INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE MPR MOTOR PROTECTION RELAY

CAUTION

It is recommended that the user become acquainted with the information in this instruction leaflet before energizing the equipment. Failure to observe this precaution may result in damage to the equipment.

SOFTWARE CAUTION NOTICE

The operation of this relay is based on Westinghouse proprietary software, resident in memory components. Purchase of this relay includes a restricted license for the use of any and all programs solely as part of the protective functions. Westinghouse reserves the right to request return of the memory components should the relay no longer be used as a protective device. The programs may not be copied, transferred or applied to any other device.

APPLICATION

The MPR is a microprocessor-based programmable relay providing the following protective functions for 3-phase ac induction motors: Overload, Locked Rotor, Jam, Instantaneous Overcurrent, Instantaneous Ground Overcurrent, Phase Differential Current, Phase Unbalance, Phase Reversal, Loss of Load, Motor Winding Overtemperature, Motor Bearing Overtemperature, Load Bearing Overtemperature, and Load Case Overtemperature.

To sense motor currents and temperatures, the MPR relay receives inputs from phase ct's, ground ct, phase differential ct's and from resistance temperature detectors (RTD's). An Emergency Restart input is available to allow a restart of a hot motor.

The MPR relay provides a digital display of motor conditions, alarm and trip output relays, alarm and trip LED indications, field settable motor parameters, and alarm, trip and time delay values.

CONSTRUCTION

The MPR relay has a Display/Interface front panel which provides a vacuum fluorescent digital display, LED indicators and function pushbuttons to allow for monitoring motor conditions and for setting of relay operating parameters. It is protected by a plastic hinged cover. External inputs to the relay are made by connections to terminal blocks on the rear of the case.

Internally, the relay consists of four printed circuit modules. 1. Power Supply/Input-Output 2. Microprocessor 3. RTD 4. Differential/Restart. Connections are made between modules through plug-in cable assemblies. The Internal Wiring/Block Diagram is shown in Fig. 1.

The MPR relay is mounted in a semiflush case similar in size to an FT-32, for panel mounting. The outline and drilling plan is shown in Fig. 19.

Power Supply/Input-Output Module

The power supply/input-output (I/O) module consists of three individual circuits - the power supply, the current input circuit, and alarm and trip output relays. The power supply provides regulated 24 volts dc, a 2.6 volt square wave voltage for the digital display and 8 volts dc, regulated to 5 volts dc on the microprocessor module. These voltages are used to operate the IC's, provide RTD current and operate the output relays.

The current input circuitry consists of three separate phase current input transformers T2, T3, T4 and a ground current transformer T5.

Alarm outputs are provided by a 24 volt dc miniature high-power relay. Trip outputs are provided by a 24 volt dc magnetic latching relay with electric reset.

The power supply module has a double row header, pins 1 to 22, labeled J1 which connects via a cable assembly to the microprocessor module header, J1 pins 5 to 26. External inputs and outputs of the power supply/IO module are wired to terminal blocks JB (1 to 9) and JC (10 to 18) on the rear of the case.

Microprocessor Module

The microprocessor module is a four layer printed circuit board with the inner two layers being +5 volt dc power and ground. The main components of this module are the microprocessor, an erasable-programmable-read-only-memory (EPROM), and electrically-erasable-programmable-read-only-memory (EEPROM), a bipolar prom, CMOS RAM, an analog-to-digital (A/D) converter and a custom linear IC, along with analog switches, logic gates and display drivers. The components on the microprocessor module that make up the display/interface front panel are the seven segment digital display, 9 red light emitting diodes (LED) for alarm and trip indication, 4 yellow LED's for relay operating functions and 5 pushbutton switches.

The microprocessor module has 3 headers which via cable assemblies, connect to the Power Supply/IO, RTD and Differential/Restart modules.

RTD Module

The RTD module contains up to 11 Balun connected input transformers, 9 multiplexers (U2-U10), a voltage amplifier and 6 precision reference resistors.

The RTD module has an 11 pin single row header labeled J2 which connects via a cable assembly, to the microprocessor module header J2, pins 1 to 11. External inputs to the RTD module are made through the 36 connector terminal strip on the rear of the case.

Differential/Restart Module

The phase differential/emergency restart module consists of three differential current input transformers T1, T2, T3, as well as a logic interface optocoupler and related circuitry for the emergency restart function.

A 10 pin double row header labeled J1 connects the differential/restart module to the microprocessor module via a cable assembly. External phase differential and emergency restart inputs are wired to terminal block JA (19 to 24) on the rear of the case. Refer to the Internal Wiring/Block Diagram in Fig. 1.

THEORY OF OPERATION

Power Supply/Input-Output

The power supply provides regulated voltages to operate the integrated circuits, the trip and alarm relays and the fluorescent display, and to provide RTD current. Refer to the power supply internal schematic (Fig. 2). Component location for this module is shown in Figure 3. Rated power supply voltage, input through case terminals JC-13 and 14, is applied to chokes L3 and L4, full wave rectified and filtered to yield a supply voltage across C7. The pulse width modulated regulator U1 maintains +43V (+29V for 48V power supply styles) across C5. When Q4 is on, current flows through L2, charging up C5. Until C5 reaches +43V, no signal is output at U1 pin 12 to turn on Q3. With Q3 off current will continue to flow through R13, R14, L1, D3 and R15 to keep Q4 on. When the voltage across C5 reaches +43V a signal is output at U1, pin 12 to turn on Q3. Current then flows through Q3, and Q4 turns off.

The +43 volts maintained at C5 is input to the center tap of T1, a ferrite pot core transformer. An 11 kHz signal at U1 pin 3 turns on Q2 to pulse dual flip flop U2 driving Q5 and Q6 to provide a square wave at the primary of T1. The secondary voltages are a rectified ± 24 Vdc and +8 Vdc as well as a 2.6 volt square wave.

Phase currents IA, IB and IC are input through case terminals JB-1 to JB-6 to transformers T2, T3, and T4 located on the power supply/input-output module. These transformers have a 2 turn primary and a 3000 turn secondary to produce a 3.33 mA output for 5A input. Each phase current is full wave rectified and loaded with a 600 ohm burden resistor (R20, 21, 22). The magnitude of the current is output to the microprocessor module through J1-1,3,5 and the current sign (+ and − polarity) is output through J1-2,4,6.

For excessive overcurrent conditions, where current transformer saturations may occur, each phase current (exceeding 43V zener diode threshold Z4, Z5, Z6) is rectified and capacitor filtered by D22 and

C36. This auxiliary instantaneous overcurrent signal is output to the microprocessor module through J1-14.

Ground current is input through case terminals JB-7 and JB-8 to transformer T5 having a 5 turn primary and 3000 turn secondary. A positive full wave rectified signal of 4.05 VRMS nominal voltage is generated across R24 for 1 amp ground current. This signal is full wave rectified, filtered and output to the microprocessor module through J1-8.

Output contacts are provided by the dual coil magnetic latching trip relay K1. Trip outputs are at case terminals JC-15 to JC18. Alarm outputs at case terminals JB-9 and JC-10 to JC12 are provided by a miniature high power relay K2. Both relays are operated by +24 Vdc. Jumper pins JMP-1 to JMP-7 are provided to select contact arrangements. These have been set with jumpers in positions JMP-1, JMP-3, JMP-5 and JMP-7 to give two normally closed alarm contacts and two normally closed trip contacts.

RTD

The RTD module is designed to monitor up to 11 RTD inputs. Refer to RTD internal schematic Fig. 4. Component location for the RTD module is shown in Fig. 5. A fixed current (IRTD) is circulated through each RTD and each compensating lead. A voltage measurement is then taken across the RTD and compensating lead. By subtraction, lead resistance is corrected for and the resultant is a voltage that represents an accurate RTD temperature measurement. These voltage signals are multiplexed by U2, U5, U7 and U9, amplified by U1 and output to the microprocessor module through J2-1. U4 switches chip-select signals CS1 to CS4. The microprocessor provides digital control signals A to E at J2-4 to J2-8.

The gain of U1 is controlled by a gain signal from the microprocessor module at J2-2. RA to RF are reference resistors used to provide reference temperature information to the processor. Metal oxide varistors (MOV) connected to each input provide voltage surge suppression.

Differential/Restart

Phase differential currents I_A DIFF, I_B DIFF and I_CDIFF are input through case terminals JA-19 to JA-22 (JA-19 to JA-24 for relays without emergency restart), to transformers T3, T2 and T1. Refer to the phase differential internal schematic (Figs. 6 and 8). Component location is shown in Figs. 7 and 9. Each transformer has a 5 turn primary and 3000 turn secondary. Each signal is full wave rectified, filtered and output to the microprocessor module through J1-7, 8, 10 (J1-1 to J1-4 for relays without emergency restart).

Emergency restart is activated by momentarily applying the rated power supply voltage to case terminals JA-23 and 24 on relays with the emergency restart function. A 3-position jumper located on the Differential/Restart module is provided to select emergency restart input voltage. This jumper has been set to the power supply voltage rating of the MPR. Optocoupler U1 rectifies this signal and provides isolation from the microprocessor. A pulse signal at U1, pin 6 is output to the microprocessor module at J1-3.

