COMPUMOTOR

F-SERIES

MOTOR/DRIVER

OPERATOR'S MANUAL

P/N 88-005728-01

COMPUMOTOR CORPORATION

5500 BUSINESS PARK DRIVE

ROHNERT PARK CA 94928

COMPUMOTOR F-SERIES MOTOR/DRIVER SYSTEMS
INSTALLATION & OPERATION MANUAL

INDEX

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COMPUMOTOR F-SERIES MOTOR/DRIVER SYSTEMS

INSTALLATION AND OPERATION MANUAL

I. INTRODUCTION:

WARNING!

Compumotor Corporation has made a special effort in the design and construction of its products to make them both versatile and easy to use. The mechanical torque produced by these motor/drivers is capable of damaging or destroying the equipment to which they are connected if improperly installed, operated or serviced. Only persons qualified in servicing and installing hazardous voltage electrical and limited-travel mechanical systems should attempt this procedure.

The F-Series motor/driver is a high power microstepping drive with a low pass filter added to reduce the 20KHZ switching noise in the ouput current which cannot be tolerated by the low inductance of F-series motors.

The F57-83 is a standard hybrid stepper motor. The F83-49 series motor driver is a disk rotor synchro-step motor. The disk rotor causes the motor to have an extremely low rotor inertia making it ideal for applications requiring high accelerations.

II. INSPECTION

Carefully inspect the shipping carton(s) for any evidence of physical abuse or damage and note any findings on the Waybill at the time of receipt. In cases of severe damage, it is recommended that the shipment be rejected entirely. Compumotor Corporation cannot be responsible for in-transit damage.

III. UNPACKING

Use care in opening the shipping carton(s) so that the cables supplied are not cut or damaged. Verify the receipt of the following items:

Qty	Description
1	Compumotor with 10 foot (3M) Drive Cable
1	Driver (Power Amplifier/Translator) Module
1	3-wire AC Line Cord 6 feet (2M) with Ground Pin
1	Pulse Source Cable Kit
1	Standard Product Line Brochure

Report any shortages and/or direct any questions regarding ordered and supplied options directly to Compumotor Corporation (see Further Notes, page 9).

IV. MOUNTING THE MOTOR AND DRIVER

The two F-series motors conform to NEMA Standard frame sizes as follows:

Compumotor Series	NEMA Standard Frame Size	Bolt Size	Bolt Grade SAE
F57	23	#8-32	3
F83	34	#10-32	3

The Compumotor should be mounted rigidly with the proper size and grade of hardware at all four corners, and the motor case should be connected to third wire ground.

The Compumotor's mounting surface acts as a heat sinking device which carries away thermal energy generated by self heating. Temperatures produced by the motor when not mounted may seem excessive, and are the result of the Compumotor having full power applied at all times, even when not rotating. This heating is normal. The motor temperature will drop considerably when the Compumotor is mounted.

The Driver may be mounted some distance from the motor if the wire lengths and minimum wire sizes listed in Appendix B are observed. Motor cable extensions are available from the factory.

Mount the Driver with the heatsink fins running vertically for best convection cooling (Figure 5). A minimum of 3 inches (7.62 cm) of clearance must surround the Driver on the heatsink top and four sides.

Route the motor cable carefully so that movements of the motor and any attached mechanism(s) will not cause interference. In addition, the motor cable should be routed away from equipment that is sensitive to electro-magnetic interference.

Environmental Considerations:

The mounting location for the Compumotor and driver must be free from all liquids and protected from conductive chips and dust. The standard Compumotor is not suitable for explosive atmospheres, vaccuum beyond 10-2 torr, or life-support equipment. The bearings in the motor are not sealed and must be protected from contaminants. Ambient conditions for the Driver are 32° to 122° F (0° to 50° C) and 0 to 95% humidity (non-condensing). The Compumotor can operate from 32° to 150° F (0° to 70° C).

Continuous operation of the F57-83 motor velocity of 10 rps may be

limited depending on the ambient temperature. See Appendix A for case temperature versus velocity for 25, 30 and 50 degree ambient temperature environment.

Coil any excess cable at the Driver and secure it with a cable tie. This cable carries high voltage (150 VDC) and all wire runs must conform to all applicable local electrical codes and OSHA requirements. Check that the model number of the Compumotor and the Driver have the same type number (e.g. F83-49). Rotate the Motor Cable Connector until it slips into the mating connector on the Driver. Turn the locking collar clockwise until it is tight.

V. CONNECTING AC POWER*

Select a source of 117 VAC power which is free from line drop outs and transient voltage spikes. The maximum current draw of the various Motor/Driver Systems is listed in Appendix B. Standard practices of sizing wire for these loads must be observed to minimize the voltage drop at the driver.

VI. CHECKOUT

Prior to energizing the Motor/Driver, manually turn the Compumotor shaft by grasping the outer radius of the dummy load. One should feel the magnetic detents characteristic of this type of AC synchronous motor employing permanent magnets.

A. Proper Torque

A dummy load of the approximate inertia listed in Appendix A should be mounted securely to the motor shaft for testing. Only collet-style mounting clamps are recommended for security and for concentricity between the load and the motor shaft. Compumotor Corporation will supply a simple dummy load for the F57 and F83 Series motors upon request. The appropriate part numbers are P/N 53-000536 for the F57 Series and P/N 53-000537 for the F83 Series.

Note: F-Series Motor/Drivers have an internal interlock built into the motor cable (Pins 3 and 7). The interlock will not allow power to be delivered to the motor connector while the motor is disconnected. This is a safety feature to protect the operator from hazardous voltages that would otherwise be present. It is important that this interlock be supported should an extension or custom cable be used to drive the motor. Consult the factory for assistance prior to making any extension or custom cables.

*Caution: Hazardous voltages inside. Refer installation and servicing to qualified personnel only.

Connect AC power to the Motor/Driver.

It is not unusual for there to be a snap or pop caused by the in-rush energy charging the Motor/Driver power supply. Check that the rated holding torque is present at the Compumotor shaft. This may be done empirically by feel, as the magnetic detent torque will have increased by at least an order of magnitude. A standard torque wrench may be used in place of the dummy load if a quick, quantifiable result is desired. Should the torque under power be low or nonexistent, proceed to Section X, Trouble Shooting (page 8).

WARNING:

DO NOT connect or disconnect the motor connector while the Motor/Driver is energized because an arc will result in the connector subsequently and damage the Motor/Driver. To do so voids the Warranty. Multiple motors may be connected, one at a time, to the same driver by use of the Remote Power Shutdown and external switches. Consult the factory if this is required.

