

**KEITHLEY**

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# **Model 7071 General Purpose Matrix Card Instruction Manual**

**Contains Operating and Servicing Information**

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# WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment.

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## STATEMENT OF CALIBRATION

This instrument has been inspected and tested in accordance with specifications published by Keithley Instruments, Inc.

The accuracy and calibration of this instrument are traceable to the National Bureau of Standards through equipment which is calibrated at planned intervals by comparison to certified standards maintained in the Laboratories of Keithley Instruments, Inc.



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**Instruction Manual  
Model 7071  
General Purpose Matrix Card**

# Safety Precautions

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The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

**Responsible body** is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

**Operators** use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

**Maintenance personnel** perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

**Service personnel** are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. **NEVER** connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. **ALWAYS** remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.


The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.


When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a  screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The  symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The  symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

# SAFETY PRECAUTIONS

The following safety precautions should be observed before using the Model 7071 and the associated instruments.

This matrix card is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over this manual carefully before using the matrix card.

ALWAYS remove power from the entire system (Model 707, test instruments, DUT, etc.) and discharge any capacitors before doing any of the following:

1. Installing or removing the matrix card from the mainframe.
2. Connecting or disconnecting cables from the matrix card. The pins of the Model 7078-MTC cable connectors are easily accessible making them extremely hazardous to handle while power is applied.
3. Making internal changes to the card (such as removing or installing jumpers and quick-disconnect terminal blocks).

Exercise extreme caution when a shock hazard is present at the test fixture. User-supplied lethal voltages may be present on the fixture or the connector jacks. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS or 42.4V peak are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Do not exceed 200V between any two pins or between any pin and earth ground.

Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the test fixture, test cables or any instruments while power is applied to the circuit under test.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground.

Do not exceed the maximum signal levels of the test fixture, as defined in the specifications and operation section of this manual.

Do not connect the matrix card directly to unlimited power circuits. This product is intended to be used with impedance limited sources. NEVER connect the matrix card directly to ac mains.

When connecting sources, install protective devices to limit fault current and voltage to the card.

The chassis connections on the PC board (located behind the front panel of the matrix card) must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

# SPECIFICATIONS

**MATRIX CONFIGURATION:**

8 rows by 12 columns.

**CROSSPOINT CONFIGURATION:**

3-pole Form A.

**CONNECTOR TYPE:** Quick disconnect using 38 pin connectors or screw terminals (HI, LO, Guard).

**MAXIMUM SIGNAL LEVEL:** 200V, 1A carry/0.5A switched, 10VA peak (resistive load).

**COMMON MODE VOLTAGE:** 200V maximum between any 2 pins or chassis.

**CONTACT LIFE:**

**Cold Switching:**  $10^8$  closures.

**At Maximum Signal Level:**  $10^8$  closures.

**PATH RESISTANCE (per conductor):**  $<0.5\Omega$  initial,  $<1.5\Omega$  at end of contact life.

**CONTACT POTENTIAL:**  $<5\mu\text{V}$  per crosspoint (HI to LO).

**OFFSET CURRENT:**  $<100\text{pA}$ .

**ISOLATION:**

**Path (1MHz,  $1\text{M}\Omega$  load):**  $>10^6\Omega$ ,  $<10\text{pF}$ ,  $>40\text{dB}$ .

**Differential:**  $10^6\Omega$ , 45pF nominal.

**Common Mode:**  $10^6\Omega$ , 165pF nominal.

**INSERTION LOSS (1MHz,  $50\Omega$  source,  $1\text{M}\Omega$  load):** 0.1dB typical.

**3dB BANDWIDTH (1M $\Omega$  load):** 5MHz typical.

**RELAY DRIVE CURRENT (per crosspoint):** 15mA.

**RELAY SETTling TIME:**  $<3\text{ms}$ .

**ENVIRONMENT:**

**Operating:**  $0^\circ$  to  $50^\circ\text{C}$ , up to  $35^\circ\text{C}$  at 70% R.H.

**Storage:**  $-25$  to  $+65^\circ\text{C}$ .

**ACCESSORY SUPPLIED:** Instruction manual

**ACCESSORIES AVAILABLE:**

Model 7078-CIT: Contact Insertion and Extraction Tools

Model 7078-HCT: Hand Crimping Tool

Model 7078-KIT: Connector Kit.

Model 7078-MTC: Mass Terminated Cable Assembly, 6m (20 ft.)

Specifications subject to change without notice.

Contains information on Model 7071 features, specifications, and accessories.

## **SECTION 1**

### **General Information**

Details installation of the Model 7071 General Purpose Matrix Card within the Model 707 Switching Matrix, covers card connections, and also discusses basic matrix configurations and matrix expansion.

## **SECTION 2**

### **Operation**

Gives two typical applications for the Model 7071, including thick film resistor network testing and transistor testing.

## **SECTION 3**

### **Applications**

Contains performance verification procedures, troubleshooting information and principles of operation for the matrix card.

## **SECTION 4**

### **Service Information**

Lists replacement parts, and also includes component layout and schematic drawings for the Model 7071.

## **SECTION 5**

### **Replaceable Parts**



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# SECTION 1

## General Information

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### 1.1 INTRODUCTION

This section contains general information about the Model 7071 General Purpose Matrix Card and is arranged in the following manner:

- 1.2 Features
- 1.3 Warranty Information
- 1.4 Manual Addenda
- 1.5 Safety Symbols and Terms
- 1.6 Specifications
- 1.7 Unpacking and Inspection
- 1.8 Repacking for Shipment
- 1.9 Optional Accessories

### 1.2 FEATURES

The Model 7071 is a general purpose, three-pole 8 × 12 (8 row by 12 column) matrix card. Some of the key features include:

- Guard capability. Each HI/LO path pair on the PC board is surrounded by a third path that can be used for guarding.
- Low contact potential and offset current for minimal effects on low-level signals.
- Quick disconnects using the "rack and panel" receptacles on the rear panel or terminal blocks on the PC board.

### 1.3 WARRANTY INFORMATION

Warranty information is located on the inside front cover of this instruction manual. Should your Model 7071 require warranty service, contact the Keithley representative or authorized repair facility in your area for further information. When returning the matrix card for repair, be sure to fill out and include the service form at the back of this manual in order to provide the repair facility with the necessary information.


### 1.4 MANUAL ADDENDA


Any improvements or changes concerning the matrix card or manual will be explained in an addendum included

with the unit. Be sure to note these changes and incorporate them into the manual.

### 1.5 SAFETY SYMBOLS AND TERMS

The following symbols and terms may be found on an instrument or used in this manual.

The symbol  on an instrument indicates that the user should refer to the operating instructions located in the instruction manual.

The symbol  on an instrument shows that high voltage may be present on the terminal(s). Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading used in this manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading used in this manual explains hazards that could damage the matrix card. Such damage may invalidate the warranty.

### 1.6 SPECIFICATIONS

Model 7071 specifications may be found at the front of this manual. These specifications are exclusive of the matrix mainframe specifications.

### 1.7 UNPACKING AND INSPECTION

#### 1.7.1 Inspection for Damage

The Model 7071 is packaged in a resealable, anti-static bag to protect it from damage due to static discharge and from contamination that could degrade its performance. Before removing the card from the bag, observe the following precautions on handling.

## GENERAL INFORMATION

---

### Handling Precautions:

1. Always grasp the card by the handle and side edges. Do not touch the edge connectors and do not touch board surfaces or components.
2. When not installed in a Model 707 mainframe, keep the card in the anti-static bag and store in the original packing carton.

After removing the card from its anti-static bag, inspect it for any obvious signs of physical damage. Report any such damage to the shipping agent immediately.

If you are going to install the card in the Model 707 mainframe at this time, be sure to follow the additional handling precautions explained in paragraph 2.2

### 1.7.2 Shipping Contents

The following items are included with every Model 7071 order:

- Model 7071 General Purpose Matrix Card.
- Model 7071 Instruction Manual.
- Additional Accessories as ordered. Note that the Model 7078-MTC may be shipped in a separate packing carton.

### 1.7.3 Instruction Manual

The Model 7071 Instruction Manual is three-hole drilled so that it can be added to the three-ring binder of the Model 707 Switching Matrix Instruction Manual. After removing the plastic wrapping, place the manual in the binder after the mainframe instruction manual. Note that a manual identification tab is included and should precede the matrix card instruction manual.

If an additional instruction manual is required, order the manual package, Keithley part number 7071-901-00. The manual package includes an instruction manual and any pertinent addenda.

## 1.8 REPACKING FOR SHIPMENT

Should it become necessary to return the Model 7071 for repair, carefully pack the unit in its original packing carton or the equivalent, and include the following information:

- Advise as to the warranty status of the matrix card.
- Write ATTENTION REPAIR DEPARTMENT on the shipping label.
- Fill out and include the service form located at the back of this manual.

## 1.9 OPTIONAL ACCESSORIES

The following accessories are available for use with the Model 7071.

### Model 7078-CIT Contact Insertion and Extraction Tools

The Model 7078-CIT contains an insertion tool that is used to insert wire crimp tail contacts into "rack and panel" plugs and receptacles. Conversely, the extraction tool is used for the removal of the contacts.

### Model 7078-HCT Hand Crimping Tool

The Model 7078-HCT is used to attach wire crimp tail contacts to #18 to #26 AWG stranded wire.

### Model 7078-KIT Connector Kit (Plug)

The Model 7078-KIT contains the parts to assemble one "rack and panel" plug. This plug will mate to either the ROWS or COLUMNS receptacle on the rear panel of the card. Parts contained in the kit include the plug, plug housing and 40 wire crimp tail contacts.

### Model 7078-MTR Connector Kit (Receptacle)

The Model 7078-MTR contains the parts to assemble and mount one "rack and panel" receptacle. Parts contained in the kit include the receptacle, 40 wire crimp tail contacts, and mounting hardware.

### Model 7078-MTC-5 Mass Terminated Cable Assembly

The Model 7078-MTC-5 is a 5-foot (1.5 meter), 36-conductor cable terminated with a "rack and panel" plug on both ends. This cable connects to either the ROWS or COLUMNS receptacle on the rear panel of the card. This cable is commonly cut in half to provide two separate cables. The cables can then be used to connect to both the ROWS and COLUMNS receptacles. The unterminated ends of the cables are then connected to instrumentation and DUTs.

**Model 7078-MTC-20 Mass Terminated Cable Assembly**

This cable assembly is the same as the Model 7078-MTC-5 except that it is 20 feet (6 meters) in length.

**CS-570-3 Quick Disconnect Terminal Block**

Three-terminal block accommodating up to 16 AWG wires. Mates to matrix board pin terminals.

# SECTION 2

## Operation

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### 2.1 INTRODUCTION

This section contains information on aspects of matrix card operation and is arranged as follows:

- 2.2 Handling Precautions:** Details precautions that should be observed when handling the matrix card to ensure that its performance is not degraded due to contamination.
- 2.3 Card Installation and Removal:** Covers the basic procedure for installing and removing the card from the Model 707 Matrix.
- 2.4 Basic Matrix Configurations:** Explains some the basic ways that a matrix can be used to source or measure. Covers single-ended switching, differential (floating) switching, sensing, shielding, and guarding.
- 2.5 Connections:** Discusses the various methods and techniques that can be used to connect DUTs and instrumentation to the matrix card.
- 2.6 Matrix Expansion:** Discusses the various matrix configurations that are possible by using multiple cards. The significance of the Model 707 backplane row jumpers on matrix configurations is also covered here.
- 2.7 Typical Connection Schemes:** Provides examples of external connections for single card, multiple card and multiple mainframe systems.

### 2.2 HANDLING PRECAUTIONS

To maintain high impedance isolation, care should be taken when handling the matrix card to avoid contamination from such foreign materials as body oils. Such contamination can substantially lower leakage resistances, degrading performance.

To avoid possible contamination, always grasp the card by the handle and side edges. Do not touch the edge connectors of the card and do not touch board surfaces or components. On "rack and panel" connectors and quick-disconnect terminal blocks, do not touch areas adjacent to the electrical contacts.

### CAUTION

**Do not store the card by leaning it against an object (such as a wall) with its edge connectors in contact with a contaminated surface (such as the floor). The edge connectors will become contaminated, and tapes and solder connections on the PC board may break as the card bends. ALWAYS store the card (in its anti-static bag) in the original shipping carton.**

Dirt build-up over a period of time is another possible source of contamination. To avoid this problem, operate the mainframe and matrix card only in a clean environment.

If the card becomes contaminated, it should be thoroughly cleaned as explained in paragraph 4.2.

### 2.3 CARD INSTALLATION AND REMOVAL

Connections to the matrix card make it awkward to install/remove the card in the mainframe. Thus, it is advisable to install the card and then make connections to it. Conversely, cables and wires should be disconnected before removing the card from the mainframe.

Referring to Figures 2-1 and 2-2, perform the following procedure to install the Model 7071 matrix card in the Model 707:

1. Turn the Model 707 off.
2. Select a slot in the mainframe and remove the cover plate. The cover plate is fastened to the mainframe chassis with two screws. Retain the cover plate and screws for future use.
3. With the relay side of the matrix card facing towards the fan, feed the card into the slot such that the top and bottom card edges seat into the the card edge guides of the mainframe. Slide the matrix card approximately  $\frac{2}{3}$  of the way into the mainframe.
4. If using quick-disconnect terminal blocks to make connections, perform the following steps. Otherwise, proceed to step 5.



**WARNING**

To avoid electrical shock which could result in injury or death, make sure all power is off and stored energy in external circuitry is discharged before making any connections to the matrix card.

- A. There are two cable clamps on the rear panel of the matrix card that serve as strain reliefs for terminal block wires. Loosen the two screws of each cable clamp and remove the top half of each clamp.
  - B. Install the pre-wired terminal blocks (see paragraph 2.5.2) on the matrix card. Make sure the pins on the card are properly mated to the terminal blocks.
  - C. Route the wires through the rear panel cable clamps. Make sure there is some slack in the wires between the terminal blocks and the clamps before tightening the clamps.
5. Slide the matrix card all the way into the mainframe and tighten the two spring loaded panel fasteners.

**WARNING**

The mounting screws must be secured to ensure a proper chassis ground connection between the card and the mainframe. Failure to properly secure this ground connection may result in personal injury or death due to electric shock.

**NOTE**

If using the terminal blocks, leave enough slack in the external cabling so that the card can slide out far enough to gain access to the connections.

- 6. To remove the card from the mainframe make sure the Model 707 is off, power is removed from external circuitry, and then reverse the above procedure.

**2.4 BASIC MATRIX CONFIGURATIONS**

A simplified schematic of the Model 7071 8 × 12 matrix card is shown in Figure 2-3. Each of the 96 crosspoints is made up of a three-pole switch. In this simple configuration, any row can be connected to any column by closing the appropriate crosspoint switch. The columns of every Model 7071 matrix card are numbered 1 through 12. However, the actual column numbers of the matrix are determined by which mainframe slot the card is installed in. For example, the columns of a matrix card installed in slot 4 of the mainframe are numbered 37 through 48. Column number assignments for all six mainframe slots are listed in Table 2-1.

**Table 2-1. Column Number Assignments**

7071 Card Location	Matrix Column Numbers
Slot 1	1 through 12
Slot 2	13 through 24
Slot 3	25 through 36
Slot 4	37 through 48
Slot 5	49 through 60
Slot 6	61 through 72

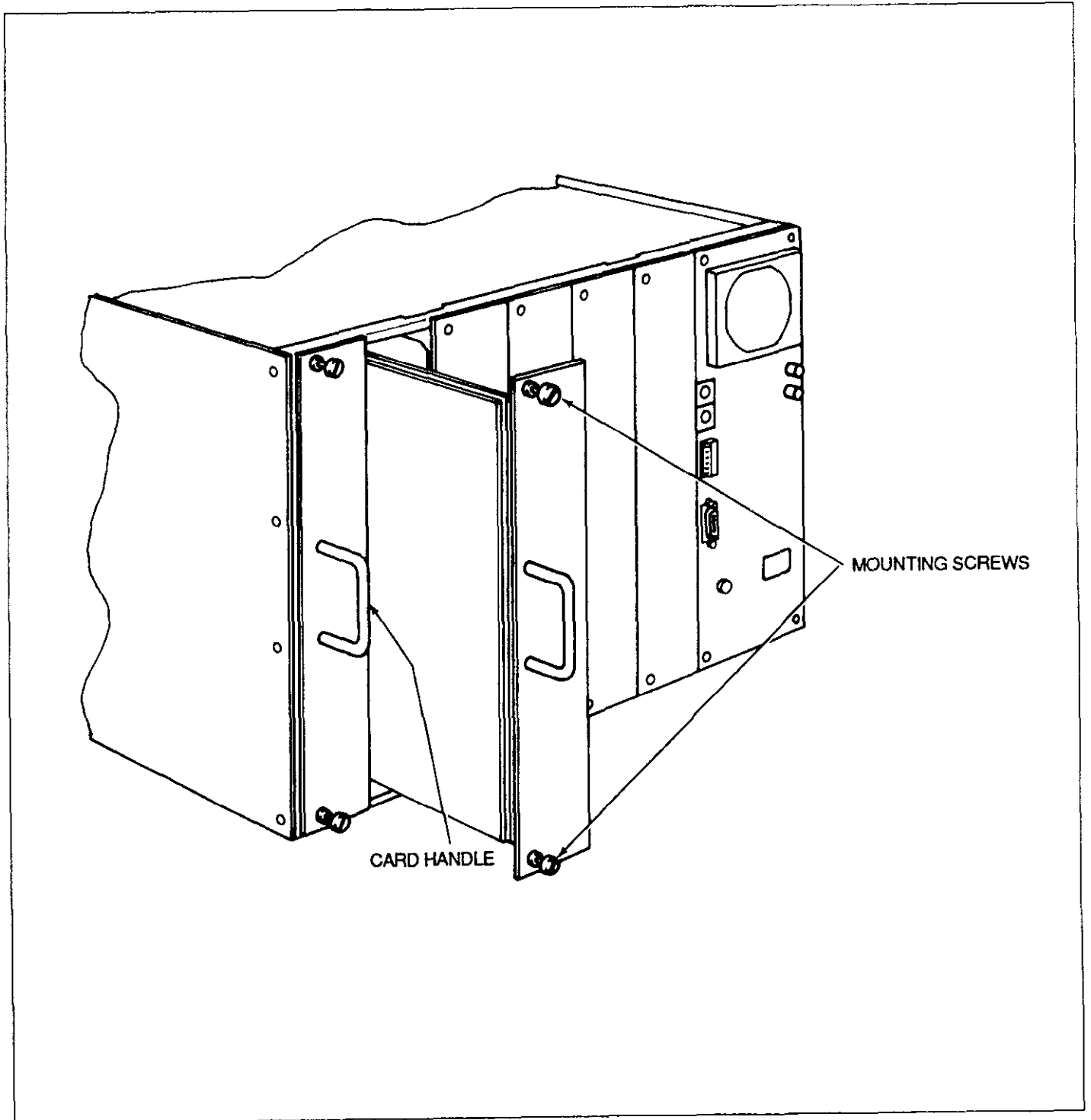


Figure 2-1. Matrix Card Installation

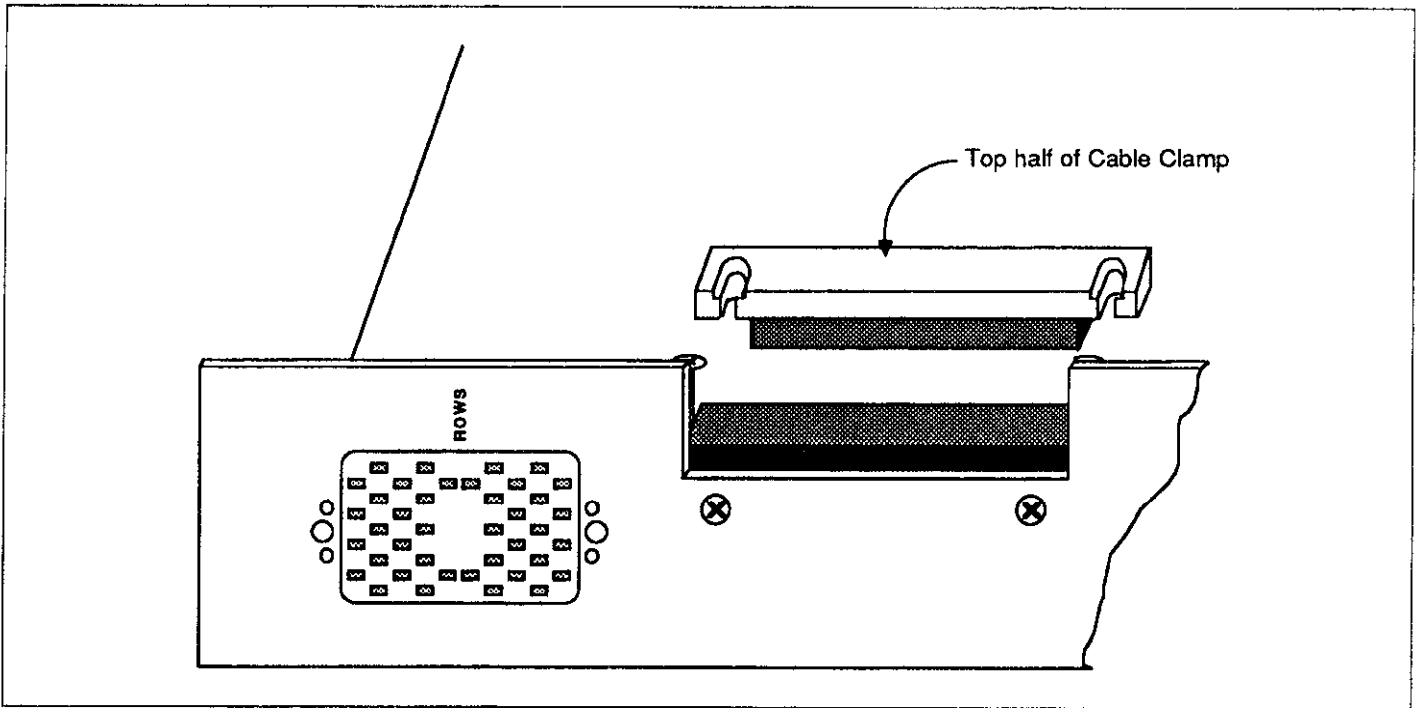


Figure 2-2. Cable Clamp Assembly

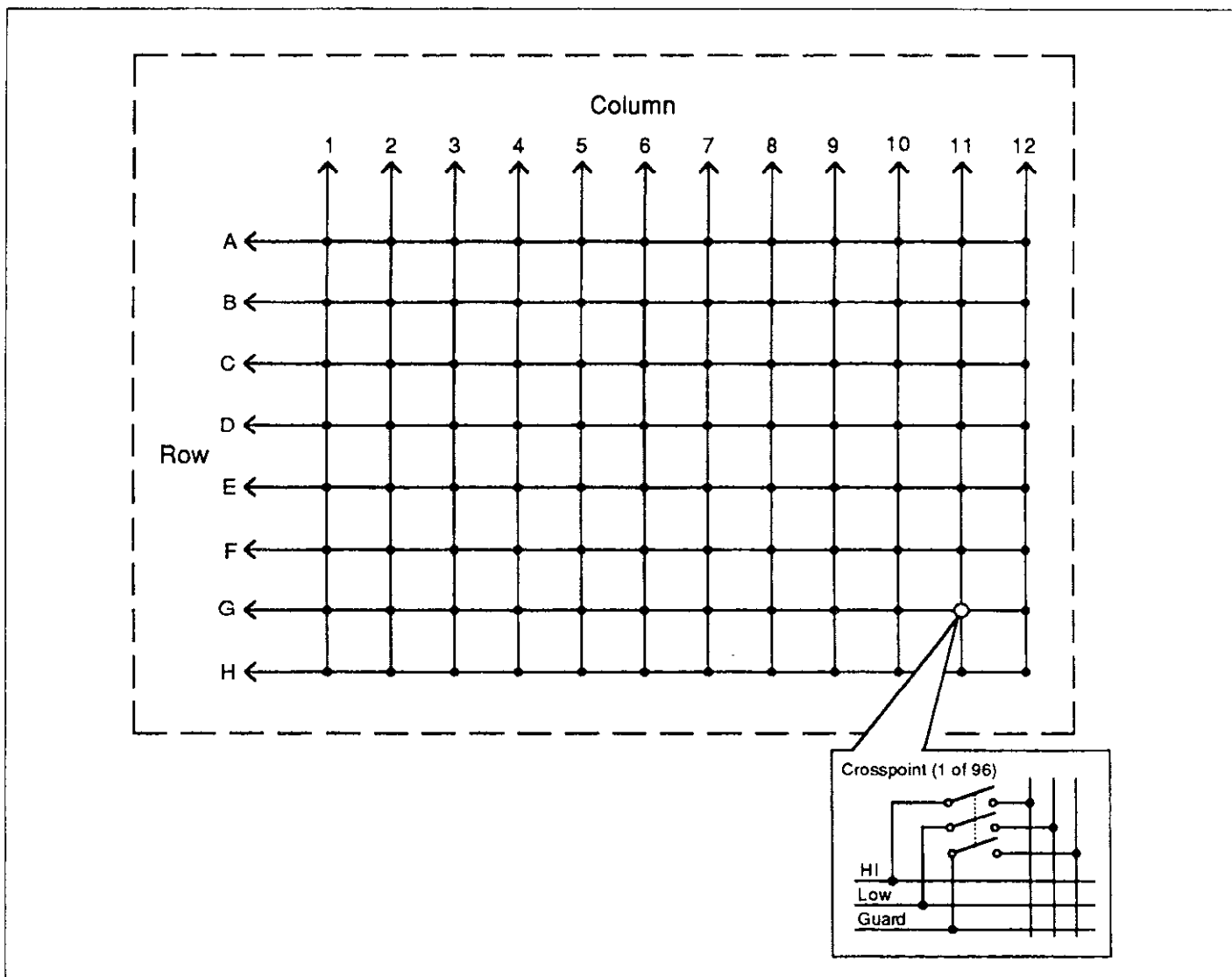


Figure 2-3. Simplified Schematic of Model 7071

### 2.4.1 Single-Ended Switching

In the single-ended switching configuration, the source or measure instrument is connected to the DUT through a single pathway as shown in Figure 2-4. Note that in the illustration that the matrix card guard (G) is used as a shield. The matrix card guard is used as the shield because its PC board trace physically surrounds the high (H) and low (L) traces.

same potential as signal high, protection from possible hazardous voltages (up to 200V) must be provided. Many instruments have the capability of configuring their input or output such that a driven guard is placed on the inner shield of a triax connector. The outer shield, connected to system common, provides protection from the guard voltage. When making connections from the matrix card to the DUT, make sure that a safety shield is used as shown in the illustration.

### 2.4.2 Differential Switching

The differential or floating switching configuration is shown in Figure 2-5. The advantage of using this configuration is that the terminals of the source or measure instrument are not confined to the same matrix crosspoint. Each terminal of the instrument can be connected to any of the 96 matrix crosspoints. Again, the guard terminals of the matrix card are used as a shield.

### 2.4.4 Sensing

Figure 2-7 shows how the matrix card can be configured to use instruments that have sensing capability. The main advantage of using sensing is to cancel the effects of matrix card path resistance ( $<1.5\Omega$ ) and the resistance of external cabling. Whenever path resistance is a consideration, sensing should be used. In the illustration, matrix card guard is again used as a shield. In a system where a driven guard is required, matrix card guard (G) can be disconnected from circuit LO and connected to the guard potential. However, make sure that the guard is adequately insulated to prevent possible electrical shock, or use quadrx cables using the outer shield as a grounded safety shield.

