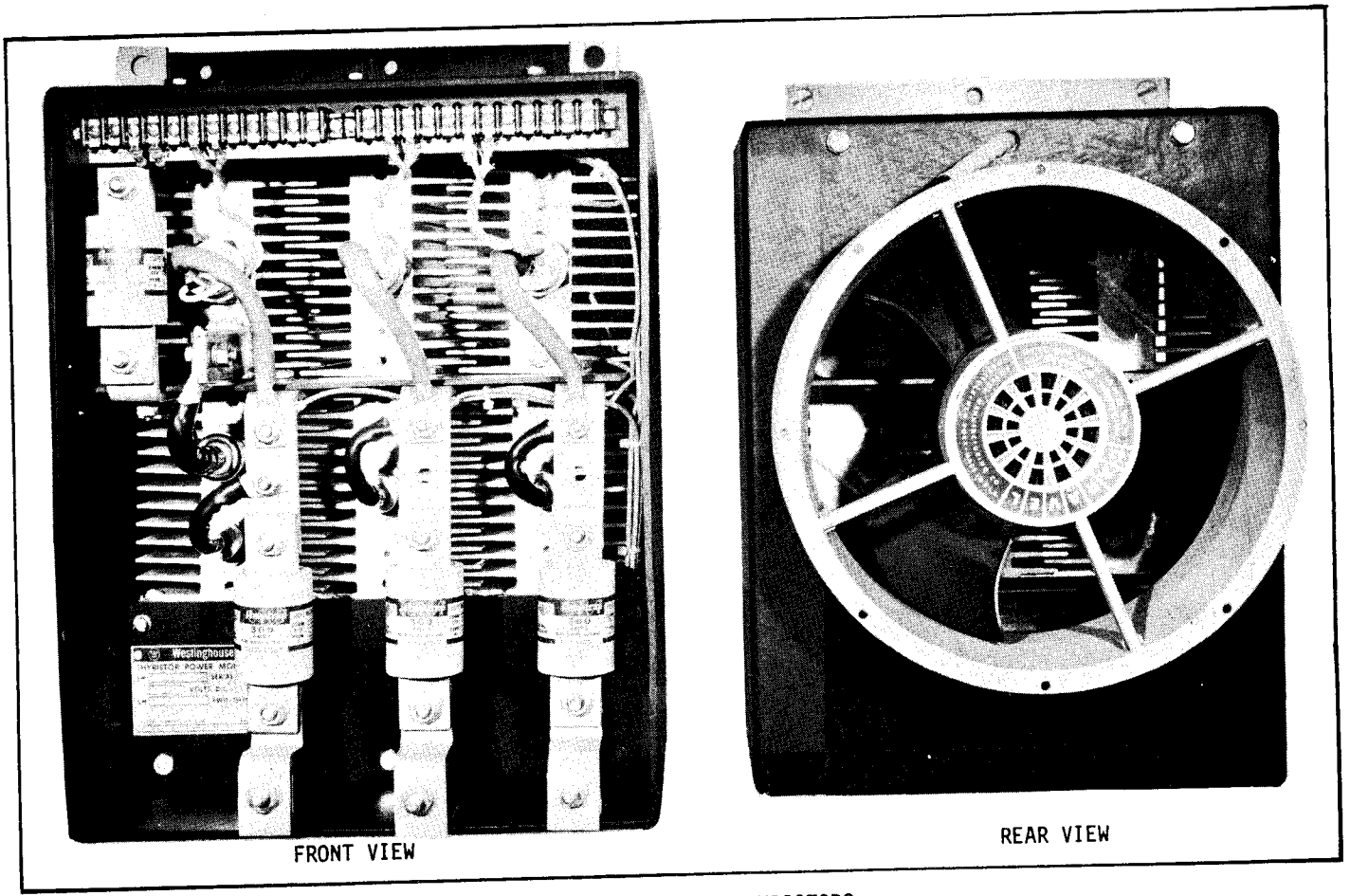
A906, A907, A908 SEMICONVERTER TPMs
For Use in S-56

I. INTRODUCTION

Semiconverter thyristor power modulators (TPMs) are used to convert ac line voltage to a controlled dc output voltage. This is accomplished by replacing half of the diodes in a conventional bridge rectifier by thyristors, and phase-controlling the gate pulses supplied to them.

S-56 TPMs are three-phase semiconverters packaged in a molded glass epoxy case (see Figure 1).



FRONT VIEW

REAR VIEW

S-56 TPM SIZE 7 THYRISTORS
FIGURE 1

Cases are integrally cooled and contain thyristors and diodes mounted on appropriate heat sinks, all necessary voltage protection networks, and current limiting fuses for size 4, 5, and 7* assemblies.

* Size 4, 5, and 7 refer to the thyristor used in the TPM. Size 4 --- 55 amps rms
Size 5 --- 110 amps rms
Size 7 --- 275 amps rms.