B. Pulse Source Indexer Connection
(25-Pin D-Connector, female)

Signal	Pin	Current
Direction Input (+)	2	20 Ma, TTL Level
Direction Return (-)	15	
Step Input (+)	1	20 Ma, TTL Level
Step Return (-)	14	
Remote Shutdown (+)	16	20 Ma, TTL Level
Shutdown Return (-)	17	
Chassis Ground	Not connected at drive.	

Check the pulse source (indexer) cable for continuity and possible shorts prior to use. Use a dummy load of 180 ohms to ensure that a minimum of 20 Ma is available to drive each of the opto-isolators in the driver (HP - #HCPL 2530).

C. Pulse Generation

Set the pulse rate of your chosen pulse source to zero. Connect the Pulse Source Cable to the Driver. Make sure that the Remote Power Shut-down signal is not asserted (Logical "0" on Pin 16).

Compumotors are designed to be accelerated and decelerated. Compumotor Corporation provides a complete line of preset indexers for creating the necessary velocity profiles and controlling total distance moved.

Gradually increase the pulse rate until the dummy load begins to noticeably rotate. Decrease again to zero and change the logic state of the

direction input. Increase the pulse rate and observe the change in direction of the Compumotor shaft. Return the pulse rate to zero. Simple frequency counters are helpful at this stage to observe velocity changes.

D. Compumotor Pulse Generation

If you are using one of Compumotor Corporation's Preset Indexers with a 25,000 step per revolution Motor/Drive system, perform the following test:

150, 170 or 2100 Series Preset Indexers

1. Set the Mode Switch to "Preset".
2. Dial in "10" rev/sec on the Acceleration thumbwheels.
3. Dial in "10.00" rev/sec (150 or 170 Series) or "10.000" rev/sec. (2100) on the Velocity thumbwheels.
4. Dial in "+20.000" revolutions on the Position thumbwheels (151 Series) or 500,000 steps (170 or 2100 Series).
5. Depress "START".

If using the 2100 Series Indexer with RS-232C Computer Interface you may do the following:

"E MN A10 V10 D500000 G<CR>" (Carriage Return)

For 2100's exercising the Model 1200 compatibility option the following will have the same results:

Type "MN A10 V10 D20 G (Carriage Return)

All of the above will accelerate the motor at the rate of 10 rev/sec until a velocity of 10 rev/sec is reached (5 complete revolutions in one second). After completing a total of 15 revolutions, the motor will begin to decelerate at the rate of 10 rev/sec to a stop. When stopped, it will have completed exactly 20 revolutions in three seconds.

VII. LIMITED-TRAVEL MECHANISM

Before connecting the actual load to the shaft of the Compumotor, all limited-travel mechanisms must be protected by the use of electrical limit switches. If one of the Compumotor Preset Indexers is used, follow the instructions included with those units. In other cases, a limit switch must signal the need for a controlled deceleration at the maximum rate possible. This rate must be consistent with load inertia and maximum load of the motor.

Note that since the required limits are not the "End-of-Travel" type, they must be tripped fat enough before the mechanical stop to allow the load to be safely decelerated. This distance may be computed using the Braking Curves of the appropriate Motor Specification Sheet and the

formulas given in Application Note #3. It also may be determined empirically by initiating the deceleration cycle in the middle of travel and measuring the distance required to stop.

VIII. DYNAMIC CHARACTERISTICS OF THE COMPUMOTOR

A Compumotor is a special case of a hybrid permanent magnet stop motor driven by a 20 KHZ, bi-polar, chopper power amplifier. Its complex wave shaping circuitry allows significant compensation for many of the mechanical and electrical imbalances inherent in step motors. The digitally-controlled proportioning of current simultaneously between multiple windings gives high torque at low speed without the jarring accelerations of traditional step motors.

The precision of Compumotor's drive proportioning techniques yields exceptional repeatability while maintaining the open-loop accuracy and ease of use characteristic of stepper motors. The Compumotor shares the dynamic response curve of the stepper motor and its stall characteristics. That is, full torque under acceleration is developed at a lag angle of approximately 1.8°. Loading which causes a larger lag angle will result in the motor losing position.

In cases of severe overloading, the rotor will lose synchronism with the rotating magnetic vector of the stator and the rotor will stall and stop. The Compumotor has been designed to allow a continuous stall condition while overloaded without damage to the Compumotor or the driver. If the motor is stalled, however, the rotating magnetic vector must be stopped by halting the input pulses, and the cause of the overloaded condition remedied before the Compumotor may be restarted and run successfully.

Up to 1.8° of dynamic error under acceleration will be recovered when a constant velocity is reached, or when the Compumotor is stopped. How much error is recovered is proportional to load friction and depends on the stick-slip characteristics of the load. The degree of recovery may therefore have to be determined empirically. If using Compumotors or step motors in multi-axis systems, the error under load (if excessive) could be compensated for in the master control system. Decelerating produces a similar error condition as the motor leads the load.

IX. PERIODIC MAINTENANCE

Periodically check the Compumotor mounting bolts and shaft couplings. The ball bearings used in the Compumotor are not sealed but are permanently lubricated and require no maintenance. There are no serviceable items in the Compumotor or maintenance items such as brushes.

The motor strain relief and cable should be inspected at appropriate intervals for signs of wearing or excessive force being applied to the cable. Tighten both cable connectors at the driver. Check that the driver

heatsink is free of dust and dirt and has a free flow of air over its entire surface.

X. TROUBLESHOOTING

If problems develop in the operation of the Compumotor, refer to the following list of symptoms and causes to identify or localize the problem:

1. Motor fails to turn

   Probable causes:

   (a) No AC power
   (b) Bad connections or bad cables
   (c) Tripped or faulty limit switches - make sure that control signals are not being inhibited by limit inputs to a preset indexer or supervisory logic.
   (d) Load is jammed - remove AC power from the driver and verify that the load can be turned manually.
   (e) No step signal coming to driver - check that a pulse train meeting all requirements for voltage, current and pulse width is available (3.5 to 6V @ mA minimum, 25 mA maximum, 500 nSec pulse width minimum).
   (f) Driver ouput is being turned off by Remote Power Shutdown Option-Pin 16 of the input cable to the driver should not be high (TTL level) relative to Pin 17.
   (g) Blown driver AC line fuse. - Disconnect AC power from the driver and dismount it from the surface to which it is attached. Remove the four Phillips-head screws which retain the sheet metal cover on the long sides of the driver. Remove the four screws on the short edges of the end plates. Slip off the cover and inspect the fuse. If the fuse is blown, return the unit for repair.

