequence, the first film being layer 1, up to and including layer 32. The first film program that will be executed with the start command is determined by programming "Layer To Start" (1 to 32) in the Executive display. This number is typically set to 1 by the IC 6000, but can be any number between 1 and 32. For example, if a process sequence contains five films and the Layer To Start is set at 3, the first two film programs of the process will be ignored.

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The layer number, the Film #, and Active Process, are displayed in the lower left corner of the Data display. With every start command, the film program of the layer following the active layer (known as "next layer") is examined to determine if it should be presoaked. If the pre-soak condition is enabled, that layer's film program is also started, but will execute up to and including the Soak 1 phase and then terminate (p. 4-17).

As each film program within the sequence completes, a "film end message" will be displayed. Relays may also be programmed to indicate the end of a film. When the last layer of the process is started, a special relay function called "Last Layer in Process" is indicated. Finally, after the last layer is completed, the "End of Process" message will be displayed and an appropriate relay is activated. A start command will now start the film program of the "Layer to Start" (as set by the Executive display), and the film sequence will be repeated with subsequent start commands.

The Run Number will increment by one each time a process is started, and may be reset at any time, via the Executive Display. The Run Number will not increment following a continue from ABORT or a FILM RESET start.

Source Output

Each source output has an internal memory register. A source output voltage can only be removed by a film program execution or by the abort/stop condition. When a film program begins, it will use any source voltage values that are present at the time of the start command as the starting output voltage. Therefore, a film program that has run to a non-zero idle power may not restart at this same power level, if an interim film program has also used the same source output module.

Starts from Idle Phase

When a film program terminates at a non-zero idle power, a subsequent start of the same film program will initiate the film sequence at the Rise 2 phase. The Rise 1 and Soak 1 phases will be ignored. The cycle time between layers is decreased, since the source has been maintained at some interim power level and does not require the long preconditioning time provided by the Rise 1/Soak 1 phases. The Rise 2 phase will begin at the power level on the source at the time of the start command, and will ramp to the programmed power level. A film program that is started from either the ready or idle zero power phases will always execute the Rise 1 phase if programmed in the film.

The termination condition of all films is remembered internally until an abort/stop condition occurs. At this time all previous film phase history is cleared, and the next active film will now begin at the Rise 1 phase, if programmed.

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FILM SEQUENCING

A film sequence begins with a start command and ends when the film in process reaches the idle phase. Any process control that occurs between these events is determined by the values programmed in the 37 possible film parameters (p. 4-5). A film sequence consists of sixteen (16) possible phases, with a phase being defined as one process event. These phases are described below:

Phase	Condition
1. Ready	Shutter closed; will accept a start command
2. Rise 1	Shutter closed; source rising to Soak 1 power
3. Soak 1	Shutter closed; source maintained Soak 1 power
4. Rise 2	Shutter closed; source rising to Soak 2 power
5. Soak 2	Shutter closed; source maintained Soak 2 power
6. Shutter Delay	Shutter closed; rate control
7. Deposit	Shutter open; rate control
8. Rate Ramp 1	Shutter open; rate control; desired rate changing
9. Rate Ramp 2	Shutter open; rate control; desired rate changing
10. Feed Ramp	Shutter closed; source changing to feed soak power
11. Feed Soak	Shutter closed; source maintained at feed soak power
12. Idle Ramp	Shutter closed; source changing to idle power
13. Idle Zero	Shutter closed; source maintained at zero power; will accept a start command
14. Idle Non-Zero	Shutter closed; source resting at idle power; will accept a start command
15. Manual	Shutter open; source power controlled by hand controller
16. Time-Power	Shutter open; crystal failed; source maintained at average control power prior to crystal failure

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You are not required to execute all IC 6000 film phases when you generate a film. For example, phases will automatically be skipped if the film parameters used to define that phase have been deleted. Or, in the case of parameters that cannot be deleted, phases will be skipped if the value is programmed to zero. (The idle phase of a film program will always be executed, however.) Finally, deleting certain parameters will also cause others to be deleted. For example, when the programmed power level for phases Rise 1, Rise 2, and Feed Ramp is zero, the corresponding soak phase will be automatically deleted and skipped in the film program. When the desired control rate is programmed to zero, the entire deposit phase (including any rate ramps) will be skipped. If no parameters have been programmed, the film will sequence immediately to the idle phase when a start command is executed.

When a film program finishes in an idle phase at a power level other than zero, a subsequent start command to this film will initiate the film program at the Rise 2 phase, skipping both the Rise 1 and Soak 1 phases if they were programmed. If a Rise 2 phase is not present in the film program, the unit will sequence to the next viable phase - shutter delay, deposit, feed ramp, idle ramp, or idle (in that order).

You can enter the manual power phase whenever the IC 6000 is not aborted or stopped. The shutter will always open and the final thickness event will be ignored. When the manual control phase is ended, the unit will sequence to the deposit phase, providing a rate other than zero has been programmed and the final thickness limit has not been exceeded. Any thickness accumulated while the unit was in manual control will be retained when the manual phase is ended, and any next layer presoak operations will be terminated when the manual control phase is entered.

The time-power control phase may only be entered while the IC 6000 is in a deposit or rate ramp phase, and the film program has been set to complete on time-power in the event of crystal failure. The source power will remain at the average value set by the control loop prior to crystal failure and the thickness will be accumulated at the rate set by the desired rate film parameter. The time-power phase will terminate when the final thickness limit is reached. Any post-deposit phase film activities will be executed exactly as if a normal deposition had occurred.

FILM PARAMETERS

Listed below are descriptions of all film parameters. Those parameters preceeded by an asterisk may be deleted from the film program, if desired, by entering a zero value. Those preceeded by two asterisks are automatically deleted if you delete the previous (one asterisk) parameter. Each of the six films can be independently programmed with values for the following 37 parameters.

1. Density (0.8-99.99 gm/cc)	Refers to the density of the evaporated material and used to convert the measured mass to a thickness. The value used is determined by type of material being evaporated (p.4-10).

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2.	Z-Ratio (0.1 to 3.999)	Used to match the acoustic properties of the film to quartz for extended, accurate measured ranges. Value is determined by the elastic properties of material being evaporated. See page 4-12 for values of some common materials.
3.	Tooling (10-399%)	A programmable constant which corrects for the geometric difference between the placement of the crystal sensors and the substrate location.
4.	Sensor (1-4)	Determines which S/S module drives a crystal for the film. The unit will accomodate up to four crystal sensors with each film having the ability to utilize any one of the four source/sensor modules.
5.	Source (1-4)	Provides a control voltage (0 - ±10 V) to the deposition power supply for automatic rate control. The unit will accomodate up to four sources with the ability for each of the films to output to any of the four source/sensor modules.
6.	Gain (1-99)	Changes the source output voltage in proportion to the error between the actual rate and the rate set point (par. #15). At the programmed setting of 10, the source voltage changes at the rate of approximately 1% per second for an error of 1 Å per second.
*7.	Approach (0-99)	Used to minimize overshoot during start up, when the source requires a considerable length of time to reach the rate set point. Without approach action the inertia of the process may cause the rate to increase above the set point and thus overshoot. With approach action, the output is reduced before the rate reaches the set point. The higher the setting, the sooner the output is reduced (p.4-18).
8	Limiter (0.1-49.9%)	An adjustable low pass amplitude filter operating on the error signal. By reducing the limiter value, more fluctuations are filtered from the output voltage.
*9.	Soak Pl (0-99%)	Power level for preconditioning new melt.

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**10.	Ramp T1 (0-99.59 M:S)	Time interval from start command to Soak P1.
**11	Soak T1 (0-99.59 M:S)	Time interval system remains at Soak P1.
*12	Soak P2 (0-99%)	Programmed power level which is selected to produce a deposition rate close to desired auto-control rate (par.#15).
**13.	Ramp T2 (0-99.59 M:S)	Time interval from end of Soak T1 to Soak P2 level.
**14.	Soak T2 (0-99.59 M:S)	Time interval system remains at Soak P2.
15.	Rate (0-999.9 Å/s)	Parameter which defines desired rate of deposition (see Rate Ramps, p.4-16).
*16.	Shutter Dly (0 to 99.59 M:S)	Delay time from start of automatic rate control to opening of shutter. Note: Crystal must be able to see source even with shutter closed, or source power will increase towards the maximum power limit (par. #24).
17.	Final Thk (0-999.9 kÅ)	The thickness at which the deposit phase ends.
*18.	Thk Lmt (0 to 999.9 kÅ)	A thickness set point which can be programmed to occur anywhere within the deposition cycle.
*19.	Feed Pwr (0 to 99%)	Power level at which wire is fed into the source.
**20.	Ramp T3 (0-99.59 M:S)	Time interval required to reach feed power.
**21.	Feed Time (0 to 99.59 M:S)	Time interval feed power is maintained and feed relay remains activated.
22.	Idle Pwr (0 to 99%)	Level at which source is maintained between depositions using that source.
*23.	Ramp T4 (0-99.59 M:S)	Time interval to reach idle power.
24.	Max Pwr (0 to 99%)	Set point which limits the maximum allowed relative power.
*25.	Stop > Max (Ø or 1)	Will stop film if maximum power is reached for 5 consecutive seconds (1 will stop, Ø will not stop).

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Crystal Fail (26, 27, 28)

26.	Stop/Comp on T P (Ø or 1)	Determines whether film is completed on time-power or stopped if crystal fails (1 will stop; Ø will complete on time-power).
*27.	Q-Factor (0-9)	Sets limits on sustained rate deviation (quality) during a process. Exceeding Q-Factor causes crystal switch (p.4-13).
*28	S-Factor (0-9)	Sets limits on accumulated crystal instabilities during a process. Exceeding the S (stability) factor causes a crystal switch (p.4-13).
*29.	Time Limit (0-99.59 M:S)	Elapsed time limit of film layer. Activates relay if relay is programmed.
*30.	Presoak En (Ø or 1)	If enabled (and source conditions allow) this layer will start when preceeding film is started and will proceed through Soak 1 phase (Ø - no; 1 - yes).

Rate Ramp I (31, 32, 33) (see p. 4-16)

*31.	New Rate (0 -999.9 Å/s)	Allows controlled change in rate set point (#15) during deposition. If 0.1 Å/sec. is used, the film terminates (end of deposition); all other values continue to final thickness.
**32.	Start Ramp (0-999.9 kÅ)	Thickness set point which initializes start of Rate Ramp 1 to the New Rate set point (par. #31).
**33.	Ramp Time	Elapsed time from par. #32 until establishing New Rate (par. #31).

Rate Ramp 2 (34, 35, 36)

*34.	New Rate (0-999.9 Å/s)	Allows controlled change in rate set point (15) during deposition. If 0.1Å/sec. is used, the film terminates (end of deposition); all other values continue to final thickness. The change is from the Rate set point (par. #15), or from the New Rate (par. #31) if Rate Ramp I has been executed.
**35.	Start Ramp (0-999.9 kÅ)	Thickness set point which initializes start of Rate Ramp 2 to New Rate set point (par. #34).
**36.	Ramp Time (0-99.59 M:S)	Elapsed time from par. #35 until establishing New Rate (par. #34).

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Analog Rate Display

37.	Plot Dwell (1-99)	Sets the number of real time measurements for each horizontal position of the analog rate display.

THICKNESS READOUT CALIBRATION

Note: Bulk density values are sufficiently accurate for most applications (see p. 4-12).

Density (Parameter 1)

Follow the steps below to determine density value:

1. Place a substrate (with proper masking for film thickness measurement) adjacent to the sensor, so that the same thickness will be accumulated on the crystal and this substrate.

2. Set density to the bulk value of the film material or to an approximate value.

3. Set Z-ratio to 1.000 and tooling to 100%.

4. Place a new crystal in the sensor and make a short deposition (1000-5000Å), using the manual control.

5. After deposition, remove the test substrate and measure the film thickness with either a multiple beam interferometer or a stylus-type profilometer.

6. Determine new density value with the following equation:

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

where D_1 = Initial density setting

T_x = Thickness reading on monitor

T_M = Measured thickness

7. A quick check of the calculated density may be made by programming the instrument with the new density value and observing that the displayed thickness is equal to the measured thickness, provided that the instrument has not been zeroed between the test deposition and the entering of calculated density.

Note: Slight adjustment of density may be necessary in order to achieve $T_x = T_M$.

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Z-Ratio (Parameter 2)

A list of Z-values for materials commonly used is given in Table 4-1. For other materials, Z can be calculated from the following formula:

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

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

where:

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

μ_f = shear modulus of deposited film

d_q = density of quartz (crystal)

μ_q = shear modulus of quartz (crystal)

(The densities and shear moduli of many materials can be found in a number of handbooks.)

Laboratory results 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 applications that require more precise calibration, the following direct method is suggested:

1. 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.

2. Place a new substrate next to the sensor and make a second, short deposition (1000-5000Å).

3. Determine the actual thickness on the substrate (as suggested in density calibration).

4. Adjust Z-value in the IC 6000 to bring thickness reading in agreement with actual thickness.

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

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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 layers 1 and 2.

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

Important:
Optimum precision requires a multiple sensor arrangement with appropriate shuttering which is provided by the IC 6000.

Tooling (Parameter 3)

1. Place a test substrate in the system's substrate holder.

2. Make a short deposition and determine actual thickness.

3. Calculate tooling from the relationship:

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

where T_s = Actual thickness at substrate holder

T_x = Thickness reading on monitor .

4. Round off perfect tooling to the nearest %.

5. When entering this new value for tooling into the program, T_s will equal T_x if calculations are done properly.

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Table 4-1 Bulk Densities and Z-Values for Common Materials

MATERIAL	SYMBOL	BULK DENSITY (g/cm³)	Z-Ratio
Aluminum	Al	2.70	1.08
Antimony	Sb	6.62	0.768
Arsenic	As	5.73	0.966
Beryllium	Be	1.85	0.543
Boron	B	2.54	0.389
Cadmium	Cd	8.64	0.682
Cadmium sulfide	CdS	4.83	1.02
Cadmium telluride	CdTe	5.85	0.980
Calcium fluoride	CaF_2	3.18	0.775
Carbon (graphite)	C	2.25	3.26
Chromium	Cr	7.20	0.305
Cobalt	Co	8.71	0.343
Copper	Cu	8.93	0.437
Gallium	Ga	5.93	0.593
Gallium arsenide	GaAs	5.31	1.59
Germanium	Ge	5.35	0.516
Gold	Au	19.3	0.381
Indium	In	7.30	0.841
Indium antimonide	InSb	5.76	0.769
Iridium	Ir	22.4	0.129
Iron	Fe	7.86	0.349
Lead	Pb	11.3	1.13
Lead sulfide	PbS	7.50	0.566
Lithium fluoride	LiF	2.64	0.774
Magnesium	Mg	1.74	1.61
Magnesium oxide	MgO	3.58	0.411
Manganese	Mn	7.20	0.377
Molybdenum	Mo	10.2	0.257
Nickel	Ni	8.91	0.331
Niobium	Nb	8.57	0.493
Palladium	Pd	12.0	0.357
Platinum	Pt	21.4	0.245
Potassium chloride	KCl	1.98	2.05
Selenium	Se	4.82	0.864
Silicon	Si	2.32	0.712
Silicon dioxide (fused quartz)	SiO_2	2.20	1.07
Silver	Ag	10.5	0.529
Silver bromide	AgBr	6.47	1.18
Silver chloride	AgCl	5.56	1.32
Sodium chloride	NaCl	2.17	1.57
Tantalum	Ta	16.6	0.262
Tellurium	Te	6.25	0.900
Tin	Sn	7.30	0.724
Titanium	Ti	4.50	0.628
Titanium oxide	TiO	4.9	not available
Titanium dioxide	TiO_2	4.3	not available
Tungsten	W	19.3	0.163
Tungsten carbide	WC	15.6	0.151
Uranium	U	18.7	0.238
Vanadium	V	5.96	0.530
Yttrium	Y	4.34	0.835
Zinc	Zn	7.04	0.514
Zinc oxide	ZnO	5.61	0.556
Zinc selenide	ZnSe	5.26	0.722
Zinc sulfide	ZnS	4.09	0.775

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CRYSTAL SWITCH FUNCTIONS (PARAMETERS 27 & 28)

At some point in the process, a crystal may become unstable or erratic, yet continue to oscillate in a frequency range that is accepted by the instrument (6.0 - 5.0 MHz). The resulting rate control and even the thickness measurements are, however, inaccurate. By programming non-zero values into parameters 27 and 28, a new crystal may be automatically substituted for the erratic one. As Q and S factors are increased toward 9, a lowered threshold of instability will be tolerated before the crystal switches.

Q-Factor (Quality)

Q-Factor is a measure of the rate control of the active process. Setting the Q-Factor between 1 and 9 activates an algorithm which sets threshold limits on sustained rate deviation. When the algorithm senses that the rate deviation is (on the average), outside the programmed threshold limits, the crystal automatically switches. The quality limits (or band of allowed deviation) are shown in the table below.

Table 4-2 Quality Limits

Q-Factor	Programmed Threshold
0	Disabled
1	30%
2	25%
3	20%
4	17.5%
5	15%
6	12.5%
7	10%
8	7.5%
9	5%

S-Factor (Stability)

Experiments show that when a crystal is near the end of its life, it is prone to instabilities. This results in a temporary increase in crystal frequency, rather than the normal decrease expected during deposition. By determining when one of these "positive frequency excursions" occurs, and accumulating its magnitude, a limit is placed on these instabilities by programming S-Factor between 1 and 9. To prevent random noise from accumulating in the S register, a minimum positive excursion of 25 Hz is required before it is accumulated. Maximum accumulations for selected S-Factors are listed in Table 4-3.

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Table 4-3 Maximum Accumulations for Selected S-Factors

S-Factor	Pos. Frequency Accum.
0	Disabled
1	5000 (max single shift 1250)
2	1000
3	500
4	400
5	200
6	200 (max single shift 100)
7	100
8	100 (max single shift 50)
9	25

DETERMINING S & Q VALUES

The S and Q parameters (#'s 27, 28) are used to make certain that the evaporation process is under the best possible rate control. The process engineer may program values between 0 and 9 for these parameters, so that when the primary crystal reaches a point where its behavior is objectionable, the crystal will switch. The requirements of both S and Q are increasingly stringent as they progress toward 9; however, they should not necessarily be increased in unison.

The crudest form of crystal switching occurs when the primary crystal ceases to oscillate and the I/O structure has been programmed to contain the XTAL SW 1 or 2 relays. Under these conditions the instrument will automatically switch to the backup crystal. The crystal behavior prior to this point may have been quite erratic, leading to various degrees of rate instabilities, and perhaps small thickness errors.

Improved rate and thickness information results from programming non-zero S and Q values. The trade-off is between improved process control, on the one hand, and lower crystal utilization, on the other. By observing the behavior of the analog rate display, you can determine, from a brief history (several runs), whether or not the programmed values are a desirable compromise.

Our laboratory experiments have shown the following values to be useful and they can serve as general guidelines until more extensive process knowledge is gained on your own production lines.

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Source	Material	S-factor	Q-factor
2" E-gun w/liner	Cu	7	7
2" E-gun	Cu	7	5
1 1/8" E-gun	Al	4	4
Integral W-Al_2O_3	Cu	7	6
1 1/8" E-gun	Ni	3	4

If the process/crystal behavior is unknown, and you want to employ the quality (Q) and stability (S) algorithms, use a starting point of S= 5, Q=5. Fine tune the parameters as suggested below.

Tuning of S & Q for New Materials

When using the analog (video) rate display (#8), the values in the S & Q accumulators can be observed throughout the deposition by pressing the decimal key. The value of the S & Q accumulators will replace the XTAL life indication. With a new crystal, the Q-value will generally be a zero or a one. If the crystal deteriorates, larger values will briefly appear, as S builds up and counts down. The switch point occurs when S = 50.

The designated count of 50 requires that the instability be sustained for several seconds, so that the algorithm does not trip out on short-lived events. As the S-value is decreased, it requires a larger rate error to add a count of one to the S accumulation (see Table 4-3).

The S-accumulator shows the total magnitude of positive frequency shifts (in Hz) from the start of deposition. Table 4-2 shows the frequency shifts required to induce a switch.

Watch the S-accumulator during gun arcs. Consistent incrementing during arcs indicates poor grounding (see p. 3-2), and the S algorithm will be of little use until this problem is rectified.

S-values are accumulated when the magnitude is greater than 25 Hz, to avoid the problems of noise and thermal drift. Experience will be useful in determining S-values, since each process and material have different characteristics. Unlike Q-values, S-values are retained and built up until the start of the next layer, or when they exceed the set point and the crystal is switched.

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RATE RAMPS
(PARAMETERS 31-36)

Each IC 6000 film program includes two independently initiated rate change programs. Each group of ramp parameters may be used to generate a precise linear variation in the evaporation rate. These rate ramp programs operate during the deposit phase of the film sequence, and are initiated when the thickness set point programmed in the start ramp parameter(s) of the film program (par. 32 and/or 35) are reached. The rate ramp phase will continue for the programmed duration of the ramp, or until the final thickness set point of the film program is reached. If the ramp phase terminates before reaching final thickness, the IC 6000 will return to the deposit phase. A second ramp may now be executed if it has been programmed. If the start ramp set points are programmed to the same value for both rate ramps, Rate Ramp 1 has priority and will complete before Rate Ramp 2 will begin. Once either rate ramp is in process, a second ramp will not be processed until the first ramp has been completed.

The slope of a rate ramp is determined by the following equation: delta rate per sec = (new rate - desired rate) divided by ramp time. If a ramp parameter is changed during the ramp, a new slope will be calculated, taking into consideration the time the ramp has already been in process.

Rate Ramp to Zero Rate

It is sometimes desirable to ramp to zero rate for alloy phasing purposes, and also to complete the film processing as if a final thickness had been achieved. Rate ramps, however, are ordinarily deleted by entering zero. Therefore, in order to implement this type of film termination, you can program the new rate set point parameter of the rate ramp to a value of 0.1 Å/sec. When this rate value is achieved, the film program will proceed as if a final thickness limit had been reached.

While a rate ramp is being processed, the desired rate parameter of the film program (par. 15) is continuously updated to the new control rate value, so that an operator can look up the exact rate control set point at any time in the process. When a rate ramp phase is completed, this value becomes the reference for any further rate ramps. The initial starting value for the desired rate is restored to the film program when that layer is completed. If the time-power processing has been enabled in the film program, a rate ramp will switch to this mode of program completion if necessary.

If the IC 6000 is zeroed after the completion of a rate ramp, the ramp will execute a second time when the start ramp set point is reached again. However, this time a rate change will not occur, since the desired rate and new rate values are the same. The unit will remain in the rate ramp phase for the ramp duration programmed.

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PRESOAK ENABLE
(PARAMETER 30)

The Presoak Enable function makes it possible to shorten a process cycle time by simultaneously conditioning two deposition sources. (The second source is the source determined by the film program that follows the active film program in the process sequence.) This presoaked film program will execute through the Rise 1 and Soak 1 phases, or until the active layer film program enters a phase where loop control must be established.

