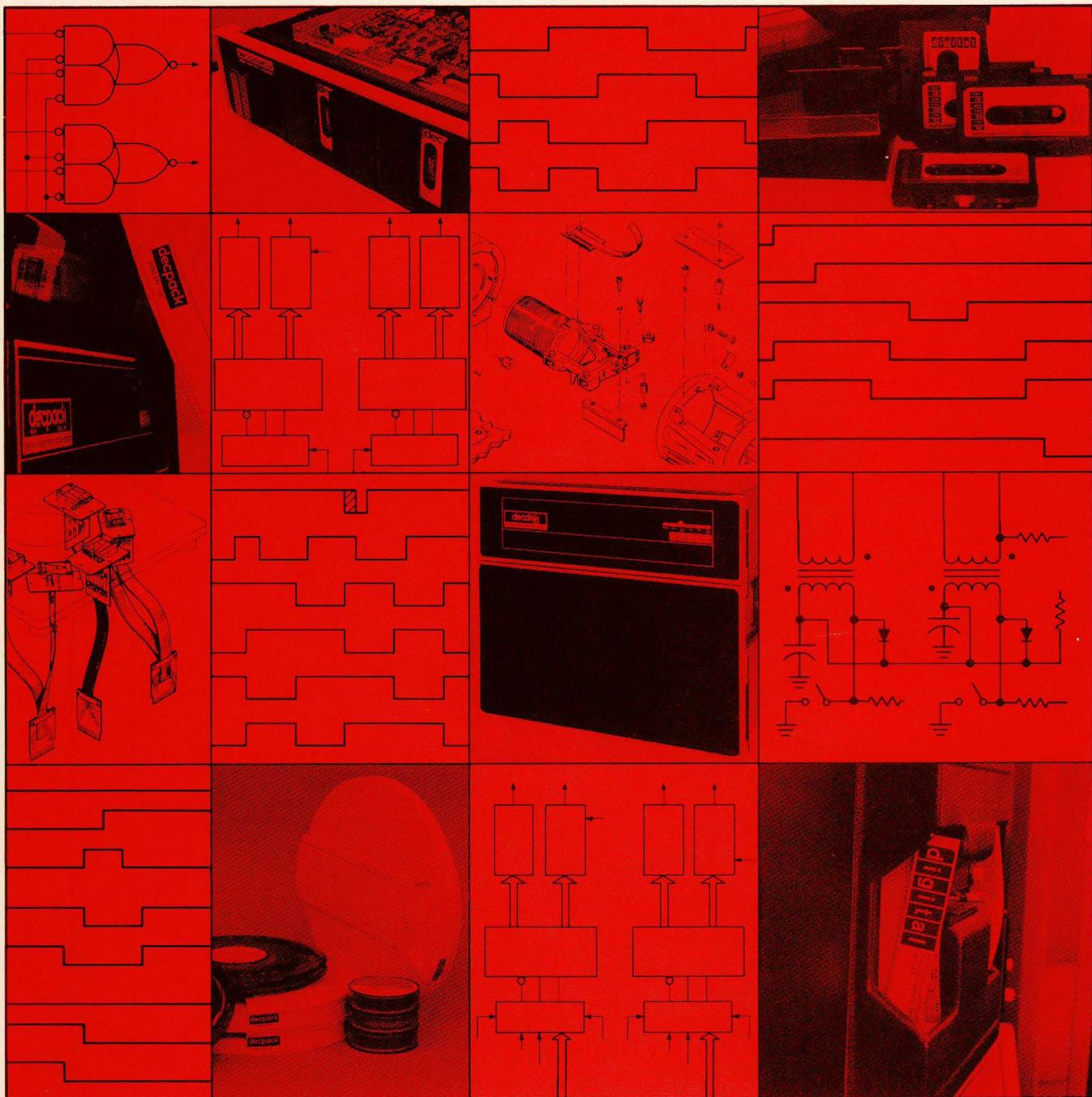


digital

RK05 disk drive user's manual



digital equipment corporation • maynard, massachusetts

RK05 disk drive user's manual

EK-RK05-OP-001

Copyright © 1976 by Digital Equipment Corporation

This material is the property of Digital Equipment Corporation
and contains trade secrets of Digital Equipment Corporation.

Digital Equipment Corporation reserves the right to make
changes and/or improvements at any time without notice or obligation.

Printed in U.S.A.

The following are trademarks of Digital Equipment:
Connection, Massey, MessageMaster.

UNIBUS	DECsystem-10	DECTERMINANT	DECTERMINANT-8	DECCOMM	DECCOMM	DECtape	DECtape
NETS	WASSERS	TAPESERIAL	TAPESERIAL-8	RS232	RS232	RS232	RS232

digital equipment corporation • maynard, massachusetts

REK02 disk drive
user's manual

EK-RK02-OP-001

Copyright © 1976 by Digital Equipment Corporation

The material in this manual is for informational purposes and is subject to change without notice.

Digital Equipment Corporation assumes no responsibility for any errors which may appear in this manual.

Printed in U.S.A.

The following are trademarks of Digital Equipment Corporation, Maynard, Massachusetts:

DEC	DECtape	PDP
DECCOMM	DECUS	RSTS
DECsystem-10	DIGITAL	TYPESET-8
DECSYSTEM-20	MASSBUS	TYPESET-11
		UNIBUS

Intelligent Massachusett's Corporation • Maynard, Massachusetts

CONTENTS

	Page
CHAPTER 1 GENERAL INFORMATION	
1.1 INTRODUCTION	1-1
1.2 WARRANTY	1-1
1.3 SPECIFICATIONS	1-1
1.4 50/60 Hz POWER OPTION	1-1
1.5 MAJOR ASSEMBLIES AND SYSTEMS	1-1
1.5.1 Controls and Indicators	1-4
1.5.2 Spindle and Drive	1-4
1.5.3 Linear Positioner	1-4
1.5.4 Cartridge-Handling System	1-4
1.5.5 Logic Assembly	1-4
1.5.6 Air System	1-4
1.5.7 Power Supply	1-4
1.5.8 Read/Write Heads	1-4
CHAPTER 2 INSTALLATION	
2.1 UNPACKING AND INSPECTION	2-1
2.2 MECHANICAL INSTALLATION AND CHECKOUT	2-3
2.3 CARTRIDGE HANDLING PRACTICES AND PRECAUTIONS	2-6
2.4 CARTRIDGE PACKING AND SHIPPING	2-6
2.5 NORMAL OPERATING PROCEDURES	2-7
2.5.1 Cartridge Loading	2-7
2.5.2 Cartridge Unloading	2-7
CHAPTER 3 INTERFACE	
3.1 GENERAL	3-1
3.2 INPUT INTERFACE LINES	3-1
3.2.1 RK11-D	3-1
3.2.2 Select (4 lines)	3-1
3.2.3 Cylinder Address (8 lines)	3-1
3.2.4 Strobe	3-1
3.2.5 Head Select	3-3
3.2.6 Write Protect Set	3-3
3.2.7 Write Data and Clock	3-3
3.2.8 Write Gate	3-3
3.2.9 Restore (RTZ)	3-3
3.2.10 Read Gate	3-3
3.3 OUTPUT INTERFACE LINES	3-3
3.3.1 File Ready (Drive Ready)	3-3
3.3.2 Read, Write, or Seek Ready/On Cylinder	3-3
3.3.3 Address Accepted	3-3
3.3.4 Address Invalid (Logic Address Interlock)	3-3
3.3.5 Seek Incomplete	3-3
3.3.6 Write Protect Status	3-3
3.3.7 Write Check	3-3
3.3.8 Read Data	3-4
3.3.9 Read Clock	3-4

CONTENTS (Cont)

	Page
3.3.10 Sector Address (4 lines)	3-4
3.3.11 Sector Pulse	3-4
3.3.12 Index Pulse	3-4
3.3.13 AC Low	3-4
3.3.14 DC Low	3-4
3.3.15 High Density/RK05 L	3-4

APPENDIX A THE RK05-TA OFF-LINE TESTER

ILLUSTRATIONS

	Title	Page
1-1 Location of Major Assemblies and Systems	1-3	
1-2 Controls and Indicators	1-6	
1-3 Spindle and Drive System	1-7	
1-4 Linear Positioner	1-7	
1-5 Cartridge Handling System	1-8	
1-6 Air System	1-9	
1-7 Head Loading	1-9	
1-8 Relationship of Disk Head, Disk, and Contaminants	1-10	
2-1 Shipping Bracket and Shipping Strap Location	2-2	
2-2 RK11C or RK11D Interface Cable Installation	2-3	
2-3 Chassis Slide Mounting	2-4	
2-4 RK8/E Interface Cable Installation	2-5	
3-1 Controller/RK05 Disk Drive Interface Lines and Pin Assignments	3-2	

TABLES

	Title	Page
1-1 Performance Specifications	1-2	
1-2 Controls and Indicators	1-5	

CHAPTER 1

GENERAL INFORMATION

1.1 INTRODUCTION

The RK05 Disk Drive, which is designed and manufactured by Digital Equipment Corporation, is a self-contained, random-access, data storage device that is especially well suited for use in small or medium-size computer systems, data acquisition systems, terminals, and other storage applications. Operational power for this device is provided by a power supply located within the drive cabinet. The RK05 is available in four models, each of which operates on a different power line.

This compact, lightweight drive uses a high-density, single-disk, 12-sector or 16-sector cartridge as its storage medium. Two movable heads, one flying above the rotating disk surface and one below, can read or record up to 406 data tracks at 1500 rpm. The double-frequency, nonreturn-to-zero (NRZ) recording method used in this drive can store up to 25 million bits of on-line data. Data formatting is governed entirely by the operating system.

With the address select logic contained in each drive, up to eight RK05 Disk Drives (depending on the type of system) can be "daisy-chained" and operated from a single controller bus.

1.2 WARRANTY

"Removable media involve use, handling and maintenance which are beyond DEC's direct control. DEC disclaims responsibility for performance of the Equipment when operated with media not meeting DEC specifications or with media not maintained in accordance with procedures approved by DEC. DEC shall not be liable for damages to the Equipment or to media resulting from such operation."

1.3 SPECIFICATIONS

Table 1-1 lists the performance specifications of the RK05 Disk Drive for the 12-sector cartridge. Wherever applicable, a second specification pertaining to a 16-sector cartridge is also listed.

1.4 50/60 Hz POWER OPTION

The RK05 Disk Drive is available in the following four power models:

- RK05-AA 95 to 130 Vac @ 60 Hz
- RK05-AB 190 to 260 Vac @ 60 Hz
- RK05-BA 95 to 130 Vac @ 50 Hz
- RK05-BB 190 to 260 Vac @ 50 Hz

Each model is shipped with a complete set of drawings. To change from 50 to 60 Hz operation requires a different spindle drive pulley, and the motor must be moved.

1.5 MAJOR ASSEMBLIES AND SYSTEMS

The RK05 Disk Drive is composed of the following major assemblies and systems:

- Controls and Indicators
- Spindle and Drive System
- Linear Positioner
- Cartridge Handling System
- Logic Assembly
- Air System
- Power Supply
- Read/Write Heads

Figure 1-1 illustrates the locations, and the subsequent paragraphs describe the functions of each of the major assemblies and systems.

Table 1-1
Performance Specifications

Characteristic	Specification
Storage Medium	
Type	Single disk magnetic cartridge
Disk Diameter	14 in.
Magnetic Heads	
Number	Two
Recording Density and Format	
Density	2200 bpi max.
Tracks	406 (200 plus 3 spares on each side of the disk)
Cylinders	203 (two tracks each)
Sectors (records)	4872 (12 per revolution)/6496 (16 per revolution)
Bit Capacities (unformatted)*	
Per Disk	25 million
Per Inch	2040 (max. at inner track)
Per Cylinder	115,200
Per Track	57,600
Per Sector	4,800/3,844
Access Times	
Disk Rotation	1500 ± 30 rpm
Average Latency	20 ms (half rotation)
Head Positioning (including settling time)	10 ms – for adjacent tracks 50 ms – average 85 ms – for 200 track movement
Bit Transfer*	
Transfer Code	Double frequency, nonreturn-to-zero recording
Transfer Rate	1.44M bits per sec
Electrical Requirements	
Voltage	115/230 Vac @ 50/60 Hz ± .05 Hz
Power	250 VA
Starting Current	Power only: 1.8 A Start spindle: 10 A (for 2 sec)
Model Designation	
RK05-AA	95 to 130 Vac @ 60 ± 0.5 Hz
RK05-AB	190 to 260 Vac @ 60 ± 0.5 Hz
RK05-BA	95 to 130 Vac @ 50 ± 0.5 Hz
RK05-BB	190 to 260 Vac @ 50 ± 0.5 Hz
Environment	
Ambient Temperature	50° to 110° F (10° to 43° C nominal)
Relative Humidity	8% to 80% (no condensation)
Barometric Pressure	10,000 ft (3,000 meters) max.
Temperature, Change Rate	10° F (6° C) per hr
Temperature, Interchangeable Range	30° F (17° C)
Dimensions and Weight	
Width	19 in. (48 cm)
Depth	26-1/2 in. (67 cm)
Height	10-1/2 in. (27 cm)
Weight	110 lb (50 kg)

*Some RK11-D systems record at 1.54M bits/sec which increases the bit density and capacity accordingly.