Notice: Probing of the driver with AC power applied should never be done by anyone other than Compumotor qualified personnel. LETHAL VOLTAGES ARE PRESENT and there is no AC isolation in the driver.

2. Motor stops during acceleration:

   Probable cause:

   This condition indicates an overload condition caused by excessive torque requirements, too steep an acceleration ramp, or a gross mismatch of load inertia and rotor inertia. Refer to Compumotor Application Note #3 for calculations of torque. A larger motor and/or lower accelerations may be indicated.

3. Motor fails to run above 20 rps (1200 rpm)

This may be due to load/Compumotor interactions which can stimulate parametric oscillations and stall the Compumotor. The addition of friction, system dampening or mechanical redesign to minimize mechanical resonances may be required singly or in combination.

4. Motor is jerky, noisy or weak

Check that there are no mechanical problems at the load causing highly variable loading conditions at the Compumotor shaft. Disconnect the Compumotor from the load and run it with a dummy load connected. If the problem persists, service repair is indicated.

XI. FACTORY SERVICE

To return the Compumotor for repair or to order replacement parts, obtain the model and serial numbers of the motor and driver. Call the Compumotor Service Department for return authorization. In California call collect: (707) 778-1244, otherwise call toll free (800) 358-9068. Return the Compumotor and Driver, freight prepaid, to:

Note: Please mark both packing slip and packing label with the Return Material Authorization number supplied by Compumotor.

XII. FURTHER NOTES

Compumotor Corporation is dedicated to be a leader in digital motion control. We invite your problems, questions or comments.

This manual has been designed to provide an introduction for the user with typical applications. Significant departures from the operating parameters outlined here are possible. If you have a volume requirement for our products (of over 250 per year) we would like to discuss your specific needs.

Call or write:

Parker Compumotor
5500 Business Park Drive
Rohnert Park, CA 94928
(707) 584-7558 (800) 358-9068
RMA # _____

In California ,call collect: *(707) 584-7558*
Outside California, call toll free: (800) 358-9068

XIII. SPECIFICATIONS

Environmental Specifications:

Operating: Driver - 32°-122° F (0°-50° C) ambient assumes driver fins mounted vertically, convection cooling. Maximum fin temp. = 150° F (50°)
0 to 95% humidity, non-condensing

Motor - 32°-104° F (0°-50°) ambient - assumes convection cooling. Maximum case temp. (measured mid-case) = 212 (100° C)
0 to 95% humidity, non-condensing

Storage: -40° to 185° F (-40° to 85° C)

Electrical Specifications:

Input power:	105 to 125 VAc 50/60 Hz with brownout protection
TTL Inputs:	3.5 to 6.0V pulse height
	500 nSec pulse width minimum
	20 mA minimum current
	750 KHZ maximum pulse rate

Driver Dimensions:

Weight:	4 lbs. (1.82 kg)
Height:	4.063 in.(10.32 cm)
Length:	8.25 in. (20.96 cm)
Width:	5.38 in. (13.67 cm)

Motor Specifications:

	F57-83	F83-49
Rotor Inertia:		
OZ-in^2	1.28	.48
kg-cm^2	.234	.008

Torque: see appendix B for speed torque curves

Motor Case Temperature Rise

Velocity (rps)	F57-83 ˚F(˚C)	F83-49 ˚F(˚C)
0	50.0(10)	50.0(10)
2	68.0(20)	50.0(10)
10	122.0(50)	71.6(22)
20	143.6(62)	78.8(26)
30	159.8(71)	78.8(26)

Continuous operation of the F57-83 motor above an RMS velocity of 10 rps may be limited depending on the ambient temperature. See Appendix A for case temperature versus velocity for 25, 30 and 50 degree ambient temperature environment.

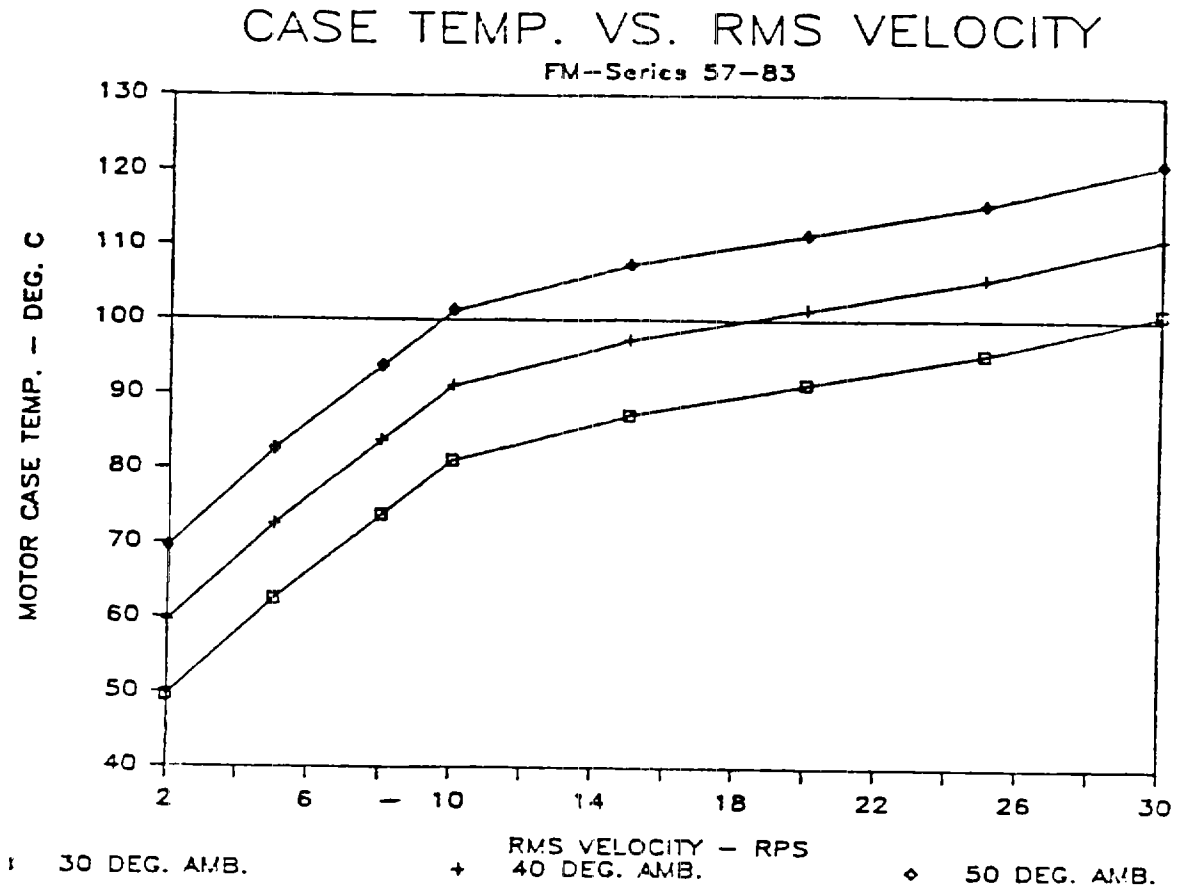
MINIMUM RECOMMENDED MOTOR/DRIVER WIRE SIZE (AWG)