When the Soak 1 phase is complete, or the active layer reaches a rate control phase, the presoaked film processing is disabled and remains disabled until the active film program is completed and another start command is received. The presoaked film then becomes the active film, and a new next layer may be presoaked, if desired.

If a film program has been completed with an idle power other than zero, and this same film is programmed to presoak, this presoaked film will sequence from the idle non-zero phase to the Soak 1 phase and terminate. (The source will soak at idle power level.) This occurs because a start from a non-zero idle power attempts to start the film sequencing at the Rise 2 phase. However, a next layer presoak cannot proceed beyond the Soak 1 phase so the film program is terminated there. All presoaked film programs are started when the active film layer program is initiated; no special start commands are needed.

To successfully implement this feature, the following rules must be observed:

1. The presoak enable film parameter must be programmed to a one (1) in the film to be presoaked, or an external presoak enable signal must be present at the time of the start command to the primary layer.

2. The film layer to be presoaked must have a different source.

SHUTTER DELAY
(PARAMETER 16)

The shutter delay film parameter is used to establish rate control before exposing the substrates to the evaporant. The sensing crystal must be exposed to the source during the shutter delay phase to accomplish this.

The control loop attempts to establish rate control at the end of the predeposition film program. However, the shutter opening is delayed (par. 16) for a period of time to insure stable rate control. When the delay time has ended,the shutter opens, the accumulated thickness is zeroed, and the substrates are immediately exposed to an evaporant that is under tight rate control. With proper adjustment of the control loop parameters, the delay time can be kept to a minimum.

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ADJUSTMENT OF CONTROL LOOP (PARAMETERS 6, 7, & 8)

Introduction

The function of the control loop is to stabilize the evaporation rate at the rate set point (parameter #15). By selecting the most favorable gain, limiter, and approach values, the operator can control sources with nearly any physical characteristics.

Even though theoretical methods exist for determining initial control settings, an experimental approach remains the most practical and least time-consuming for most installations. This approach requires recognition of basic symptoms of incorrect adjustment, from the shape of the analog display or the (optional) rate output on a chart recorder.

In some processes it may be necessary to compromise final adjustments for the sake of best overall control action. You should avoid setting the control loop to values of gain, limiter and approach where minor changes in process conditions can introduce a cyclic system response. Satisfactory control settings are those which produce acceptable results in overall rate control without sacrificing control stability. These settings will be arrived at experimentally as described below. Remember to allow conditions to stabilize between adjustments in order to properly assess the adjusted performance, especially in the case of slow sources. Once the best settings have been determined, they should be recorded to facilitate future resetting, if it ever becomes necessary.

Setting Gain (Parameter 6)

As you initially adjust the gain, you should keep the limiter and approach parameters at the preprogrammed values of 10% and 0, respectively. As the gain is increased, the rate of change of the control voltage increases for a given rate error. To find the initial gain setting, the gain setting on the IC 6000 must be progressively increased. Observe the effect of the gain change on the analog deviation display or chart recorder. Use the same rate change for both rate increases and decreases. Allow sufficient time after each adjustment for the system to stabilize. When the system is cycling (oscillating) steadily, note the frequency of the cycle and decrease the gain until the cycling stops or is minimized. If extremely low values of gain (less than 10) are necessary to achieve this increase the approach by units of five and repeat the above procedure until cycling is eliminated.

Setting Approach (Parameter 7)

Approach should be increased when the rate control displays overshoot and cycling for a step change of rate. The correct approach setting is made experimentally, and in conjunction with gain setting. Use the minimum value of approach that eliminates (or nearly eliminates) overshoot, since large values tend to increase control loop noise.

Fig. 4-1 shows the effects of the approach setting adjustment on the control loop.

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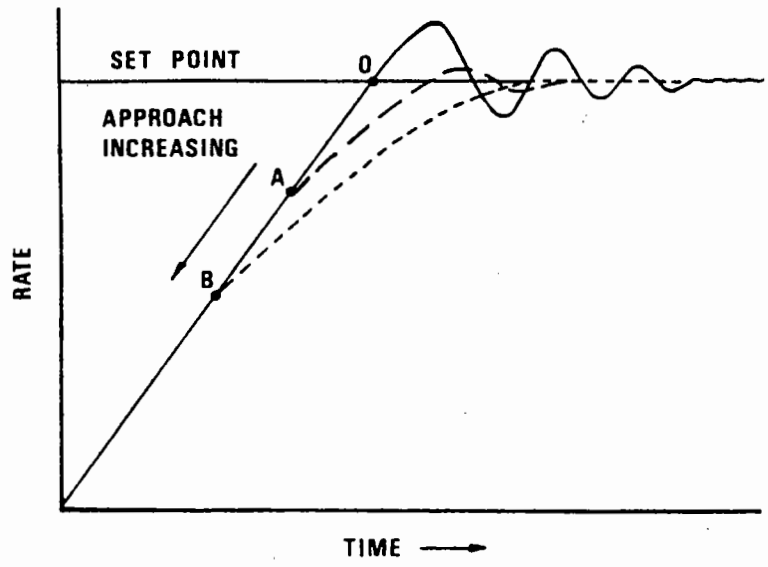


Fig. 4-1 Effects of Approach Setting on Control Loop

Setting Limiter (Parameter 8)

Limiter should be used to (1) limit the response to system noise, such as gun arcs, and (2) limit the activity of the control voltage when the source is very noisy. (Its use for this should be limited to extreme cases.) Limiter is preprogrammed to limit the output voltage to changes of 10% per second; other values can be programmed by the user, keeping in mind that the largest practical values should always be used.

As the limiter setting is decreased, the maximum allowed change in control voltage per measurement decreases for a given rate error. Limiter should only be reduced from the preprogrammed value of 10 when short-term source instabilities (such as gun arcing) cause unnecessary control action. In this case, watch the movement of the analog display, or the (optional) rate output on a chart recorder, for excessive activity. Decrease the limiter setting until the control action reaches a satisfactory level. Small limiter values cause the control to deteriorate, so keep the setting as large as possible for best control.

Summary of Control Loop Adjustments

Note: Allow sufficient time after each adjustment for the system to stabilize.

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1. Adjust gain to the maximum stable setting for acceptable rate deviation.
2. If cycling or overshoot with step changes of rate occurs, increase the approach setting. As gain and approach controls interact, steps 1 and 2 should be repeated to determine best values.
3. Adjust limiter to the maximum stable setting; in most cases you should use 10% to minimize noise effects.
4. Reverse any adjustments that deteriorate control performance. If cycling cannot be totally eliminated, adjust approach and gain for best overall control action.

Fig. 4-2 shows the analog display response to both positive and negative rate steps.

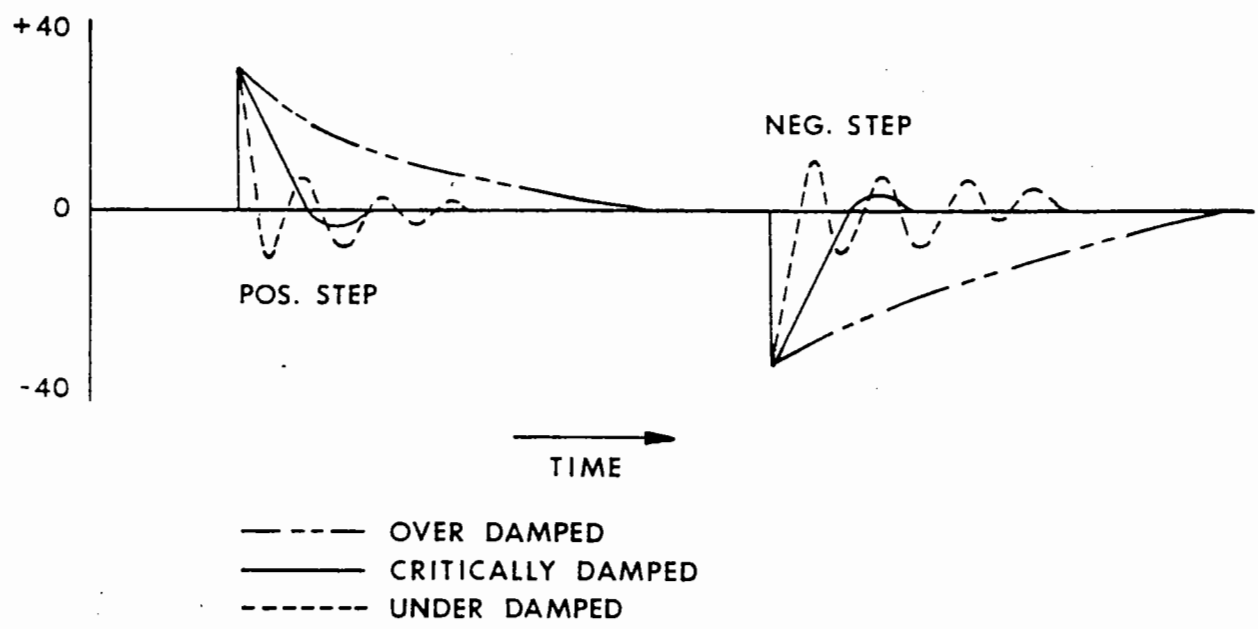


Fig. 4-2 Analog Display Response to Rate Steps

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INFICON
LEYBOLD-HERAEUS

SECTION 5
SENSOR MAINTENANCE AND REPAIR

Section 5 of the IC 6000 manual provides maintenance and repair procedures for the regular, dual, bakeable and sputtering sensors. The areas covered in this section are listed below:

- Troubleshooting the Regular, Dual, and Bakeable Sensors
- Troubleshooting the Sputtering Sensor
- Replacing the Crystal in the Regular, Dual, Bakeable, and Sputtering Sensors
- Actuator Alignment - Dual Sensor
- Improved Cooling for the Bakeable Sensor

CAUTION: All service and maintenance should be performed only by qualified personnel.

WARNING: Disconnect all interface connectors when working on the unit.

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TROUBLESHOOTING THE SENSOR

Regular, Dual and Bakeable Sensor and Crystals

	SYMPTOM		CAUSE		REMEDY
1.	large jumps of thickness reading during deposition	a.	mode hopping due to defective crystal	a.	replace crystal
		b.	crystal near the end of its life	b.	replace crystal
		c.	scratches or foreign particles on the crystal holder seating surface	c.	clean or polish the crystal seating surface on the crystal holder
2.	crystal ceases to oscillate during deposition before it reaches its "normal" life Note: crystal life is highly dependent on process conditions of a. rate b. heat radiated from source c. location d. material e. residual gas composition	a.	crystal is being hit by small droplets of molten material from the evaporation source	a.	use a shutter to shield the sensor during initial period of evaporation; move the sensor further away from the evaporation source
		b.	defective crystal	b.	change crystal
		c.	built-up material on edge of crystal holder touching crystal	c.	clean the crystal holder
		d.	material on crystal holder partially masking full crystal area	d.	clean crystal holder
3.	crystal does not oscillate or oscillates intermittently (both in vacuum and in air)	a.	defective or damaged crystal	a.	replace crystal
		b.	existence of electrical short or poor electrical contacts	b.	check for electrical continuity and short in sensor cable, connector, contact springs, and the connecting wire inside the sensor; check for electrical continuity in feedthroughs

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	SYMPTOM		CAUSE		REMEDY
4.	crystal oscillates in vacuum but stops oscillation after open to air	a.	crystal was near the end of its life; opening to air causes film oxidation, which increases film stress	a.	replace crystal
		b.	excessive moisture accumulation on the crystal	b.	turn off cooling water to sensor 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)	a.	crystal is not properly seated	a.	check and clean crystal seating surface of the crystal holder
		b.	excessive heat input to the crystal	b.	if heat is due to radiation from the evaporation source, move sensor further away from source and use sputtering crystals for better thermal stability; if the crystal heating is due to secondary electron bombardment from the electron beam source, change regular sensor to a sputtering sensor
		c.	no cooling water	c.	check cooling water flow rate. (0.2 gpm at 20 C)
		d.	in older sensors (those without integral cooling passages), poor contact between water line and sensor	d.	tighten waterline to body

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SYMPTOM	CAUSE	REMEDY
6. poor thickness reproducibility	a. erratic source emission characteristics	a. move sensor to a different location; check the evaporation source for proper operating conditions; insure relatively constant pool height and avoid tunneling into the melt
	b. material does not adhere to the crystal	b. check the cleanliness of the crystal surface; evaporate a layer of proper material on the crystal to improve adhesion

Dual Sensor Only

1. crystal erratic but fails to switch	a. S and Q values set to 0 or set too low	a. change S and Q values
	b. crystal switch output not connected or improperly wired	b. connect or wire properly
	c. not programmed on I/O display	c. program I/O display
	d. miswired or faulty valve assembly	d. check wiring; check air supply; remove output line from actuator valve and check for air flow with electrical power on

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SYMPTOM	CAUSE	REMEDY
2. power goes to and remains at max pwr after crystal switch	a. shutter not exposing crystal	a. check for obstruction, jammed aparatus, or failure to actuate through I/O
3. deposition is in process but no rate or thickness indication on display	a. source/sensor modules inter-changed, so active crystal is shuttered	a. exchange s/s modules 1 and 2 or 3 and 4

Sputtering Sensor and Crystals

1. large jumps of thickness read-ings during sputtering	a. improper crystal seating	a. check and clean the crystal seating surface
	b. small pieces of material fell on the crystal (for crystal facing-up situation)	b. check the crystal surface and blow it with clean air
	c. small pieces of magnetic material being attracted by the sensor magnet and con-tacting the crystal	c. check the sensor opening hole and remove any for-eign material
2. thickness read-ing jumps back and forth	a. RF interference from the sputter-ing power supply	a. check groundings; change location of instrument and oscillator; con-nect instrument to different power line.

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SYMPTOM	CAUSE	REMEDY
3. large drift of thickness reading (greater than 200 Å for density reading = 5.00 gm/cc) after termination of sputtering	a. crystal heating due to poor thermal contact	a. check and clean the crystal seating surface
	b. external magnetic field interferes with the sensor magnetic field	b. rotate the sensor magnet to a proper orientation with respect to the external magnetic field
	c. sensor magnet defective	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

REPLACING THE CRYSTAL (FIGS. 5-1, 5-2, 5-3, 5-4)

Regular, Dual, and Bakeable Crystals

The procedure for replacing the crystal is basically the same with either the regular, dual or bakeable sensor. (Refer to p.5-10 for replacement of sputtering sensor.) Before you begin, please observe the following precautions:

- Always use clean nylon lab gloves and plastic tweezers to handle the crystal (to avoid contamination which may lead to poor adhesion).
- Do not rotate the ceramic retainer assembly after it is seated (as this will scratch the crystal electrode and cause poor contact).

In addition to the above precautions, please note the following:

- Certain materials, especially dielectrics, may not adhere strongly to the crystal surface and may cause erratic readings.
- Thick deposits of some materials, such as SiO, Si, and Ni will normally peel off the crystal when it is exposed to air, as a result of changes in film stress caused by gas absorbtion.

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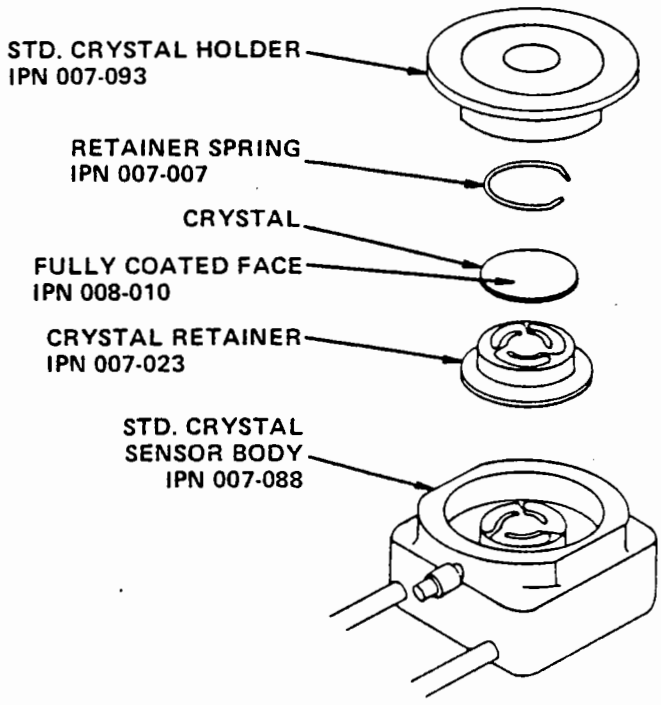


Fig. 5-1 Regular Crystal Sensor (Exploded View)

Follow the procedure below to replace the crystal in the regular sensor (Fig. 5-1):

1. Gripping the crystal holder with your fingers, pull it straight out of the sensor body.

2. Gently pry the crystal retainer from the holder (or use crystal snatcher; see p. 5-10).

3. Turn the retainer over so that the crystal drops out.

4. Install a new crystal with the electrode face up.

5. Push the retainer back into the holder and replace the holder in the sensor body.

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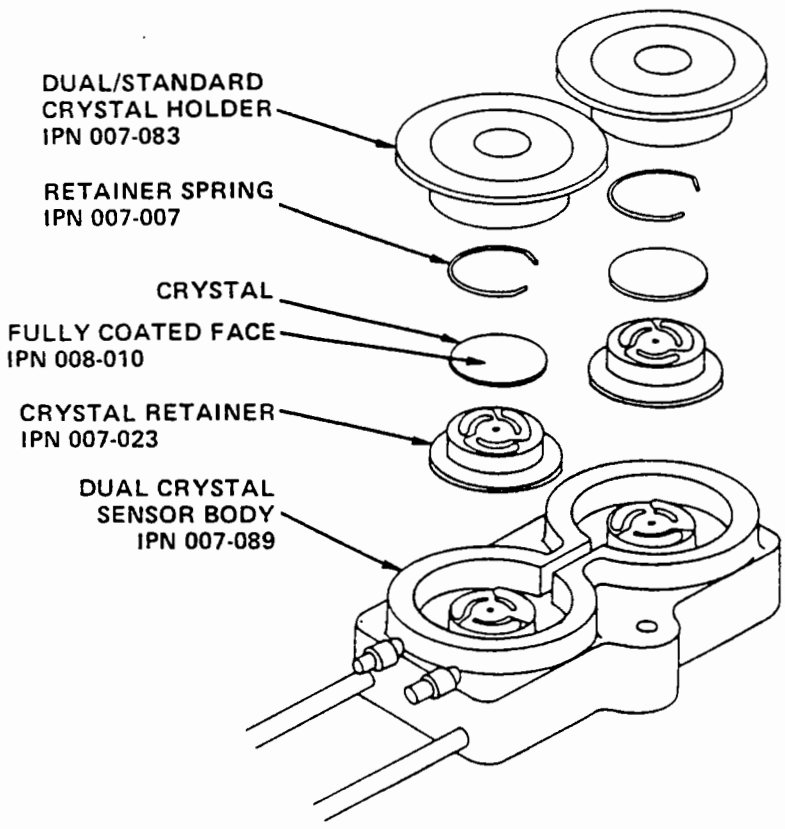


Fig. 5-2 Dual Crystal Sensor (Exploded View)

For the dual sensor, the procedure is identical for both crystals, except that you must flip up the shutter in order to remove the holder assemblies (Fig. 5-2).

For the bakeable sensor, the procedure is the same as the regular crystal except that you must first unlock the cam assembly by flipping it up. Once the crystal has been replaced, place a flat edge of the holder flush with the cam mechanism and lock it in place with the cam (Fig. 5-3).

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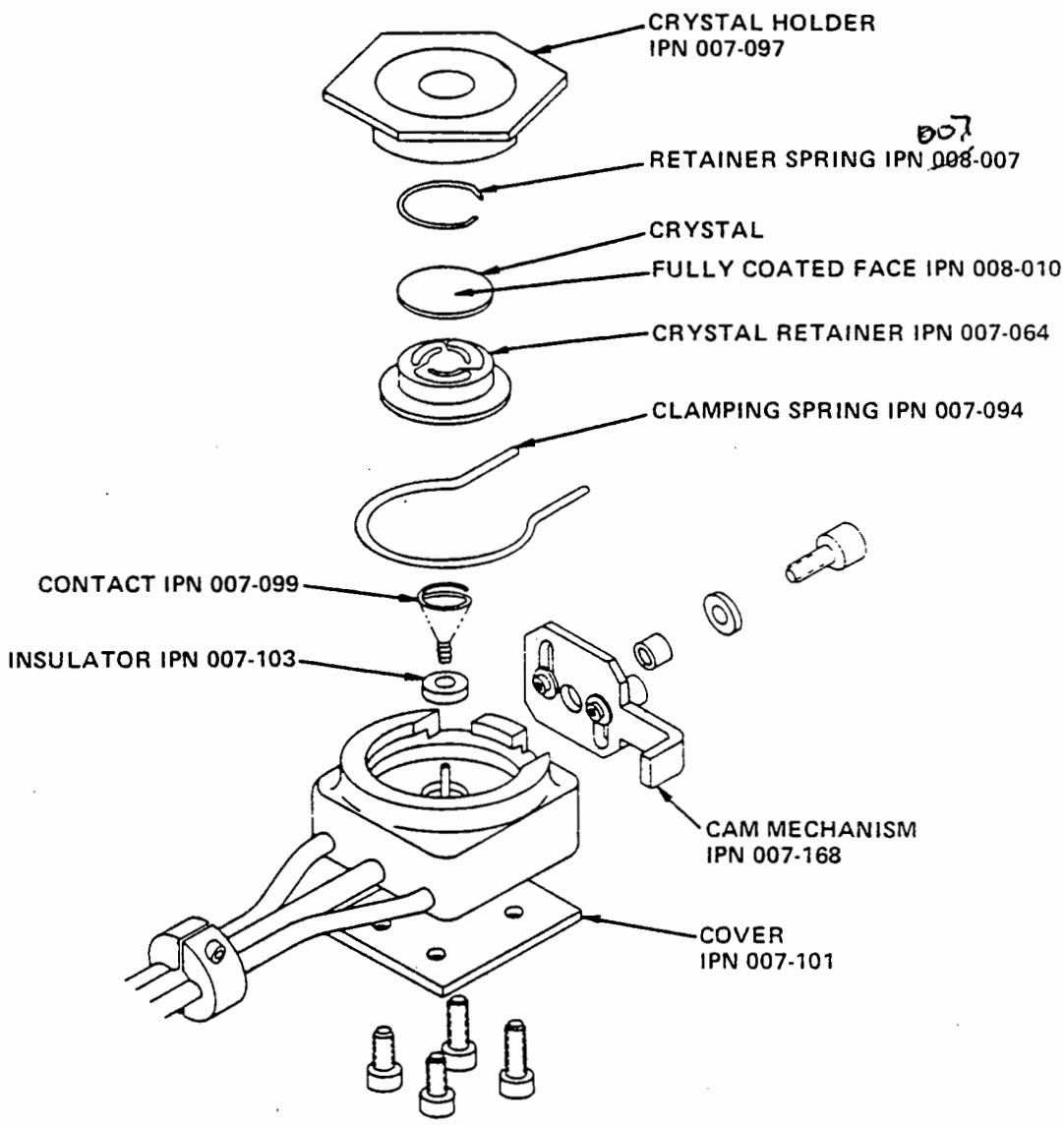


Fig. 5-3 Bakeable Crystal Sensor (Exploded View)

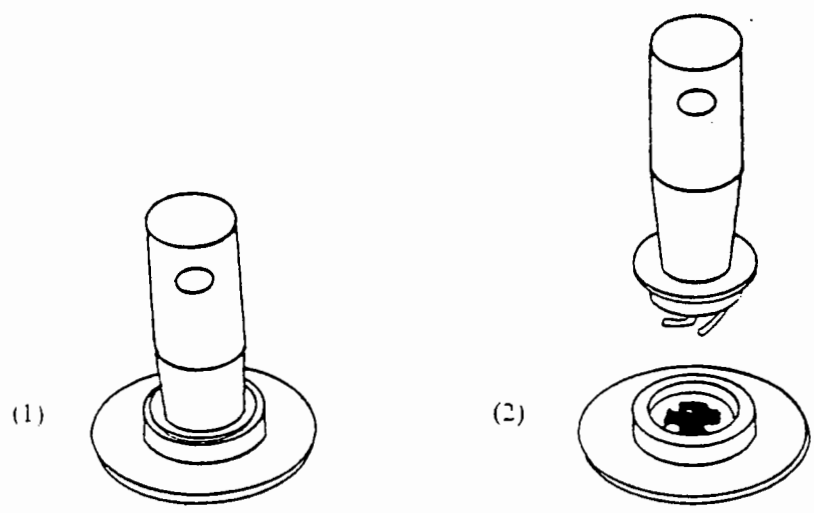
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To use the crystal snatcher supplied with the sensor follow the instructions below:

1. Insert the crystal snatcher into the ceramic retainer (1) and apply a small amount of pressure. This locks the retainer to the snatcher and allows the retainer to be pulled straight out (2).