### 2.4.3 Guarding

Figure 2-6 shows how the matrix card can be used with a driven guard. Since the driven guard is at virtually the

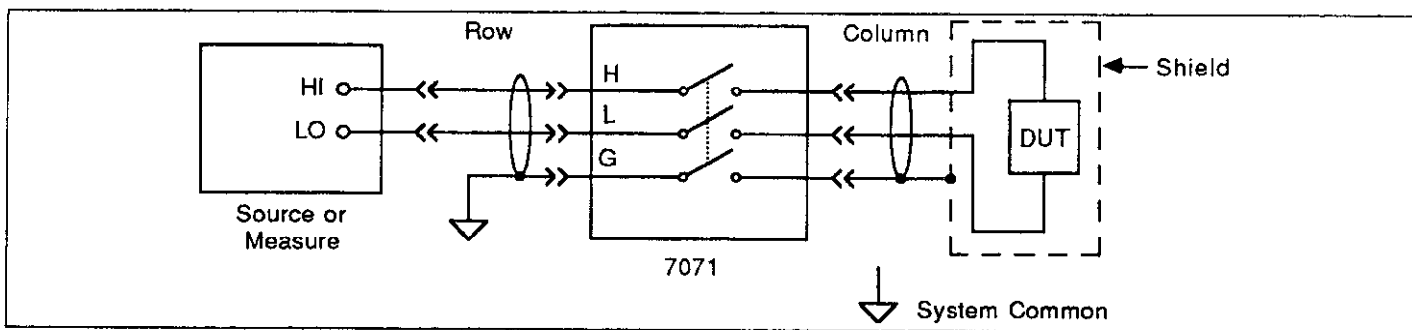


Figure 2-4. Single-Ended Switching Example (Guard Used as Shield)

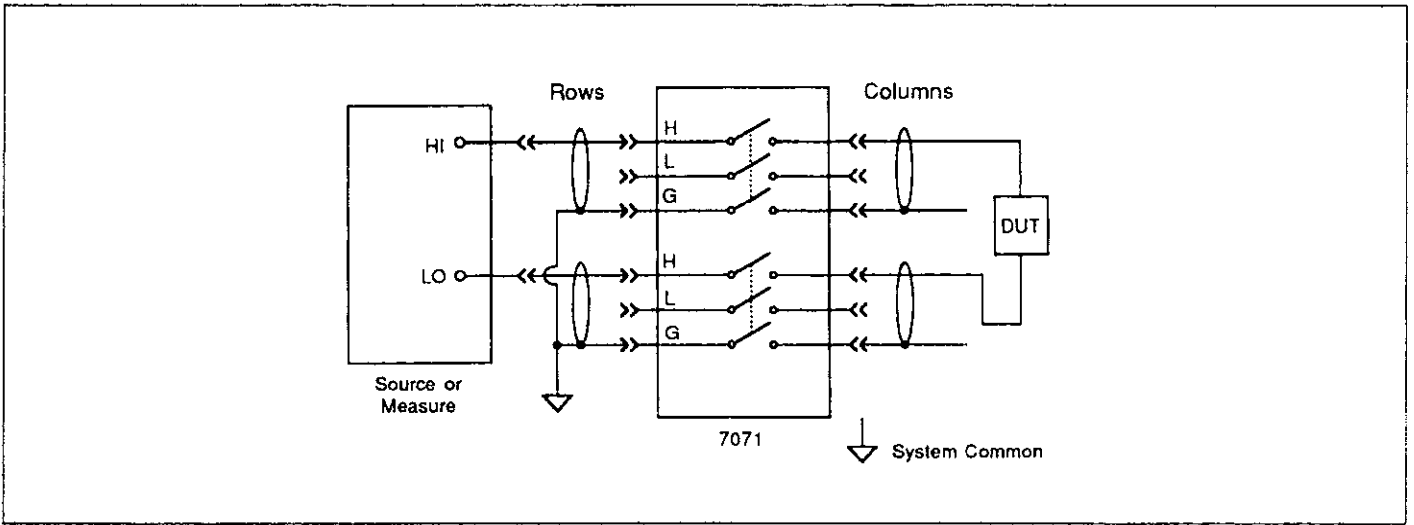


Figure 2-5. Differential Switching Example (Shielded)

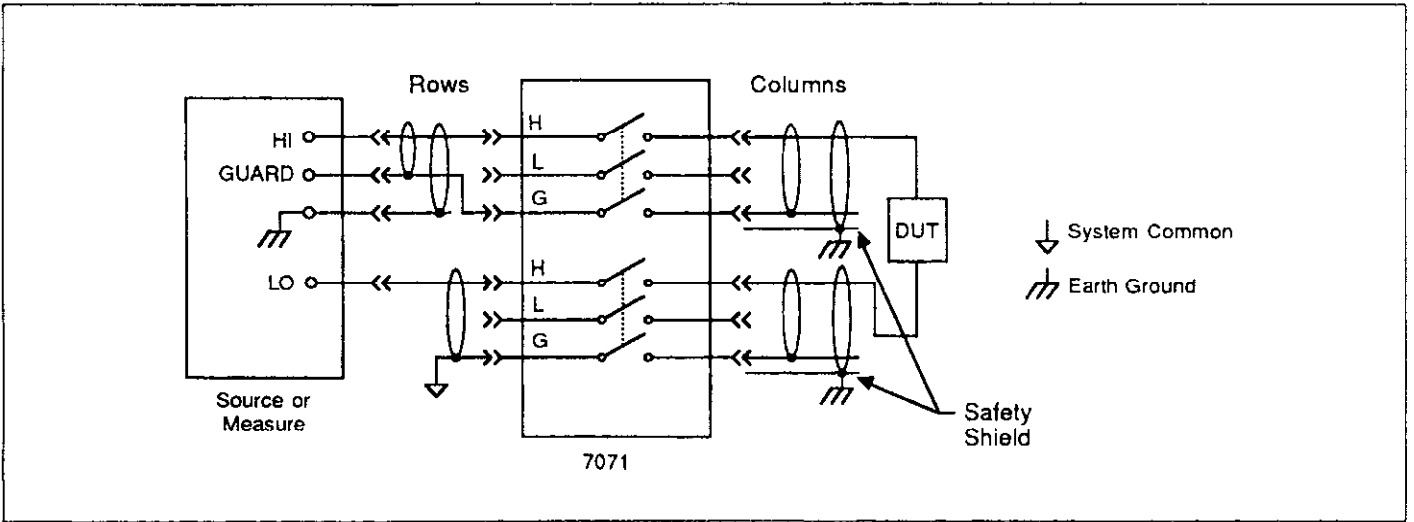


Figure 2-6. Driven Guard Example (Shielded)

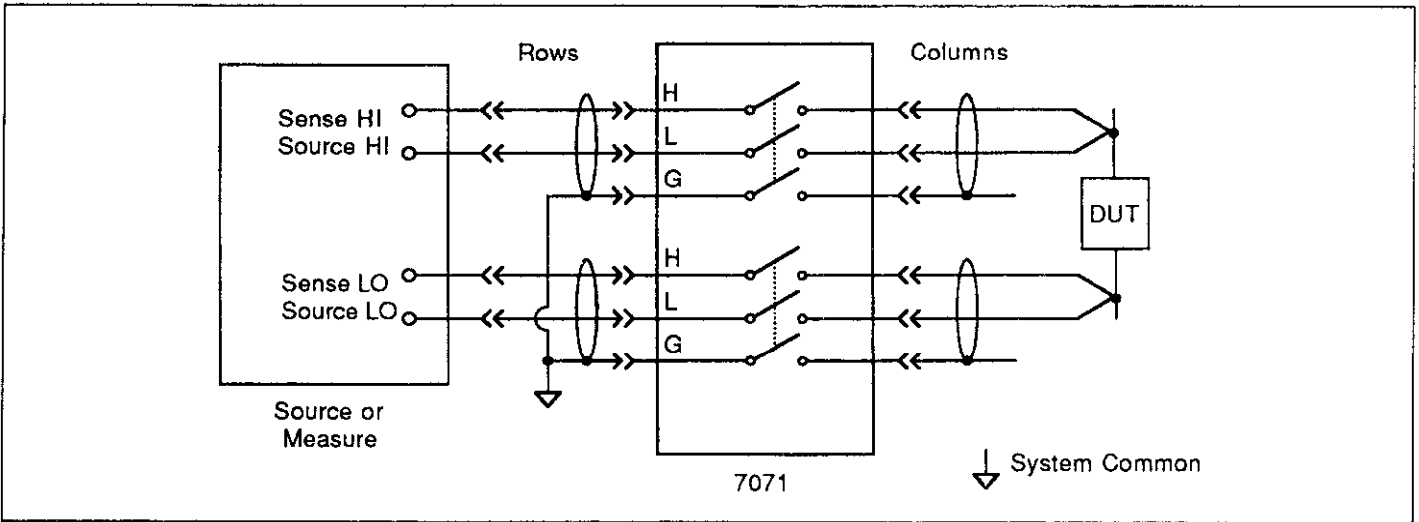


Figure 2-7. Sensing Example (Shielded)

## 2.5 CONNECTION METHODS

As shipped, all rows and columns of the 8 × 12 matrix are connected to the two “rack and panel” receptacles mounted on the rear panel of the matrix card. These receptacles will mate with either the optional mass terminated cable (Model 7078-MTC) or the plug provided in the optional connector kit (Model 7078-KIT). If the receptacles are not going to be used, they should be disconnected from the matrix. Connections are then made directly to quick-disconnect terminal blocks.

The following paragraphs explain the three connection methods. Keep in mind that based on convenience and performance considerations, it may best to use a combination of connection methods. For example, it may be most convenient to connect instrumentation to the matrix using quick-disconnect terminal blocks, while connecting DUT to the matrix using a mass terminated cable.

Some advantages of each of the connection methods are as follows:

**Mass Terminated Cable Method (Model 7078-MTC)**—Probably the most convenient method to make connections to the matrix card. By cutting the cable in half (or wherever appropriate), two separate cables, unterminated at one end, will result. These cables can then be hard wired to DUTs or to a user’s test fixture. The plug on each cable will then connect to the ROWS or COLUMNS receptacle on the card. Using the whole cable (both plugs intact)

makes it most convenient to connect the matrix card to a test fixture that uses a “rack and panel” receptacle.

**Direct Connection Method**—This method makes connections at the quick-disconnect terminal blocks bypassing the “rack and panel” receptacles. This method should be used when optimum guarding and/or shielding (i.e. high frequency noise) are required. If using the Model 7078-MTC cable, the concentric guard or shield conductor will be terminated at the receptacle. The direct connection method allows concentric guard and shield conductors to be extended to the terminal blocks. Another advantage of this method is that it is convenient to connect unterminated cables from instrumentation to the terminal blocks.

**Connector Kit (Model 7078-KIT)**—This kit contains a plug that mates to the “rack and panel” receptacles. This plug is used to custom build a cable assembly that meets the user’s requirements. This allows the user to select the cable and wire only the rows and columns needed for a particular application. This can result in a cable assembly that is much smaller in diameter than the Model 7078-MTC.

Each conductor of the 20-foot Model 7078-MTC-20 cable has 480mΩ of resistance. Each conductor of the 5-foot Model 7078-MTC-5 cable has 120mΩ of resistance. In an application where path resistance is critical, this path resistance may be too high. Thus, another advantage of the connector kit is to build shorter, low resistance cables. An alternative to building a cable from scratch is to cut the Model 7078-MTC cable at a length that is suitable and then attach the plug to it.

**WARNING**

To avoid electrical shock which could result in injury or death, make sure all power is off and stored energy in external circuitry is discharged before making any connections to the matrix card.

**CAUTION**

Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the handle and side edges. Do not touch the edge connectors of the card, and do not touch the board surfaces or components. On "rack and panel" connectors and quick disconnect terminal blocks, do not touch areas adjacent to the electrical contacts.

### 2.5.1 Connections Using Mass Terminated Cable (Model 7078-MTC)

The Model 7078-MTC is a 36 conductor cable terminated with a "rack and panel" plug on each end. This cable is used to connect the "COLUMNS" or "ROWS" receptacle on the rear panel of the card to external instrumentation and test circuits. Figure 2-8 shows how two cables can be used to connect rows and columns of the matrix card to external "rack and panel" receptacles. The external receptacles can then be hard wired to other connectors or wired directly to instrumentation and DUTs.

Use the following procedure to connect the Model 7078 MTC cable to the matrix card:

1. Install the matrix card in the Model 707 mainframe as explained in paragraph 2.3.
2. Place the plug of the cable on the appropriate "rack and panel" receptacle such that the large diameter keying pin of the plug aligns with the large keyway of the receptacle (see Figure 2-9).
3. Using a slotted screwdriver, turn the locking screw clockwise until the plug is fully mated to the receptacle.

The same basic procedure applies for connecting the cable plug to an external receptacle.

#### Receptacle Wiring

"Rack and panel" receptacles (Model 7078-MTR) along with recommended installation tools are available from Keithley (see Table 2-2). Perform the following steps to wire a "rack and panel" receptacle.

1. Remove 1/8" of insulation from the wires that are to be connected to the receptacle.
2. Using the Model 7078-HCT crimping tool, connect a wire crimp tail to each of the wires.
3. Figure 2-10 provides contact identification for "ROWS" and "COLUMNS" receptacles. Using this illustration as a guide, insert the wire crimp tails into the receptacle. Use the Model 7078 CIT insertion tool to push each wire crimp tail completely into the receptacle.

#### Modified Mass Terminated Cable

Another way to use the Model 7078-MTC cable is to remove one of the plugs. Cutting the cable in half will provide two 10 foot cables. Each cable can then be mated to the "ROWS" or "COLUMNS" receptacle (see Figure 2-11). The wire end of each cable can then be wired to another connector or wired directly to instrumentation or DUTs. The cable contains twelve bundles of wires each of which corresponds to a row or column. Each bundle contains three wires; a bare wire (guard) and two insulated wires that have a unique color combination for identification purposes. Table 2-3 provides the color combinations for each bundle. For example, with the cable connected to the "ROWS" receptacle of the matrix card, Row E can be identified by locating the bundle that has a red insulated wire (H) and a blue insulated wire (L). The bare wire in the bundle is guard (G).

**NOTE**

If another "rack and panel" plug is to be attached to the unterminated end of the cable, refer to the connection procedure in paragraph 2.5.3.

The outer side of the foil shield is insulated while the inner wrapping is conductive (guard). When the cable is cut, it is likely that the conductive side of the bundle wrapping will become exposed. Thus, each bundle, as well as each bare wire, should be insulated as follows:

1. Place a length of Teflon® tubing over each bare wire.
2. Place a length of shrink tubing over the bundle such that the frayed end of the bundle wrapping and part of the Teflon® tubing is covered.
3. Heat the shrink tubing.



**Table 2-2. Model 7071 Available Accessories**

Model or Part	Description
Model 7078-CIT: Insertion and Extraction Tools	Used to install/remove wire crimp tails into/from "rack and panel" plugs and receptacles.
Model 7078-HCT: Hand Crimping Tool	Used to connect wire crimp tails to #18 to #26 gage wire.
Model 7078-KIT: Connection Kit (Plug)	Contains one "rack and panel" plug, housing and 40 wire crimp tails.
Model 7078-MTC-5: Mass Terminated Cable	1.5 meter (5 ft.), 36 conductor cable terminated with "rack and panel" plugs. Mates to "rack and panel" receptacles.
Model 7078-MTC-20: Mass Terminated Cable	Same as the Model 7078-MTC-5 except that it is 6 meters (20 ft.) in length.
Model 7078-MTR: Connector Kit (Receptacle)	Contains one "rack and panel" receptacle, 40 wire crimp tails, and mounting hardware.
CS-570-3: Quick Disconnect Terminal Block	3-terminal block accomodates up to 16 AWG wires. Mates to matrix card board pin terminals.

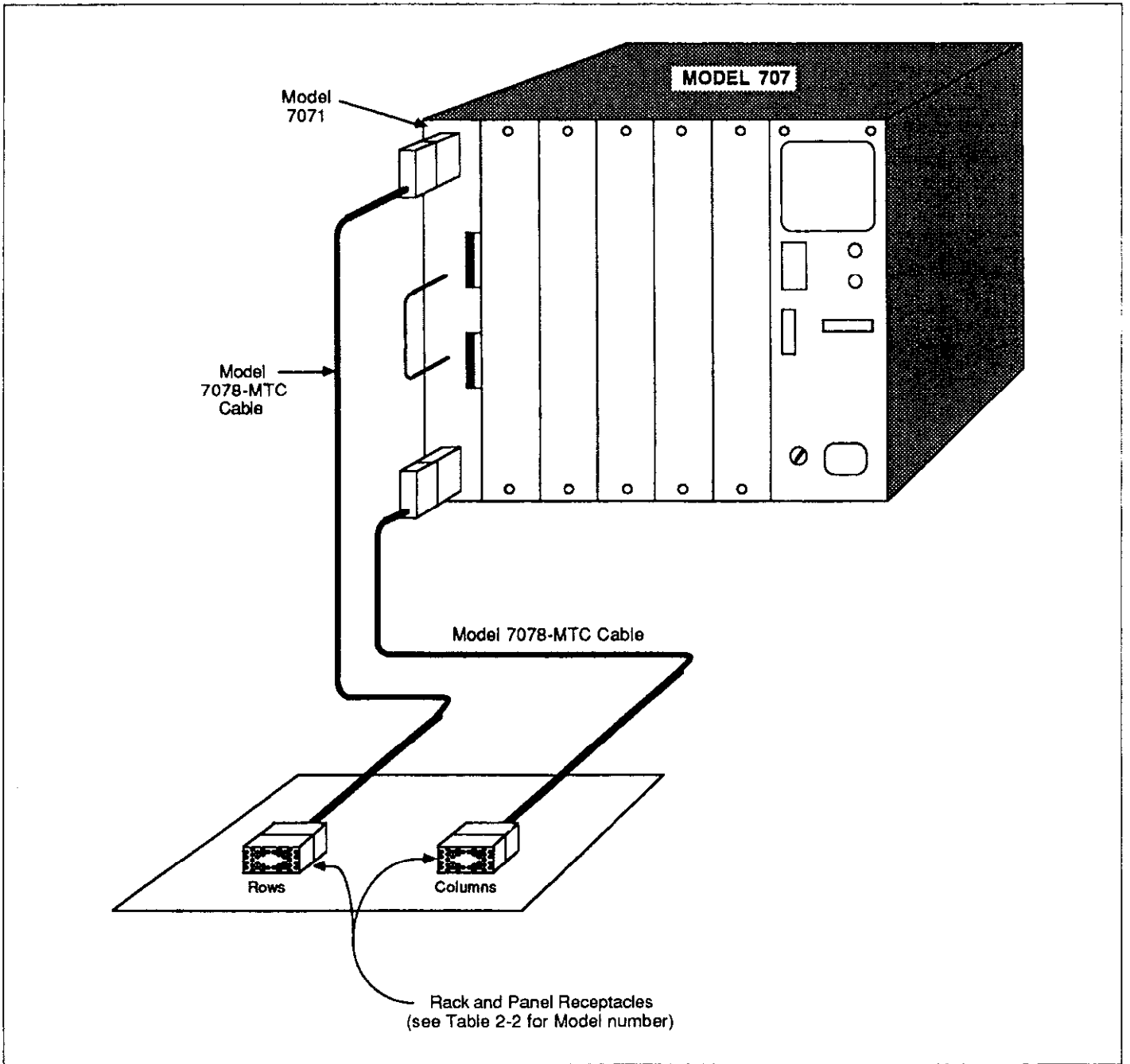
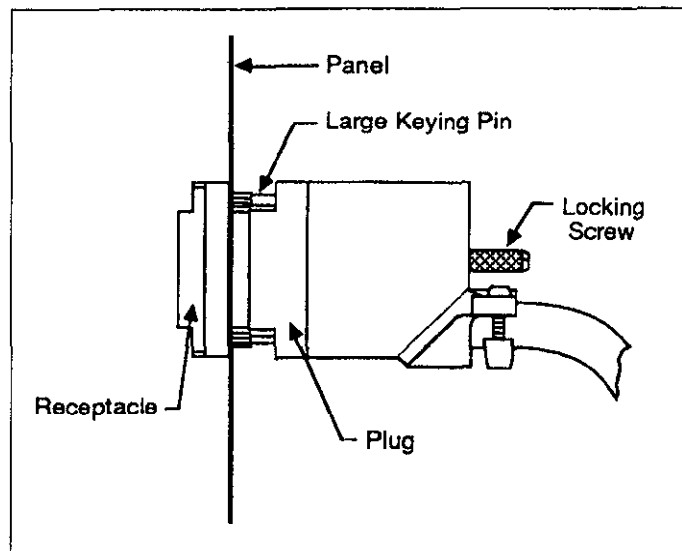


Figure 2-8. Connections Using two Model 7078-MTC Cables

**Table 2-3. Model 7078-MTC Wire Identification**

Wire Set	Terminal*	Insulation Color	Wire Set	Terminal*	Insulation Color
COL 1 or ROW A	H L G	Black Blue Bare Wire	COL 7	H L G	Red White Bare Wire
COL 2 or ROW B	H L G	Red Brown Bare Wire	COL 8 or ROW E	H L G	Black Brown Bare Wire
COL 3 or ROW C	H L G	Black Red Bare Wire	COL 9	H L G	Black White Bare Wire
COL 4	H L G	Black Green Bare Wire	COL 10 or ROW F	H L G	Red Blue Bare Wire
COL 5 or ROW D	H L G	Red Yellow Bare Wire	COL 11 or ROW G	H L G	Black Orange Bare Wire
COL 6	H L G	Black Yellow Bare Wire	COL 12 or ROW H	H L G	Red Green Bare Wire

\*H = High  
L = Low  
G = Guard



**Figure 2-9. Connecting Plug to Receptacle**

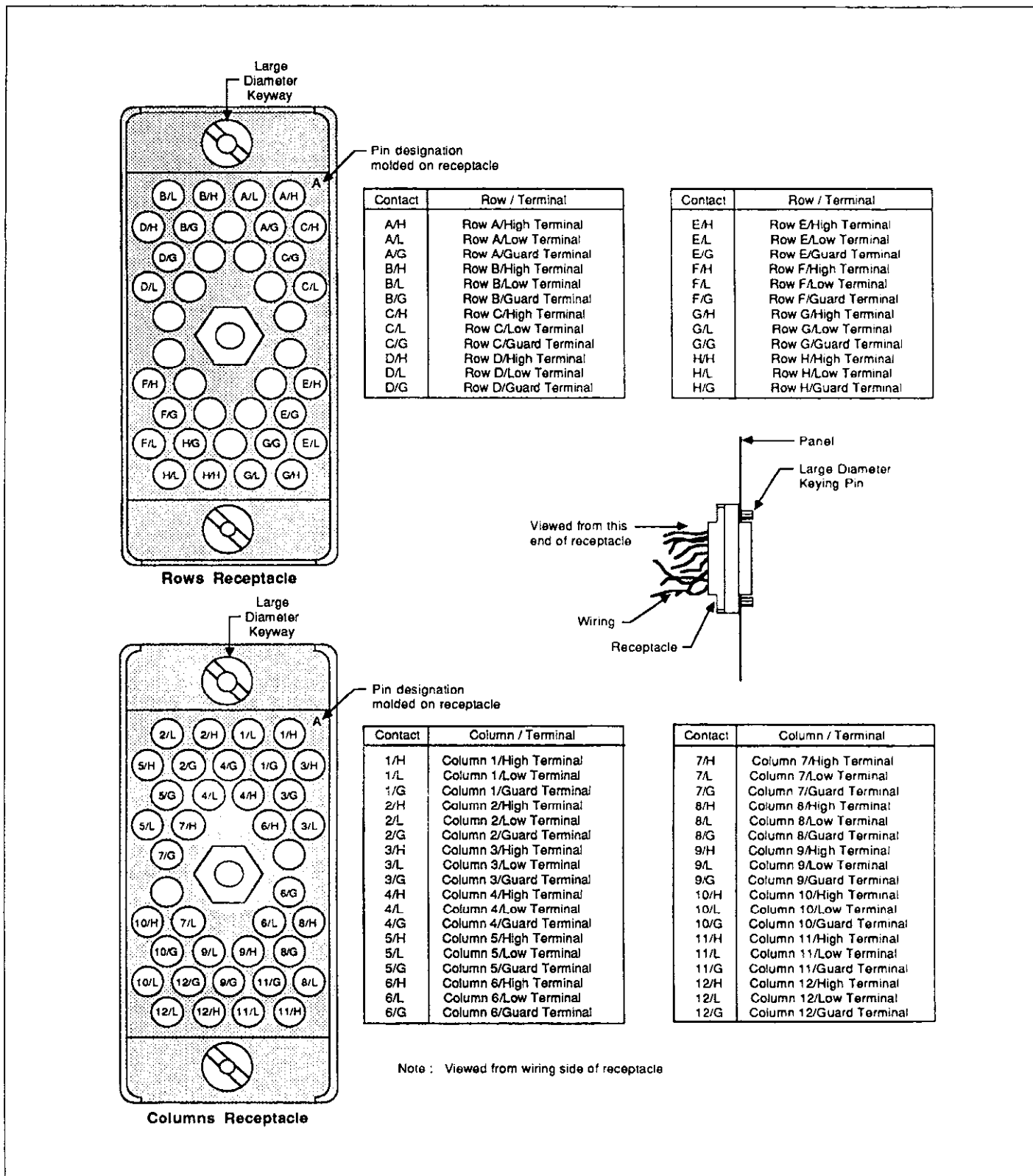
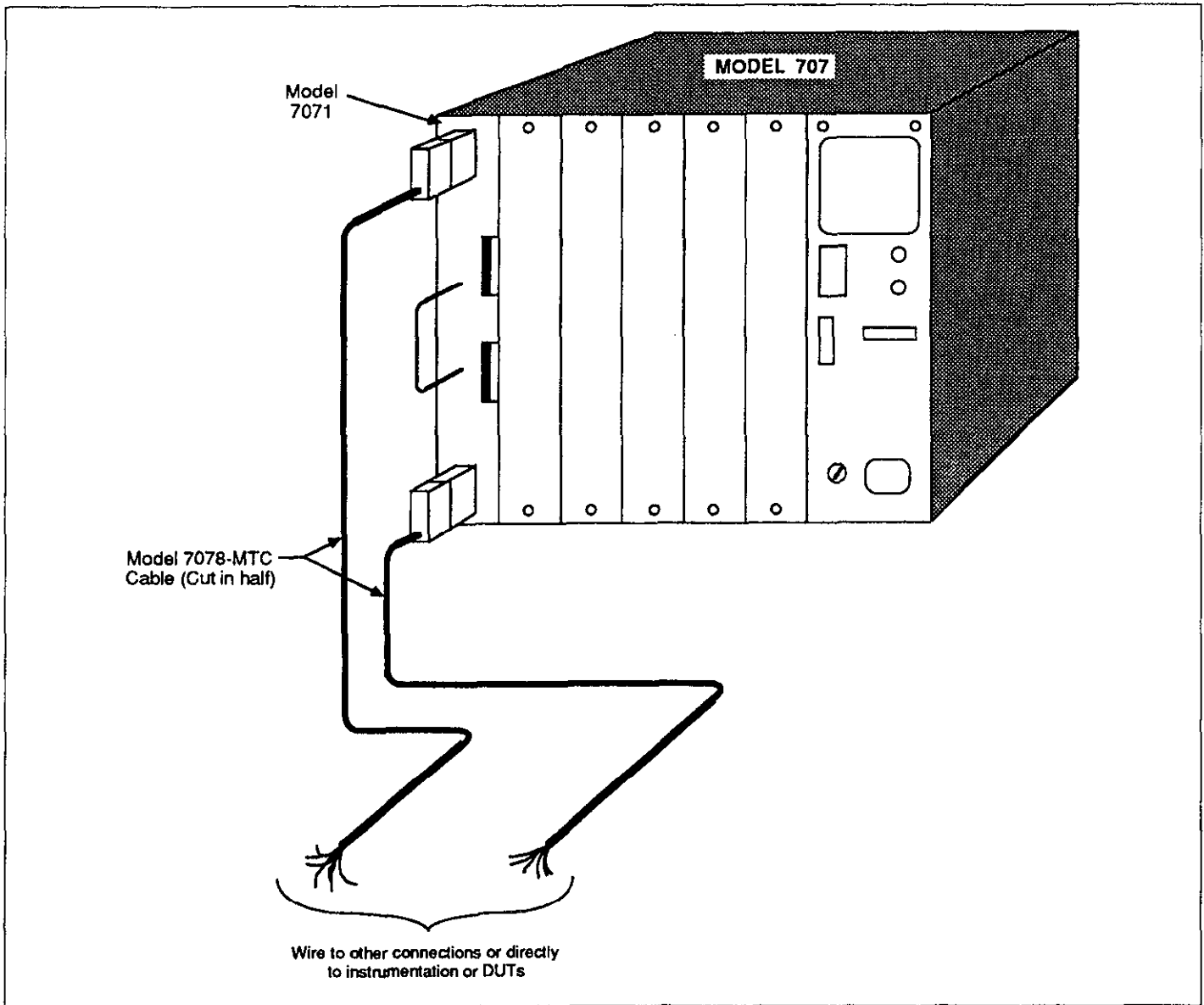


Figure 2-10. Receptacle Contact Assignments



**Figure 2-11. Connections Using One Model 7078-MTC Cable Cut in Half**

## 2.5.2 Direct Connections

With this method, connections are made directly to quick-disconnect terminal blocks. The "rack and panel" receptacles are not used. Additional terminal blocks are available from Keithley (see Table 2-2).

### NOTE

For optimum performance, use a low noise, shielded cable that has excellent insulation qualities such as Teflon® or polystyrene).

Perform the following steps to wire the matrix card:

1. Perform one of the following procedures (A or B):
  - A. If leaving the terminal blocks connected to the receptacles, carefully pull the appropriate blocks off the matrix PC board. Tie wrap or tape the loose assemblies together and position them out of the way.
  - B. If using the supplied terminal blocks, disconnect the receptacle wires from the ones you are going to use and carefully pull them off the PC board. Tie wrap or tape the loose receptacle wires together and position them out of the way.

### NOTE

Receptacle wires are tagged for identification. Red wires are HI terminals, black wires are LO, and white wires are GUARD. Contact identification at the receptacles is provided in Figure 2-10.