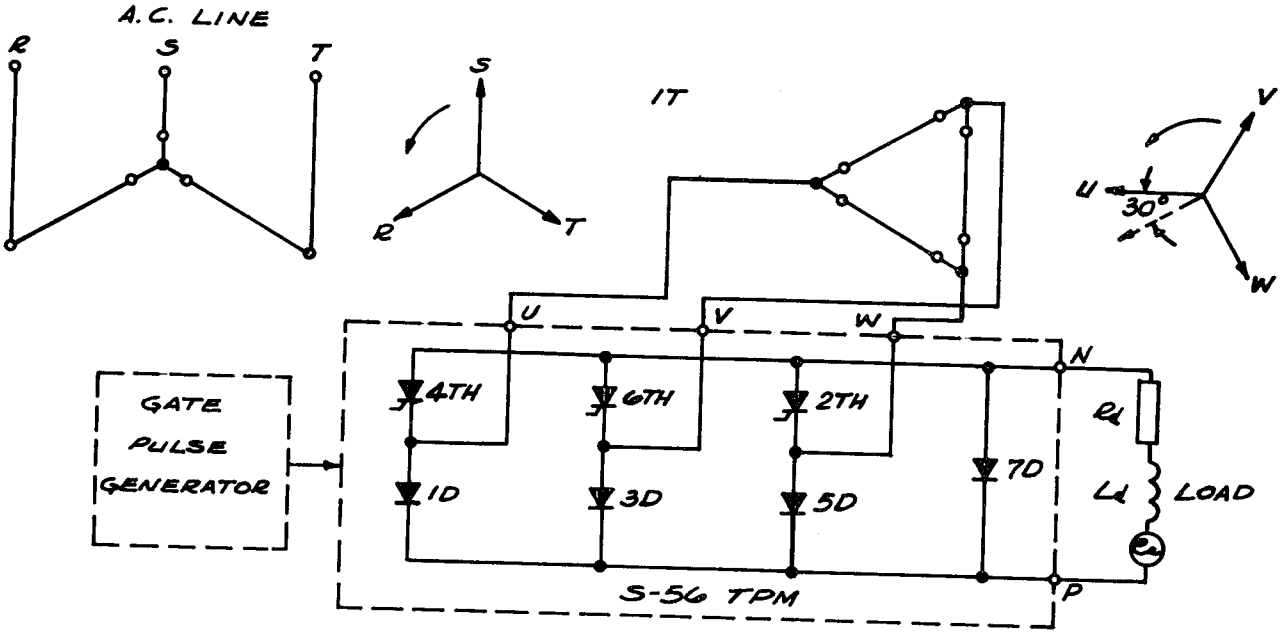
Power connections to the TPM are three, ac, input leads to stud connections at the bottom of the case, and two, dc outputs from studs at the top of the case, All control input and output connections are made at the terminal block located at the top front of the assembly.

Cabinet mounting is not restricted to the vertical position shown in Figure 1. A minimum of four inches of free space must be allowed in any configuration for intake and exhaust of air to achieve rated performance from the TPM.

II. DESCRIPTION

A. Electrical Operation

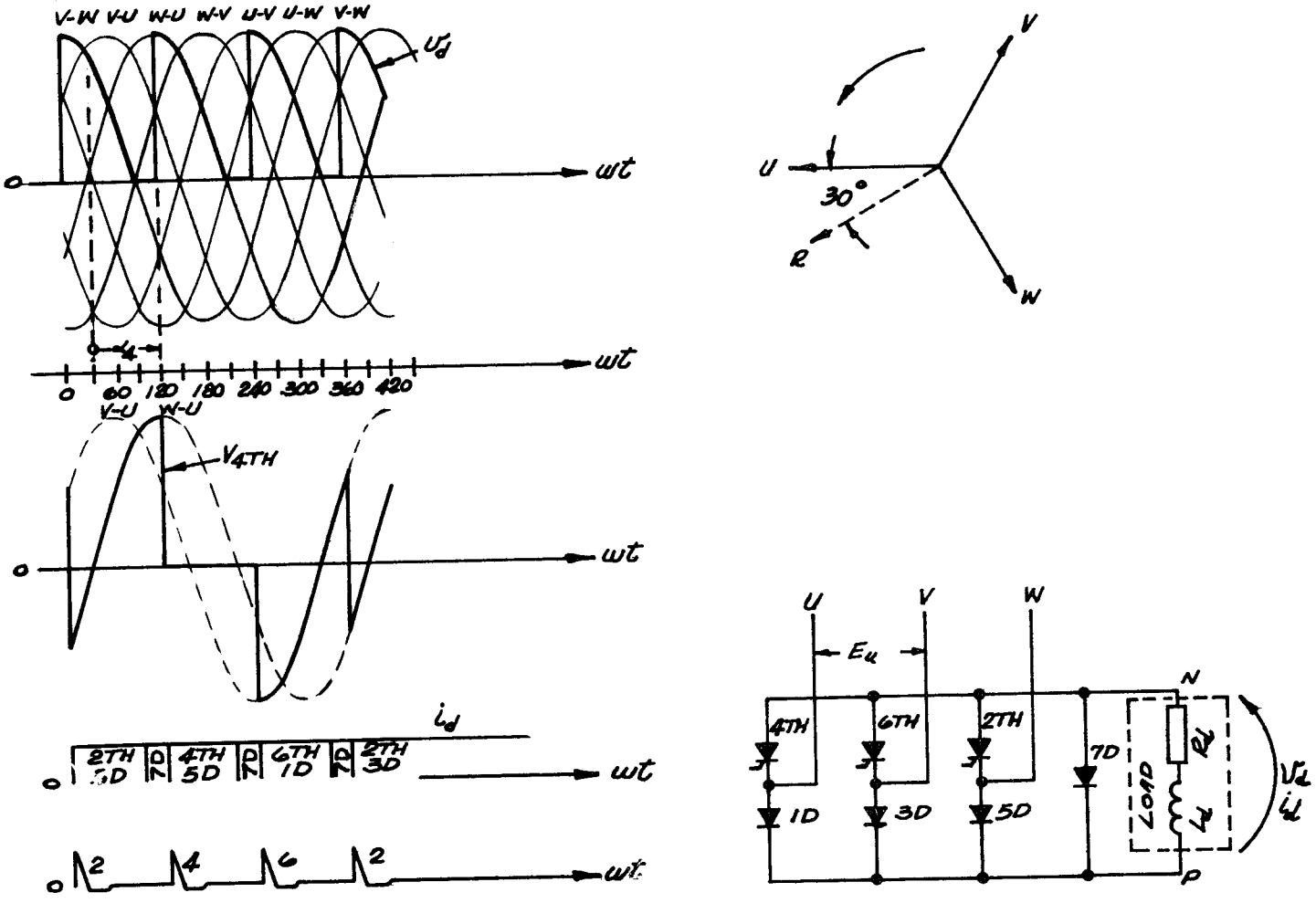
The thyristor is a three-terminal, silicon device which exhibits characteristics similar to a thyratron. It is capable of blocking both forward and reverse voltages; and when forward biased (anode positive with respect to the cathode), will switch to the conducting state if the gate is supplied with a positive signal. Once turned on, the cell continues to conduct until the voltage across it reverses or the current through it falls below a minimum value--termed the holding current.