Motor Series	Maximum Current per phase (A)	Less Than 100 ft.(20.5m)	100-200 Ft. (30.5-71m)
F57	1	22	20
F83	2	20	18

1. Cable runs of over 200 ft. (71) are not recommended.

2. Voltage drop per motor phase = (cable $\frac{\text{length}}{100}$ (A) x 2) X R
   where R = wire resistance in ohms per 100 ft.

Wire Size (AWG)	R (ohms/100 ft)
16	.4
18	.64
20	1.0
22	1.6

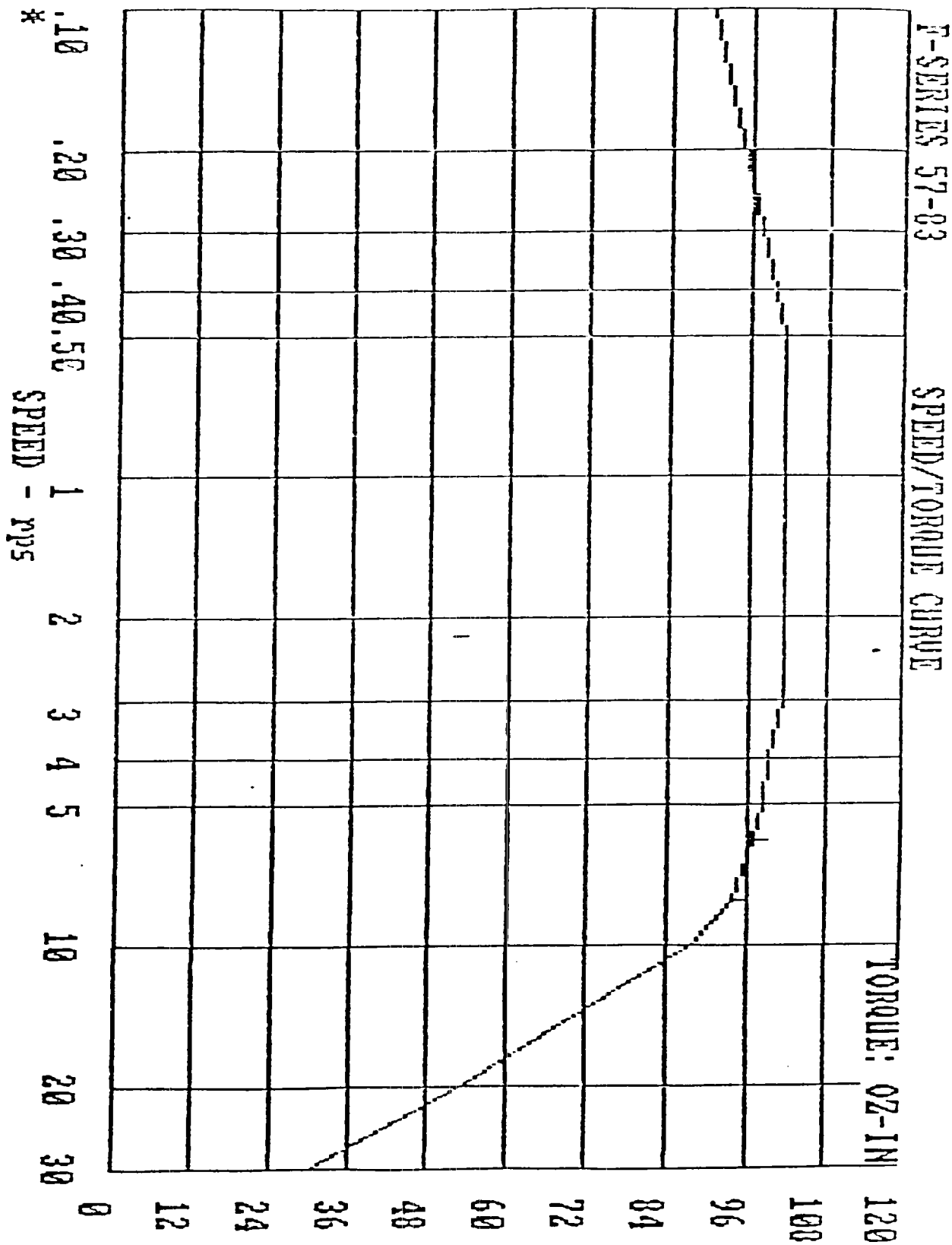


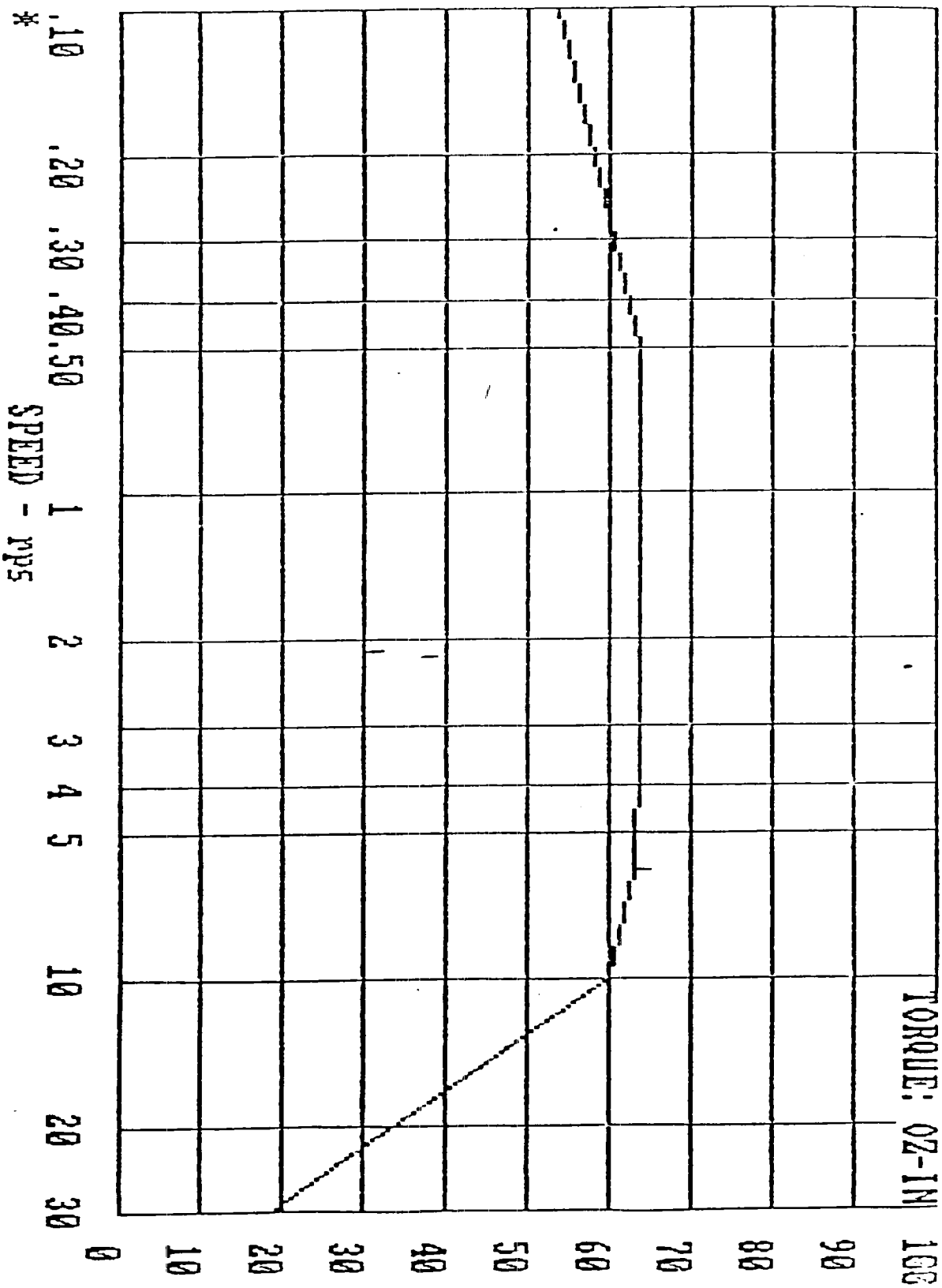
To calculate rms velocity:

Vrms = SQRT((V1**2t1 + V2**2t2 + ...Vn**2tn)/(t1+t2+...tn)

where: Vn is constant velocity
tn is time at constant velocity

The time, tn, spent at constant velocity, Vn, greater than 10 rps must be less than 30 minutes.


F-SERIES 57-83
SPEED/TORQUE CURVE
TORQUE: OZ-IN
SPEED - rps
0
12
24
36
48
60
72
84
96
108
120
30
20
10
5
4
3
2
1
40.50
30
20
10


F-SERIES 83-49
SPEED TORQUE CURVE
TORQUE: OZ-IN
SPEED - RPS
0
10
20
30
40
50
60
70
80
90
100
.10
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3
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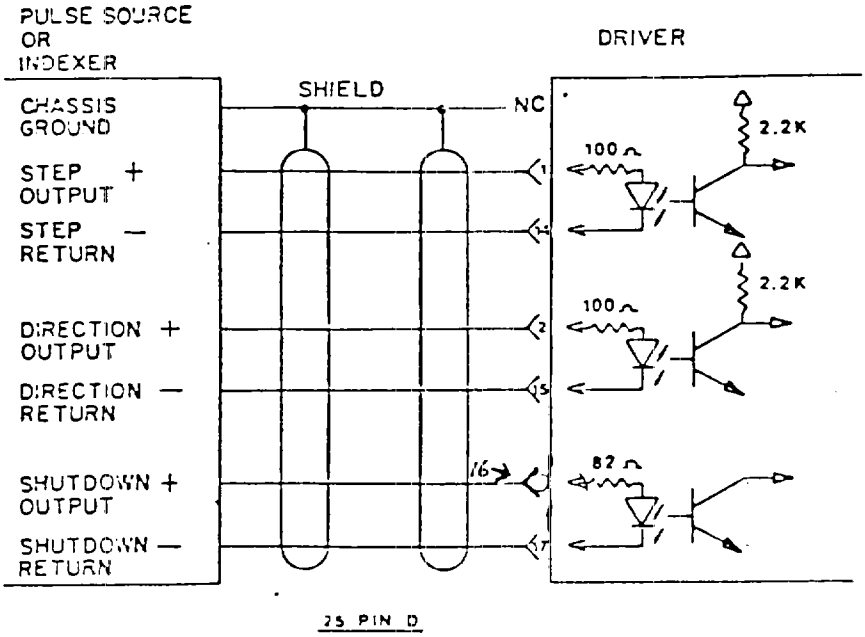
20
30

APPENDIX C



25 PIN D

LIMITED WARRANTY.

Seller warrants that the products sold will be free from defects in material and workmanship and perform to Seller's applicable published specifications for a period of 1 year from date of shipment. The liability of Seller hereunder shall be limited to replacing or