2. Re-insert the retainer into the holder after the crystal has been changed.

3. Release the crystal snatcher with a slight side-to-side motion.



Replacing the Sputtering Crystal (Fig. 5-4)

Observe the general precautions (p. 5-6) for replacing crystals and follow the instructions below to replace the crystal in a sputtering sensor.

1. Grip the back part of the sensor with your fingers and pull it straight out to separate it from the water-cooled front part. (You may have to disconnect the sensor cable in order to separate the parts.)

2. Pull the crystal holder straight out from the back of the sensor.

3. Remove the ceramic retainer from the crystal holder by pulling it straight out with your fingers or a tweezer.

4. Turn the crystal holder upside down so that the crystal drops out.

5. Drop a new crystal into the crystal holder with the patterned electrode facing the back and contacting the leaf springs on the ceramic retainer. (Use only special crystals for sputtering, IPN 008-009.)

6. Put the ceramic retainer back into the crystal holder and put the holder into the back part of the sensor.

7. Align the position of the back part so that the connector matches with the notch on the front of the sensor. Snap the two parts together. Reconnect the sensor cable if it has been disconnected.

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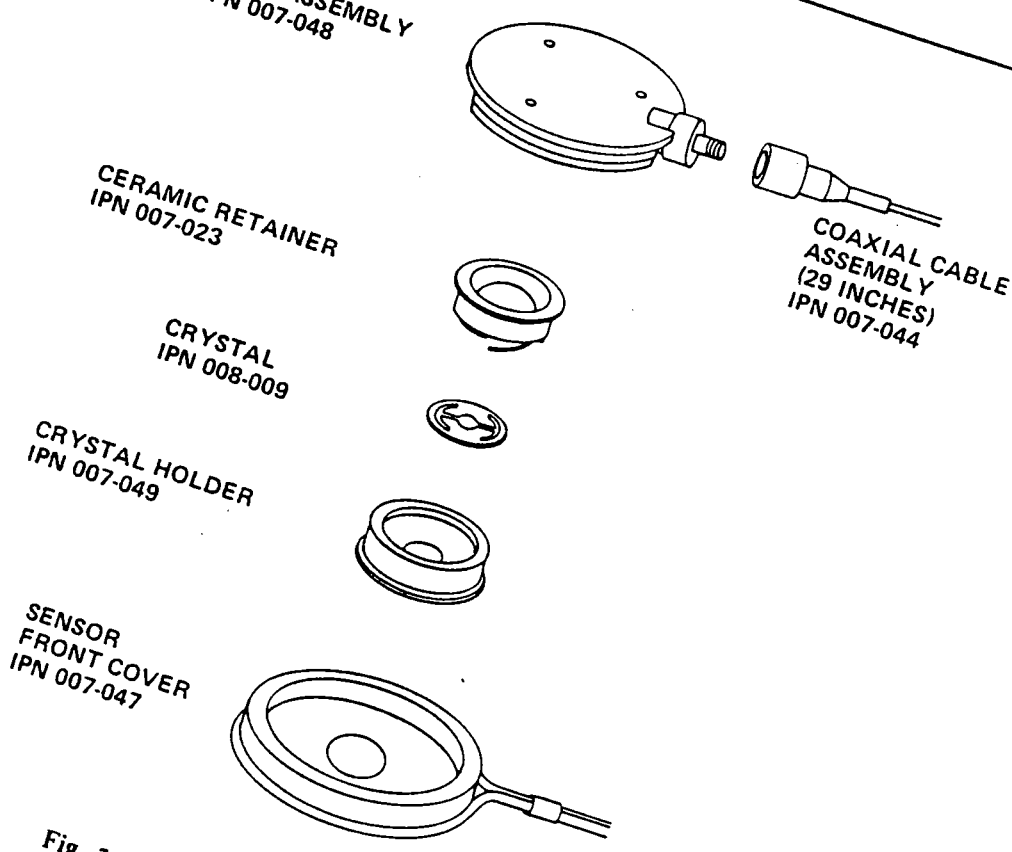
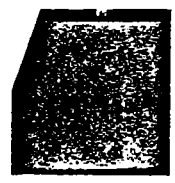


Fig. 5-4 Sputtering Crystal Sensor (Exploded View)



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ACTUATOR ALIGNMENT — DUAL SENSOR

Step 1: To adjust the stroke length of the piston assembly, compress the spring fully and turn the piston into the piston coupling until you obtain the correct stroke ($\frac{.160"}{.180"}$ $\frac{4.0}{4.6}$ mm) (Fig. 5-5).

Step 2: To attach the piston assembly to the actuator (Fig. 5-6), center the piston in the actuator, insert and tighten the two #4-40 x .38" lockwashers and screws into the actuator. Operate the assembly by applying air at 80 psi to be sure that the piston is correctly aligned.

Step 3: Add the cam assembly to the dual sensor body as shown in Fig. 5-7a.

Step 4: Add the actuator assembly to the dual sensor body (Fig. 5-6b) by inserting the piston coupling into the cam pin, aligning the actuator assembly with the #4-40 holes on the back of the sensor body, and inserting the two #4-40 x 5/8" screws and lockwashers (do not tighten).

Step 5: To align the actuator, leave it in a relaxed position (zero pressure) and align the assembly so that the cam pin is about $\frac{.010"}{.040"}$ from the left edge of the slot in the piston coupling. Firmly tighten the screws.

Step 6: Check to be sure that the assembly continues to operate when installed in the coating system by stroking the piston with air at ∿80 psi (10-25 cycles should be adequate). If the mechanism does not operate smoothly, check for

a. correct alignment (step 5)
b. correct piston stroke (step 1)
c. burrs on piston coupling, cam, or piston.

Note: If you wish, use molybdenum disulfide or graphite (IPN 009-175) to lubricate the parts.

Step 7: With the actuator in the relaxed (zero pressure) position, attach the shutter assembly to the cam. Adjust the position so that the shutter clears the crystal holders and the edge of the shutter is splitting the distance between the crystal holders (Fig. 5-8). Be sure that both crystals can be covered by the shutter and readjust if necessary.

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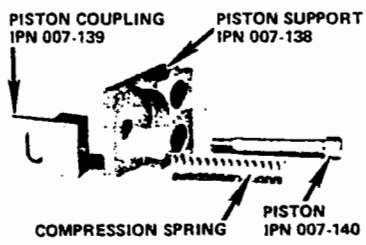


Fig. 5-5a Piston Assembly

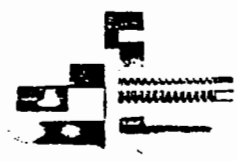


Fig. 5-5b

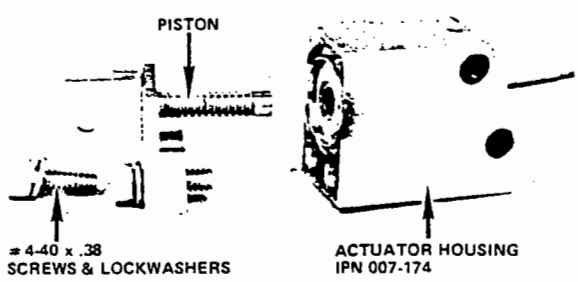


Fig. 5-6a Actuator Assembly

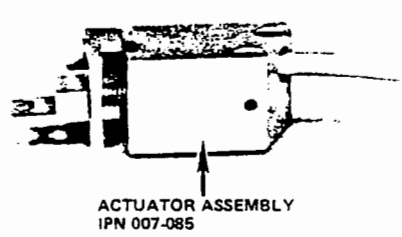


Fig. 5-6b

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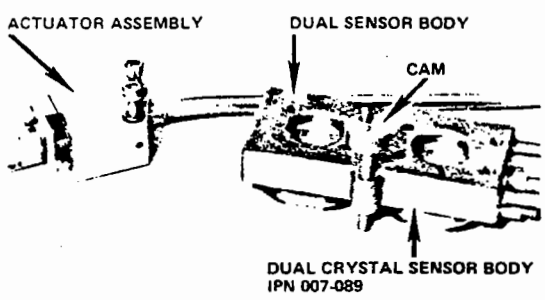


Fig. 5-7a Actuator Assembly & Dual Sensor Body

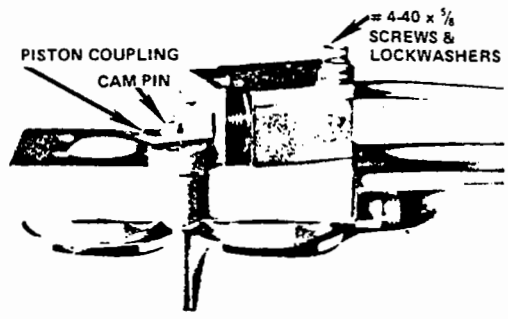


Fig. 5-7b



Fig. 5-8a Dual Crystal Sensor

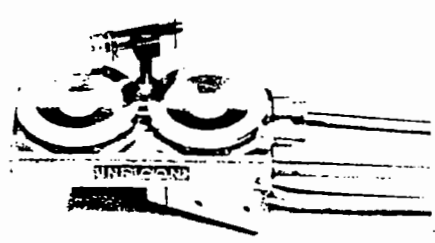


Fig. 5-8b

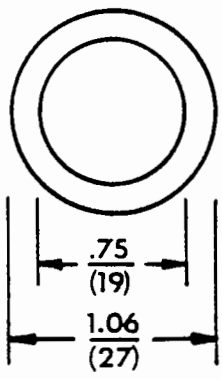
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PROVIDING IMPROVED COOLING FOR THE BAKEABLE SENSOR

Because of temperature requirements, the bakeable sensor is made entirely of stainless steel. This fact poses a difficult problem from the design standpoint of thermal transfer. After trying several concepts, our laboratory found that the clamping action of the spring and cam mechanism provided better transfer of heat than other methods, because it allows continuous contact pressure throughout the temperature cycles encountered. However, for some applications where the materials are evaporated at high rate and/or high temperatures, thermal transfer may still be insufficient for ideal operation of the quartz crystal.

To improve the thermal transfer between the crystal holder and the water-cooled body of the bakeable sensor, you can fabricate a thin washer of easily deformable metal to insert between the holder and the body. Once fabricated, this washer will last indefinitely, and can provide a 50% improvement in thermal transfer between the two parts, by increasing the surface contact over the non-deformable stainless steel.

Both gold and aluminum have been used successfully in this way, but since aluminum foil is nearly perfect in thickness, it should be the first choice. (Gold works only slightly better.) The illustration is a guide to the fabrication of the washer.



Matl. - Au, Al
Recommended thickness range -
.0005" - .003" (.025 mm - .08 mm)

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Section 6 contains electrical schematics and outline drawings to assist in installation and maintenance of the IC 6000 Deposition Controller. Please note that service on the unit should be performed by qualified personnel only.

WARNING: Remove all interface connections when working on the unit.

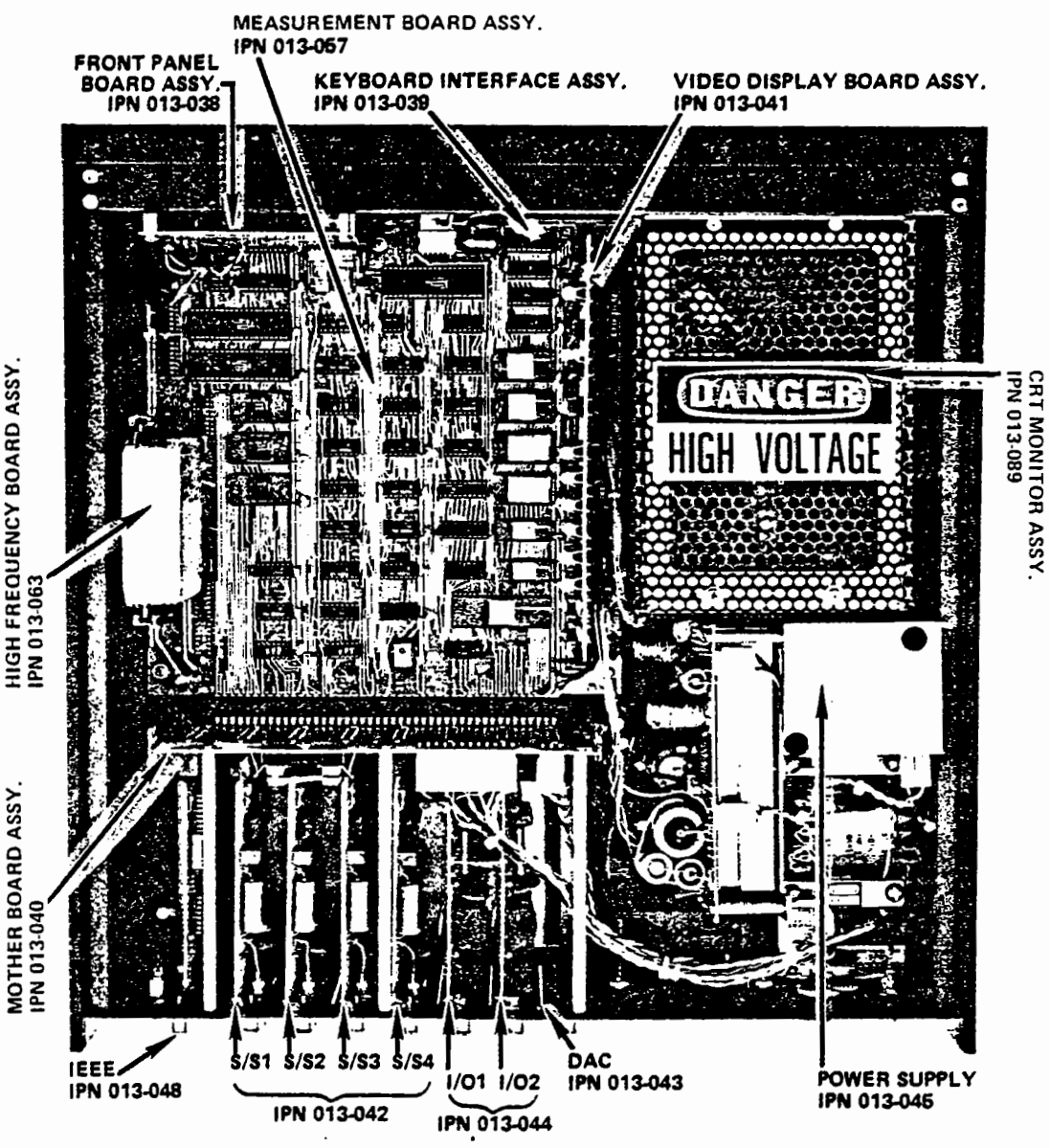
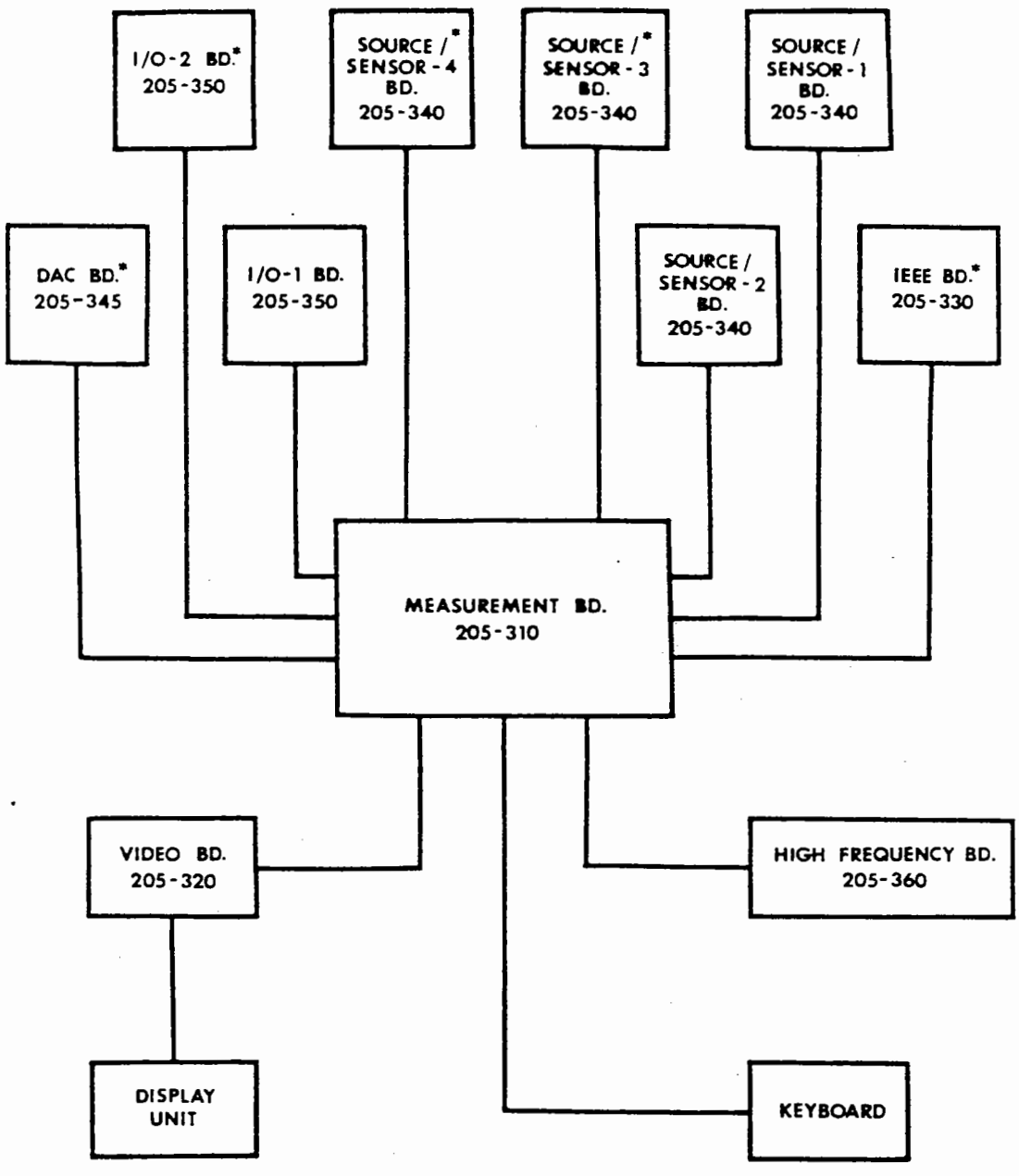


Fig. 6-1 IC 6000 Chassis Interior

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*OPTIONAL—NOT IN ALL UNITS

Fig. 6-2 IC 6000 Block Diagram

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Fig. 6-3 I/O Board Schematic

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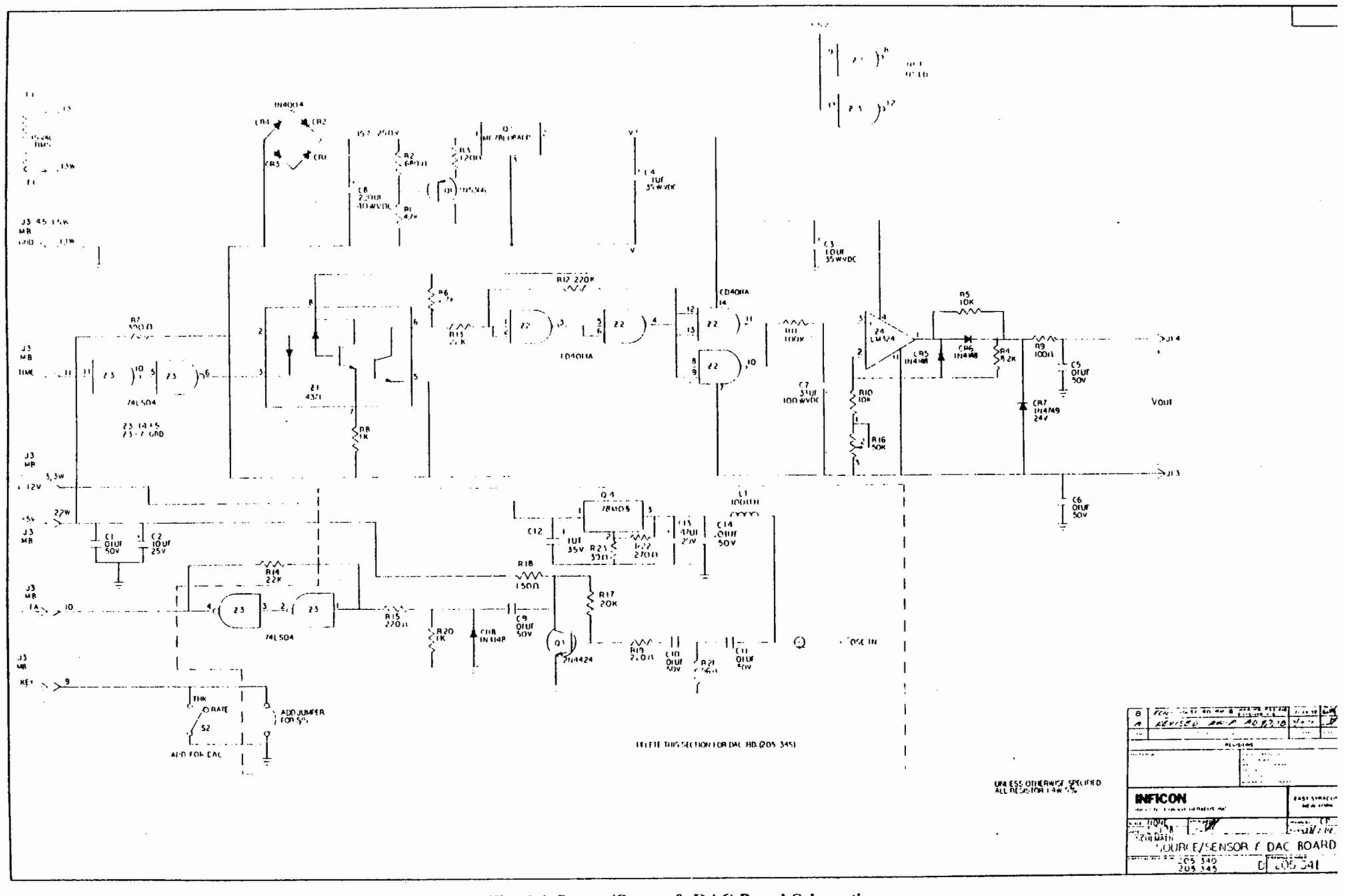