S-56 TPM
ELEMENTARY SCHEMATIC POWER SEMICONVERTER
FIGURE 2

Figure 2 is a simplified schematic of the S-56 semiconverter. The power transformer 1T is shown in the commonly-used, wye-delta connection and provides isolation, adjusts line voltage to proper levels, and introduces inductance to limit rates of current during commutation. Phase-controlled gate pulses to fire the thyristors are provided by the gate pulse generator described in I.L. 16-800-105. The dc output of the semiconverter is shown connected to a motor armature load consisting of a CEMF e_a, resistance R_d, and inductance L_d. Operation of the circuit will be explained with reference to Figure 3.

Figure 3 illustrates the operation of the semiconverter having assumed a motor armature (CEMF) load continuous load current i_d, and a phase angle $\alpha = 90^0$. $\alpha = 0$ for a particular semiconductor corresponds to the point in time it becomes the most forward biased device in the bridge circuit.

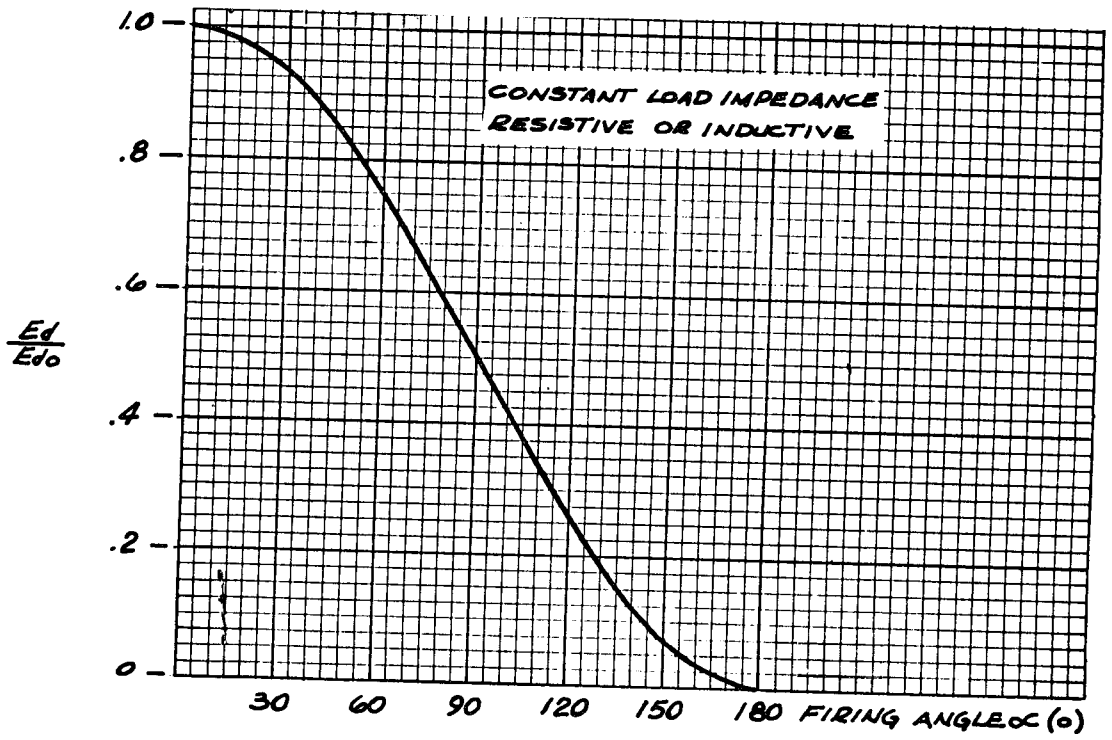


BASIC WAVEFORMS IN SIX-PHASE, DOUBLE-WAY CIRCUIT
FIGURE 3

Upper traces show the secondary line-to-line voltages measured from the first terminal letter to the second terminal letter. Prior to ωt = 0, all thyristors are blocking. At ωt = 0, a gate pulse is applied to the forward biased thyristor 2TH, and as diode 3D is also forward biased at this time, a path is completed for load current. The path exists from V through 3D to P, through the load to N, and to W through 2TH; hence, line voltage V_{V-W} appears across the load terminals P-N. (With a resistive load, reversal of

line voltage V_{V-W} at $\omega t = 90^{o}$ would reverse bias the semiconductors and load current would cease until 4TH is gated at $\omega t = 120^{o}$.) With an inductive load (as shown), when V_{V-W} reverses, load flux will collapse attempting to keep i_d constant. The accompanying voltage reversal at terminals P-N forces commutation to free-wheeling diode 7D, which conducts until 4TH receives a gate pulse at $\omega t = 120^{o}$ and carries load current with 5D. Load current subsequently commutates to 7D, 1TH and 6D, 7D and back to 2TH-3D completing the cycle.

A transfer curve relating output voltage E_d and phase angle α may be generated by integrating the output voltage waveshape with respect to α. Results of the integration are shown in the normalized curve of Figure 4, where $E_{do} = 3E_{\mu}\sqrt{2}/\pi = 1.35E_{\mu}$. Semiconverter TPMs are limited to applications requiring neither output voltage or current reversal.



