

FANUC AC SPINDLE MOTOR

I series

DESCRIPTIONS

B-65022E/01

- No part of this manual may be reproduced in any form.
- The appearance and specifications of this product are subject to change without notice.

The products in this manual are controlled based on Japan's "Foreign Exchange and Foreign Trade Law". The export from Japan may be subject to an export license by the government of Japan.

Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.

Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual, we endeavor to include all pertinent matters.

There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume.

It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

PREFACE

This manual describes following models.

Series name	Model name
FANUC AC SPINDLE MOTOR I series	MODEL 3I, MODEL 6I, MODEL 8I

JR AUTOMATION TECHNOLOGIES INC*
JDOWLING

TABLE OF CONTENTS

1. GENERAL	1
2. FEATURES	1
3. ORDER SPECIFICATIONS	2
4. SPECIFICATIONS	4
4.1 AC Spindle Motor	4
4.2 AC Spindle Servo Unit	4
5. OUTPUT CHARACTERISTICS	5
6. MOTOR EXTERNAL DIMENSIONS	6
7. CONFIGURATION	12
7.1 Configuration	12
8. CONNECTIONS	13
8.1 Overall Connection Diagram	13
8.1.1 Models 3I/6I (using one 15-ohm resistor unit)	13
8.1.2 Models 3I/6I (using two 30-ohm resistor units)	14
8.1.3 Models 3I/6I (using four 15-ohm resistor units)	15
8.1.4 Model 8I	16
8.2 AC Spindle Servo Unit and Magnetics Cabinet Connection Diagram	17
9. SPINDLE UNIT EXTERNAL DIMENSIONS	18
9.1 Models 3I/6I	18
9.2 Model 8I	19
10. RESISTOR UNIT EXTERNAL DIMENSIONS	20
11. INSTALLATION	21
11.1 Environmental Requirement	21
11.2 Input Power Supply and Grounding	21
12. LOAD METER	23
APPENDIXES	
APPENDIX 1. COOLING	27
APPENDIX 2. RESISTOR UNITS FOR MODELS 3I/6I	28

1. GENERAL

The I Series AC SPINDLE MOTOR, Models 3I/6I/8I developed for exclusive use of a lathe, has compact construction of belt coupling with no gear. Since the I Series motor is designed for exclusive use of a lathe, electrical orientation cannot be added.

2. FEATURES

- 1) Speed feedback is used to minimize speed fluctuations and maintain full cutting capacity with 30 minutes rated output.
- 2) Acceleration control for minimum time is used to improve productivity by minimizing non-production time.

3. ORDER SPECIFICATIONS

Name		Drawing No.	Remarks
AC Spindle Motor, Model 3I		A06B-0743-B100	Flange type, with key, backward exhaust
		A06B-0743-B101	Flange type, with key, forward exhaust
		A06B-0743-B200	Foot mounting type, with key, backward exhaust
		A06B-0743-B201	Foot mounting type, with key, forward exhaust
AC Spindle Motor, Model 6I		A06B-0744-B100	Flange type, with key, backward exhaust
		A06B-0744-B101	Flange type, with key, forward exhaust
		A06B-0744-B200	Foot mounting type, with key, backward exhaust
		A06B-0744-B201	Foot mounting type, with key, forward exhaust
AC Spindle Motor, Model 8I		A06B-0745-B100	Flange type, with key, backward exhaust
		A06B-0745-B101	Flange type, with key, forward exhaust
		A06B-0745-B200	Foot mounting type, with key, backward exhaust
		A06B-0745-B201	Foot mounting type, with key, forward exhaust
AC spindle servo unit	Model 3I	A06B-6060-H003#H503	6000rpm, using resistor unit
	Model 6I	A06B-6060-H007#H504	6000rpm, using resistor unit
	Model 8I	A06B-6060-H008#H500	4500rpm
Connectors		A06B-6060-K101	Soldered type
		A06B-6060-K102	Crimped type
Fuses	Model 3I/6I	A06B-6060-K003	
	Model 8I	A06B-6060-K008	

Name		Drawing No.	Remarks
Resistor unit	Model 3I/6I	A06B-6052-K050	15 ohms (Note 1)
		A06B-6052-K051	30 ohms (2 pcs.) (Note 1)
		A06B-6052-K050	15 ohms (4 pcs.): 4 sets (Note 1)
AC line filter	Model 3I	A81L-0001-0083/3C	Specify it surely when not using a power transformer.
	Model 6I	A81L-0001-0083/4C	
Power trans-former (option)	Model 3I	A06B-6052-J001	For 380/415/460 VAC input
	Model 6I/8I	A06B-6044-J006	
Unit adapter	Model 8I	A06B-6059-K032	

Note 1) Refer to Appendix 2 for selecting the unit.

4. SPECIFICATIONS

4.1 AC Spindle Motor

Item	Model 3I	Model 6I	Model 8I
30-minute rated output (kW)	5.5	7.5	11
Base speed (rpm)	1500	1500	1500
Maximum speed (rpm)	6000	6000	4500
Output torque (kg-cm)	357	487	714
Rotor inertia (kg-cm-S ²)	0.15	0.15	0.22
Weight (kg)	46	46	60
Allowable overload capacity	120% (1 min.) (30-minute rated output)		
Vibration	V5 or less		
Noise	75dB or less		

4.2 AC Spindle Servo Unit

Item	Model 3I	Model 6I	Model 8I
Power supply capacity at 30-minute rating (kVA)	9	12	17
Power supply (Note 1)	200/220/230 VAC +10%, -15%, 50/60Hz $\pm$ 1Hz		
Feedback	Speed feedback by a pulse generator		
Regenerative energy processing	Electrical discharge of resistance (Note 2)		Power source regeneration
Input command voltage	10 VDC (maximum speed) - 0V (stop)		
Speed control range (rpm)	120 - 6000 (1:50)		120 - 4500
Speed regulation	Less than 0.5% of the maximum speed (load variation 10% - 100%)		
Heat generation (W) (at 30-minute rating)	420	500	660
Cooling system (Note 2)	External heat radiation		

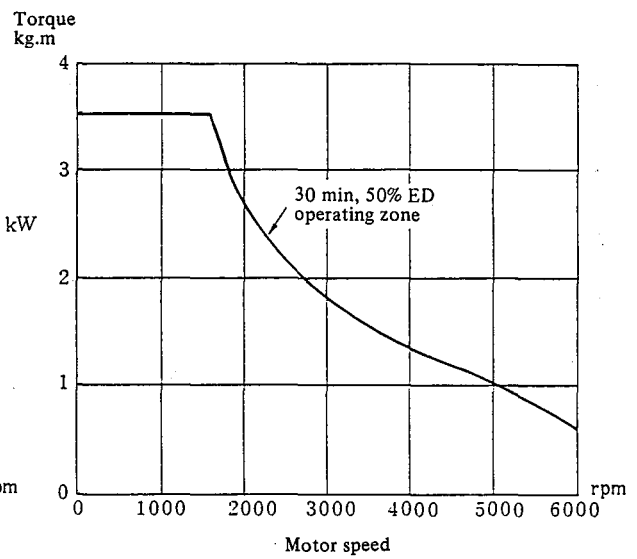
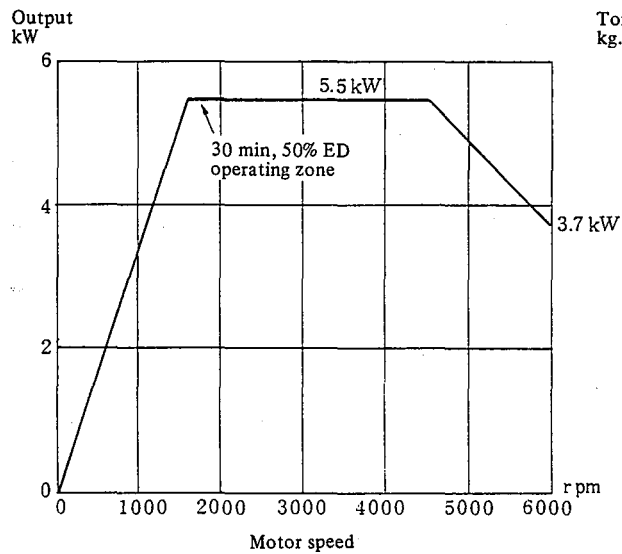
Note 1) A transformer is required for all power supply voltages other than the above.

Note 2) The servo unit is not equipped with a fan for cooling heat radiation section, therefore, use forced air cooling with a fan motor providing an air speed of 3m/sec. or more to cool the heat radiation sections. (Refer to Appendix 1.)

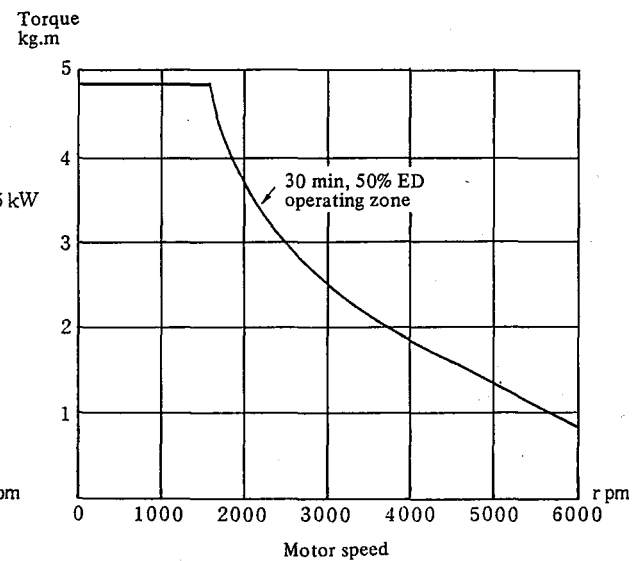
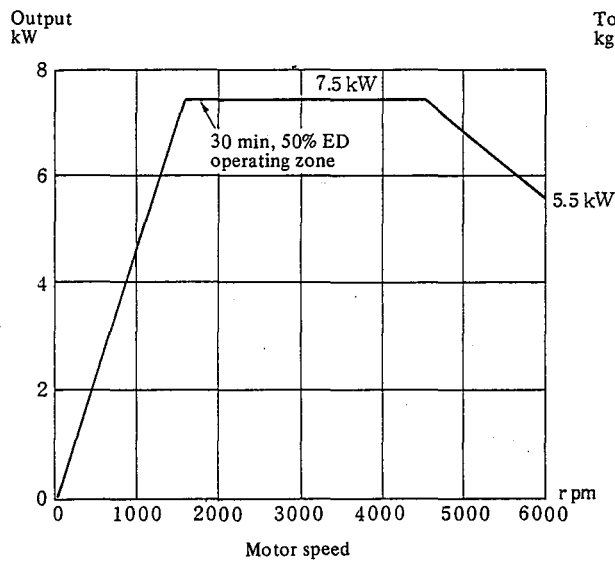
Forced air cooling is also required for regenerative electrical discharge of resistance. (Refer to Appendices 1 and 2.)