Fig. 6-4 Source/Sensor & DAC Board Schematic

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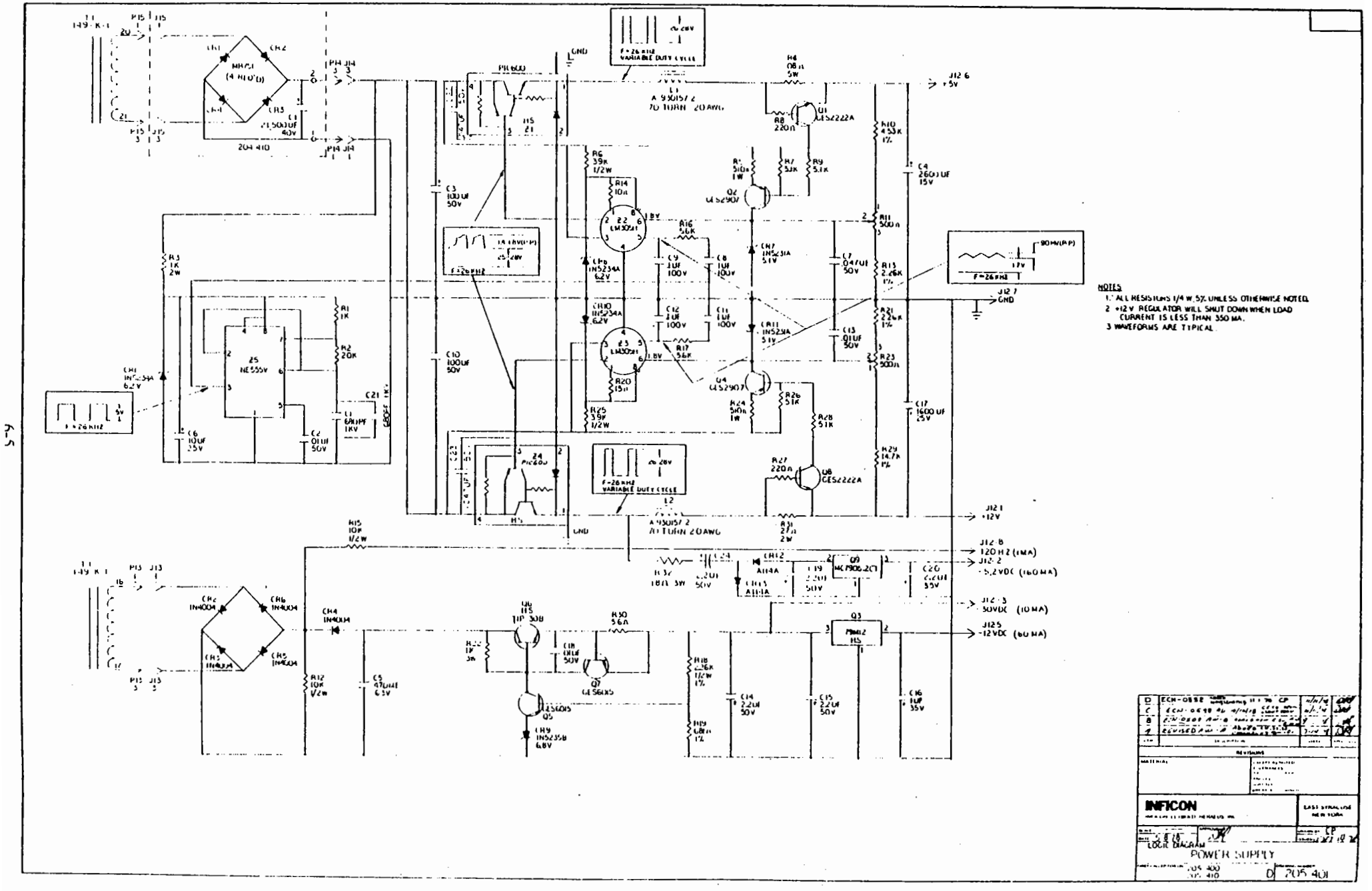


Fig. 6-5 Power Supply Schematic

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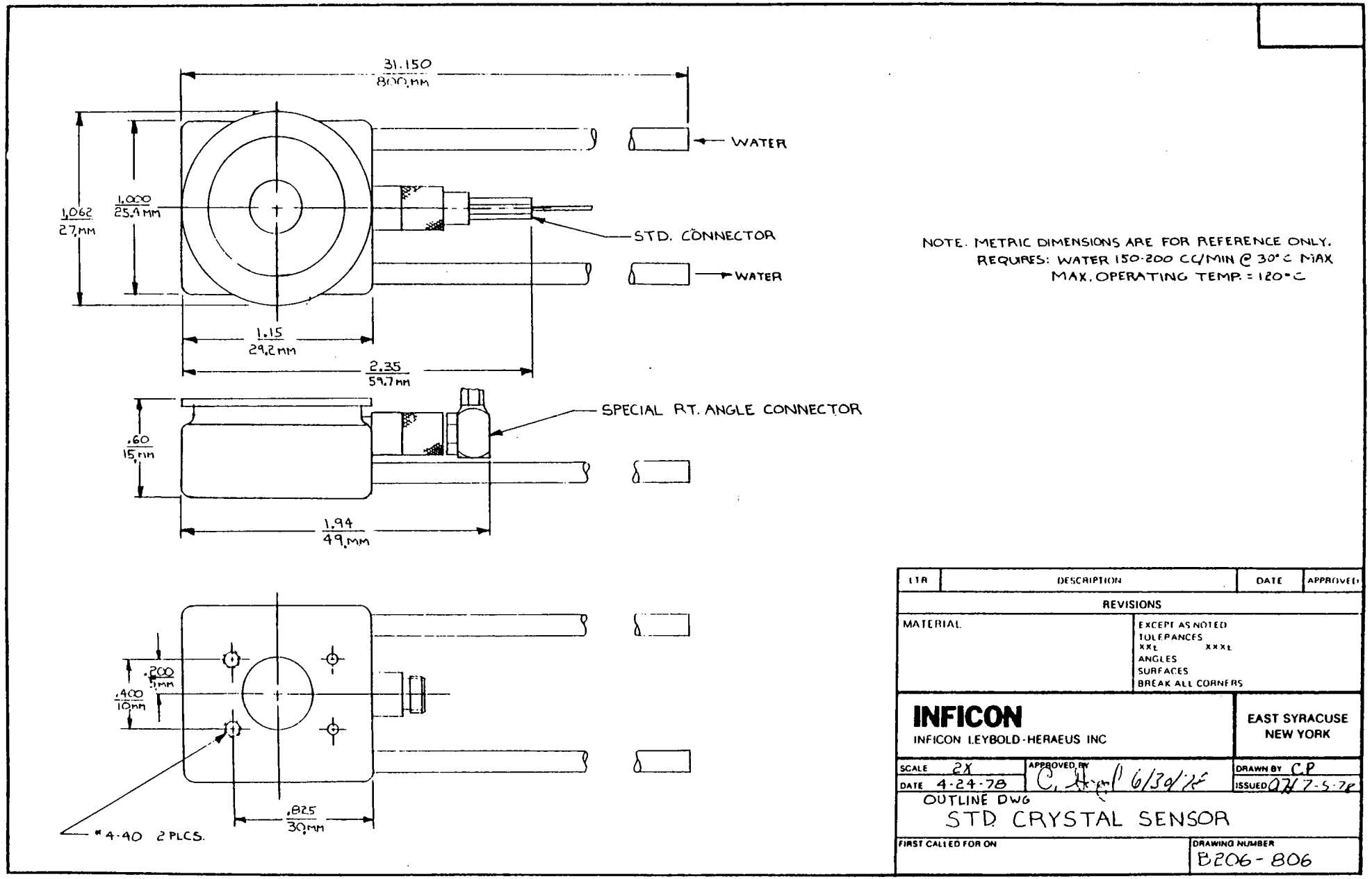


Fig. 6-6 Regular (Standard) Sensor

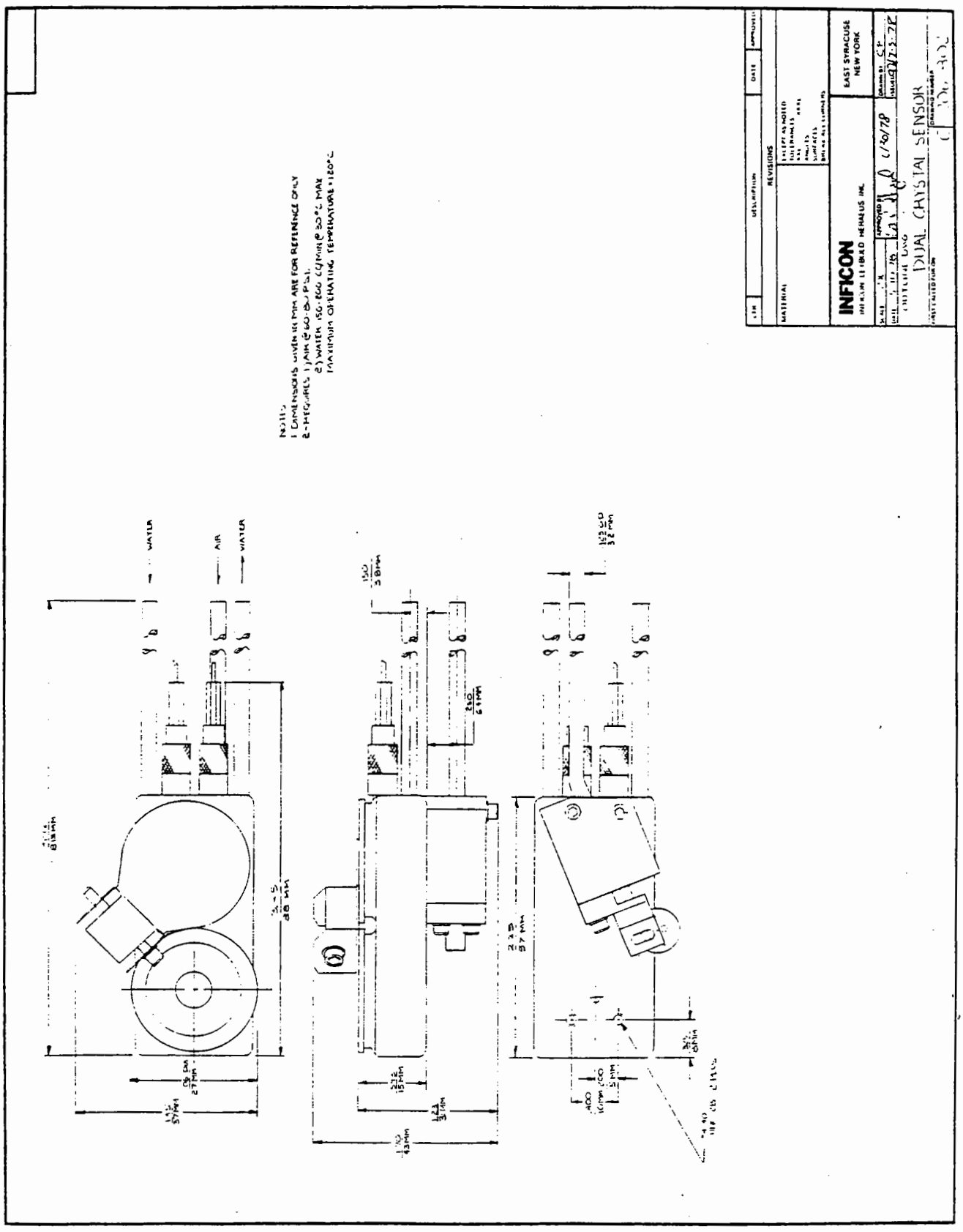


Fig. 6-7 Dual Sensor

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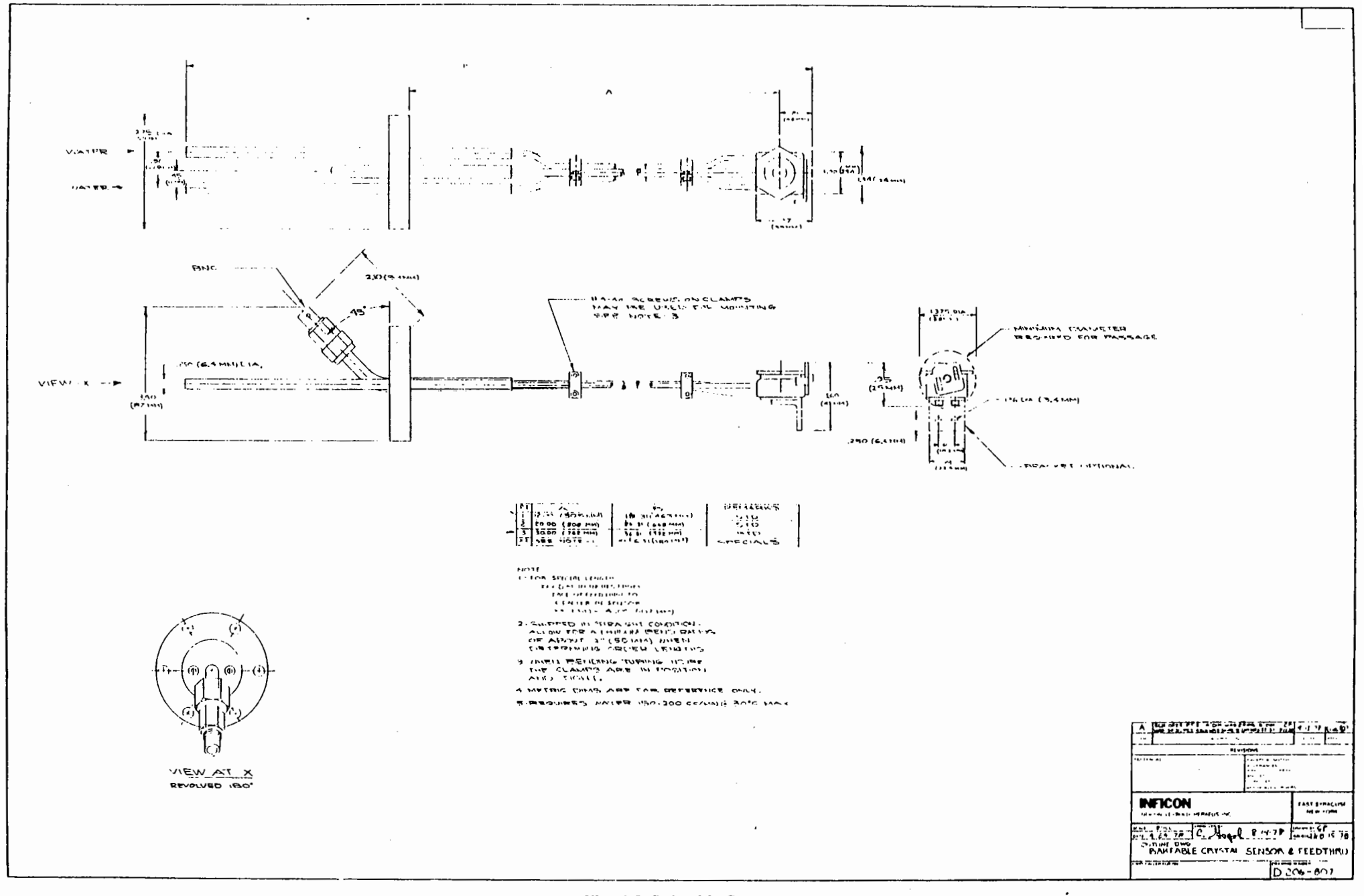


Fig. 6-8 Bakeable Sensor

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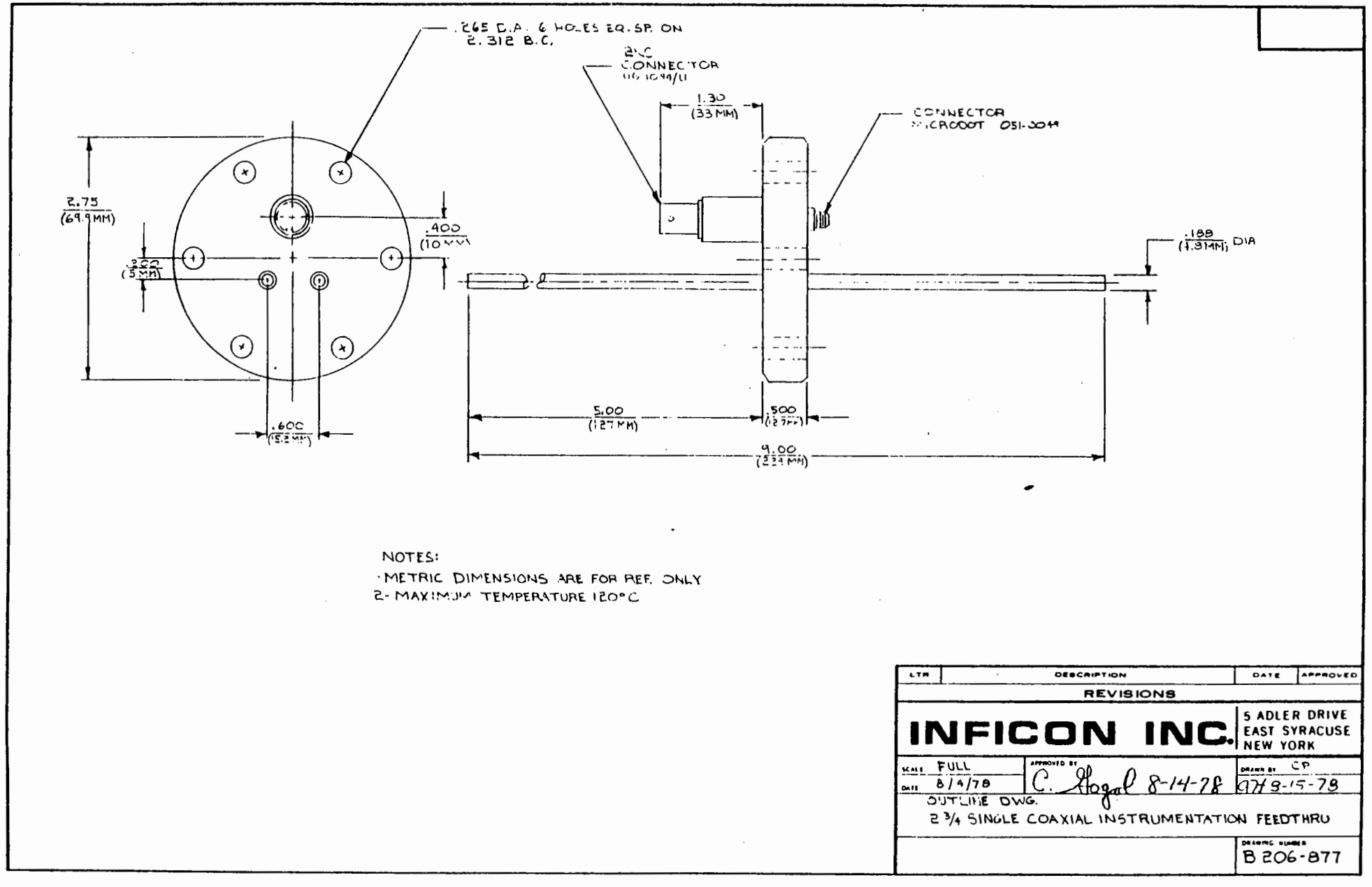


