TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

INTRODUCTION

The following represents the most up-to-date information on motor terminal marking for proper connection to power source for all alternating current motors manufactured in accordance with standards adopted by the National Electrical Manufacturers' Association.

In addition, this section contains important data covering internal wiring to motor terminals which will prove invaluable to the Refrigeration Service Engineer in solving motor problems.

The source of this information is Part 2 of the NEMA Standards Publication, for which reprint permission was granted RSES by the National Electrical Manufacturers' Association.

MG 1-2.01 LOCATION OF TERMINAL MARKINGS

Terminal markings shall be placed on or directly adjacent to terminals to which connections must be made from outside circuits or from auxiliary devices which must be disconnected for shipment. Wherever specified, color coding may be used instead of the usual letter and numeral marking.*

MG 1-2.02 TERMINAL MARKINGS

A combination of capital letters or symbols and an arabic numeral shall be used to indicate the character or function of the windings which are brought to the terminal.*

The following letters and symbols shall be used for motors and generators and their auxiliary devices when they are included within or mounted on the machine.*

Resistance (shunt field adjusting)–V1, V2, V3, etc.

Shunt braking resistor–DR1, DR2, DR3, DR4, etc.

Space heaters–H1, H2, H3, H4, etc.

Stator ‡–T1, T2, T3, T4, etc.

Starting switch–K.

Terminal protector–P1, P2, P3, P4, etc.

Equalizing lead– = (equality sign).

Neutral connection–Terminal letter with numeral 0.

For the significance of the arabic numeral, see MG 1-2.20 for alternating-current machines.

‡ For alternating-current machines only.

Armature–A1, A2, A3, A4, etc.

Brake–B1, B2, B3, B4, etc.

Alternating-current rotor windings (collector rings) ‡–M1, M2, M3, M4, etc.

Capacitor–J1, J2, J3, J4, etc.

Control signal lead attached to commutating winding–C.

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Dynamic braking resistor–BR1, BR2, BR3, BR4, etc.

Field (series)–S1, S2, S3, S4, etc.

Field (shunt)–F1, F2, F3, F4, etc.

Line–L1, L2, L3, L4, etc.

Magnetizing winding (for initial and maintenance magnetization and demagnetization of permanent magnetic fields)–E1, E2, E3, E4, etc. (NOTE–E1, E3, or other odd-numbered terminals should be attached to the positive terminal of the magnetizing power supply for magnetization and to the negative terminal for demagnetization.) •

Resistance (armature and miscellaneous)–R1, R2, R3, R4, etc.

* *Approved as NEMA Standard 11-16-1967*

‡*Approved as Authorized Engineering Information 11-16-67*

•*Added as NEMA Standard 11-16-68*

ALTERNATING-CURRENT MOTORS AND GENERATORS

MG 1-2.20 Numerals on Terminals Of Alternating-Current Polyphase Machines

A. SYNCHRONOUS MACHINES

The numerals 1, 2, 3, etc., indicate the order in which the voltages at the terminals reach their maximum positive values (phase sequence) with clockwise shaft rotation when facing the connection end of the coil windings: hence, for counterclockwise shaft rotation (not standard) when facing the same end, the phase sequence will be 1, 3, 2.†

B. INDUCTION MACHINES

Terminal markings of polyphase induction machines are not related to the direction of rotation.†

* *Approved as NEMA Standard 11-16-1967*

†*Approved as Authorized Engineering Information 11-16-1967*

MG 1-2.21 Definition Of Phase Sequence

Phase sequence is the order in which the voltages successively reach their maximum positive values between terminals.*

MG 1-2.22 Phase Sequence

The order of numerals on terminal leads does not necessarily indicate the phase sequence, but the phase sequence is determined by the direction of shaft rotation relative to the connection end of the coil winding.†

MG 1-2.23 Direction Of Rotation Of Vectors

Vector diagrams shall be shown so that advance in phase of one vector with respect to another is in the counterclockwise direction.

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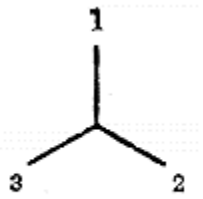


Fig. 2-11

See Fig. 2-11 in which vector 1 is 120 degrees in advance of vector 2 and the phase sequence is 1, 2, 3. (See MG 1-2.21.)*

MG 1-2.24 Direction Of Rotation

The standard direction of rotation for alternating generators is clockwise when facing the end of the machine opposite the drive.*

The direction of rotation of a generator mounted as a part of an engine-generator set is usually counterclockwise when facing the end opposite the drive.†

The standard direction of rotation for all alternating-current single-phase motors, all synchronous motors, and all universal motors shall be counterclockwise when facing the end of the machine opposite the drive.*

MG 1-2.25 Reversal Of Rotation, Polarity And Phase Sequence

Alternating-current generators driven counterclockwise when facing the connection end of the coil windings will generate without change in connections, but the terminal phase sequence will be 1, 3, 2.†

Synchronous condensers and synchronous motors may be operated with counterclockwise shaft rotation viewed from the connection end of the coil windings by connecting them to leads in which the phase sequence is 1, 2, 3, in the following manner:†

Power leads..... 1, 2, 3

Machine terminals.....1, 3, 2

ALTERNATING-CURRENT GENERATORS AND SYNCHRONOUS MOTORS

MG 1-2.30 Connections And Terminal Markings–Alternating-Current Generators And Synchronous Motors–One, Two, And Three Phase

The alternating-current windings of three-phase alternating-current generators and synchronous motors shall have terminal markings as given in MG 1-2.61 for three-phase single-speed induction motors.*

The alternating-current windings of two-phase alternating-current generators and synchronous motors shall have terminal markings as given in MG 1-2.66 for two-phase single-speed induction motors.*

The alternating-current windings of single-phase alternating-current generators and synchronous motors shall have terminal markings as given in Fig. 2-12.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

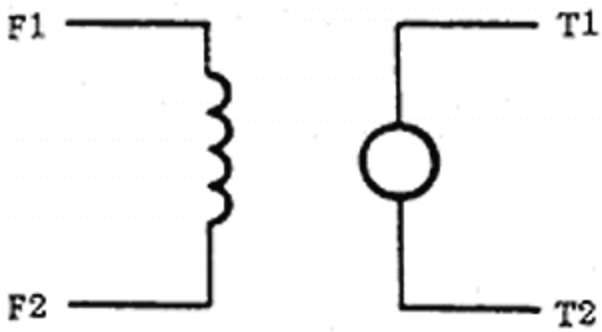


Fig. 2-12
Single Phase

The terminal markings of direct-current field windings shall be F1 and F2.*

NOTE:

See MG 1-2.02 for terminal letters assigned to different types of windings and MG 1-2.20 for the significance of the numerals.†

SINGLE-PHASE MOTORS

MG 1-2.40 General

A. DUAL VOLTAGE

Regardless of type, when a single-phase motor is reconnectible series-parallel for dual voltage, the terminal marking shall be determined as follows:*

For the purpose of assigning terminal markings, the main winding is assumed to be divided into two halves, and T1 and T2 should be assigned to one half and T3 and T4 to the other half.*

For the purpose of assigning terminal markings, the auxiliary winding (if present) is assumed to be divided into two halves, and T5 and T6 should be assigned to one half and T7 and T8 to the other half.*

Polarities shall be established so that the standard direction of rotation (counterclockwise facing the end opposite the drive) is obtained when the main winding terminal T4 and the auxiliary winding terminal T5 are joined or when an equivalent circuit connection is made between the main and auxiliary winding.*

The terminal marking arrangement is shown diagrammatically in Fig. 2-13.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

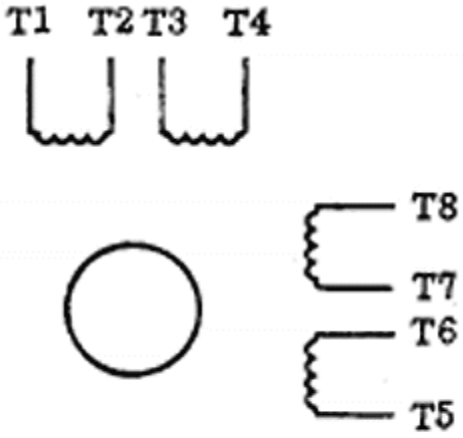


Fig. 2-13
Dual Phase

B. SINGLE VOLTAGE

If a single-phase motor is single voltage or if either winding is intended for only one voltage, the terminal marking shall be determined as follows.*