2. Using a screwdriver, connect the circuitry to the terminal blocks. Figure 2-12 shows how a triaxial cable may be connected. The screw terminals accept up to #16 AWG wire.
3. The terminal blocks should be connected to the matrix card during installation of the card into the mainframe. The procedure to do this is contained in paragraph 2.3.

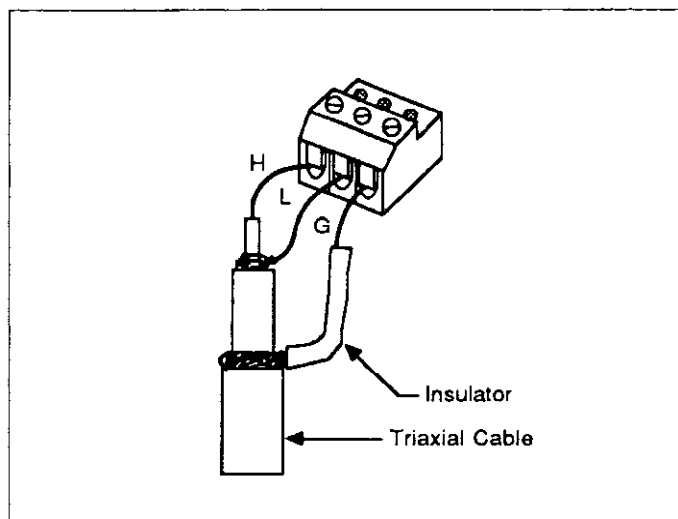


Figure 2-12. Terminal Block Connections

## 2.5.3 Connections Using Connector Kit (Model 7078-KIT)

The Model 7078-KIT contains the parts of one "rack and panel" plug. This kit allows the user to build a cable that will mate to the "rack and panel" receptacles of the matrix card.

### NOTE

The following procedure shows how to properly connect a 36 conductor cable to a "rack and panel" plug. The cable used in the procedure is the same one used in the Model 7078-MTC and is available from Belden (P/N 9734). Modify the procedure accordingly if using a different cable or individual wires and use Figure 2-23 instead of Figure 2-14.

Perform the following steps to connect the 36 conductor Belden cable to the Model 7078-KIT plug:

1. Feed one end of the cable through the plug housing. Slide the housing far enough down the cable to set it out of the way.

## OPERATION

### NOTE

Refer to Figure 2-13 for steps 2 through 5.

2. Using a sharp knife, remove  $1\frac{3}{4}$ " of insulation from the end of the cable. Be careful not to cut into the insulated shield of any of the internal wire bundles.
3. Remove one inch of insulated shielding from each of the 12 bundles of wires.
4. Insulate the bare guard wire of each bundle so that they do not short out to each other. The insulation must be able to withstand a 200V potential.
5. Remove  $\frac{1}{8}$ " of insulation from the 24 insulated wires.
6. Using the Model 7078-HCT crimping tool, connect a wire crimp tail to each of the 36 wires. The wires are 24 gage so be sure to use the slot labeled "22-26" on the tool.

### NOTE

Figure 2-14 shows where the wires of each bundle belong. The wires in each bundle have a unique color combination that is different from the color combination of any other bundle.

7. Insulate the locking screws of the plug with shrink tubing as shown in Figure 2-15.
8. Orient the cable to the plug as shown in Figure 2-15, and using Figure 2-14 as a guide, insert the wire crimp tails into the plug. Use the Model 7078 CIT insertion tool to push each wire crimp tail completely into the plug.
9. Slide the housing over plug and install the four screws that secure the housing to the plug.
10. Tighten the two cable clamp screws on the housing.

The "rack and panel" plug will mate to either receptacle on the matrix card in the same manner as the Model 7078 MIC cable. The other end of the cable can be wired directly to instrumentation or DUTs, or to another connector.

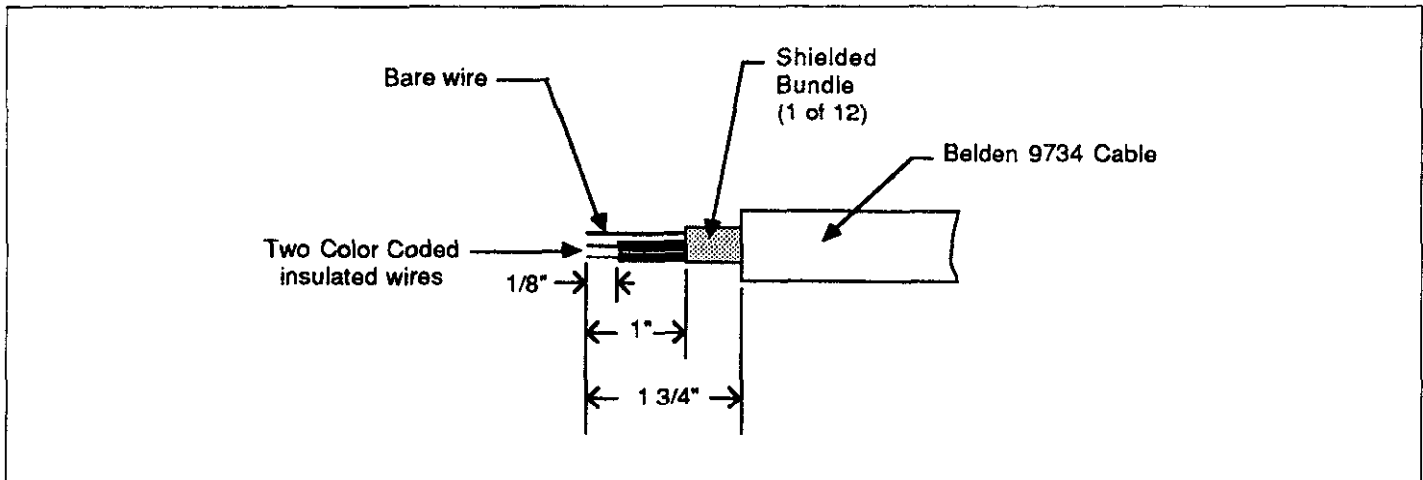


Figure 2-13. Cable Preparation

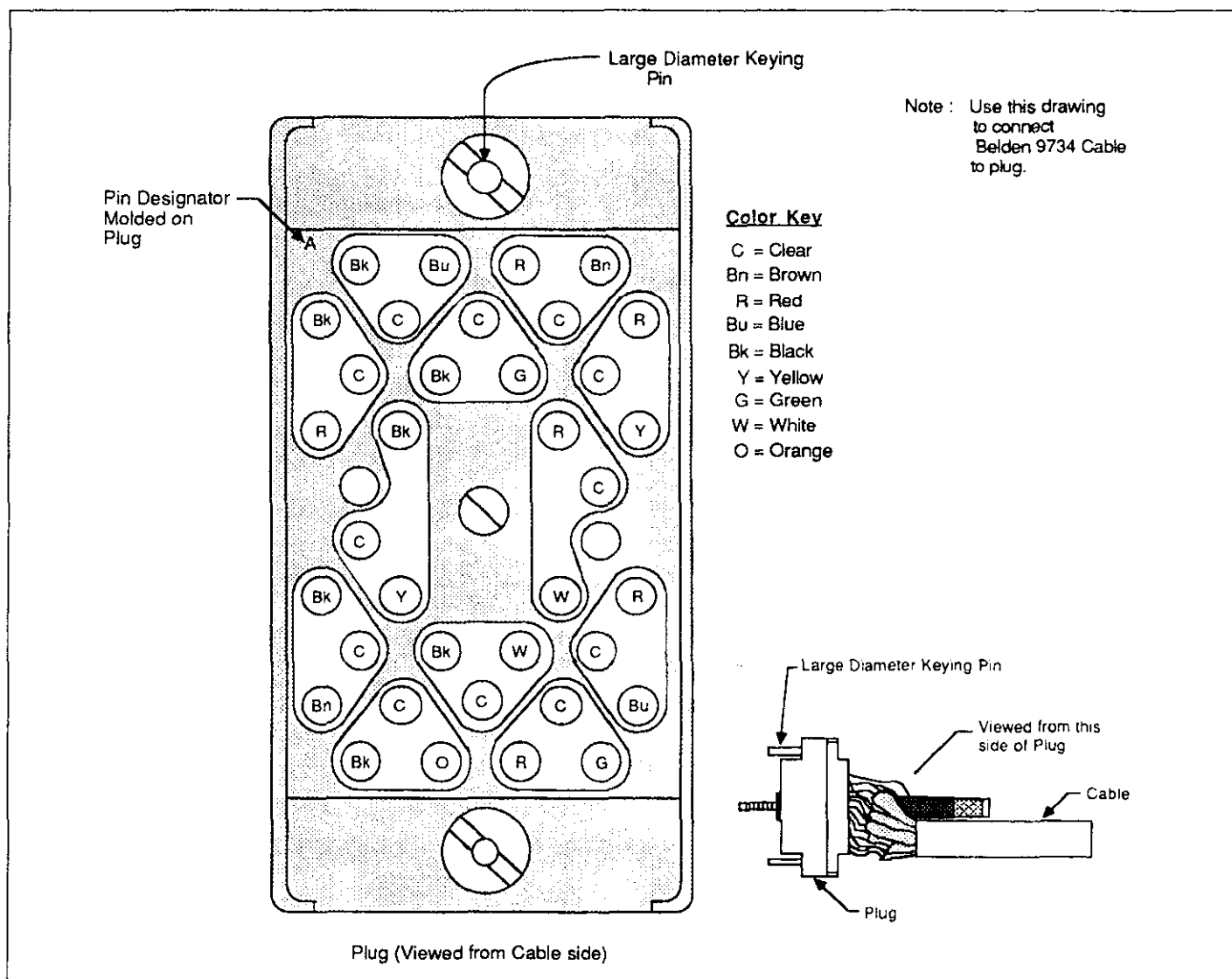


Figure 2-14. Connecting Belden 9734 Cable to Plug

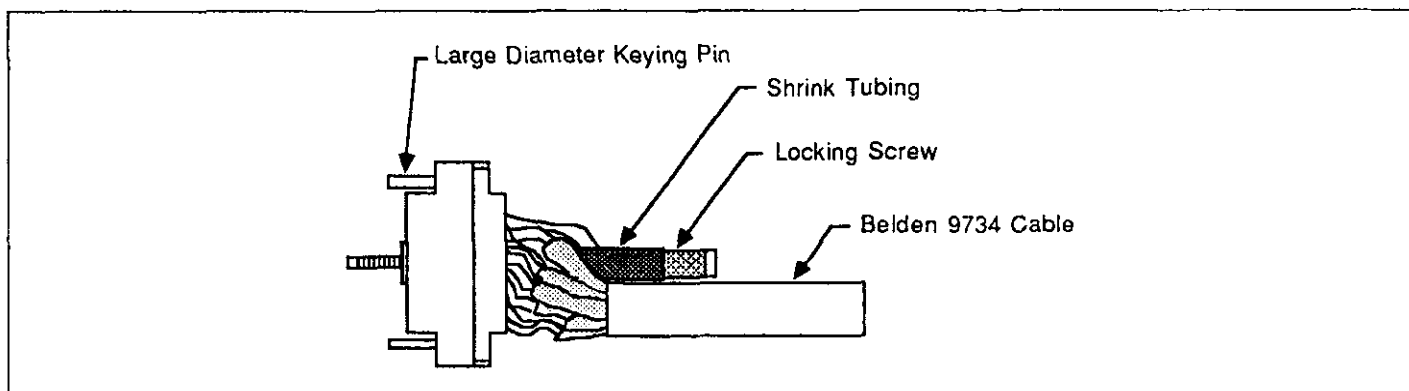


Figure 2-15. Cable Positions



## 2.6 MATRIX EXPANSION

With the use of additional Model 7071 matrix cards, larger matrices can be configured and are described in the following paragraphs.

### NOTE

Some configurations require that the backplane row jumpers of the Model 707 be removed. The procedure to remove these jumpers can be found in the Model 707 Instruction Manual.

Model 7071 matrix cards installed in slots 1, 2 and 3 of the Model 707 can be electrically isolated from slots 4, 5 and 6 by removing the backplane row jumpers. With the jumpers removed, the Model 707 can accommodate two complete, separate matrices using Model 7071 matrix cards (see Figure 2-17).

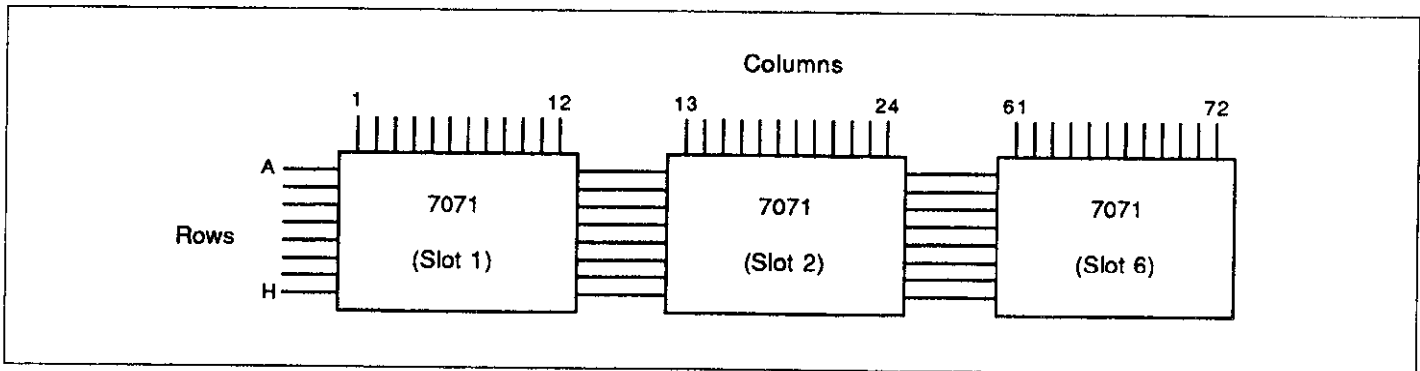
**Table 2-4. Narrow Matrix Expansion\***

Installed Matrix Cards	Resulting Matrix
1 Card	8 × 12
2 Cards	8 × 24
3 Cards	8 × 36
4 Cards	8 × 48
5 Cards	8 × 60
6 Cards	8 × 72

### 2.6.1 Narrow Matrix Expansion

As shipped from the factory, the rows of all six slots of the Model 707 are internally connected together. Thus, each card installed in the mainframe extends the matrix by 12 columns. For example, three cards installed in the Model 707 will result in an 8 × 36 matrix. Figure 2-16 shows three matrix cards installed in slots 1, 2 and 6.

\*Backplane row jumpers between slots 3 and 4 of mainframe must be installed for a matrix larger than 36 columns.



**Figure 2-16. Narrow Matrix Example (8 × 36) (Backplane Jumpers Not Removed)**

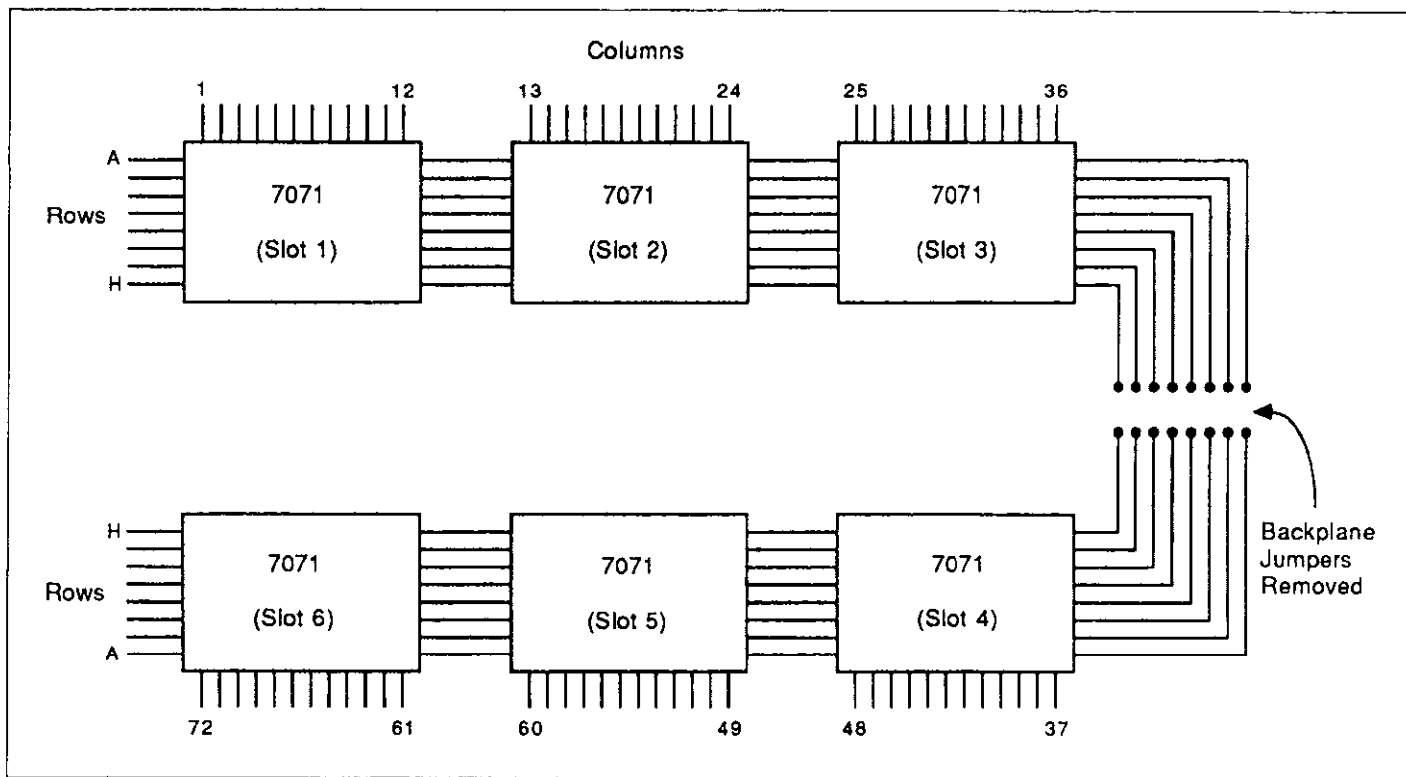


Figure 2-17. Two 8 × 36 Matrices Using Six Model 7071s

### 2.6.2 Wide Matrix Expansion

With the backplane row jumpers of the Model 707 removed, a wide matrix (16 rows) can be configured as shown in Figure 2-18. Columns of two cards can be connected together by using the Model 7071 MTC cable or by using individual wires from the "COLUMN" terminal blocks of one card to the "COLUMN" terminal blocks of another. Column connections to DUTs can be made at the "COLUMN" terminal blocks or at a "COLUMNS" receptacle (if not already used) using methods described in paragraph 2.5. Each screw terminal of the terminal blocks will accommodate an additional #22 AWG wire.

Table 2-5. Wide Matrix Expansion\*

Installed Matrix Cards	Card Locations in 707		Resulting Matrix
	Slots 1, 2 or 3	Slots 4, 5 or 6	
2 Cards	1 Card	1 Card	16 × 12
4 Cards	2 Cards	2 Cards	16 × 24
6 Cards	3 Cards	3 Cards	16 × 36

\*Model 707 backplane row jumpers removed.

Table 2-5 summarizes the wide matrix possibilities per Model 707 mainframe.

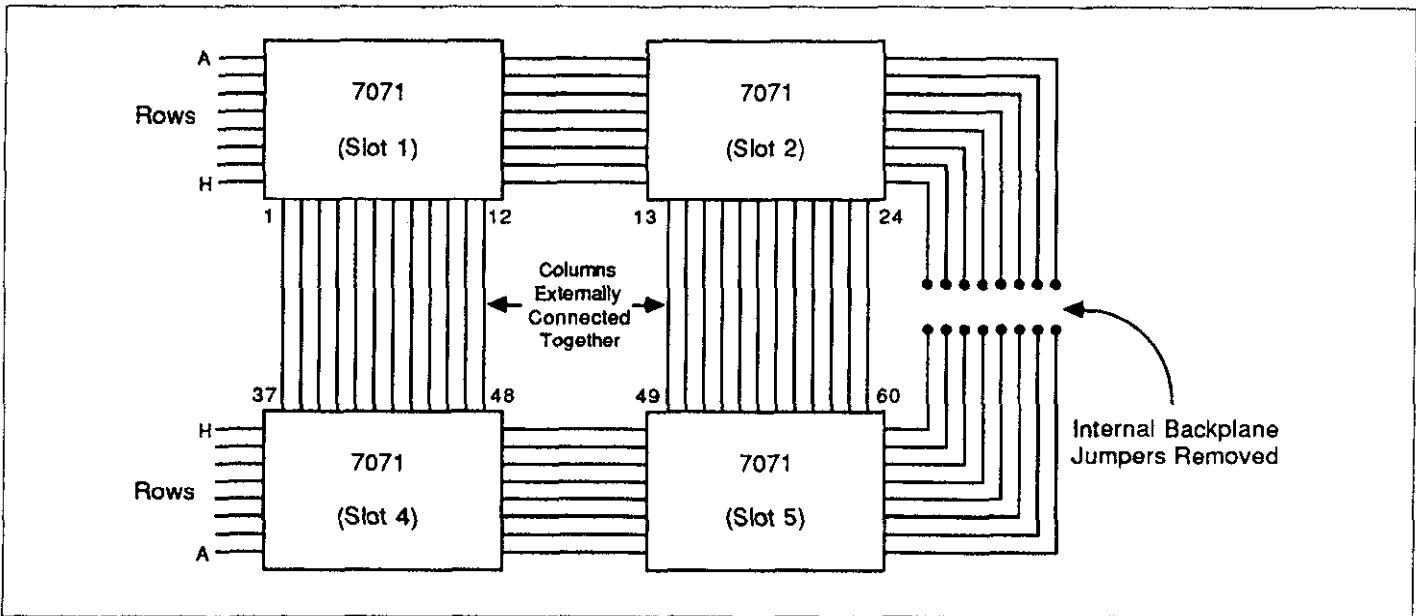


Figure 2-18. Wide Matrix Example (16 × 24)

### 2.6.3 Partial Matrix Implementation

A fully implemented matrix provides a relay at each potential crosspoint. For example, a fully implemented 16 × 24 matrix utilizing four Model 7071 matrix cards contains 384 crosspoints. A partially implemented matrix can be obtained by removing one Model 7071 from the mainframe (see Figure 2-19). The partial matrix is still 16 × 24, but contains only 288 crosspoints. An obvious advantage of a partial matrix is that fewer matrix cards are needed. Another reason to use a partial matrix is to keep certain devices from being connected directly to other certain devices. For example, a source in Figure 2-19 cannot be connected to DUT #2 with one "accidental" crosspoint closure. Three specific crosspoints must be closed in order to connect a source to DUT #2.

Methods to connect columns together and to external circuitry are explained in the previous paragraph.

### 2.6.4 Mainframe Matrix Expansion

Matrices using up to 30 Model 7071 matrix cards are possible by daisy-chaining five Model 707 mainframes together. Using 30 Model 7071 matrix cards provides 2880 crosspoints.

In general, connecting columns of a card in one mainframe to the columns of a card in another mainframe increases the row numbers of the matrix. Connecting rows of any card in one mainframe to the rows of any other card in a second mainframe increases the column numbers of the matrix. See the Model 707 Instruction Manual for detailed information on daisy-chaining Model 707 mainframes.

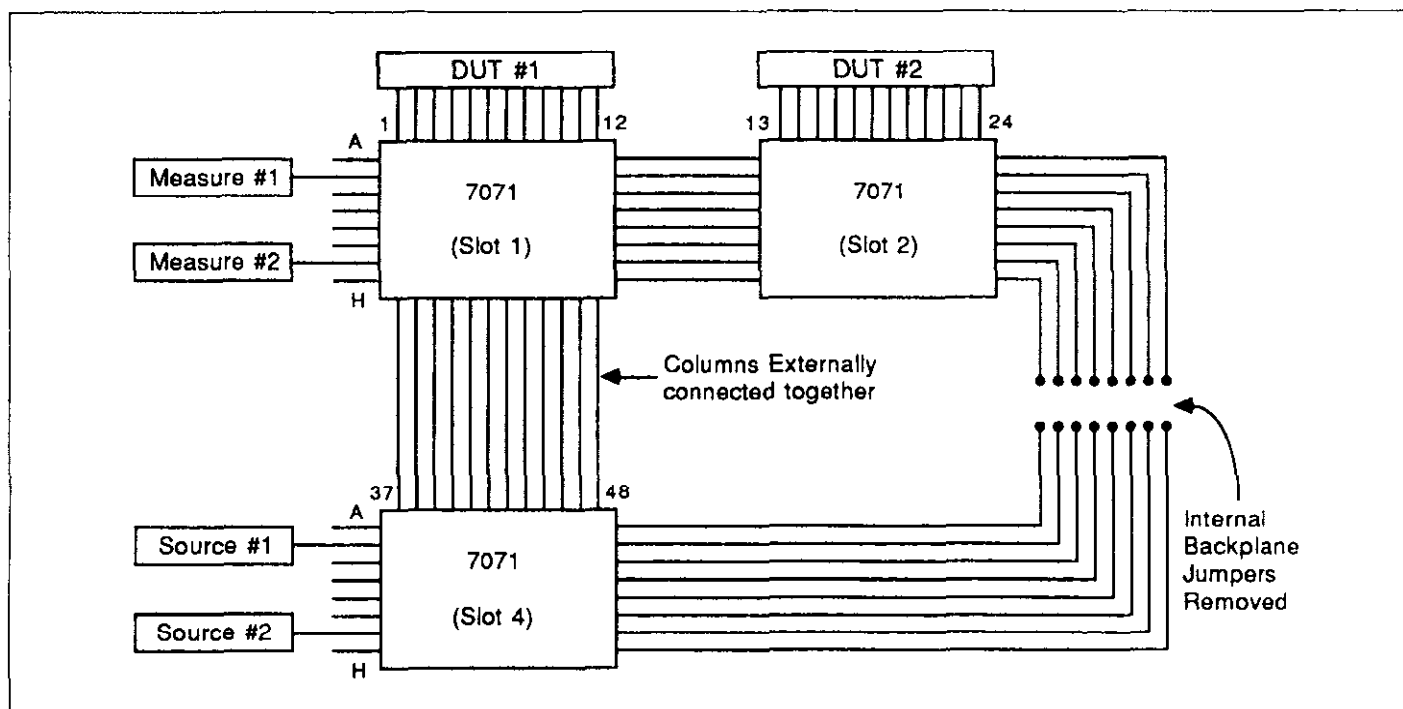


Figure 2-19. Partial Matrix Expansion (16 × 24)

## 2.7 TYPICAL CONNECTION SCHEMES

The information in this paragraph provides some typical connection schemes for single card, multiple card and multiple mainframe system configurations. All of the following examples show Model 7078-MTC cables cut in half. Keep in mind however, that in systems where path resistance is critical, cables should be kept as short as possible.

### 2.7.1 Single Card System

Figure 2-20 shows how external connections for a single card system might be made. Instrumentation is connected to matrix card rows. Using standard instrument cables that are unterminated at one end make it convenient to make connections at the quick-disconnect terminal blocks of the matrix card. Instrumentation uses only four rows allowing the rest of the rows to be used by DUTs. A Model 7078-MTC cable cut in half, is then used to connect DUTs to matrix card columns and the remaining rows.