Fig. 6-9 2¼" Single Coaxial Feedthrough

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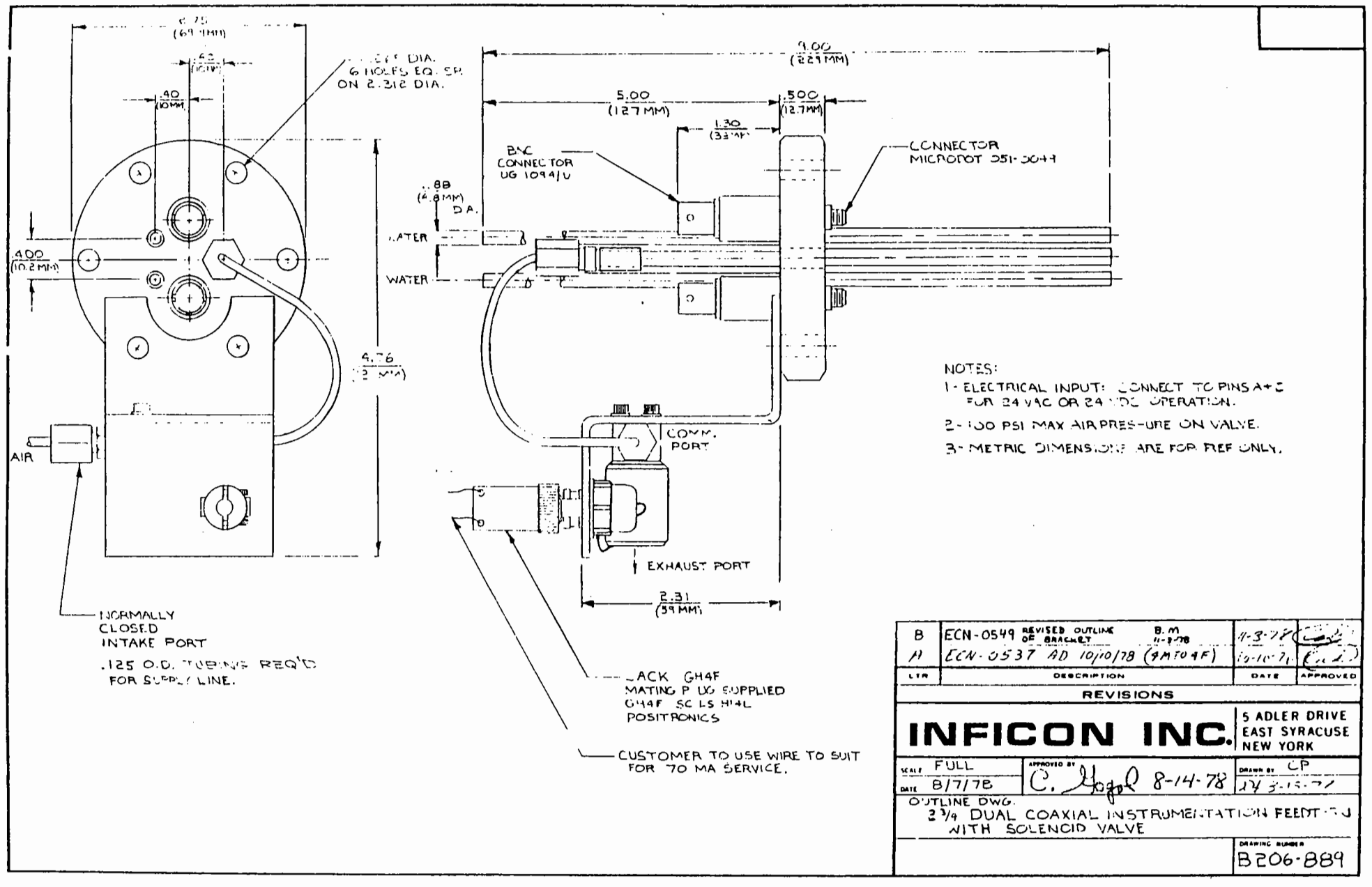
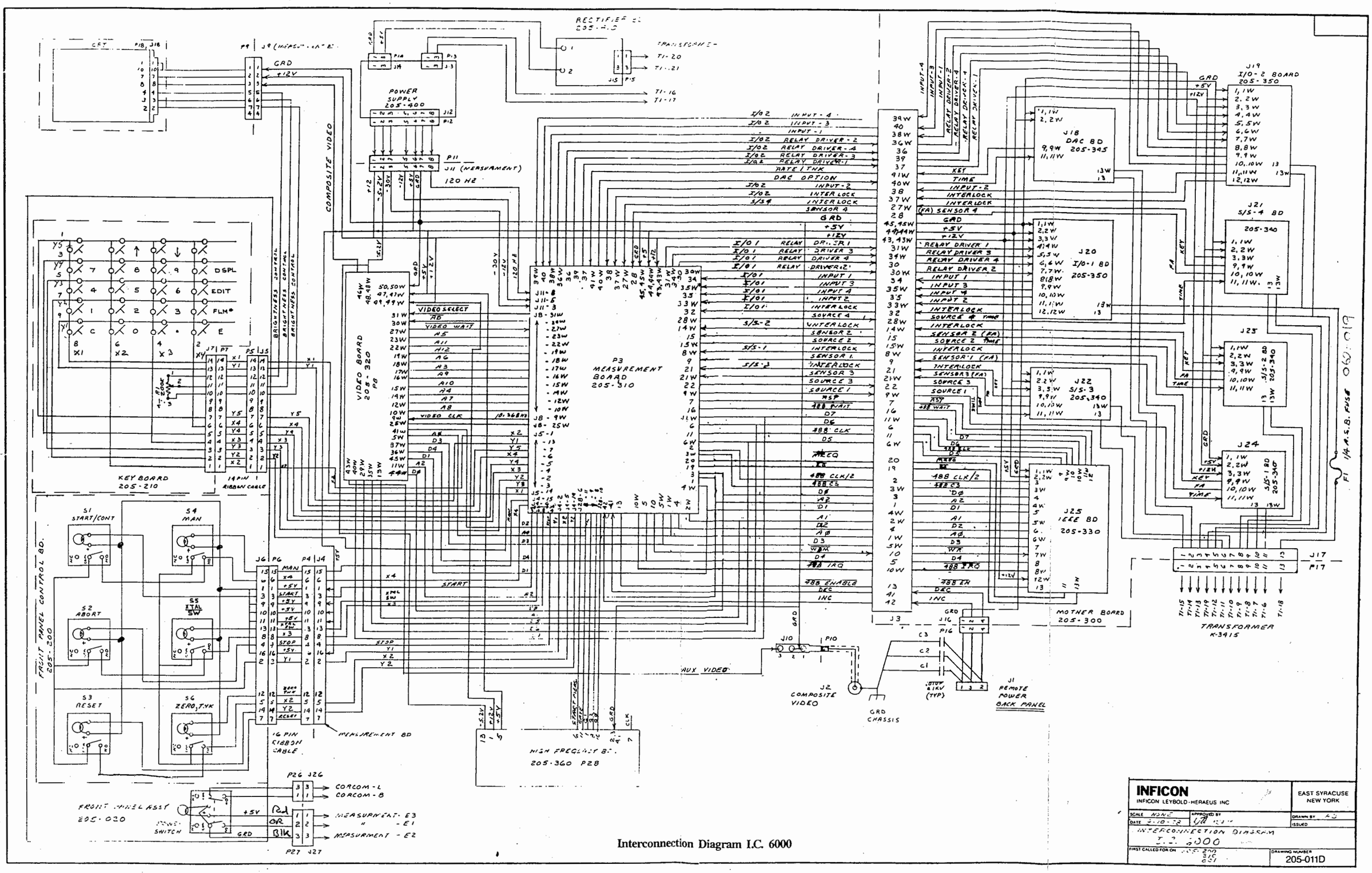


Fig. 6-10 2¼" Dual Coaxial Feedthrough

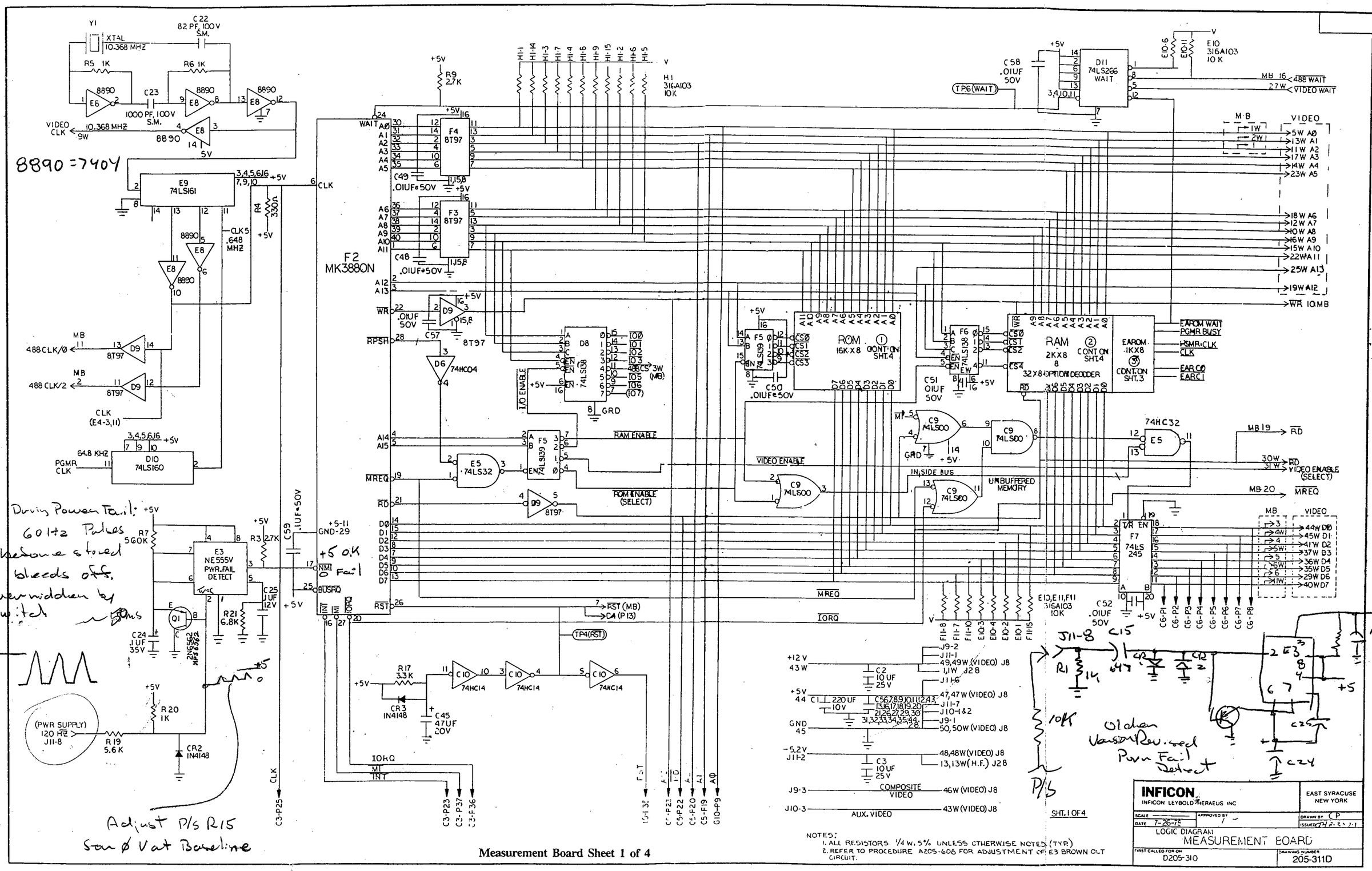
P&T - Bourns 3329H-1-204



Interconnection Diagram I.C. 6000

INFICON INFICON LEYBOLD-HERAEUS INC	EAST SYRACUSE NEW YORK
SCALE NONE DATE 2-10-82 APPROVED BY DRAWN BY AJ ISSUED	
INTERCONNECTION DIAGRAM I.C. 6000	
FIRST CALLED FOR ON 205-200 320 021	DRAWING NUMBER 205-011D

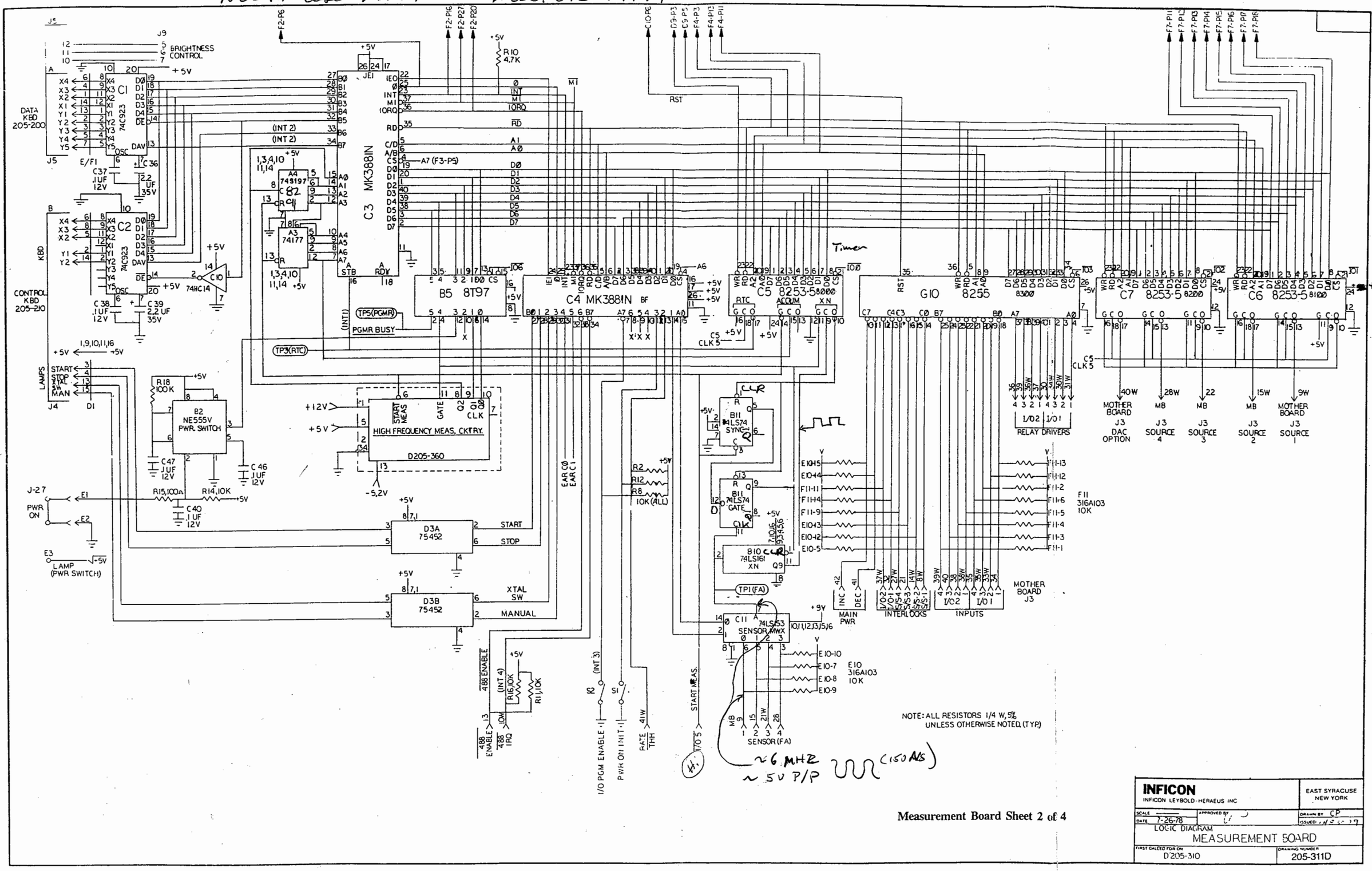
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Measurement Board Sheet 1 of 4

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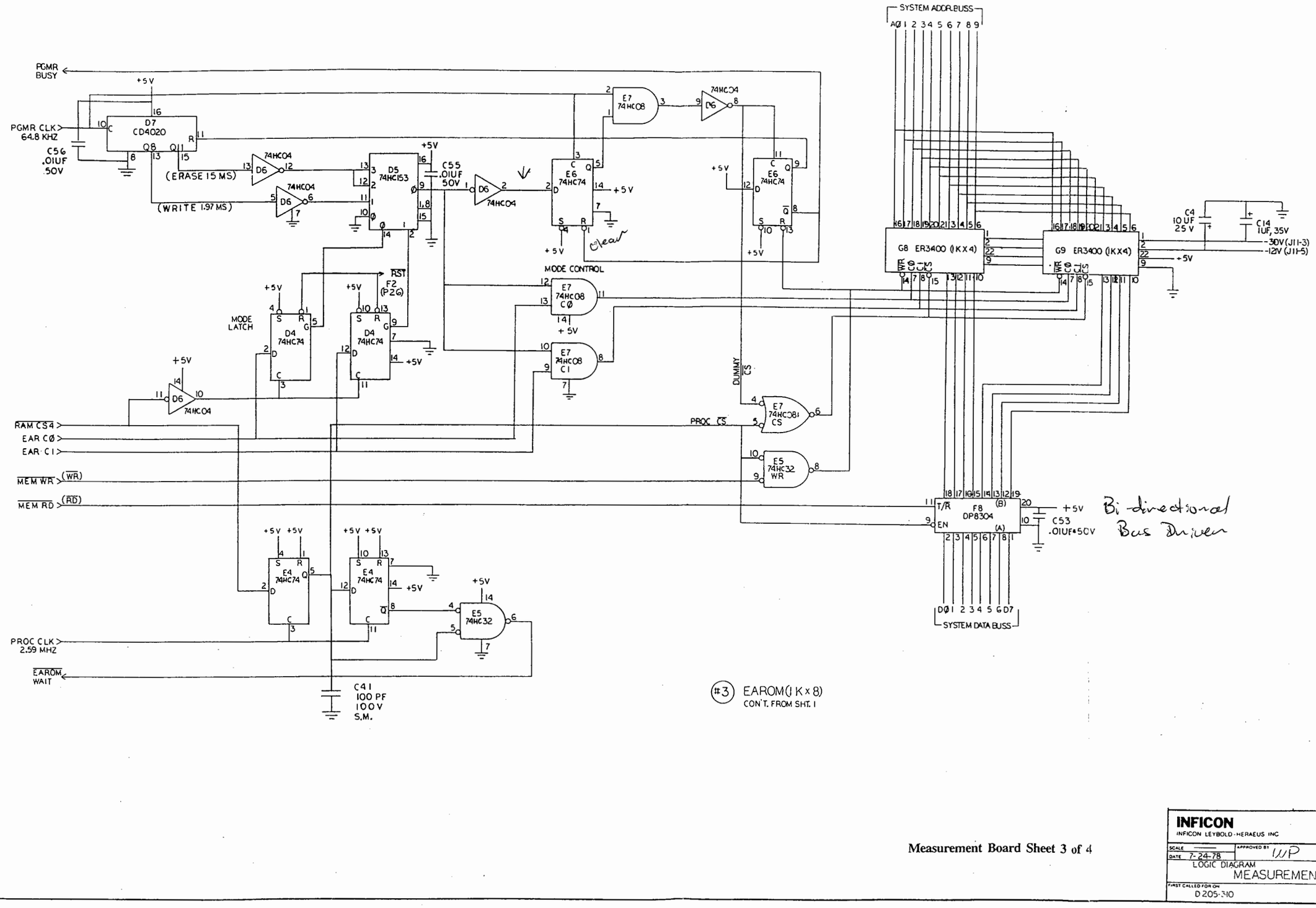
N8291A use 74197 N8281 use 74177



INFICON INFICON LEYBOLD-HERAEUS INC	EAST SYRACUSE NEW YORK
SCALE —— APPROVED BY	DRAWN BY CP
DATE 7-26-78	ISSUED
LOGIC DIAGRAM MEASUREMENT BOARD	
FIRST CALLED FOR ON D205-310	DRAWING NUMBER 205-311D

Measurement Board Sheet 2 of 4

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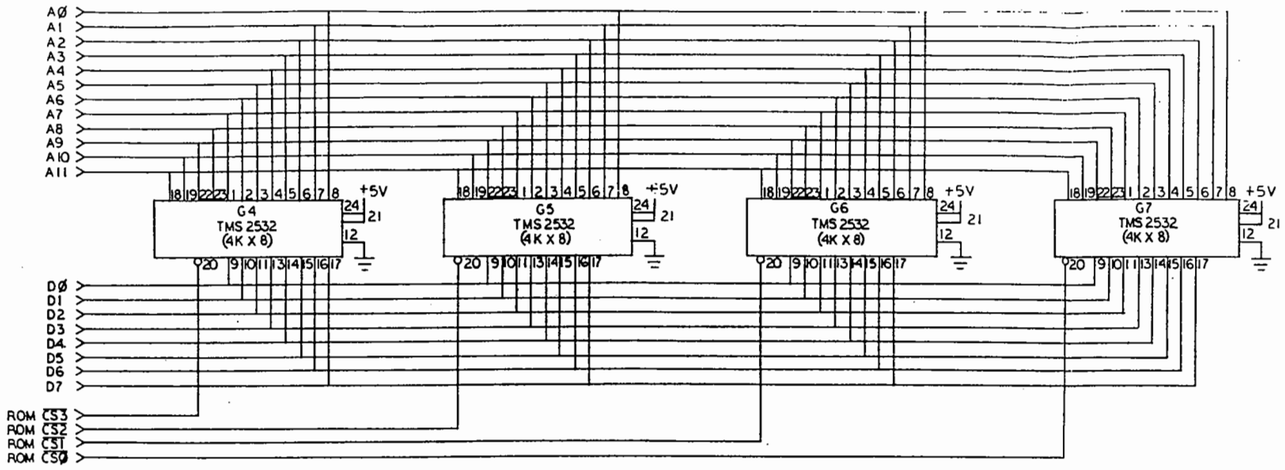


(#3) EAROM (1K x 8)
CON'T. FROM SHT. 1

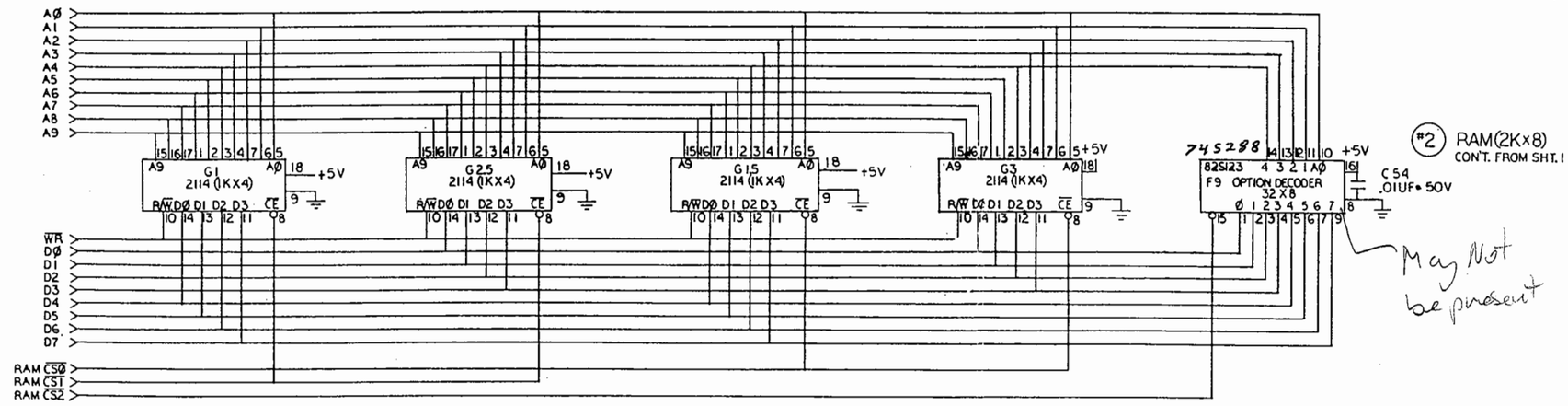
Measurement Board Sheet 3 of 4

INFICON INFICON LEYBOLD-HERAEUS INC	EAST SYRACUSE NEW YORK
SCALE —— APPROVED BY WP	DRAWN BY CP
DATE 7-24-78	ISSUED 8-10-79
LOGIC DIAGRAM MEASUREMENT BOARD	
FIRST CALLED FOR ON D 205-310	DRAWING NUMBER 205-311D

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(#1) ROM (16K x 8)
CON'T. FROM SHT. 1