T1 and T4 shall be assigned to the main winding and T5 and T8 to the auxiliary winding (if present) with the polarity arrangement such that the standard direction of rotation is obtained if T4 and T5 are joined to one line and T1 and T8 to the other.*

The terminal marking arrangement is shown diagrammatically in Fig. 2-14.*

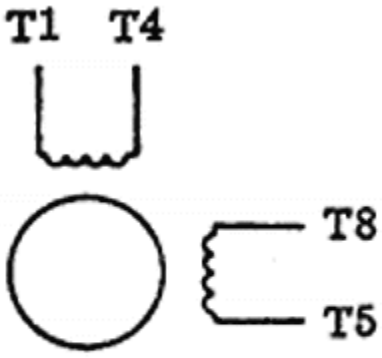


Fig. 2-14
Single Voltage

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

NOTE:

It has been found to be impracticable to follow this standard for the terminal markings of some definite-purpose motors. See Part 18.†

NOTE:

No general standards have been developed for terminal markings of multispeed motors because of the great variety of methods employed to obtain multiple speeds.†

MG 1-2.41 Terminal Markings Identified By Color

When single-phase motors use lead colors instead of letter and number markings to identify the leads, the color assignment shall be determined from the following:*

T1–Blue

T2–White

T3–Orange

T4–Yellow

T5–Black

T8–Red

P1–No color assigned

P2–Brown

NOTE:

It has been found to be impracticable to follow this standard for the lead markings of some definite-purpose motors. See Part 18.†

MG 1-2.42 Auxiliary Devices Within Motor

The presence of an auxiliary device or devices, such as a capacitor, starting switch, terminal protector, etc., permanently connected in series between the motor terminal and the part of the winding to which it ultimately connects shall not affect the marking unless a terminal is provided at the junction.*

Where a terminal is provided at the junction, the terminal marking of this junction shall be determined by the part of the winding to which it is connected. Any other terminals connected to this auxiliary device shall be identified by a letter indicating the auxiliary device within the motor to which the terminal is connected.*

MG 1-2.43 Auxiliary Devices External To Motor

Where the capacitors, resistors, inductors, transformers or other auxiliary devices are housed separately from the motor, the terminal markings shall be those established for the device.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.44 Marking Of Rigidly-Mounted Terminals

On a terminal board, the identification of rigidly-mounted terminals shall be either by marking on the terminal board or by means of a diagram attached to the machine. When all windings are permanently connected to rigidly mounted terminals, these terminals may be identified in accordance with the terminal markings specified in this article. When windings are not permanently attached to rigidly-mounted terminals on a terminal board, the rigidly-mounted terminals shall be identified by numbers only, and the identification need not coincide with that of the terminal leads connected to the rigidly-mounted terminals.*

MG 1-2.45 Internal Auxiliary Devices Permanently Connected To Rigidly-Mounted Terminals

If the motor design is such that the starting switch, terminal protector or other auxiliary device is permanently connected to a rigidly mounted terminal, some variation from the connection arrangements illustrated in MG 1-2.47 through MG 1-2.53 will be required. However, any variations shall be based on the provisions of MG 1-2.46.*

MG 1-2.46 General Principles For Terminal Markings For Single-Phase Motors

The terminal marking and connection procedure given in MG 1-2.40 through MG 1-2.45 and in the schematic diagrams which follow are based on the following principles:†

A. FIRST PRINCIPLE

The main winding of a single-phase motor is designated by T1, T2, T3 and T4 and the auxiliary winding by T5, T6, T7 and T8 to distinguish it from a quarter-phase motor which uses odd numbers for one phase and even numbers for the other phase.†

B. SECOND PRINCIPLE

By following the first principle, it follows that odd-to-odd numbered terminals of each winding are joined for lower voltage (parallel) connection and odd-to-even numbered terminals of each winding are joined for higher voltage (series) connection.†

C. THIRD PRINCIPLE

The rotor of a single-phase motor is represented by a circle, even though there are no external connections to it. It also serves to distinguish the single-phase motor schematic diagram from that of the quarter-phase motor in which the rotor is never represented.†

* Approved as NEMA Standard 11-16-67

† Approved as Authorized Engineering Information 11-16-67

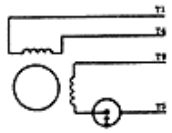
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.47 Schematic Diagrams for Split-Phase Motors—Single Voltage—Reversible

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

Without Thermal Protector

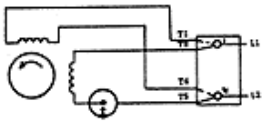
Line Leads



	L1	L2
Counter-clockwise rotation	T1, T8	T4, T5
Clockwise rotation	T1, T5	T4, T8

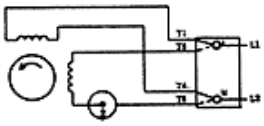
Fig. 2-15

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-16.a



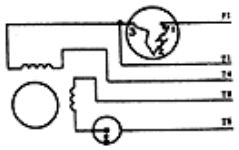
To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-16.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

With Thermal Protector

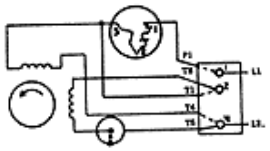
Line Leads



	L1	L2	Join
Counter-clockwise rotation	P1	T4, T5	T1, T8
Clockwise rotation	P1	T4, T8	T1, T5

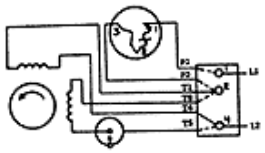
Fig. 2-17

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-18.a



To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-18.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

NEMA Standard 11-16-1967.

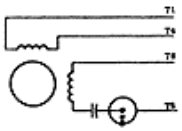
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.48A Schematic Diagrams for Capacitor-Start Motors—Reversible

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

Single Voltage—Without Thermal Protector

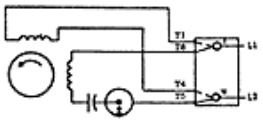
Line Leads



	L1	L2
Counter-clockwise rotation	T1, T8	T4, T5
Clockwise rotation	T1, T5	T4, T8

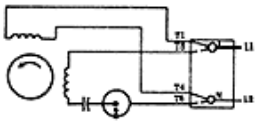
Fig. 2-19

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-20.a



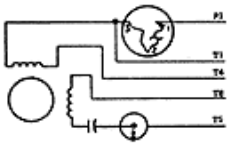
To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-20.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

Single Voltage—With Thermal Protector

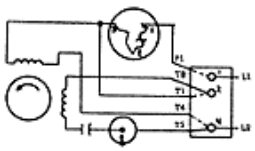
Line Leads



	L1	L2	Join
Counter-clockwise rotation	P1	T4, T5	T1, T8
Clockwise rotation	P1	T4, T8	T1, T5

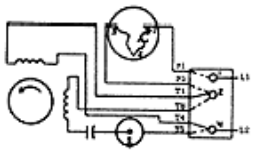
Fig. 2-21

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-22.a



To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-22.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

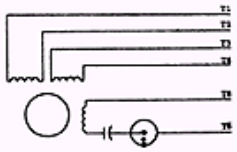
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.48B Schematic Diagrams for Capacitor-Start Motors—Reversible—(*Continued*)

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

DOUBLE VOLTAGE—WITHOUT THERMAL PROTECTOR

Line Leads

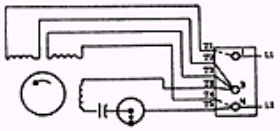


		L1	L2	Join
Higher nameplate voltage	Counter clockwise rotation	T1	T4, T5	T2, T3 and T8
	Clockwise rotation	T1	T4, T8	T2, T3 and T5
Lower nameplate voltage	Counter-clockwise rotation	T1, T3, T8	T2, T4, T5	
	Clockwise rotation	T1, T3, T5	T2, T4, T8	

Fig. 2-23

Terminal Board

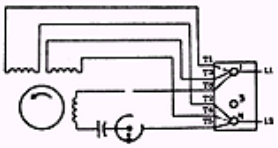
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-24.a