Microprocessor

The primary circuitry of the microprocessor module consists of the 8-bit microprocessor (U1), a custom linear IC (U7) and a 4-channel A/D (analog to digital) converter (U12). The processor is supported by an EPROM (U3), EEPROM (U6), an external RAM (U5) and a bipolar PROM (U4). A processing speed of 12 MHz is set by crystal Y1. Refer to the microprocessor internal schematic Fig. 10. Component location is shown in Fig. 11.

The 8-bit microprocessor utilizes 3 ports for transferring of data and address information. Lines AD0 to AD15 are address bus lines. AD0 to AD7 also function as a data bus. Port P10 to P17 is an input port to service the data output of the A/D converter (U12).

The custom linear IC (U7) performs four functions: 1. Multiplexing 2. Gain control 3. Voltage regulation. 4. Processor reset. This IC contains a 4-channel multiplexer to control input of the phase and instantaneous current signals. Multiplexing signals are input at S1 and S2. The current signals are then multiplied by the appropriate gain of 1, 1/2, 1/4, or 1/16, controlled by inputs at R1 and R2. Truth tables for multiplexing and gain are shown in Tables 1 and 2. Current is then output at U7, pin 15. This level is trimmed by potentiometer P1 and input to the A/D (U12, pin 3). The custom linear IC is also used to regulate the +5 Vdc supply voltage. Finally, this IC will send out a reset signal (U7, pin 12) should the processor fail to generate the square wave input signal at RESTART (U7, pin 11).

Table 1

S1	S2	Input
0	0	A
0	1	B
1	0	C
1	1	G

Table 2

R1	R2	Gain
0	0	1
0	1	1/2
1	1	1/4
1	0	1/16

Motor parameters and alarm, trip and time delay values are written to the non-volatile EEPROM during the setting procedure. These settings are displayed as each one is being entered or changed. The EEPROM also stores trip LED target indication. If power is lost to the relay, these settings and LED target indications are stored in the EEPROM and are recalled on power up of the relay.

Phase currents are input to the microprocessor module at J1-5, 7 and 9. The sign (polarity) of the phase current is input at J1-6. 8 and 10. The microprocessor samples each phase current along with phase current sign 3 times each cycle. After a 12 cycle period (36 samples), I^2RMS is generated for each positive and negative sequence phase current. $I_H{}^2$is calculated as follows:

$$I_H{}^2 = I_1{}^2 + KI_2{}^2$$

I_1 = positive sequence component of the three-phase input currents (RMS).

I_2 = negative sequence component of the three-phase input currents (RMS).

K = weighting factor for negative sequence heating.

I_H is used for overload/overtemperature, locked rotor/jam and load loss protection functions. Positive and negative sequence currents are used in phase unbalance protection. Phase reversal protection is accomplished by examining the sequence of the 3 current phases. If a sequence other than ABC is detected (twice, for security) immediate tripping occurs.

Ground current is input to the microprocessor module at J1-12 and phase differential currents at J1-1, 2 and 3. The microprocessor samples these currents 3 times each cycle. A 2 cycle average is calculated each cycle to provide alarm and tripping functions.

For each protection function associated with a time delay, the current signal is compared to the trip and alarm settings. If the current is greater than the setting, a counter is incremented. This process continues until the counter has reached a value associated with the time delay setting, causing the relay to then alarm and trip. Loss of phase and phase unbalance protections are delayed on motor starting, based on the 1 to 10 second jam delay time setting. During running conditions, loss of phase and phase unbalance follow the time curves. Jam and load loss are delay inhibited by 2 times the locked rotor delay time setting.

The emergency restart signal is input to the microprocessor module at J3-1. When emergency restart has been activated the I^2t value of motor heating in memory is reset from a "tripped condition" level to a "hot motor" level. This will reset the trip relay, the trip LED and value display and allow the motor to be restarted as a "hot" start.

The microprocessor module interfaces with the RTD module through cable connections J2. A fixed current (IRTD) at J2-3 is output to the RTD module, multiplexed, then circulated through each RTD and its leads. The voltage drops across the RTD and across the leads are input to the microprocessor module as VRTD at J2-1. Digital multiplexing signals (J2-4 to J2-8) switch these RTD currents and voltages. The processor calculates temperature based on VRTD. Transistors Q3 to Q6 and U26A generate IRTD based on high and low signals "One" and "Two" at U22.

U26B, Q8 and Q9 and precision resistors R60-63 are used to maintain the voltage level VRTD between 0.5 Vdc and 4.5 Vdc for input to the A/D (U12, pin 5). Signal "Three" at U22 and Q7, output to the RTD module at J2-2, provides amplifier gain for VRTD. A low signal is used for 10 ohm copper RTD's. A high signal is used with nickel and platinum RTD's.

The display/interface circuitry on the microprocessor module consists of a 9 character 7 segment vacuum fluorescent display, 9 indicating LED's, 4 relay operating function LED's and 5 user operated pushbutton switches. The display DS1 is driven by two display drivers (U16, U17). Display data is transferred from the microprocessor via DISPDAT, DISPSK, FUNCTCS and VALUECS. Pushbutton status information is loaded to the data bus via an octal bus driver U15. Alarm and trip LED data is fed to octal latches U18 and U19. The LED's (DS2 to DS16) are driven by line drivers U20 and U21.

CHARACTERISTICS

Rated current:	1A, 5A
Maximum current	
continuous:	10A
two seconds:	200A
Frequency:	50/60 Hz
Power supply voltage:	120 Vac (70-132 Vac) 125 Vdc (93.5-144 Vdc) 48 Vdc (38.5-52.8 Vdc) 250 Vdc (187-288 Vdc)
Burden	
Phase current ct's:	.075 VA @ 5A
Ground & Phase differential ct's:	.010 VA @ 1A
Power supply:	25 VA max.
Temperature range:	−20 to +55° C (ANSI C37.90)
Accuracy:	+ 10% timing variation ± 5% pickup level
RTD Types:	10 ohm copper 100 ohm nickel 120 ohm nickel 100 ohm platinum
RTD Temperature (10 to 190°C)	
Accuracy:	±3° C
Contact Data	
Trip (2 form C):	30A make and carry, 1 sec. 7.5A interrupting, 120 Vac resistive
Alarm (2 from C):	5A interrupting, 120 Vac resistive
Insulation Test Voltage:	1.5 kV, 50/60 Hz, 1 minute (ANSI C37.90)
Impulse Voltage Withstand:	5 kV peak, 1.2/50 us, 0.5 joule (IEC 255-5)
Fast Transient Voltage:	5 kV, 10/100 ns (Proposed ANSI C37.90a)
SWC:	ANSI C37.90 (1978), IEC 255.5

Time Curves

Figures 12 to 15 show MPR typical time curve characteristics. Fig. 12 represents the MPR relay utilizing RTD cold start overtemperature protection with the RTD's at a constant ambient temperature of 55°C. Locked rotor delay time is set at 6 times full load current. Each curve represents trip characteristics for various locked rotor delay times from 5 to 30 seconds. The lower three curves show the MPR's ability to track over a varied temperature range by calculating I_H based on current and RTD inputs.

Time curves with RTD protection representing a hot start are shown in Fig. 13. RTD's are set at a constant 120°C and locked rotor at 6 times full load current. Locked rotor delay time is varied from 5 to 30 seconds. Protection is provided for restarts in the hot condition by correctly producing shorter trip times.

Figures 14 and 15 illustrate tripping characteristics for overload without RTD protection. Again locked rotor is set to 6 times full load current and locked rotor delay is varied from 5 to 45 seconds. The MPR produces trip times based on I_H for both cold start and hot restart conditions. To allow the MPR to reach a hot start condition, full load current is applied for a time greater than one half of I^2t seconds, where I is the multiple of full load current and t is the locked rotor delay time. The curves in Fig. 15 reflect a shorter tripping time to protect the motor under hot restarting conditions.

On removal of current after a trip occurs the MPR relay algorithm allows for rotor cooling before restart, based on the locked rotor current and time delay settings. Relays with emergency restart can override the cooling time and reset the I^2t memory to a hot motor level. The relay will then follow the time curves for a hot start, shown in Figures 13 and 15. Minimum overload trip is set to 190% of full load current when RTD protection is provided. For protection without the additional RTD temperature information the overload trip setting is typically 125%.

FUNCTIONS AND SETTINGS

The MPR relay is designed to protect a motor by sensing any one or a combination of operating conditions in a range where damage and/or reduced operating life may result. The following sections detail the protection functions available, the protection concept involved and the operating conditions that each function considers.

Overload — Without RTD's

Measurement of overload where RTD's are not available is accomplished by using the expression $I_H^2 = I_1^2 + KI_2^2$, where I_1, is the positive sequence component of the three phase input currents, I_2 is the negative sequence component and K is a weighting factor to accommodate the increased influence on heating produced by negative sequence current. The relay is given a locked rotor (full voltage) current setting and a "cold" permissible locked rotor time setting. This establishes a point on the I_H^2t curve (Figure 14). This is an inverse squared curve with a cutoff at the pickup level setting. The motor is protected for all currents, from moderate overload to locked rotor levels, assuming the ambient and ventilating conditions are in accordance with the design limits.