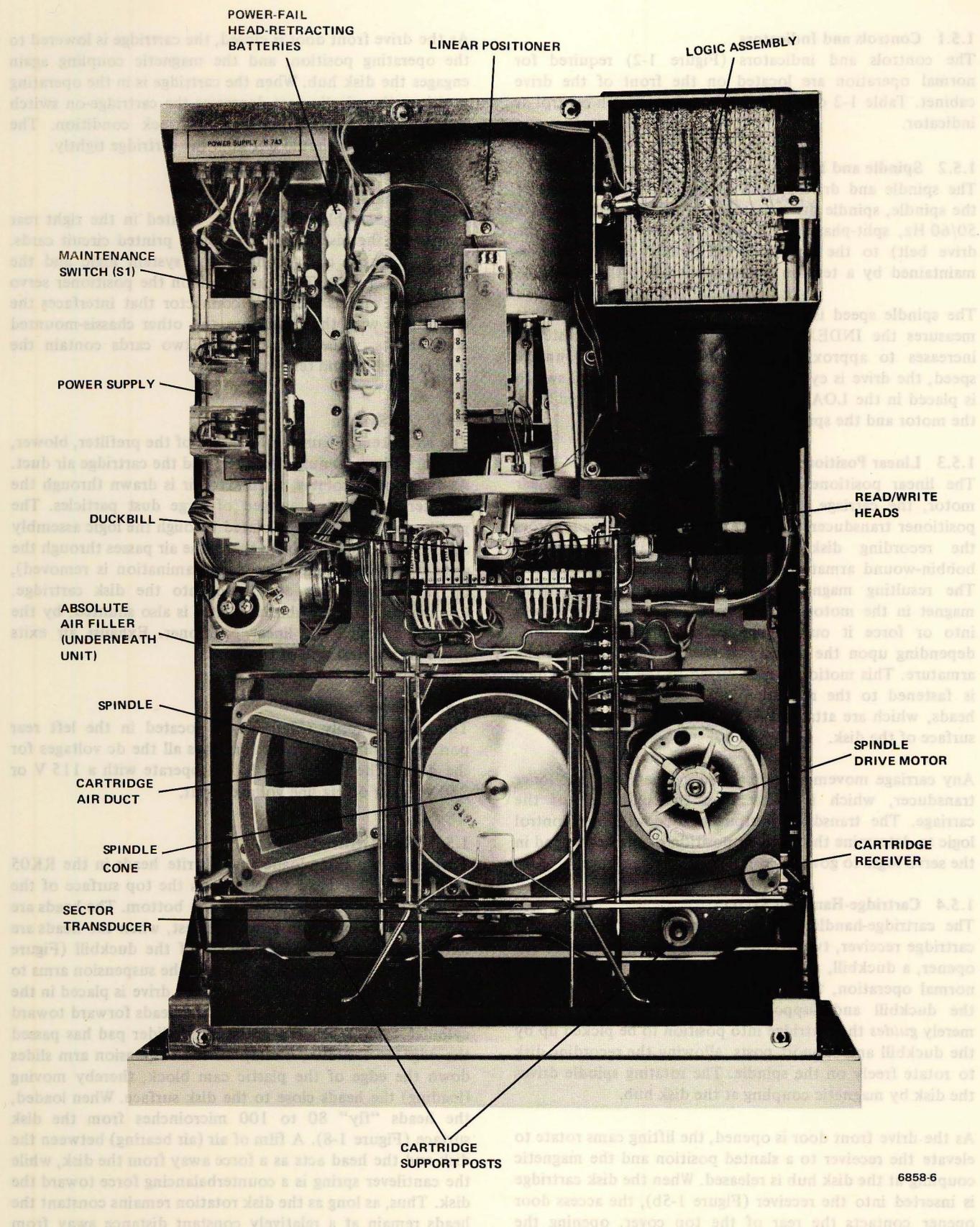


Figure 1-1 Location of Major Assemblies and Systems

6858-6

1.5.1 Controls and Indicators

The controls and indicators (Figure 1-2) required for normal operation are located on the front of the drive cabinet. Table 1-2 describes the function of each control or indicator.

1.5.2 Spindle and Drive

The spindle and drive system (Figure 1-3) is composed of the spindle, spindle drive motor, and the recording disk. A 50/60 Hz, split-phase ac motor transfers torque (via the drive belt) to the spindle drive pulley. Belt tension is maintained by a tension spring anchored to the baseplate.

The spindle speed is electronically tested by a circuit that measures the INDEX PULSE interval. When the interval increases to approximately 45 ms, indicating an unsafe speed, the drive is cycled down. If the RUN/LOAD switch is placed in the LOAD position, ac power is removed from the motor and the spindle coasts to a halt.

1.5.3 Linear Positioner

The linear positioner (Figure 1-1) consists of the linear motor, the carriage, the read/write heads, and the linear positioner transducer. To move the read/write heads across the recording disk, dc current is applied to the bobbin-wound armature (Figure 1-4) of the linear motor. The resulting magnetic field reacts with a permanent magnet in the motor housing to either pull the armature into or force it out of the permanent magnetic field, depending upon the polarity of the current applied to the armature. This motion is transferred to the carriage, which is fastened to the armature. As a result, the read/write heads, which are attached to the carriage, move across the surface of the disk.

Any carriage movement is detected by the linear positioner transducer, which is located on the underside of the carriage. The transducer output is used with the control logic to determine the cylinder position of the heads, and in the servo logic to govern the speed of carriage travel.

1.5.4 Cartridge-Handling System

The cartridge-handling system (Figure 1-5a) consists of a cartridge receiver, two receiver lifting cams, an access door opener, a duckbill, and two cartridge support posts. During normal operation, the plastic cartridge is located *only* by the duckbill and support posts. The cartridge receiver merely *guides* the cartridge into position to be picked up by the duckbill and support posts, allowing the recording disk to rotate freely on the spindle. The rotating spindle drives the disk by magnetic coupling at the disk hub.

As the drive front door is opened, the lifting cams rotate to elevate the receiver to a slanted position and the magnetic coupling at the disk hub is released. When the disk cartridge is inserted into the receiver (Figure 1-5b), the access door opener contacts the rear of the top cover, opening the access door to allow entry of the read/write heads.

As the drive front door is closed, the cartridge is lowered to the operating position, and the magnetic coupling again engages the disk hub. When the cartridge is in the operating position, the plastic case depresses the cartridge-on switch and removes the no-cartridge interlock condition. The cartridge receiver should *not* hold the cartridge tightly.

1.5.5 Logic Assembly

The logic assembly (Figure 1-1), located in the right rear portion of the disk drive, holds eight printed circuit cards. Three of these cards contain the system logic and the read/write circuits. Two cards contain the positioner servo logic. One card is the cable connector that interfaces the electronics with the positioner and other chassis-mounted components, while the remaining two cards contain the interface cables and terminators.

1.5.6 Air System

The air system (Figure 1-6) consists of the prefilter, blower, absolute filter, plenum chamber, and the cartridge air duct. As the blower rotates, unfiltered air is drawn through the prefilter, where it is purged of large dust particles. The prefiltered air is then circulated through the logic assembly and into the plenum. From there, the air passes through the absolute filter (where minute contamination is removed), up the cartridge air duct, and into the disk cartridge. Cooling air from the absolute filter is also shunted, by the plenum, through the linear positioner. Exhaust air exits through the front grill of the drive.

1.5.7 Power Supply

The power supply (Figure 1-1), located in the left rear portion of the disk drive, furnishes all the dc voltages for the drive. The power supply can operate with a 115 V or 230 V, 50 or 60 Hz line voltage input.

1.5.8 Read/Write Heads

There are two ramp-loaded read/write heads in the RK05 Disk Drive. One head functions on the top surface of the recording disk and the other on the bottom. The heads are mounted on suspension arms that rest, when the heads are unloaded, on a plastic cam block of the duckbill (Figure 1-7). Flat cantilever springs connect the suspension arms to the head-support tailpieces. When the drive is placed in the RUN mode, the positioner moves the heads forward toward cylinder zero. When the entire head slider pad has passed the edge of the disk, a ramp on the suspension arm slides down the edge of the plastic cam block, thereby moving (loading) the heads close to the disk surface. When loaded, the heads "fly" 80 to 100 microinches from the disk surface (Figure 1-8). A film of air (air bearing) between the disk and the head acts as a force away from the disk, while the cantilever spring is a counterbalancing force toward the disk. Thus, as long as the disk rotation remains constant the heads remain at a relatively constant distance away from the disk surface.

Table 1-2
Controls and Indicators

Controls and Indicators	Description
RUN/LOAD (rocker switch)	<p>Placing this switch in the RUN position (providing that all interlocks are safe):</p> <ul style="list-style-type: none"> a. locks the drive front door b. accelerates the disk to operating speed c. loads the read/write heads d. lights the RDY indicator. <p>Placing this switch in the LOAD position:</p> <ul style="list-style-type: none"> a. unloads the read/write heads b. stops the disk rotation c. unlocks the drive front door when the disk has stopped d. lights the LOAD indicator. <p>CAUTION Do not switch to the LOAD position during a write operation; this results in erroneous data being recorded.</p>
WT PROT (rocker switch – spring-loaded off)	<p>Placing this momentary contact switch in the WT PROT position lights the WT PROT indicator and prevents a write operation; it also turns off the FAULT indicator, if that is lit.</p> <p>Depressing this switch in the WT PROT position a second time turns off the WT PROT indicator and allows a write operation.</p>
PWR (indicator) RDY (indicator)	<p>Lights when operating power is present. Goes off when operating power is removed.</p> <p>Lights when:</p> <ul style="list-style-type: none"> a. the disk is rotating at the correct operating speed. b. the heads are loaded. c. no other conditions are present (all interlocks safe) to prevent a seek, read, or write operation. <p>Goes off when the RUN/LOAD switch is set to LOAD.</p>
ON CYL (indicator)	<p>Lights when:</p> <ul style="list-style-type: none"> a. the drive is in the Ready condition. b. a seek or restore operation is not being performed. c. the read/write heads are positioned and settled. <p>Goes off during a seek or restore operation.</p>

Table 1-2 (Cont)
Controls and Indicators

Controls and Indicators	Description	Controls and Indicators
FAULT (indicator)	<p>Lights when:</p> <ul style="list-style-type: none"> a. erase or write current is present without a WRITE GATE. b. the linear positioner transducer lamp is inoperative. <p>Goes off when the WT PROT switch is pressed, or when the drive is recycled through a RUN/LOAD sequence.</p>	RUN/LOAD (switch)
WT PROT (indicator)	<p>Lights when:</p> <ul style="list-style-type: none"> a. the WT PROT switch is pressed. b. the operating system sends a Write Protect command. <p>Goes off when the WT PROT switch is pressed a second time, or when the drive is recycled through a RUN/LOAD sequence.</p>	WT PROT (switch)
LOAD (indicator)	Lights when the read/write heads are fully retracted and the spindle has stopped rotating.	RDY (indicator)
WT (indicator)	Lights when a write operation occurs. Goes off when the write operation terminates.	WT (switch)
RD (indicator)	Lights when a read operation occurs. Goes off when the read operation terminates.	RD (switch)