Lower Nameplate Voltage



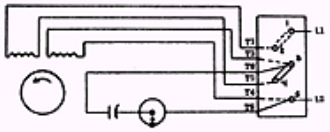
To obtain clockwise rotation, interchange leads T5 and T8

Fig. 2-24.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

Terminal Board with Links

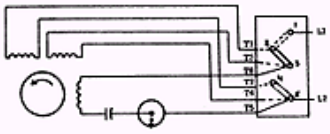
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-25.a

Lower Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-25.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

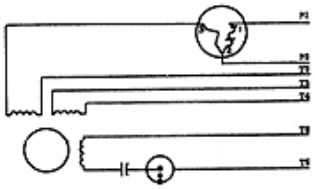
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.48C Schematic Diagrams for Capacitor-Start Motors—Reversible—(*Continued*)

NOTE I—The design proportions for dual-voltage, reversible, capacitor-start motors are such that three different groups of diagrams are necessary to show the means for obtaining adequate protection for these motors. These three groups of diagrams (I, II, and III) insert the thermal protector at different points in the circuit; therefore, different currents are provided to actuate the thermal protector.
NOTE II—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

GROUP I—DOUBLE VOLTAGE—WITH THERMAL PROTECTOR

Line Leads

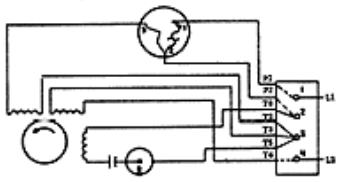


		L1	L2	Join	Join
Higher nameplate voltage	Counter-clockwise rotation	P1	T4	P2, T8	T2, T3 T5
	Clockwise rotation	P1	T4	P2, T5	T2, T3, T8
Lower nameplate voltage	Counter-clockwise rotation	P1	T2, T4, T5	P2, T3, T8	...
	Clockwise rotation	P1	T2, T4, T8	P2, T3, T5	...

Fig. 2-26

Terminal Board

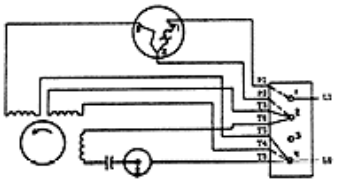
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-27.a

Lower Nameplate Voltage



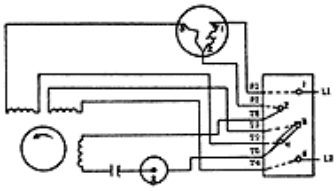
To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-27.b

NOTE III—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.
NOTE IV—Proper connection depends upon design of motor and thermal protector; refer to motor manufacturers' information for proper diagram.

Terminal Board with Links

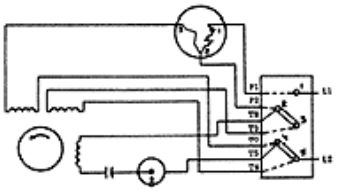
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-28.a

Lower Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-28.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

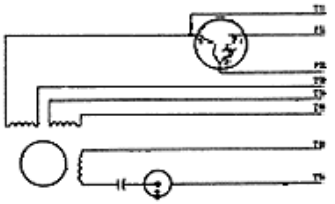
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.48D Schematic Diagrams for Capacitor-Start Motors—Reversible—(*Continued*)

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

GROUP II—DOUBLE VOLTAGE—WITH THERMAL PROTECTOR

Line Leads

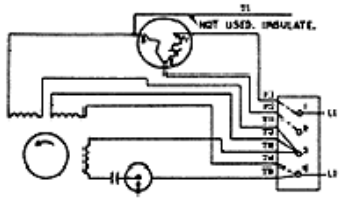


		L1	L2	Join	Join	Insulate Separately
Higher nameplate voltage	Counter-clockwise rotation	P1	T4, T5	T2, T3, T8	...	P2, T1
	Clockwise rotation	P1	T4, T8	T2, T3, T5	...	P2, T1
Lower nameplate voltage	Counter-clockwise rotation	P1	T2, T4, T5	P2, T3	T1, T8	...
	Clockwise rotation	P1	T2, T4, T8	P2, T3	T1, T5	...

Fig. 2-29

Terminal Board

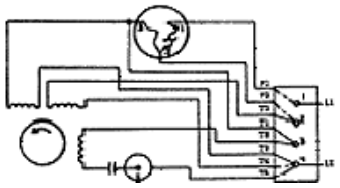
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8

Fig. 2-30.a

Lower Nameplate Voltage



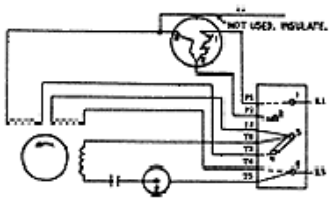
To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-30.b

NOTE I—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.
NOTE II—Proper connection depends upon design of motor and thermal protector; refer to motor manufacturers' information for proper diagram.

Terminal Board with Links

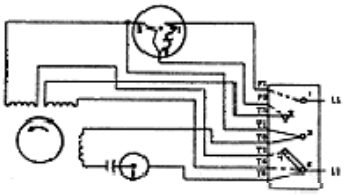
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-31.a

Lower Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-31.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

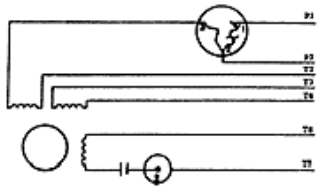
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.48E Schematic Diagrams for Capacitor-Start Motors—Reversible—(*Continued*)

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

GROUP III—DOUBLE VOLTAGE—WITH THERMAL PROTECTOR

Line Leads

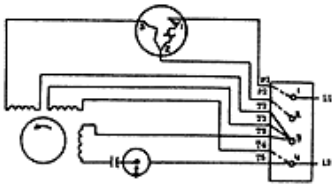


		L1	L2	Join	Insulate Separately
Higher nameplate voltage	Counter-clockwise rotation	P1	T4, T5	T2, T3, T8	P2
	Clockwise rotation	P1	T4, T8	T2, T3, T5	P2
Lower nameplate voltage	Counter-clockwise rotation	P1	T2, T4, T5	P2, T3, T8	...
	Clockwise rotation	P1	T2, T4, T8	P2, T3, T5	...

Fig. 2-32

Terminal Board

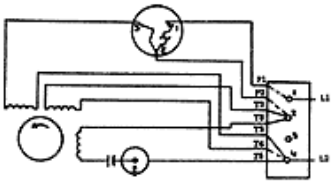
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-33.a

Lower Nameplate Voltage



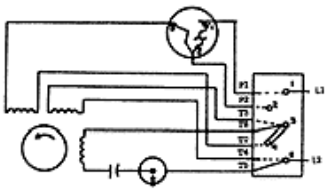
To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-33.b

NOTE I—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.
NOTE II—Proper connection depends upon design of motor and thermal protector; refer to motor manufacturers' information for proper diagram.

Terminal Board with Links

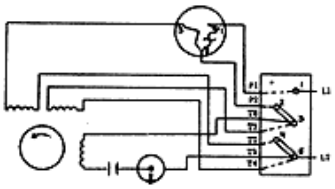
Higher Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-34.a

Lower Nameplate Voltage



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-34.b

NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

NEMA Standard 11-16-1967.

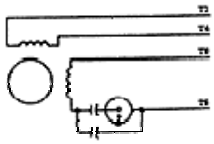
TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.49 Schematic Diagrams for Two-Value Capacitor Motors—Single Voltage—Reversible

NOTE—Motor starting switch shown in running position. All directions of rotation shown are facing the end opposite the drive.

Without Thermal Protector

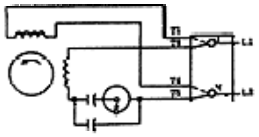
Line Leads



	L1	L2
Counter-clockwise rotation	T1, T8	T4, T5
Clockwise rotation	T1, T5	T4, T8

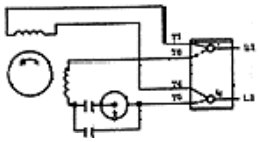
Fig. 2-35

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-36.a

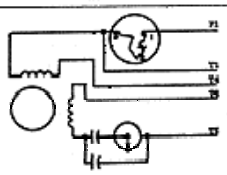


To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-36.b

With Thermal Protector

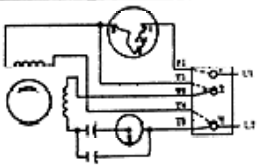
Line Leads



	L1	L2	Join
Counter-clockwise rotation	P1	T4, T5	T1, T8
Clockwise rotation	P1	T4, T8	T1, T5

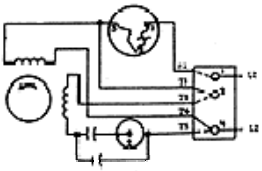
Fig. 2-37

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-38.a



To obtain clockwise rotation, interchange leads T1 and T4.