NORMALIZED TRANSFER CURVE OF THREE PHASE TPM
FIGURE 4

B. Characteristics and Ratings

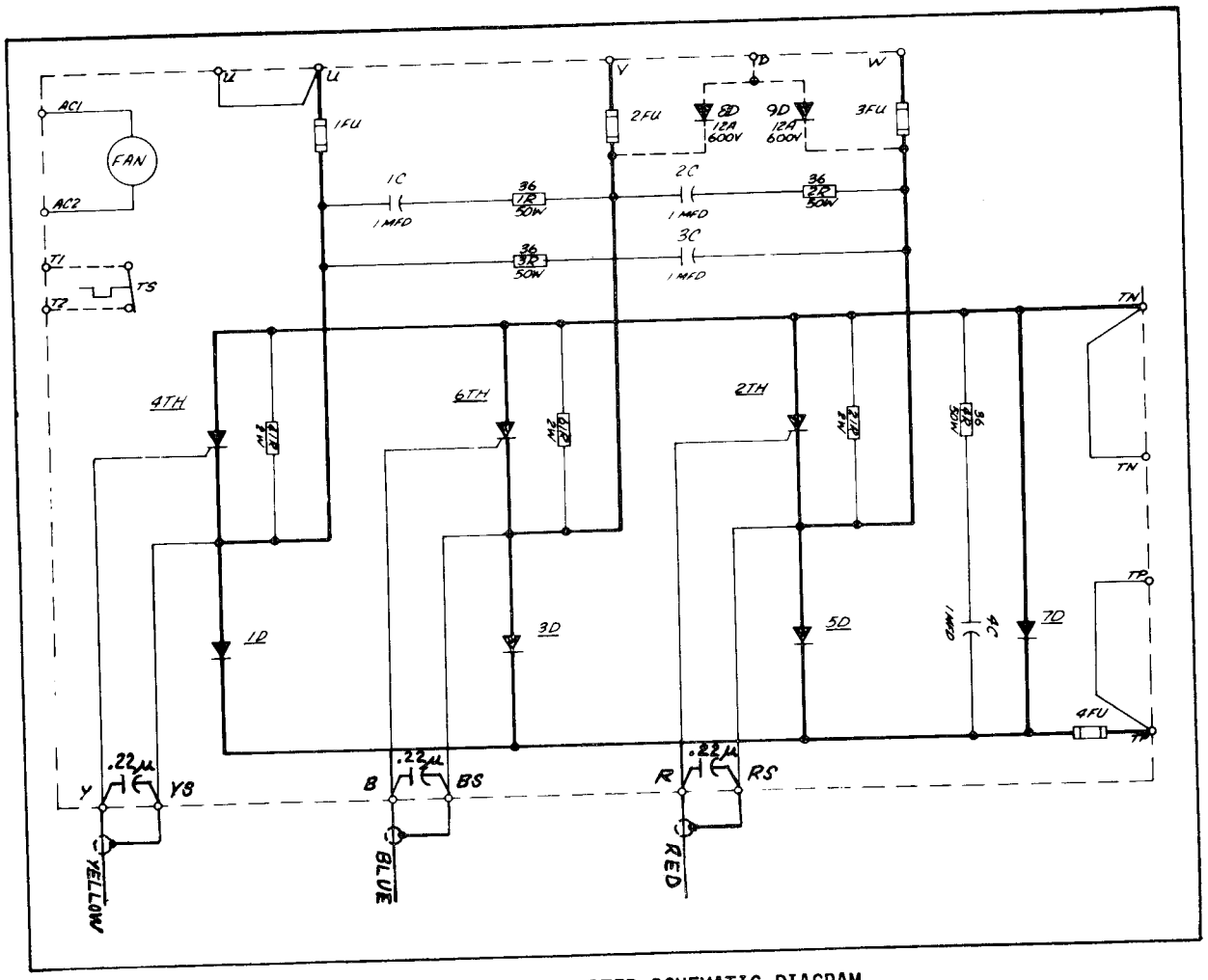
The current-carrying capability of the TPM is dependent on the thyristors and diodes incorporated in the bridge circuit. For short-time overloads, the limiting factor is the rms rating of the device; while for continuous ratings, thermal considerations prevail. Steady-state ratings from 80a to 360a are available in singl , integrally-cooled cases based on a maximum external ambient of 40°C.

Available dc voltage ratings of the TPM are 500V, 375V, and 250V dependent on the voltage ratings of semiconductors used. In all cases, the reverse blocking capability of devices is at least 1.80 times the nominal peak, ac voltage to protect against line voltage transients.

A nameplate located on the front, left side of the RC network subassembly gives the voltage rating for the particular TPM and identifies the thyristor used by a Buffalo style number.

C. MISCELLANEOUS

Figure 5 is a complete schematic diagram of the TPM showing all components packaged in the molded case.



S-56 SEMICONVERTER SCHEMATIC DIAGRAM
FIGURE 5

An RC line filter (1R-1C, 2R-2C, 3R-3C) is connected across each incoming line to limit incoming transient voltages. The output filter 4R-4C, in conjunction with the line filters, provide a damping network to limit ringing associated with normal commutation.

Current limiting fuses (1FU, 2FU, 3FU) are provided in each line to protect the semiconductors during fault condit ons, while 4FU in the + output protects the motor against excessive currents should the free-wheeling diode 7D fail short.

Gate pulses for the thyristors are coupled from the gate pulse generator (E01 pc board) through pulse transformers and series limiting resistors physically mounted in the rear of the basic regulator cage assembly. Shielded leads are used for noise isolation and leads are color coded to aid in identification. . . . . red, yellow, and blue feeding thyristors 2TH, 4TH, and 6TH respectively.

Thermal protection in the advent of fan loss may be provided as an option. This is accomplished by embedding a thermo switch (T.S.) in the heat sink of 6TH to detect abnormally-high temperatures and sequence the drive off.

Constant potential field excitation may also be provided as an option when ac input power is 230 volts rms. Diodes 8D and 9D are added, and in conjunction with bridge diodes 3D and 5D, provide a single-phase bridge rectifier with dc output at TP(+) and D(-). The maximum capability of the bridge circuit is 180 vdc at 12 amps.