Overtemperature — With RTD's

Temperature conditions may be examined in a more refined way when RTD's are available. The MPR relay monitors up to 6 winding RTD's. The RTD is located between windings in the motor stator slot, and is therefore subjected to all of the same influences of heating as the stator insulation, including ambient and ventilation. The RTD has an appreciable deviation from winding temperature when the motor is subjected to a large change in current, such as during starting or upon a jam occurrence. The RTD is also a poor indicator of rotor temperature. Because of these limitations, I_H sensing is also required to complement the RTD behavior.

Excessive temperature of the RTD will cause tripping without additional time delay. Time delay is inherent in the increase in temperature of the motor itself. For large currents in excess of the I_H pickup setting, the need for tripping is sensed by a combination of RTD and current influences. Effective rotor temperature is calculated by this means.

Locked Rotor — Without RTD's

Locked rotor current value (as a multiple of full load current) and locked rotor delay time are settings that are provided as inputs to the MPR relay. A "cold" motor is identified through a retention of information regarding previous loading. "Hot" is identified by whether or not the motor has recently been running. It is assumed to be running if current in excess of 20% of full load current is present for a time in excess of twice the locked rotor delay setting. The MPR trip characteristic will remain in the "hot" condition following reduction of current to zero for a period determined by the time constant which is calculated from locked rotor current and time. With terminal voltage at values different from rated, locked rotor current will vary accordingly. The shape of the I_H time curve is such that the actual trip time varies with I_H in the same way as permissible locked rotor time varies with I_H. The reduction in trip time for a "hot" motor is influenced by the calculated time constant.

Locked Rotor — With RTD's

An approximation of rotor temperature is calculated based on RTD temperature (to indicate previous loading history) and on I_H level. The trip time at a given value of current will be modified by the relay so that the total temperature of the limiting element in the rotor circuit will be essentially the same as for a "cold" start trip.

Jam

A sudden large increase in current after the motor is running is indicative of a jam condition on the motor. A jam is sensed when the magnitude of I_H is above the load jam trip setting.

Instantaneous Overcurrent

Detection of faults is achieved by the measurement of individual phase current levels. When the highest phase current magnitude exceeds the instantaneous overcurrent trip level setting for a period of time in excess of the instantaneous overcurrent delay setting, immediate tripping and indication will occur. This function is set, with margin, to allow for maximum locked rotor current with dc offset. Any current in excess of this setting is clearly fault current, contributed by the power system, and not starting current, not jam current nor contribution from the motor to a fault elsewhere in the system. The relay is designed to trip correctly on high fault currents even with saturated ct's.

Ground Overcurrent

Motors are generally ungrounded. By using a "through-type" ct (such as the BYZ-S 50:5) with all three phase conductors routed through it, sensitive detection of ground faults in the motor or motor supply cables can be obtained by measuring the ct secondary current. The ground fault trip current and ground fault trip delay are selectable. This delay is necessary to override such phenomenon as discharge and energization of surge protective capacitors that are often connected from phase-to-ground at the motor terminals.

Phase Differential

Additional protection for motor windings is provided by sensing the current from 3 ct's connected to measure the differential current in each winding.

Load Loss

A sudden decrease in current is indicative of a loss of load (shaft breakage or a driven load problem). If the motor is running, load loss is sensed by a drop in the magnitude of I_H below the load loss setting and remaining there for a period greater than the load loss delay setting. After this delay a trip signal is generated and load loss is indicated. Reduction of current to less than 20% of full load current is recognized as removal of the motor from the line and no tripping or indication will occur.

Phase Reversal

Phase reversal protection is based on the examination of the sequence of the three phase currents. If a reversed phase sequence occurs twice, phase reversal has been detected and an immediate trip is generated. This protection function is disabled if the motor is to be run with phases reversed by entering a setting of 9999.

Phase Unbalance

Unbalanced phase currents contain I_2 (negative sequence components). Abnormal I_2 is an alarm condition. Excessive heating caused by I_2 produces a phase unbalance trip.

Loss of phase represents an extreme case of phase unbalance. Loss of phase is identified when I_2 is very nearly equal to I_1.

Motor Bearing, Load Bearing & Load Case RTD's

The MPR relay monitors up to 2 motor bearing RTD's, 2 load bearing RTD's and 1 load case RTD.

When the resistance measured represents a temperature greater than the selected setting, trip and indication occur. Alarm settings are also selectable.

Alarm

When a protective function senses a current or temperature that has reached a preset alarm value, then an alarm condition exists. The corresponding LED will flash and the normally energized alarm relay will be de-energized and drop out. These alarm indications will exist only as long as the alarm values of current or temperature exist.

The MPR relay also has its own self-alarming indications. If the power supply voltage is lost, the "Power On" LED turns off and the alarm relay drops out. If the microprocessor stops functioning, the "Monitor On" LED which is normally flashing during relay operation, will stop flashing and remain either constant "off" or constant "on". The alarm relay will then drop out.

Trip

When a protective function senses a current or temperature that has reached a preset trip value for the preset delay time then a trip condition exists. The corresponding LED will turn on and the trip relay will pick up. The value of current or temperature at the time the relay tripped will remain in the VALUE display after the trip condition no longer exists. Pushing the reset button will return the VALUE display to show the present motor operating values. In trip mode 1, the LED will remain on and the trip relay sealed in for all trip conditions, until manually reset. The trip relay is sealed in for all conditions except winding RTD overtemperature in mode 2. There is no trip seal-in for mode 3.

When sealed-in, the LED and trip relay can be reset after a time determined by the motor cooling algorithm, which is based on the overcurrent and/or overtemperature conditions at the time of trip, the locked rotor trip setting, locked rotor time delay settings, and previous loading conditions. Initiating emergency restart will override the cooling algorithm to reset the I^2t memory to "hot" motor level. The trip relay, trip LED and VALUE display will also be reset.

If power supply voltage is lost, the trip LED will be stored in memory and will indicate on return of power supply voltage. If the power is not restored and the trip relay is sealed in, it may be manually reset. The armature of the trip relay can be pushed open by inserting a suitable size screwdriver through the hole on top of the MPR relay case.

Error Message

If a condition exists where one or more RTD's become shorted or open, then the VALUE display will flash an error message "EEEE". The two digit number that appears in the FUNCTION display is the number of the RTD that is shorted or open, not a function number. To disable the error message, simultaneously press the RAISE and LOWER buttons. Error messages will continue to flash for each shorted or open RTD until all error messages have been disabled. When disabling more than one error message, wait for the next error message to flash on and off before pressing the RAISE and LOWER buttons again.

If the power supply voltage is removed after disabling the error messages then reapplied the error messages will be reactivated and will have to be disabled again. This will provide a warning that a malfunctioning RTD still exists.

The relay will continue to monitor, alarm and trip for any RTD's which are still functioning and for all other MPR functions both before and after the error messages are disabled.

After the error message has been disabled and the RTD malfunction has been corrected the MPR relay must be reset in order to again monitor that RTD. This can be done by either removing then re-applying power to the relay, or by resetting the applicable RTD function (20,21,22,23) using the Setting Procedure.

Display Procedures

One of the functions of the Display/Interface front panel allows the user to read motor operating values. Motor operating values that can be viewed in the VALUE display are shown in Table 3 (functions 00 to 19). These values should be used as indicator quantities and not in place of ammeters or other standard instruments. The following procedure will display the present motor operating values for a given function.

1. Determine the function number of the parameter to be displayed.

2. Press the SELECT button. The LED below the button will turn on and the relay will be in the FUNCTION SELECT mode.

3. Press the RAISE or LOWER buttons to increment the FUNCTION display up or down 1 digit. Holding the RAISE or LOWER buttons down will cause the display to change to a fast mode. Only those functions available in a given style relay will be displayed. Functions not available will be bypassed.

4. When a function is selected, the VALUE display will show the present operating value after an approximate 1 to 3 second delay. When the SELECT button is pressed again the SELECT LED will turn off and the relay will be in a stand-by mode.

Setting Procedure

The Display/Interface front panel allows the user to set motor characteristics and alarm, trip and delay time values for the parameters shown in Table 4 (functions 20 to 56). The following is the procedure for programming settings into the MPR relay.

1. Press the SELECT button. The SELECT LED will turn on.

2. Press the RAISE or LOWER button until the desired FUNCTION number appears in the FUNCTION display. Functions not available will be bypassed.

3. The VALUE display will show the existing setting of the FUNCTION selected.

4. To enter or change the reading press the SET button. The SET LED will turn on and the SELECT LED will turn off.

5. Use the RAISE or LOWER button to choose the desired value to be entered. The relay is programmed so that an invalid setting may not be entered.

6. When the desired reading is shown, press the SET button and "0000" will appear in the VALUE display.

7. Press the SET button again and the setting chosen will appear. Now press and *hold* the SET button until the SET LED turns off and the SELECT LED turns on.