Fig. 2-38.b

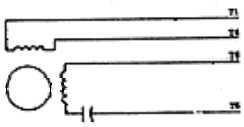
NOTE—When terminal boards are shown, they are viewed from the front. Dotted lines indicate permanent connection.

NEMA Standard 11-16-1967.

MG 1-2.50 Schematic Diagrams for Permanent-Split Capacitor Motors—Single Voltage—Reversible

NOTE 1—All directions of rotation shown are facing the end opposite the drive.
NOTE 1C—There are other terminal markings for definite-purpose permanent-split capacitor motors; see Part 18.

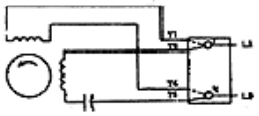
Line Leads



	L1	L2
Counter-clockwise rotation	T1, T8	T4, T5
Clockwise rotation	T1, T5	T4, T8

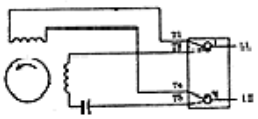
Fig. 2-39

Terminal Board



To obtain clockwise rotation, interchange leads T5 and T8.

Fig. 2-40.a



To obtain clockwise rotation, interchange leads T1 and T4.

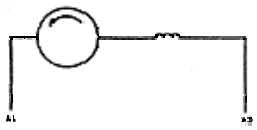
Fig. 2-40.b

NEMA Standard 11-16-1967.

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

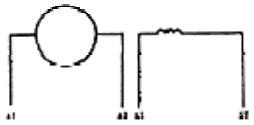
MG 1-2.51 Schematic Diagrams for Universal Motors—Single Voltage

Non-reversible



L1 to A1
L2 to A2
Fig. 2-41.a

Reversible



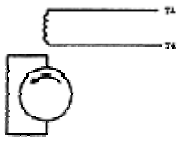
	L1	L2	Join
Counter-clockwise rotation	A1	S2	A2, S1
Clockwise rotation	A1	S1	A2, S2

Fig. 2-41.b

MG 1-2.52 Schematic Diagrams for Repulsion, Repulsion-Start Induction and Repulsion-Induction Motors

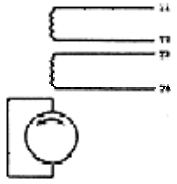
Reversible by Shifting Brushes

Single Voltage



L1 to T1
L2 to T4
Fig. 2-42.a

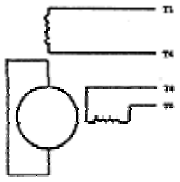
Double Voltage



	L1	L2	Join
Higher nameplate voltage	T1	T4	T2, T3
Lower nameplate voltage	T1, T3	T2, T4	...

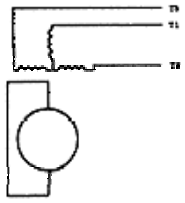
Fig. 2-42.b

Single Voltage—Externally Reversible



	L1	L2	Join
Counter-clockwise rotation	T1	T5	T4, T8
Clockwise rotation	T1	T8	T4, T5

Fig. 2-43.a



	L1	L2	Insulate
Counter-clockwise rotation	T1	T5	T8
Clockwise rotation	T1	T8	T5

Fig. 2-43.b

NEMA Standard 11-16-1967.

NEMA Standard 11-16-1967.

POLYPHASE INDUCTION MOTORS

MG 1-2.60 General Principles For Terminal Markings For Polyphase Induction Motors

A. The markings of the terminals of a motor serve their purpose best if they indicate the electrical relations between the several circuits within the motor. The windings of a motor are seldom accessible, and the arrangement of the terminal numbers varies with the combinations of connections which are required. However, if a definite system of numbering is used, the marking of the terminals may be made to tell the exact relations of the windings within the motor. As far as practicable, MG 1-2.61 and MG 1-2.66 are formulated to embody such a system, which system employs as one of its fundamental points a clockwise rotating spiral with T1 at the outer end and finishing with the highest number at its inner end as a means for determining the sequence of the numerals. See Fig. 2-46.

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

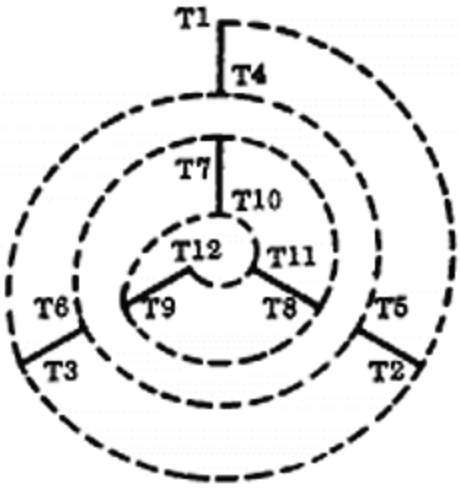


Figure 2-46
Terminal Markings for
Two Circuits per Phase

The numbering of the terminals on polyphase induction motors does not imply standardization of the direction of rotation of the motor shaft.†

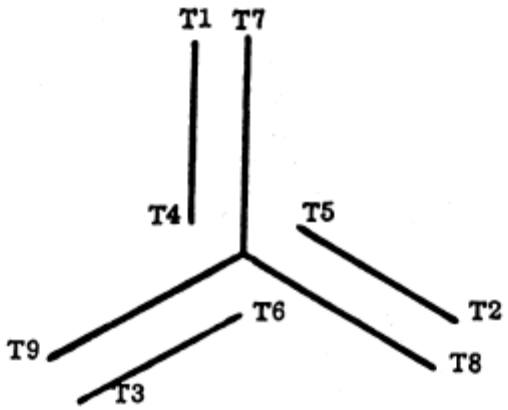
B. For three-phase motors having two synchronous speeds obtained from a reconnectible winding, it is undesirable to adhere to the clockwise system of numbering for all terminals as this would cause the motor to run with clockwise shaft rotation on one speed and counterclockwise on the other speed if the power lines are connected to each set of terminals in the same sequence. This feature may be considered an advantage as a winding with part of its terminals following a clockwise sequence and part following a counterclockwise sequence can be recognized immediately as a two-speed motor with a reconnectible winding.†

C. For two-phase motors, the terminal markings are such that all odd numbers are in one phase and all even numbers are in the other phase. The markings of all motors except those for two speed motors using a single reconnectible winding are based, as are three-phase windings, on a clockwise spiral system of rotation in the sequence of terminal numbering.†

MG 1-2.61 Terminal Markings For Three-Phase Single-Speed Induction Motors

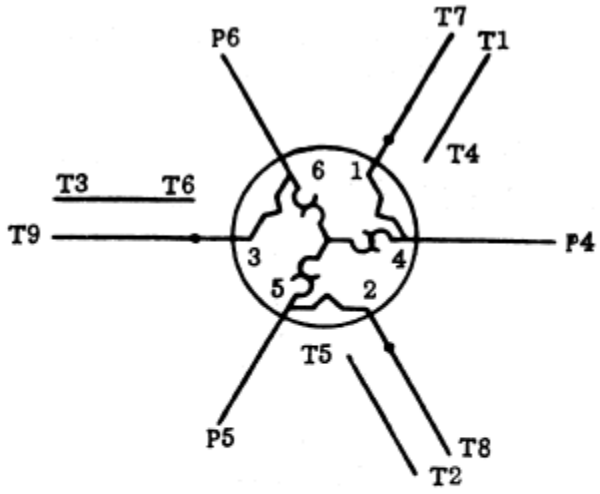
The terminal markings for three-phase singlespeed induction motors shall be as shown in Fig. 2-51, 2-52, 2-53 and 2-54.