5. OUTPUT CHARACTERISTICS

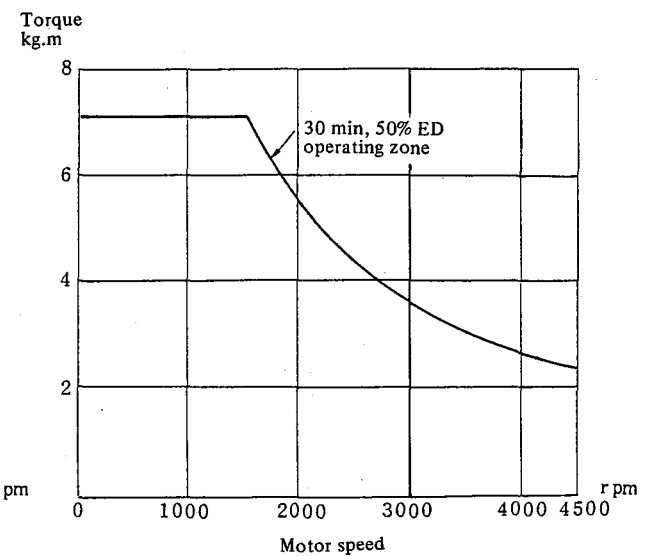
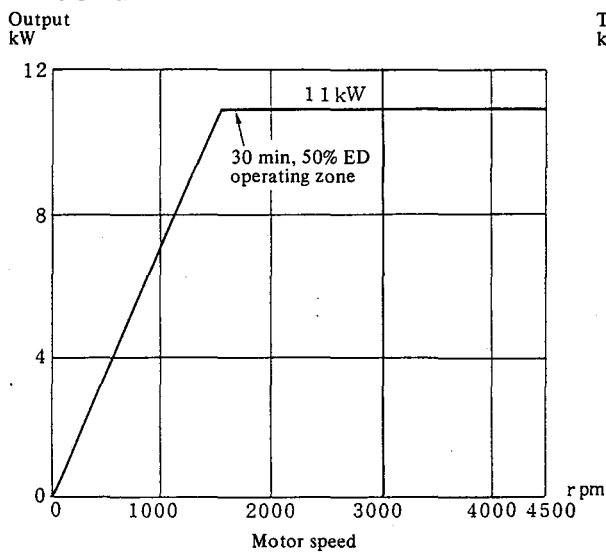
MODEL 3I



MODEL 6I

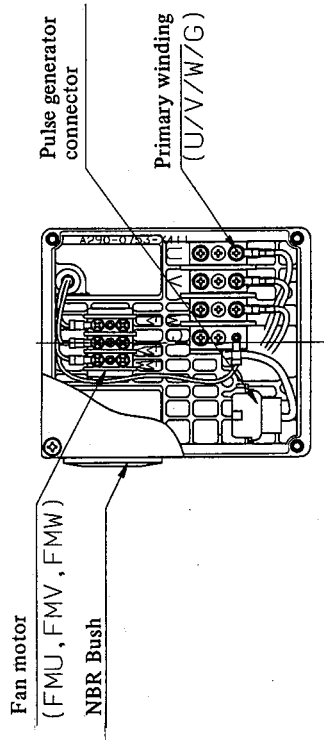


MODEL 8I

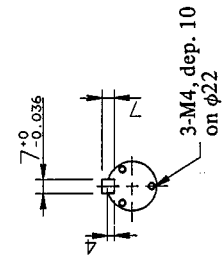
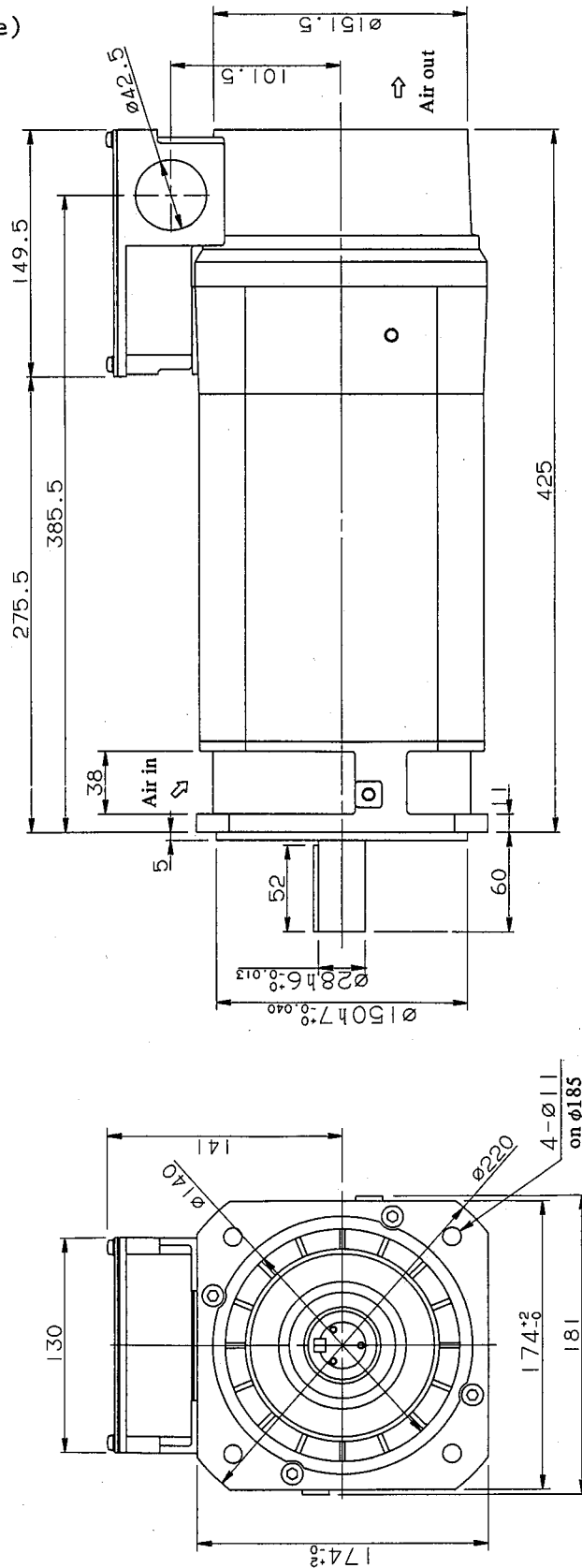


6. MOTOR EXTERNAL DIMENSIONS

MODEL 3I (Flange type)

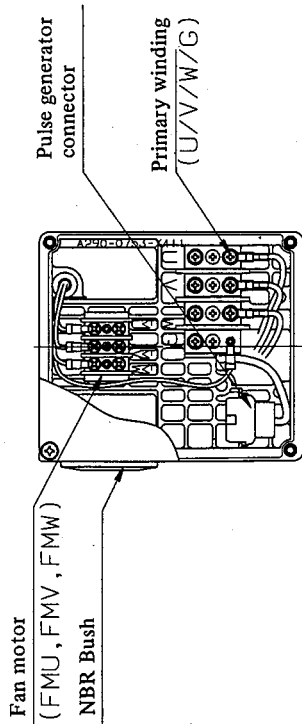


③ Blue PB	② Black PA	① Red +5V
⑥ White RB	⑤ Green RA	④ Yellow OV
⑨ OH2	⑧ SS	⑦ OH1