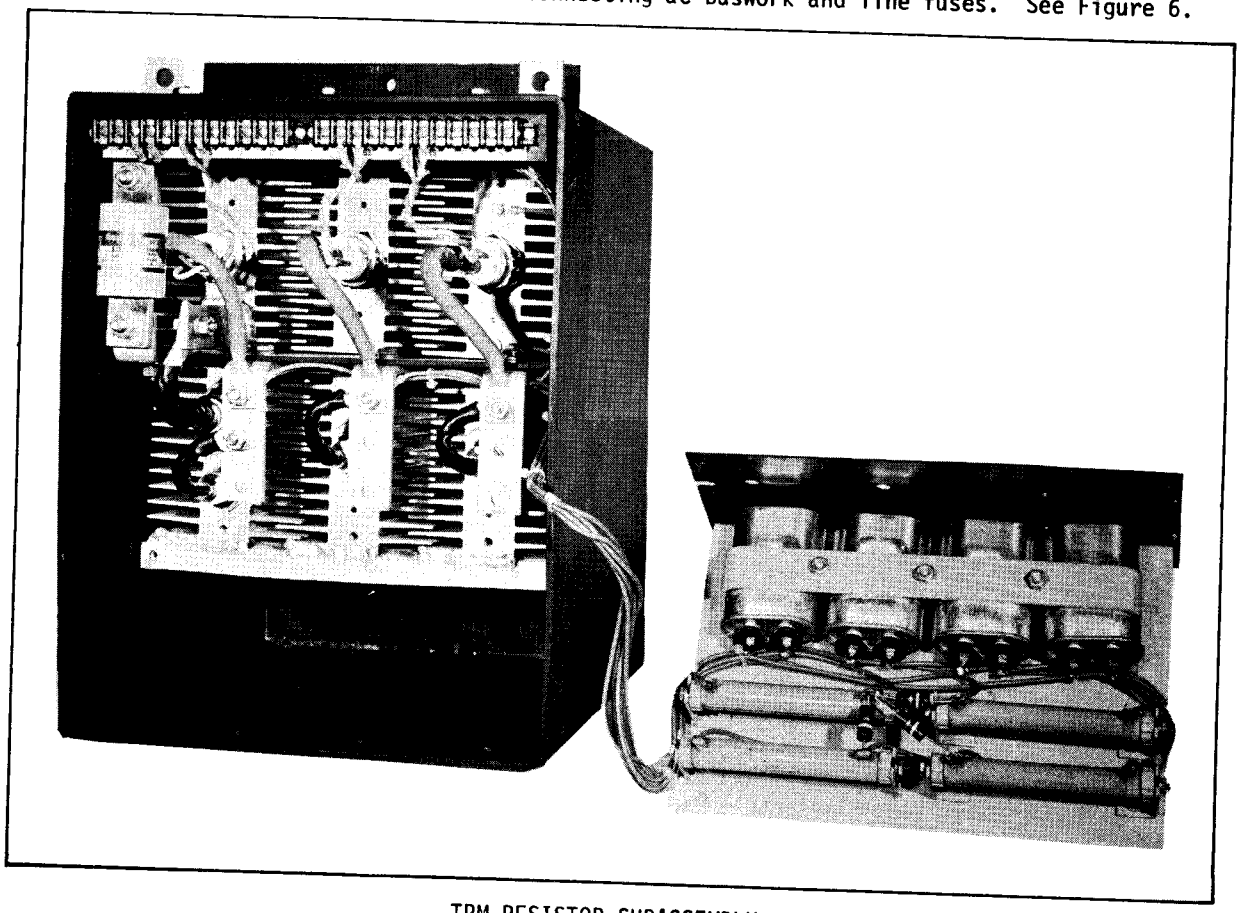
III. SERVICE

Current limiting fuses and semiconductors are components most likely to fail if the TPM is subjected to fault conditions; hence, are positioned for easy access.

(a) Current limiting fuses must be of the same type and rating supplied. These are special fuses and substitutions cannot be used.

(b) Thyristors and diodes are front removable and should be replaced with spare devices obtained through Buffalo Industrial Systems Division. When replacing semiconductors, procedures outlined in I.L. 16-800-15 must be followed to insure proper heat transfer from the device junction.

Replacing RC networks, rewiring, fan replacement, and similar bench-type repairs are seldom encountered. Should such repair be necessary, the fan assembly is held by "Tinnerman" hardware and is removable from the rear. RC networks are packaged in the bottom subassembly which is easily removed from the front after disconnecting ac buswork and line fuses. See Figure 6.



TPM RESISTOR SUBASSEMBLY
FIGURE 6

Should a complete TPM or S-56 cage assembly be received as a replacement part, check the polarity of gate pulses at the terminal block located at the top front of the TPM assembly. If the gate is not positive with respect to the cathode interchange the leads from the thyristor to the terminal block. Prior to June 1968 the positive leads were the shields of the color coded cables from the cage assembly, however, the interconnections have since been changed as shown on Figure 4, sheet 5 of I.L. 16-800-101A.

TPMs requiring substantial electrical or mechanical repair should be returned to:

Westinghouse Electric Corporation
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P. O. Box 225
Buffalo, New York 14240

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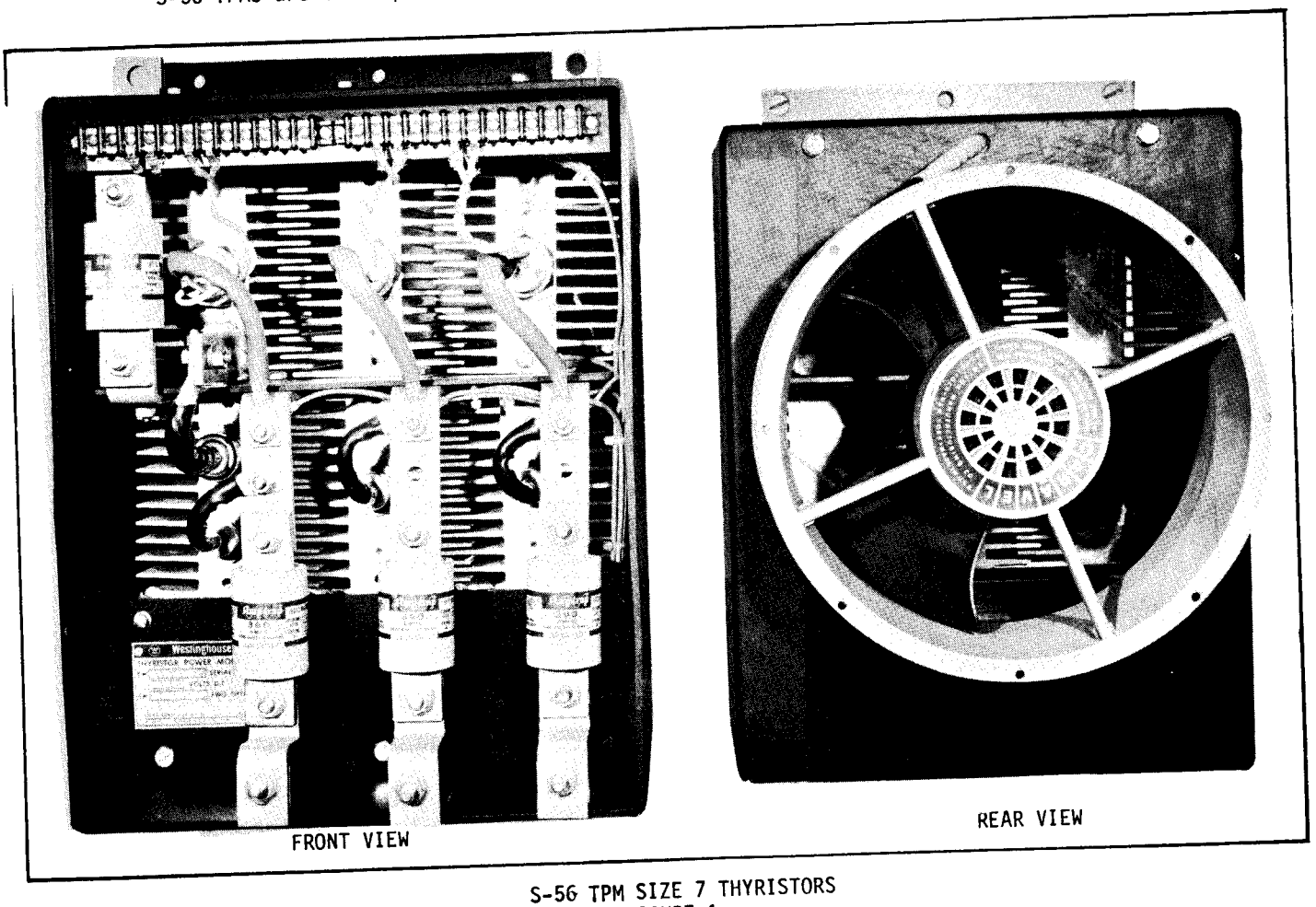