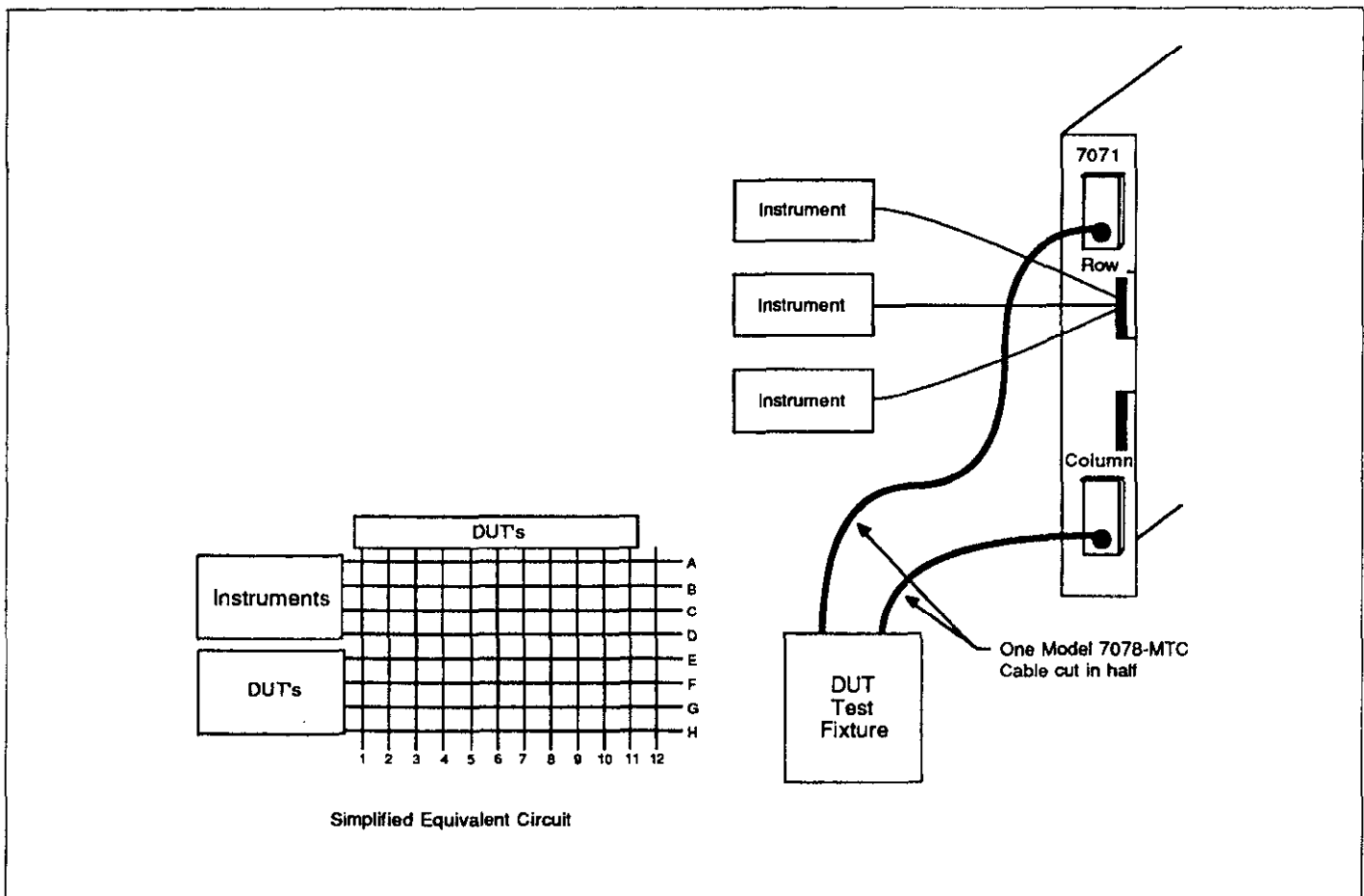


Figure 2-20. Single Card System Example

### 2.7.2 Multiple Card System

Figure 2-21 shows a system using four matrix cards. Again, instrumentation is connected to matrix card rows via the quick-disconnect terminal blocks. However, these connections could have been made using a Model 7078-MTC cable if desired. DUTs are connected to columns using two Model 7078-MTC cables cut in half.

### 2.7.3 Multiple Mainframe System

Figure 2-22 shows a system using eight matrix cards, requiring two Model 707s daisy-chained together. In this configuration all instrumentation and DUTs are connected to matrix card columns using four Model 7078-MTC cables cut in half. A single Model 7078-MTC cable is used to connect the rows of the master mainframe to the rows of the slave mainframe. Note that if path resistance is a critical factor, use a cable that is as short as possible. A Model 7078-MTC cable can be shortened or a custom cable can be built using two Model 7078-KIT connector kits.

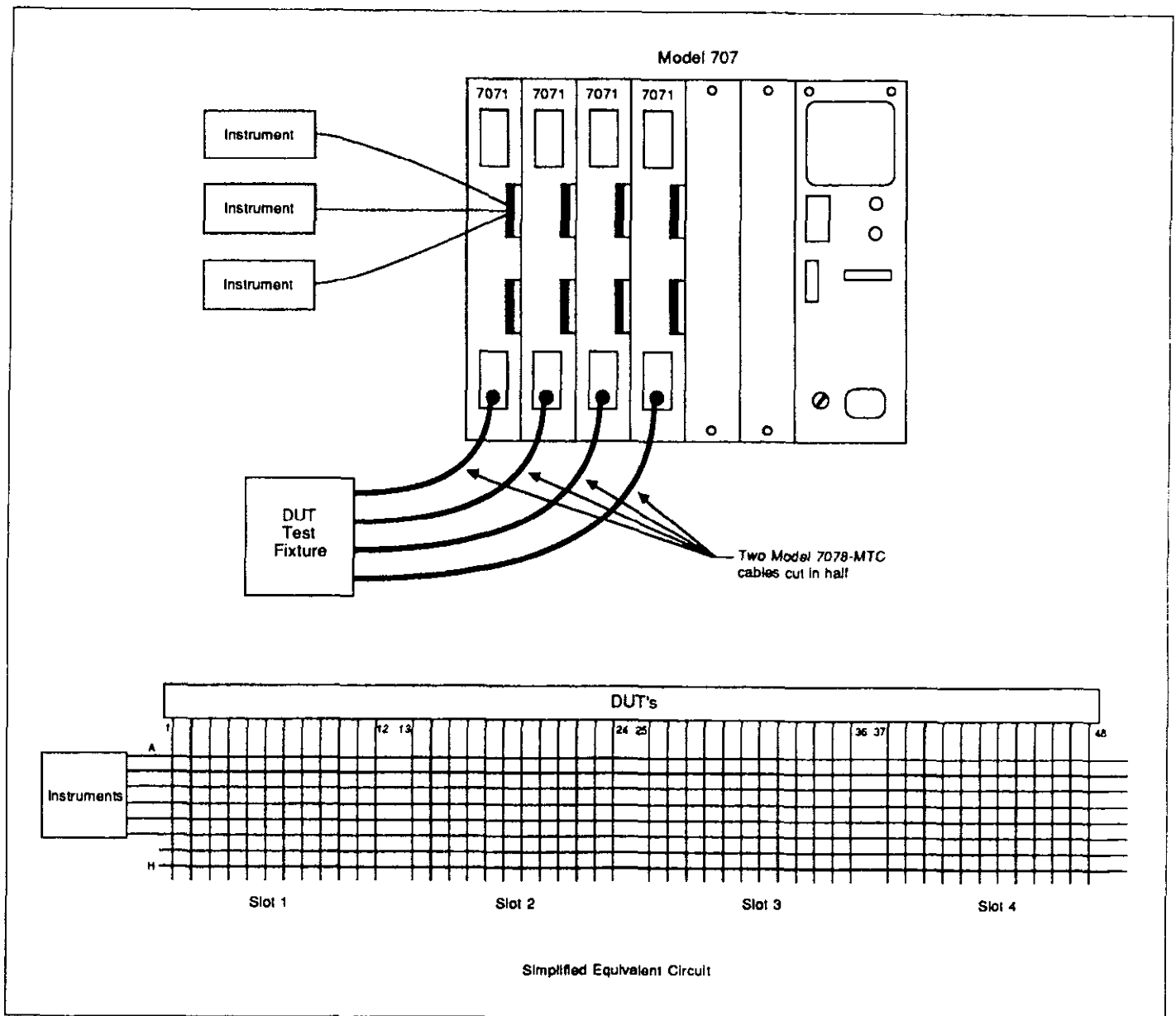
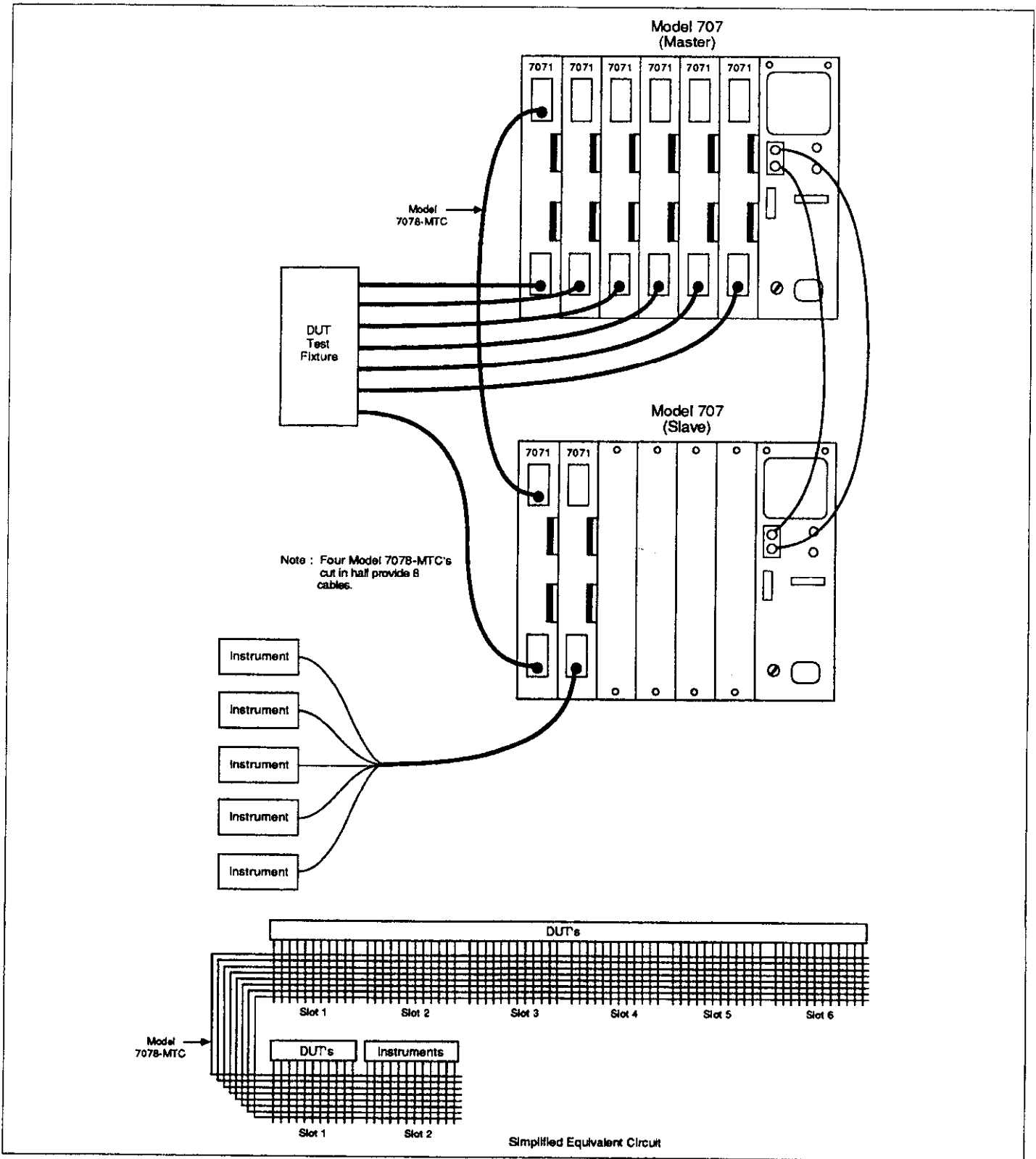
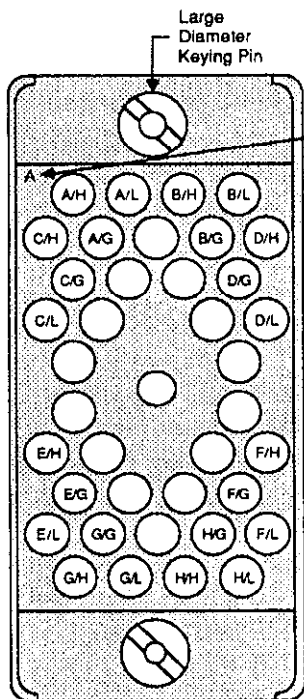


Figure 2-21. Multiple Card System Example



**Figure 2-22. Multiple Mainframe Example**

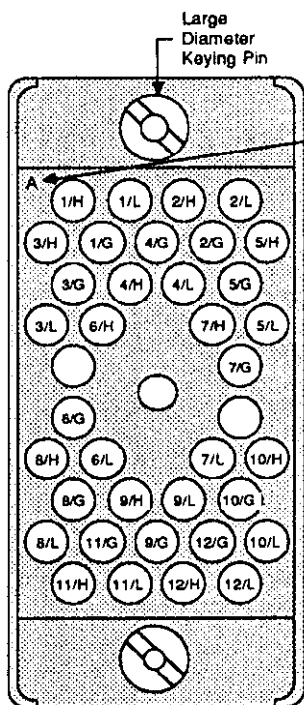
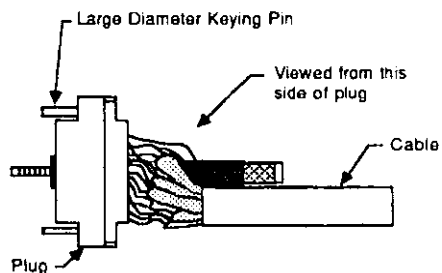


Rows Plug

Note : Use this drawing to connect custom cable to plug.

Contact	Row / Terminal
A/H	Row A/High Terminal
A/L	Row A/Low Terminal
A/G	Row A/Guard Terminal
B/H	Row B/High Terminal
B/L	Row B/Low Terminal
B/G	Row B/Guard Terminal
C/H	Row C/High Terminal
C/L	Row C/Low Terminal
C/G	Row C/Guard Terminal
D/H	Row D/High Terminal
D/L	Row D/Low Terminal
D/G	Row D/Guard Terminal

Contact	Row / Terminal
E/H	Row E/High Terminal
E/L	Row E/Low Terminal
E/G	Row E/Guard Terminal
F/H	Row F/High Terminal
F/L	Row F/Low Terminal
F/G	Row F/Guard Terminal
G/H	Row G/High Terminal
G/L	Row G/Low Terminal
G/G	Row G/Guard Terminal
H/H	Row H/High Terminal
H/L	Row H/Low Terminal
H/G	Row H/Guard Terminal



Columns Plug

Contact	Column / Terminal
1/H	Column 1/High Terminal
1/L	Column 1/Low Terminal
1/G	Column 1/Guard Terminal
2/H	Column 2/High Terminal
2/L	Column 2/Low Terminal
2/G	Column 2/Guard Terminal
3/H	Column 3/High Terminal
3/L	Column 3/Low Terminal
3/G	Column 3/Guard Terminal
4/H	Column 4/High Terminal
4/L	Column 4/Low Terminal
4/G	Column 4/Guard Terminal
5/H	Column 5/High Terminal
5/L	Column 5/Low Terminal
5/G	Column 5/Guard Terminal
6/H	Column 6/High Terminal
6/L	Column 6/Low Terminal
6/G	Column 6/Guard Terminal

Contact	Column / Terminal
7/H	Column 7/High Terminal
7/L	Column 7/Low Terminal
7/G	Column 7/Guard Terminal
8/H	Column 8/High Terminal
8/L	Column 8/Low Terminal
8/G	Column 8/Guard Terminal
9/H	Column 9/High Terminal
9/L	Column 9/Low Terminal
9/G	Column 9/Guard Terminal
10/H	Column 10/High Terminal
10/L	Column 10/Low Terminal
10/G	Column 10/Guard Terminal
11/H	Column 11/High Terminal
11/L	Column 11/Low Terminal
11/G	Column 11/Guard Terminal
12/H	Column 12/High Terminal
12/L	Column 12/Low Terminal
12/G	Column 12/Guard Terminal

Note : Viewed from cable side of plug.

Figure 2-23. Plug Contact Assignments



# SECTION 3

## Applications

### 3.1 INTRODUCTION

General applications to test thick film resistor networks and transistors are provided in this section. These applications are intended to demonstrate the versatility of using the matrix card in test systems.

### 3.2 THICK FILM RESISTOR NETWORK TESTING

A dedicated matrix system for testing thick film resistor networks is shown in Figure 3-1. This particular system

provides three different methods to check thick films; four-wire resistance measurements, voltage measurements using an applied voltage, and voltage measurements using an applied current. In general, the method to use for testing is dictated by the intended application of the resistor network and the values of the resistors.

The system shown in Figure 3-1 tests three 3-element thick films, but can be expanded to test more by simply using additional Model 7071 matrix cards. The Model 707 will accommodate six matrix cards. Daisy-chaining five Model 707s expands the system to 30 matrix cards allowing 90 three-element thick films to be tested.

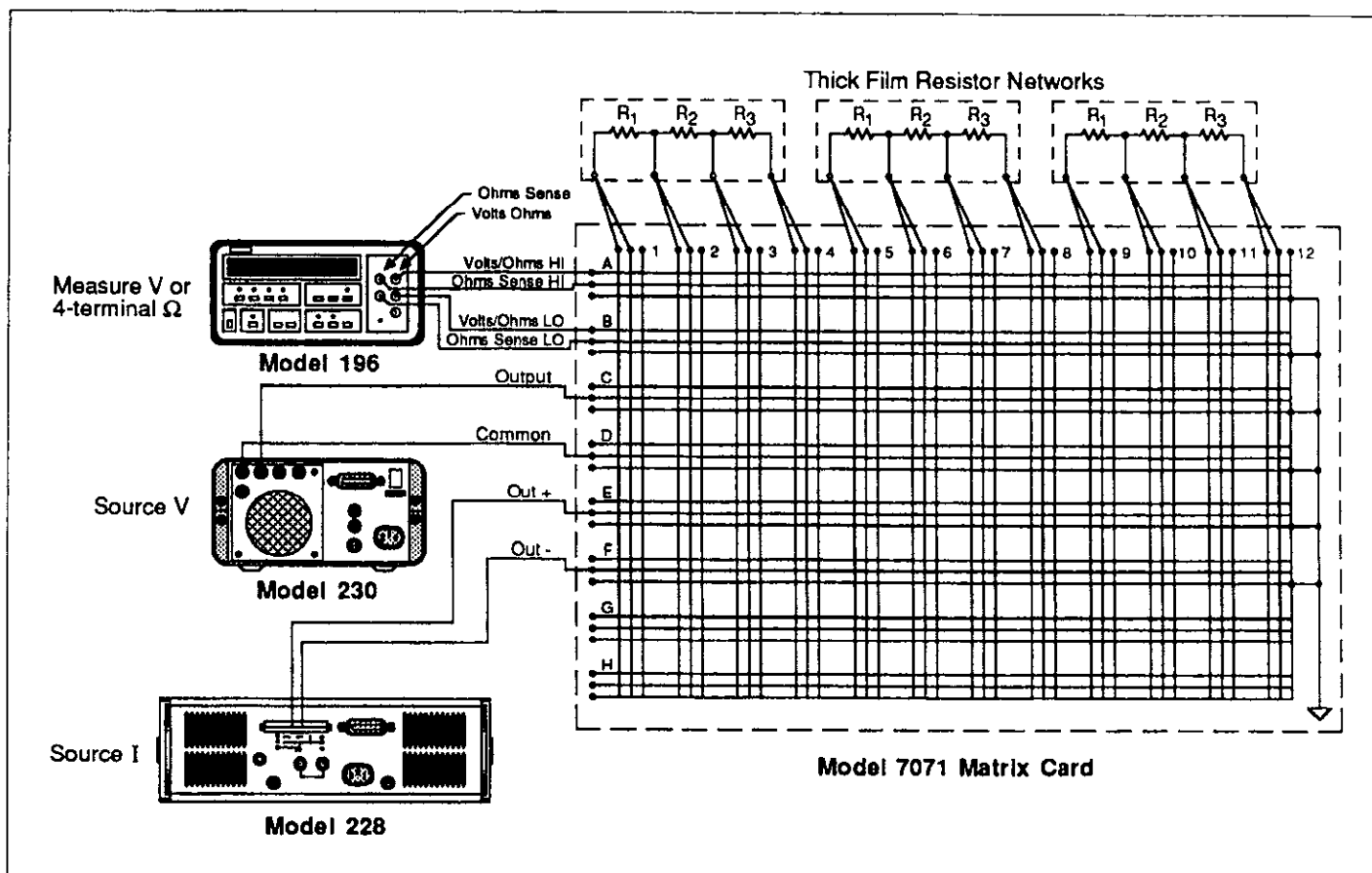


Figure 3-1. Thick Film Resistor Network Testing

### 3.2.1 Four-terminal Ohms Measurements

For general purpose testing, the Keithley Model 196 can be used to make 4-terminal resistance measurements of each thick film. As shown in Figure 3-2, OHMS HI and OHMS SENSE HI are connected to one matrix row, and OHMS LO and OHMS SENSE LO are connected to another matrix row. The third pole (G) of the matrix is not shown since it is not used. With this configuration, the resistance of each resistor element and/or combined elements can be measured by closing the appropriate crosspoints. In Figure 3-2, crosspoints A1 (row A, column

1) and B3 are closed to measure the combined resistance of R1 and R2.

The effects of thermal EMFs generated by relay contacts and connections can be cancelled by using the offset compensated ohms feature of the Model 196. To compensate for thermal EMFs, close two crosspoints (such as A1 and B1) that will short the input of the Model 196, enable ZERO to cancel internal offset, and then enable offset compensated ohms.

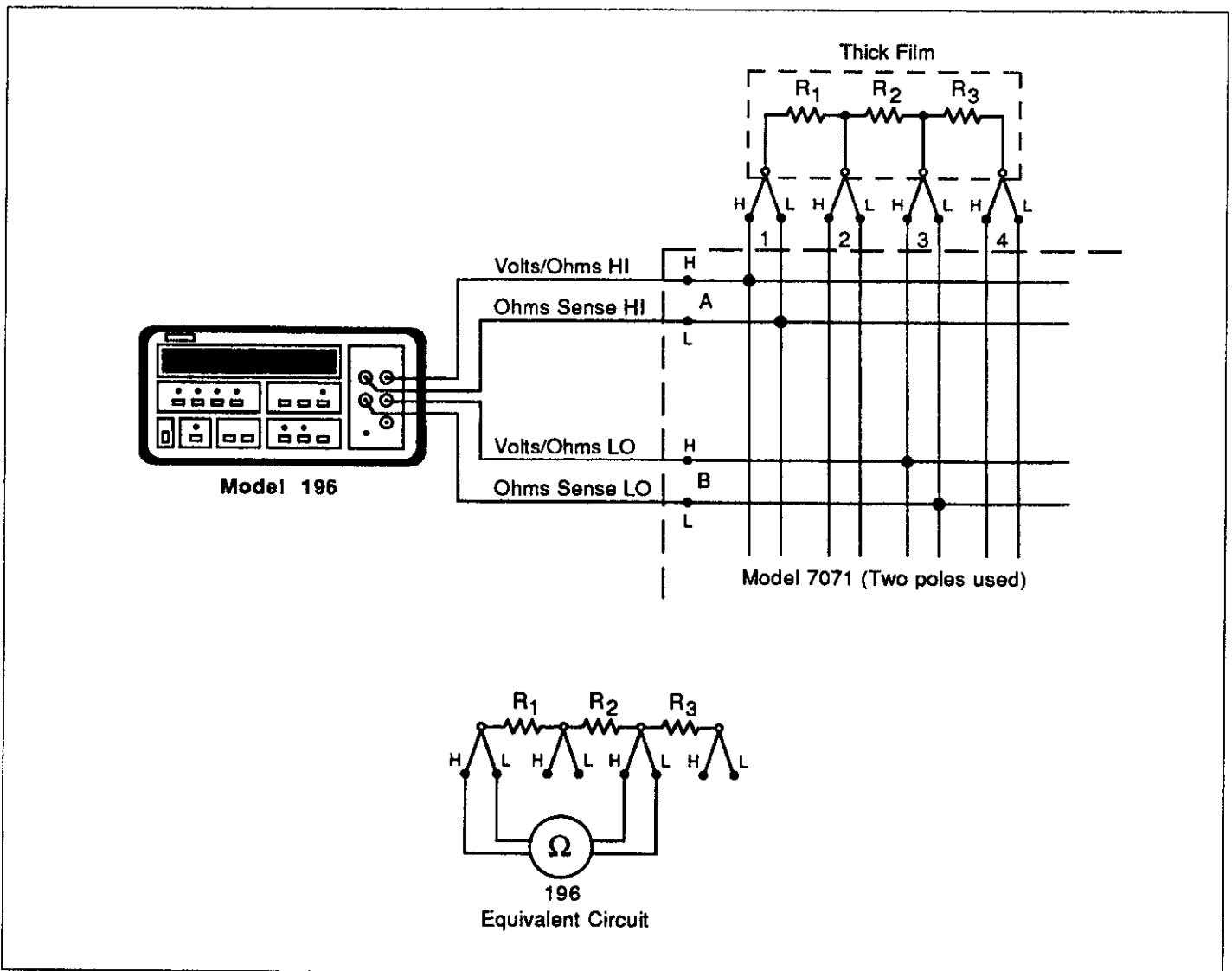


Figure 3-2. 4-Terminal Ohms Measurements

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### 3.2.2 Voltage Divider Checks

For thick film resistor networks that are going to be used as voltage dividers, it may be desirable to test them using voltages that simulate actual operating conditions. This is a particularly useful test for resistor networks that have a voltage coefficient specification. The test system in Figure 3-1 uses a Keithley Model 230 to source voltage and the Model 196 to measure voltage.

A consideration in these checks is the affect of the Model 196 input impedance on voltage measurements. The input impedance is shunted across the resistor being measured. The resultant divider resistance is the parallel combination of the resistor under test and the input impedance. As long as the input impedance is much larger than the resistor being tested, the error introduced into the measurement will be minimal. Minimum input impedance requirements are, of course, determined by the accuracy needed in the measurement. The input impedances of the Model 196 are as follows: 300mV and 3V ranges,  $>1G\Omega$ ; 30V range,  $11M\Omega$ ; 300V range,  $10.1M\Omega$ . For better input impedance requirements, the Keithley Model

617 Electrometer can be incorporated into the test system to measure voltage.

Another factor to be considered when checking low voltage dividers is thermal EMFs generated by the matrix card. A matrix card crosspoint can generate up to  $\pm 5\mu V$  of thermal EMF. Thus, when making low voltage measurements be sure to account for this additional error,

Even though four-terminal connections are made at the Model 196 and the resistor networks, the sense leads are internally disconnected from the input of the DMM when the volts function is selected. The simplified test system is shown in Figure 3-3.

The thick film is tested by applying a voltage across the resistor network and measuring the voltage across each resistor element and/or across combined elements. In Figure 3-3, crosspoints C1 and D4 are closed to apply voltage across the network, and crosspoints A3 and B4 are closed to measure the voltage drop across R3.

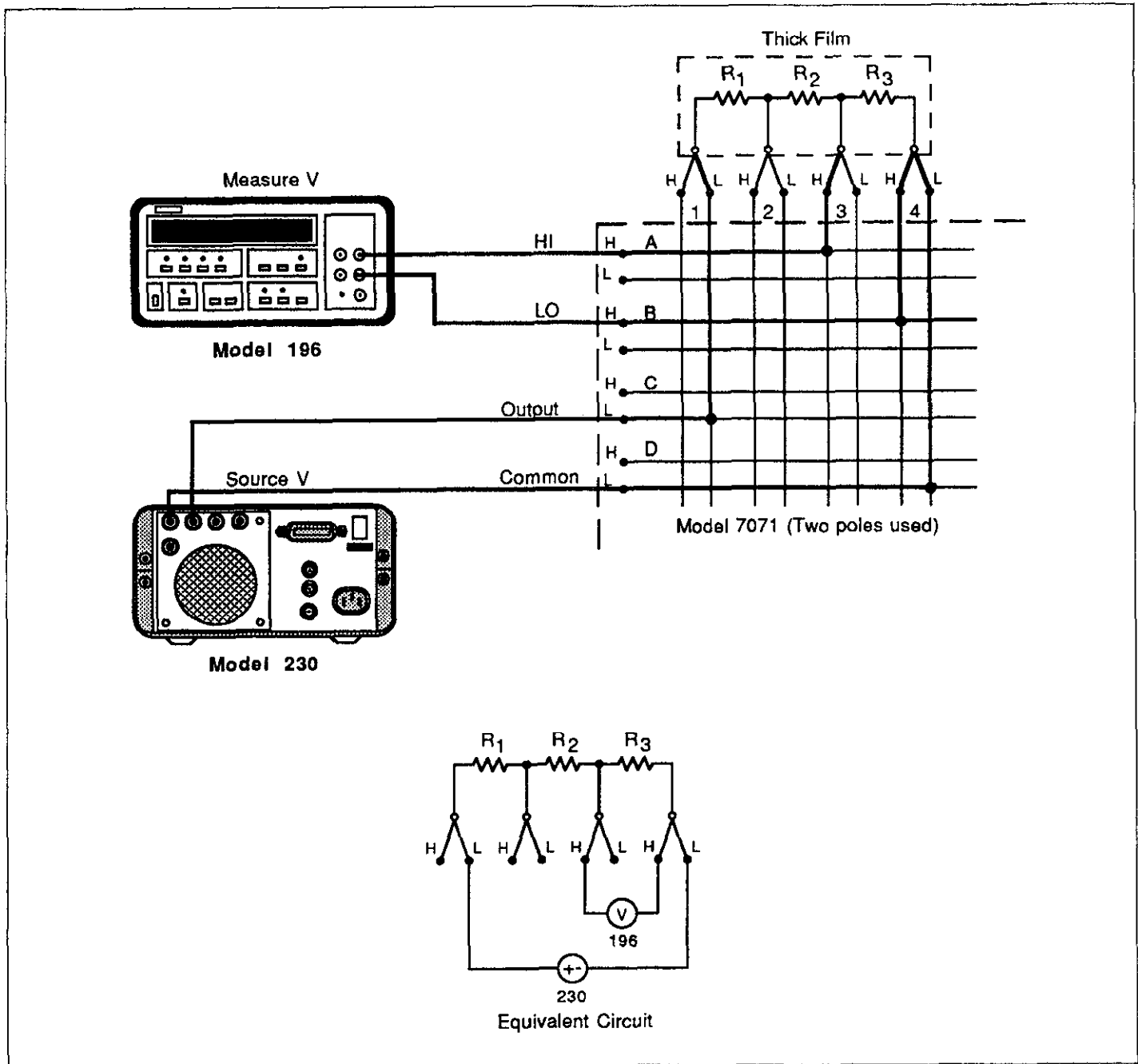


Figure 3-3. Voltage Divider Checks

### 3.2.3 Current Shunt Checks

As with voltage dividers, it may be desirable to test current shunt resistor networks under simulated operating conditions. The test system in Figure 3-1 uses a Keithley Model 228 to source current through the thick film resistor network and the Model 196 to measure voltage. As previously mentioned, the sense leads of the Model 196 are internally disconnected from its input in the volts function resulting with the simplified test circuit shown in Figure 3-4.