The new setting is now in memory and will be read out on the VALUE display. All settings remain in memory during loss of power supply voltage to the relay. When setting Type and Quantity of RTD's (functions 20 to 23), the VALUE display will return to function 00 after step 7 and the new setting will be in memory.

Note that when setting type and quantity of RTD's, RTD's or substitute resistors should be connected to the terminals per the external connection diagram (Fig. 18) or the test connection diagrams (Figs. 16 and 17). If not, the VALUE display will flash "EEEE". Refer to "Error Message" described previously.

Alarm and trip functions may be disabled by entering 9999 as the setting for those functions. Locked Rotor Overcurrent Trip (function 28) and Overload Trip (function 32) cannot be disabled. RTD's can be disabled by entering "0" into functions 20 to 23 or by entering an RTD quantity of zero for any given type of RTD. For example "30" is zero quantity of 120 ohm nickel type RTD's

FUNCTION	VALUE DISPLAY	UNITS
00	Load Current - Phase A	% FLC
01	Phase A Current	Amps
02	Phase B Current	Amps
03	Phase C Current	Amps
04	Max RTD Temp	°C
05	RTD 1 Winding Temp	°C
06	RTD 2 Winding Temp	°C
07	RTD 3 Winding Temp	°C
08	RTD 4 Winding Temp	°C
09	RTD 5 Winding Temp	°C
10	RTD 6 Winding Temp	°C
11	RTD 7 Motor Bearing Temp	°C
12	RTD 8 Motor Bearing Temp	°C
13	RTD 9 Load Bearing Temp	°C
14	RTD 10 Load Bearing Temp	°C
15	RTD 11 Load Case Temp	°C
16	Ground Fault Current	% Trip
17	Phase A Diff Current	% Trip
18	Phase B Diff Current	% Trip
19	Phase C Diff Current	% Trip

TABLE 3

FUNCTION	DATA	SET POINT	UNITS
20	Type & Qty of Winding RTD's	0 to 46	Number
21	Type & Qty of Motor Bearing RTD's	0 to 42	Number
22	Type & Qty of Load Bearing RTD's	0 to 42	Number
23	Type & Qty of Load Case RTD	0 to 41	Number
24	Motor Factor K	2 to 10	Number
25	CT Ratio	2 to 800	Ratio
26	Primary Full Load Current	1 to 9999	Amps
27	Frequency of Motor Current	50 or 60	Hertz
FUNCTION	**TRIPS AND TIME DELAY**	**SET POINT**	**UNITS**
28	Locked Rotor Current Trip	3 to 12	X FLC
29	Locked Rotor Delay	1 to 99	Sec
30	Inst Overcurrent Trip	3 to 15	X FLC
31	Inst Overcurrent Delay	0.04 to 0.2	Sec
32	Overload Trip	100 to 190	% FLC
33	RTD Winding Temp Trip	10 to 190	°C
34	RTD Motor Bearing Temp Trip	10 to 190	°C
35	RTD Load Bearing Temp Trip	10 to 190	°C
36	RTD Load Case Temp Trip	10 to 190	°C
37	Phase Reversal Trip	1	—
38	Ground Fault Trip	0.1 to 1.0	Amps
39	Ground Fault Delay	0.1 to 1.0	Sec
40	Load Loss Trip	20 to 95	% FLC
41	Load Loss Delay	1 to 16	Sec
42	Phase Diff Trip	0.1 to 1.0	Amps
43	Phase Diff Delay	0.04 to 0.2	Sec
44	Load Jam Trip	0.7 to 12.0	X FLC
45	Load Jam Delay	1 to 10	Sec
FUNCTION	**ALARMS AND ALARM DELAY**	**SET POINT**	**UNITS**
46	Winding Temp	2 to 20	°C Below Trip
47	Motor Bearing Temp	2 to 20	°C Below Trip
48	Load Bearing Temp	2 to 20	°C Below Trip
49	Load Case Temp	2 to 20	°C Below Trip
50	Phase Unbalance	5 to 30	I_2 % of I_1
51	Ground Fault	30 to 100	% Trip
52	Load Loss	20 to 95	% FLC
53	Load Loss Alarm Delay	1 to 16	Sec
54	Phase Diff	30 to 100	% Trip
FUNCTION	**FEATURES**	**SET POINT**	
56	Reset Mode Selection	1 to 3	

TABLE 4

FUNCTIONS 20-23 — A two digit setting is chosen to identify the type and quantity of RTD (resistance temperature detectors) in use for a particular function. All RTDIs for a given function must be of the same type. The first digit identifies the type as follows:

1 - 10 ohm copper

2 - 100 ohm nickel

3 - 120 ohm nickel

4 - 100 platinum

The second digit identifies the number of RTD's in use. A setting, for example, of 26 would represent 100 ohm nickel with a quantity of 6 RTD's.

FUNCTION 24 — The K factor in $I_1^2 + KI_2^2$ provides a weighting influence for negative sequence current heating compared to that for positive sequence. Using ANSI/NEMA MG 1-1978, MG 1-14.34, K can be estimated conservatively: $K = 230/(I_{LR})^2$. For a motor having a per unit locked rotor current I_{LR} of 6, $K = 230/(6)^2 = 6.39$. The setting on the MPR for function 24 would be 7.0. When more explicit heating data is available on the particular motor being protected, a different value may be selected.

FUNCTION 25 — The ct ratio is entered directly. For example a 200:5 ct would require any entry of 40, A 200:1 ct would require an entry of 200.

FUNCTION 26 — The motor rated load amperes are entered.

FUNCTION 27 — Enter the appropriate frequency for the application. Either 50 or 60 hertz will be accepted.

FUNCTION 28 — Locked rotor current is entered as a multiple of full load current. In the absence of a specific, full voltage locked rotor value, an estimate of the value may be obtained from the code letter on the nameplate (See MG 1-10.36). For example, code letter G corresponds to 5.6-6.3 KVA per horsepower. The setting would be chosen in this case to be 6, the nearest even multiple.

FUNCTION 29 — Locked rotor delay is the maximum permissible time in seconds, with full voltage applied and the rotor unable to rotate. This time, in conjunction with FUNCTION 28, establishes the motor heating curve.

FUNCTION 30 — Instantaneous overcurrent trip setting is selected as a multiple of full load current. This value must be set to ignore maximum locked rotor current, including the effect of the maximum dc offset. This requires a setting of 1.5 times the maximum symmetrical locked rotor current. For the example of FUNCTION 28, a value of $1.5 \times 6.3 = 9.45$ is required. Enter a setting of 10.

FUNCTION 31 — Occasionally a delay is necessary in tripping with the "instantaneous" unit to avoid possible misoperation due to such phenomenon as surge protective capacitor inrush. A setting of 0.04 seconds will usually suffice.

FUNCTION 32 — Overload trip is selectable from 100 to 190 percent of full load current. This is the level of current above which time delay tripping occurs. Other elements, such as instantaneous trip or jam, may cause faster tripping. In general, it would be set at 105 to 115% of full load current where RTD's are not available and at 190% where they are available.

FUNCTION 33-36 — The trip temperature is dependent on the temperature class of the particular motor insulation or expected operating temperature of bearings or case. See ANSI/NEMA MG 1-20.40 for insulation limitations. A motor rated over 1500 HP and less than 7000 volts with class B insulation may use a setting of 125 °C for the winding RTD trip level. Knowledge of the normal bearing or casing operating temperature may be used to select a trip temperature for these functions. The same level is applicable to all RTD's in a group. The groups are winding, motor bearing, load bearing and load case. Each group requires a setting, when RTD's are used, and each group may be set independently.

FUNCTION 37 — Phase reversal trip is not dependent on a level setting. It is made operative by entering 1. To disable phase reversal trip and allow reversal of motor rotation, enter 9999.

FUNCTION 38 — Ground fault trip is generally set at its lowest value, 0.1 amp, when it is supplied by a "doughnut" type ct. Where this type ct is not available, the "residual" return circuit for the phase ct's may be used to supply this circuit. A setting as high as 1.0 amp may be required to override the residual error current where this alternative arrangement is used.

FUNCTION 39 — A ground fault delay setting of 0.1 second will usually suffice to override those phenomenon which must be ignored where a "doughnut" ct scheme is used. A much longer setting, up to 1.0 second, may be required where the "residual" circuit supplies the ground current.

FUNCTION 40 — Load loss trip setting must be set below the lowest load level expected and below the alarm level set in Function 52. A minimum load level of 80% would allow an alarm level setting of 75% and a load loss trip level setting of 70%. Sudden reduction to a current level less than 20% of full load signifies removal of the motor from the line by other means, (such as a manual trip) and no alarm or trip action takes place.

FUNCTION 41 — Reduction of load below the load loss trip level for a period of time in excess of the load loss delay will cause tripping and "Load Loss" indication. A load loss delay of 1.0 second will usually suffice.

FUNCTION 42 — Phase differential trip may be set at 0.1 amperes, provided any surge protective capacitors are outside the protected zone.

FUNCTION 43 — Phase differential trip delay may generally be set to 0.04 seconds. Longer time delays up to 0.2 seconds may be required.