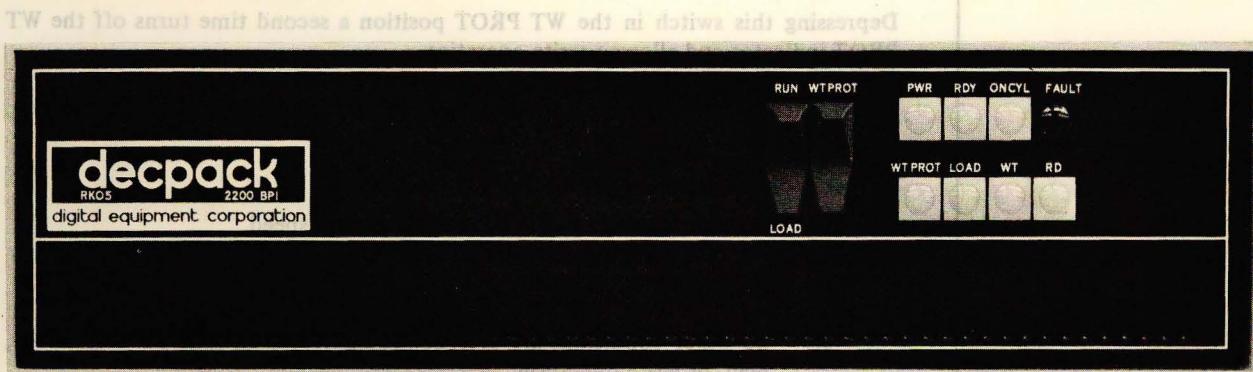


Figure 1-2 Controls and Indicators

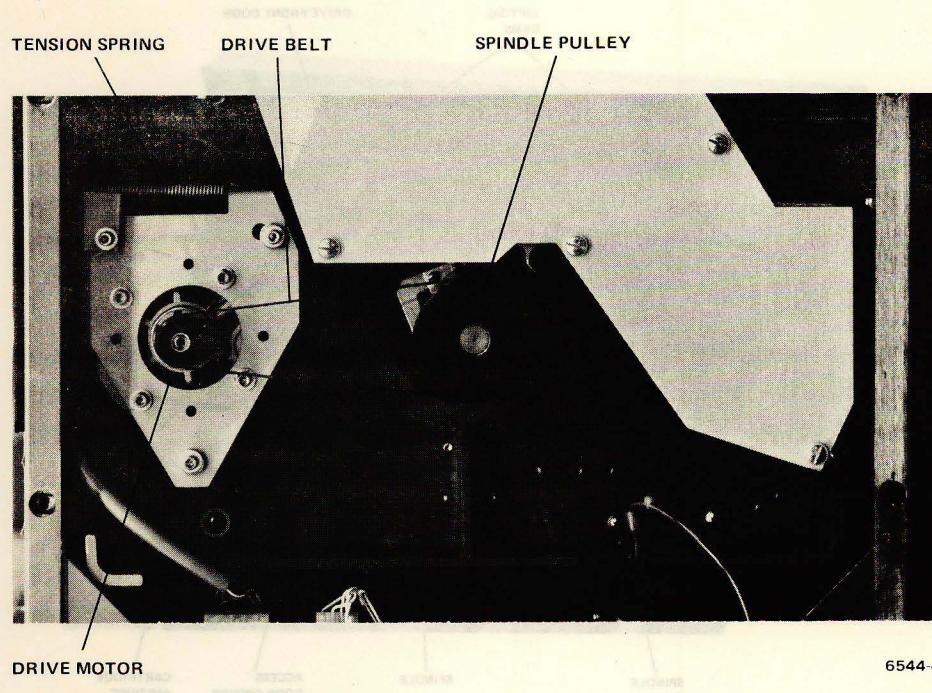


Figure 1-3 Spindle and Drive System

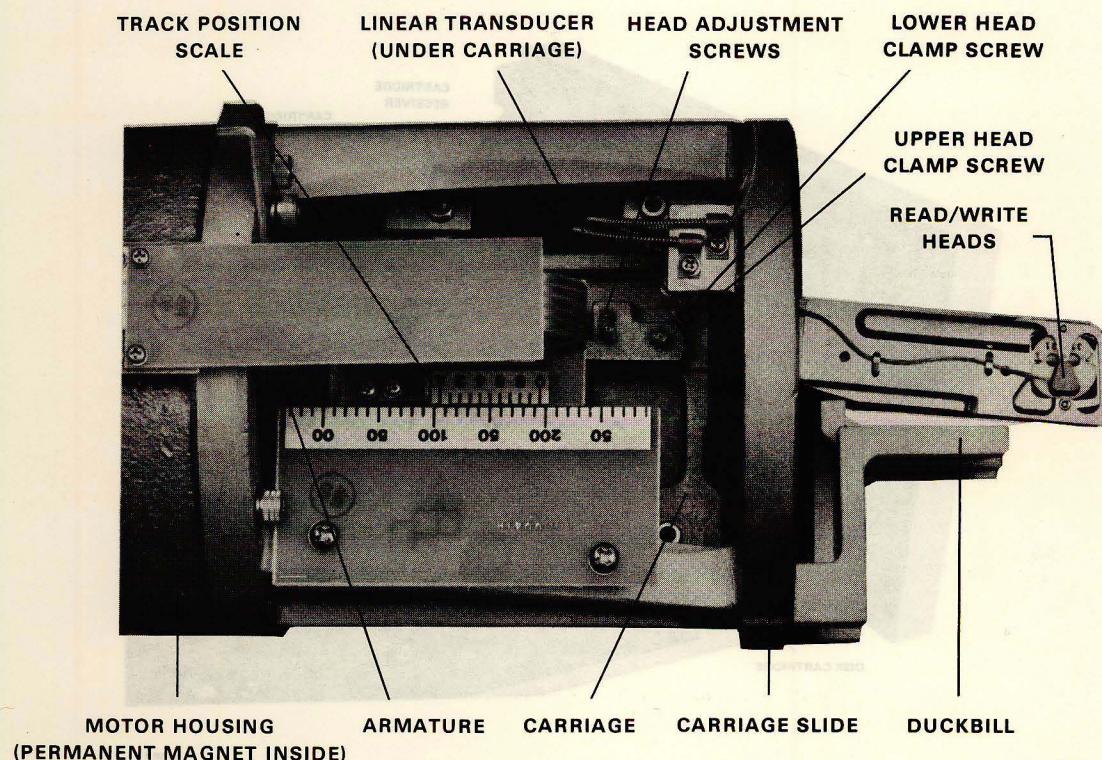
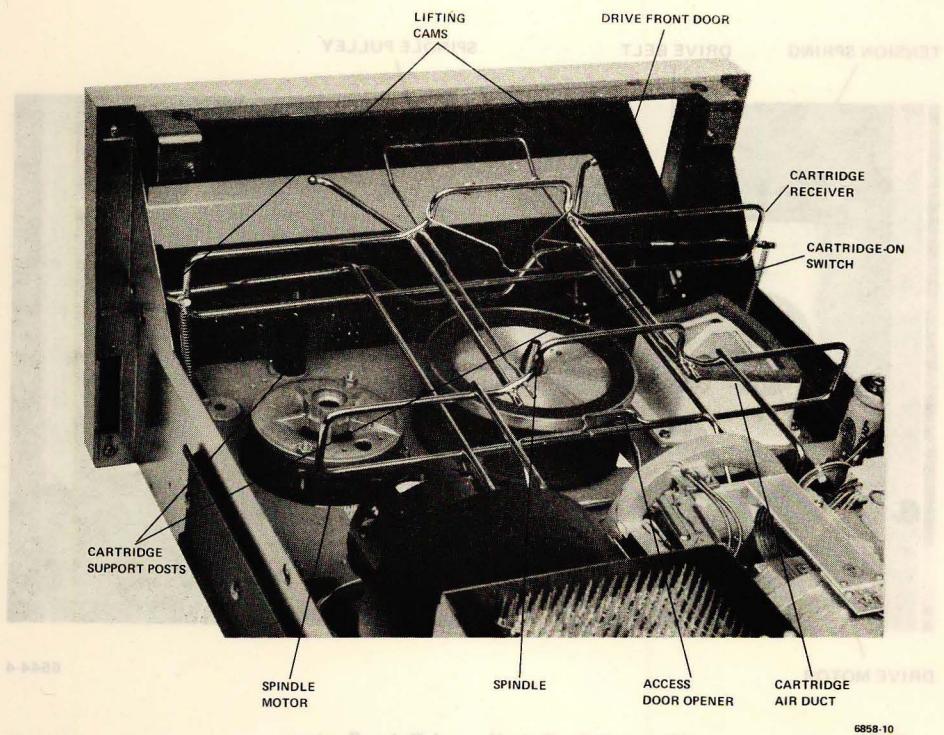
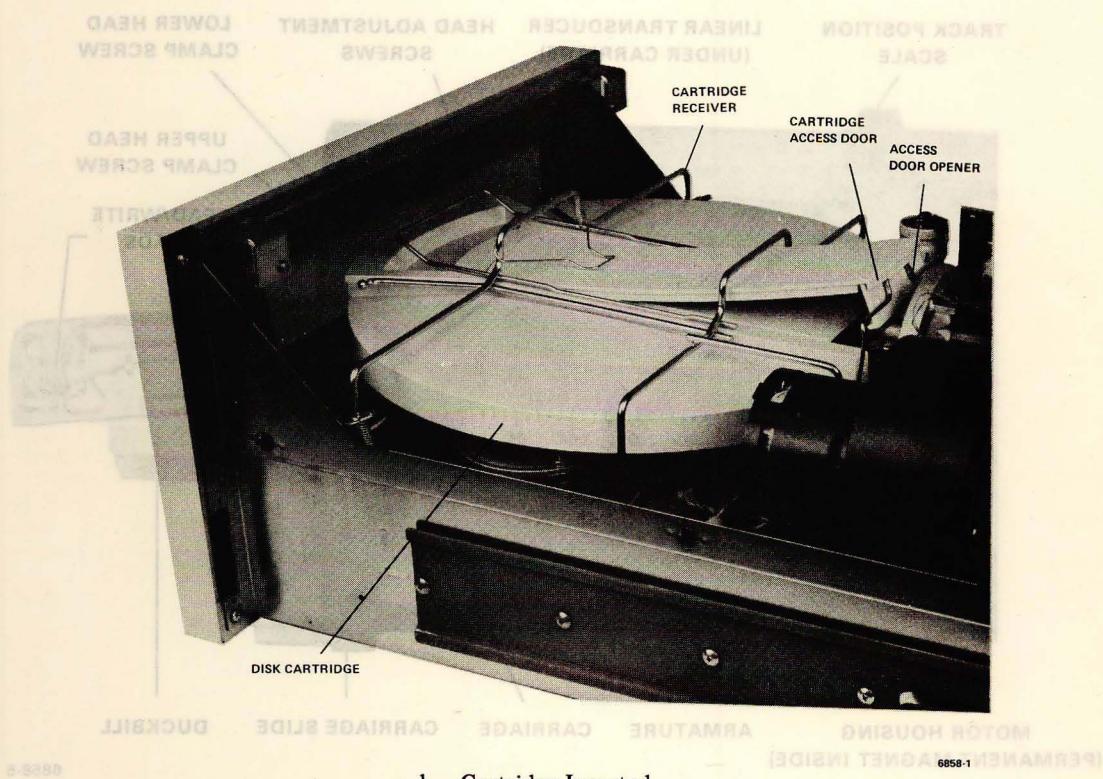