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Voltage	L1	L2	L3	Tie Together		
Low	(T1,T7)	(T2,T8)	(T3,T9)		(T4,T5,T6)	
High	T1	T2	T3	(T4,T7)	(T5,T8)	(T6,T9)

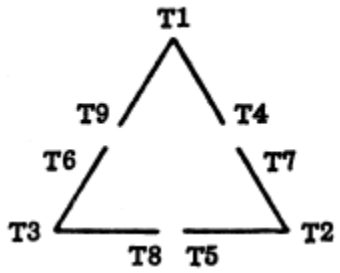
Figure 2-51
Y-connected, Dual Voltage



Volt-age	L1	L2	L3	Tie Together			Insulate Separately
Low	(T1,T7)	(T2,T8)	(T3,T9)	(T4,P4)	(T5,P5)	(T6,P6)	
High	T1	T2	T3	(T4,T7)	(T5,T8)	(T6,T9)	P4-P5-P6

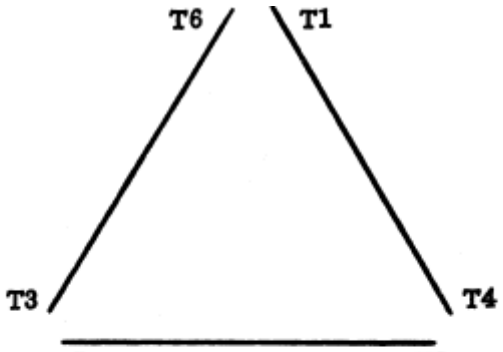
Figure 2-52
Terminal Markings for Three-phase Dual-voltage Single-speed Induction Motors with Protector in Neutral

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Volt-age	L1	L2	L3	Tie Together		
Low	(T1,T6,T7)	(T2,T4,T8)	(T3,T5,T9)	...	...	...
High	T1	T2	T3	(T4,T7)	(T5,T8)	(T6,T9)

Figure 2-53
Delta-connected, Dual Voltage



	L1	L2	L3	Tie Together
Start	T1	T2	T3	(T4,T5,T6)
Run	(T1,T6)	(T2,T4)	(T3,T5)	...

Y-delta-connected, Dual Voltage
(Voltage Ratio $\sqrt{3}$ to 1)

	L1	L2	L3	Tie Together
High Voltage	T1	T2	T3	(T4,T5,T6)
Low Voltage	(T1,T6)	(T2,T4)	(T3,T5)	...

Figure 2-54
Y-connecated Start, Delta-connected Run,
Single Voltage

These terminal markings were developed in accordance with the following procedure which shall be used in developing terminal markings for other combinations of motor stator circuits:*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

A. FIRST

A schematic vector diagram should be drawn showing an inverted Y connection with the individual circuits in each phase arranged for series connection with correct polarity relation of circuits. The diagram for two circuits per phase, for example, is as shown in Fig. 2-45.*

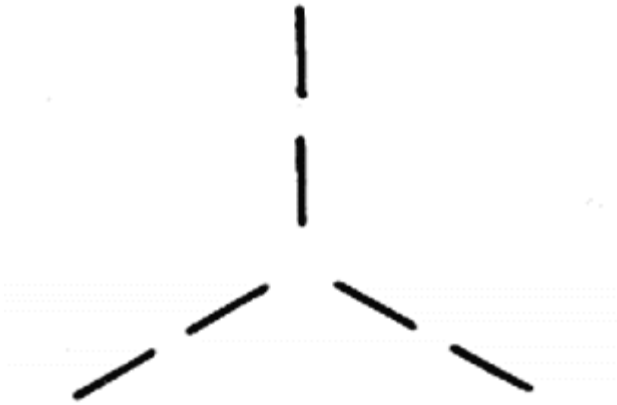


Figure 2-45
Diagram for Two Circuits per Phase

B. SECOND

Starting with T1 at the outside and top of the diagram, the ends of the circuit shall be numbered consecutively in a clockwise direction proceeding on a spiral towards the center of the diagram. For two circuits per phase, for example, the terminals are marked as shown in Fig. 2-46.*

C. THIRD

A schematic vector diagram shall be drawn showing the particular interconnection of circuits for the motor under consideration, and the terminal markings determined in accordance with par. A and B shall be arranged to give the correct polarity relation of circuits. For example, if the winding shown in Fig. 2-46 is to be connected with two circuits in multiple per phase, the diagram and markings shall be as shown in Fig. 2-47.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

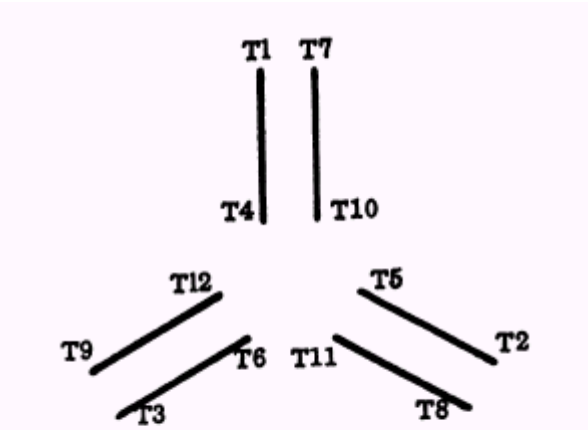


Figure 2-47
Terminal Markings for Two Circuits in Multiple per Phase

D. FOURTH

The highest numbers shall be dropped and only the lowest number shall be retained where two or more terminals are permanently connected together. For example, if the winding shown in Fig. 2-47 is to have the two circuits in each phase permanently connected together with three line leads and three neutral leads brought out, the terminal markings shall be as shown in Fig. 2-48,

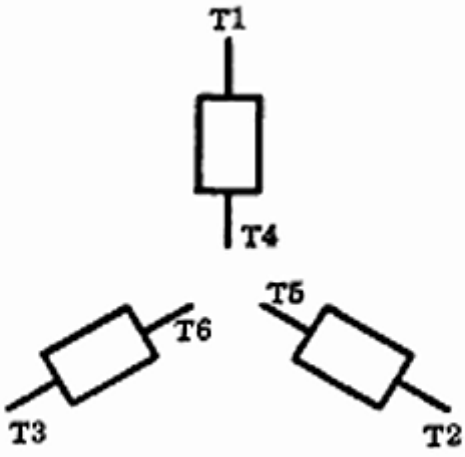


Figure 2-48
Terminal Markings for Two Circuits in Multiple per Phase, Permanently Connected

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

or, if the winding shown in Fig. 2-46 is to be arranged for either a series or a multiple connection with the neutral point brought out, the vector diagram and terminal markings shall be as shown in Fig. 2-49.*

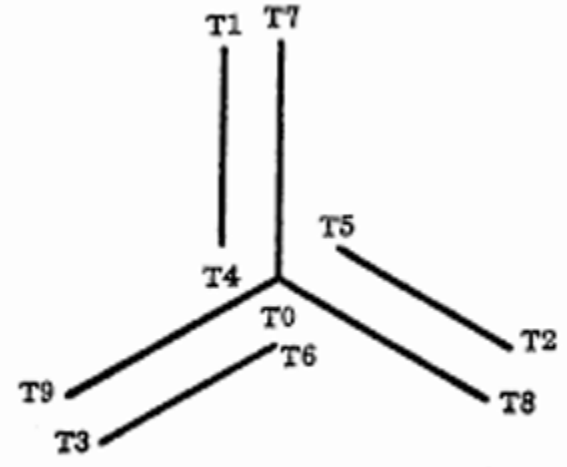


Figure 2-49
Terminal Markings with Neutral Point Brought Out.