FUNCTION 44 — Following the presence of current greater than 20% of full load current, for a time in excess of two times the locked rotor delay that was set in Function 29, a sudden overcurrent will cause "Load Jam". A typical jam setting is 1.5 times full load but may be increased to 3.0 or more where RTD's are supplied.

FUNCTION 45 — The motor will contribute to a fault on the supply system and this current can approach locked rotor value. To avoid misoperation, the jam delay setting must be set to override this fault contribution. Generally, a setting of 10 seconds will suffice.

FUNCTIONS 46-49 — This alarm level (°C below trip) will serve to warn an operator of impending shutdown. A setting of 5 will generally be satisfactory for each of these functions.

FUNCTION 50 — The lowest setting compatible with normal unbalance conditions should be used. A setting of 5% will nominally be useable. A negative sequence current in excess of 5% of the positive sequence current will cause the alarm relay to dropout. A trip caused by excessive $I_1^2 + KI_2^2$, that is accompanied by a phase unbalance alarm will indicate "Phase Unbalance" only.

FUNCTION 51 — Any secondary ground current flow when the "doughnut" ct scheme is applied is abnormal and may be used to sense that a more serious problem is impending. A setting of 30% of the trip value may be used.

FUNCTION 52 — The load loss alarm must be set below the lowest expected load level and above the trip level of Function 40. This function will either be set at 5% below the minimum load level or will be disabled by setting 9999.

FUNCTION 53 — A load loss alarm delay setting of 1.0 second will usually be adequate.

FUNCTION 54 — The phase differential scheme uses "doughnut" ct's to sense the sum of current in and out of individual phase windings of the motor. These ct's will, under normal conditions have no secondary current flow. An alarm setting of 30% (of trip setting) will be useable, provided any surge protective equipment is outside the protected zone.

FUNCTION 55 — not used.

FUNCTION 56 — Tripping Mode Operation is selected by a number as outlined below:

1. Trip output and indication sealed in until reset. This is the factory set condition. This setting should be selected when "three-wire" ac control is used and automatic restart is not desired.

2. Trip is sealed in for all conditions except winding RTD overtemperature. An overtemperature trip will remain operative only as long as any winding RTD temperature is above the set point. All other trip conditions will seal in. This setting is used with "two-wire" ac control when automatic restart can be accomplished safely.

3. No trip seal-in. All trip signals will be maintained only as long as a trip condition exists. This setting is selected when a switchgear type motor controller is used.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, corrosive fumes and heat. The maximum temperature outside the relay case should not exceed +55°C for normal operation.

Mount the relay vertically by means of the four mounting studs on the flanges. The mounting studs may be utilized for grounding the relay. External toothed washers are provided for use in the locations shown on the outline and drilling plan to facilitate making a good electrical connection be tween the relay case, its mounting studs and the relay panel. See Fig. 19 for the outline and drilling plan.

NOTE: All of the RTD's must be three wire devices having two excitation leads and one compensating lead. The excitation lead, connected with the compensated lead at the RTD, must be terminated to chassis ground at the MPR RTD terminal strip, not at the motor. These leads may or may not be tied together at the motor. Refer to Fig. 18, External Connection Diagram.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of the relay have been made at the factory. Upon receipt of the relay, no further adjustments other than those covered under "SETTINGS" should be required.

Acceptance Test

The following acceptance test is recommended to insure that the relay is in proper working order. All test values in this procedure are relative to each function parameter as it was set at the factory. Refer to Table 5, Function Test Settings. Settings other than those shown in Table 5 may result in test values different from those listed in the following procedure. Functions not applicable to a given style relay will not appear in the display and the procedures should be bypassed.

1. Refer to Figs. 16 or 17, Test Connection Diagram. Connect a 0 to 25 amp balanced three-phase current source to the phase current inputs. Connect the phase differential and ground inputs to a single phase current source. Using a .050 to 50 second timer, connect "stop" to the output trip relay contacts, case terminals 15-16, and connect "start" to a switch controlling the current sources. The trip relay contacts, terminals 17-18, should also be used to open the current circuit after trip (SW-2, SW-3, and SW-5). Connect a rated power supply voltage source to case terminals 13-14. For relays with Emergency Restart, rated power supply voltage is applied to terminals 23 and 24 through a pushbutton switch (SW-4).

2. Apply power supply voltage to the relay, then press the RESET button.

3. Using the "Display Procedure" check that each function's settings are per Table 5. If not, use the "Setting Procedure" to change a particular function to the setting required. Function 40 is disabled, 9999. Set this function to 40% for the Acceptance Test.

Function		Setting
20	Type & Qty of Winding RTD's	30
21	Type & Qty of Motor Bearing RTD's	30
22	Type & Qty of Load Bearing RTD	30
23	Type & Qty of Load Case RTD	30
24	Motor Factor K	6
25	CT Ratio	50
26	Primary Full Load Current	100
27	Frequency of Motor Current	60
28	Locked Rotor Current Trip	6
29	Locked Rotor Delay	10
30	Inst Overcurrent Trip	10
31	Inst Overcurrent Delay	.04
32	Overload Trip	190
33	RTD Winding Temp Trip	135
34	RTD Motor Bearing Temp Trip	90
35	RTD Load Bearing Temp Trip	90
36	RTD Load Case Temp Trip	75
37	Phase Reversal Trip	1
38	Ground Fault Trip	0.1
39	Ground Fault Delay	0.1
40	Load Loss Trip	40
41	Load Loss Delay	10
42	Phase Diff Trip	0.2
43	Phase Diff Delay	.04
44	Load Jam Trip	3.0
45	Load Jam Delay	10
46	Winding Temp	5
47	Motor Bearing Temp	5
48	Load Bearing Temp	5
49	Load Case Temp	5
50	Phase Unbalance Alarm	10
51	Ground Fault Alarm	50
52	Load Loss Alarm	60
53	Load Loss Alarm Delay	5
54	Phase Diff Alarm	30
56	Reset Mode Selection	1

TABLE 5 FUNCTION TEST SETTINGS

4. Apply 3.5 amps balanced three-phase current and note that the relay does not alarm or trip.

5. JAM. Apply 6 amps balanced three-phase current. The Overload LED will begin to flash. The alarm relay will drop out and the Jam LED will flash after 20 seconds. The trip relay will pick up and the Jam LED will remain "ON" at 30-33 seconds.

6. RESET. To reset the relay after each test, turn the power "OFF", then "ON". Push the RESET button to clear all relays and LED's. Applied current will then represent a "cold" start.

7. OVERLOAD. Apply 8 amps balanced three-phase current. The Overload LED will begin to flash. The trip relay will pick up, the alarm relay will drop out and the overload LED will remain "ON"' at 22 seconds. RESET.

8. LOCKED ROTOR. Apply 12 amps balanced three-phase current. The Overload LED will begin to flash. The trip relay will pick up, the alarm relay will drop out and the Locked Rotor LED will remain "ON" at 10 seconds. RESET.

9. EMERGENCY RESTART. For relays with Emergency Restart, apply trip current (12 amps three-phase). The trip relay will operate and the LED will remain "ON". Momentarily apply rated power supply voltage to terminals 23 and 24. The trip relay, LED and VALUE display will reset. Power down to clear memory.

10. INST. CURRENT. Apply 22 amps balanced three-phase current. The trip relay will pick up, the alarm relay will drop out and the Instantaneous Current LED will remain "ON" after .060 second. RESET.

11. LOAD LOSS. Apply less than 1.2 amp balanced three-phase current. The Load Loss LED will flash and the alarm relay will drop out after 25 seconds. Apply less than .8 amp. The load loss LED will flash and the alarm relay will drop out after 25 seconds. The trip relay will pick up and the Load Loss LED will remain "ON" at 30 seconds. RESET.

12. PHASE UNBALANCE. Apply current Phase A = Phase B = 2 amps, PHASE C = 1 amp. The phase unbalance LED will flash and the alarm relay will drop out at 30-33 seconds. RESET.

13. LOSS OF PHASE. Remove Phase C and neutral and apply 2 amps to Phases A and B. The trip relay will pick up, the alarm relay will drop out and the Phase Unbalance LED will remain "ON" at 10 seconds. RESET.

14. PHASE REVERSAL. Reconnect Phase C and neutral. Reverse Phases B and C and apply 2 amps three-phase. The trip relay will pick up, the alarm relay will drop out and the Phase Reversal LED will remain "ON". RESET. Reconnect phase A-B-C rotation.

15. GROUND FAULT. Apply greater than .050 amp single phase and note that the alarm relay drops out and the Ground Fault LED flashes. Apply greater than .100 amp. The trip relay will pick up and the LED will remain "ON". RESET.

16. PHASE DIFF. Apply greater than .060 amp single phase and note that the alarm relay drops out and the Phase Diff. LED flashes. Apply greater than .250 amp. The trip relay will pick up and the LED will remain "ON". RESET. Turn off the power supply voltage.

17. Connect variable resistors or decade boxes, 250 ohms minimum with 1 ohm increments, to RTD terminals 30 to 64. Connect shorting leads between the second and third terminals of each resistor input. Refer to the Test Connection Diagrams, Figs. 16 and 17. Set resistors 1 to 6 at 225 ohms, resistors 7 to 10 at 185 ohms and resistor 11 at 175 ohms.