Figure 1-4 Linear Positioner

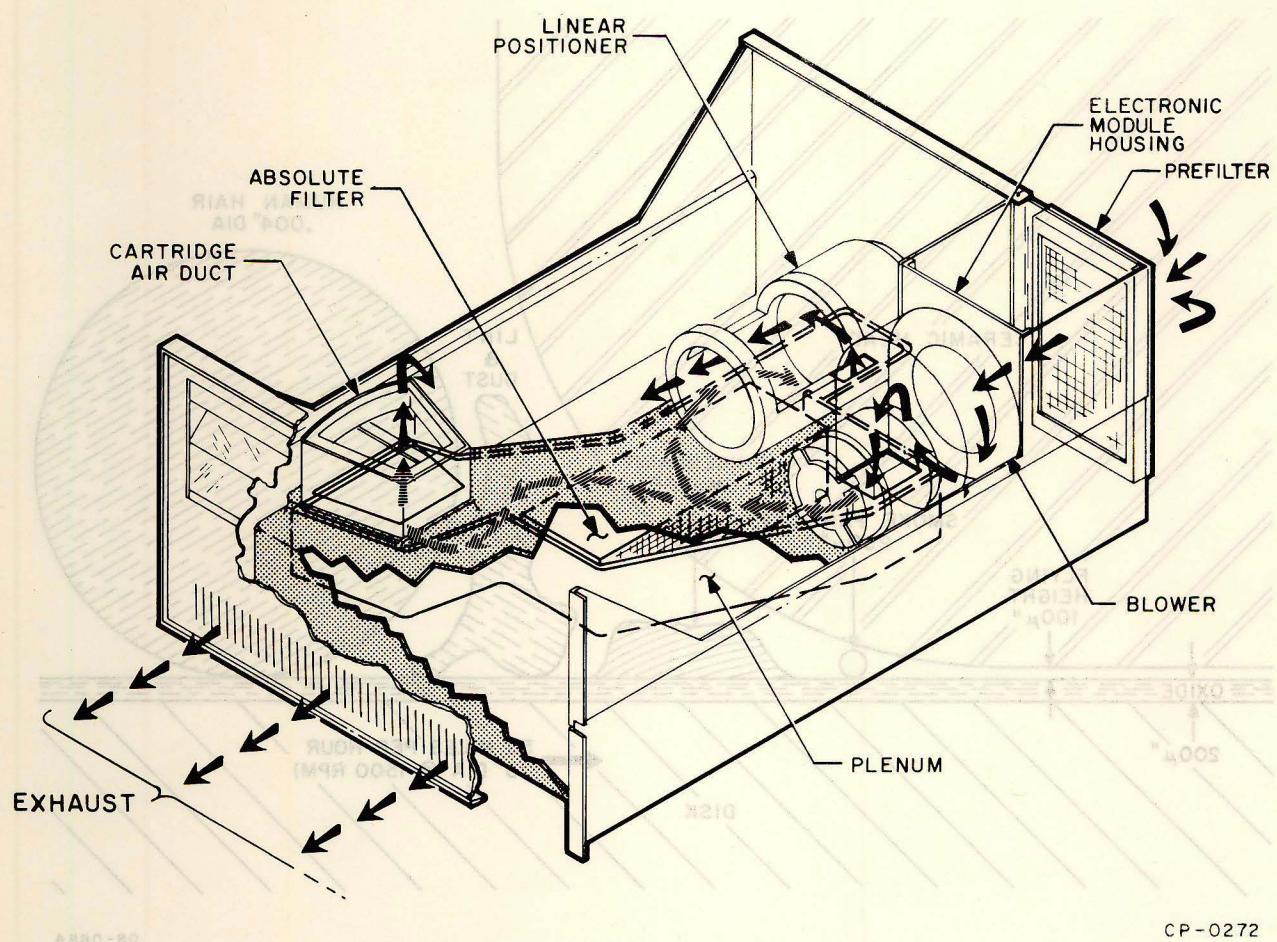


a. Cartridge Removed



b. Cartridge Inserted

Figure 1-5 Cartridge Handling System

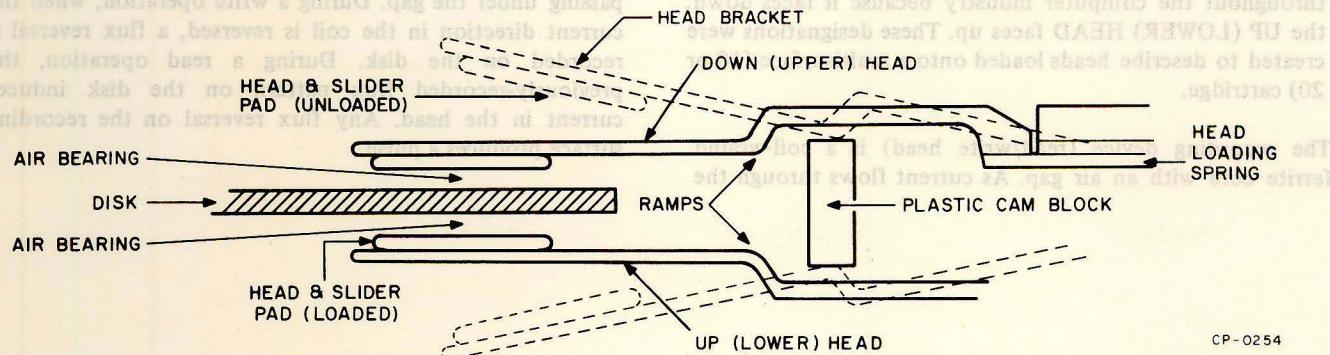


CP-0272

Figure 1-6 Air System

...the induced air flow generates the surface of the disk passing under the head. During a write operation, air is forced directly under the head to reduce the seek time. As the disk rotates, the air bearing provides a constant lift force to the head.

The DOWN (UPPER) HEAD is so-called by convention throughout the computer industry because it first contacts the surface of the disk when it is loaded. The UP (LOWER) HEAD uses a similar configuration but is positioned above the lower head.



CP-0254

Figure 1-7 Head Loading

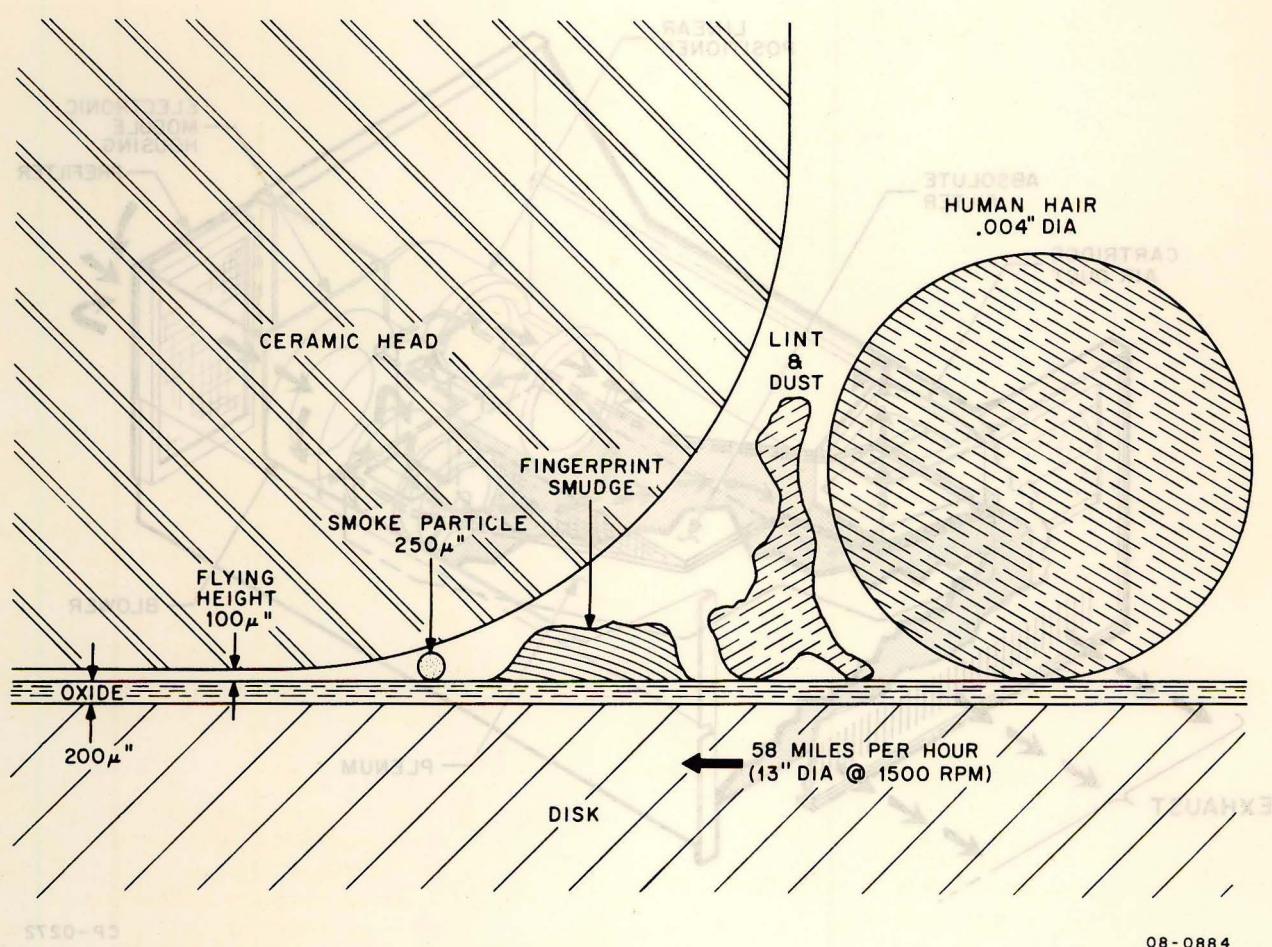


Figure 1-8 Relationship of Disk Head, Disk, and Contaminants

The DOWN (UPPER) HEAD is so-called by convention throughout the computer industry because it faces down; the UP (LOWER) HEAD faces up. These designations were created to describe heads loaded onto a multisurface (10 or 20) cartridge.

The recording device (read/write head) is a coil-wound ferrite core with an air gap. As current flows through the

coil, the induced flux magnetizes the surface of the disk passing under the gap. During a write operation, when the current direction in the coil is reversed, a flux reversal is recorded on the disk. During a read operation, the previously-recorded flux pattern on the disk induces current in the head. Any flux reversal on the recording surface produces a pulse.

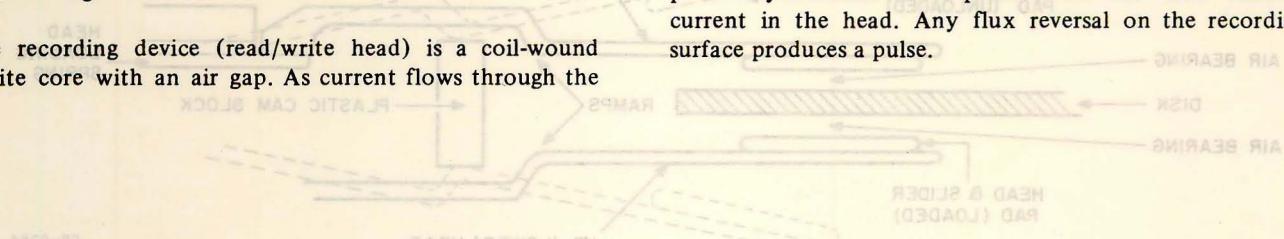


Figure 1-7 Head Loading

CHAPTER 2

INSTALLATION

2.1 UNPACKING AND INSPECTION

The RK05 Disk Drive can be shipped in a rack as an integral part of a system or in a separate container. If the drive is shipped in a rack, the rack should be positioned in the final installation location and unpacked as follows:

1. Remove the shipping brackets from the drive by removing the snap-on bezel beneath the lowest drive.
2. Remove the screws attaching the shipping bracket and latch molding to both sides of the drive.

CAUTION

Do not use the drive front door handle to pull the drive out from the rack.

3. Slide the drive out about 3 inches from the rack and pull the shipping brackets out from the sides of the drive. Attach the latch molding back onto the drive with the shipping bracket screws.
4. Slide the lowest drive out far enough to gain access to the shipping brackets on the drive directly above it and remove the screws from these two shipping brackets.
5. Repeat Steps 3 and 4 for each drive in the rack.
6. Remove the drive bottom cover and remove the screws that attach the three internal shipping brackets to the baseplate (Figure 2-1a).

CAUTION

Do not operate drive with shipping brackets attached.

7. If RK05 drives are "daisy-chained" with RK03 drives in a multidrive installation, arrange the RK05s consecutively at the controller end of the bus to avoid interruption of the AC LOW and DC LOW interface lines, which are not carried by the RK03s. If this arrangement is not possible, all RK05s that are separated on the bus by RK03s must be connected by separate cables between their J06 connections (Figure 2-2).

8. Remove the drive top cover and remove the mounting screw and shipping strap from the linear positioner (Figure 2-1b). Turn the shipping strap upward and replace it on the linear positioner, making sure it is tightly secured.

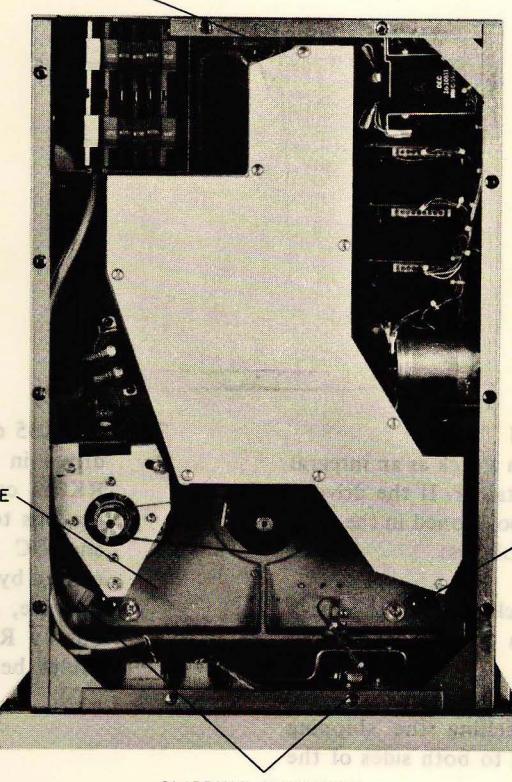
9. Retain all packing material for possible reshipment. Inspect the drive for possible damage. Report any damage to the carrier and to Digital Equipment Corporation.

10. In the case of RK05 Disk Drive relocation or reshipment, replace the shipping brackets and shipping strap in the shipping position; repeat this unpacking and inspection procedure when the drive is reinstalled.

If the drive is shipped in a separate container, use care while unpacking it. Do not drop the drive or subject it to unreasonable impact.

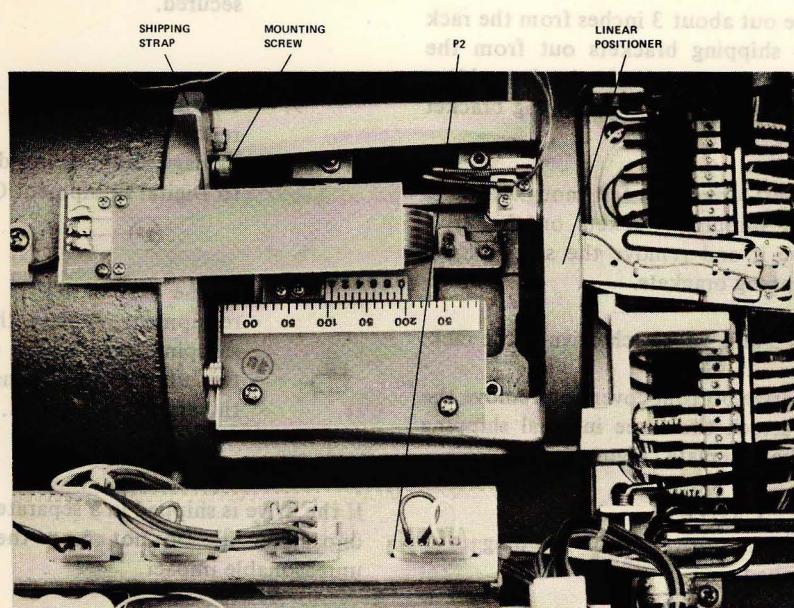
CHAPTER 2 INSTALLATION

The K203 Disk Drive can be shipped in several ways. If it is to be shipped in a carton or a shipping container, it must be secured to a base or a baseplate. If it is to be shipped in a bag or a sleeve, the base or baseplate must be secured to the bag or sleeve. If it is to be shipped in a box or a case, the base or baseplate must be secured to the box or case.