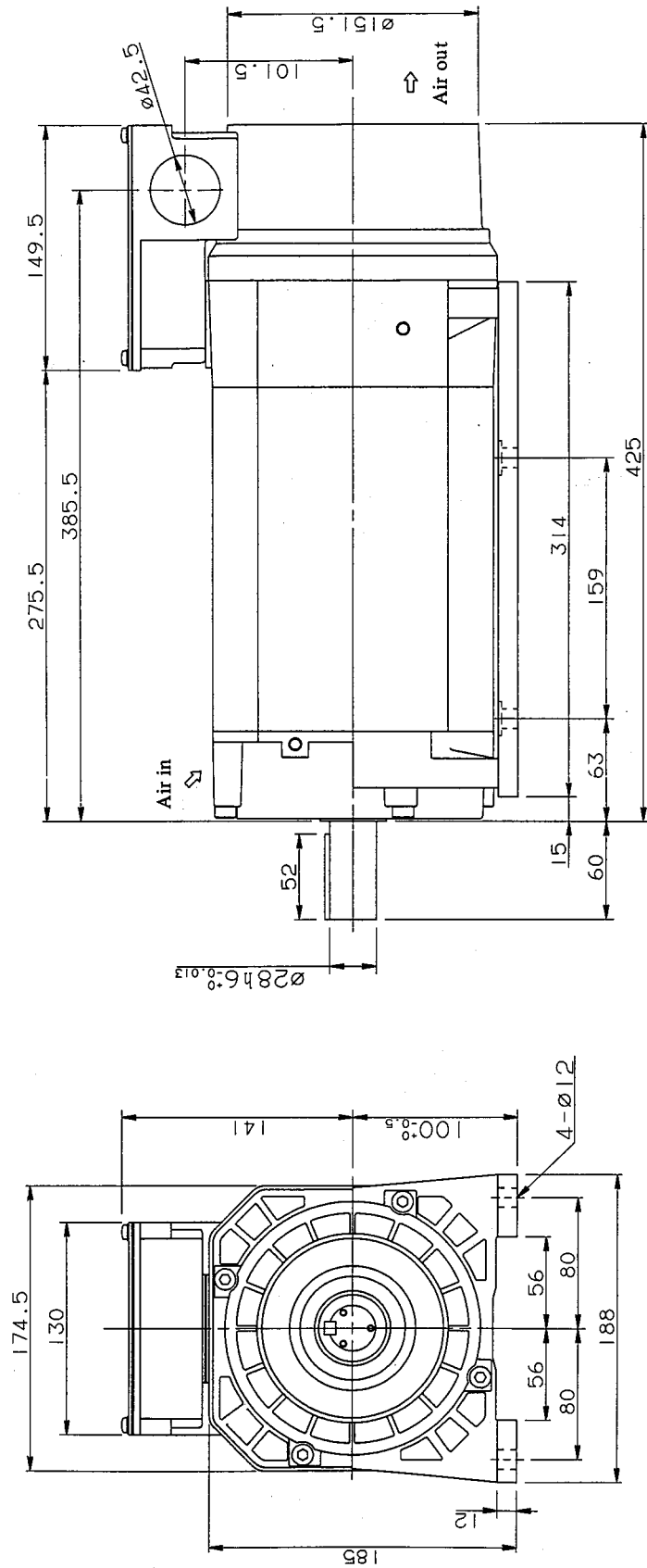


- Note)
1. The output shaft should be horizontal or vertical downward.
 2. Use hexagon bolts M10, length 35 mm or less as mounting bolts.
 3. The motor of which cooling air flow direction is reversed is also available.

MODEL 3I (Foot mounting type)



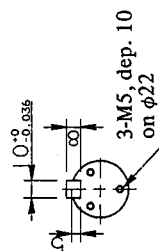
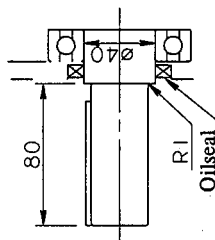
③ Blue	② Black	① Red
PB	PA	+5V
⑥ White	⑤ Green	④ Yellow
RB	RA	0V
⑨	⑧	⑦
OH2	SS	OH1



- Note)
1. The output shaft should be horizontal or vertical downward.
 2. Use hexagon bolts M10, length 20 mm or less as mounting bolts.
 3. The motor of which cooling air flow direction is reversed is also available.

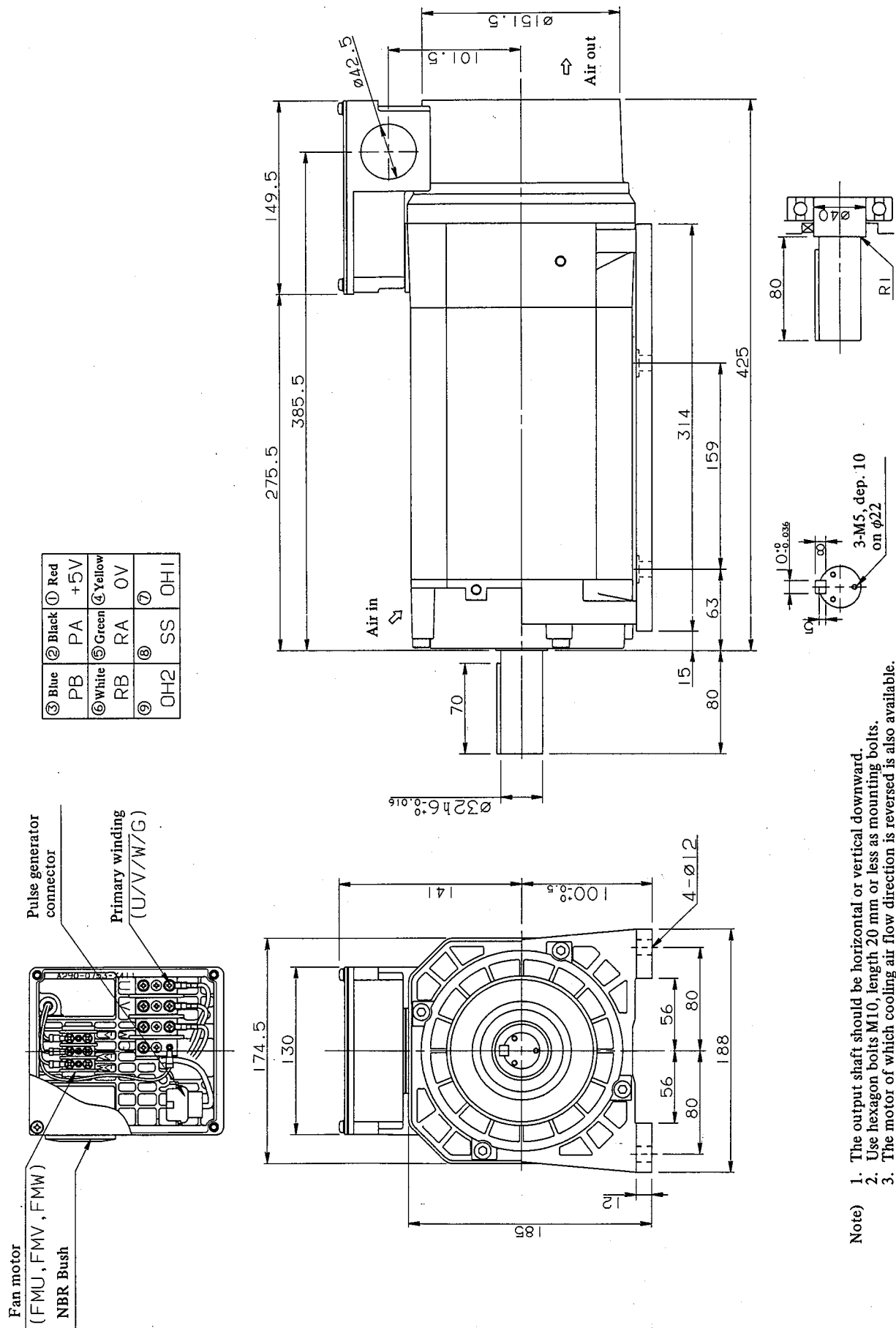
Diagram illustrating the components of the motor assembly:

- Fan motor (FMU, FMV, FMW)
- NBR Bush
- Pulse generator connector
- Primary winding (U/V/W/G)



1. The output shaft should be horizontal or vertical downward.
2. Use hexagon bolts M10, length 35 mm or less as mounting bolts.
3. The motor of which cooling air flow direction is reversed is also available.

MODEL 6I (Foot mounting type)



- Note)
1. The output shaft should be horizontal or vertical downward.
 2. Use hexagon bolts M10, length 20 mm or less as mounting bolts.
 3. The motor of which cooling air flow direction is reversed is also available.

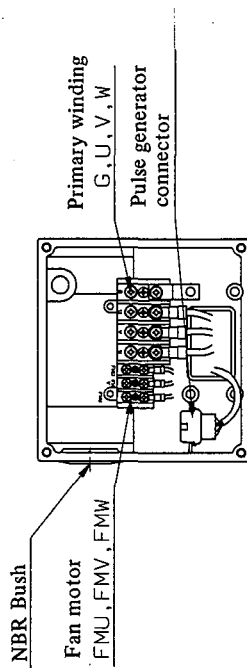


10

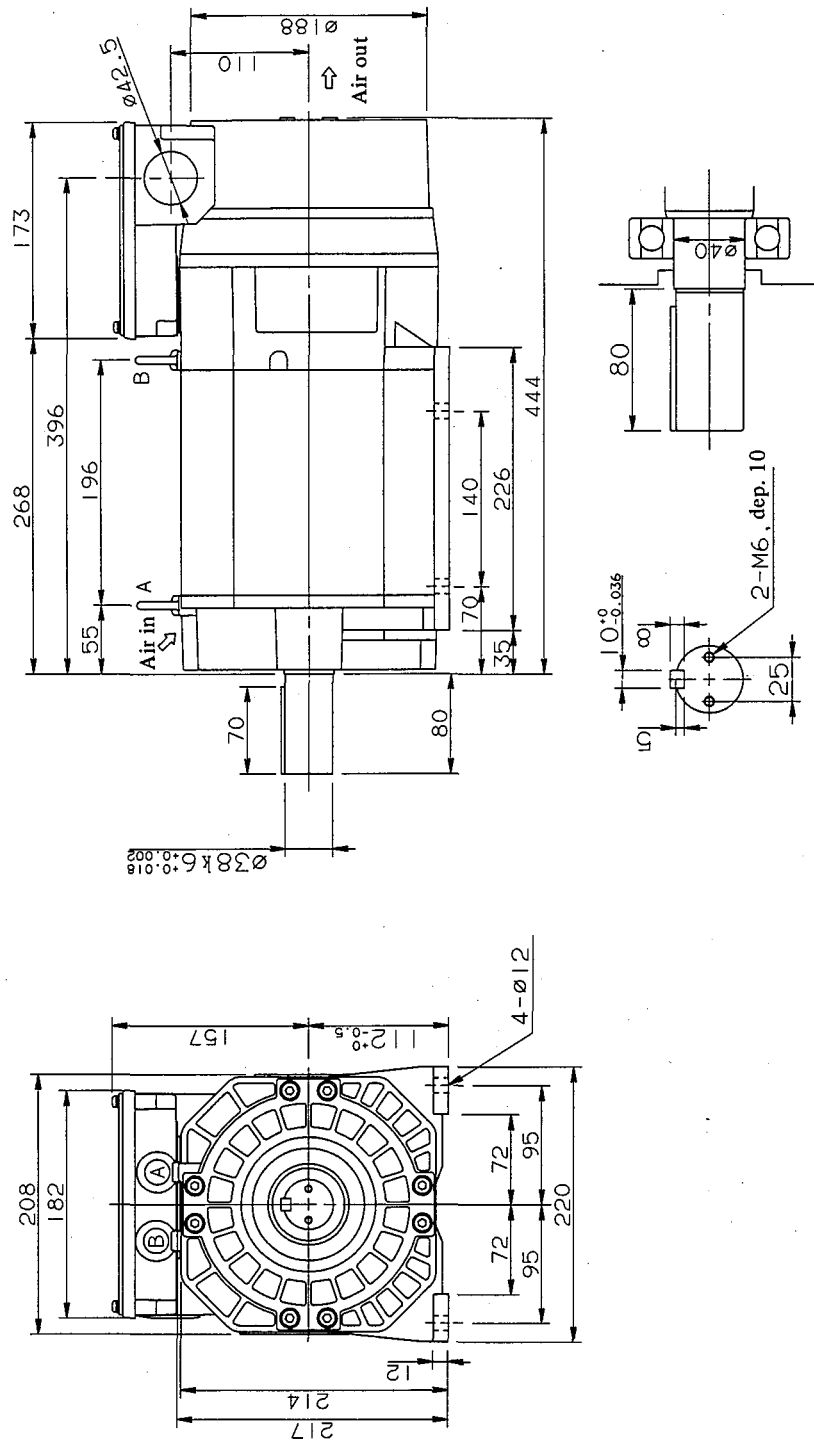


10

MODEL 8I (Foot mounting type)