repairing, at its option, any defective units which are returned F.O.B. Seller's plant, Petaluma, California. In no case are products to be returned without first obtaining permission and a customer return order number from Seller. In no event shall Seller be liable for any consequential or incidental damages.

Equipment or parts which have been subject to abuse, misuse, accident, alteration, neglect, unauthorized repair or installation are not covered by warranty. Seller shall make the final determination as to the existence and cause of any alleged defect. No liability is assumed for expendable items such as lamps and fuses. No warranty is made with respect to custom equipment or products produced to Buyer's specifications except as specifically stated in writing by Seller in the contract for such custom equipment.

This warranty is the only warranty made by Seller with respect to the goods delivered hereunder, and may be modified or amended only by a written instrument signed by a duly authorized officer of Seller and accepted by Buyer.

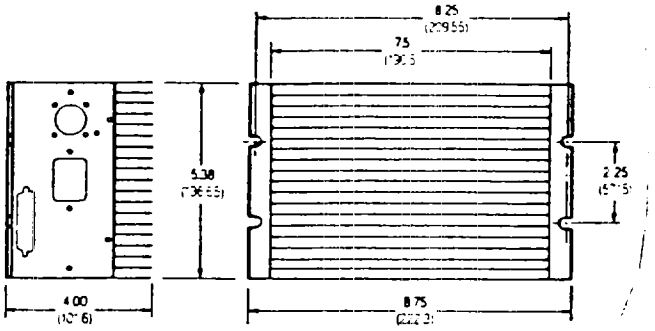
Except as hereinabove provided, SELLER MAKES NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

APPENDIX A

F Series Drive

Dimensions

The drive should be mounted with heat sink vertical (not as shown below). Allow a 5" vertical and 3" horizontal clearance for proper convection cooling.