a. Shipping Brackets

Remove the drive top cover and remove the mounting screw and shipping strap from the front positioner (Figure 3-1P). Turn the shipping strap around and replace it on the front positioner, making sure it is tight.



b. Shipping Strap

Figure 2-1 Shipping Bracket and Shipping Strap Locations

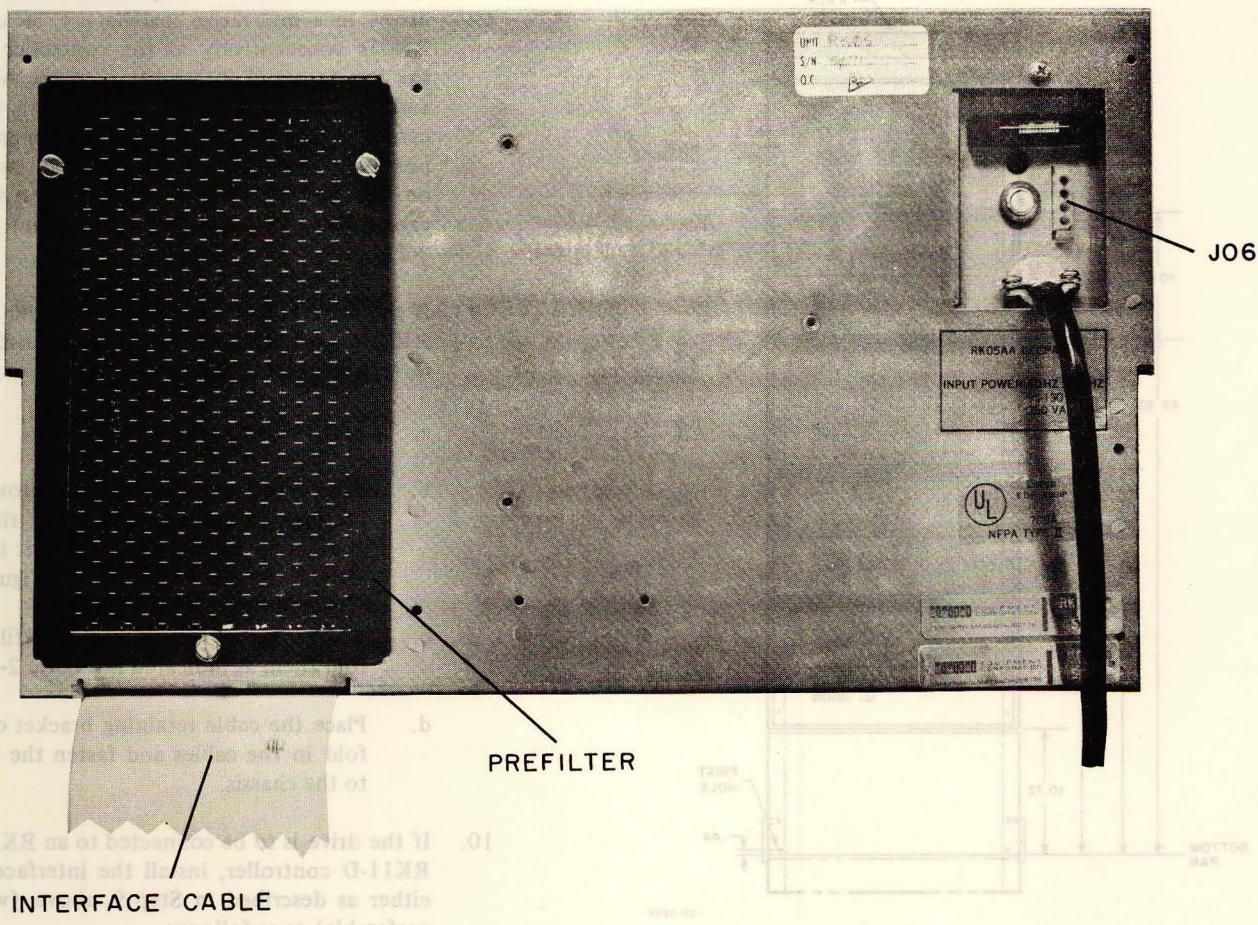


Figure 2-2 RK11C or RK11D Interface Cable Installation

2.2 MECHANICAL INSTALLATION AND CHECKOUT

If the RK05 Disk Drive is to be installed in an existing rack, the chassis slides should first be installed in the rack (Figure 2-3). The disk drive should be mounted on the chassis slides as follows: (If necessary, refer to the RK05 Option Configuration Dwg. No. D-OC-RK05-0-15 for detailed mechanical specifications of a multidrive installation.)

1. Install cabinet stabilizers before mounting the drive, unless the weight of the rack is sufficient to prevent tipping when the drive is fully extended.
2. Pull the chassis slides out until they lock in the extended position.

Figure 2-3 Chassis Slides Mounting

3. Slide the drive onto the chassis slides until it locks.
4. Remove the drive bottom cover and remove the screws that attach the three internal shipping brackets to the baseplate (Figure 2-1a).
5. Remove the drive top cover and remove the mounting screw and shipping strap from the linear positioner (Figure 2-1b). Turn the shipping strap upward and replace it on the linear positioner. Pull the heads forward as far as possible without going off the ramp (Figure 1-7) and confirm that the batteries (Figure 1-1) return the heads to the home position.

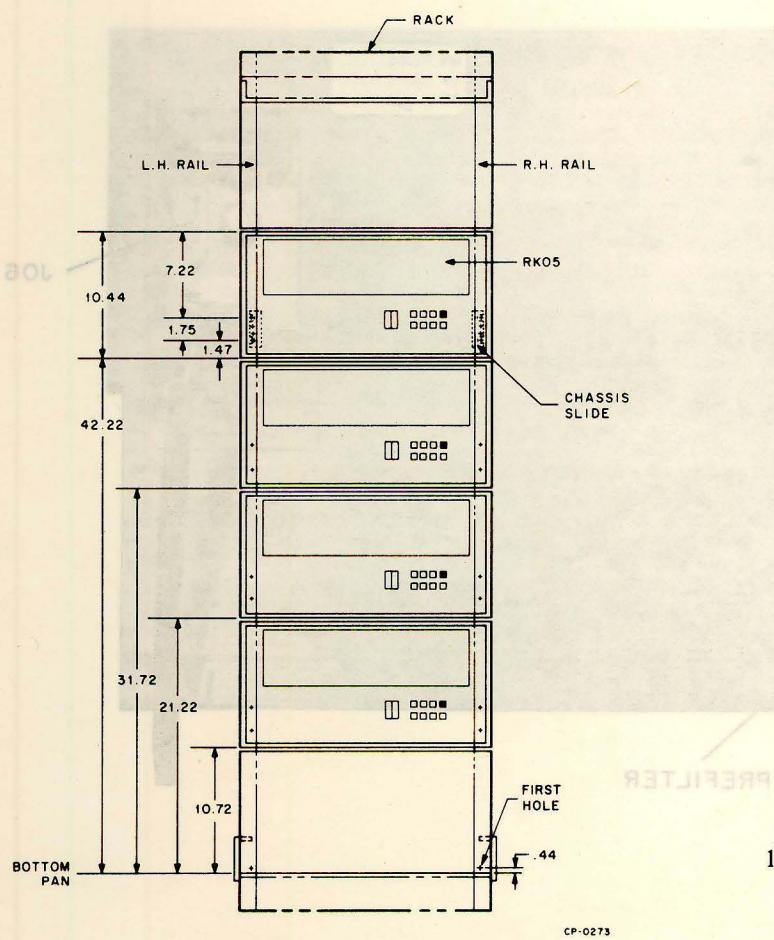


Figure 2-3 Chassis Slide Mounting

6. Inspect P2 (Figure 2-1) and the spindle pulley to ensure that the drive is configured properly for the input power to be used. If P2 contains two jumpers, the supply is configured for 115 Vac operation. If P2 contains only one jumper, the supply is configured for 230 Vac. The operating frequency is stamped on the spindle pulley.
7. Check the logic assembly to ensure that no pins are bent or broken, and then plug the interface cable card into card position 7 or 8 of the logic assembly. If there is only one drive in the system, or if this is the last drive of the daisy-chain, ensure that an M930 terminator card (Dwg. No. RK05-0-2) is in the unused interface card position.

8. If RK05 drives are daisy-chained with RK03 drives in a multidrive installation, arrange the RK05s consecutively at the controller end of the bus to avoid interruption of the AC LOW and DC LOW interface lines, which are not carried by the RK03s. If this arrangement is not possible, connect all RK05s that are separated on the bus by RK03s by means of separate cables between their J06 connections (Figure 2-2).
9. If the drive is to be connected to other than an RK11-C or RK11-D controller, install the interface cables as follows:
 - a. Remove the prefilter and frame.
 - b. Route the interface cables through the prefilter opening and reinstall the filter and frame so that the cables fit into the slot on the side of the frame (Figure 2-4).
 - c. Route the cables over the prefilter and fold them as indicated in Figure 2-4.
 - d. Place the cable retaining bracket over the fold in the cables and fasten the bracket to the chassis.
10. If the drive is to be connected to an RK11-C or RK11-D controller, install the interface cables either as described in Step 9, above, (which is preferable) or as follows:
 - a. Fold the interface cables and route them through the slot just below the prefilter at the rear of the drive cabinet (Figure 2-4).
 - b. Hold the cables in position and replace the bottom cover.
11. To avoid random errors, confirm that the grounding strap is firmly in place between the base plate and the chassis, and that brushes are mounted securely and in the proper plane. Confirm that all connectors are securely in place.
12. Configure the M7700 select switch to address a valid drive (Paragraph 3.2.2).
13. Plug the power cord into the switched ac line receptacle.

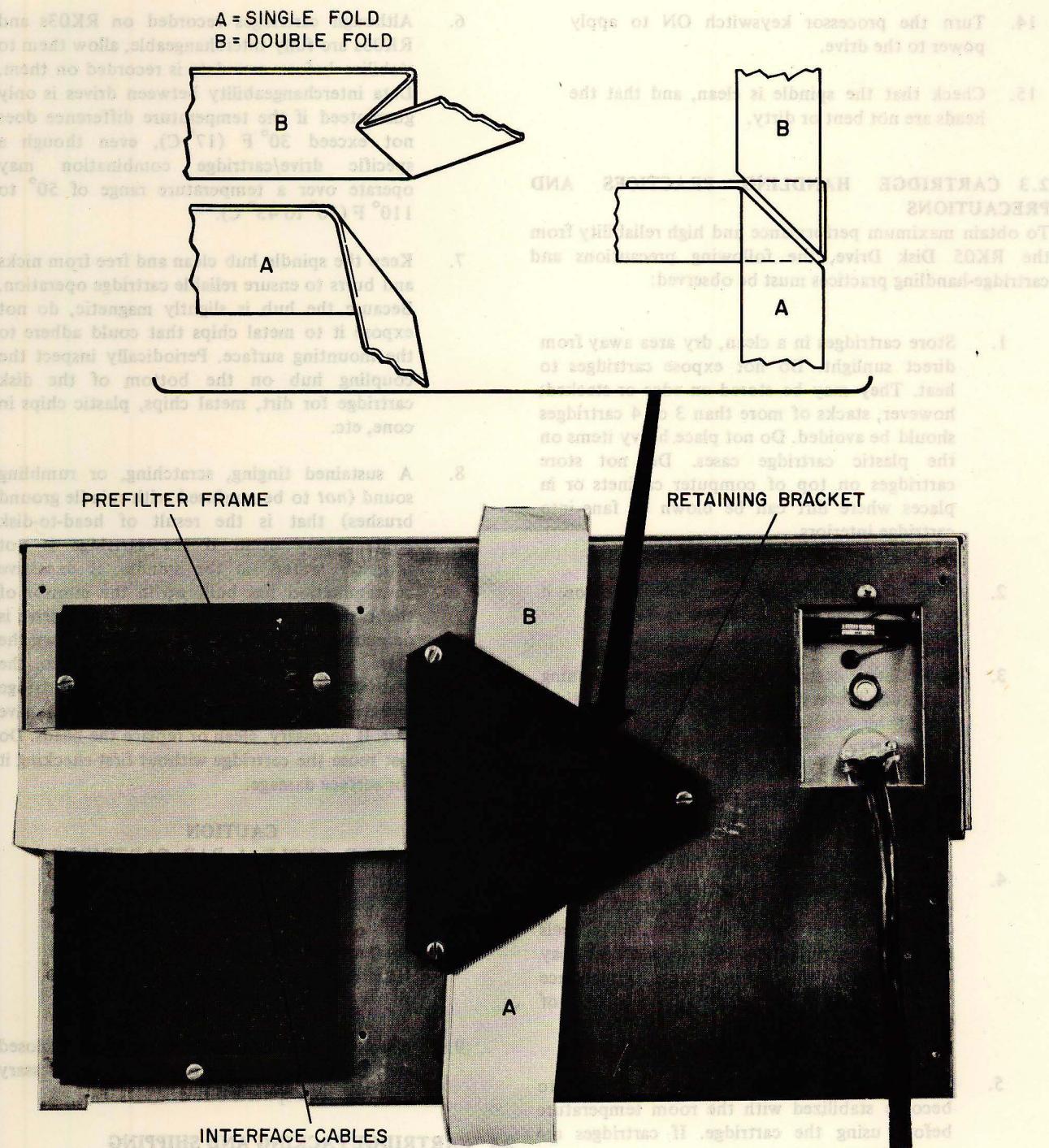


Figure 2-4 RK8/E Interface Cable Installation

14. Turn the processor keyswitch ON to apply power to the drive.
15. Check that the spindle is clean, and that the heads are not bent or dirty.