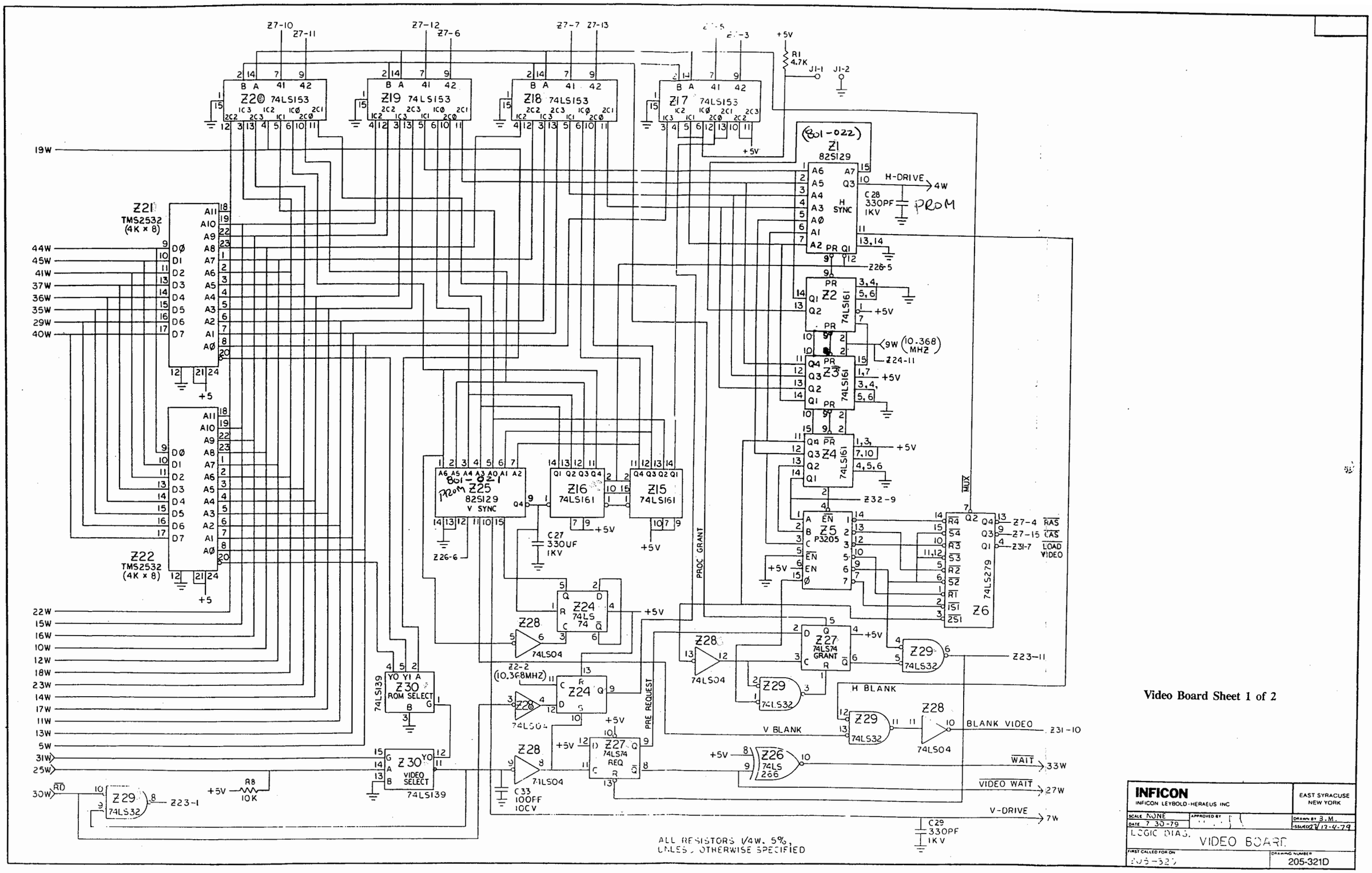
(#2) RAM (2K x 8)
CON'T. FROM SHT. 1

May Not be present

Measurement Board Sheet 4 of 4

INFICON INFICON LEYBOLD-HERAEUS INC		EAST SYRACUSE NEW YORK
SCALE: ——	APPROVED BY: WJD	DRAWN BY: CP
DATE: 7-24-78		ISSUED: 7/8-30-79
LOGIC DIAGRAM MEASUREMENT BOARD		
FIRST CALLED FOR ON: D205-310		DRAWING NUMBER: 205-311D

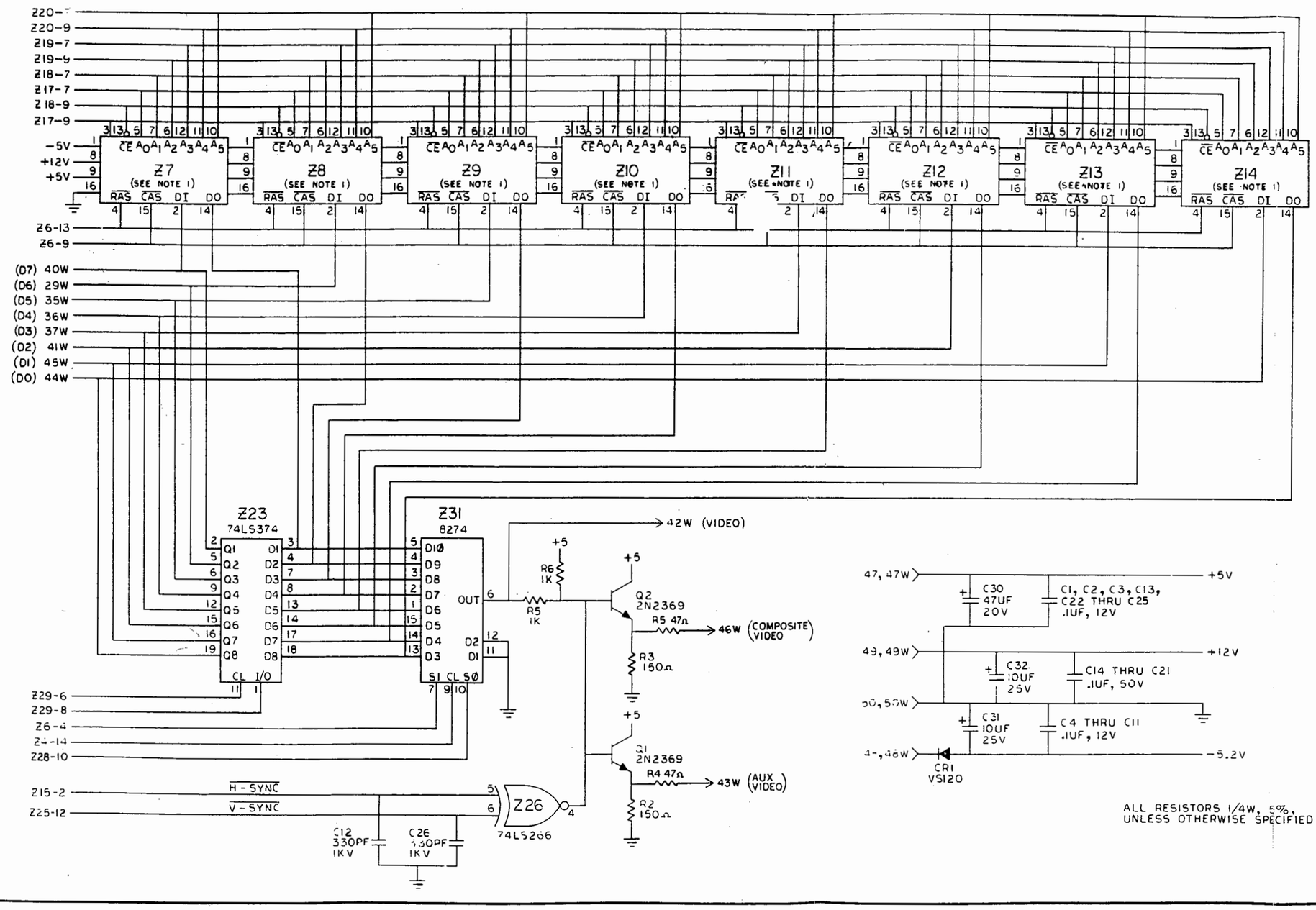
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Video Board Sheet 1 of 2

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Note: ① Old Video Board w/ 16 X 4K RAM chips ② Rev H Bds - Add trace wire from C-14 (Bottom) to Z20-1 and Z20-8
Rpl Top Row w/ 8 X 16K (4116) GND trace is not allways sufficient (It misses display
Leave Second row empty



NOTE:

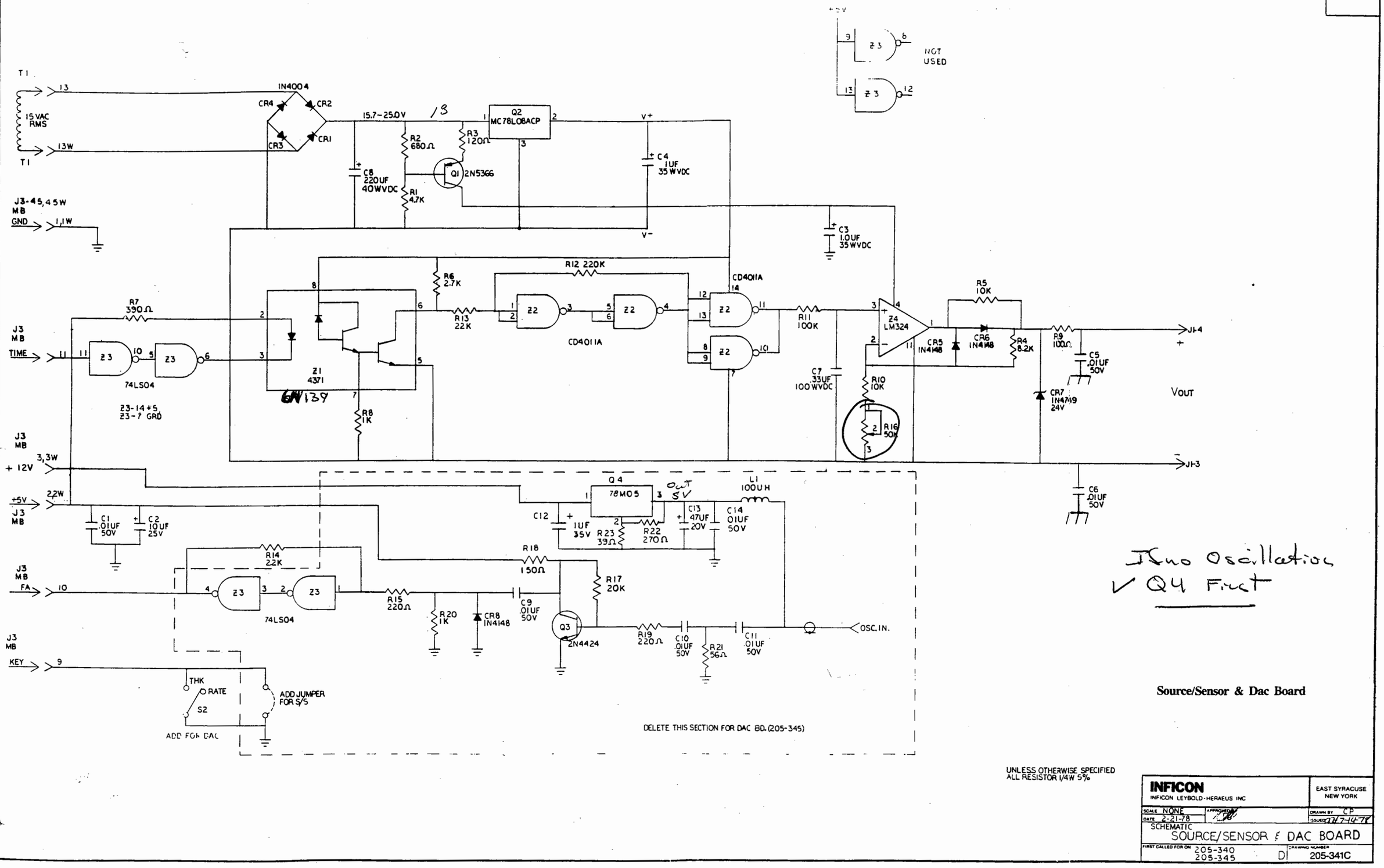
1. IF JUMPER IS USED BETWEEN J1-1 AND J1-2 (SEE SHEET 1) Z7 THRU Z14 PART NO. IS MK4115-40, IF NO JUMPER IS USED Z7 THRU Z14 PART NO. IS MK4115-41.

Video Board Sheet 2 of 2

ALL RESISTORS 1/4W, 5%, UNLESS OTHERWISE SPECIFIED

INFICON INFICON LEYBOLD-HERAEUS INC		EAST SYRACUSE NEW YORK
SCALE NONE	APPROVED BY	DRAWN BY B. M.
DATE 7-18-79		ISSUED 7-23-79
LOGIC DIAG. VIDEO BOARD		
FIRST CALLED FOR ON 205-320		DRAWING NUMBER 205-321C

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No Oscillation
✓ Q4 Fuct

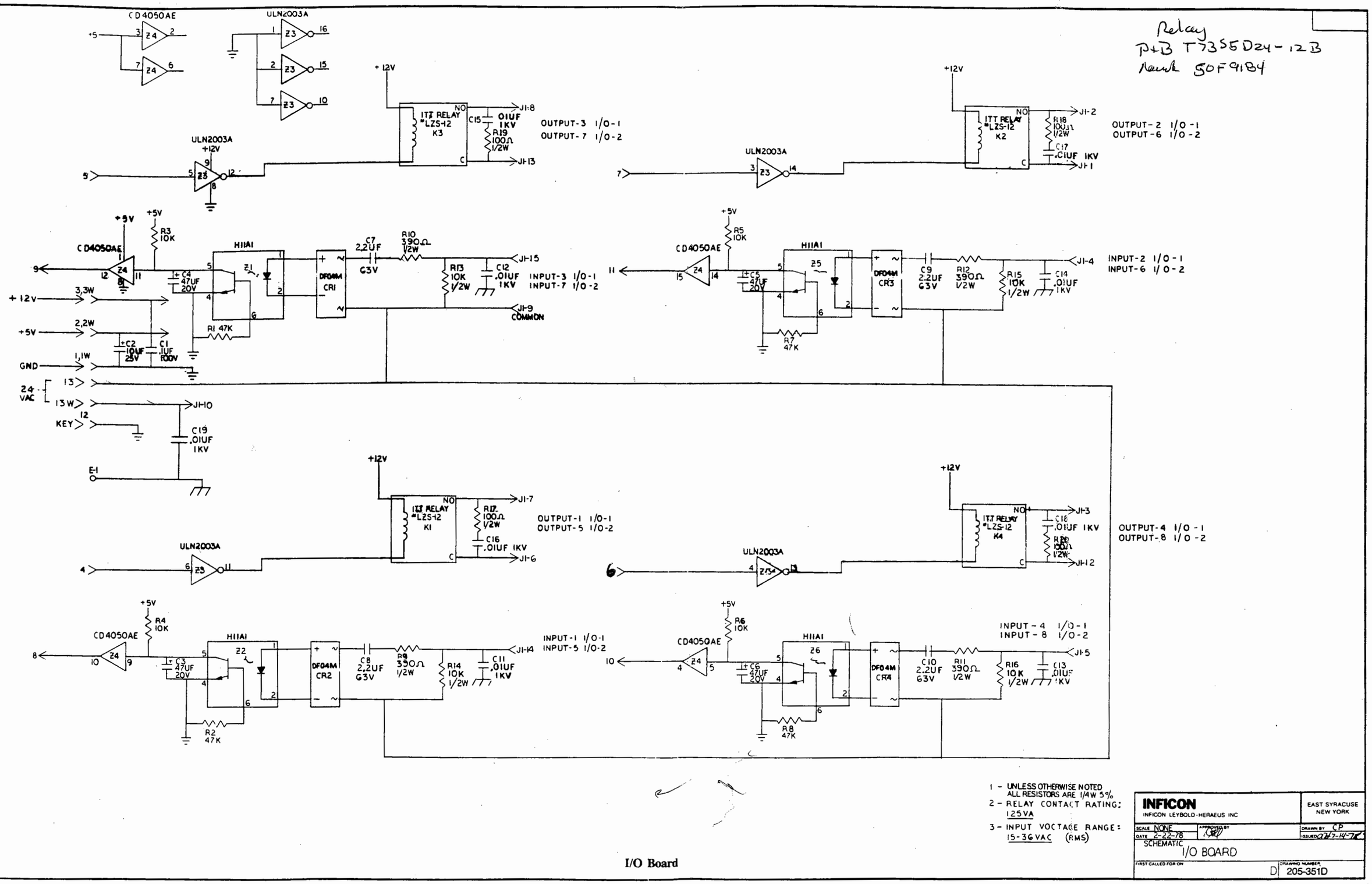
Source/Sensor & Dac Board

UNLESS OTHERWISE SPECIFIED
ALL RESISTOR 1/4W 5%

INFICON INFICON LEYBOLD-HERAEUS INC		EAST SYRACUSE NEW YORK
SCALE NONE	APPROVED	DRAWN BY CP
DATE 2-21-78		ISSUED 7-14-78
SCHEMATIC SOURCE/SENSOR & DAC BOARD		
FIRST CALLED FOR ON 205-340 205-345	D	DRAWING NUMBER 205-341C

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Relay
P+B T73SDZ4-12B
Mark 50F9184



1 - UNLESS OTHERWISE NOTED ALL RESISTORS ARE 1/4W 5%
2 - RELAY CONTACT RATING: 125VA
3 - INPUT VOCTAGE RANGE: 15-36VAC (RMS)

INFICON INFICON LEYBOLD-HERAEUS INC	EAST SYRACUSE NEW YORK
SCALE NONE DATE 2-22-78 APPROVED BY DRAWN BY CP ISSUED 2-14-78	
SCHEMATIC I/O BOARD	
FIRST CALLED FOR ON	DRAWING NUMBER D 205-351D

I/O Board

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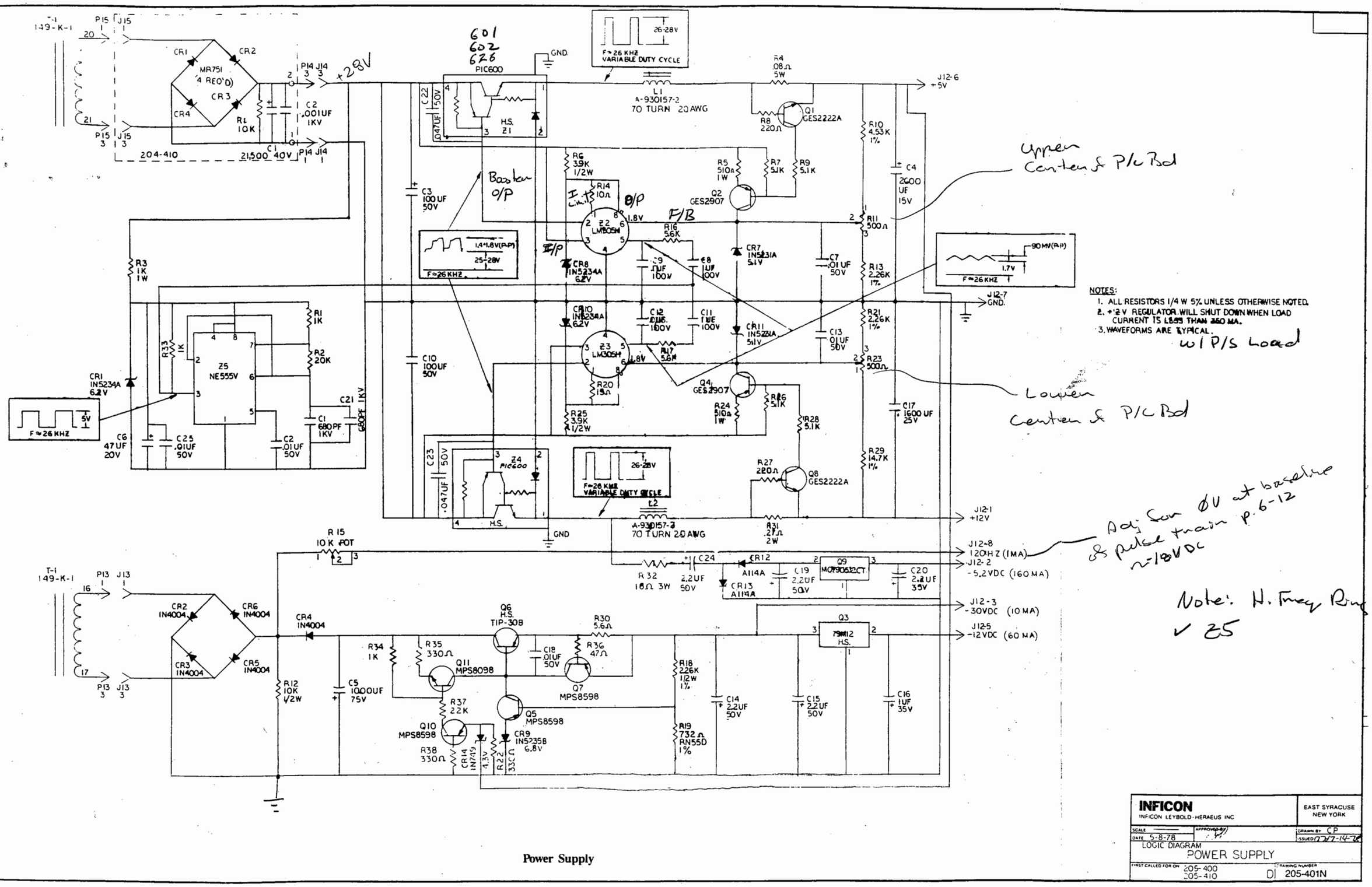
5/15/97 -
(1) gross fluctuations in thickness display traced to this module
(2) C5 was shorted - Rpl = OK

+12V P28-P1
FERRITE BEAD 1
MC78L08ACP
8V P/S (7.8)
IN Z5 OUT
GRD
C17 2.2UF 35V
C18 47UF 20V
R4 100Ω
C1 2.5/7.5PF
C6 5PF NPO
L1 #22AWG 2T
C3 5PF NPO
R6 33K
C8 .01UF 50V
.757
Q1 2N3563
6.98
C2 01 UF 50V
C5 1UF 35V
C.10 15 PF S.M.
R7 27K
Y1 XTAL 112.3301 MHZ
L2 1 UHY
C11 15 PF S.M.
C13 4.5/20 PF
GRD P28-P2,3,4
TP-1
R1 56Ω
C4 001UF 1KV
R2 33K
R3 680Ω
C7 1000PF 1KV
+5V
C12 .01UF 50V
GATE P28-11
Z2 ME10124
R5 560Ω
C15 .01UF 50V
-5.2V
40mSec
100 mHz
20mV (AC)
C9 .01 UF 50V
+5V P28-P5
FERRITE BEAD 2
C20 220UF 10V
+5V
-5.2V P28-P13
FERRITE BEAD 3
C21 47UF 20V
-5.2V
+5V
C14 .01UF 50V
SM P28-6
+5
Z3 74S04
R8 1.8K
R9 10K
R10 10K
Z1 SP873GB
CL CI
A B C
Q0 P28-10
Q1 P28-9
+5V
C19 .01UF 50V
Z4 MC10125
74S04 Z3
Q2 P28-8
CLK P28-7
Inverse
R11 1.5K 1/4W 5%
C16 .01UF, 50V
-5.2V
4V
0

NOTE - ALL RESISTORS ARE 1/4W 5% UNLESS OTHERWISE NOTED.