Drive weight: 5 lbs. (2.2Kg)
Heatsink Fin Area: 350 in^2 (2258 cm^2)

Drive Connector Listing

Motor			Cable Color
1	Phase 2	+	Black
2	Phase 1	-	Green
3	Interlock	-	Yellow
4	Earth Gnd		Shield
5	NC		
6	Phase 2	-	Red
7	Interlock	+	Yellow
8	Phase 1	+	White

Indexer Connector

25 Pin "D"

Pin No.	Signal	
1	Step	+
2	Direction	+
14	Step	-
15	Direction	-
16	Shutdown	+
17	Shutdown	-

Remaining pins are NC
(No Connection)

APPENDIX B
(Continued)

L5A Configurations

Complete System

F-L5A-P15	LE-L5A-P13
F-L5A-P26	LE-L5A-P26
F-L5A-P54	LE-L5A-P54

Drive and Forcer	Forcer only
F-L5A	L5A
LE-L5A	

	Platen only
	PO-L5A-P13
Drive only	PO-L5A-P26
F-LA	PO-L5A-P54
LE-LA	

APPENDIX B

Specifications

System Name:	F-L5A-PXX	LE-L5C-PXX
Drive Type:	F-Series	LE Series
Static Force:	5 Lbs (2.25 Kg)	6 Lbs (2,70Kg)
Maximum Bearing Load:	10 lbs (4.05 Kg)	10 lbs (4.05 Kg)
Resolutions:	12,500	12,500
steps/inch R-14	25,000*	25,000
R-13	18,000	
Maximum Current:	1 amp	1 amp
Maximum Speed: (inch/second)	40	40
Drive Weight:	4 lbs (1.82 Kg)	
Drive Inputs:	Step/Direction	Step/Direction
Repeatability: (unidirectional)	±.00004" (±1 Micron)	
Hysteresis:	.0005" (.013 mm)	
Error:		
Cyclic	.002" TIR (.005 mm)	
Cumulative Platen	.0002 inch per inch (.2mm per meter)	
Cumulative Thermal	±.0000066 in/in/°F (±0.07 Micron/cm/°C)	
Max Forcer Case Temperature:	230°F (110°C)	
Weight:		
Forcer	.8 lbs (.36 Kg)	
Platen	4.16 oz per inch (.0045 Kg/mm)	
Bearing:	Ball bearing rollers	
Load:		
Perpendicular	10 lbs (4.05 Kg)	
Unidirectional	10 lbs (4.05 Kg)	
Flatness requirement for mounting:	.001 inch/foot	
Standard platen lengths: inch (mm)	P13-13 (330); P26-26 (660); P54-54 (1320) Shorter lengths available for cost of standard length plus a cutting charge.	

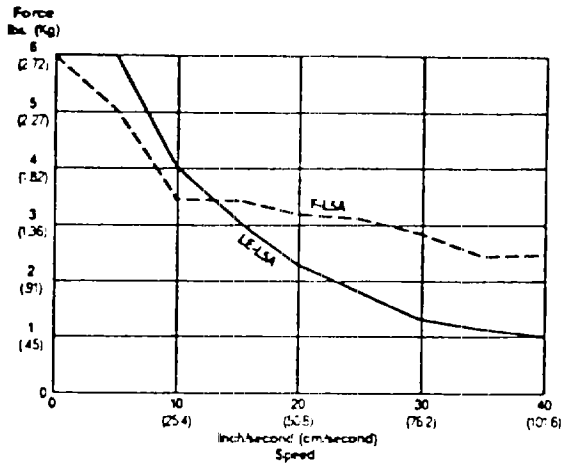
*R-option by special order. These options may reduce maximum speed.

APPENDIX B

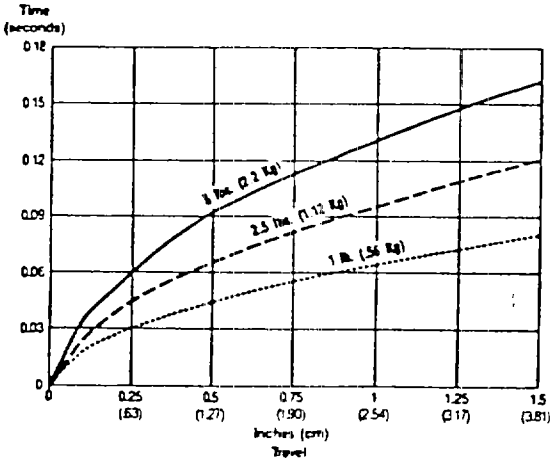
(Continued)

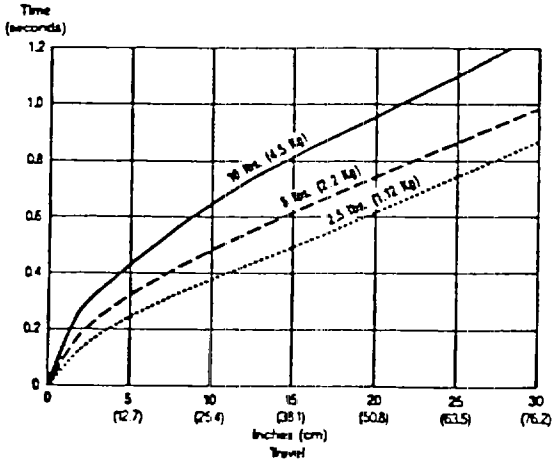
Performance Curves

Speed/Force

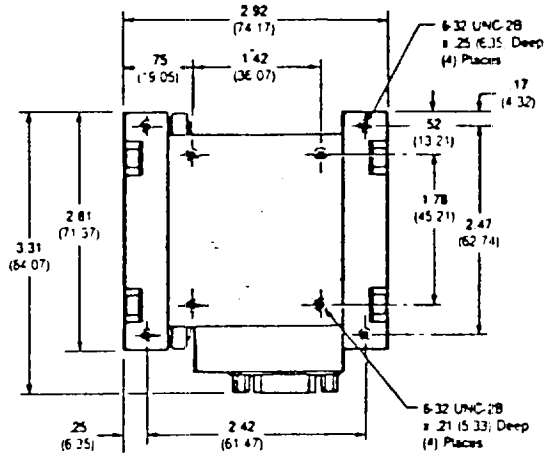


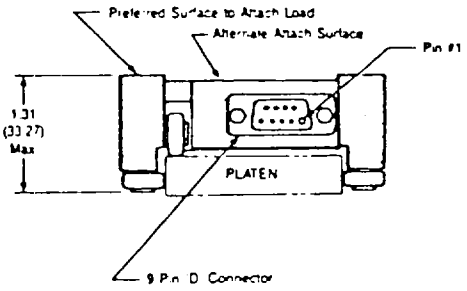
Distance vs. Move Time
(under various load conditions)