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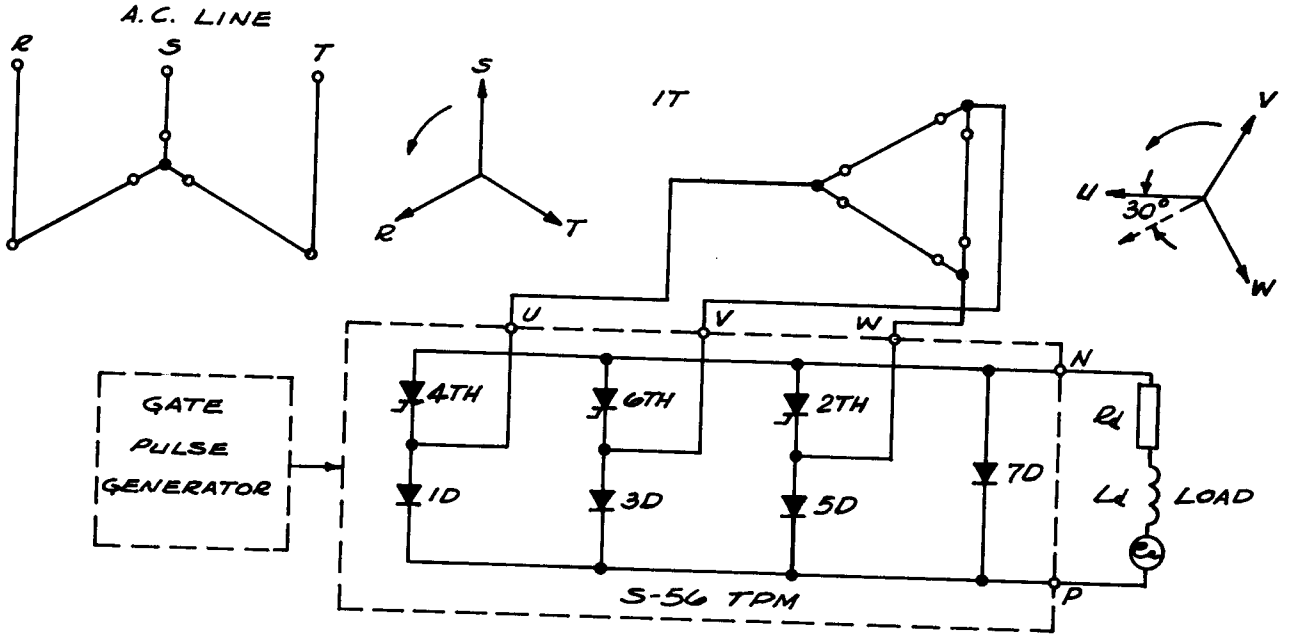