18. Turn on the power supply voltage. Use the "Setting Procedure" to set functions 20, 21, 22 and 23 to type and quantities 36, 32 32 and 31 respectively.

19. Use the "Display Procedure" to monitor function 5, RTD 1 temperature. Increase the RTD 1 resistor to the values given in Table 6 and check alarm and trip temperatures. RESET.

20. Repeat Step 18 for all 11 RTD's, functions 5 to 15.

21. Before removing resistors, disable functions 20 to 23 by setting them to "30". This will prevent an "Error Message".

22. Turn off the power supply voltage.

		Alarm		Trip	
RTD	**Function**	**Temp.** (°C)	**Ohms** (±3)	**Temp.** (°C)	**Ohms** (±3)
1	5	130	232	135	236
2	6	130	232	135	236
3	7	130	232	135	236
4	8	130	232	135	236
5	9	130	232	135	236
6	10	130	232	135	236
7	11	85	192	90	196
8	12	85	192	90	196
9	13	85	192	90	196
10	14	85	192	90	196
11	15	75	180	80	184

TABLE 6 RTD TEST VALUES

Routine Maintenance

All relays should be checked at least once every year per the Acceptance Test procedures.

Calibration

The trimpot P1 located on the microprocessor module has been calibrated at the factory and should not be disturbed unless the relay is out of calibration.

If calibration is necessary use the following procedure then recheck the relay following the "Acceptance Test" procedures. The relay's accuracy not only depends on the trimpot's adjustment but the accuracy of the measuring instruments used in calibration.

1. Apply three phase balanced full load current. (This is 2 amps if Functions 25 and 26 are set per Table 5.) Use an ammeter standard to measure this current.

2. Trimpot P1 is located near the bottom of the microprocessor module mounted to the front panel.

3. Monitor Function 00 and adjust P1 for 100 percent in the VALUE display. Check Functions 1, 2 and 3 for 100 ± 3%.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate date.

REFERENCE DRAWINGS

Sub. 1
1608C64

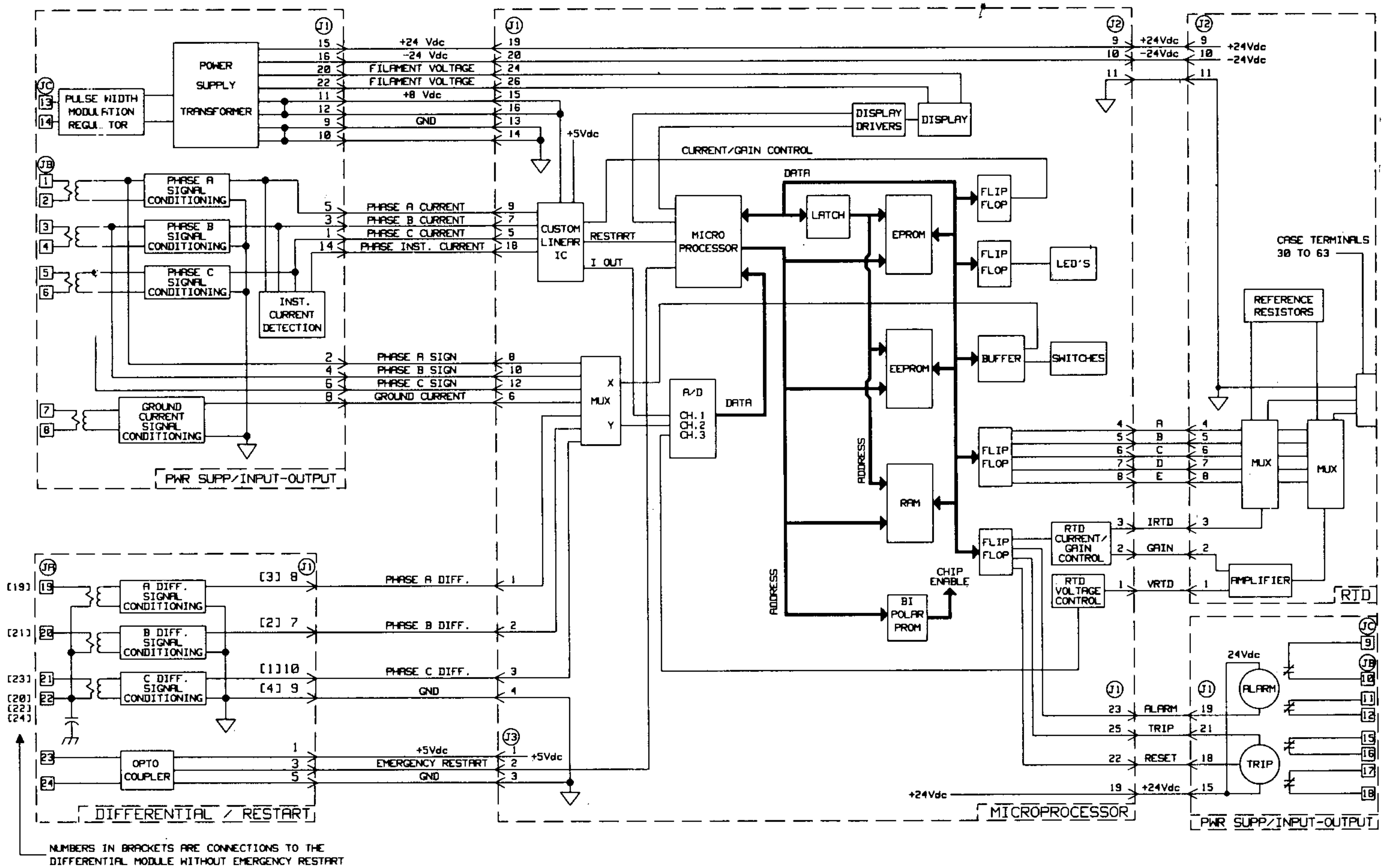
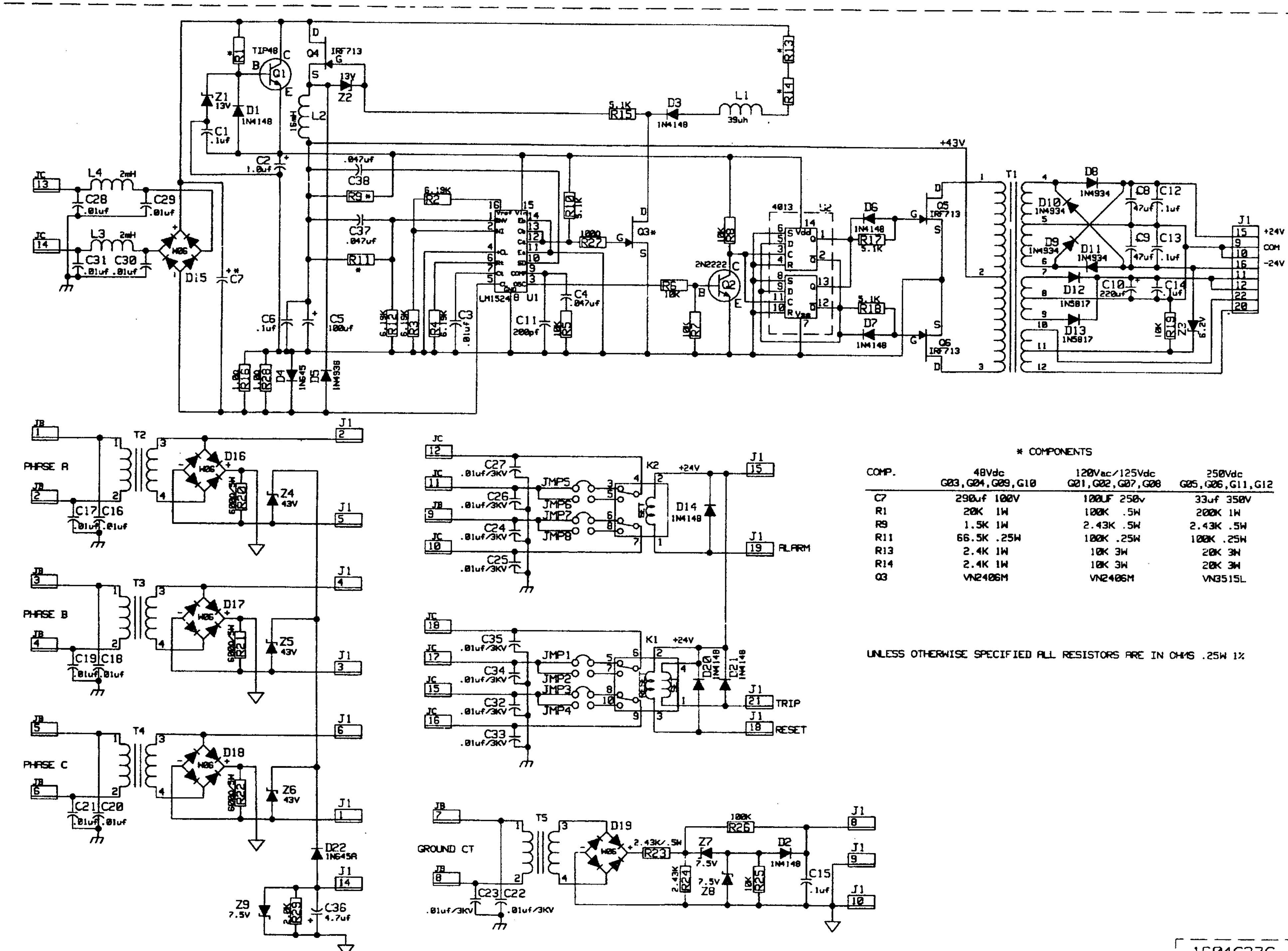