E. FIFTH

Where the ends of three coils are connected together to form a permanent neutral, the terminal markings of the three leads so connected shall be dropped. If the neutral point is brought out, it shall always be marked T0. See Fig. 2-49.*

F. SIXTH

If a winding is to be delta-connected, the inverted Y diagram (Fig. 2-45) shall be rotated 30 degrees counterclockwise. T1 shall be assigned to the outer end of the top leg and the balance of the numbering shall be in accordance with MG 1 2.60 and Fig. 2-46. A schematic delta shall then be constructed in which the T1 leg of the rotated Y becomes the right-hand side of the delta, the T2 leg becomes the bottom (horizontal) side, and the T3 leg becomes the left side of the delta. MG 1-2.60 shall be applied insofar as it applies to a delta connection. See Fig. 2-50.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

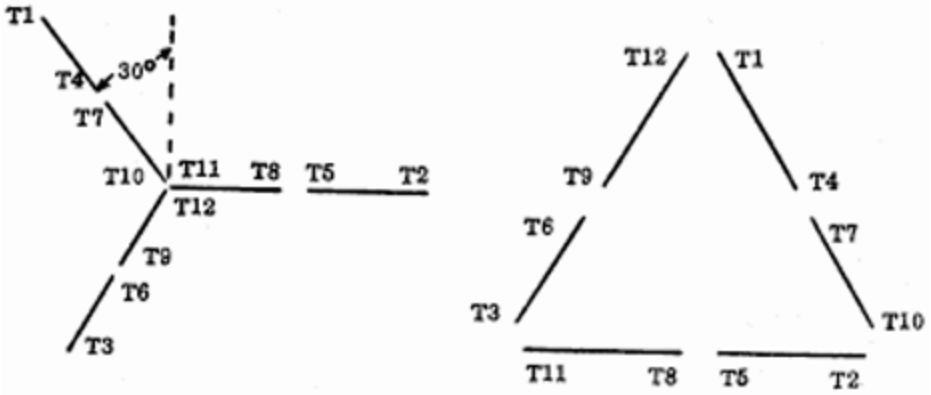


Figure 2-50
Terminal Markings for Two Circuits per Phase, Delta Connected.

* Approved as NEMA Standard 11-16-67

† Approved as Authorized Engineering Information 11-16-67

MG 1-2.62 Terminal Markings For Y-And Delta-Connected Dual-Voltage Motors

Fig. 2-51 through 2-54 illustrate the application of MG 1-2.61 in determining terminal markings of Y-and delta-connected dual-voltage motors.†

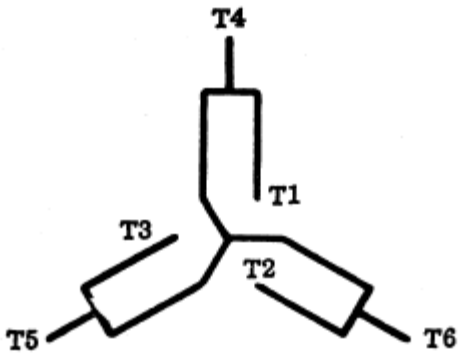
MG 1-2.63 Terminal Markings For Three-Phase Two-Speed Single-Winding Induction Motors

The general principles for terminal markings for polyphase induction motors given in par. B of MG 1-2.60 are not applicable to three-phase two-speed single-winding induction motors because, if followed and the terminals are connected in the same sequence, the direction of rotation at the two speeds will be different.†

MG 1-2.64 Terminal Markings For Y-And Delta-Connected Two-Speed Single-Winding Motors

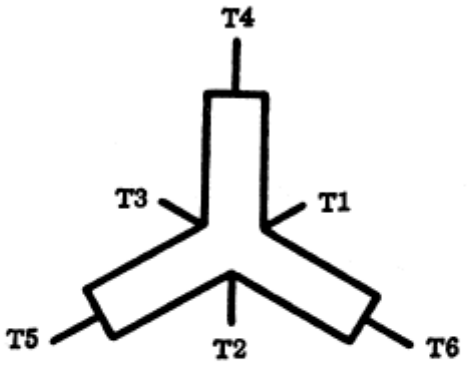
The terminal markings for Y-and delta-connected two-speed single-winding three-phase induction motors shall be in accordance with Fig. 2-55 through 2-59.

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	T4-T5-T6	...
High	T6	T4	T5	...	(T1,T2,T3)

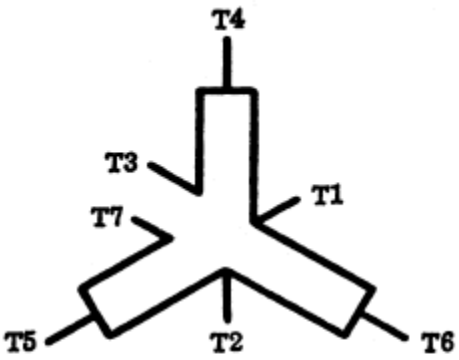
Figure 2-55
Variable Torque Motors



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	T4-T5-T6	...
High	T6	T4	T5	...	(T1,T2,T3)

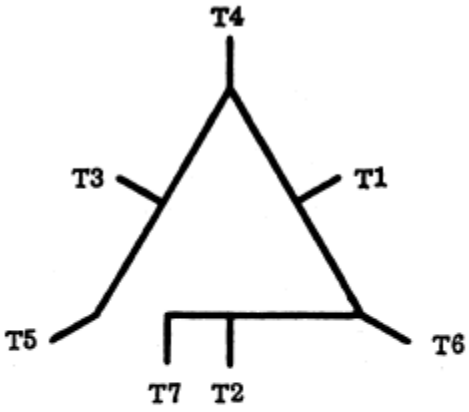
Figure 2-56
Constant Torque Motors

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	(T3,T7)	T4-T5-T6	...
High	T6	T4	T5	...	(T1,T2,T3,T7)

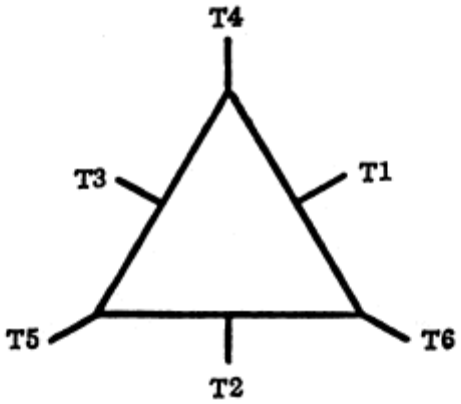
Figure 2-57
Constant-torque Motors



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	...	(T4,T5,T6,T7)
High	T6	T4	(T5,T7)	T1-T2-T3	...

Figure 2-58
Constant Horsepower Motors

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	...	(T4,T5,T6)
High	T6	T4	T5	T1-T2-T3	...

Figure 2-59
Constant Horsepower Motors

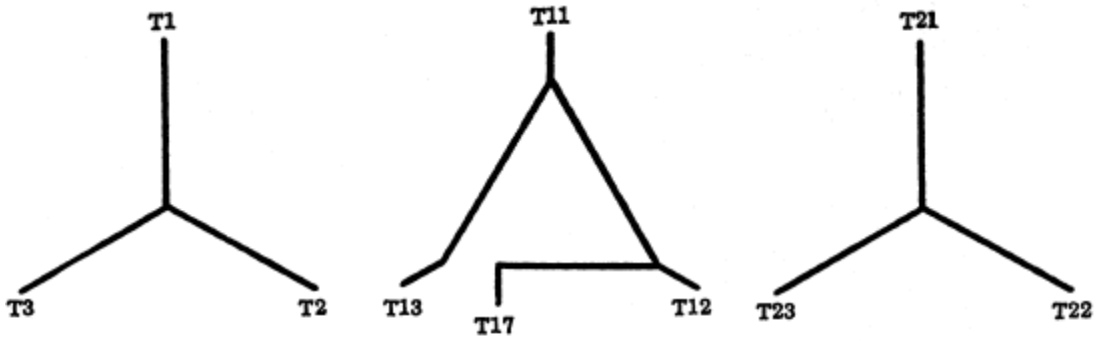
The neutral terminal, if brought out, shall be marked T0*.

MG 1-2.65 Terminal Markings For Three-Phase Induction Motors Having Two Or More Synchronous Speeds Obtained From Two Or More Independent Windings

A. EACH INDEPENDENT WINDING GIVING ONE SPEED

The winding giving the lowest speed shall take the same markings as determined from MG 1-2.61 for the particular winding used. The terminal markings for the higher speed windings shall be obtained by adding 10, 20, or 30, etc., to the terminal markings as determined from MG 1-2.61 for the particular winding used, the sequences being determined by progressing each time to the next higher speed. The terminal markings for a three-speed motor using three windings are given in Fig. 2-60.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	T11-T12-T13-T17-T21-T22-T23	...
Second	T11	T12	(T13,T17)	T1-T2-T3-T21-T22-T23	...
High	T21	T22	T23	T1-T2-T3-T11-T12-T13-T17	...

Figure 2-60
Three-speed Motor Using Three Windings.