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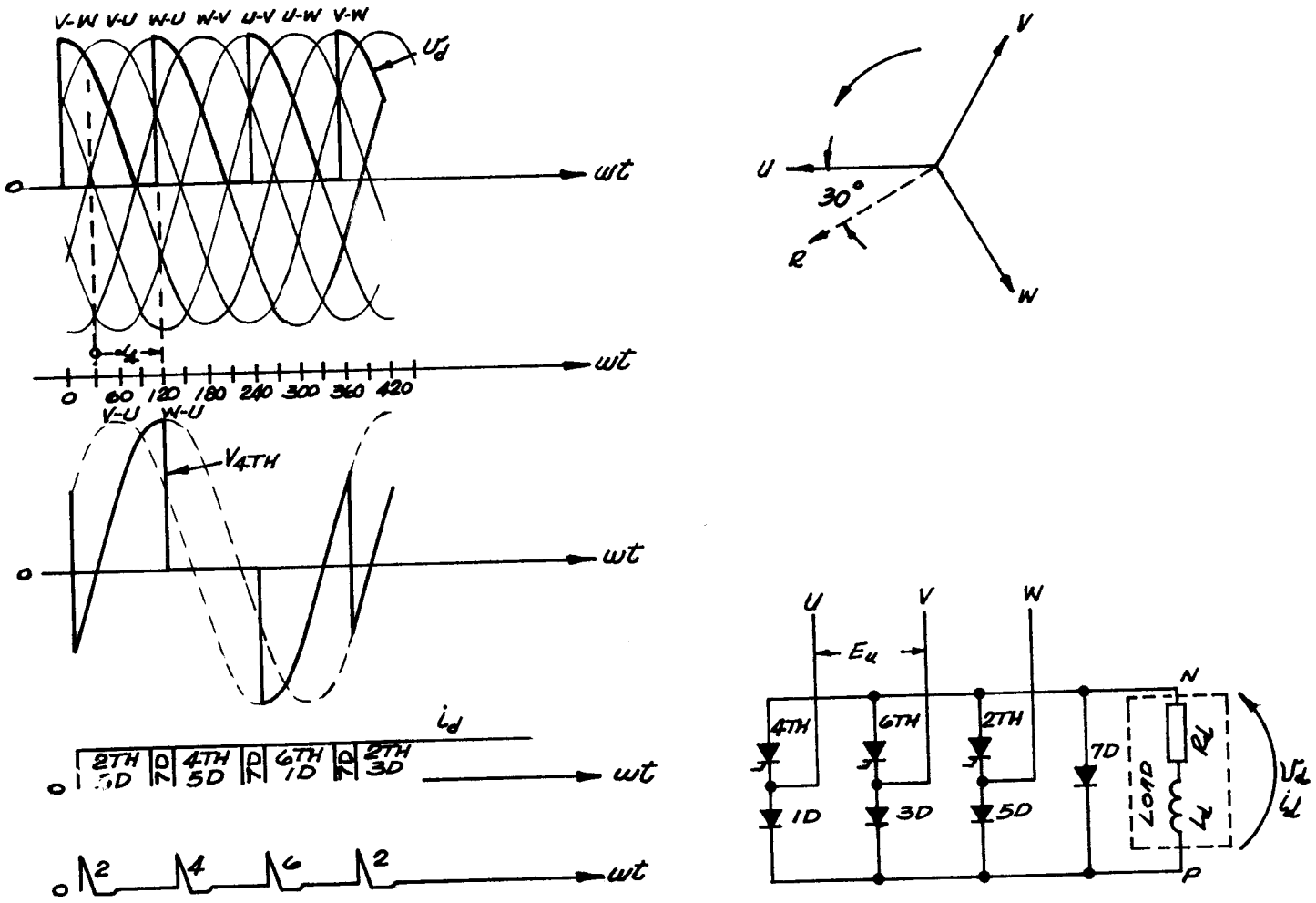

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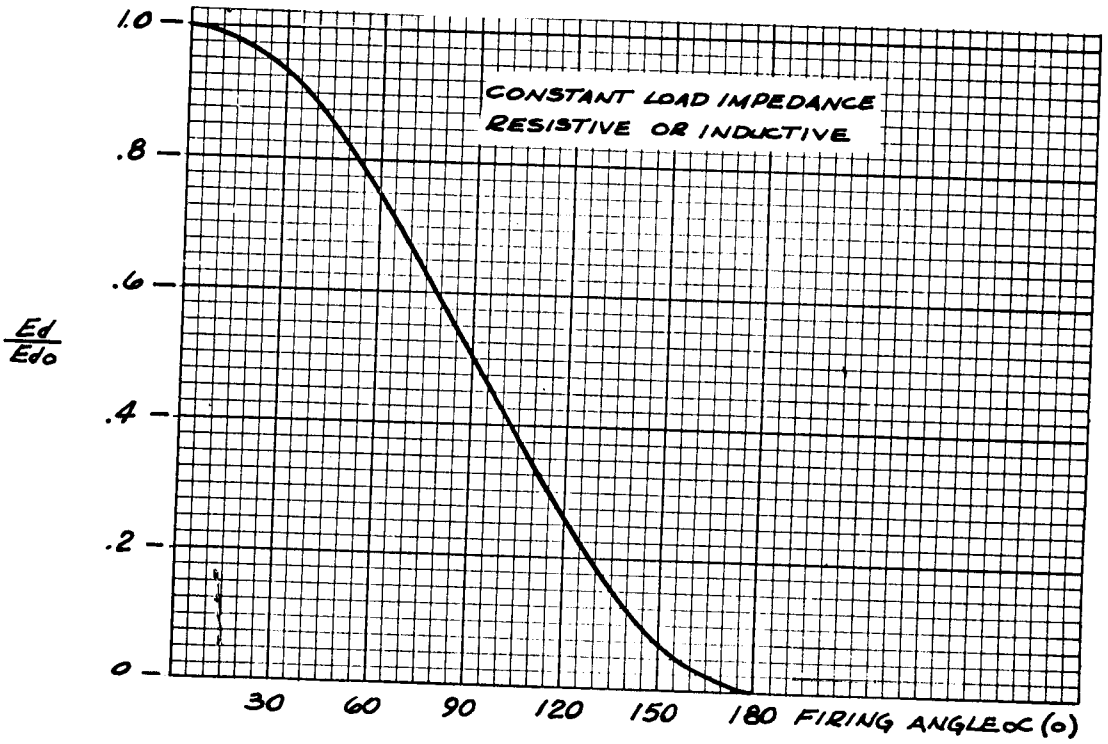