#### CAUTION

**To prevent damage not covered by the warranty, never source more than 1A to the matrix card and never switch more than 0.5A. To safely source more than 0.5A (but less than 1A), first set the current source to output zero and then close and/or open the appropriate crosspoints. This is called "cold" switching.**

The thick film is tested by sourcing a current through the current shunt network and measuring the voltage drop across each resistor element and/or across combined resistor elements. In Figure 3-4, crosspoints E1 and F4 are

closed to source current through the shunt, and crosspoints A1 and B2 are closed to measure the voltage drop across R1.

### 3.3 TRANSISTOR TESTING

A matrix system for testing DC parameters of transistors is shown in Figure 3-5. This system uses a current source (Keithley Model 224), a voltage source (Keithley Model 230) and a DMM (Keithley Model 196) to measure current and/or voltage. This system tests three transistors, but can be expanded to test more by simply using additional Model 7071 matrix cards. The Model 707 will accommodate six matrix cards. Daisy-chaining five Model 707s expands the system to 30 matrix cards allowing 90 transistors to be tested.

#### NOTE

To check FETs, or transistors that have high gain or low power, equipment that has lower offset current and higher impedance must be used. To check these devices, the Keithley Model 7072 Semiconductor Matrix Card and the Keithley Model 617 Electrometer can be used.

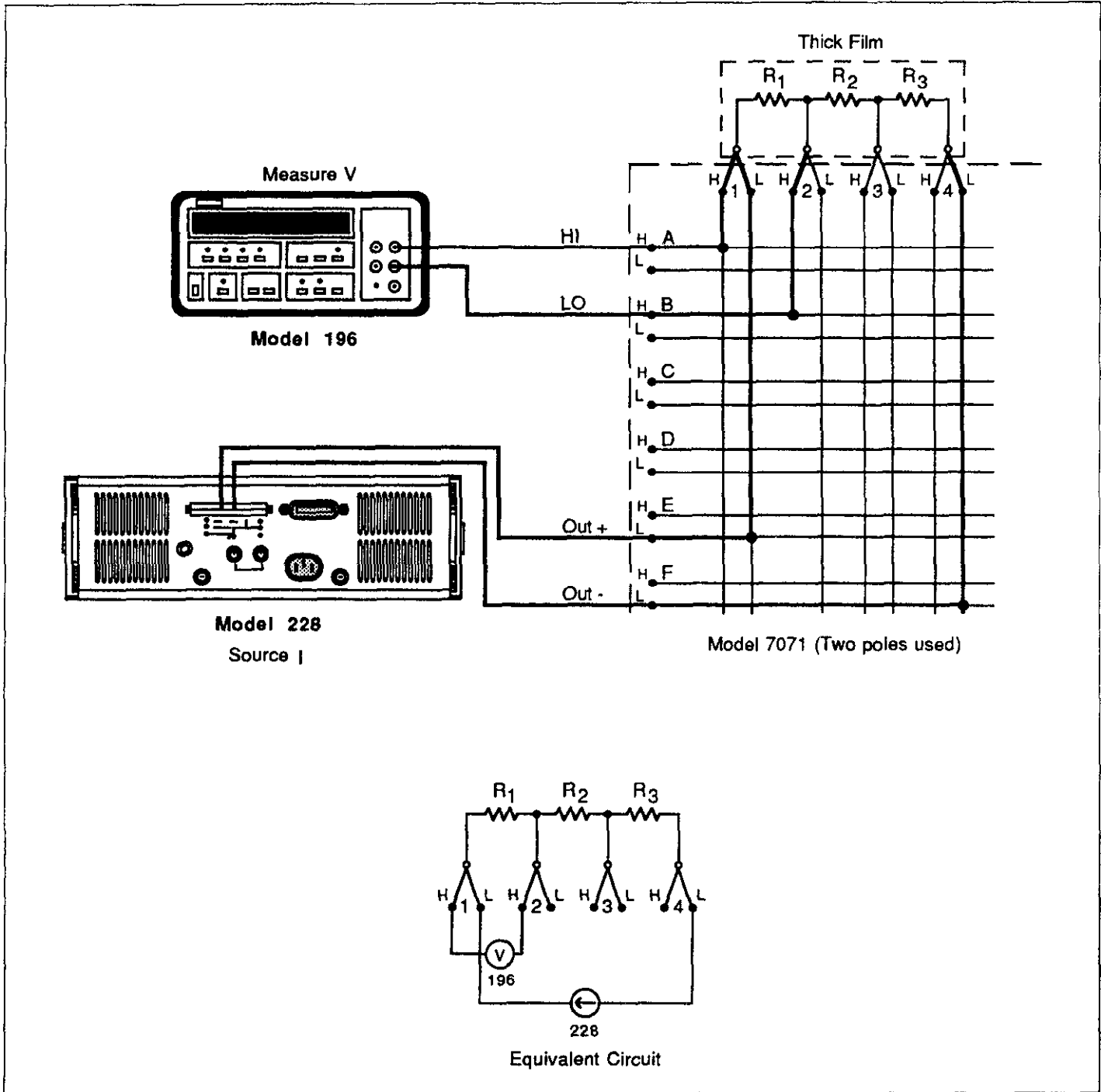


Figure 3-4. Current Shunt Checks

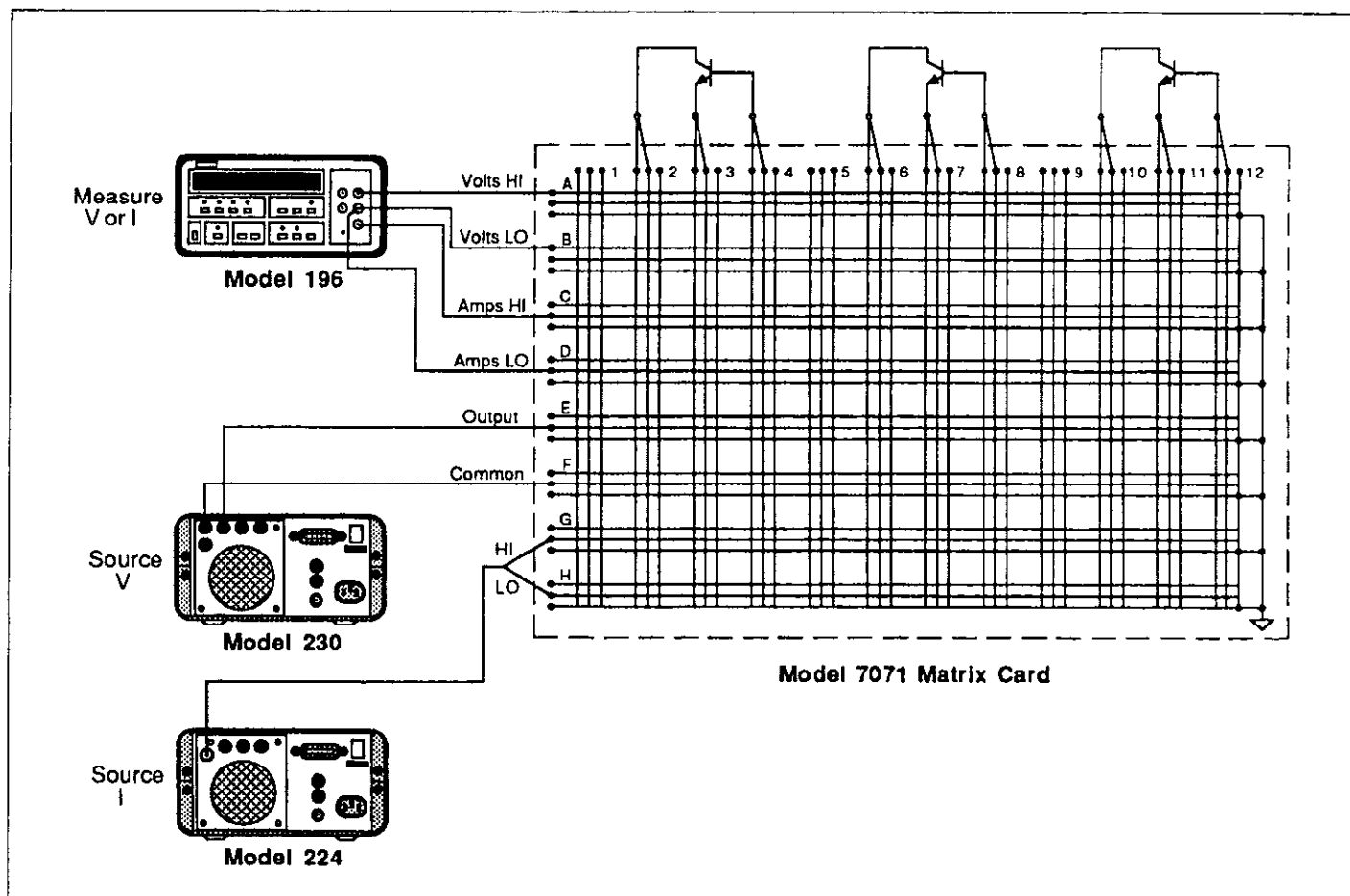


Figure 3-5. Transistor Testing

### 3.3.1 Current Gain Checks

The DC current gain of a general purpose transistor can be checked by configuring the transistor as a common-emitter amplifier. Figure 3-6 shows which crosspoints to close to configure the amplifier circuit. In this circuit, gain is calculated by dividing collector current (measured by the Model 196) by base current (sourced by the Model 224). A profile of the transistor operating characteristics can be obtained by measuring the collector current over a specified voltage range ( $V_{CE}$ ) for different base bias currents. For example, Figure 3-7 shows the characteristics of a typical NPN silicon transistor at base bias currents ( $I_B$ ) of  $20\mu A$ ,  $40\mu A$ ,  $60\mu A$  and  $80\mu A$ .

### 3.3.2 $I_E$ and $V_{BE}$ Measurements

The versatility of using a matrix is demonstrated in Figures 3-8 and 3-9. The transistor is still configured as a common-emitter amplifier, but the Model 196 is removed from the collector circuit and used to measure emitter current and base-to-emitter voltage. Notice that external connection changes are not required. All connection changes are accomplished by control of matrix crosspoints.

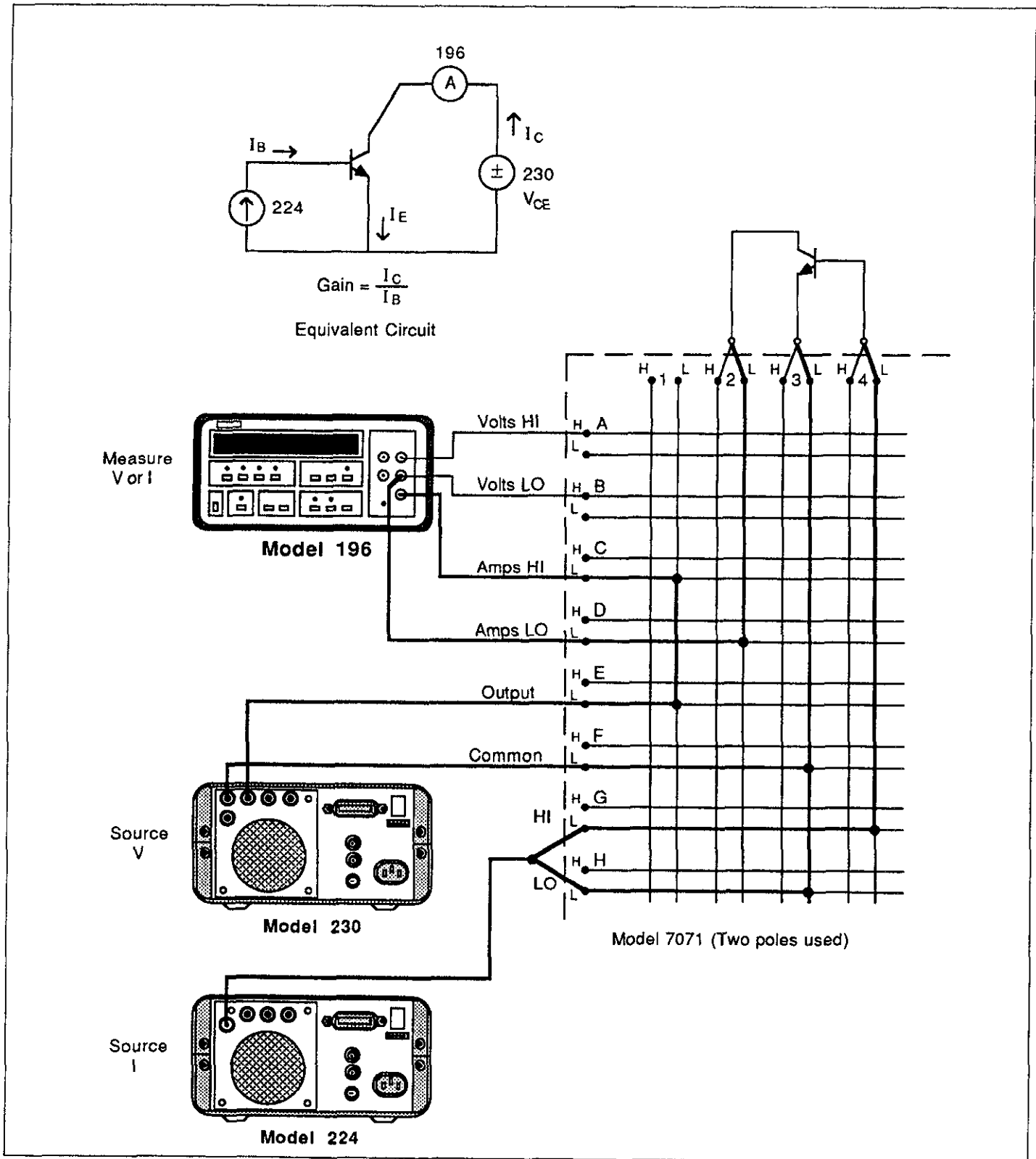


Figure 3-6. Transistor Current Gain Checks



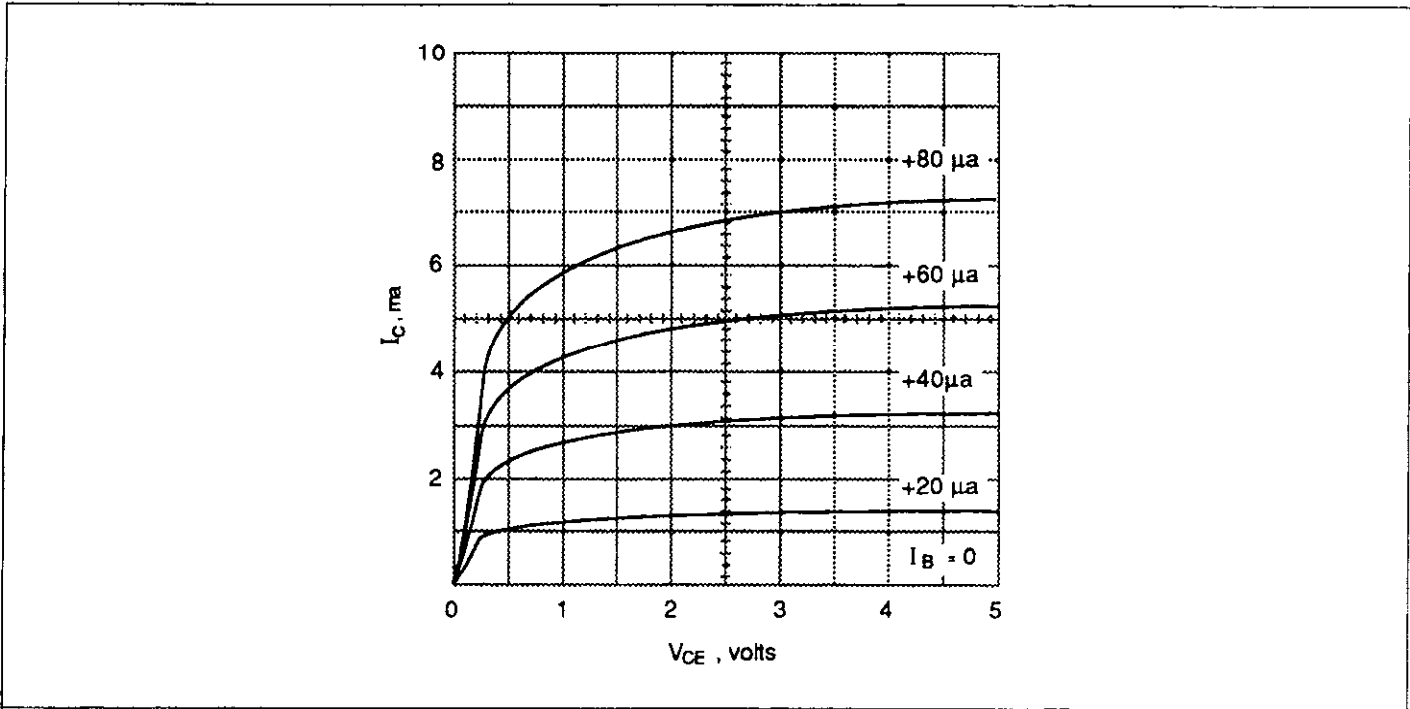


Figure 3-7. Common-Emitter Characteristics of an NPN Silicon Transistor

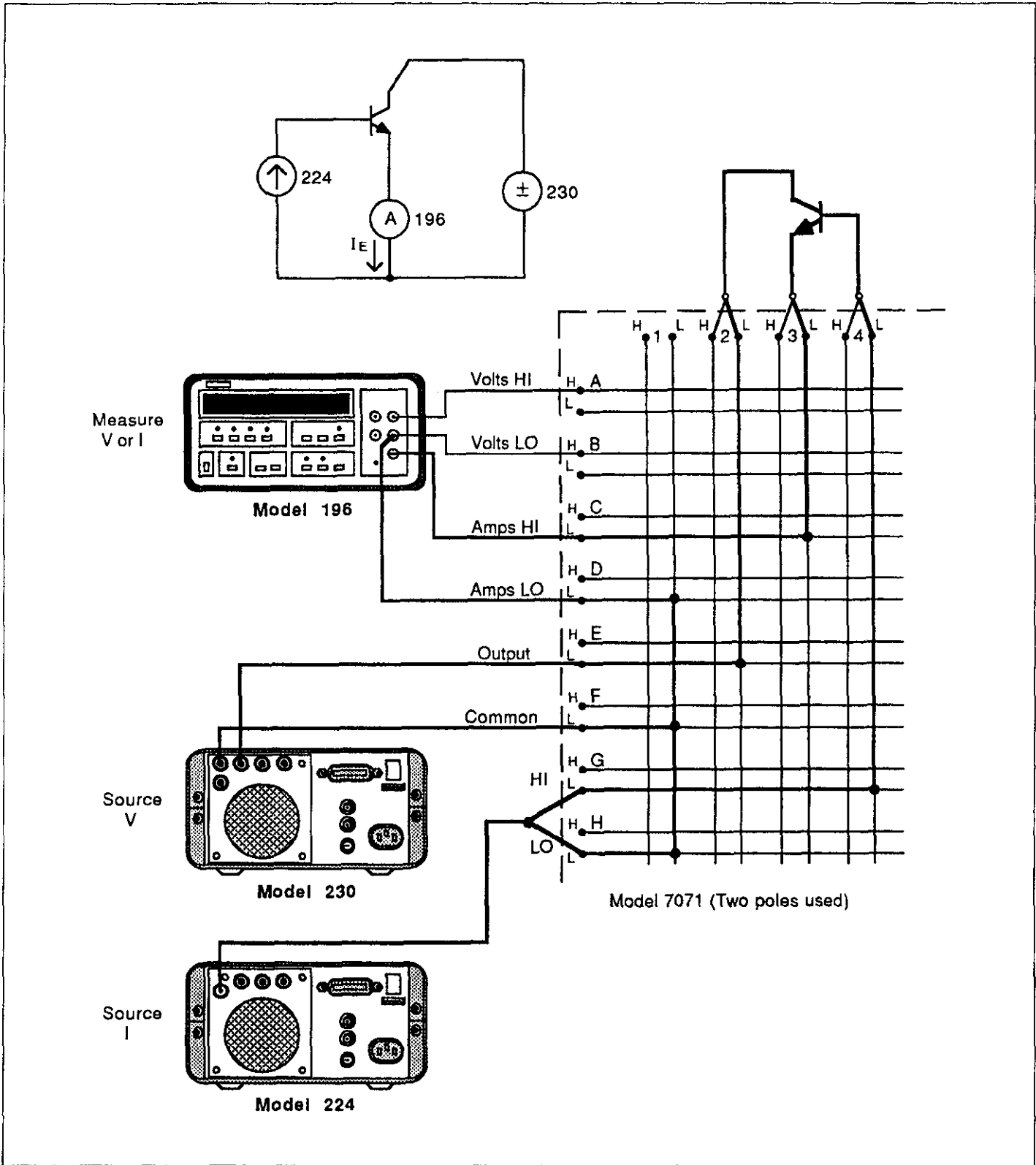


Figure 3-8. Transistor  $I_E$  Measurements

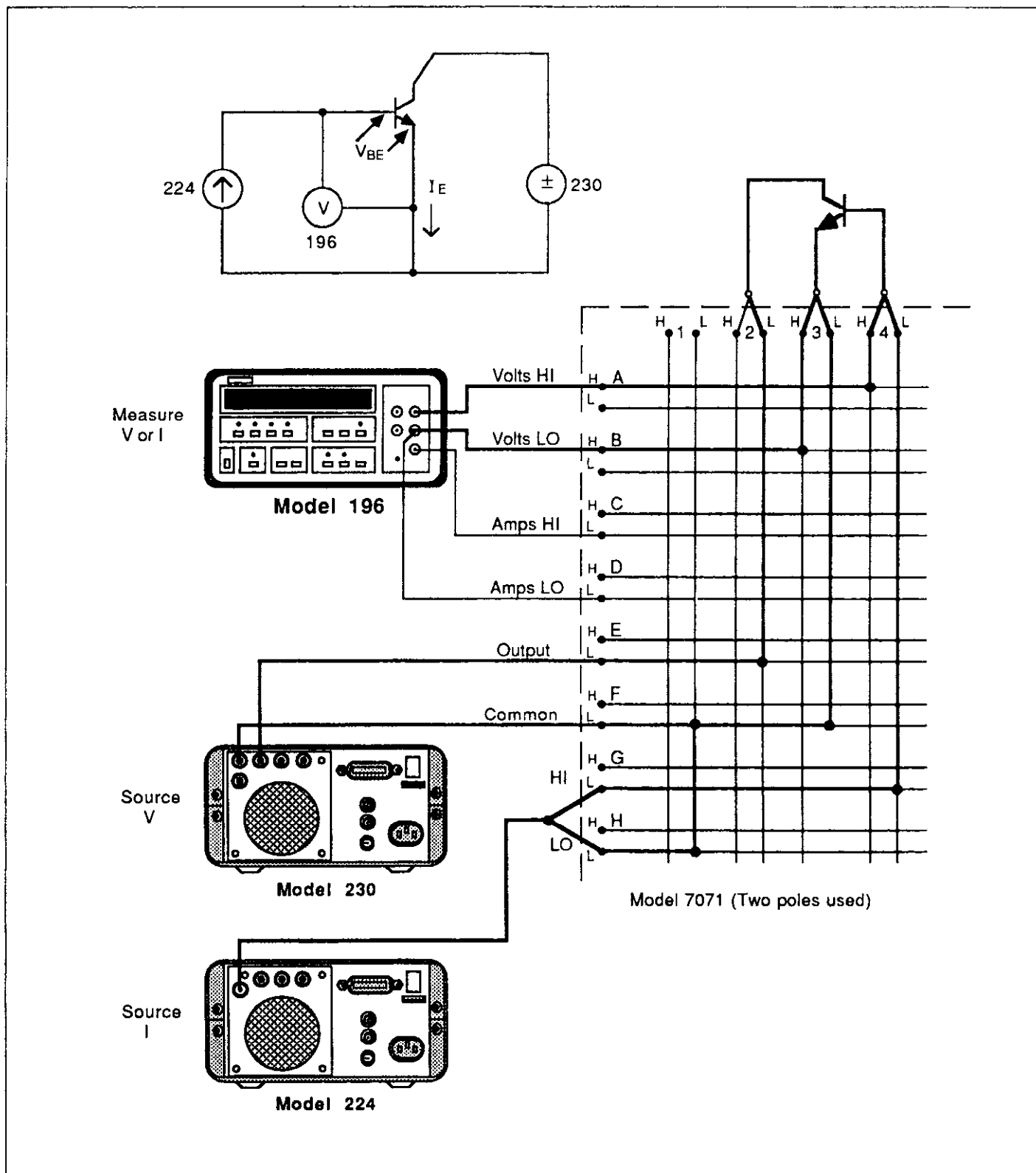


Figure 3-9. Transistor  $V_{BE}$  Measurements

# SECTION 4

## Service Information

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### 4.1 INTRODUCTION

This section contains information necessary to service the Model 7071 General Purpose Matrix Card and is arranged as follows:

- 4.2 **Handling and Cleaning Precautions:** Discusses handling procedures and cleaning methods for the matrix card.
- 4.3 **Relay Test Program:** Explains how to connect the matrix card to the Model 707 mainframe for the relay test program.
- 4.4 **Performance Verification:** Covers the procedures necessary to determine if the card is operating properly.
- 4.5 **Principles of Operation:** Briefly discusses circuit operation.
- 4.6 **Special Handling of Static-Sensitive Devices:** Reviews precautions necessary when handling static-sensitive devices.
- 4.7 **Troubleshooting:** Presents some troubleshooting tips for the matrix card.

### 4.2 HANDLING AND CLEANING PRECAUTIONS

Because of the high impedance circuits on the Model 7071, care should be taken when handling or servicing the card to prevent possible contamination, which could degrade performance. The following precautions should be taken when handling the matrix card.

- 1. Do not store or operate the card in an environment where dust could settle on the circuit board. Use dry nitrogen gas to clean dust off the card if necessary.
- 2. Handle the card only by the handle and side edges. Do not touch any board surfaces, components, or edge con-

nectors. Do not touch areas adjacent to electrical contacts. When servicing the card, wear clean, white cotton gloves.

- 3. If making solder repairs on the circuit board, use a flux that is rosin RMA based. Remove the flux from these areas when the repair is complete. Use Freon® TMS or TE, or the equivalent along with plenty of clean cotton swabs to remove the flux. Take care not to spread the flux to other areas of the circuit board. Once the flux has been removed, swab only the repaired area with methanol, then blow dry the board with dry nitrogen gas.
- 4. After cleaning, the card should be placed in a 50°C low humidity environment for several hours.

### 4.3 RELAY TEST PROGRAM SETUP

The Model 707 comes equipped with a test program on disk that will test all relays of Model 7071s installed in the mainframe. The test program will flag any relay that fails to close when energized or open when de-energized. Instructions for using the test program with an IBM PC or XT, or HP 200 or 300 series computer are contained in the Model 707 Instruction Manual.

Perform the following steps to configure the Model 7071 for relay testing:

- 1. Remove the relay test terminal block from the rear panel of the Model 707. This is a quick-disconnect terminal block and simply pulls off the rear panel terminal strip.
- 2. Connect the relay test terminal block to rows A and B of any Model 7071 card installed in the mainframe as shown in Figure 4-1. Note that terminals 5 and 6 of the relay test terminal block must be shorted together. Terminals H, L and G of row B of the Model 7071 must also be shorted together.
- 3. Re-install the relay test terminal block into the rear panel of the Model 707 mainframe and refer to the Model 707 Instruction Manual to run the test program.