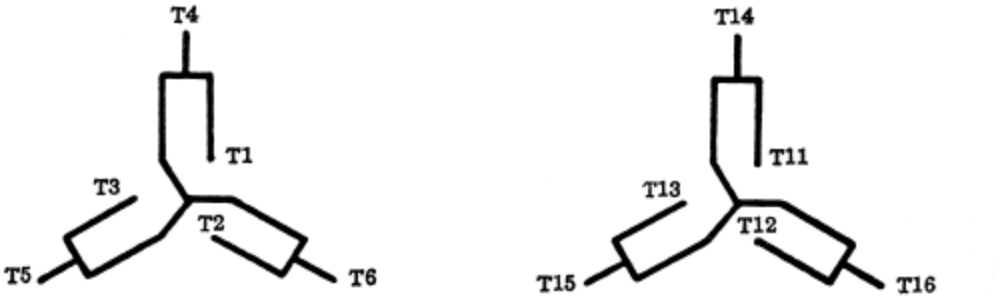
B. EACH INDEPENDENT WINDING RECONNECTIBLE TO GIVE, TWO SYNCHRONOUS SPEEDS

1. First–Vector diagrams of the windings to be used shall be drawn and each winding given the terminal markings shown in MG 1-2.64.*

2. Second–No change shall be made in any of the terminal markings of the winding giving the lowest speed, irrespective of whether the other speed obtained from this winding is an intermediate or the highest speed.*

3. Third–Ten shall be added to all terminal markings of the winding giving the next higher speed, and an additional 10 shall be added to all the terminal markings for each consecutively higher speed winding. The terminal markings for a four-speed motor using two windings are given in Fig. 2-61.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	T3	T4-T5-T6-T11-T12-T13-T14-T15-T16	...
Second	T11	T12	T13	T1-T2-T3-T4-T5-T6-T14-T15-T16	...
Third	T6	T4	T5	T11-T12-T13-T14-T15-T16	(T1,T2,T3)
High	T16	T14	T15	T1-T2-T3-T4-T5-T6	(T11,T12,T13)

Figure 2-61
Four-speed Motor Using Two Windings.

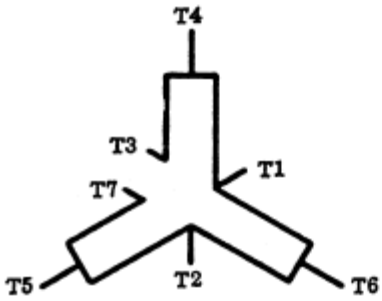
C. TWO OR MORE INDEPENDENT WINDINGS AT LEAST ONE, OF WHICH GIVES ONE SYNCHRONOUS SPEED AND THE OTHER WINDING GIVES TWO SYNCHRONOUS SPEEDS

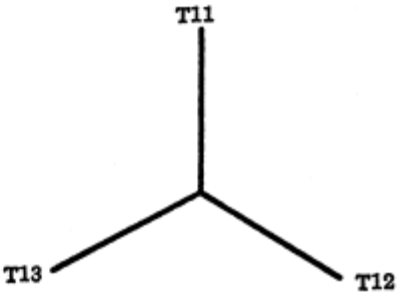
1. First–Each winding shall be given the markings determined in accordance with MG 1-2.61 or MG 1-2.64.*

2. Second–No change shall be made in any of the terminal markings of the winding giving the lowest speed.*

3. Third–Ten shall be added to all terminal markings of the winding giving the next higher speed, and an additional 10 shall be added to all the terminal markings for each consecutively higher speed winding. A typical terminal marking for a three-speed motor using two windings where one of the windings is used for the high speed only is given in Fig. 2-62.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS





Speed	L1	L2	L3	Insulate Separately	Tie Together
Low	T1	T2	(T3,T7)	T4-T5-T6-T11-T12-T13	...
Second	T6	T4	T5	T11-T12-T13	(T1,T2,T3,T7)
High	T11	T12	T13	T1-T2-T3-T4-T5-T6-T7	...

Figure 2-62
Three-speed Motor Using Two Windings

NOTE:

If, under any of the provisions of this standard, the addition of 10, 20, 30, etc., to the basic terminal markings causes a duplication of markings due to more than nine leads being brought out on any one winding, then 20, 40, 60, etc., should be added instead of 10, 20, 30, etc., to obtain the markings for the higher speeds.†

NOTE:

The illustrative figures in this standard apply when all leads are brought out on the same end of the motor. When one or more of the windings have some leads brought out on one end of the motor and some on the other end, the rotation of the terminal markings for leads brought out on one end may be shown on the diagram as shown in the illustrative figures, and the terminal markings for those brought out on the opposite end may be shown reversed in rotation. When diagrams use this reversed rotation of markings, an explanatory note should be included for the benefit of the control manufacturer and user to inform them that, when L1, L2 and L3 are connected to any winding with the same sequence of numbers (T1, T2, T3; or T4, T5, T6; or T11, T12, T13, etc.), the shaft rotation will be the same.†

** Approved as NEMA Standard 11-16-1967*

†Approved as Authorized Engineering Information 11-16-1967

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

MG 1-2.66 Two-Phase Single-Speed Induction Motors

A. FIRST

A schematic vector diagram shall be drawn showing a plus connection with the individual circuits in each phase arranged for series connection with correct polarity relation of circuits. The diagram for three circuits per phase, for example, is as shown in Fig. 2-63.*

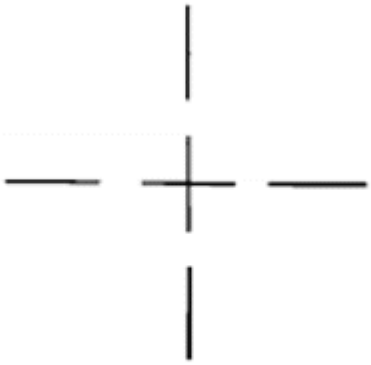


Figure 2-63
Diagram for Three Circuits per Phase

B. SECOND

Starting with T1 at the outside and top of the diagram, the ends of the circuit shall be numbered consecutively in a clockwise direction proceeding on a spiral towards the center of the diagram. For three circuits per phase, for example, the terminals are marked as shown in Fig. 2-64.*

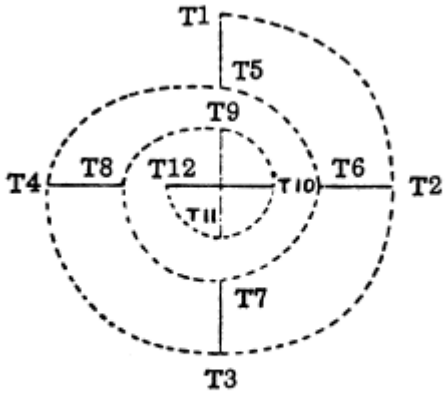


Figure 2-64
Terminal Markings for Thrree Circuits per Phase

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

C. THIRD

A schematic vector diagram shall be drawn showing the particular interconnection of circuits for the motor under consideration and the terminal markings as determined in accordance with par. A and B shall be arranged to give correct polarity relation of circuits. If the winding in Fig. 2-64 is to be connected with three circuits in multiple per phase, the diagram and markings shall be as shown in Fig. 2-65.*

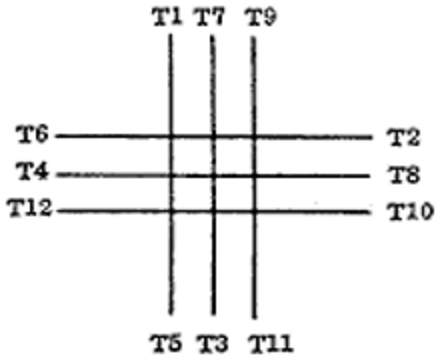


Figure 2-65
Terminal Markings for Three Circuits per Phase, All Circuit Leads Brought Out.

D. FOURTH

The highest numbers shall be dropped and only the lowest number shall be retained where two or more terminals are permanently connected together. If the winding shown in Fig. 2-65 is to have the three circuits in each phase permanently connected together with a single line lead brought out from each end of each phase, the terminal markings shall be as shown in Fig. 2-66.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

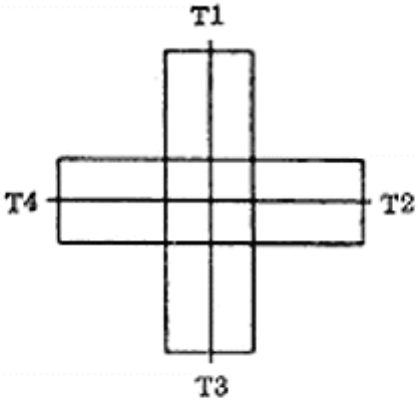


Figure 2-66
Terminal Markings for Three Circuits per Phase Connected in Parallel Inside the Motor.