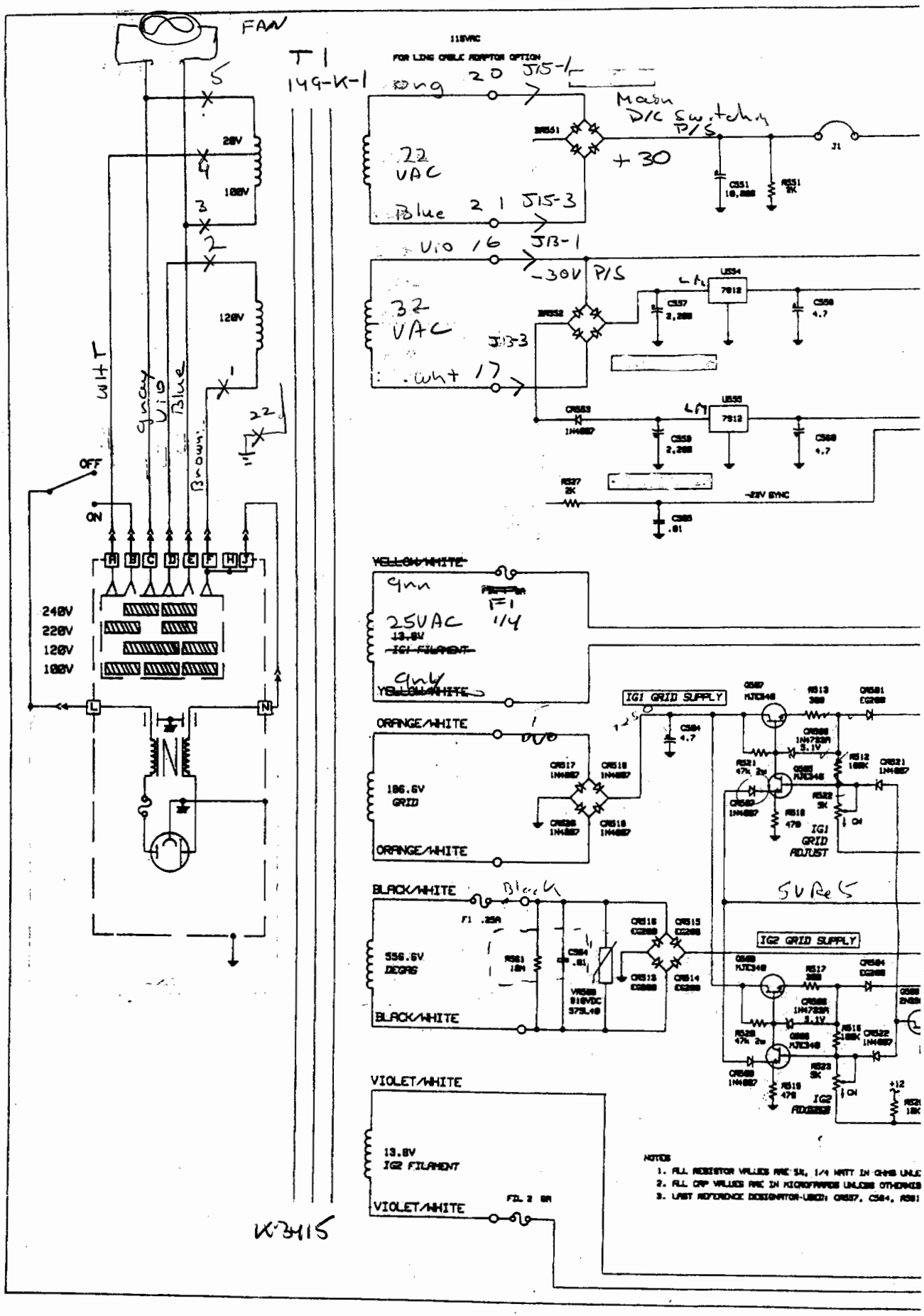
INFICON
INFICON LEYBOLD-HERAEUS INC
EAST SYRACUSE NEW YORK
SCALE
DATE 9-5-79
APPROVED BY
DRAWN BY AD
ISSUED
HIGH FREQUENCY BD
FIRST CALLED FOR ON C205-320
DRAWING NUMBER 205-361M

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Power Supply

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IC-6000 T1 Wiring

6-17a

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APPENDIX A
GLOSSARY
PROGRAMMING AND OPERATING THE IC 6000

abort.....A machine condition in which in-process film terminates, and control voltage to all sources is zeroed. The abort and/or stop relay is activated, if programmed.

active film.....The film program that is determining the deposition cycle.

active process..The film sequence that is executed from start commands.

active relay ....A relay that is not in the static state.

film ..... A film program defines a sequence of events which allows a controlled deposition of a material. Any single film consists of a sequence of programmed (or deleted) parameters. The IC 6000 can accomodate up to 6 different film programs, each having up to 37 parameters.

layer.....A layer is any given film stratum within a process sequence.

layer to start...A programmable value that sets the first layer to be started in a process sequence (normally set to 1).

mode..... A static state of the instrument.

next film .....The film following the active film in the process sequence of films.

page ..... One full video display of film program parameters.

parameter ..... A variable that is given a constant value for a specific purpose.

parameter range .....The upper and lower limits within which a parameter must be programmed.

phase ..... One of the 16 states of a film deposition cycle.

phase time .... Time remaining to a phase completion (or in deposit or idle phase, refers to elapsed time).

predeposition.. Events which occur prior to deposition.

preprogrammed value .....Value to which a parameter or function is initialized.

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process.....A process is an ordered sequence of films 1 through 6, consisting of from 1 to 32 layers. The IC 6000 has three definable processes; the fourth process is manual film selection. In the following example, the process (#1) is made up of 6 films, arranged in the sequence 1313242456 for a total of 10 layers. The first layer of the process consists of film #1; the second layer of the process consists of film #3, etc. (Process #1 - 1313242456)

run number ....A programmable counter that indicates the number of times a process is initiated.

sequence .....Sequence refers to the selected order and arrangement of individual films within a process. That is, a process is made up of any combination of six films, arranged in a sequential pattern.

stop.....A machine condition in which the in-process film terminates, and all source voltages are zeroed. The abort relay is not activated.

time-power ..... If a unit is programmed to complete on time-power and a (how computed) failure occurs which requires this function, the value of source control voltage prior to failure is maintained and set point rate is assumed for the time required to reach final thickness.

APPENDIX B
STATUS MESSAGES AND DEFINITIONS

At some time during the course of a process run, the machine may be stopped or aborted for one of the reasons listed below. If this occurs, the Data display will appear (except in the case of End Group messages) and a flashing status message will give the reason for the machine condition. Possible messages and definitions of these messages are listed below.

STOP GROUP - All source powers are set to zero. The phase status at the time the stop event occurred is retained on the Data display. The stop relay is activated, but the abort relay function is not. The following events may cause a stop to occur:

STOP MAX POWER

An active source output (either the active film or a film being presoaked) has equaled the max power limit set for that source for five (5) consecutive seconds, and the stop on max power parameter (#25) has been enabled in the film program involving that source.

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STOP NO FILM	An attempt has been made to start a process that has not been programmed.
STOP MANUAL	While in the manual power mode of operation, the hand controller was keyed downward.
STOP XTAL FAIL	Entering the time-power mode of layer completion with no previous control loop power voltage established to use as the power voltage reference. Indicates that no usable sensor crystal is present in the system and that the abort on xtal fail parameter (#26) has been enabled in the film program.
STOP IO PROGRAM	Indicates that the I/O security switch (red toggle switch inside IC-6000 chassis) has been placed in the low security position and at some time returned to the high security position.
STOP NO SOURCE	Indicates that an attempt has been made to start a process calling for a source/ sensor module that is not present.
STOP EXTERNAL	An external stop command has been received.

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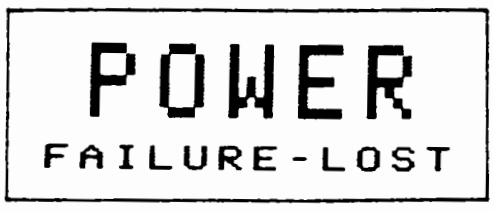
ABORT GROUP - All source powers are set to zero. The process status at the time the abort event occurred is retained on the Data display. Both the abort relay and stop relay functions are enabled. The following events can cause an abort to occur:

ABORT FRONT PANEL	The front panel ABORT button has been pressed.
ABORT EXTERNAL	An external abort command has been received.
ABORT POWER FAIL	A line power outage for a period of less than 150 ms has occurred.

POWER GROUP - Gives the status of vital process information when a loss of line power for a period greater than 150 ms has occurred. The instrument status is the same as a front panel abort event with the appropriate memory message displayed.

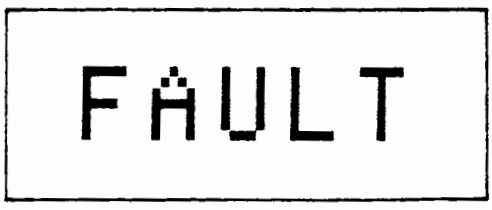
POWER FAILURE-SAFE	All vital process data is retained and displayed on the Data display. Vital Process Data 1. Thickness 2. Active Process 3. Active Film 4. Phase Status 5. Phase Time 6. Layer Time 7. Run Number 8. Layer Number

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Vital process data has been lost and reset to initial values; program data is retained.

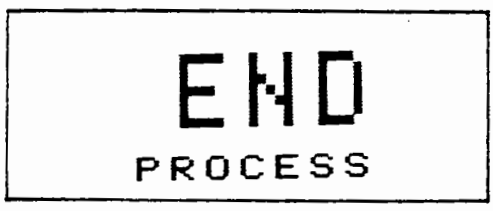
FAULT MESSAGE - The fault message indicates that a line power outage has occurred and that all vital process information as well as all film and I/O program information has been lost and reset to initial values. The instrument status is the same as a front panel abort with the fault message displayed.



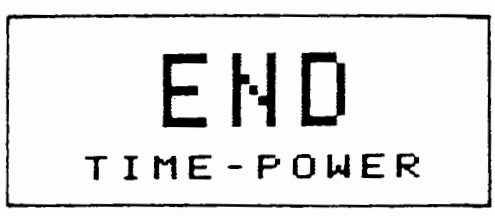
END GROUP - This group indicates process sequence status and mode of completing a film layer.



A film program has been completed normally and the instrument is ready to continue a process.



A process has been completed and the instrument is ready to continue.



Indicates that a film program was completed in the time-power mode of operation and that the problem causing the switch to the time-power phase should be corrected before continuing.

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Indicates that a film reset function was executed.



Indicates that an abort/stop condition was followed by a process reset function.



Indicates that an abort/stop condition was followed by a continue function.

APPENDIX C
IC 6000 CONFIDENCE TESTS

The IC 6000 automatically performs a series of confidence checks each time it is turned on. As soon as these checks are performed and the initial warm-up period (10-15 seconds) is over, one of the video displays (p. 2-2) should appear on the screen. However, if this does not occur and one of the video patterns shown below appears, a problem is indicated.

The pattern shown in Fig. C-1 indicates an improper program in one or more proms, or a hardware problem associated with the proms. You should check to make sure that the proms are plugged into the proper sockets and that the prom pins are not bent. If this does not solve the problem, call Inficon. This check ensures that a valid program is controlling the IC 6000. The instrument will not operate until the problem is alleviated.

The pattern shown in Fig. C-2 (or Fig. C-4) indicates a faulty video memory chip (or faulty associated circuitry). If you are unable to locate the problem chip, call Inficon. The instrument will not work until the problem is cleared up.

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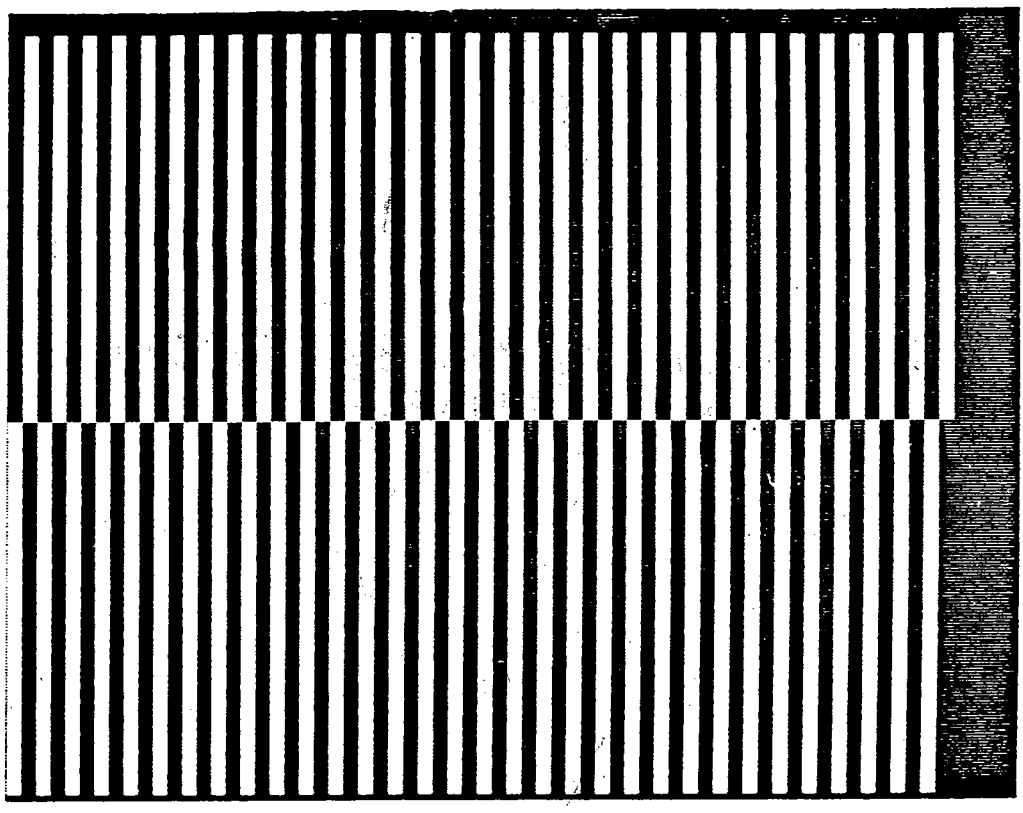


Fig. C-1 Rom Failure Display

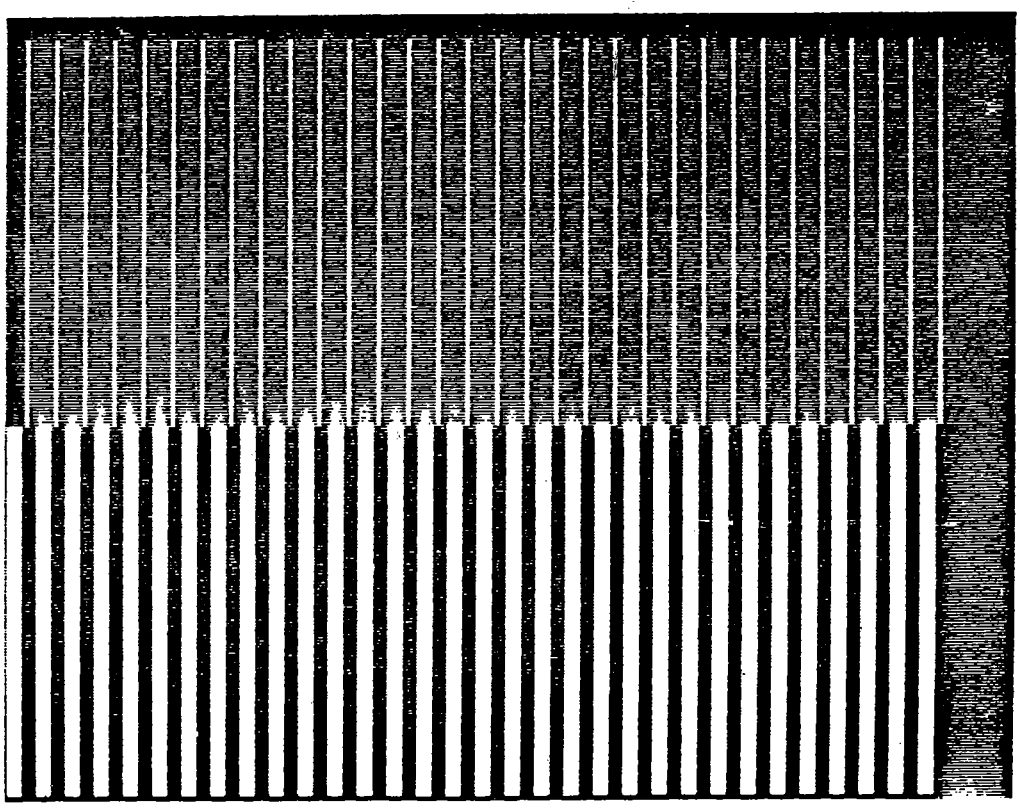


Fig. C-2 Video Ram Failure Display

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The pattern shown in Fig. C-3 (or Fig. C-4) indicates a faulty static ram chip (or faulty associated circuitry). If you are unable to locate the faulty chip, call Inficon. The instrument will not work until the problem is cleared up.

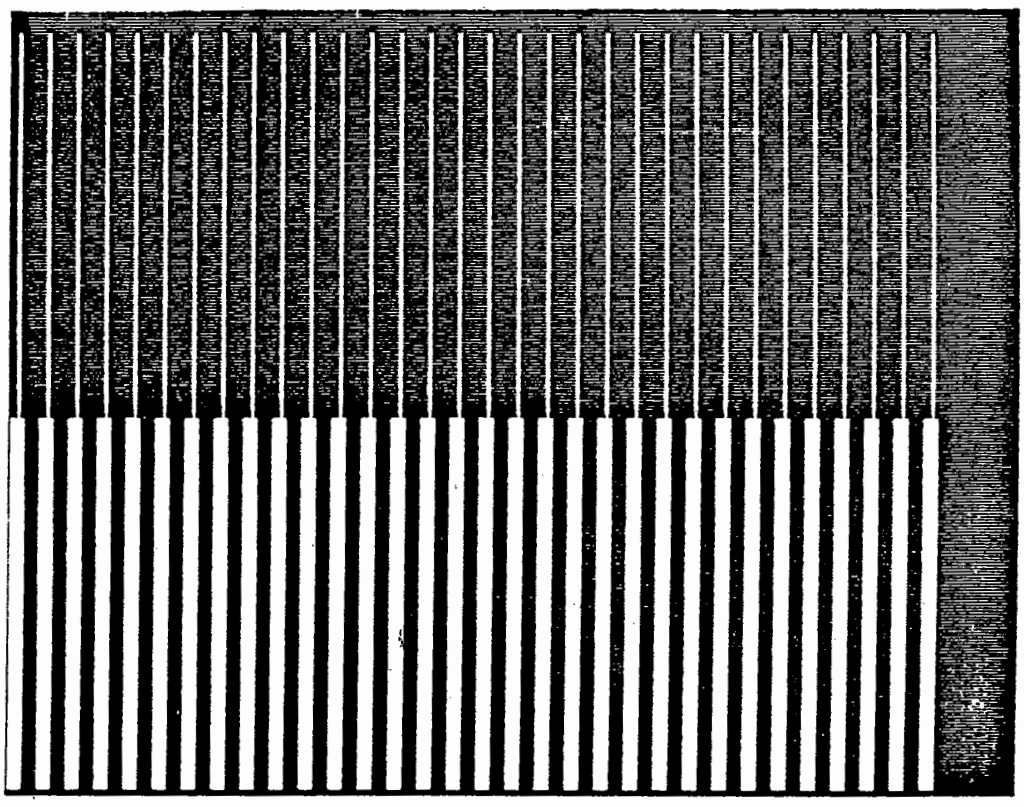


Fig. C-3 Static Ram Failure Display

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The pattern shown in Fig. C-4 indicates a problem with both the video memory chip and the static ram. Call Inficon if this pattern appears.

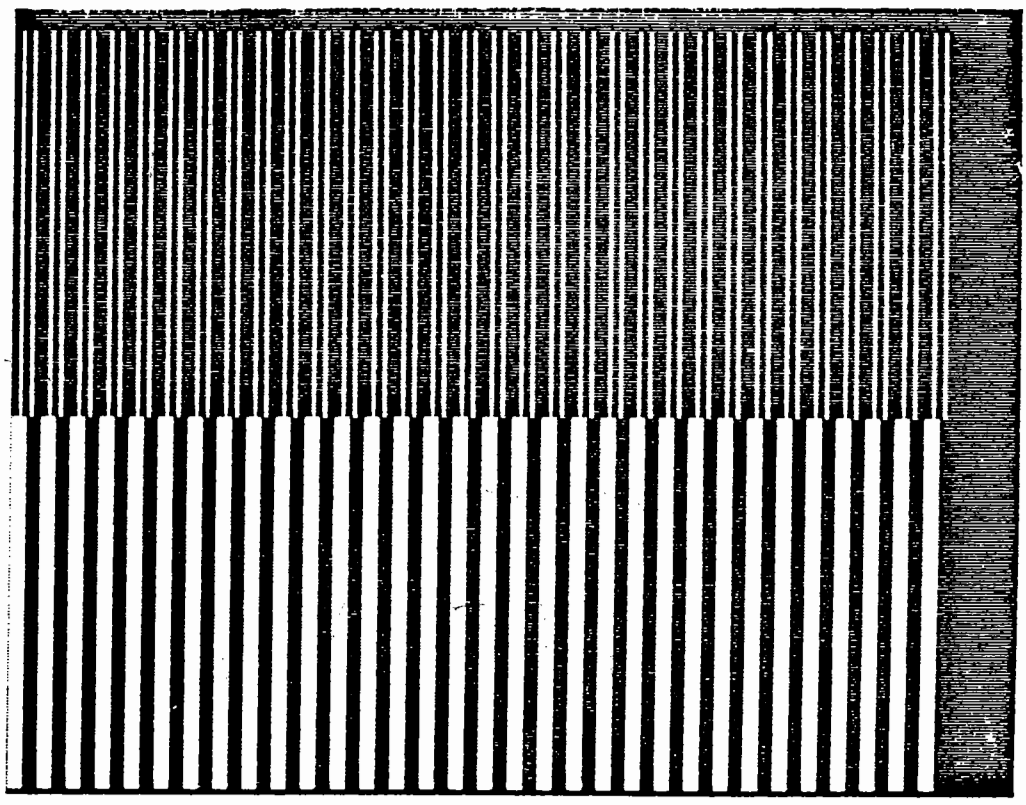


Fig. C-4 Combination Failure Display

If neither the normal displays nor the fault displays appear, you should contact Inficon immediately.