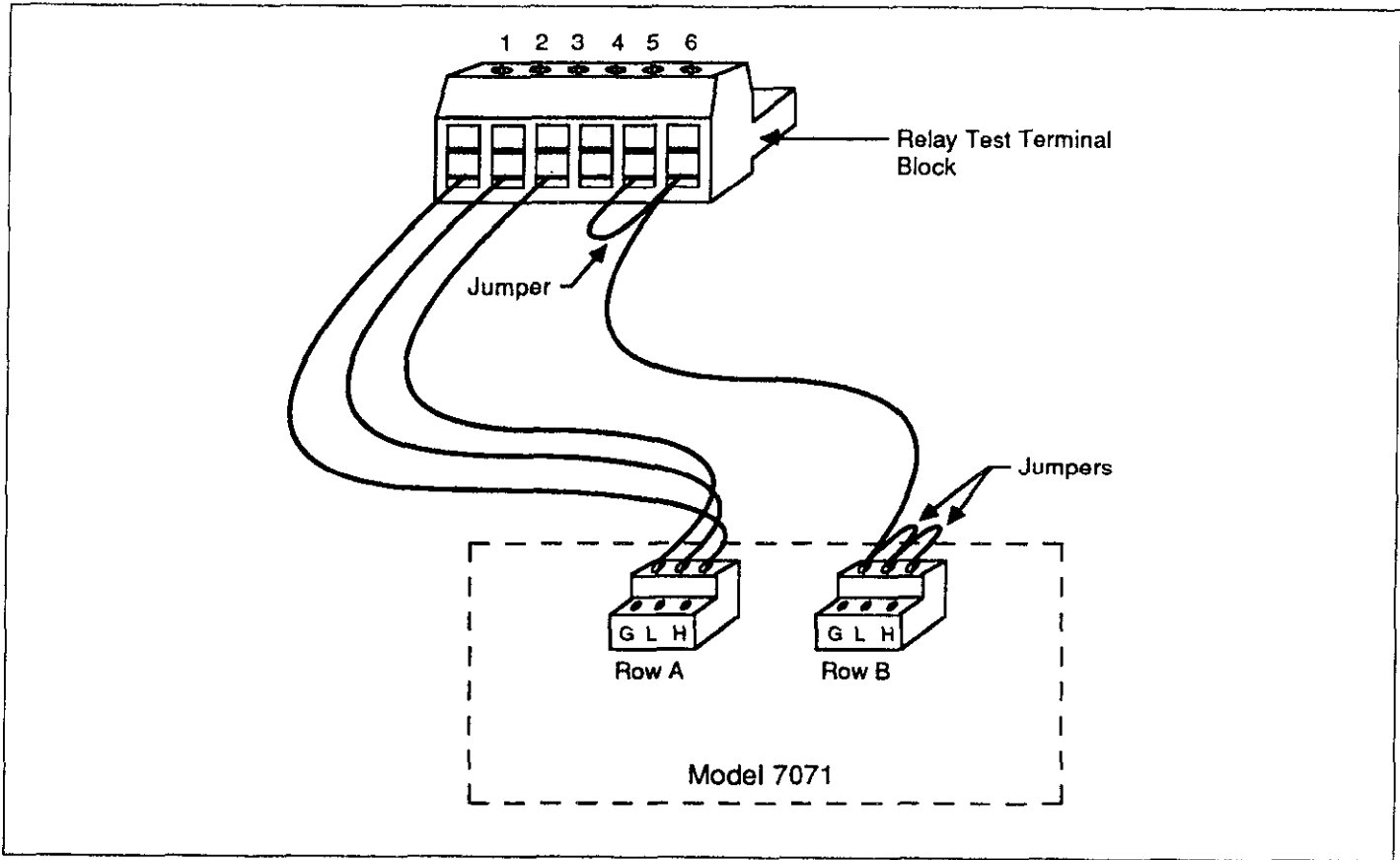


Figure 4-1. Relay Test Setup

#### 4.4 PERFORMANCE VERIFICATION

The following paragraphs discuss performance verification procedures for the Model 7071, including path resistance, offset current, contact potential, and isolation.

The procedures in this section are rather lengthy due to the large number of row and column combinations that are checked. As an alternative to this extensive testing, it may be desirable to check only those paths that are going to be used, or those that are suspected of being faulty.

The procedures in this section make external equipment connections at the terminal strip on the PC board. If using the "rack and panel" receptacles of the matrix card to make connections, modify the procedures accordingly. Connection techniques to "rack and panel" receptacles are covered in Section 2.

The performance verification procedures must be per-

formed with only one matrix card (the one being checked) installed in the Model 707 mainframe. Also, the Model 707 must not be daisy-chained to another Model 707.

#### CAUTION

**Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the handle and side edges. Do not touch the edge connectors of the card, and do not touch the board surfaces or components. On "rack and panel" connectors and quick disconnect terminal blocks, do not touch areas adjacent to the electrical contacts.**

#### NOTE

Failure of any performance verification test may indicate that the matrix card is contaminated. See paragraph 4.2 to clean the card. If the test still fails after cleaning, then try cleaning the backplane (see the Model 707 Instruction Manual).

### 4.4.1 Environmental Conditions

All verification measurements should be made at an ambient temperature between 18° and 28°C, and at a relative humidity of less than 70%.

### 4.4.2 Recommended Equipment

Table 4-1 summarizes the equipment necessary for performance verification, along with the application for each unit.

#### NOTE

Do not use the Model 7070 Universal Adapter Card as an extender card to verify performance of the Model 7071. The Model 7071 must be installed in the Model 707 mainframe.

### 4.4.3 Path Resistance Tests

Perform the following steps to verify that each contact of every relay is closing properly and that the resistance is within specification.

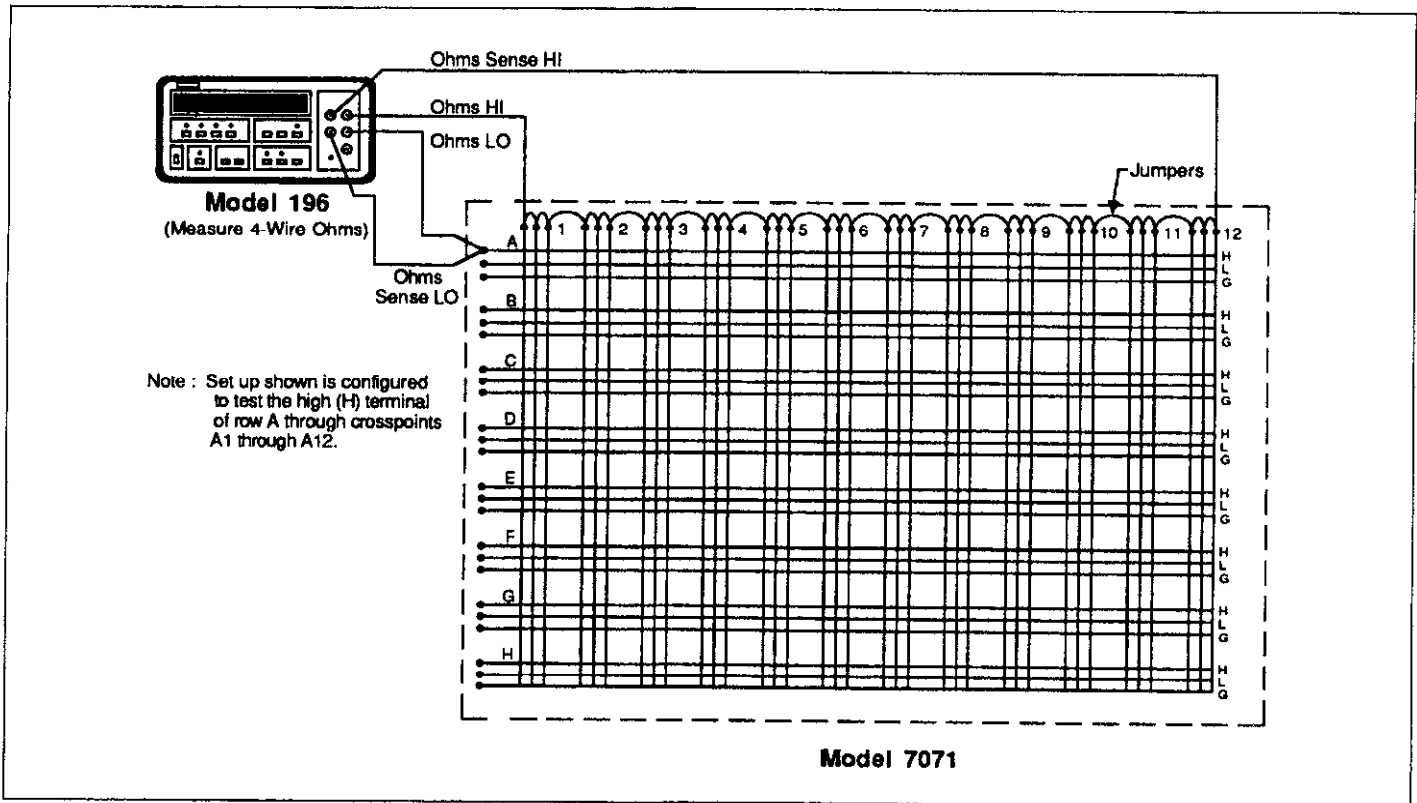
#### NOTE

Refer to Figure 4-2 for the following procedure.

1. Turn the Model 707 off if it is on.
2. Using bare jumper wires, connect all terminals of the matrix columns together to form one common terminal. Each screw terminal of the quick-disconnect terminal blocks will accommodate two #22 AWG wires. Keep the jumper wires as short as possible.
3. Remove the eight "ROWS" quick-disconnect terminal blocks from the PC board of the matrix card. This allows test lead connections to be made at the PC board terminal posts.
4. Place the Model 7071 in slot 1 of the Model 707, but do not push it all the way into the mainframe.
5. Set the Model 196 to the 300Ω range and connect four test leads to the OHMS and OHMS SENSE input.
6. Short the four test leads together and zero the Model 196. Leave zero enabled for the entire test.
7. Connect OHMS HI and OHMS SENSE HI of the Model 196 to the common terminal (jumper). It is recommended that the physical connections be made at columns 1 and 12 as shown in Figure 4-2.
8. Connect OHMS LO and OHMS SENSE LO to the high (H) terminal post of ROW A.
9. Feed the test leads through the cable clamp of the matrix card and push the card all the way into the mainframe. Tighten the two spring loaded screws to completely mate the card with the backplane.
10. Turn on the Model 707 and program it to close crosspoint A1 (ROW A, COLUMN 1), and verify that the resistance of this path is <math><1.5\Omega</math>.
11. Open crosspoint A1, and close A2. Verify that the resistance of this path is <math><1.5\Omega</math>.
12. Open crosspoint A2, and close A3. Verify that the resistance of this path is <math><1.5\Omega</math>.
13. Using the basic procedure of steps 10 through 12, check the resistance of ROW A high (H) terminal paths for COLUMNS 4 through 12 (crosspoints A4 through A12).
14. Turn the Model 707 off and pull the matrix card out of the mainframe approximately 6" in order to gain access to the terminals.
15. Move the OHMS LO and OHMS SENSE LO test leads to the low (L) terminal of ROW A.
16. Repeat steps 9 through 12 to check the low (L) terminal paths of ROW A.
17. Turn the Model 707 off and move the OHMS LO and OHMS SENSE LO test leads to the guard (G) terminal of ROW A.
18. Repeat steps 10 through 12 to check the guard (G) terminal paths of ROW A.
19. Repeat the basic procedure in steps 1 through 18 for ROWS B through H.

**Table 4-1. Verification Equipment**

Description	Model	Specifications	Application
DMM	Keithley 196	300Ω; 0.01%	Path resistance
Electrometer w/voltage source	Keithley 617	10pA, 100pA; 1.6% 100V source; 0.2%	Offset current isolation
Nanovoltmeter	Keithley 181	2mV; 0.015%	Contact potential
Triax cable (unterminated)	Keithley 7025	—	Offset current isolation
Low thermal cable (unterminated)	Keithley 1484	—	Contact potential



**Figure 4-2. Path Resistance Testing**

#### 4.4.4 Offset Current Tests

These tests check leakage current between high (H) and low (L) (differential offset current) and from high and low to guard (G) (common mode offset current) of each pathway. In general, these tests are performed by simply measuring the leakage current with an electrometer. In the following procedure, the Model 617 is used to measure leakage current.

Perform the following procedure to check offset current:

1. Turn the Model 707 off if it is on.
2. Connect the Model 617 to a quick-disconnect terminal block as shown in Figure 4-3. Do not connect the terminal block to the matrix card at this time.
3. Place the matrix card in slot 1 of the Model 707, but do not slide it all the way into the mainframe.
4. On the Model 617, select the 200pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
5. Connect the pre-wired terminal block to ROW A of the matrix card.
6. Feed the test leads through the cable clamp of the matrix card and push the card all the way into the mainframe. Tighten the two spring loaded screws to completely mate the card with the backplane.
7. Turn on the Model 707
8. Program the Model 707 to close crosspoint A1.
9. On the Model 617, disable zero check and verify that it is  $< 100\text{pA}$ . This measurement is the leakage current of the pathway.
10. On the Model 617, enable zero check and on the Model 707, open crosspoint A1.
11. Repeat the basic procedure in steps 8 through 10 to check the rest of the pathways (crosspoints A2 through A12) of the row.
12. Turn off the Model 707 and slide out the matrix card far enough to gain access to the pre-wired terminal block.
13. Move the terminal block down to ROW B and repeat the basic procedure in steps 6 through 11 to check crosspoints B1 through B12.
14. Repeat the basic procedure in steps 12 and 13 for the remaining rows (ROWS C through H).
15. Turn off the Model 707, and slide the matrix card out far enough to gain access to the pre-wired terminal block.
16. Rewire the terminal block as shown in Figure 4-4.
17. Repeat steps 5 through 14 to check common mode offset current.



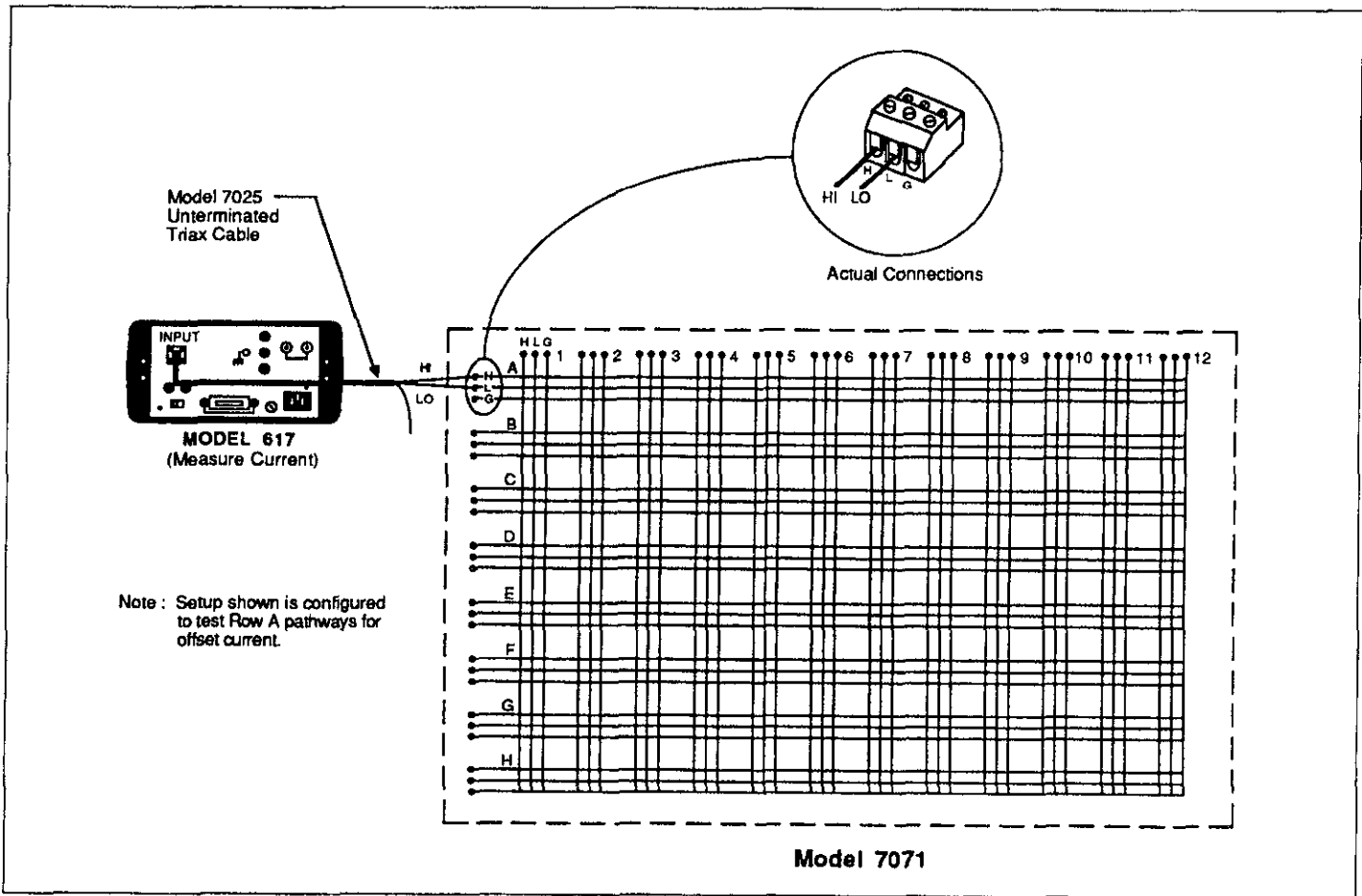


Figure 4-3. Differential Offset Current Testing

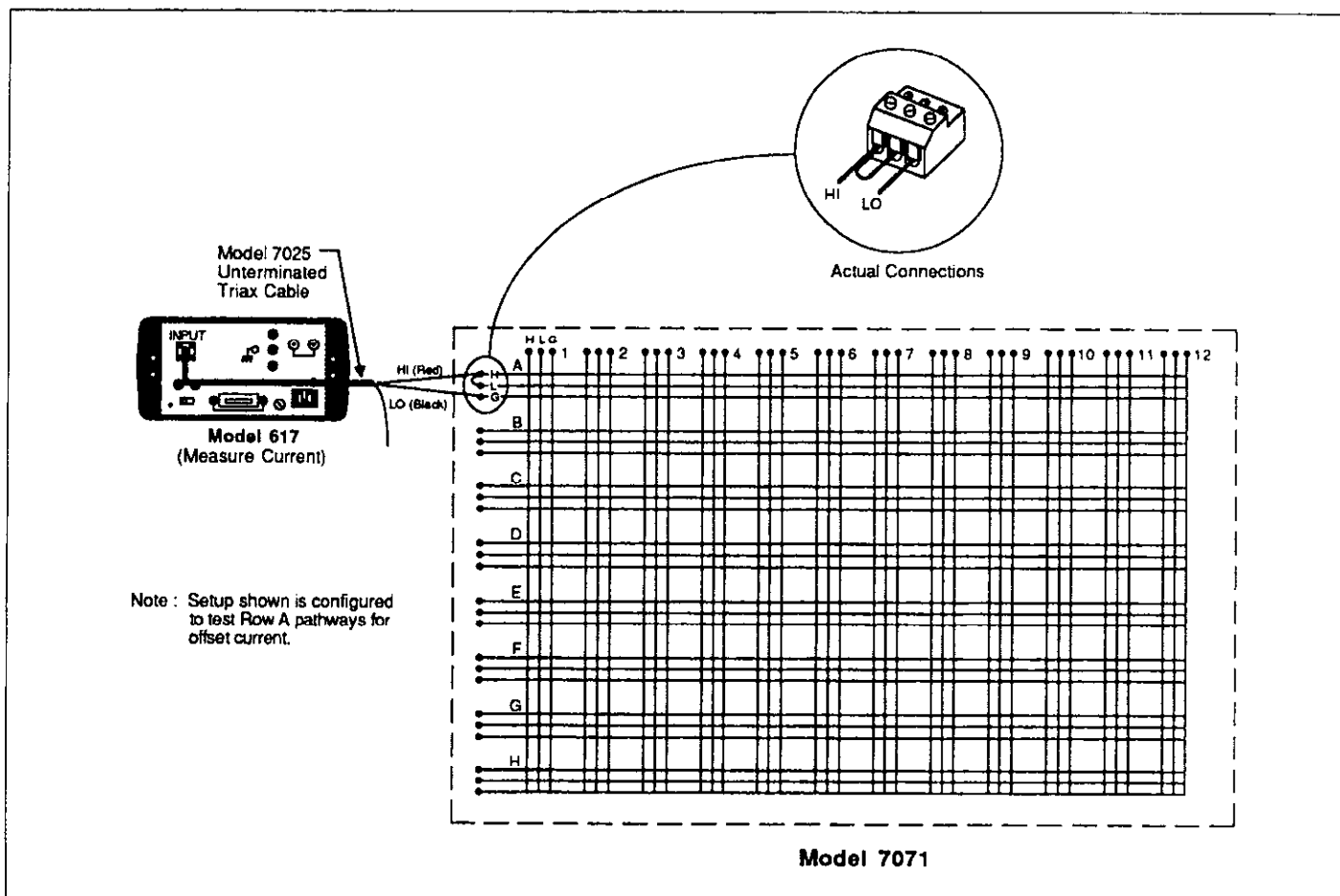


Figure 4-4. Common Mode Offset Current Testing

#### 4.4.5 Contact Potential Tests

These tests check the EMF generated by each relay contact pair (H and L) for each pathway. The tests simply consist of using a nanovoltmeter (Model 181) to measure the contact potential.

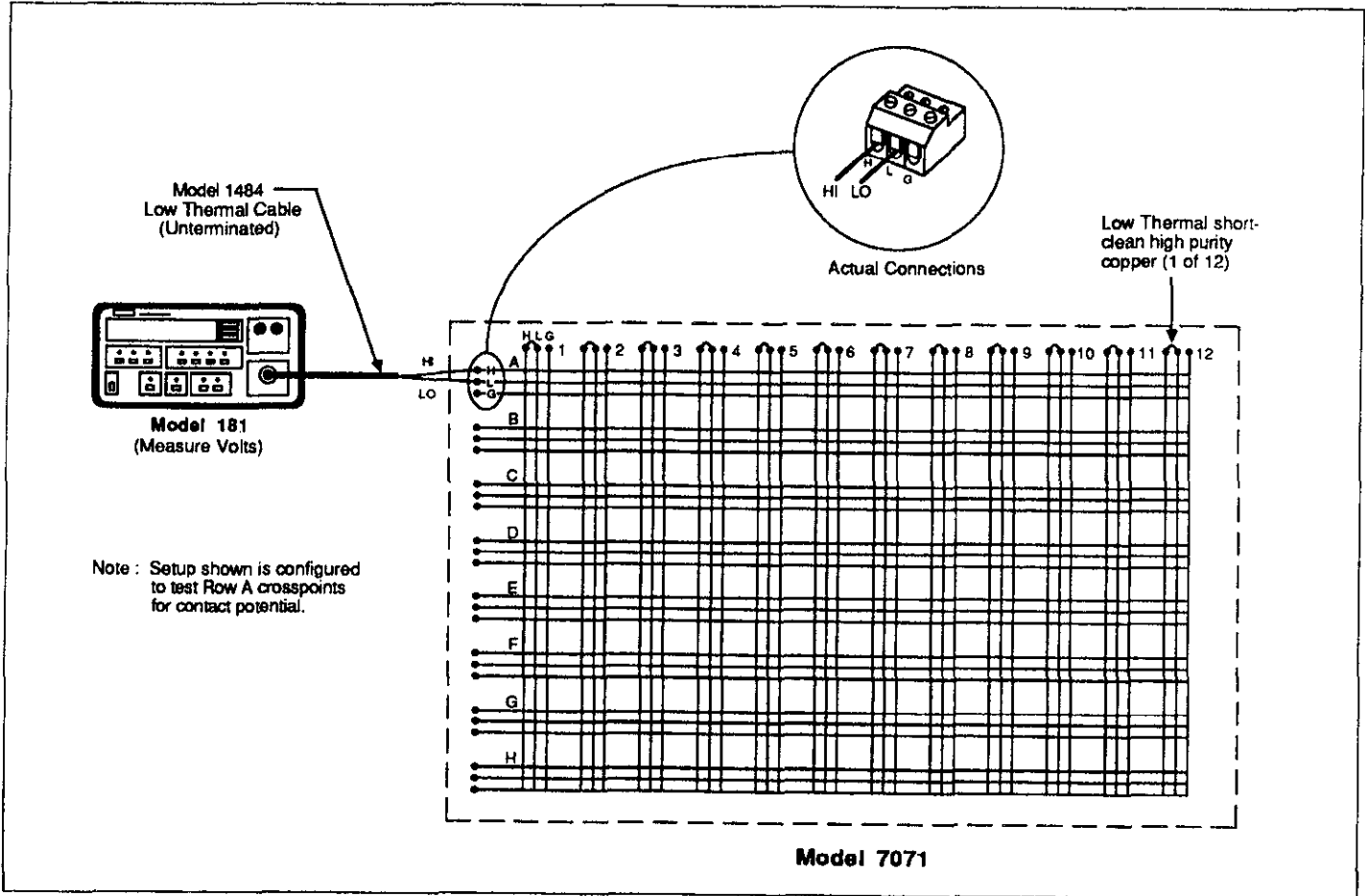
Perform the following procedure to check contact potential of each path:

1. Turn the Model 707 off if it is on.
2. Set the Model 181 to the 2mV range, short the input leads and press ZERO to null out internal offset. Leave ZERO enabled for the entire procedure.
3. Connect the Model 181 to a quick-disconnect terminal block as shown in the illustration caption of Figure 4-5. Do not connect the terminal block to the matrix card at this time.
4. Place the matrix card in slot 1 of the Model 707, but do not slide it all the way into the mainframe.
5. Connect the pre-wired terminal block to ROW A of the matrix card.
6. Feed the test leads through the cable clamp of the matrix card and push the card all the way into the mainframe. Tighten the two spring loaded screws to completely mate the card with the backplane.
7. Turn on the Model 707
8. Program the Model 707 to close crosspoint A1.
9. Verify that the reading on the Model 181 is  $< 5\mu\text{V}$ . This measurement is the contact potential of the pathway.
10. From the Model 707, open crosspoint A1.
11. Repeat the basic procedure in steps 8 through 10 to check the rest of the pathways (crosspoints A2 through A12) of the row.
12. Turn off the Model 707 and slide out the matrix card far enough to gain access to the pre-wired terminal block.

**SERVICE INFORMATION**

13. Move the terminal block down to ROW B and repeat the basic procedure in steps 6 through 11 to check crosspoints B1 through B12.

14. Repeat the basic procedure in steps 12 and 13 for the remaining rows (ROWS C through H).



**Figure 4-5. Contact Potential Testing**

#### 4.4.6 Path Isolation Tests

These tests check the leakage resistance (isolation) between adjacent paths. A path is defined as the high (H), low (L), guard (G) circuit from a row to a column that results by closing a particular crosspoint. In general, the test is performed by applying a voltage (+100V) across two adjacent paths and then measuring the leakage current across the paths. The isolation resistance is then calculated as  $R = V/I$ . In the following procedure, the Model 617 functions as both a voltage source and an ammeter. In the V/I function, the Model 617 internally calculates the resistance from the known voltage and current levels and displays the resistive value.

#### NOTE

Refer to Figure 4-6 for the following procedure.

1. Turn the Model 707 off if it is on.
2. Connect the Model 617 to two quick-disconnect terminal blocks as shown in the illustration. Also, be sure to install the three jumper wires as shown. Do not connect the terminal blocks to the matrix card at this time.
3. On the matrix card, unplug all ROW terminal blocks from the PC board.
4. Place the matrix card in slot 1 of the Model 707, but do not slide it all the way into the mainframe.

#### WARNING

**The following steps use high voltage (100V). Be sure to remove power from the circuit before making connection changes.**

5. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
6. Connect the two pre-wired terminal blocks to ROWS A and B of the matrix card.
7. Feed the test leads through the cable clamp of the matrix card and push the card all the way into the mainframe. Tighten the two spring loaded screws to completely mate the card with the backplane.
8. On the Model 617, select the 20pA range and release zero check.
9. On the Model 617, press suppress to cancel offset current and then enable zero check.
10. On the Model 617, set the voltage source for +100V, and select the 20nA current range. Make sure the voltage source is in standby.
11. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.
12. Turn on the Model 707, and program it to close crosspoints A1 (ROW A, COLUMN 1) and B2 (ROW B, COLUMN 2).
13. On the Model 617, disable zero check and press OPERATE to source 100V.
14. After allowing the reading on the Model 617 to settle, verify that it is  $>10G\Omega$ . This measurement is the leakage resistance (isolation) between ROW A, COLUMN 1 and ROW B, COLUMN 2.
15. Place the Model 617 in standby and enable zero check.
16. Turn off the Model 707, and slide the matrix card approximately six inches out of the mainframe to gain access to the terminal blocks.
17. Move the two pre-wired terminal blocks down one row so that they are located on ROW B and ROW C.
18. Reinstall the matrix card and turn on the Model 707.
19. Program the Model 707 to close crosspoints B2 and C3.
20. On the Model 617, disable zero check and press OPERATE to source 100V.
21. After allowing the reading on the Model 617 to settle, verify that it is  $>10G\Omega$ .
22. Using Table 4-2 as a guide, repeat the basic procedure of steps 15 through 21 for the rest of the path pairs (test numbers 3 through 11 in the table).