E. FIFTH

If a two-phase three-wire power supply is used, T3 and T4 shall be connected together and only the T3 marking shall be retained for the common wire.*

F. SIXTH

If the two phases are to be interconnected at the midpoint to connect to a two-phase five-wire system, the midpoint terminal shall be marked T0.*

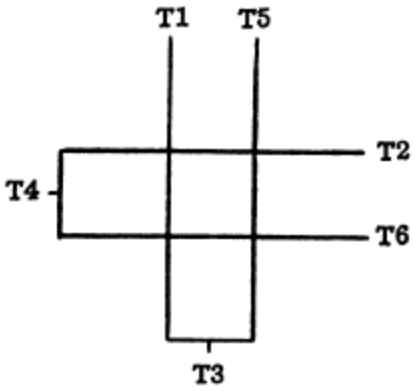
* Approved as NEMA Standard 11-16-67

† Approved as Authorized Engineering Information 11-16-67

MG 1-2.67 Two-Speed Single-Winding Two-Phase Induction Motors

Since there is only one commonly used winding arrangement for these motors, no attempt has been made to develop a method for determining terminal markings. The schematic diagram for the commonly used winding arrangement shall be as shown in Fig. 2-67.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS



Speed	L1	L3	L2	L4	Insulate Separately
Low	T1	T5	T2	T6	T3-T4
High	(T1,T5)	T3	(T2,T6)	T4	. . .

Figure 2-67
Two-speed Two-phase Variable Torque

MG 1-2.68 Terminal Markings For Two-Phase Induction Motors Having Two Or More Synchronous Speeds From Two Or More Independent Windings

A. EACH INDEPENDENT WINDING GIVING MORE THAN ONE SPEED

The winding giving the lowest speed shall take the same terminal markings as determined from MG 1-2.66 for the particular winding used. The terminal markings for the higher speed windings shall be obtained by adding 10, 20, or 30, etc., to the terminal markings determined from MG 1-2.66 for the particular winding used, the sequences being determined by progressing each time to the next higher speed. The terminal markings for a two-speed motor using two single-speed windings shall be as shown in Fig. 2-68.*

B. EACH INDEPENDENT WINDING RECONNECTIBLE TO GIVE TWO SYNCHRONOUS SPEEDS

1. First–Each winding shall be given the terminal markings shown in Fig. 2-67 of MG 1-2.67.*

2. Second–No change shall be made in any of the terminal markings of the winding giving the lowest speed irrespective of whether the other speed obtained from this winding is an intermediate or the highest speed.*

3. Third–Ten shall be added to terminal markings of the winding giving the next higher speed and an additional 10 shall be added to all the terminal markings for each consecutively higher speed winding. The terminal markings for a four-speed motor using two windings shall be as shown in Fig. 2-69.*

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

C. TWO INDEPENDENT WINDINGS AT LEAST ONE OF WHICH GIVES ONE SYNCHRONOUS SPEED AND THE OTHER WINDING GIVES TWO SYNCHRONOUS SPEEDS

1. First–Each winding shall be given the markings determined in accordance with MG 1-2.66 or MG 1-2.67.*

2. Second–No change shall be made in any of the terminal markings of the winding giving the lowest speed.*

3. Third–Ten shall be added to all terminal markings of the winding giving the next higher speed, and an additional 10 shall be added to all the terminal markings of each consecutively higher speed winding. The terminal markings for a three-speed motor using two windings shall be as shown in Fig. 2-70.*

NOTE:

If, under any of the provisions of this standard, the addition of 10, 20, 30, etc., to the basic terminal markings causes a duplication of markings due to more than nine leads being brought out on any one winding, then 20, 40, 60, etc. should be added instead of 10, 20, 30, etc., to obtain the markings for the higher speeds.†

MG 1-2.69 Terminal Markings Of The Rotors Of Wound-Rotor Induction Motors

See Fig. 2-71.a and 2-71.b.*

* Approved as NEMA Standard 11-16-67

† Approved as Authorized Engineering Information 11-16-67

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS

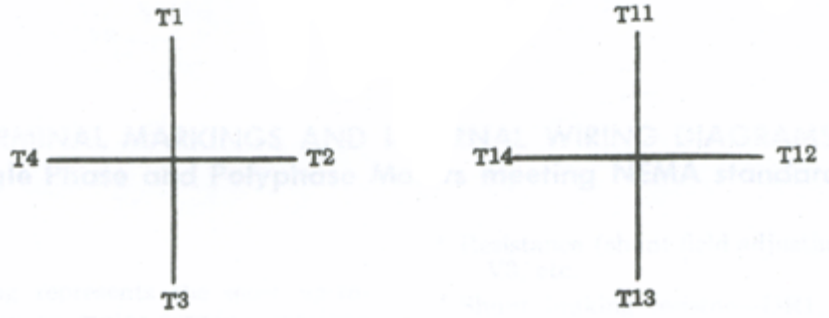


Fig. 2-68

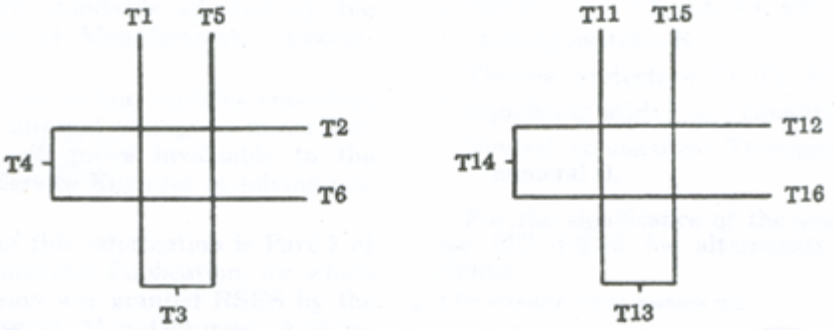


Fig. 2-69

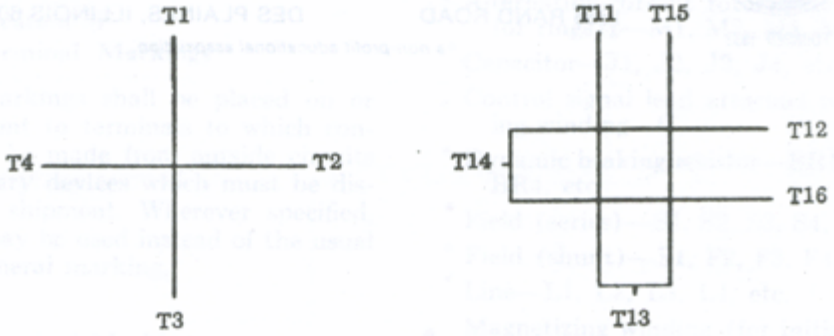


Fig. 2-70

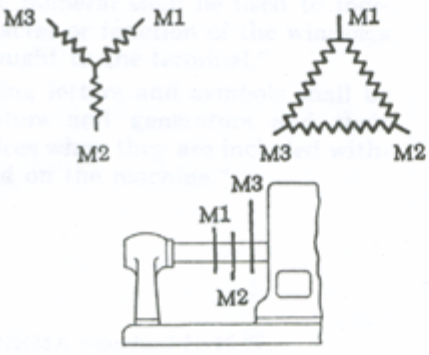


Fig. 2-71.a
Three-phase Wound Rotor

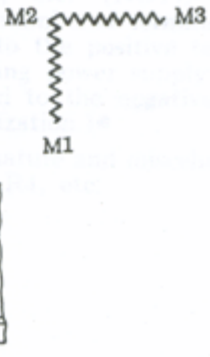


Fig. 2-71.b
Two-phase Wound Rotor

TERMINAL MARKINGS AND INTERNAL WIRING DIAGRAMS SINGLE PHASE AND POLYPHASE MOTORS MEETING NEMA STANDARDS