③ Blue	② Black	① Red
PB	PA	+5V
⑥ White	⑤ Green	④ Yellow
RB	RA	OV
⑨	⑧	⑦
OH2	SS	OH1



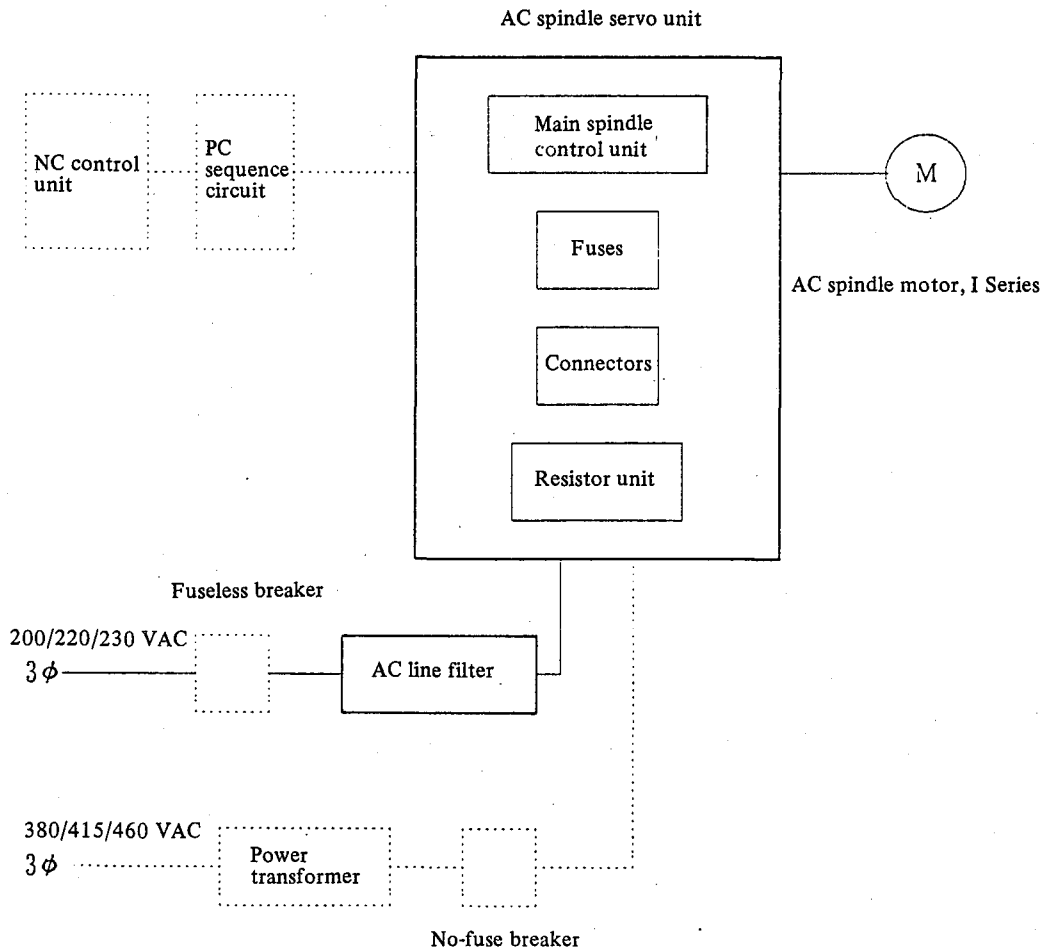
- Note)
1. The output shaft should be horizontal or vertical downward.
 2. Use hexagon bolts M10, length 30 mm or less as mounting bolts.
 3. The motor of which cooling air flow direction is reversed is also available.

7. CONFIGURATION

7.1 Configuration

The I Series AC Spindle motors (Models 3I, 6I, 8I) consist of the following units or parts.

- 1) Main spindle control unit (basic)
- 2) Fuses (basic)
- 3) Connectors (basic)
- 4) Resistor unit (3I/6I) (basic)
- 5) AC line filter (3I/6I) (basic option)
- 6) Power supply transformer (option)



Note 1) Resistor units and AC line filters are used for models 3I and 6I.

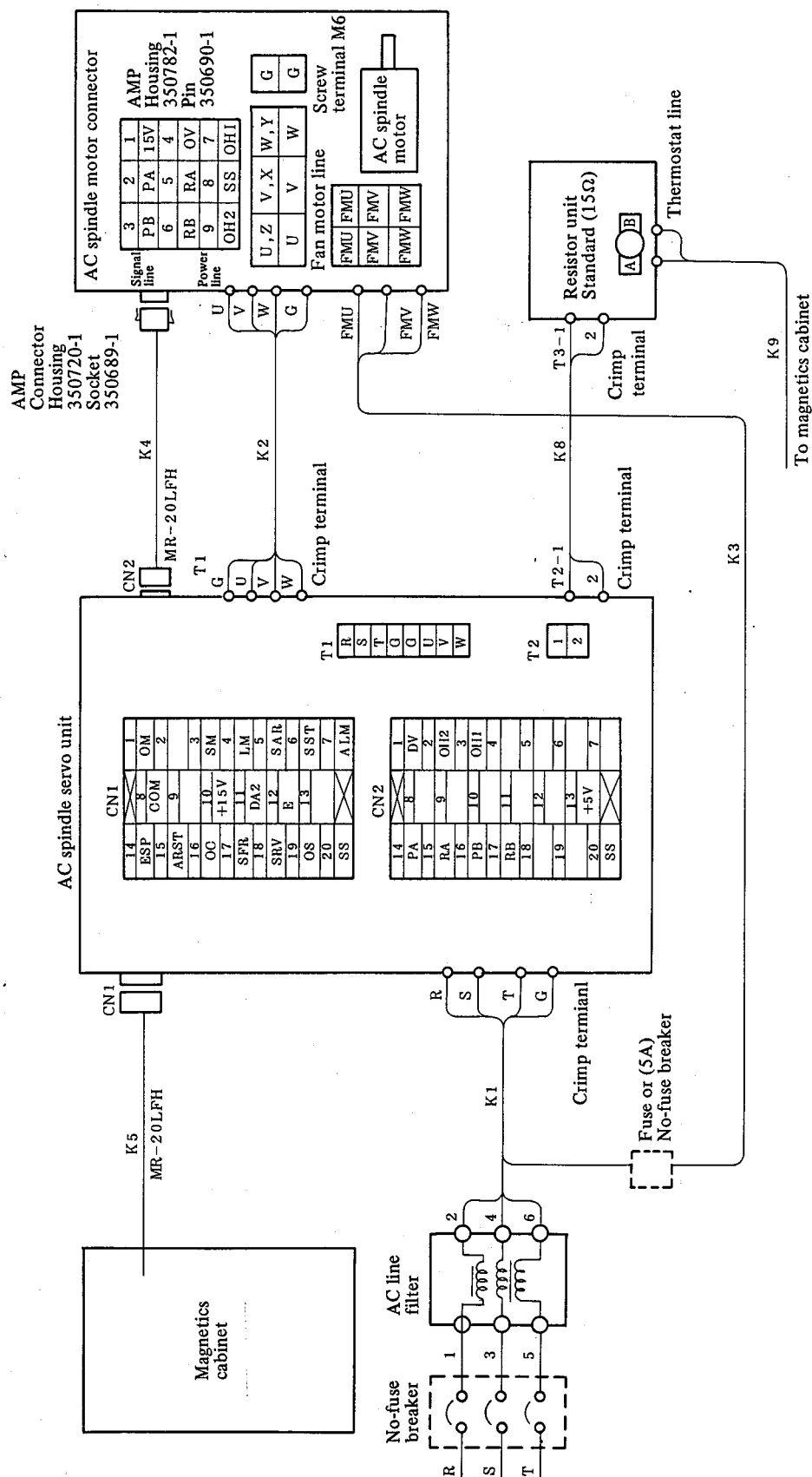
Note 2) Use an AC line filter surely when not using a power supply transformer.

Note 3) Attach the over-current protector such as no-fuse breaker of suitable capacity to the input power supply.