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APPENDIX D
MEASUREMENT THEORY

Commercial quartz-crystal film thickness monitors have evolved in three distinct stages: (1) frequency measurement technique, (2) period measurement technique, and (3) z-match technique.

Sauerbrey[1] used the quartz-crystal resonator to measure deposited film thickness; this was later developed into a commercial unit. The thickness frequency used is given by

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

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)

Experiments have shown that in order to keep the thickness measurement reasonably accurate, the maximum frequency shift allowable is limited to about 2% of f_q.

The period measurement technique was used by the second generation quartz-crystal thickness monitors, with the following equation used for thickness computation:

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

In this equation, $t_c = 1/f_c$ and $t_q = 1/f_q$ are the periods of oscillation for the loaded and original crystals, respectively. For a small frequency shift, Eq (1) becomes a good approximation of Eq (2).

Although experiments 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 has been lacking. Tests on the validity of Eq (2) indicate 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 time become even more serious, because the thickness error is a time-varying function, and rate is the derivative of thickness with respect to time.

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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 it is possible to achieve frequency shifts of more than 20% of f_q. Also, complex and precise mathematical calculations can be easily performed with modern microcomputers.

Miller and Bolef[2] 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

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

is the acoustic impedance ratio with μ_f and μ_q the shear moduli of deposited film and quartz crystal, respectively.[4] 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.[3] The experimental results demonstrated that if the density and Z-value of the deposited material are known, Eq (3) is remarkably accurate in determining film thickness.

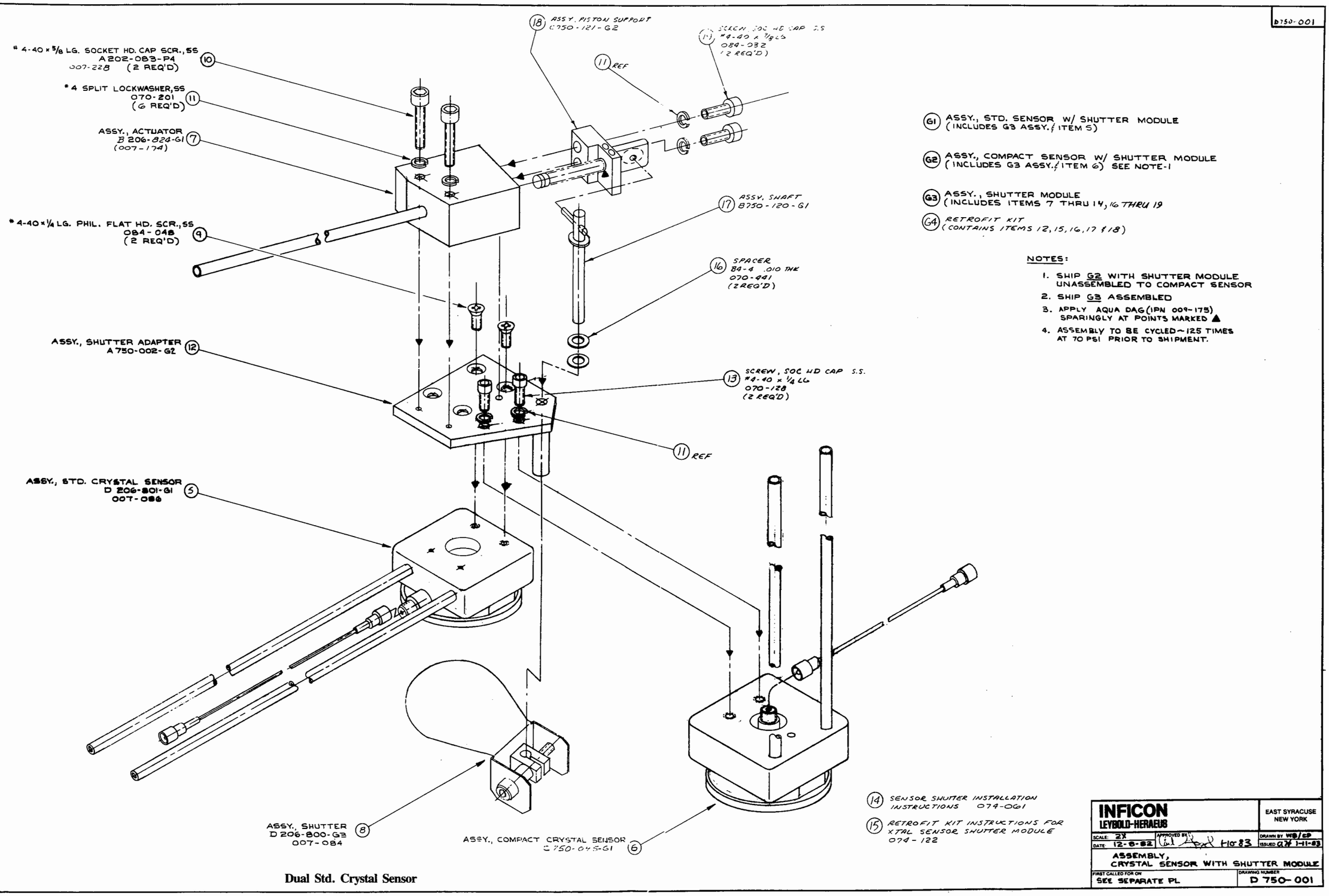
Another significance of Eq (3) is that for the first time the validity of "period measurement" technique, or Eq (2), can be explained from a theoretical point of view. Through a simple algebraic exercise, one can easily show that Eq (2) is a special case of Eq (3) with Z = 1, or quartz-on-quartz.

The IC 6000 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.

[1]Sauerbrey, G.Z., Physik 155, 206 (1959).
[2]Miller, J.G. and Bolef, D.I., J Applied Phys 39, 4589 and 5815 (1968).
[3]Lu, Chih-Shun, J. Vac. Sci. Technology 12, (1975).

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D750-001



G1 ASSY., STD. SENSOR W/ SHUTTER MODULE (INCLUDES G3 ASSY. & ITEM 5)

G2 ASSY., COMPACT SENSOR W/ SHUTTER MODULE (INCLUDES G3 ASSY. & ITEM 6) SEE NOTE-1

G3 ASSY., SHUTTER MODULE (INCLUDES ITEMS 7 THRU 14, 16 THRU 19

G4 RETROFIT KIT (CONTAINS ITEMS 12, 15, 16, 17 & 18)

NOTES:

1. SHIP G2 WITH SHUTTER MODULE UNASSEMBLED TO COMPACT SENSOR
2. SHIP G3 ASSEMBLED
3. APPLY AQUA DAG (IPN 009-175) SPARINGLY AT POINTS MARKED ▲
4. ASSEMBLY TO BE CYCLED ~ 125 TIMES AT 70 PSI PRIOR TO SHIPMENT.

14 SENSOR SHUTTER INSTALLATION INSTRUCTIONS 074-061

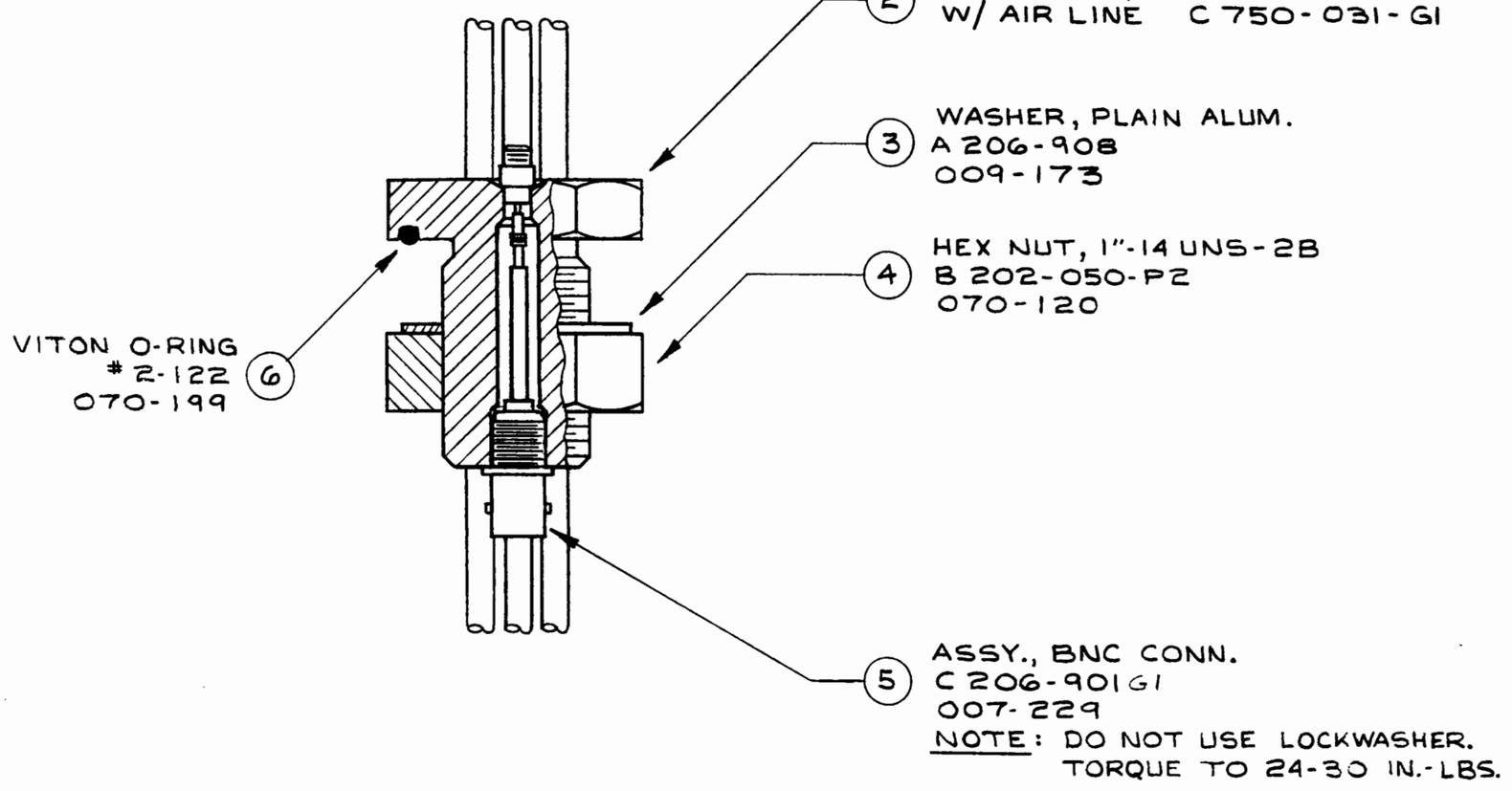
15 RETROFIT KIT INSTRUCTIONS FOR XTAL SENSOR SHUTTER MODULE 074-122

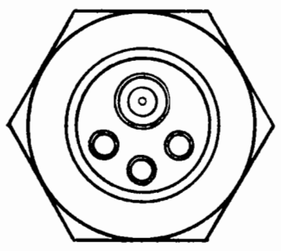
INFICON LEYBOLD-HERAEUS	EAST SYRACUSE NEW YORK
SCALE: 2X	APPROVED BY: HOB3
DATE: 12-8-82	DRAWN BY WB/CP ISSUED QA 1-11-83
ASSEMBLY, CRYSTAL SENSOR WITH SHUTTER MODULE	
FIRST CALLED FOR ON: SEE SEPARATE PL	DRAWING NUMBER: D 750-001

Dual Std. Crystal Sensor

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750-030



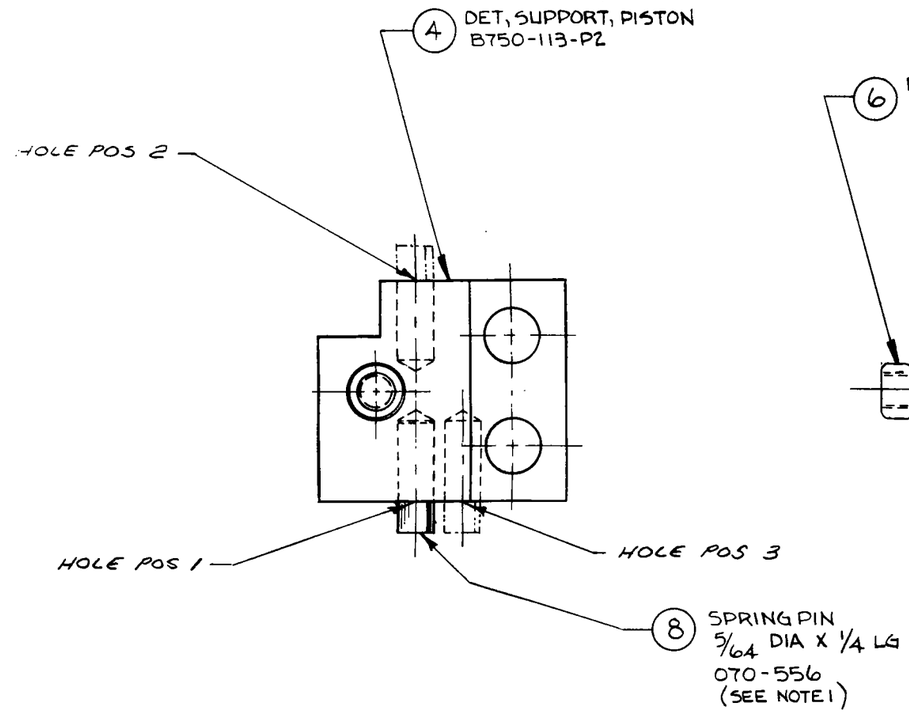


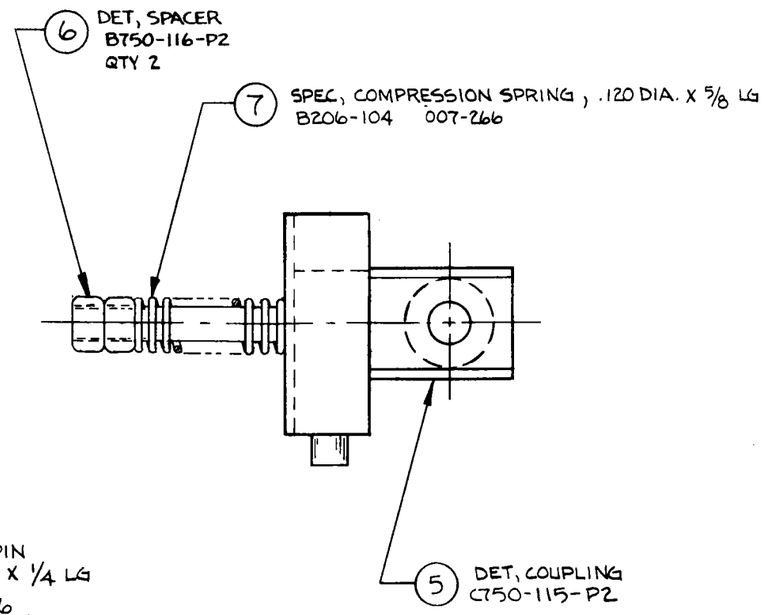
G1 ASSEMBLY

Fig. 8-17 1″ Crystal Feedthru w/Airline (750-030-G1)

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C750-121

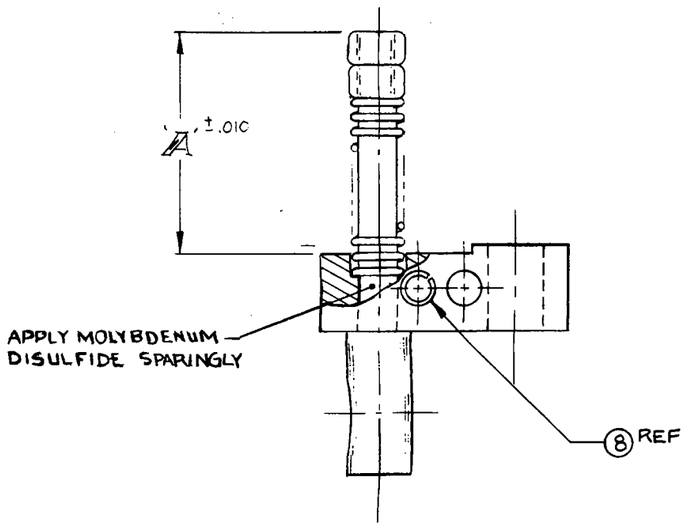




NOTES:

1. PRESS FIT IT 8 TO FULL DEPTH OF HOLE

DWG	A
C750-121-G1	.500
-G2	.500
-G3	.420



G1 ASSY, SUPPORT, PISTON, DUAL HEAD ASSY POS 1

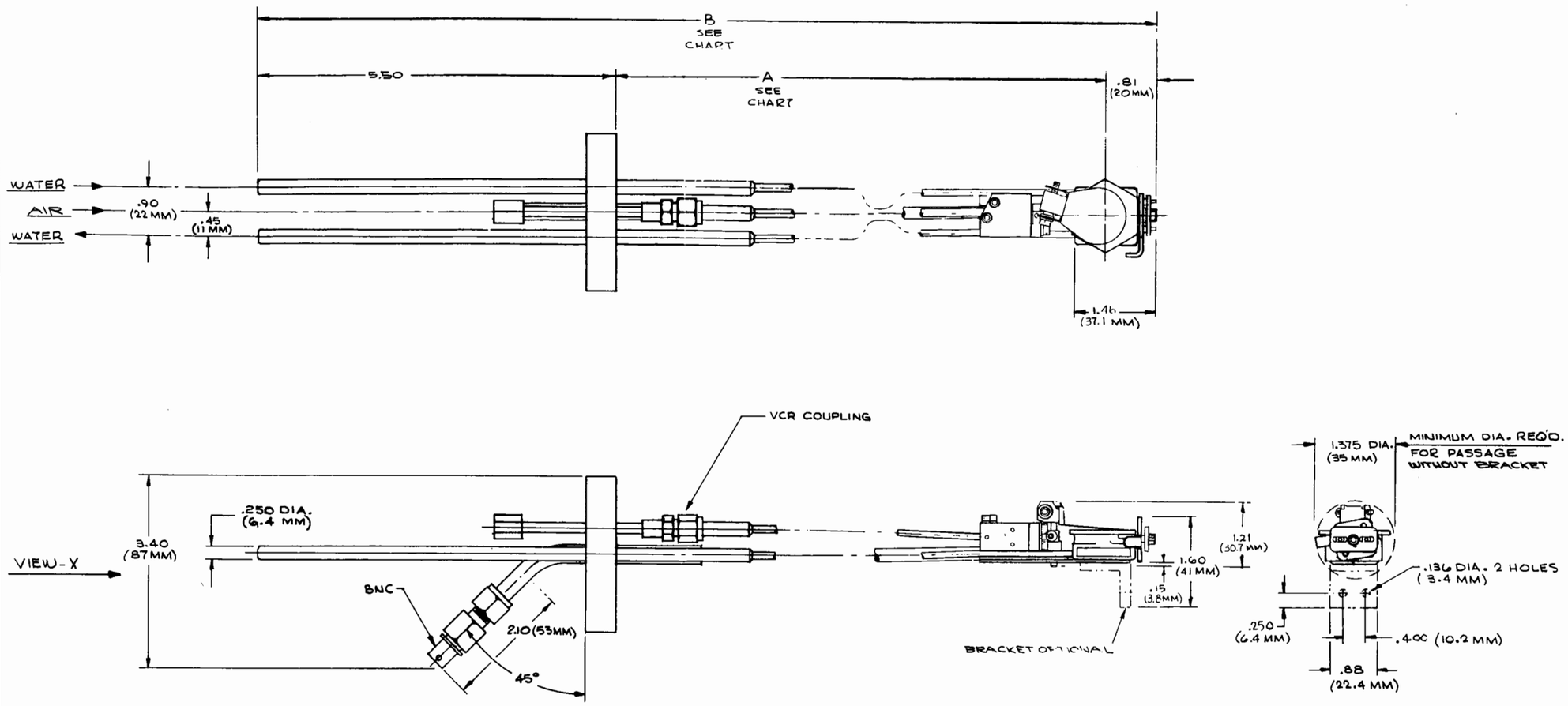
G2 ASSY, SUPPORT, PISTON POS 2, SINGLE, COMPACT AND SPUTTERING SHUTTER ASSYS.

G3 ASSY, SUPPORT, PISTON POS 3 BAKEABLE SHUTTER ASSY

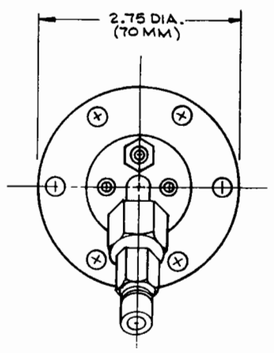
INFICON LEYBOLD-HERAEUS		EAST SYRACUSE NEW YORK
SCALE: 4X	APPROVED BY [signature] 8-20-86	DRAWN BY MT
DATE: 8-19-86		ISSUED 8-26-86
ASSY, SUPPORT, PISTON		
FIRST CALLED FOR ON SEE SEP. PL D206-800		DRAWING NUMBER C750-121

Fig. 8-18 Assembly, Support, Piston

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PART	A	B	REMARKS
1	12.00 (305MM)	18.31 (465MM)	STD.
2	20.00 (508 MM)	26.31 (668MM)	STD.
3	30.00 (762 MM)	36.31 (922 MM)	STD.
XX	SEE NOTE-1	XX + 6.31 (160MM)	SPECIALS



VIEW AT X

NOTE:

1. FOR SPECIAL LENGTHS:
   XX = DIM. IN INCHES FROM FACE OF FEEDTHRU TO CENTER OF SENSOR. XX MIN. 6.687". (170 MM), XX MAX 40.00" (1016 MM)
2. SHIPPED IN STRAIGHT CONDITION- ALLOW FOR A MINIMUM BEND RADIUS OF ABOUT 2" (50 MM) WHEN DETERMINING ORDER LENGTHS.
3. WHEN BENDING TUBING INSURE THE CLAMPS ARE IN POSITION AND TIGHT.
4. METRIC DIMS. ARE FOR REFERENCE ONLY.
5. REQUIRES WATER 150-200 CC/MIN. @ 30°C MAX. FOR OPERATION
6. REQUIRES AIR AT 70-80 PSI
7. MAX BAKEOUT TEMPERATURE 400 °C WITH WATER DRAINED

INFICON LEYBOLD-HERAEUS		EAST SYRACUSE NEW YORK
SCALE: FULL	APPROVED BY: Carl Vogel 3-1-84	DRAWN BY: G.U.
DATE: 10-13-83		ISSUED QTY: 3-7-84
OUTLINE: BAKEABLE CRYSTAL SENSOR WITH FEEDTHRU & SHUTTER		
FIRST CALLED FOR ON		DRAWING NUMBER: D750-033

Figure 8-19

Fig. 8-19 Bakeable Crystal Sensor with Feed Thru & Shutter

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