2.3 CARTRIDGE HANDLING PRACTICES AND PRECAUTIONS

To obtain maximum performance and high reliability from the RK05 Disk Drive, the following precautions and cartridge-handling practices must be observed:

1. Store cartridges in a clean, dry area away from direct sunlight. Do not expose cartridges to heat. They may be stored on edge or stacked; however, stacks of more than 3 or 4 cartridges should be avoided. Do not place heavy items on the plastic cartridge cases. Do not store cartridges on top of computer cabinets or in places where dirt can be blown by fans into cartridge interiors.
2. Whenever a cartridge is not in a drive, enclose it in a plastic bag to exclude dust or dirt.
3. Professional cartridge disassembly and cleaning is required every six months; however, disks should be cleaned whenever they are excessively dirty, or when a high transient error rate is encountered. In such instances, a disk-cleaning service, listed by Digital Equipment Corporation, should be contacted at once.
4. Place stiff cardboard or plastic labels only in the molded frame at the front edge of the disk cartridge without using any adhesives. Labels placed on any other part of the cartridge may interfere with the drive operation or introduce contamination into the drive or the interior of the cartridge.
5. Allow the temperature of the cartridge to become stabilized with the room temperature before using the cartridge. If cartridges are exposed to outside temperature extremes, or if the temperature differential between drive and cartridge exceeds 20° F, a two-hour stabilization period is necessary.

6. Although cartridges recorded on RK03s and RK05s are fully interchangeable, allow them to stabilize before new data is recorded on them. Data interchangeability between drives is only guaranteed if the temperature difference does not exceed 30° F (17° C), even though a specific drive/cartridge combination may operate over a temperature range of 50° to 110° F (10° to 43° C).
7. Keep the spindle hub clean and free from nicks and burrs to ensure reliable cartridge operation. Because the hub is slightly magnetic, do not expose it to metal chips that could adhere to the mounting surface. Periodically inspect the coupling hub on the bottom of the disk cartridge for dirt, metal chips, plastic chips in cone, etc.
8. A sustained tingling, scratching, or rumbling sound (*not* to be confused with spindle ground brushes) that is the result of head-to-disk contact may occur if the cartridge is not properly seated on the spindle, if excessive contamination has built up in the interior of the cartridge, or if the cartridge or the drive is defective. If this sound is heard, shut down the drive immediately to avoid damage to the read/write heads. Remove the disk cartridge and examine the heads for damage or excessive dirt. If necessary, clean or replace the heads. Do not reuse the cartridge without first checking it for surface damage.

CAUTION

NEVER CYCLE A BAD CARTRIDGE THROUGH AN INSTALLATION OF SEVERAL DRIVES. This practice can ruin all the read/write heads or contaminate all drives in a multidrive installation, which will, in turn, damage all other cartridges run in these drives.

9. Always keep the front door of the drive closed and keep all covers on to prevent unnecessary entry of atmospheric dirt or dust.

2.4 CARTRIDGE PACKING AND SHIPPING

Data recorded on disk cartridges may be degraded by exposure to any sort of small magnet brought into intimate contact with the disk surface. If cartridges are to be shipped in the cargo hold of an aircraft, precautions are necessary against possible exposure to magnetic sources. Because physical separation from the magnetic source is the best

protection against accidental erasure of a cartridge, cartridges should be packed at least three inches within the box. This amount of separation should be adequate to protect against any magnetic sources likely to be encountered during transportation, making it generally unnecessary to ship cartridges in specially shielded boxes.

2.5 NORMAL OPERATING PROCEDURES

All drives in a multidrive system must have operating power applied even when the drive is not in use. In addition, unused drives should be left write-enabled, and with the RUN/LOAD switch in the LOAD position.

IMPORTANT: ON EARLIER MODEL RK05 DISK DRIVES EQUIPPED WITH A POWER ON/OFF SWITCH, DO NOT USE THE ON/OFF SWITCH DURING SYSTEM OPERATION TO REMOVE OPERATING POWER FROM AN INDIVIDUAL DRIVE.

Because the DC LOW interface signal is common to all drives in a multidrive system, a power loss in any one drive disables all the drives in the system. If the drive power is controlled by a processor keyswitch, all drive ON/OFF switches should be left ON; however, all RUN/LOAD switches should be set to LOAD before system power is removed.

2.5.1 Cartridge Loading

The procedure for cartridge loading is as follows:

1. Set the RUN LOAD switch on all drives to LOAD and observe that the LOAD indicator lights.

CAUTION

If the LOAD indicator is not lit, the drive front door is locked. In this case, do not attempt to force the front door open.

2. Open the front door of the drive and *gently* insert a clean, operable disk cartridge fully into the cartridge receiver. DO NOT TWIST OR FORCE THE CARTRIDGE DURING INSERTION!
3. Close the front door of the drive and set the RUN/LOAD switch to RUN.
4. Wait for the RDY and ON CYL indicators to light, the drive is now ready to perform seek, read, or write operations.

2.5.2 Cartridge Unloading

The procedure for cartridge unloading is as follows:

1. Set the RUN/LOAD switch to LOAD and observe that the RDY indicator goes out. After approximately 30 seconds, the LOAD indicator will light.
2. Open the drive front door and *gently* withdraw the disk cartridge.
3. If another cartridge is not loaded, close the drive front door to prevent unnecessary entry of atmospheric dirt or dust.
4. Store the cartridge in a clean plastic bag.

CHAPTER 3

INTERFACE

3.1 GENERAL

The flexibility achieved with the address select logic and the eight-position address select switch permits the RK05 Disk Drive to be connected to a variety of computer systems. In the RK11-C and RK8/E systems, up to four drives can be serially connected to a single bus; in the RK11-D system, up to eight drives can be serially connected.

Interface cable connection of the RK05 Disk Drive is made to card position 7 or 8 of the electronic module. These card positions are parallel-wired so that several drives may be daisy-chained in a multidrive configuration; that is, card position 7 or 8 of the first drive is connected to card position 7 or 8 of the succeeding drive, etc. (By convention, card position 7 is used for input signals; card position 8 is used for output signals.) If there is only one drive in the system, an M930 terminator card must be installed in the unused interface card position; if there is more than one drive in the system, only the last drive on the bus must have the M930 terminator card in the unused interface card position. The interface signal levels are determined by the M930 terminator card. An assertion, or logic 1, is approximately +0.5 Vdc, and a negation, or logic 0, is approximately +3.5 Vdc.

Figure 3-1 illustrates and the following paragraphs describe the function of each interface line. The signals listed, being bus signals, operate according to negative logic; they are asserted low. Appendix A contains a glossary of RK05 backplane connections.

3.2 INPUT INTERFACE LINES

3.2.1 RK11-D

This line (BUS RK11-D L) transmits a signal that configures the address select logic to operate with a particular controller type. A logical 0 on this line indicates that the controller is not an RK11-D (thus, the controller is either an RK11-C or an RK8/E, both of which control only four drives on a single bus), while a logical 1 indicates that the controller is an RK11-D.

3.2.2 Select (4 lines)

BUS SEL DR 0/A/E, 1/B/F, 2/C/H, and 3/D/J L operate in conjunction with the RK11-D interface line and an eight-position address select switch on the M7700 card to determine the drive address assignment and selection by one of the following two methods:

- a. With a logical 0 on the RK11-D line, the M7700 selection circuit is configured to decode the four selection lines as a linear set. In a particular drive, only one of the four lines is internally connected (via positions 0 through 3 of the address select switch) to the drive control logic. To select a drive, the controller places a logical 1 on the desired select line. This line remains at logical 1 throughout the entire data transfer or control operation.

- b. With a logical 1 on the RK11-D line, the M7700 selection is configured to decode the four selection lines as a binary-encoded set. To select a drive, the controller places a 3-bit binary code, which corresponds to the drive address, on these select lines. This binary code is then translated by a three-line-to-eight-line decoder to activate only one of the eight address select switch positions.

3.2.3 Cylinder Address (8 lines)

BUS CYL ADD 0 L through BUS CYL ADD 7 L determine the cylinder position of the read/write heads. In order to move the heads to a desired cylinder, the controller places a corresponding 8-bit binary code on the lines (valid codes=0 through 202_{10}). These lines are gated by the Strobe signal to position the heads at the selected cylinder. The binary code remains on the lines until either the Address Acknowledged or the Address Invalid signal is returned from the drive (Paragraph 3.3.3).

3.2.4 Strobe

BUS STROBE L transmits a signal that gates the Cylinder Address or Restore line. The controller places a logical 1 on the Strobe line, only after the Cylinder Address or the Restore signals are fully settled on their respective lines.

RK05 INPUT FROM CONTROLLER	BUS RK11D-L	A 07 U1
	BUS SEL DR Ø/A/E L	A 07 J2
	BUS SEL DR 1/B/F L	A 07 K2
	BUS SEL DR 2/C/H L	A 07 L2
	BUS SEL DR 3/D/J L	A 07 M2
	BUS CYL ADD Ø L	A 07 K1
	BUS CYL ADD 1 L	A 07 D1
	BUS CYL ADD 2 L	A 07 L1
	BUS CYL ADD 3 L	A 07 C1
	BUS CYL ADD 4 L	A 07 F1
	BUS CYL ADD 5 L	A 07 J1
	BUS CYL ADD 6 L	A 07 E1
	BUS CYL ADD 7 L	A 07 H4
	BUS STROBE L	B 07 H1
	BUS HEAD SELECT L	B 07 M2
	BUS WT PROTECT L	B 07 R2
	BUS WT DATA & CLK L	A 07 F2
	BUS WT GATE L	B 07 L2
	BUS RESTORE L	A 07 M1
	BUS RD GATE L	B 07 R1
	BUS FILE READY L	B 08 N1
	BUS R/W/S RDY L	A 08 H2
	BUS ADDRESS ACCEPTED L	A 08 R2
	BUS ADDRESS INVALID L	A 08 T2
	BUS SEEK INCOMPLETE L	A 08 S2
	BUS WT PROT STATUS L	B 08 P1
	BUS WT CHK L	B 08 K1
	BUS RD DATA L	B 08 S2
	BUS RD CLK L	B 08 S1
	BUS SEC CNTR Ø L	B 08 L1
	BUS SEC CNTR 1 L	A 08 P2
	BUS SEC CNTR 2 L	B 08 K2
	BUS SEC CNTR 3 L	B 08 J1
	BUS SEC PLS L	B 08 N2
	BUS INDX PLS L	B 08 M1
	BUS AC LO L	B 08 F1
	BUS DC LO L	B 08 F2
	BUS RK05/HIGH DENSITY L	B 08 P2
RK05 OUTPUT TO CONTROLLER		

Figure 3-1 Controller/RK05 Disk Drive Interface Lines and Pin Assignments

CP - 0841

The Strobe line remains at logical 1 until either the Address Acknowledged or the Address Invalid signal is returned from the drive.

3.2.5 Head Select

BUS SEL UPPER HD L transmits a signal that determines which of the two read/write heads is to be selected. The controller places a logical 1 on this line to select the upper head, and a logical 0 to select the lower head. Either signal remains on the line throughout the entire read or write operation.

3.2.6 Write Protect Set

BUS WT PROTECT L transmits a signal that disables the drive write amplifiers to prevent a write operation. The controller places a logical 1 on this line to set the Write Protect flip-flop and inhibit the write capability of the drive. The Write Protect flip-flop is also set if the WT PROT indicator is off and the operator presses the WT PROT switch (Paragraph 1.4.1).

3.2.7 Write Data and Clock

BUS WT DATA & CLK L transmits multiplexed data and clock pulses to the disk drive.

3.2.8 Write Gate

BUS WT GATE L transmits a signal to simultaneously turn on both the write and erase current in the selected write head. The controller places a logical 1 on this line 1 μ s prior to transmitting the write data. This line remains at logical 1 throughout the data transmission time.

3.2.9 Restore (RTZ)

BUS RESTORE L transmits a signal to position the read/write heads at cylinder zero. The controller places a logical 1 on this line prior to issuing the Strobe (BUS STROBE L) signal. About 2 μ s after this signal is issued, the drive returns an Address Acknowledged signal, clears the address register, and moves the heads to cylinder zero. The Restore line remains at logical 1 until the Address Acknowledged signal is received by the controller.

3.2.10 Read Gate

BUS RD GATE L transmits a signal that allows data to be read from the drive. The controller places a logical 1 on this line to enable the Read Clock and Read Data output lines. This line remains at logical 1 throughout the entire read operation.

3.3 OUTPUT INTERFACE LINES

3.3.1 File Ready (Drive Ready)

BUS FILE RDY L transmits a logical 1 to indicate the following conditions:

- a. Drive operating power is correct.
- b. A disk cartridge is properly loaded.

c. The drive front door is closed.

d. RUN/LOAD switch is in the RUN position.

e. Spindle is rotating at the correct speed.

f. Read/write heads are loaded.

g. Write Check is false.