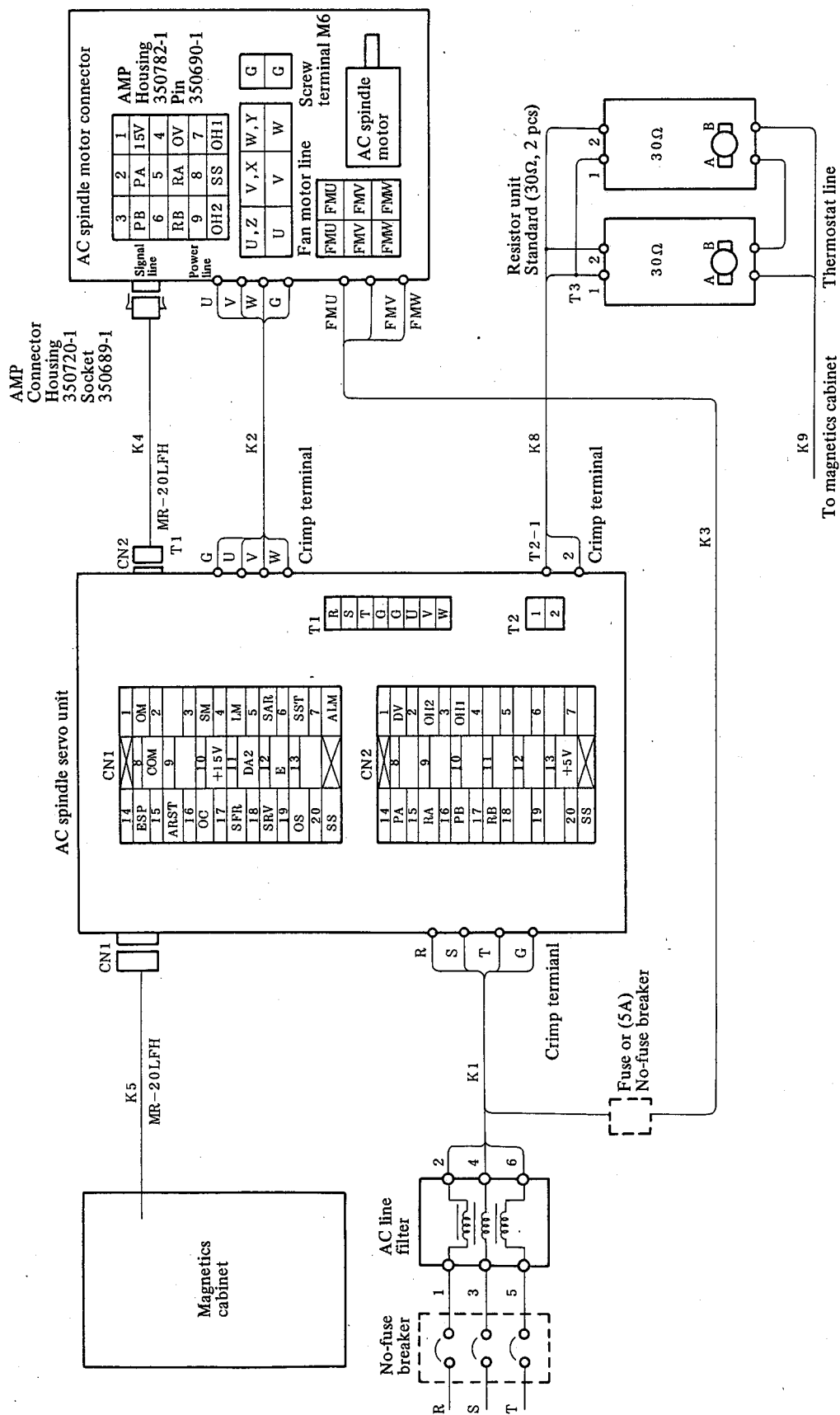
8. CONNECTIONS

8.1 Overall Connection Diagram

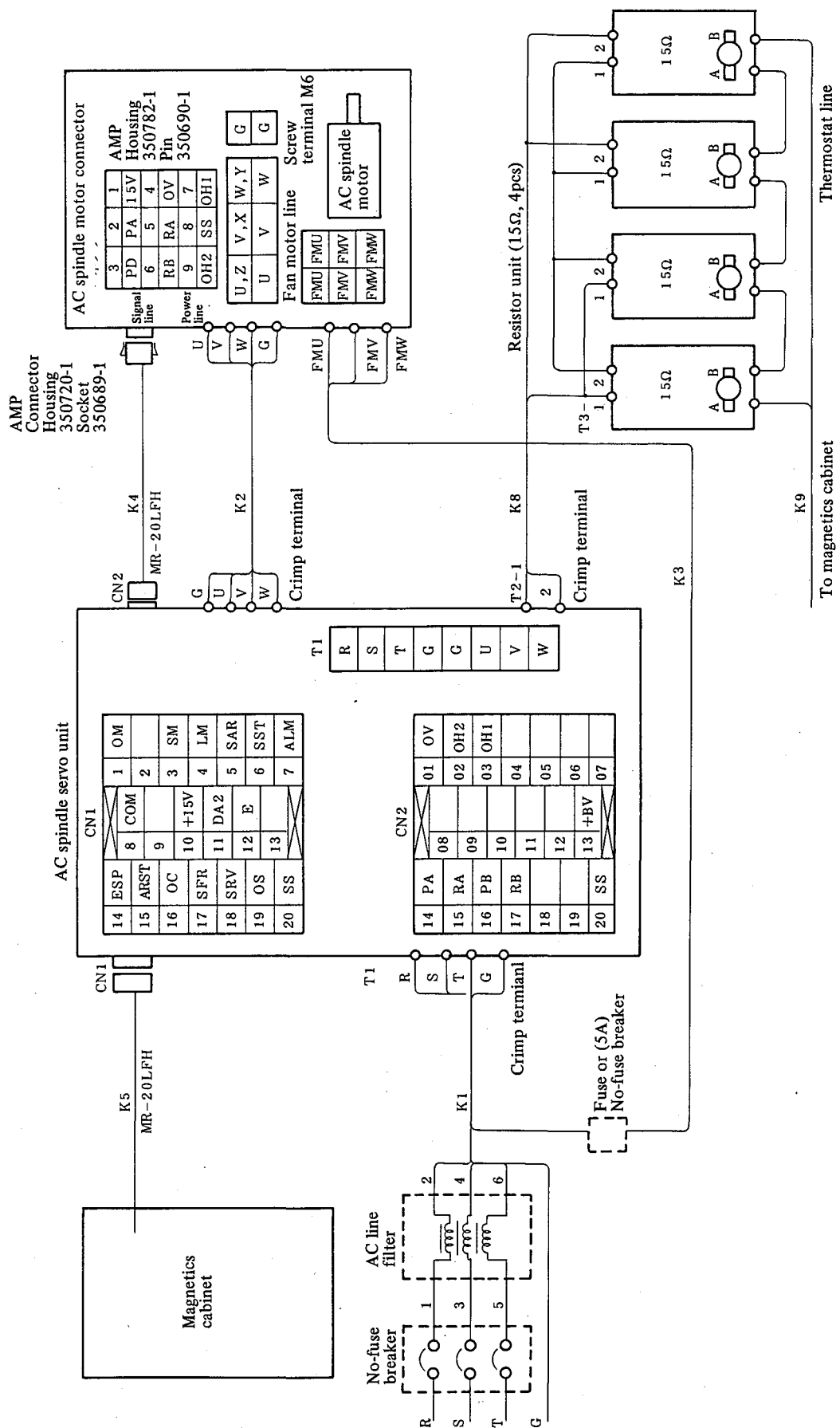
8.1.1 Models 31/61 (using one 15-ohm resistor unit)



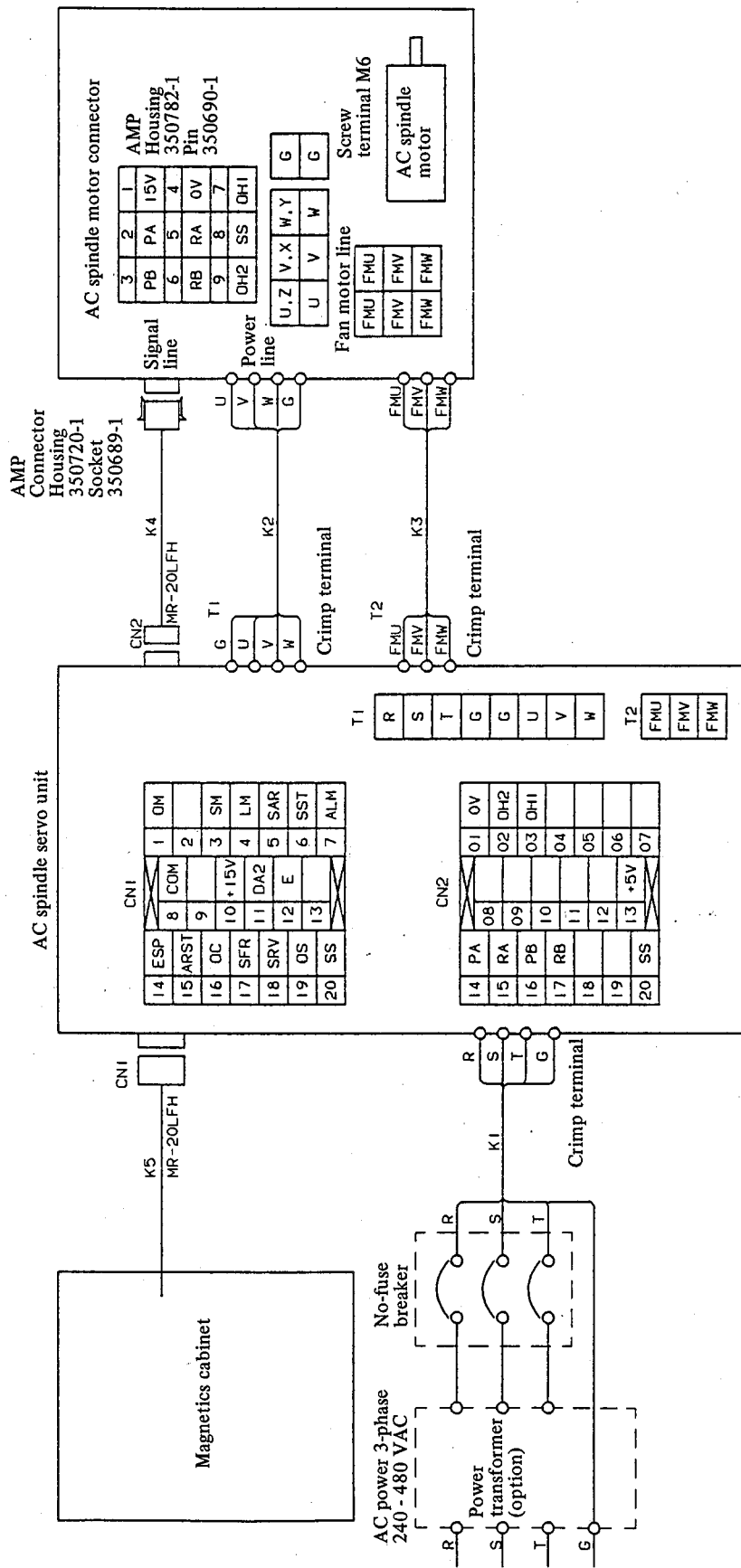
8.1.2 Models 31/61 (using two 30-ohm resistor units)