Fig. 1 Internal Wiring/Block Diagram

1354D08



* COMPONENTS

COMP.	48Vdc G03,G04,G09,G10	120Vac/125Vdc G01,G02,G07,G08	250Vdc G05,G06,G11,G12
C7	290uf 100V	100UF 250v	33uf 350V
R1	20K 1W	100K .5W	200K 1W
R9	1.5K 1W	2.43K .5W	2.43K .5W
R11	66.5K .25W	100K .25W	100K .25W
R13	2.4K 1W	10K 3W	20K 3W
R14	2.4K 1W	10K 3W	20K 3W
Q3	VN2406M	VN2406M	VN3515L

UNLESS OTHERWISE SPECIFIED ALL RESISTORS ARE IN OHMS .25W 1%

1604C37G

1354D08

POWER SUPPLY MODULE 1604C37

CAPACITOR

Ref	Part No.	Description	Groups
C01	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C02	837A241H15	1.0MFD 35V 10% TANT	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C03	3534A26H04	.01MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C04	3534A68H07	.047 MFD/100V 5% MET-POLY CARB	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C05	9645A13H11	100MFD 100V 20% AL ELEC	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C06	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C07	9645A13H08	33MFD 350V 20% ALUM ELEC	G05 G06 G11 G12
C07	9645A13H06	290MFD 100V -10 +100% ALUM ELEC	G03 G04 G09 G10
C07	9645A13H05	100MFD 250V -10 +75% AL ELEC	G01 G02 G07 G08
C08	9645A13H02	47MFD 35V -10 +100% AL ELEC	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C09	9645A13H02	47MFD 35V -10 +100% AL ELEC	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C10	9645A13H01	220MFD 10V -10 +100% AL ELEC	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C11	762A757H11	200PF 500V 2% MICA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C12	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C13	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C14	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C15	3534A26H05	.1MFD 50V 10% CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C16	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C17	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C18	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C19	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C20	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C21	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C22	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C23	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C24	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C25	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C26	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C27	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C28	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C29	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C30	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C31	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C32	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C33	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C34	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C35	3536A32H02	.01MFD 20% 3000V CER	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C36	184A661H12	4.7 MFD 35V +10% TANT	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C37	3534A68H07	.047 MFD/100V 5% MET-POLY CARB	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
C38	3534A68H07	.047 MFD/100V 5% MET-POLY CARB	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

CHOKE

Ref	Part No.	Description	Groups
L01	9645A17H01	WEE-39 39MH 5%	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
L02	9645A18H01	EC30HL35 16MH 200UA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
L03	3500A27H01	2.0MH 1.3MHZ 0.8A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
L04	3500A27H01	2.0MH 1.3MHZ 0.8A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

DIODE

Ref	Part No.	Description	Groups
D01	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D02	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D03	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D04	837A692H03	1N645A 225V .2 AMP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D05	836A928H10	1N4936 400V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D06	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D07	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D08	836A928H11	1N4934 100V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D09	836A928H11	1N4934 100V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D10	836A928H11	1N4934 100V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D11	836A928H11	1N4934 100V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D12	9648A05H01	1N5817 20V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D13	9648A05H01	1N5817 20V 1A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D14	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D15	3510A67H01	TYPE W06M	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D16	3510A67H01	TYPE W06M	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D17	3510A67H01	TYPE W06M	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D18	3510A67H01	TYPE W06M	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D19	3510A67H01	TYPE W06M	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D20	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D21	836A928H06	1N4148 75V 10MA	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
D22	837A692H03	1N645A 225V .2 AMP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

INT CKT

Ref	Part No.	Description	Groups
U01	3534A92H01	SG 1524 PULSE WIDTH MODULATOR	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
U02	3527A26H06	MC14013BAL DUAL D FLIP FLOP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

RELAY

Ref	Part No.	Description	Groups
K01	9645A16H01	R30D-E1-W2 24V	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
K02	9645A10H01	FBR621D024	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

RESISTOR

Ref	Part No.	Description	Groups
R01	187A643H58	20K 1W 5% MOLD COMP	G03 G04 G09 G10
R01	862A378H01	100K .5W 1% METAL FILM	G01 G02 G07 G08
R01	187A643H82	200K 1W 5% MOLD COMP	G05 G06 G11 G12
R02	3535A38H77	6.19K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R03	3535A38H77	6.19K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R04	3535A38H77	6.19K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R05	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R06	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R07	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R08	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R09	862A376H38	2.43K 1% .5W METAL FILM	G01 G02 G05 G06 G07 G08 G11 G12
R09	187A643H31	1500 OHM 1W 5% MOLD COMP	G03 G04 G09 G10
R10	3535A36H69	5.11K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R11	3535A37H80	66.5K .25W 1% METAL FILM	G03 G04 G09 G10
R11	3532A38H01	100K .25W 1% METAL FILM	G01 G02 G05 G06 G07 G08 G11 G12
R12	3535A38H77	6.19K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R13	763A126H88	20K 3W 1%	G05 G06 G11 G12
R13	763A126H20	10K 3W 1%	G01 G02 G07 G08
R13	185A207H36	2400 OHM 1W 5% MOLD COMP	G03 G04 G09 G10
R14	763A126H88	20K 3W 1%	G05 G06 G11 G12
R14	185A207H36	2400 OHM 1W 5% MOLD COMP	G03 G04 G09 G10
R14	763A126H20	10K 3W 1%	G01 G02 G07 G08
R15	3535A38H69	5.11K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R16	3537A56H01	1.00 OHM .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R17	3535A38H69	5.11K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R18	3535A38H69	5.11K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R19	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R20	9645A12H01	600 OHM 5W 1% MOLD COMP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R21	9645A12H01	600 OHM 5W 1% MOLD COMP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R22	9645A12H01	600 OHM 5W 1% MOLD COMP	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R23	862A376H38	2.43K 1% .5W METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R24	3535A38H38	2.43K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R25	3535A37H01	10.0K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R26	3532A38H01	100K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R27	3535A39H01	100 OHM .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R28	3537A56H01	1.00 OHM .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
R29	3535A38H30	2.00K .25W 1% METAL FILM	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

TRANSFORMER

Ref	Part No.	Description	Groups
T01	1804C87G01		G01 G02 G05 G06 G07 G08 G11 G12
T01	1604C87G02		G03 G04 G09 G10
T02	1604C86G01		G01 G03 G05 G07 G09 G11
T02	1604C86G02		G02 G04 G06 G08 G10 G12
T03	1604C86G01		G01 G03 G05 G07 G09 G11
T03	1604C86G02		G02 G04 G06 G08 G10 G12
T04	1604C86G02		G02 G04 G06 G08 G10 G12
T04	1604C86G01		G01 G03 G05 G07 G09 G11
T05	1604C86G01		G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

TRANSISTOR

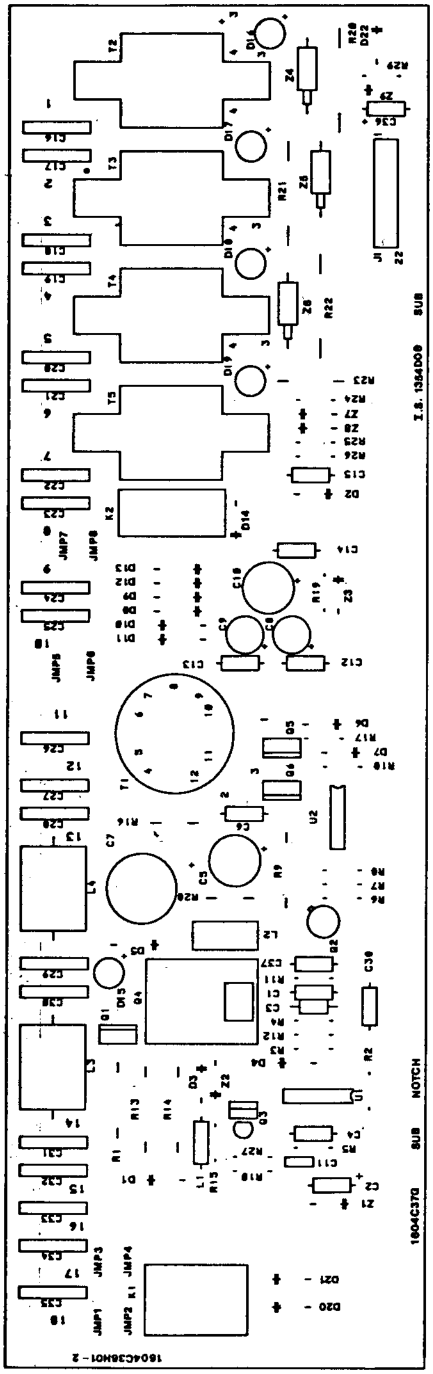
Ref	Part No.	Description	Groups
Q01	861A634H02	T1P48 300V, 1.0A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Q02	762A672H15	2N2222A, NPN 40V .8A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Q03	9641A07H03	VN2406M 240V 0.25A	G01 G02 G03 G04 G07 G08 G09 G10
Q03	9641A07H04	VN3515L 350V 0.18A	G05 G06 G11 G12
Q04	9641A07H02	1RF713 350V 0.9A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Q05	9641A07H02	1RF713 350V 0.9A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Q06	9641A07H02	1RF713 350V 0.9A	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