3.3.2 Read, Write, or Seek Ready/On Cylinder

BUS R/W/S RDY L transmits a logical 1 to indicate that the drive is in the File Ready condition (Paragraph 3.3.1) and is not performing a seek operation.

3.3.3 Address Accepted

BUS ADDRESS ACCEPTED L transmits a 5- μ s negative pulse to indicate that the drive has accepted a Seek command with a valid address and the command execution has begun. The negative pulse is generated about 2 μ s after receipt of the Strobe signal, even if there is no change from the present address.

3.3.4 Address Invalid (Logic Address Interlock)

BUS LOG ADD INT L transmits a 5- μ s negative pulse to indicate that the drive has received a nonexecutable Seek command with a cylinder address greater than 202. For this case, the Seek command is suppressed in the drive and the heads are not moved. The pulse generation time is the same as for the Address Acknowledged signal.

3.3.5 Seek Incomplete

BUS SIN L transmits a logical 1 to indicate that some malfunction in the drive did not allow the seek operation to be completed. This line remains low until a Restore command is received or the operator sets the RUN/LOAD switch to LOAD and then back to RUN.

3.3.6 Write Protect Status

BUS WT PROT STATUS L transmits a logical 1 to indicate that the write capability of the drive is inhibited (write protected). When this line is at logical 1, the WT PROT indicator on the drive control panel lights (Paragraph 1.4.1).

3.3.7 Write Check

BUS WT CHK L transmits a logical 1 to indicate the following conditions:

- a. Erase or write current without a WRITE GATE.
- b. Inoperative linear positioner transducer lamp.

When the Write Check signal is at a logical 1, all external commands to the drive are suppressed and the FAULT indicator on the drive control panel lights. If the fault condition is temporary, the operator may turn off the FAULT indicator by pressing the WT PROT switch. This

action, however, causes the WT PROT indicator to light; the WT PROT switch must be pressed a second time to turn off the WT PROT indicator (Paragraph 1.4.1).

3.3.8 Read Data

BUS RD DATA transmits read data only (160-ns pulses).

3.3.9 Read Clock

BUS RD CLK L transmits read clock pulses only (160-ns pulses).

3.3.10 Sector Address (4 lines)

BUS SEC CNTR 0 through 3 L indicate which sector is passing under the read/write heads. The sector address is a 4-bit binary code derived from the Sector Address counter.

3.3.11 Sector Pulse

BUS SEC PLS L transmits a 2- μ s negative pulse each time a sector slot passes the sector transducer. The index slot (unique slot) is suppressed in this line and is transmitted on a separate Index Pulse line.

3.3.12 Index Pulse

BUS INDX PLS L transmits a single 2- μ s negative pulse for each revolution of the disk. The Index Pulse occurs 600 μ s

after the last sector pulse and is generated each time the index slot (unique slot) is detected by the sector transducer.

3.3.13 AC Low

BUS AC LO L transmits a logical 1 when there is a loss (for more than 45 ms) of the 30 Vac within the drive. When AC Low occurs, the drive finishes reading/writing the current sector, then initiates a normal head-retract and unload cycle. If a total power loss occurs before the heads are completely retracted, the safety relay is de-energized to retract the heads under battery power (emergency retract).

3.3.14 DC Low

BUS DC LO L transmits a logical 1 when the ± 15 Vdc within the drive drops to 12 Vdc or below. When DC Low is generated, the safety relay is de-energized to retract the heads under battery power (emergency retract). Since the RUN gate of each drive is connected to the DC Low bus, a DC Low signal from any one drive in a multidrive system disables all the drives in the system.

3.3.15 High Density/RK05 L

BUS RK05 L transmits a logical 1 (indicating high density only) whenever the drive is selected. (All RK05s are high density.)

3.3 OUTLINE INTERFACE LINES

Press to write current million a WRITE GATE

Inoperative unless position transmitter ready

Press the Write Gate if it is a logical 1, all external connections to the drive are addressed and the FAULT condition is removed, the oscillator may turn off the FAULT indicator by pressing the WT PROT switch. The

* Write sector - selects a sector from sectors 0 through 2 only to write on sectors 0 through 2 only.

* Seek up - selects a cylinder address lower than the current cylinder address.

APPENDIX A THE RK05-TA OFF-LINE TESTER

* Cylinder write - writes continuous data to the selected cylinder; the write button need not be pressed.

* DG class - when ON, enables seeks on a sector (to sectors) when the WRITE button is pressed; when OFF, enables writing on a sector (sector) when the WRITE button is pressed.

A.1 MOVE FUNCTIONS

1. STEP - incrementing cylinder seek to limit and a high speed return.
2. ALT (Alternate) - an incrementing seek from the cylinder address selected.
3. OSC - oscillate between 0 and the cylinder address selected (not affected by FOR/REV).
4. RAND - random cylinder seek.
5. Drive Selector - selects the drive number selected on the M7700 module in the RK05.
6. RUN - enables all move functions.
7. RTZ - forces a zero recalibrate.
8. FOR/REV - selects the initial drive motion in step and alternate.
9. Cylinder Address - selects any cylinder address from 0 to 202₁₀.

INDICATORS

1. Address invalid - cylinder address set up to an illegal address; i.e., > 202.
2. Seek incomplete - excess time to perform the seek.
3. Power on - indicates power is applied to the drive.

A.2 WRITE FUNCTIONS

1. *Write sector – selects a sector (from sectors 0 through 9 only) to write on and simulates a write data. “All” simulates a write all. Note: the unit cannot read to check headers.
2. Head select – selects or enables either the upper or lower head. Only one head can be selected at a time; thus only one surface is written on.
3. *Write button causes a write one-shot to write or erase on the sector selected (or the track, if “All” is selected).
4. *Constant write – when set, writes continuously on the sector selected; the write button need not be pressed.
5. *DC erase – when ON, enables erase on a sector (or sectors) when the WRITE button is pressed; when OFF, enables writing on a sector (sectors) when the WRITE button is pressed.
6. Data bits – sets a 4-bit data pattern to be written on the sector selected.

*After the RK05-T has been used to perform write or erase operations, the disk will have to be reformatted.

A.3 CONNECTING THE RK05-T OFF-LINE TESTER

1. Disconnect the ac line cord.
 - a. Remove the interface cable from the RK05.
 - b. Check the RK05 and the tester to ensure that a M930 Terminator module is present in one of them (slot 7 or 8 of the RK05, or slot 2 of the RK05-TA Off-Line Tester).
 - c. Connect a BC11-A cable from slot 1 or 2 of the tester to slot 7 or 8 in the RK05.
 - d. Disconnect connector J1 in the RK05 (logic voltage connector).
 - e. Plug one end of the tester power cable into the tester.
 - f. Check for proper keying of the pins and plug the male connector of the power cable into the female connector of J1.
 - g. Connect the remaining connector to the plug leading to the logic block of the RK05.
 - h. Reconnect the ac line cord.
 - i. Toggle RTZ to initialize and clear all error conditions and proceed with testing.

Reader's Comments

RK05 DISK DRIVE
USER'S MANUAL
EK-RK05-OP-001

Your comments and suggestions will help us in our continuous effort to improve the quality and usefulness of our publications.

What is your general reaction to this manual? In your judgment is it complete, accurate, well organized, well written, etc.? Is it easy to use? _____

What features are most useful? _____

What faults do you find with the manual? _____

Does this manual satisfy the need you think it was intended to satisfy? _____

Does it satisfy *your* needs? _____ Why? _____

Would you please indicate any factual errors you have found. _____

Please describe your position. _____

Name _____ Organization _____

Street _____ Department _____

City _____ State _____ Zip or Country _____

Reader's Comments

KR02 DISK DRIVE
USER'S MANUAL
EK-KR02-OP-001

Your comments and suggestions will help us in our continuing effort to improve the quality and usefulness of our publications.

What is your best section of this manual? If your answer is a composite, please, tell us how.

What is it easy to read?

Fold Here

What features are most useful?

What parts do you find difficult?

Does this manual satisfy the need you think it was intended to satisfy?

Why

Does it satisfy your needs?

Do Not Tear - Fold Here and Staple

**FIRST CLASS
PERMIT NO. 33
MAYNARD, MASS.**

BUSINESS REPLY MAIL

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

Postage will be paid by:

Organization

Department

Zip or County

Digital Equipment Corporation
Technical Documentation Department
Maynard, Massachusetts 01754

DIGITAL EQUIPMENT CORPORATION **digital** WORLDWIDE SALES AND SERVICE

MAIN OFFICE AND PLANT

Maynard, Massachusetts, U.S.A. 01754 • Telephone: From Metropolitan Boston 646-8600 • Elsewhere: (617)-897-5111
TWX: 710-347-0212 Cable: DIGITAL MAYN Telex: 94-847

DOMESTIC

NORTHEAST

REGIONAL OFFICE:
235 Wyman Street, Waltham, Mass. 02154
Telephone: (617)-890-0330 Dataphone: 617-890-3012 or 3013

CONNECTICUT

Meriden
240 Pomeroy Ave., Meriden, Conn. 06450
Telephone: (203)-237-8441/7466 Dataphone: 203-237-8205

Fairfield
1275 Post Road, Fairfield, Conn. 06430
Telephone: (203)-255-5991

NEW YORK
Rochester
130 Allens Creek Road, Rochester, New York
Telephone: (716)-461-1700 Dataphone: 716-244-1680

Syracuse
6700 Thompson Road, Syracuse, New York 13211
Telephone: (315)-437-1593/7085 Dataphone: 315-454-4152

MASSACHUSETTS
Marlborough
One Iron Way
Marlborough, Mass. 01752
Telephone: (617)-481-7400 Telex: 710-347-0348

MID-ATLANTIC

REGIONAL OFFICE:
U.S. Route 1, Princeton, New Jersey 08540
Telephone: (609)-452-2940

FLORIDA
Orlando
Suite 130, 7001 Lake Ellenton Drive, Orlando, Florida 32809
Telephone: (305)-851-4450 Dataphone: 305-859-2360

GEORGIA
Atlanta
201 Peachtree Place, Suite 100
Atlanta, Georgia 30303
Telephone: (404)-451-7411 Dataphone: 305-859-2360

NORTH CAROLINA
Durham/Chapel Hill
Executive Park
3700 Chapel Hill Blvd.
Durham, North Carolina 27707
Telephone: (919)-489-3347 Dataphone: 919-489-7832

NEW JERSEY
Fairfield
253 Passaic Ave., Fairfield, New Jersey 07006
Telephone: (201)-227-9280 Dataphone: 201-227-9280

Metuchen
95 Main Street, Metuchen, New Jersey 08840
Telephone: (201)-549-4100/2000 Dataphone: 201-548-0144

MID-ATLANTIC (cont.)

Princeton
Route 1, Princeton, New Jersey 08540
Telephone: (609)-452-2940 Dataphone: 609-452-2940

NEW YORK
Long Island
1 Huntington Quadrangle
Suite 1507 Huntington Station, New York 11746
Telephone: (516)-694-4131, (212)-895-8095
Dataphone: 516-293-5693

Manhattan
810 7th Ave., 22nd Floor
New York, N.Y. 10019
Telephone: (212)-582-1300

PENNSYLVANIA
Philadelphia
Digital Park
1740 Walton Road, Blue Bell, Pennsylvania 19422
Telephone: (215)-825-4200

TENNESSEE
Knoxville
6311 Kingston Pike, Suite 21E
Knoxville, Tennessee 37919
Telephone: (615)-588-6571 Dataphone: 615-584-0571

WASHINGTON D.C.
Lanham 30 Office Building
4900 Princess Garden Parkway, Lanham, Maryland
Telephone: (301)-459-7900 Dataphone: 301-459-7900 X53

CENTRAL

REGIONAL OFFICE:
1850 Frontage Road, Northbrook, Illinois 60062
Telephone: (312)-498-2500 Dataphone: 312-498-2500

INDIANA
Indianapolis
21 Beachway Drive, Suite G
Indianapolis, Indiana 46224
Telephone: (317)-243-8341 Dataphone: 317-247-1212

ILLINOIS
Chicago
1850 Frontage Road
Northbrook, Illinois 60062 Dataphone: 312-498-2500

LOUISIANA
New Orleans
3100 RidgeLake Drive, Suite 108
Metairie, Louisiana 70022
Telephone: (504)-837-0257 Dataphone: 504-833-2800

CENTRAL (cont.)