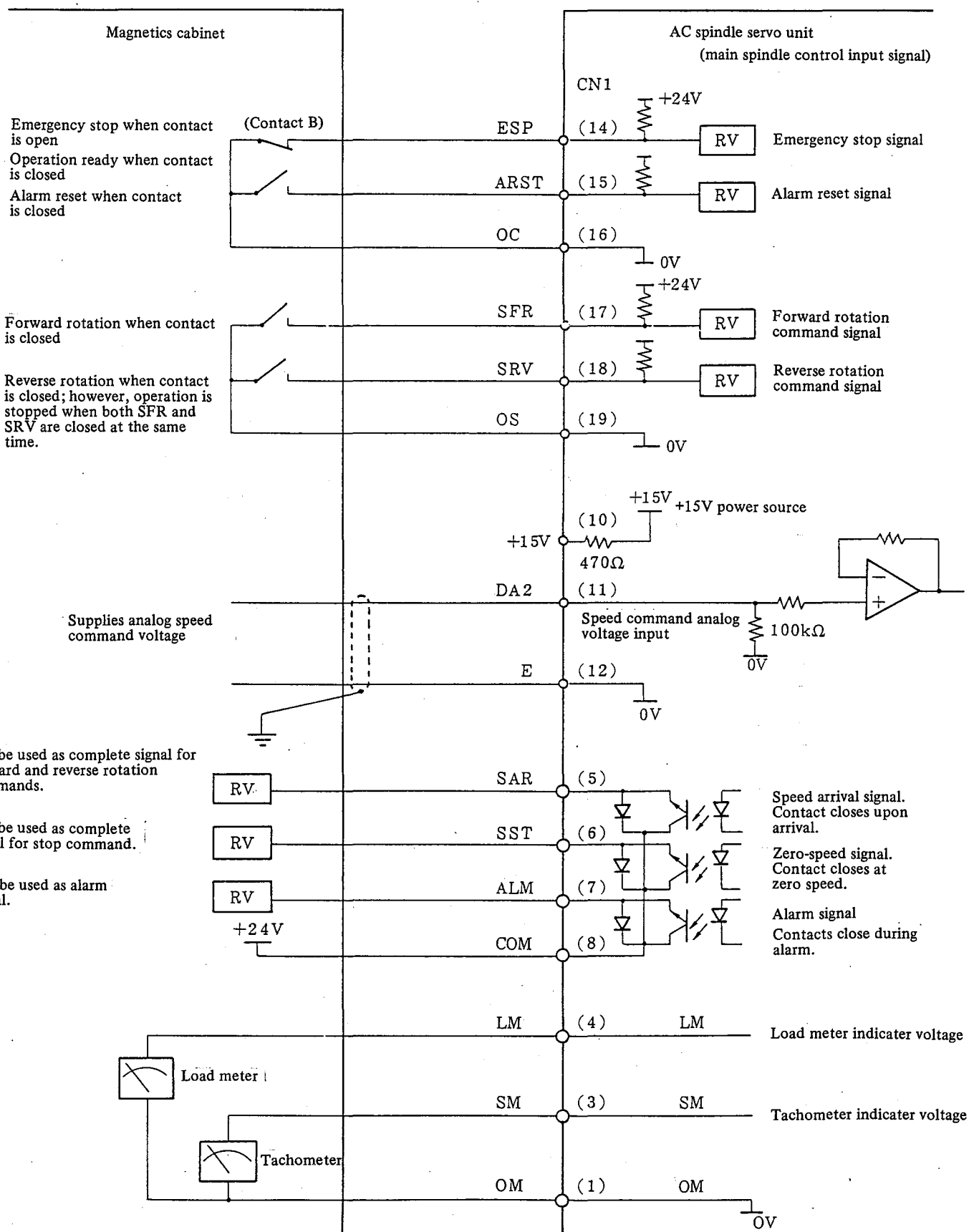
8.1.3 Models 3I/6I (using four 15-ohm resistor units)