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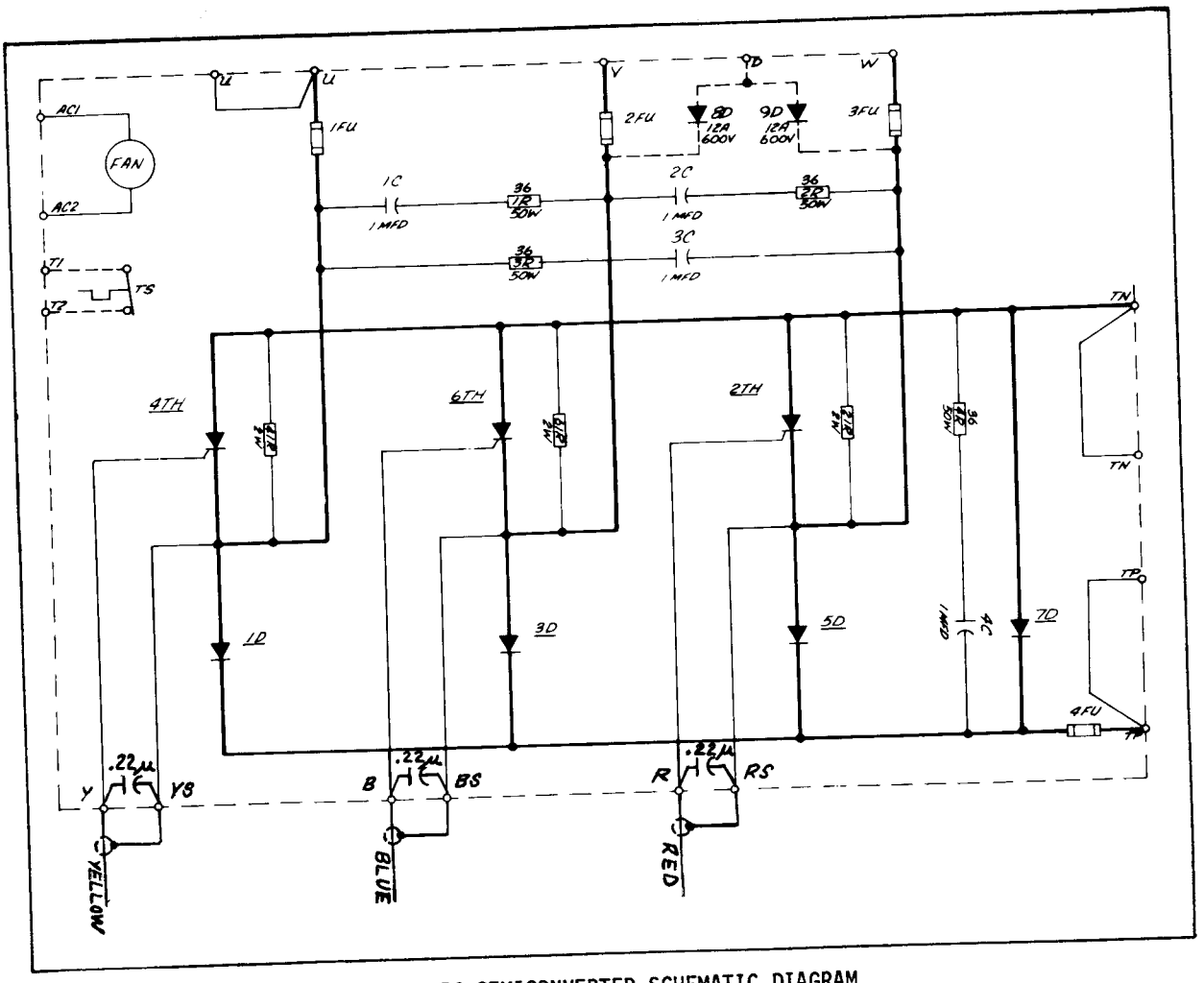

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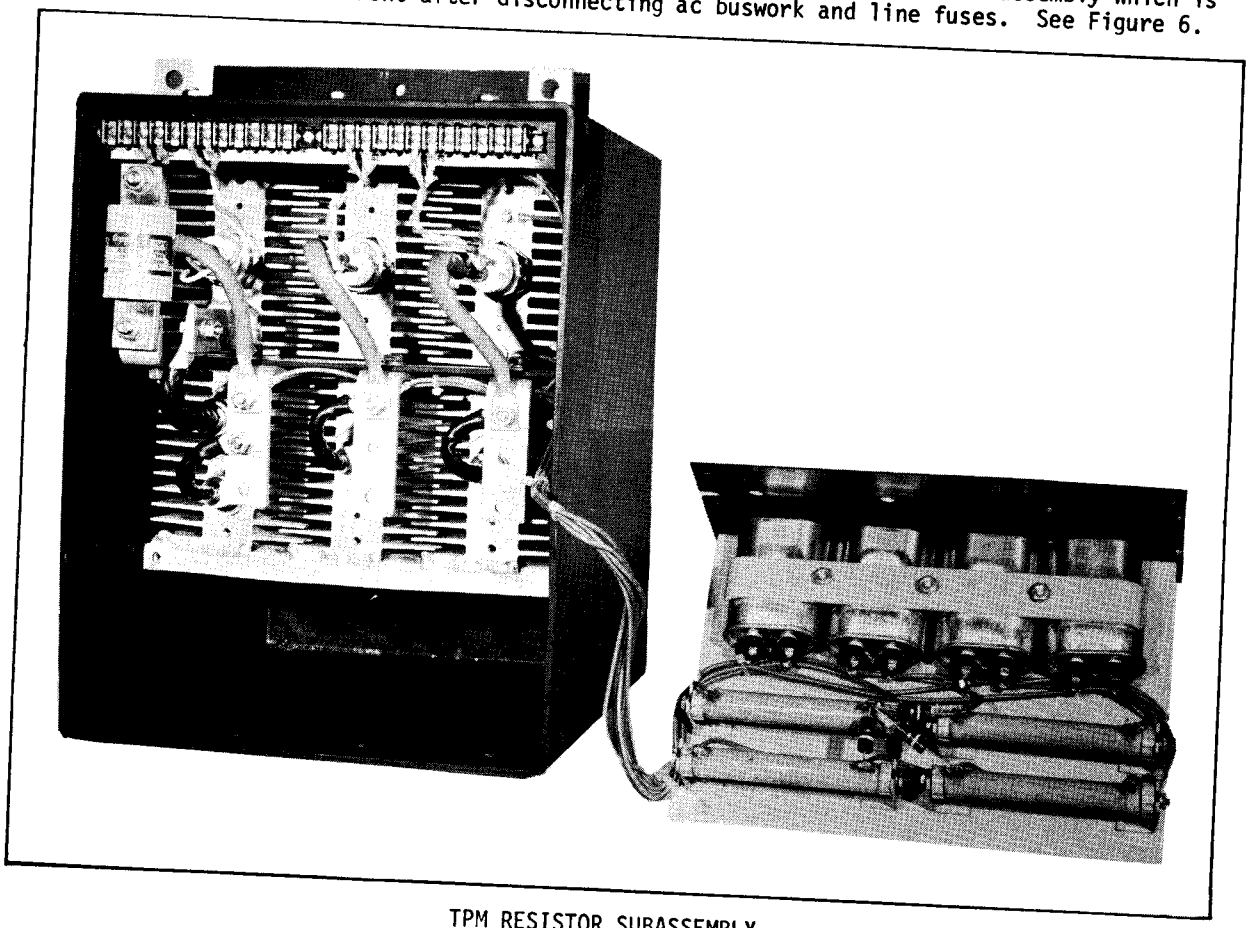

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