MICHIGAN
Ann Arbor
230 Huron View Boulevard, Ann Arbor, Michigan 48103
Telephone: (313)-761-1150 Dataphone: 313-769-9883

Detroit
23777 Greenfield Road
Suite 189
Southfield, Michigan 48075 Dataphone: 313-557-3063

MINNESOTA
Minneapolis
8030 Cedar Ave. South, Minneapolis, Minnesota 55420
Telephone: (612)-854-6562-3-4-5 Dataphone: 612-854-1410

MISSOURI
Kansas City
12401 East 43rd Street, Independence, Missouri 64055
Telephone: (816)-252-2300 Dataphone: 816-461-3100

St. Louis
Suite 110, 115 Progress Parkway
Maryland Heights, Missouri 63043
Telephone: (314)-878-4310 Dataphone: 816-461-3100

OHIO
Cleveland
2500 Euclid Avenue, Euclid, Ohio 44117
Telephone: (216)-946-8484 Dataphone: 216-946-8477

Dayton
100 Kettering Boulevard
Dayton, Ohio 45439
Telephone: (513)-294-3323 Dataphone: 513-298-4724

OKLAHOMA
Tulsa
3140 S. Winston
Winston Sq. Bldg., Suite 4, Tulsa, Oklahoma 74135
Telephone: (918)-749-4476 Dataphone: 918-749-2714

PENNSYLVANIA
Pittsburgh
100 Penn Center Boulevard, Pittsburgh, Pennsylvania 15235
Telephone: (412)-243-9404 Dataphone: 412-824-8730

TEXAS
Dallas
Plaza North, Suite 513
2880 LBJ Freeway, Dallas, Texas 75234
Telephone: (214)-620-2051 Dataphone: 214-620-2061

HOUSTON
6658 Hornwood Drive
Monterey Park, Houston, Texas 77036
Telephone: (713)-777-3471 Dataphone: 713-777-1071

WISCONSIN
Milwaukee
8531 West Capitol Drive, Milwaukee, Wisconsin 53222
Telephone: (414)-463-9110 Dataphone: 414-463-9115

WEST

REGIONAL OFFICE:
310 Soquel Way, Sunnyvale, California 94086
Telephone: (408)-735-9200 Dataphone: 408-735-1820

ARIZONA
Phoenix
4358 East Broadway Road, Phoenix, Arizona 85040
Telephone: (602)-268-3488 Dataphone: 602-268-7371

CALIFORNIA
Santa Ana
2110 S. Anne Street, Santa Ana, California 92704
Telephone: (714)-979-2460 Dataphone: 714-979-7850

San Diego
6154 Mission Gorge Road
Suite 110, San Diego, California
Telephone: (714)-280-7880/7870 Dataphone: 714-280-7825

San Francisco
1400 Tierra Bella, Mountain View, California 94040
Telephone: (415)-964-6200 Dataphone: 415-964-1436

Oakland
7850 Edgewater Drive, Oakland, California 94621
Telephone: (415)-935-5453/7830 Dataphone: 415-562-2160

West Los Angeles
1510 Cotner Avenue, Los Angeles, California 90025
Telephone: (213)-479-3791/4318 Dataphone: 213-478-5626

COLORADO
7901 E. Bellevue Avenue
Suite 5, Englewood, Colorado 80110
Telephone: (303)-770-6150 Dataphone: 303-770-6628

NEW MEXICO
Albuquerque
10200 Menual N.E., Albuquerque, New Mexico 87112
Telephone: (505)-296-5411/5428 Dataphone: 505-294-2330

OREGON
Portland
Suite 168
5319 S.W. Westgate Drive, Portland, Oregon 97221
Telephone: (503)-297-3761/3765

UTAH
Salt Lake City
429 Lawn Dale Drive, Salt Lake City, Utah 84115
Telephone: (801)-487-4669 Dataphone: 801-467-0535

WASHINGTON
Bellevue
1340 N.E. Bellevue, Redmond Road, Suite 111
Bellevue, Washington 98005
Telephone: (206)-545-4059/455-5404 Dataphone: 206-747-3754

INTERNATIONAL

EUROPEAN HEADQUARTERS

Digital Equipment Corporation International Europe
B1 route de l'Air
1211 Geneva 26, Switzerland
Telephone: 221-79-53 Telex: 226 683

FRANCE

Digital Equipment France
Centre de Service Cidex L 225
94533 Rungis, France
Telephone: 687-23-33 Telex: 26840

GRENOBLE

Digital Equipment France
Tour Mangin
16 Rue du Gal Mangin
38100 Grenoble, France
Telephone: (76)-87-56-01 Telex: 212-32882

GERMAN FEDERAL REPUBLIC

Digital Equipment GmbH

MUNICH
8 Muenchener Str., Wallensteinplatz 2
Telephone: 0811-35031 Telex: 524-226

COLOGNE

5 Koeln 41, Aachener Strasse 311
Telephone: 0221-44-40-95 Telex: 888-2269

FRANKFURT

6078 Neu-Isenburg 2
Am Forsthaus Gravelbruch 5-7
Telephone: 06102-5526 Telex: 41-76-82

HANNOVER

3 Hannover, Podbielskistraße 102
Telephone: 0511-69-70-95 Telex: 922-952

STUTTGART

D-7000 Stuttgart
Marco-Polo-Straße 1
Telephone: (0711)-45-50-65 Telex: 841-722-393

AUSTRIA

Digital Equipment Corporation Ges.m.b.H.
VIENNA
Mariahilferstrasse 136, 1150 Vienna 15, Austria
Telephone: 85-51-86

UNITED KINGDOM

Digital Equipment Co. Ltd.
U.K. HEADQUARTERS
Farnborough, Balfour Centre
Reading RG1 7QN, England
Telephone: (0734)-589355 Telex: 8483278

BIRMINGHAM

Maney Buildings
29/31 Birmingham Rd., Sutton Coldfield
Warwickshire, England
Telephone: 021-355-5501 Telex: 337-060

BRISTOL

Fish Ponds Road, Fish Ponds
Bristol, England BS163HQ
Telephone: Bristol 651-431

EALING

Bilton House, Ubrique Road, Ealing, London W.5.
Telephone: 01-519-2344 Telex: 22371

EDINBURGH

Shiel House, Craigshill Livingston,
West Lothian, Scotland
Telephone: 32705 Telex: 727113

LONDON

Management House
43 Portland St., Holborn, London
WC1B 2PT, England
Telephone: 01-405-2614/4067 Telex: 27560

MANCHESTER

Arndale House
Chester Road, Stretford, Manchester M32 9BH
Telephone: (061)-865-7011 Telex: 668666

UNITED KINGDOM (cont.)

READING
Fountain House, Butts Centre
Reading RG1 7QN, England
Telephone: (0734)-583555 Telex: 8483278

NETHERLANDS
Digital Equipment N.V.
THE HAGUE
Sir Winston Churchillian 370
Rijswijk/The Hague, Netherlands
Telephone: 94-9220 Telex: 32533

BELGIUM
Digital Equipment AB
STOCKHOLM
Englundavagen 7, 171 41 Solna, Sweden
Telephone: 98-13 90 Telex: 170 50
Cable: Digital Stockholm

NORWAY
Digital Equipment Corp. A/S
OSLO
Trondheimsveien 47
Oslo 5, Norway
Telephone: 02/68 34 40 Telex: 1907 DEC N

DENMARK
Digital Equipment Aktiebolag
COPENHAGEN
Hellerupvej 66
2900 Hellerup, Denmark

FINLAND
Digital Equipment AB
HELSINKI
Titsimantahti 6
SF-00710 Helsinki 71
Telephone: (090)-370133 Telex: 106-213933

SWITZERLAND
Digital Equipment Corporation S.A.
GENEVA
20, Quai Ernest Ansermet
Boite Postale 23, 1211 Geneva 8, Switzerland
Telephone: 02 20 40 20 and 20 58 93 and 20 68 93
Telex: 28 92 01

ZURICH
Digital Equipment Corp. AG
Schaffhauserstr. 315
CH-8050 Zurich, Switzerland
Telephone: 01-46-94-91 Telex: 56059

ITALY
Digital Equipment S.p.A.
MILAN
Curso Garibaldi 49, 20121 Milano, Italy
Telephone: (02)-879-051/2/3/4/5 Telex: 843-33615

SPAIN
Digital Equipment Corporation Ltd.
MADRID
Atao Ingenieros S.A., Enrique Larreta 12, Madrid 16
Telephone: 215 35 43 Telex: 27249

BARCELONA
Atao Ingenieros S.A., Granduxer 76, Barcelona 6
Telephone: 221 44 66

CENTRAL (cont.)

MICHIGAN
Ann Arbor
230 Huron View Boulevard, Ann Arbor, Michigan 48103
Telephone: (313)-761-1150 Dataphone: 313-769-9883

Detroit
23777 Greenfield Road
Suite 189
Southfield, Michigan 48075 Dataphone: 313-557-3063

MINNESOTA
Minneapolis
8030 Cedar Ave. South, Minneapolis, Minnesota 55420
Telephone: (612)-854-6562-3-4-5 Dataphone: 612-854-1410

MISSOURI
Kansas City
12401 East 43rd Street, Independence, Missouri 64055
Telephone: (816)-252-2300 Dataphone: 816-461-3100

OHIO
Cleveland
2500 Euclid Avenue, Euclid, Ohio 44117
Telephone: (216)-946-8484 Dataphone: 216-946-8477

OKLAHOMA
Tulsa
3140 S. Winston
Winston Sq. Bldg., Suite 4, Tulsa, Oklahoma 74135
Telephone: (918)-749-4476 Dataphone: 918-749-2714

PENNSYLVANIA
Pittsburgh
100 Penn Center Boulevard, Pittsburgh, Pennsylvania 15235
Telephone: (412)-243-9404 Dataphone: 412-824-8730

TEXAS
Dallas
Plaza North, Suite 513
Monterey Park, Houston, Texas 77036
Telephone: (713)-777-3471 Dataphone: 713-777-1071

MONTRÉAL
Montreal
1000 De Lièvre
Dorval, Quebec, Canada H9P 2M9
Telephone: (514)-636-9393 Telex: 610-422-4124

CALGARY
Edmonton
Suite 140, 6940 Fisher Road S.E.
Calgary, Alberta, Canada
Telephone: (403)-435-4881 TWX: 403-255-7408

VANCOUVER
Suite 202
644 S.W. Marine Dr., Vancouver
British Columbia, Canada V6P 5Y1
Telephone: (604)-329-3231 Telex: 610-929-2006

MONTREAL
Montreal
1450 René Lévesque
Montreal, Quebec, Canada H3B 2M5
Telephone: (514)-875-5000 Telex: 510-421-3399

GENERAL INTERNATIONAL SALES
REGIONAL OFFICE
146 Main Street, Maynard, Massachusetts 01754
Telephone: (617)-875-5111
From Metropolitan Boston, 646-8600

TWX: 710-347-0217/0212
Cable: DIGITAL MAYN
Telex: 94-8457

AUSTRALIA
Digital Equipment Australia Pty. Ltd.
ADELAIDE
6 Montrouge Avenue
Norwood, South Australia 5067
Telephone: (080)-42-1339 Telex: 790-8225

BRISBANE
133 Leichhardt Street
Spring Hill
Brisbane, Queensland, Australia 4000
Telephone: (07)-293098 Telex: 790-40616

CANBERRA
27 Collie St.
Fyshwick, A.C.T. 2609 Australia
Telephone: (062)-950073

MELBOURNE
60 Park Street, South Melbourne, Victoria 3205
Australia
Telephone: (03)-699-2888 Telex: 790-30700

Sydney
643 Murray Street
West Perth, Western Australia 6005
Telephone: (092)-21 4993 Telex: 790-92140

Sydney
P.O. Box 491, Crown Nest
N.S.W. Australia 2065
Telephone: (02)-439-2565 Telex: 790-20740

NEW ZEALAND
Digital Equipment Corporation Ltd.
AUCKLAND
Hilton House, 430 Queen Street, Box 2471
Auckland, New Zealand
Telephone: 75533

JAPAN

Digital Equipment Corporation International
Kowa Building No. 18 Annex, First Floor
9-20 Akasaka 1-Chome
Minato-Ku, Tokyo 107, Japan
Telephone: 588-2771 Telex: J-26428

Rikei Trading Co., Ltd. (sales only)
Kozato-Kaikan Bldg.
No. 18-14 Nishishimbashi 1-Chome
Minato-Ku, Tokyo, Japan
Telephone: 591-5246 Telex: 781-4208

Puerto Rico
Digital Equipment Corporation De Puerto Rico
407 del Parque Street
Santurce, Puerto Rico 00912
Telephone: (809)-723-8068/67 Telex: 385-9056

ARGENTINA
BUENOS AIRES
Coisin S.A.
Casoni S.A.
Virrey del Pino, 4071, Buenos Aires
Telephone: 52-3185 Telex: 02-2284

BRAZIL
RIO DE JANEIRO — GB
Ambrex S.A.
Rua Ceará, 104, 2 e 3 andares ZC - 29
Rio De Janeiro — CB
Telephone: 264-7406/0461/7625

SÃO PAULO
Ambrex S.A.
Rue Tupi, 535
São Paulo — SP
Telephone: 52-7806/1870, 51-0912

PORTO ALEGRE — RS
Rua Coronel Vicente 421/101
Porto Alegre — RS
Telephone: 24-7411

CHILE
SANTIAGO
Coisin Chile Ltda. (sales only)
Casilla 1458, Correo 15,
Telephone: 396713 Telex: COACHIL

INDIA
BOMBAY
Hindtron Computers Pvt. Ltd.
69/A, L. Jagmohandas Marg.
Bombay 4 (WB), India
Telephone: 38-1615, 36-5344 Telex: 011-2594 Plenty

MEXICO
MEXICO CITY
Mexitek, S.A.
Eugenio 408 Deptos. 1
Apdo. Postal 12-1012
Mexico 12, D.F.
Telephone: (905) 536-0910