8.1.4 Model 8I

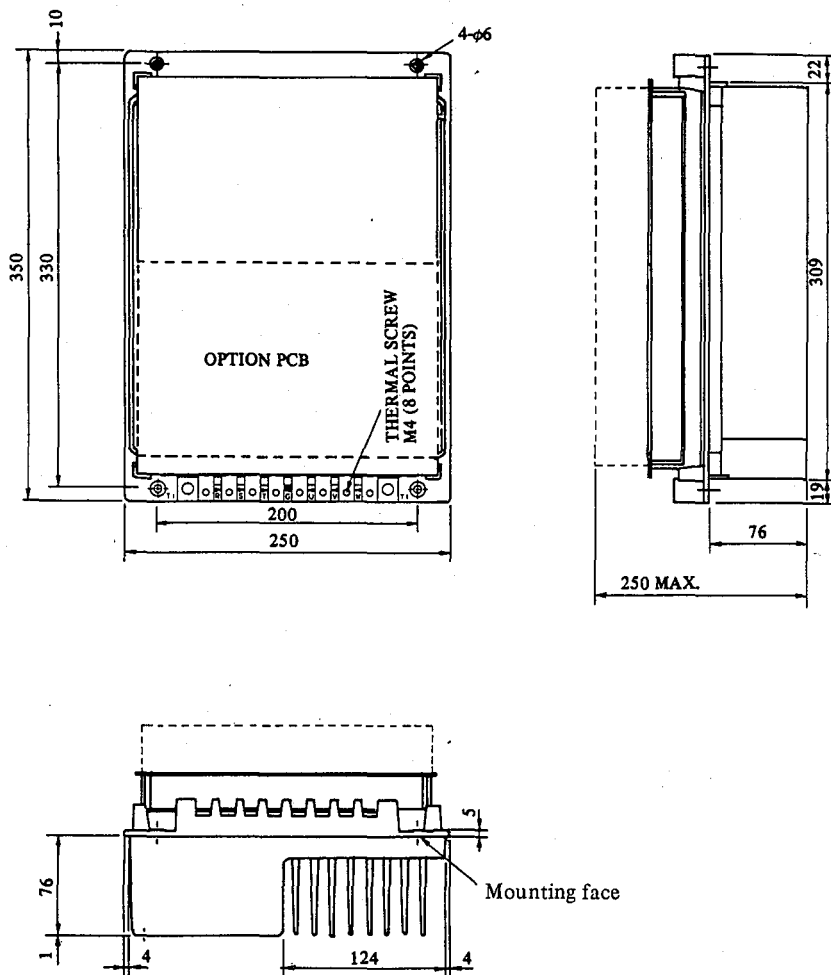


8.2 AC Spindle Servo Unit and Magnetics Cabinet Connection Diagram

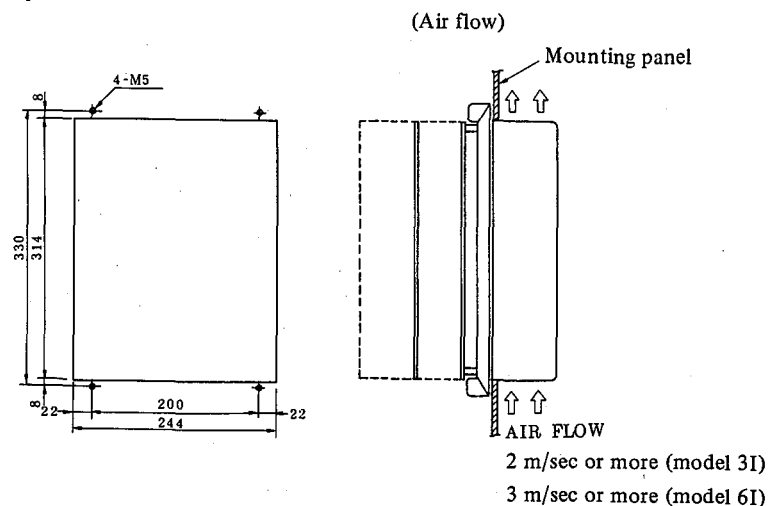


9. SPINDLE UNIT EXTERNAL DIMENSIONS

9.1 Models 3I/6I

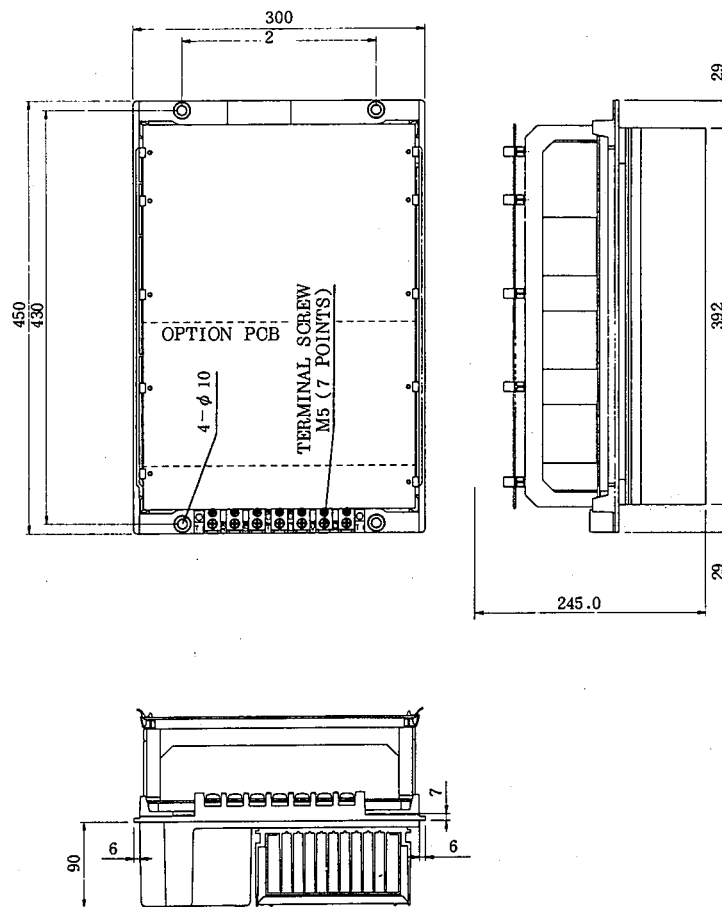


Panel-cut layout

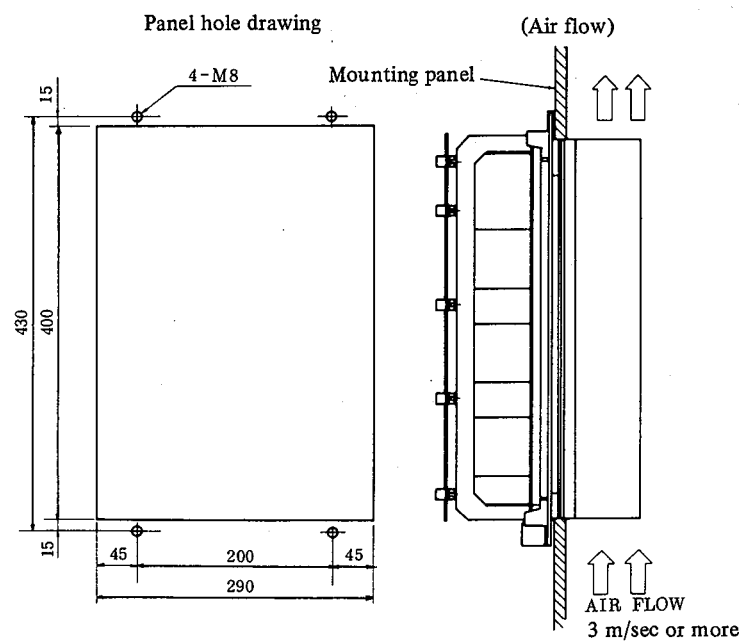


Note) Cooling fan is not attached to the spindle servo unit or resistor unit.
When using these units, cool the radiation part using a wind of 2 m/sec (model 3I) or 3 m/sec (model 6I) or more.

9.2 Model 8I

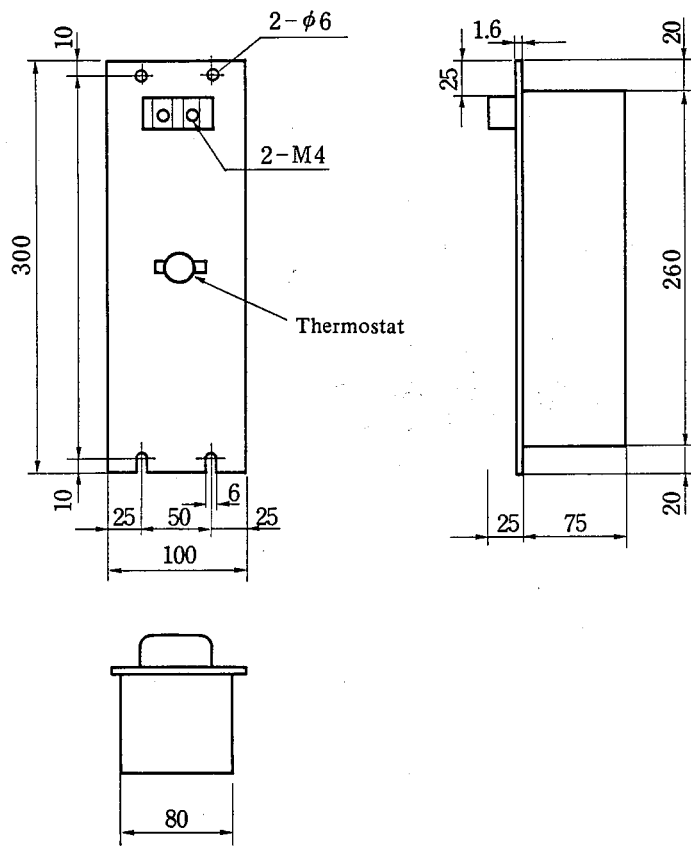


Panel-cut layout

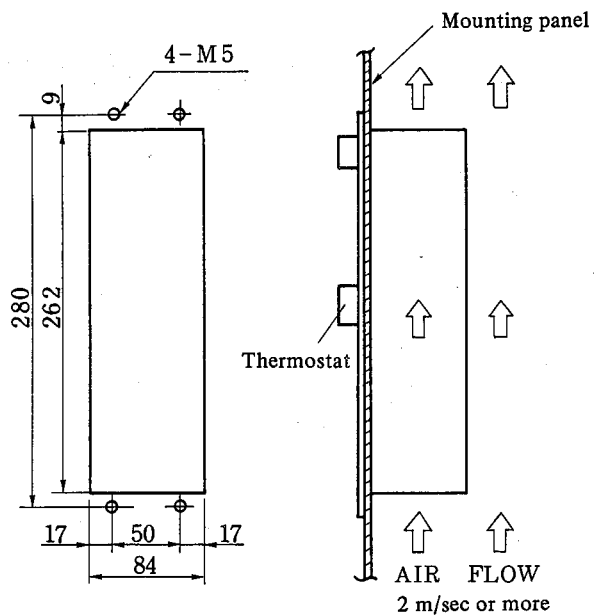


Note) Cooling fan is not attached to the spindle control unit.
When using these unit, cool the radiation part using a wind of 3 m/sec or more.

10. RESISTOR UNIT EXTERNAL DIMENSIONS



(Air flow)



11. INSTALLATION

11.1 Environmental Requirement

Install the AC spindle servo unit in a place satisfying the following environmental conditions.

Ambient temperature

Ambient temperature around unit: 0° to 55°C

Ambient temperature in

the cabinet : 0° to 45°C

Humidity

Normally : 95% RH or less; no dew

Vibration

When operating : 0.5G or less

Atmosphere

Keep corrosive or conductive mist and dew away from the electric circuits.

11.2 Input Power Supply and Grounding

1) Input power supply

- . Nominal rated voltage : 200/220/230VAC
- . Allowable voltage fluctuation width : -15% to +10%
- . Power supply frequency : 50/60Hz
- . Allowable fluctuation width : ± 1 Hz
- . Power supply impedance : According to load (1.2 times of the 30 min. rate)
Voltage fluctuation is 7% or less.
- . Power supply unbalance : The deviation width of each phase in the 3-phase power supply is 15% or less of the rated voltage.

- . Mount the circuit breaker having enough capacity at the input side either of the AC spindle servo unit or machine tool.
- . Power factor of input power is 0.9 or more when driving AC spindle motor. Capacitor for leading power factor is not required at the input side of AC spindle servo unit.

- . Alarm No. 4 may occur at open-phase or temporary power failure.

- . Leakage current when driving AC spindle motor

Since the drive circuit employs the transistor-drive-pulse-width modulation-control, when the component of high-frequency leakage current flows to the earth through the spindle motor or connection cable, 50/60 Hz component of leakage current is less than sensitive current (15 mA) of high-sensitive/high-speed leakage breaker for the cable of 50 m or less.

- . Radio noise

Since the drive circuit employs the pulse-width-modulation control, a radio near AC spindle motor or drive circuit may be affected by noise due to high-frequency current when switching the transistor. The AM radio is interfered but TV or FM radio is not. To avoid a noise, mount the unit or install the machine tool using following notices.

- (1) Mount the AC spindle servo unit in the metal cabinet.
- (2) Cable connecting between the servo unit and AC spindle motor is routed through the metal duct and ground the duct.
- (3) Connect the G terminals (ground) between the servo unit and AC spindle motor as specified.

2) Grounding

The following ground lines must always be connected.

- . Input power supply grounding line
- . Motor grounding line

Note 1) The rotation energy of the AC spindle motor is regenerated to the power source by using an inverter during the deceleration time. Accordingly, the following restriction and effect may be produced, if the power line impedance is high.

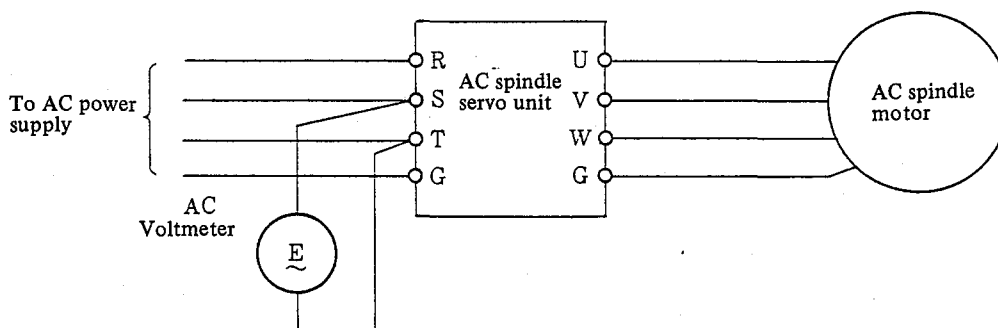
Particularly be careful with this caution when a power transformer having comparatively small capacity is used or a long power cable is used.

The power impedance which may be almost free of the restriction in item (1) is within about 7% when the load is the maximum value of overload capacity (120% load of 30 min. rated value) (*)

(1) If the power line impedance (including the impedance of transformer) is high, it may be necessary to reduce the regenerative current and increase the deceleration time. (The AC spindle servo unit must be readjusted.)

(2) It is possible that the power voltage waveform is disturbed by a commutation change of the inverter, and such a waveform distortion affects other units.