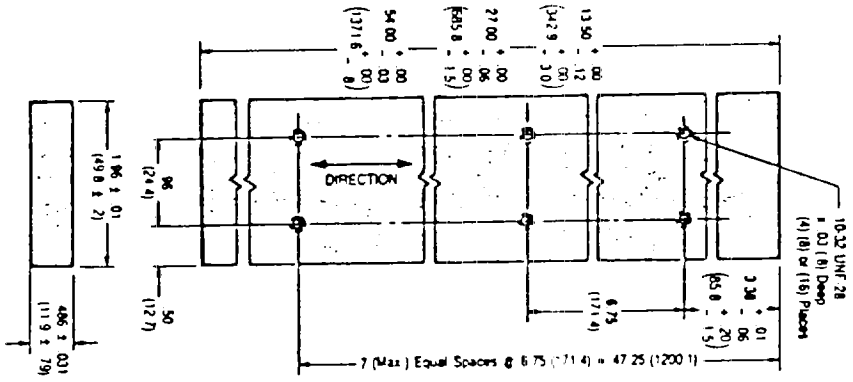


Dimensions
Forcer

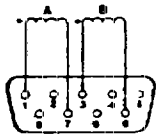




Platen



Forcer Pin-out



APPENDIX C

Minimum Recommended Linear Motor Wire Size (AWG)

Motor Series	Maximum Current per Phase (A)	Awg Less Than 100 ft. (30.5M)	Awg 100-200 Ft. (30.5M-01M)
F-L5A	1.0	20	18
LE-L5A	1.5	20	18
F-L3C	2.0	20	18
C-L3C	1.09	20	10
CX-L3C	1.09	20	18
F-L9A	2.0	20	18

NOTE:

1. Cable runs over 200 ft. 61M are not recommended.
2. Voltage drop in the wire:

$V = I \times R$ I - peak current per phase

$R = \frac{\text{wire resistance per 100 ft}}{100} \times \text{length in ft} \times 2 \text{ lengths}$

Wire Size (AWG)	R (ohms/100 ft)
16	0.4
18	0.64
20	1.0
22	1.6

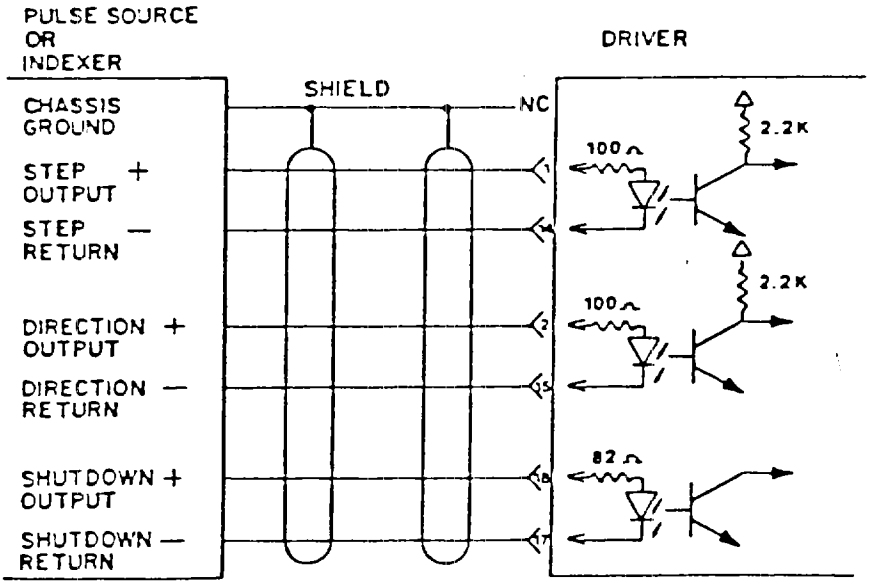
APPENDIX C
(Continued)

F Drive Pulse Source (Indexer) Connection

(25-Pin D-Connector, female)

Signal	Pin	Current
Direction Input (+)	2	20 Ma, TTL Level
Direction Return (-)	15	
Step Input (+)	1	20 Ma, TTL Level
Step Return (-)	14	
Remote Shutdown (+)	16	20 Ma, TTL Level
Shutdown Return (-)	17	
Chassis Ground	Not connected at drive.	