Table 4-2. Path Isolation Tests

Test No.	Path Isolation	Test Equipment Location	Crosspoints Closed
1	Row A, col 1 to Row B, col 2	Row A and Row B	A1 and B2
2	Row B, col 2 to Row C, col 3	Row B and Row C	B2 and C3
3	Row C, col 3 to Row D, col 4	Row C and Row D	C3 and D4
4	Row D, col 4 to Row E, col 5	Row D and Row E	D4 and E5
5	Row E, col 5 to Row F, col 6	Row E and Row F	E5 and F6
6	Row F, col 6 to Row G, col 7	Row F and Row G	F6 and G7
7	Row G, col 7 to Row H, col 8	Row G and Row H	G7 and H8
8	Row G, col 8 to Row H, col 9	Row G and Row H	G8 and H9
9	Row G, col 9 to Row H, col 10	Row G and Row H	G9 and H10
10	Row G, col 10 to Row H, col 11	Row G and Row H	G10 and H11
11	Row G, col 11 to Row H, col 12	Row G and Row H	G11 and H12

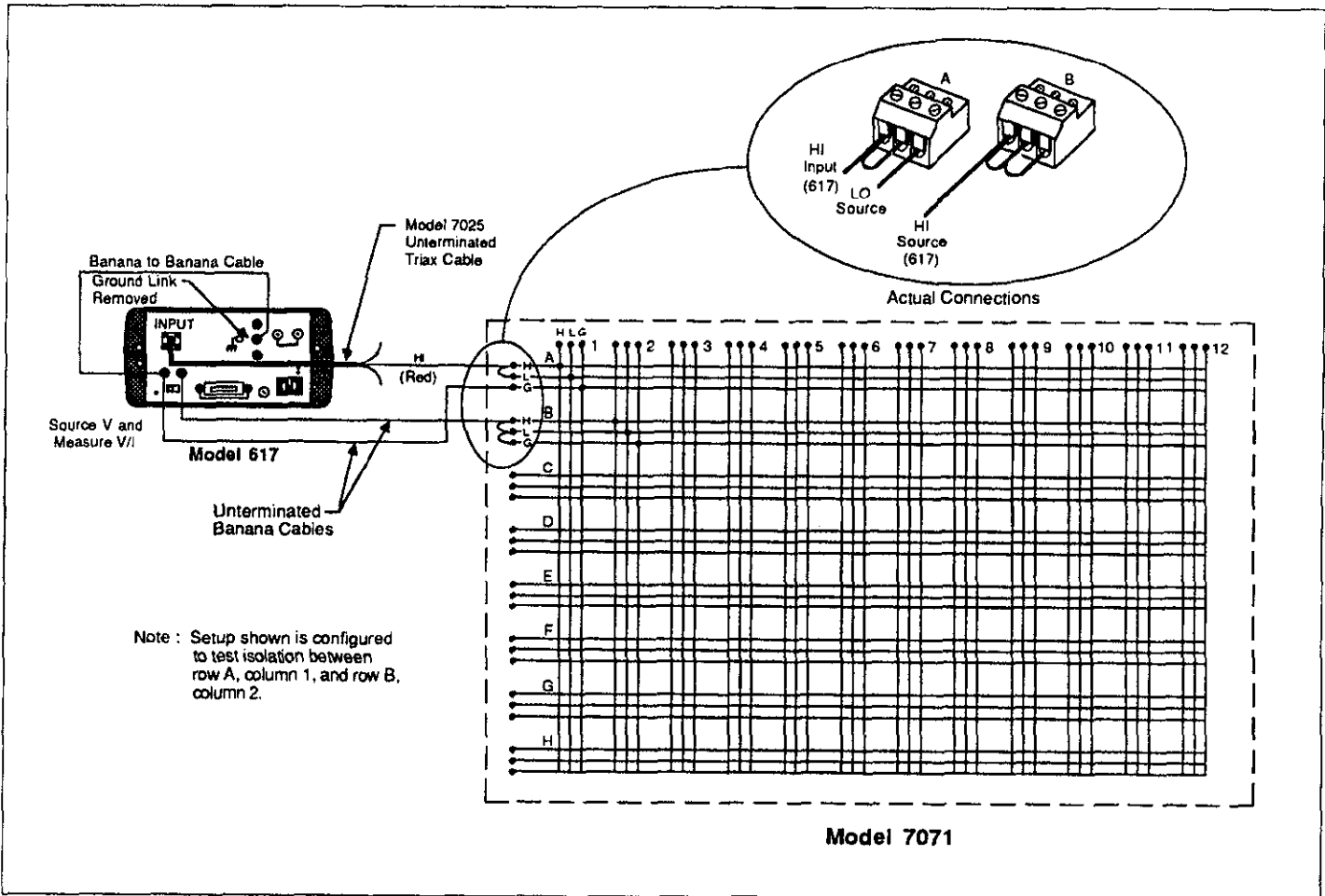


Figure 4-6. Path Isolation Testing (Guarded)

#### 4.4.7 Differential and Common Mode Isolation Tests

These tests check the leakage resistance (isolation) between high (H) and low (L) (differential), and from high and low to guard (G) (common mode) of every row and column. In general, the test is performed by applying a voltage (100V) across the terminals and then measuring the leakage current. The isolation resistance is then calculated as  $R = V/I$ . In the following procedure, the Model 617 functions as a voltage source and an ammeter. In the V/I function, the Model 617 internally calculates the resistance from the known voltage and current levels and displays the resistance value.

1. Turn the Model 707 off if it is on.
2. Connect the Model 617 to a quick-disconnect terminal block as shown in Figure 4-7. Do not connect the terminal blocks to the matrix card at this time.
3. Place the matrix card in slot 1 of the Model 707, but do not slide it all the way into the mainframe.

#### WARNING

The following steps use high voltage (100V). Be sure to remove power from the circuit before making connection changes.

4. On the Model 617, select the 2pA range, and enable zero check and zero correct in that order. Leave zero correct enabled for the entire procedure.
5. On the Model 617, set the voltage source for +100V, and select the 200nA current range. Make sure the voltage source is still in standby.
6. Place the Model 617 in the V/I measurement function by pressing SHIFT OHMS.
7. With the Model 617 in standby, connect the pre-wired terminal block to ROW A of the matrix card.
8. Feed the test leads through the cable clamp of the matrix card and push the card all the way into the mainframe. Tighten the two spring loaded screws to completely mate the card with the backplane.
9. Turn on the Model 707, but do not program any crosspoints to close. All crosspoints must be open.
10. On the Model 617, disable zero check and press OPERATE to source 100V.

11. After allowing the reading on the Model 617 to settle, verify that it is  $>1G\Omega$ . This measurement is the leakage resistance (isolation) of ROW A.
12. Place the Model 617 in standby and enable zero check.
13. Program the Model 707 to close crosspoint A1.
14. On the Model 617, disable zero check and press OPERATE to source 100V.
15. After allowing the reading on the Model 617 to settle, verify that it is also  $>1G\Omega$ . This measurement checks the isolation of COLUMN 1.
16. Using Table 4-3 as a guide, repeat the basic procedure of steps 12 through 15 for the rest of the columns and rows (test numbers 3 through 20 of the table).
17. Turn the Model 707 off and slide the matrix card out of the mainframe far enough to gain access to the prewired terminal block.
18. Remove the terminal block from the matrix card and rewire the it as shown in Figure 4-8.
19. Repeat steps 7 through 16 to check common mode isolation.

Table 4-3. Differential and Common Mode Isolation Test

Test No.	Differential or Common Mode Test	Crosspoints Closed
1	ROW A	None
2	COLUMN 1	A1
3	COLUMN 2	A2
4	COLUMN 3	A3
5	COLUMN 4	A4
6	COLUMN 5	A5
7	COLUMN 6	A6
8	COLUMN 7	A7
9	COLUMN 8	A8
10	COLUMN 9	A9
11	COLUMN 10	A10
12	COLUMN 11	A11
13	COLUMN 12	A12
14	ROW B	A1 and B1
15	ROW C	A1 and C1
16	ROW D	A1 and D1
17	ROW E	A1 and E1
18	ROW F	A1 and F1
19	ROW G	A1 and G1
20	ROW H	A1 and H1

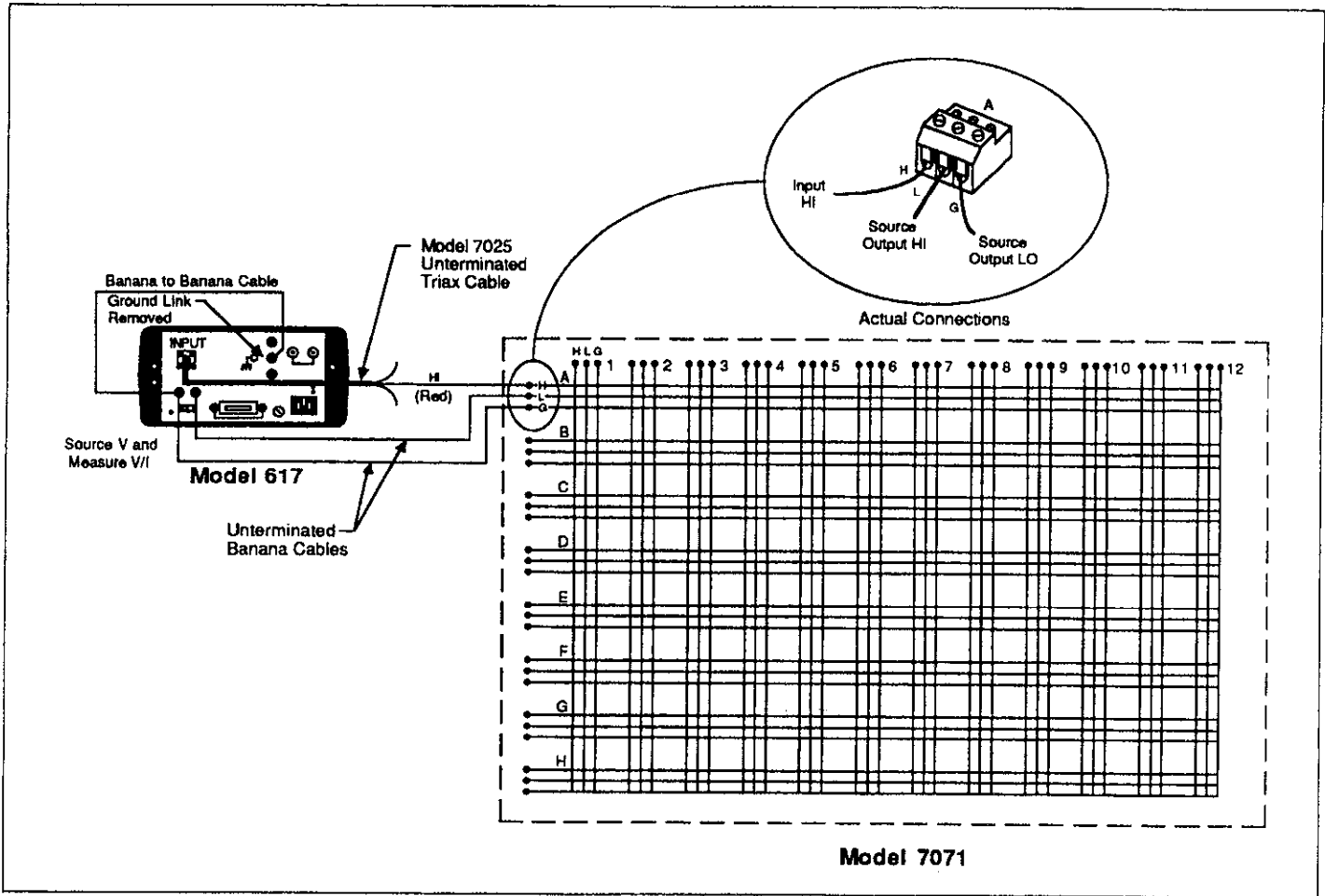


Figure 4-7. Differential Isolation Testing

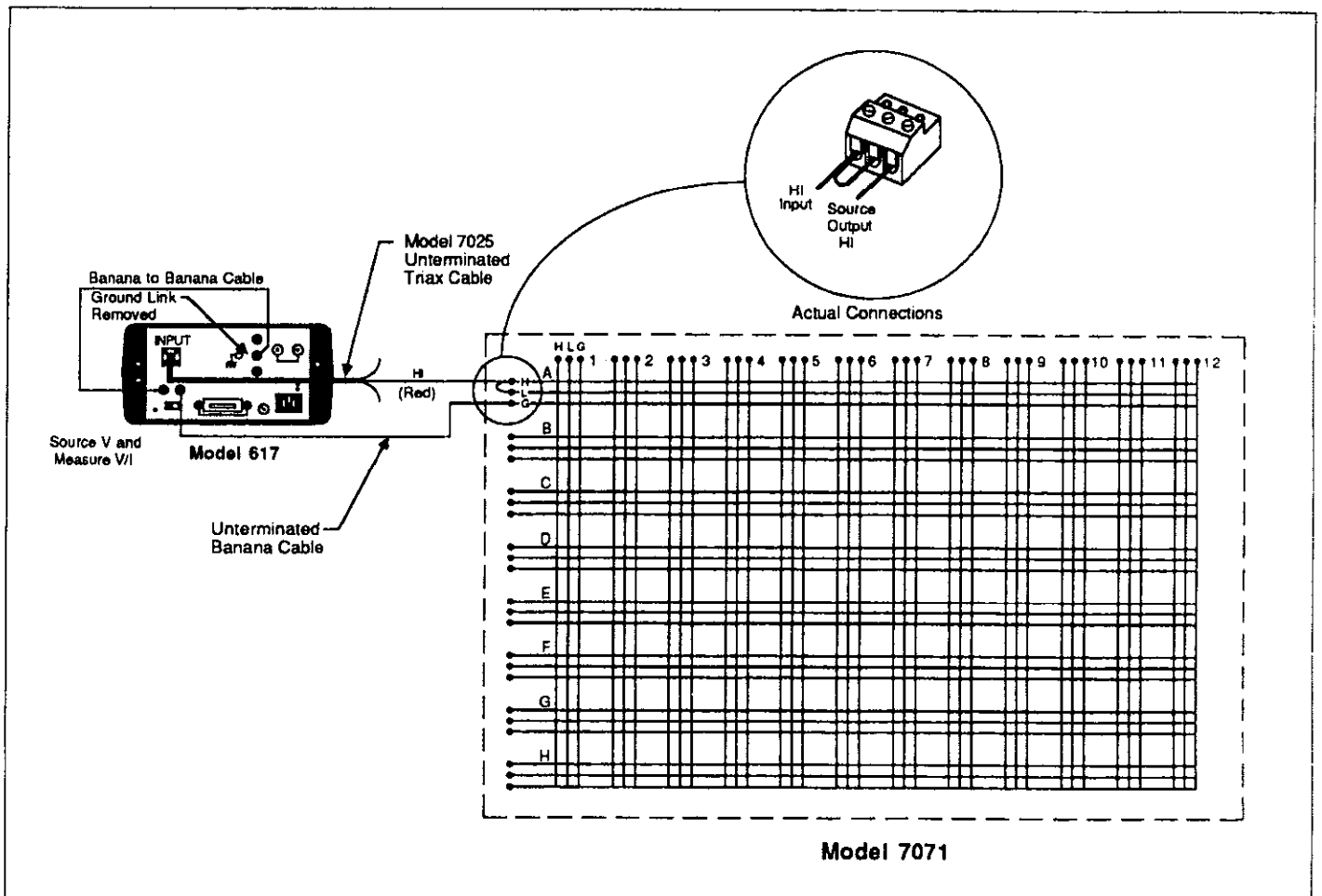


Figure 4-8. Common Mode Isolation Testing

## 4.5 PRINCIPLES OF OPERATION

The paragraphs below discuss the basic operating principles for the Model 7071 and can be used as an aid in troubleshooting the matrix card. The schematic drawing of the matrix card is shown on drawing number 7071-106, located at the end of Section 5.

### 4.5.1 Card Identification

Identification coding and a matrix configuration table is stored in an erasable programmable read-only memory (EPROM). This information is sent to the Model 707 so that it "knows" which type of matrix card is installed in that

particular mainframe slot. This enables the Model 707 to send valid configuration data to the matrix card.

On power up, control line CARDSEL goes low turning on the EPROM (U27). That control line, as well as the other control lines from the Model 707, are buffered by U44. Lines CLK, NEXT ADDR and CLR ADDR along with counter U45 control the task of loading data from the EPROM into the parallel to serial shift register (U43). Data sent from U47 to the Model 707 via the IDDATA line is strobed by the CLK control line. The timing diagram in Figure 4-9, shows the first byte of identification data during the transfer sequence. For subsequent bytes, the CLRADDR line stays low.



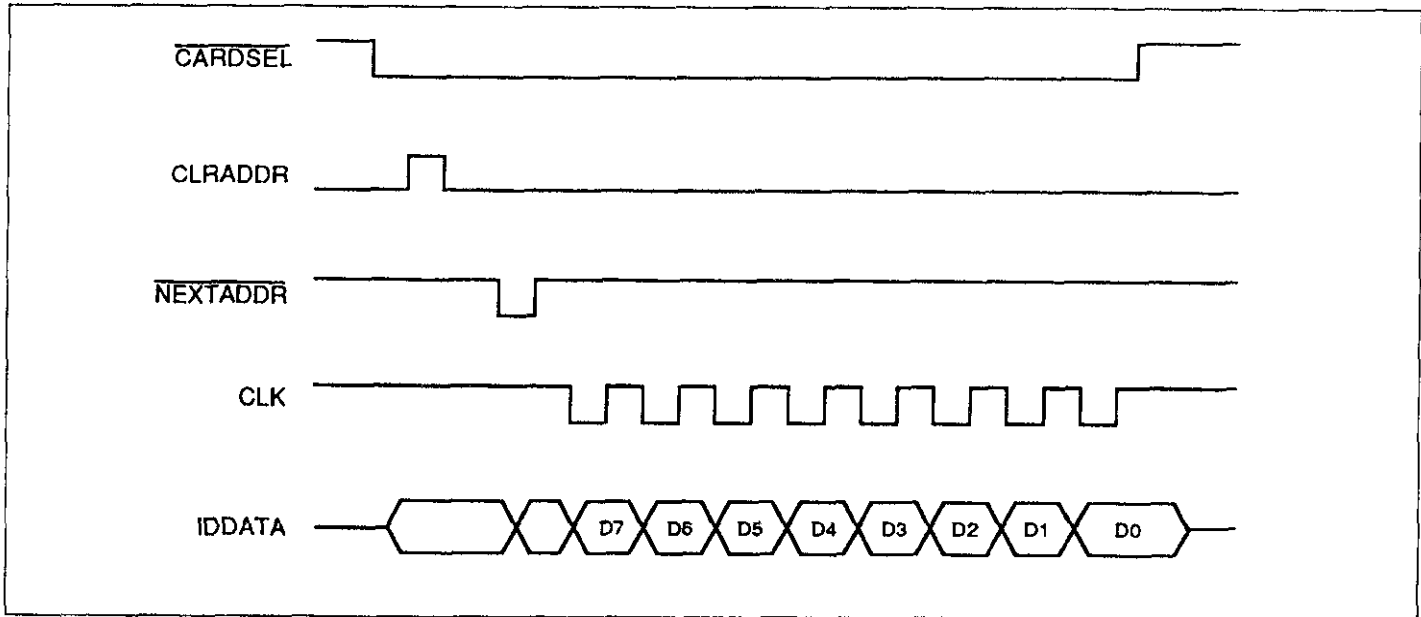


Figure 4-9. IDDATA Timing Diagram

#### 4.5.2 Switching Circuitry

Matrix configuration data is sent from the Model 707 via the RELAY DATA control line and serially loaded into the 12 shift registers (U30 through U41). The matrix card relays configure accordingly when the registers receive the STROBE signal from the Model 707. A relay is energized when a register output is low (connected to digital common). A register output is low when a "high" data bit is clocked into it (i.e. inverting drivers).

#### 4.5.3 Power Up Safeguard

To prevent relays from inadvertently energizing and causing possible damage during power up, a safeguard circuit has been incorporated into the design. The protection circuit is comprised of a dual NAND gate (U42) and an RC network (R1, C20 and CR1). The time constant of the RC network keeps the the output of the NAND gate high during the power up sequence. This high signal is applied to the OEN input of the shift registers keeping the relays de-energized. After the capacitor of the RC network charges, a STROBE signal will then force the output of the NAND gate low allowing configured relays to energize.

#### 4.6 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

CMOS and other high-impedance devices are subject to possible static discharge damage because of the high-impedance levels involved. The following precautions pertain specifically to static-sensitive devices. However, since many devices in the Model 7071 are static-sensitive, it is recommended that they all be treated as static-sensitive.

1. Such devices should be transported and handled only in containers specially designed to prevent or dissipate static build-up. Typically, these devices will be received in anti-static containers made of plastic or foam. Keep these parts in their original containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Also ground yourself with a suitable wrist strap while working with these devices.
3. Handle the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must first be grounded to the bench or table.
5. Use only anti-static type de-soldering tools and grounded-tip soldering irons.

## 4.7 TROUBLESHOOTING

The Keithley Model 7070 Universal Adapter Card is an extender card that allows access to circuit components of the Model 7071 during troubleshooting. Also, Figure 4-10, which provides receptacle contact identification, is included as a troubleshooting aid.

### 4.7.1 Recommended Equipment

Table 4-4 summarizes the equipment necessary for general troubleshooting.

### 4.7.2 Troubleshooting Procedure

In order to service the matrix card, it may be necessary to remove the rear shield. Referring to Figure 4-11, perform the following procedure to remove and reinstall the rear shield:

1. Disconnect the jumper wire from the matrix card chassis. The wire is secured to the matrix card chassis with a screw.
2. The rear shield is secured to the matrix card by eight standoffs. Carefully slide the rear shield upward until the eight standoffs align with the large clearance holes in the shield and remove the shield.
3. To reinstall the shield, reverse the above procedure. Make sure the metal side of the shield is facing outward.

#### CAUTION

Failure to observe the following precautions could result in damage not covered by the warranty:

1. The shield must be installed such that the metal side is facing away from the matrix card. Backward installation will cause PC board connections to short out against the metal shield.
2. The jumper wire must be connected as shown in order to provide circuit protection from static discharge.

**Table 4-4.**  
**Recommended Troubleshooting Equipment**

Description	Application
DMM (Keithley 196)	Measure DC voltage
Dual-trace, triggered sweep oscilloscope, DC to 50MHz	Check clock and logic pulses
Extender Card (Keithley 7070)	Allow circuit access

Table 4-5 outlines the troubleshooting procedure for the matrix card.

#### CAUTION

Contamination will degrade the performance of the matrix card. To avoid contamination, always grasp the card by the handle and side edges. Do not touch the edge connectors of the card, and do not touch the board surfaces or components. On "rack and panel" connectors and quick disconnect terminal blocks, do not touch areas adjacent to the electrical contacts.

**Table 4-5. Troubleshooting Summary\***

Step	Item/Component	Comment	Required Condition
1	TP1	+6V supply	+6V DC
2	TP3	+5V supply	+5V DC
3	TP5	CLR ADDR line**	High logic pulse at beginning of each card identification byte transfer sequence (upon power up).
4	TP4	NEXT ADDR line**	Low logic pulse before each byte transfer.
5	TP9	CLK line	1.79MHz clock
6	TP6	IDDATA line**	Card identification logic pulse train (on power up).
7	TP10	Power up safeguard	Remains high during power up
8	TP8	RELAY DATA line	Logic pulse train to load relay configuration registers.
9	TP7	STROBE line	High logic pulse to strobe relay configuration registers.
10	U30 thru U41, pins 11 thru 18	Relay Drivers	+6V for open crosspoints ≈ 0V for closed crosspoints

\*All measurements referenced to digital common (TP2)

\*\*See Figure 4-9

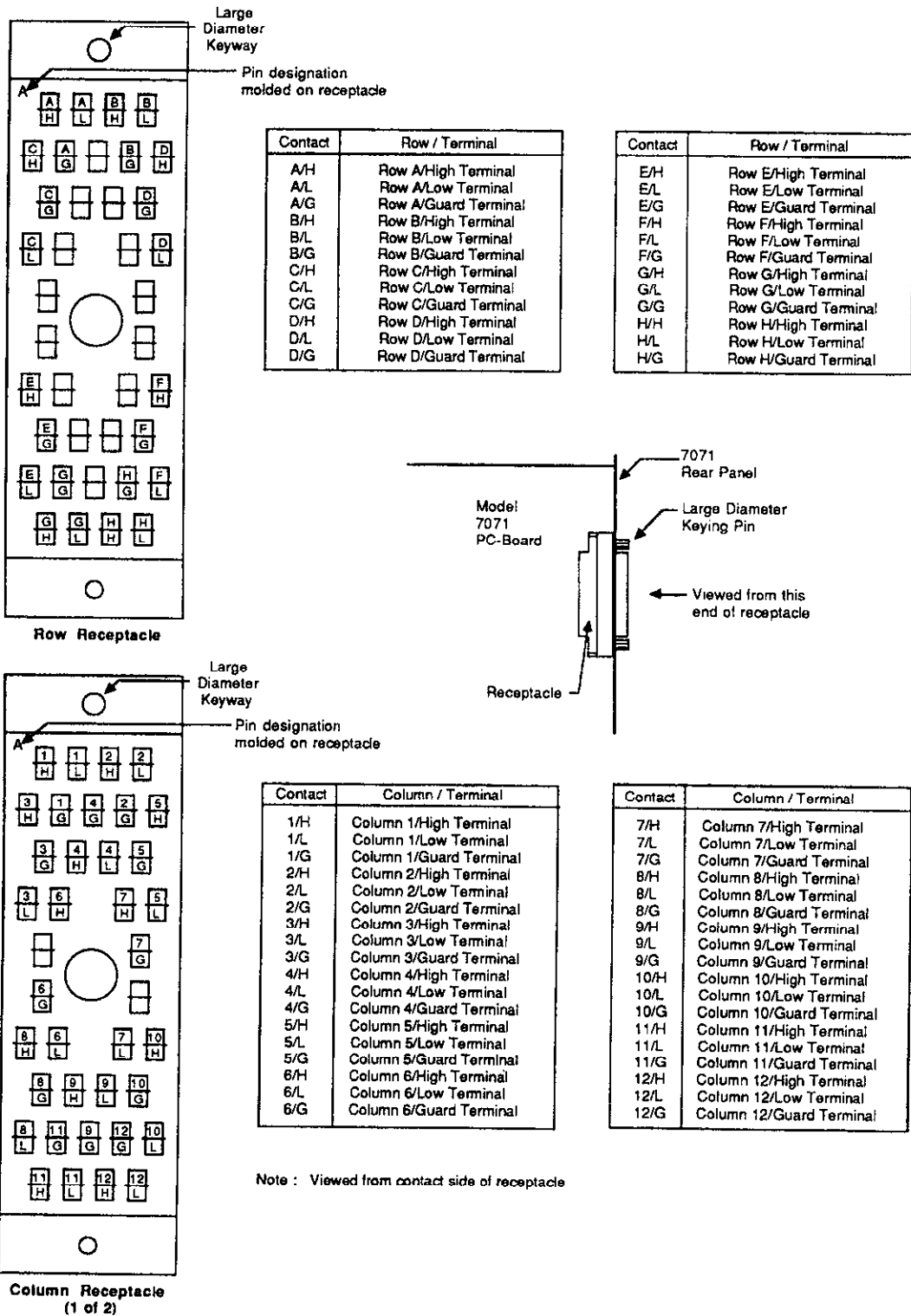


Figure 4-10. Receptacle Contact Identification

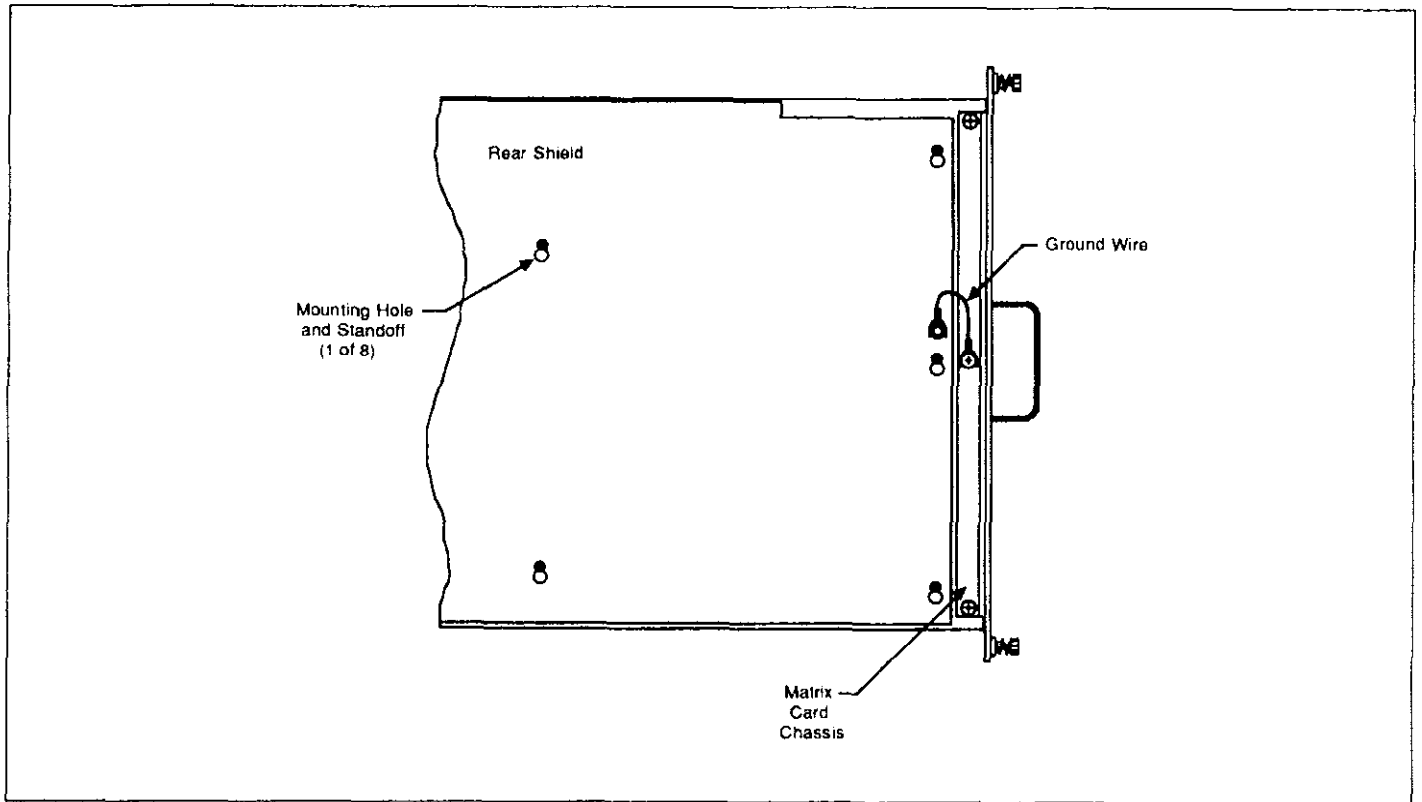


Figure 4-11. Rear Shield

# SECTION 5

## Replaceable Parts

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### 5.1 INTRODUCTION

This section contains a list of replaceable electrical and mechanical parts for the Model 7071, as well as a component layout drawing and schematic diagram of the matrix card.