(*) Example of method of confirming the power impedance



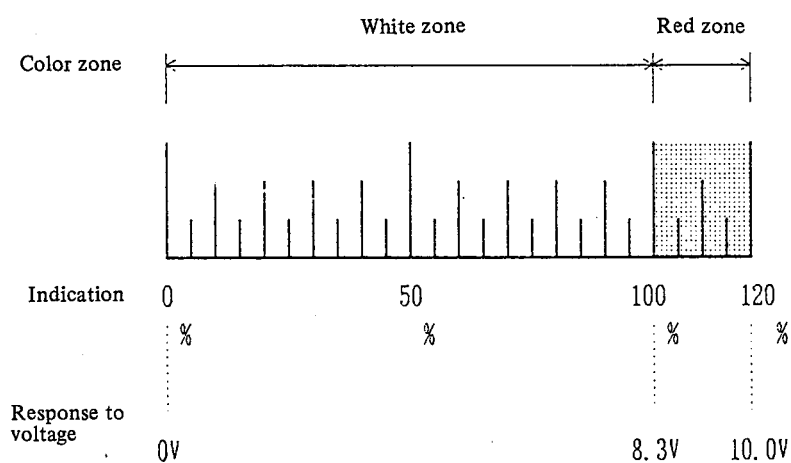
$$\frac{E_0 - E_1}{E_0} \times 100 (\%) < 7 (\%)$$

E_0 : Voltage during motor stop

E_1 : Voltage during motor acceleration or just before the motor speed begins reducing with heavy load applied.

12. LOAD METER

- 1) The load meter indicates the load ratio, that is, the ratio of the load with the main spindle of the machine operating without a load, or the load during cutting, in relation to the maximum output of the main spindle.
- 2) The indications of the load motor use the 30-minute rating output of the spindle motor as 100%. The diagram below shows the relationship between the spindle motor and load meter indications.
- 3) The indicator voltage accuracy differs depending on the speed used and input voltage, but maximum error is $\pm 15\%$.



APPENDIX

APPENDIX 1 COOLING

The I Series AC spindle servo unit is designed so that the heat radiation section of the power circuit which is the major source of heat, is cooled externally. Forced air cooling must be used for this heat radiation section. The fan motors required for forced air cooling are needed to prepare at machine manufacturer side.

Note 1) The AC spindle servo units, Series 3I/6I are not equipped with built-in fan motors for cooling.

Note 2) If cooling is insufficient, the increased temperature will cause an alarm and can cause a malfunction.

1) Cooling of AC spindle servo unit

Cool the AC spindle servo unit heat radiation section from bottom to top using forced air cooling referring the air speed table below. The following method discharges approximately 70% of the heat generated by the unit to the outsides.

Model	3I	6I/8I
Required air speed	2m/sec. or more	3m/sec. or more

2) Resistor unit cooling

Cool the surface of the resistor unit (excluding the connection terminals) using forced air cooling referring the air speed table below.

Model	3I/6I
Required air speed	2m/sec. or more

APPENDIX 2 RESISTOR UNITS FOR MODELS 3I/6I

The Models 3I/6I use resistor units as do the conventional compact AC spindle servo units, models 1, 2 and 3.

The resistor units are used to discharge the regeneration energy from the motor. The resistor unit selected must have a capacity appropriate for the motor load and operation cycle time. During design, it is necessary to provide proper cooling for the resistors composing the "resistor unit", and to secure the required capacity.

1) Types

The following three types of resistor units are available for different applications.

Type	Name	Specification Drawing No.	Quantity	Description
A	Resistor unit	A06B-6052-K050	1	Uses one 15-ohm resistor
B		A06B-6052-K051	1	Uses two 30-ohm resistors in parallel
C		A06B-6052-K050	4	Uses four 15-ohm resistors in series-paralleled

Note) Type (C) uses four type (A) units.

2) Selection

Select one of the three resistor unit types indicated above that is included in the "usable range" in accordance with the conditions described in items (1) - (4).

[Conditions]

- ① AC spindle motor model (motor rotor inertia J_m)
- ② Motor speed N
- ③ Load inertia converted to the motor shaft J_L
- ④ Operation duty cycle time Dt

[Formula]

Use the following formulas to determine the allowable operation duty cycle times for resistor unit types (A), (B) and (C).

Type (A), one 15-ohm resistor: $Dt \geq 179.2 \times [J_L + J_m] \times N^2 \times 10^{-6} \text{ [sec]}$

Type (B), two 30-ohm resistors: $Dt \geq 89.6 \times [J_L + J_m] \times N^2 \times 10^{-6} \text{ [sec]}$

Type (C), four 15-ohm resistors: $Dt \geq 44.8 \times [J_L + J_m] \times N^2 \times 10^{-6} \text{ [sec]}$

The below diagram shows the results of calculating for resistor unit type (A) for the Models 3I/6I.

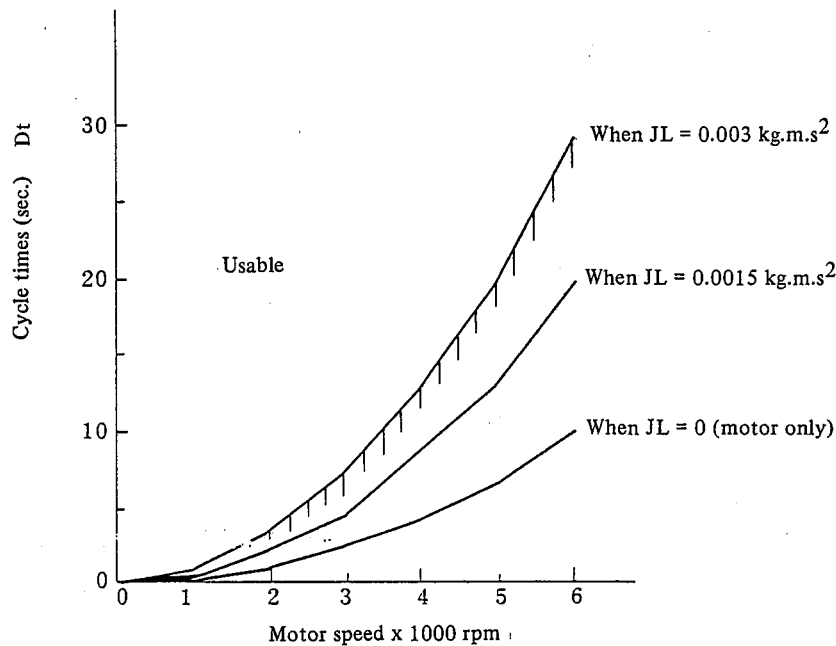


Fig. 1 Allowable duty cycle times for Models 31/61

How to interpret the above graph:

- (1) The operation duty cycle times for load inertias converted to motor shaft above the curve are usable. As Resistor overheating may occur below this curve, use is not recommended.
- (2) The cycle time is 1/2 for resistor unit type (B).
The cycle time is 1/4 for resistor unit type (C).

3) External dimension

Refer to item 10 for the external views when using one resistor. The external view is the same regardless of the resistance value.

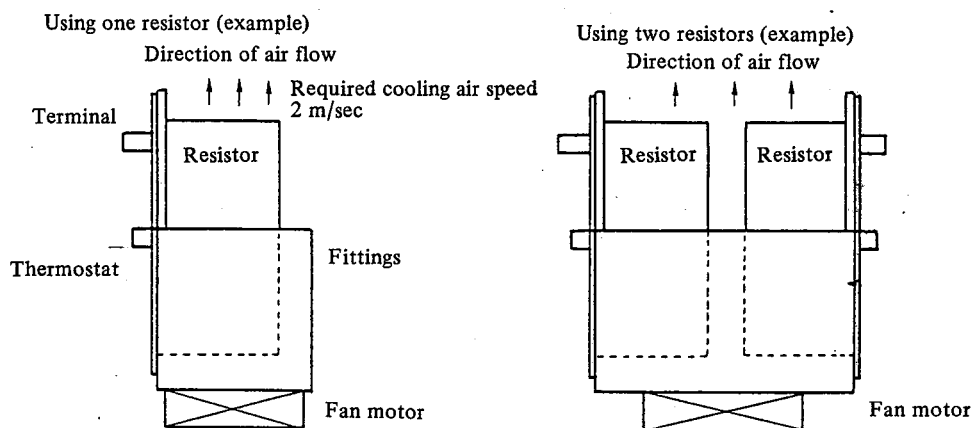
When Type (A): Use one resistor shown in the right diagram.

When Type (B): Use two resistors shown in the right diagram.

When Type (C): Use four resistors shown in the right diagram.

4) Cooling construction

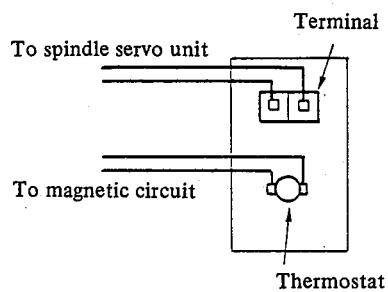
As shown in the example in the diagram below, use duct construction for forced air cooling of the surfaces of the resistors. Fan motors and fittings are required to prepare by the user.



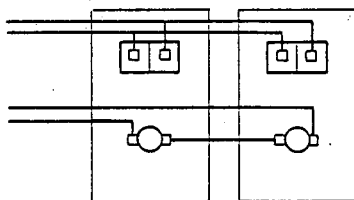
Note) Cooling of the surface where the thermostat is attached is not necessary.

5) Connection

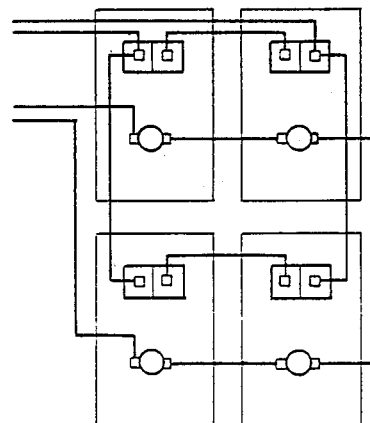
When using one resistor



When using two resistors



When using four resistors



I series AC SPINDLE MOTOR DESCRIPTIONS (B-65022E)

[illegible]

JR AUTOMATION TECHNOLOGIES INC*
JDOWLING

B-65022E/01



* B - 6 5 0 2 2 E / 0 1 *