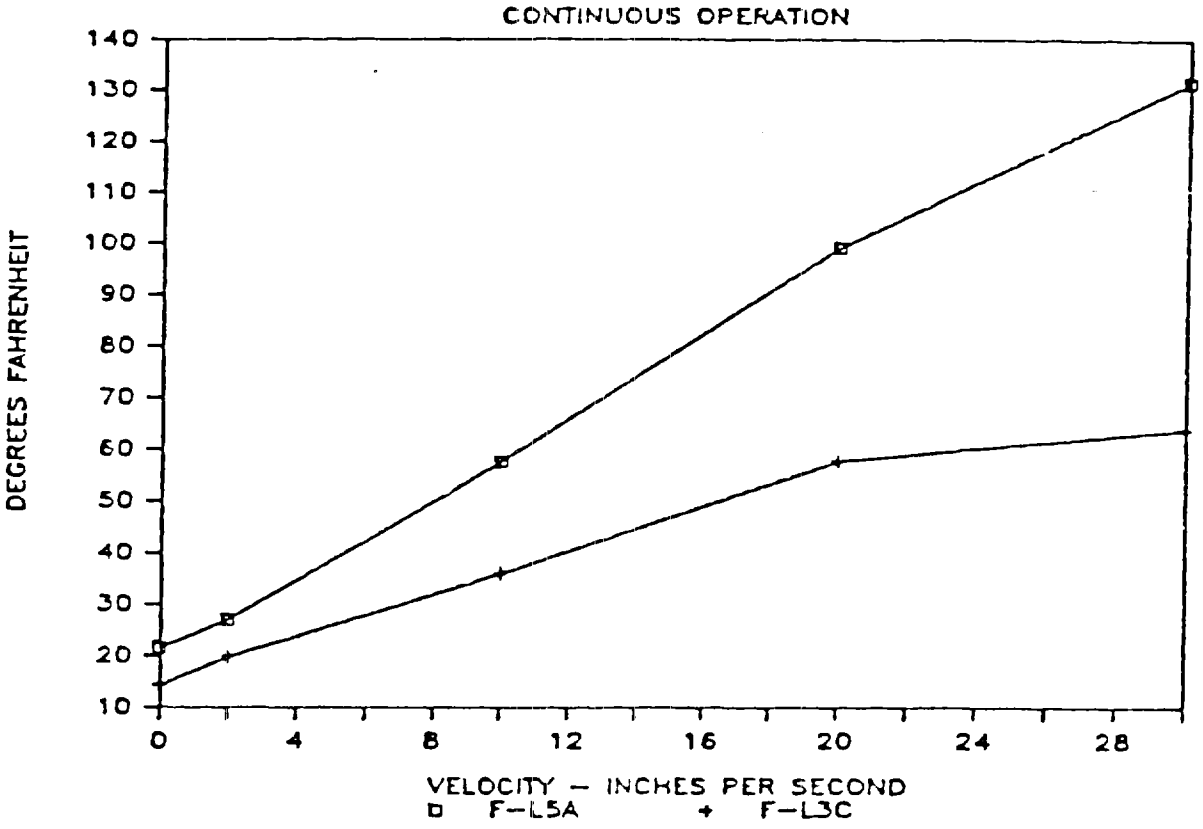
Check the pulse source (indexer) cable for continuity and possible shorts prior to use. Use a dummy load of 180 ohms to ensure that a minimum of 20 Ma is available to drive each of the opto-isolators in the driver (HP #HCPL 2530).



25 PIN D

APPENDIX E

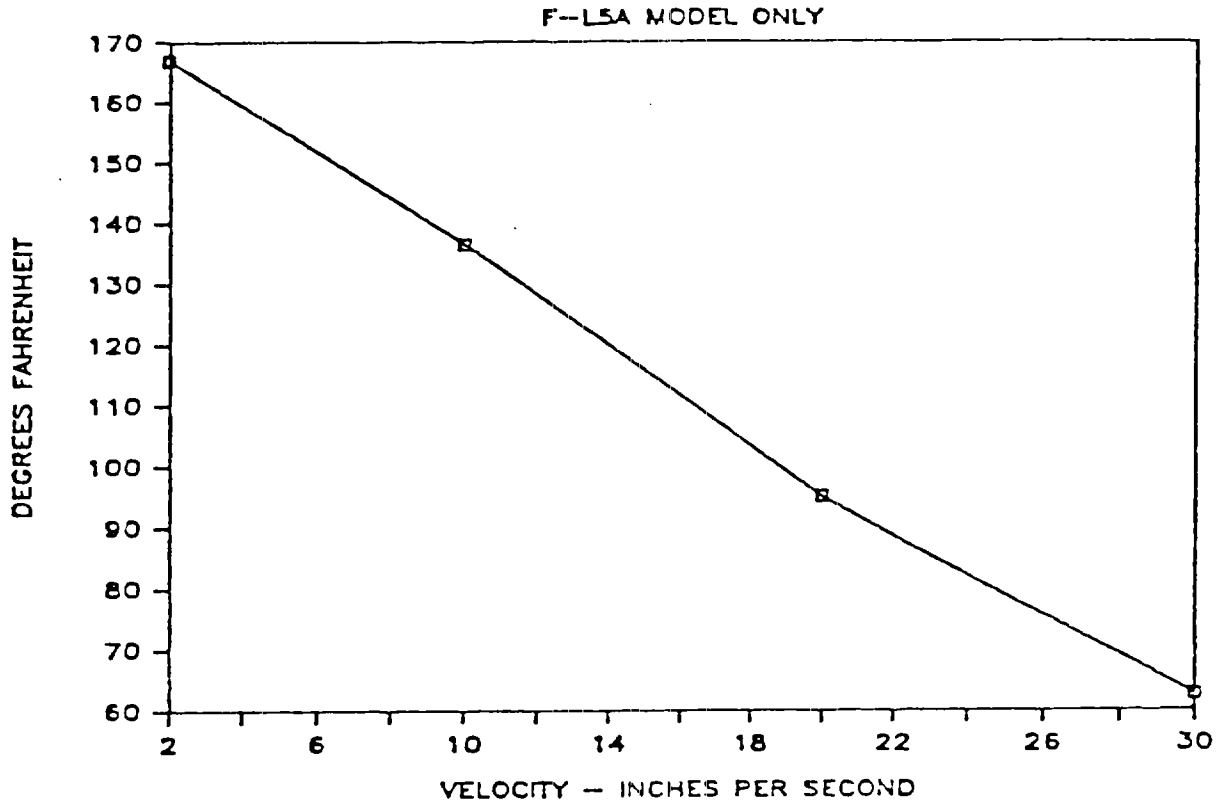
Case Temperature Rise vs. Velocity



Note: These curves are based on a 90-100% duty cycle.

APPENDIX F

Maximum Ambient Temperature Curve



Note: These curves assume operation at duty cycles of 90-100%.

APPENDIX G

Air Gap Adjustment for F-L5A

1) Remove the spring from the forcer's spring loaded bearing.

2) For the following procedure use a piece of 0.0015 (1mil) shim stock for motor operation below 20 IPS, or use 0.002" (2mil) shim stock for continuous motor operation more than 20 IPS. Place the shim stock on the platen covering the platen teeth but, leave the bearing track open (see Figure A). Approx. dimensions of shim are 5" x 1 1/4".

3) Place the forcer on the platen over the shim stock. Make sure that the bearings are resting on the platen and not on the shim.

4) Loosen the 4 socket head screws on the 2 side sections of the forcer.

5) Press down firmly on the side section with the spring loaded bearings and tighten the socket head screws.

6) Next tighten the screws on the other side section. Since this section has only one bearing in contact with the platen surface, the section can pivot. Make sure the section is in the same plane as the forcer body when the screws are tightened.

7) Remove forcer from platen, replace spring. Remove shim from platen, replace forcer on the platen. If the gap has been set correctly the forcer will move freely.

If the forcer won't move or if there is interference, repeat the procedure.

Firm downward pressure on the side sections is necessary when tightening the screws.

APPENDIX G
Figure A