### 5.2 PARTS LISTS

Electrical parts are listed in order of circuit designation in Table 5-1. Table 5-2 summarizes miscellaneous parts.

### 5.3 ORDERING INFORMATION

To place a parts order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see the inside front cover for addresses). When ordering parts, be sure to include the following information:

1. Matrix card model number (7071)
2. Card serial number

3. Part description
4. Circuit description, if applicable
5. Keithley part number

### 5.4 FACTORY SERVICE

If the matrix card is to be returned to Keithley Instruments for repair, perform the following:

1. Complete the service form at the back of this manual and include it with the card.
2. Carefully pack the card in the original packing carton.
3. Write ATTENTION REPAIR DEPT on the shipping label.

Note: It is not necessary to return the matrix mainframe with the card.

### 5.5 COMPONENT LAYOUT AND SCHEMATIC DIAGRAM

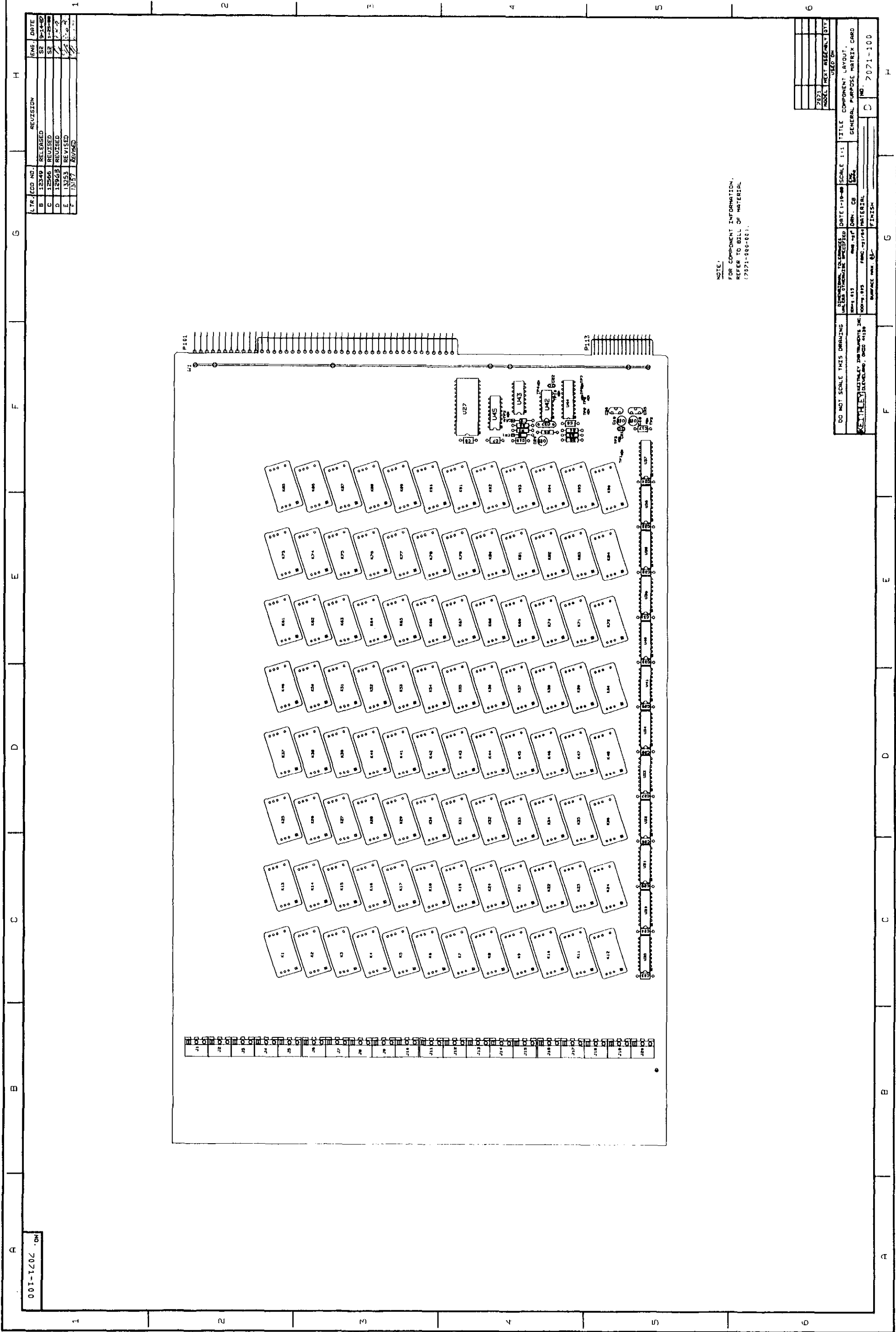
Figure 5-1 shows a component layout of the Model 7071, while Figure 5-2 shows a schematic diagram.

**TABLE 5-1. MODEL 7071, PARTS LIST**

CIRCUIT DESIG.	DESCRIPTION	KEITHLEY PART NO.
C18..C19	CAP,10uF,-20+100%,25V,ALUM ELEC	C-314-10
C20	CAP,47uF,10%,16V,ALUM ELEC	C-321-47
C21,C22	CAP,.01uF,20%,50V,CERAMIC	C-237-.01
C23..C34		
C35,C36	CAP,270pF,20%,100V,CERAMIC/FERRITE	C-386-270P
C37	CAP,.01uF,10%,1000V,CERAMIC	C-64-.01
C6..C8,C16,C17,	CAP,.1uF,20%,50V,CERAMIC	C-365-.1
CR1	DIODE,SILICON,1N4148 (DO-35)	RF-28
CR2	DIODE,SCHOTTKY,1N5711	RF-69
J1..J20	CONN,3 PIN	CS-570-3
J21,J22	SOCKET,CONNECTOR	CS-593
K1..K96	RELAY	RL-67
R1	RES,47K,5%,1/4W,COMPOSITION OR FILM	R-76-47K
R2	RES,10K,5%,1/4W,COMPOSITION OR FILM	R-76-10K
R3	RES,120K,5%,1/4W,COMPOSITION OR FILM	R-76-120K
R4	RES,11K,5%,1/4W,COMPOSITION OR FILM	R-76-11K
R5	RES,910,5%,1/4W,COMPOSITION OR FILM	R-76-910
R6	RES,200,5%,1/4W,COMPOSITION OR FILM	R-76-200
TP1..TP10	CONN,TEST POINT	CS-553
U27	PROGRAM	7071-800
U30..U41	IC,8-BIT SERIAL-IN/LTCH DRIVE,UCN-5841A	IC-536
U42	IC,QUAD 2 INPUT NAND,74HCT00	IC-399
U43	IC,8 BIT PARALLEL TO SERIAL,74HCT165	IC-548
U44	IC,OCTAL BUFFER/LINE DRIVER,74HCT244	IC-489
U45	IC,12 STAGE BINARY COUNTER,74HCT4040	IC-545
W1	STIFFENER,BOARD	J-16

**TABLE 5-2. MODEL 7071, MISCELLANEOUS, PARTS LIST**

QUANTITY	DESCRIPTION	KEITHLEY PART NO.
2	UPPER CLAMP ASSEMBLY	-
2	UPPER CLAMP	7071-305
2	RUBBER STRIP	7071-307-1
2	LOWER CLAMP ASSEMBLY	-
2	LOWER CLAMP	7071-306
2	RUBBER STRIP	7071-307-1
1	HANDLE	HH-33-1
1	CONNECTOR STRIP	CS-576-60
1	SOCKET (FOR U27)	SO-69
1	SHIELD, REAR	7071-311
8	STANDOFFS	7071-310



001-1202 .0H

LTR. FCC NO.	REVISION	ENG.	DATE
B 12349	RELEASED	SP	9-14-60
C 12566	REVISED	SP	1-25-61
D 12943	REVISED	SP	7-17-62
E 13253	REVISED	SP	3-26-63
F 13577	REVISED	SP	7-1-63

NOTE:  
FOR COMPONENT INFORMATION,  
REFER TO BILL OF MATERIAL  
(7071-000-02).

DO NOT SCALE THIS DRAWING UNLESS OTHERWISE SPECIFIED	DATE 1-19-60	SCALE 1:1	TITLE
DESIGNED BY: J. W. BROWN	DATE: 1-19-60	SCALE: 1:1	TITLE: COMPONENT LAYOUT
DRAWN BY: J. W. BROWN	DATE: 1-19-60	SCALE: 1:1	GENERAL PURPOSE MATRIX CARD
CHECKED BY: J. W. BROWN	DATE: 1-19-60	SCALE: 1:1	
APPROVED BY: J. W. BROWN	DATE: 1-19-60	SCALE: 1:1	
MATERIAL			NO. 7071-100
FINISH			

Figure 5-1. Model 7071 Component Location Drawing, Dwg. No. 7071-100



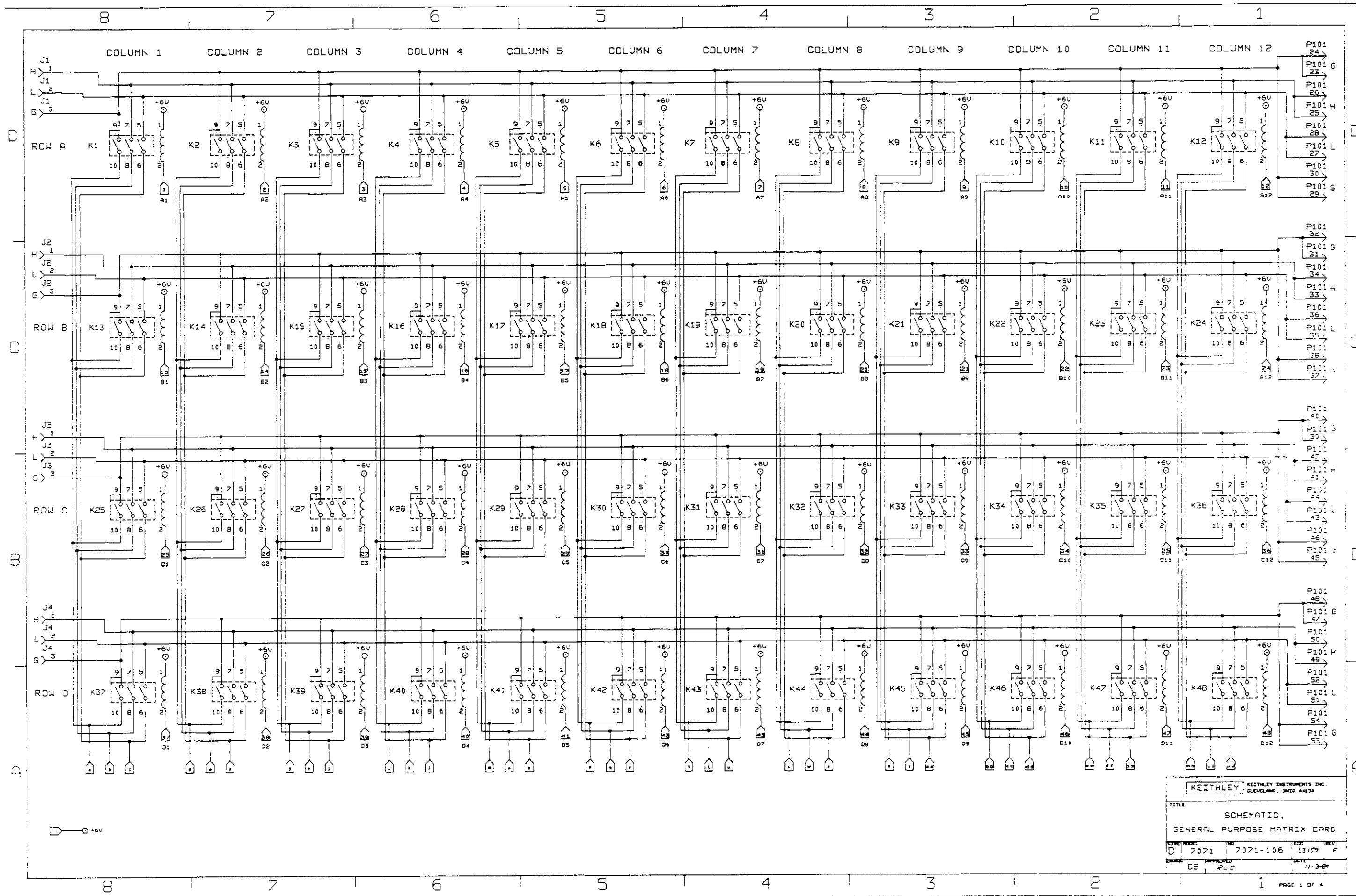
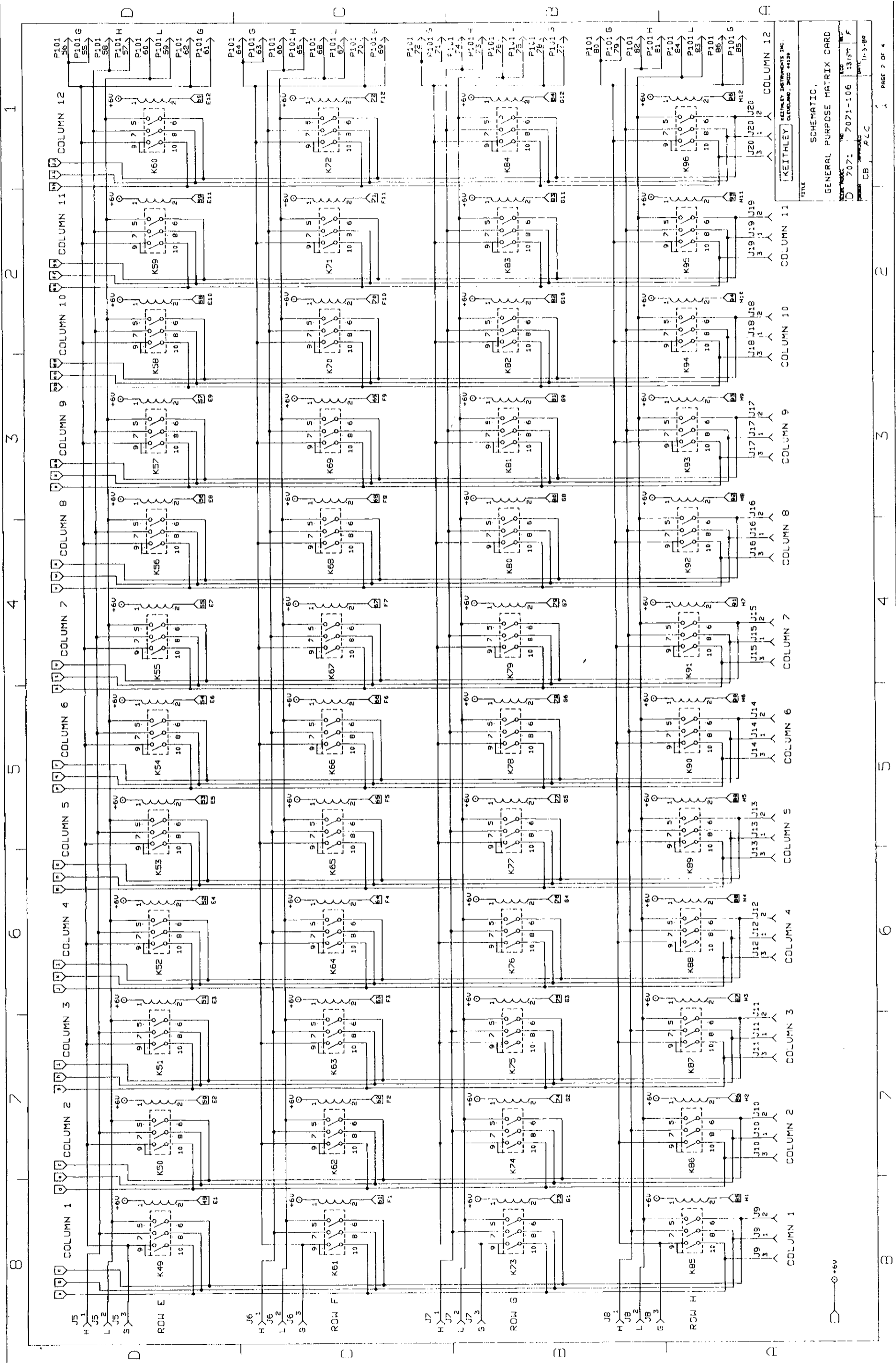
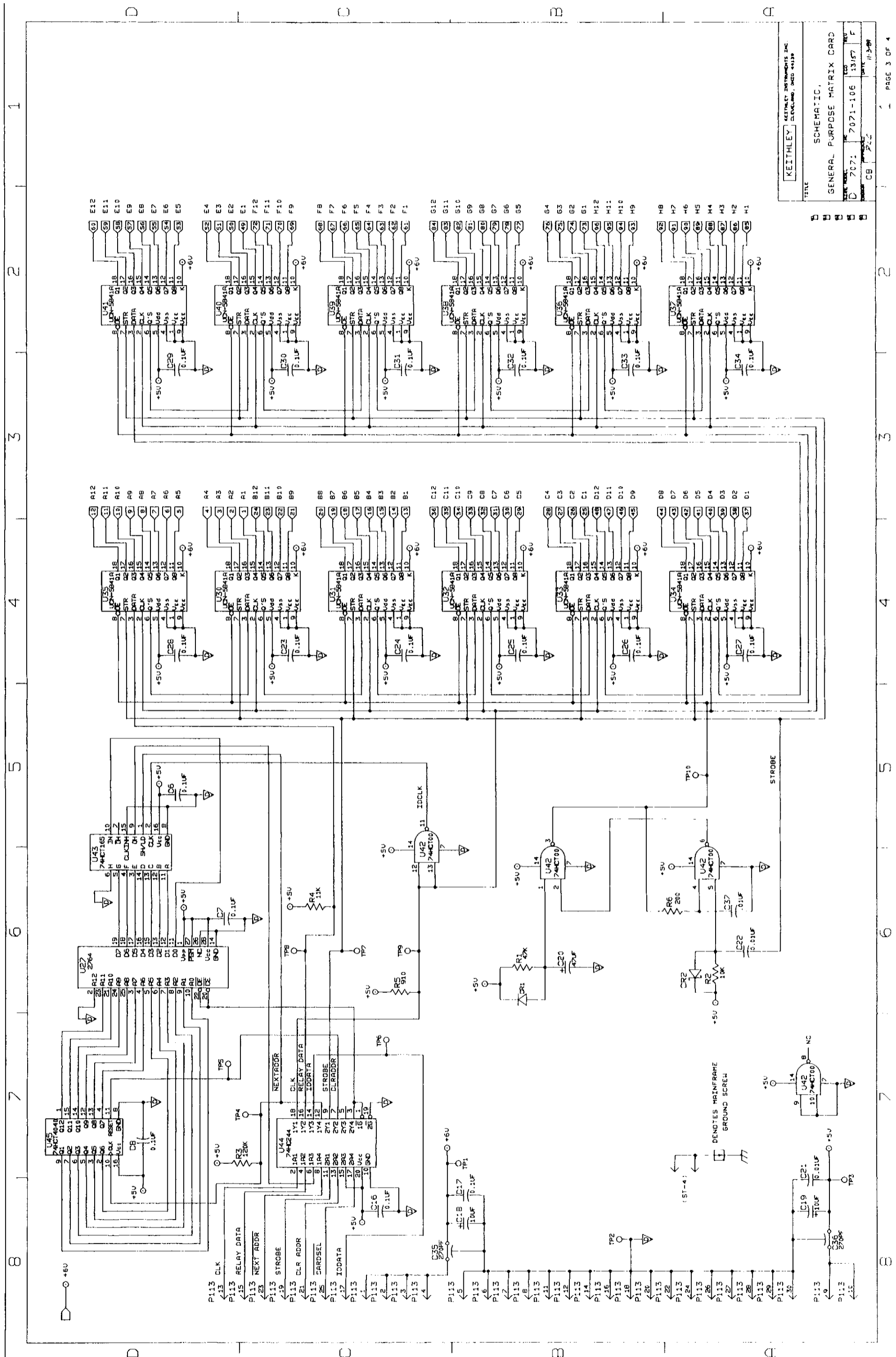


Figure 5-2. Model 7071 Schematic Diagram, Dwg. No. 7071-106 (sheet 1 of 4)



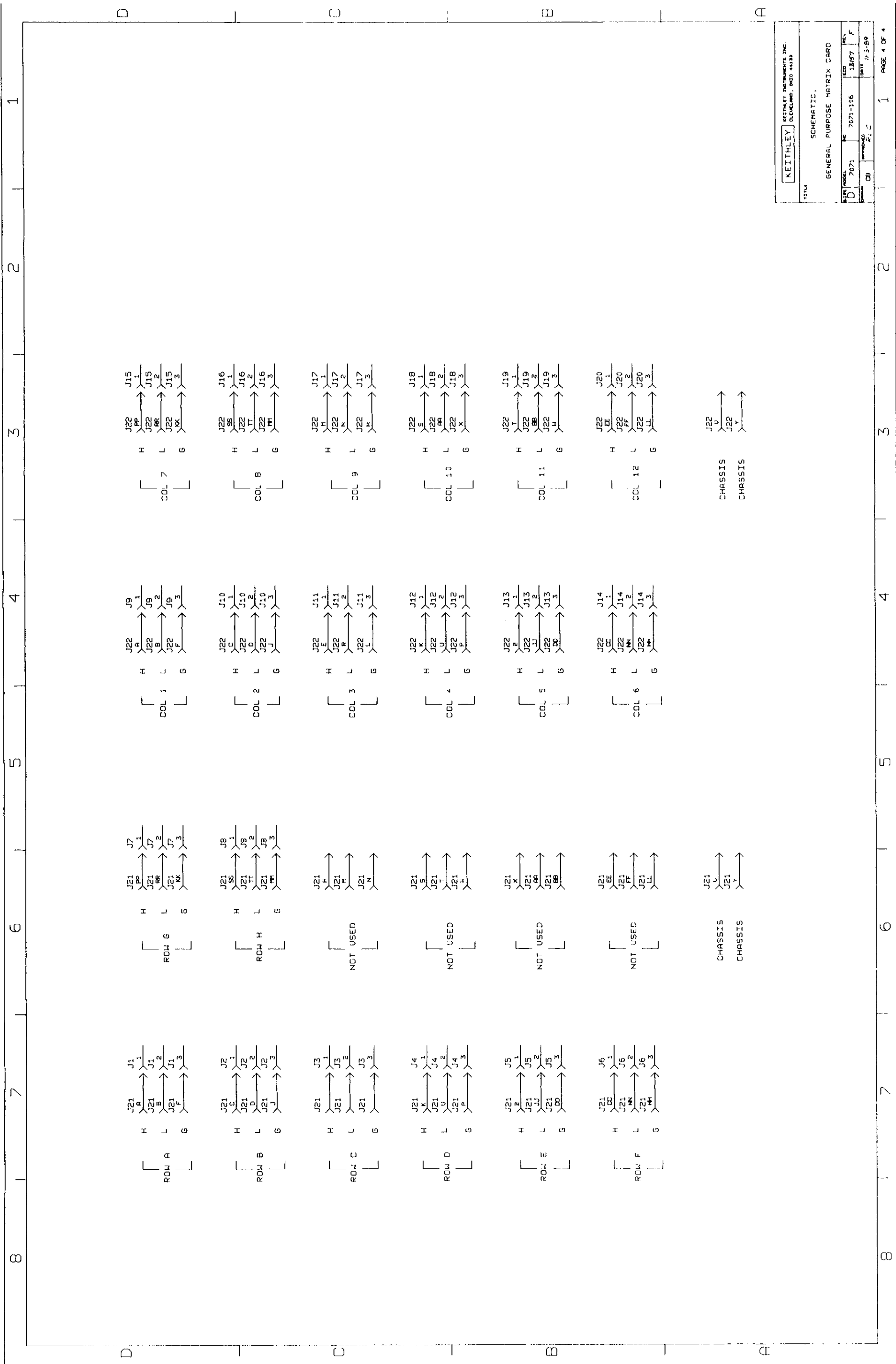
KEITHLEY INSTRUMENTS INC.  
 GENERAL PURPOSE MATRIX CARD  
 MODEL 7071  
 D 7071-106  
 13157  
 F  
 CB #2C  
 1-5-89

Figure 5-2. Model 7071 Schematic Diagram, Dwg. No. 7071-106  
 (Sheet 2 of 4)



KEITHLEY ELECTRIC INSTRUMENTS INC.  
 GENERAL PURPOSE MATRIX CARD  
 7071-106  
 CB 2-5  
 11-3-89

Figure 5-2. Model 7071 Schematic Diagram, Dwg. No. 7071-106 (sheet 3 of 4)



KEITHLEY INSTRUMENTS INC.		CLEVELAND, OHIO 44139	
SCHEMATIC			
GENERAL PURPOSE MATRIX CARD			
DATE	NO.	REV.	DATE
7-3-89	7071-106	13057	F
DB	REVISED	DATE	7-3-89

Figure 5-2. Model 7071 Schematic Diagram, Dwg. No. 7071-106 (sheet 4 of 4)



# Service Form

Model No. \_\_\_\_\_ Serial No. \_\_\_\_\_ Date \_\_\_\_\_

Name and Telephone No. \_\_\_\_\_

Company \_\_\_\_\_

List all control settings, describe problem and check boxes that apply to problem. \_\_\_\_\_

- |  |  |  |
|--|--|--|
| <input type="checkbox"/> Intermittent            | <input type="checkbox"/> Analog output follows display   | <input type="checkbox"/> Particular range or function bad; specify _____ |
| <input type="checkbox"/> IEEE failure            | <input type="checkbox"/> Obvious problem on power-up     | <input type="checkbox"/> Batteries and fuses are OK                      |
| <input type="checkbox"/> Front panel operational | <input type="checkbox"/> All ranges or functions are bad | <input type="checkbox"/> Checked all cables                              |

Display or output (check one)

- |                                   |  |
|-----------------------------------|--|
| <input type="checkbox"/> Drifts   | <input type="checkbox"/> Unable to zero              |
| <input type="checkbox"/> Unstable | <input type="checkbox"/> Will not read applied input |
| <input type="checkbox"/> Overload |  |

- |   |  |
|---|--|
| <input type="checkbox"/> Calibration only | <input type="checkbox"/> Certificate of calibration required |
| <input type="checkbox"/> Data required    |  |

(attach any additional sheets as necessary)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)

\_\_\_\_\_

What power line voltage is used? \_\_\_\_\_ Ambient temperature? \_\_\_\_\_ °F

Relative humidity? \_\_\_\_\_ Other? \_\_\_\_\_

Any additional information. (If special modifications have been made by the user, please describe.)

\_\_\_\_\_

Be sure to include your name and phone number on this service form.



**KEITHLEY**

**Keithley Instruments, Inc.**  
28775 Aurora Road  
Cleveland, Ohio 44139  
Printed in the U.S.A.