ZENER

Ref	Part No.	Description	Groups
Z01	862A606H16	1N964B 13V 5% 400MW	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z02	862A606H16	1N964B 13V 5% 400MW	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z03	862A288H07	1N5235B 6.8V 5% 500MW	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z04	188A302H08	1N3035B 43V 5% 1W	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z05	188A302H08	1N3035B 43V 5% 1W	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z06	188A302H08	1N3035B 43V 5% 1W	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z07	837A398H18	1N958B 7.5V 5% 400MW	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z08	837A398H18	1N958B 7.5V 5% 400MW	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12
Z09	849A515H08	1N4737A 7.5V 5% 1W	G01 G02 G03 G04 G05 G06 G07 G08 G09 G10 G11 G12

PART NAME | APPAR. TYPE | PART DESCRIPTION | SUB

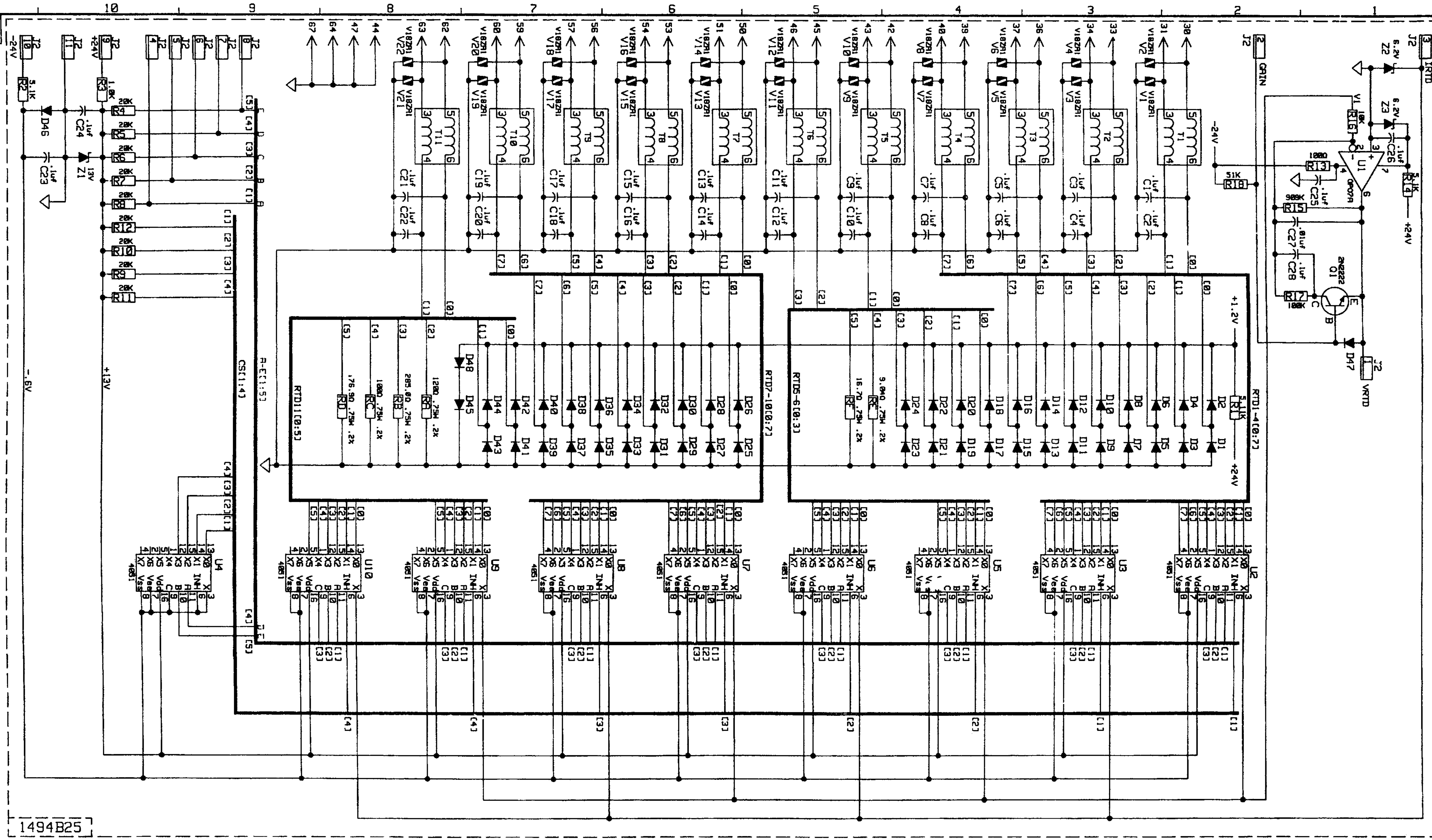
2



Sub. 3
1604C38

Fig. 3 Power Supply Module Component Location

1353D02



1494B25

DRAWING ROUTING CODE	A	P	V	F	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47

PART NAME	APPAR. TYPE	PART DESCRIPTION	SUB
			4

1353D02

RTD MODULE 1494B25

CAPACITORS

C01	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C02	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C03	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C04	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C05	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C06	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C07	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C08	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C09	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C10	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C11	9461A00H1C	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C12	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C13	9461A00H16	.1MFD 50V 10% CER	G01	G02		G04	G05	
C14	9461A00H16	.1MFD 50V 10% CER	G01	G02		G04	G05	
C15	9461A00H16	.1MFD 50V 10% CER	G01	G02		G04	G05	
C16	9461A00H16	.1MFD 50V 10% CER	G01	G02		G04	G05	
C17	9461A00H16	.1MFD 50V 10% CER	G01			C04		
C18	9461A00H16	.1MFD 50V 10% CER	G01			G04		
C19	9461A00H16	.1MFD 50V 10% CER	G01			G04		
C20	9461A00H16	.1M D 50V 10% CER	G01			G04		
C21	9461A00H16	.1MFD 50V 10% CER	G01			G04		
C22	9461A00H16	.1MFD 50V 10% CER	G01			G04		
C23	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C24	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C25	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C26	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C27	9461A00H04	.01MFD 50V 10% CER	G01	G02	G03	G04	G05	G06
C28	9461A00H16	.1MFD 50V 10% CER	G01	G02	G03	G04	G05	G06

DIODES

D01	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D02	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D03	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D04	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D05	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D06	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D07	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D08	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D09	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D10	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D11	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D12	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D13	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D14	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D15	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D16	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D17	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D18	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D19	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D20	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D21	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D22	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D23	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D24	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D25	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D26	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D27	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D28	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D29	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D30	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D31	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D32	837A692H03	1N645A 225V .2 AMP	G01	G02		G04	G05	
D33	837A692H03	1N645A 225V .2 AMP	G01			G04		
D34	837A692H03	1N645A 225V .2 AMP	G01			G04		
D35	837A692H03	1N645A 225V .2 AMP	G01			G04		
D36	837A692H03	1N645A 225V .2 AMP	G01			G04		
D37	837A692H03	1N645A 225V .2 AMP	G01			G04		
D38	837A692H03	1N645A 225V .2 AMP	G01			G04		
D39	837A692H03	1N645A 225V .2 AMP	G01			G04		
D40	837A692H03	1N645A 225V .2 AMP	G01			G04		
D41	837A692H03	1N645A 225V .2 AMP	G01			G04		
D42	837A692H03	1N645A 225V .2 AMP	G01			G04		
D43	837A692H03	1N645A 225V .2 AMP	G01			G04		
D44	837A692H03	1N645A 225V .2 AMP	G01			G04		
D45	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D46	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D47	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06
D48	837A692H03	1N645A 225V .2 AMP	G01	G02	G03	G04	G05	G06

INT CKT'S

U01	3533A96H02	OP-07AZ	G01	G02	G03	G04	G05	G06
U02	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U03	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U04	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U05	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U06	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U07	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02		G04	G05	
U08	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02		G04	G05	
U09	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06
U10	9447A67H52	MC14051BAL 8-CHAN MUX	G01	G02	G03	G04	G05	G06

RESISTORS

R01	3535A38H69	5.11K-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R02	3535A38H69	5.11K-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R03	184A763H27	1K .5W 5% FIXED COMP.	G01	G02	G03	G04	G05	G06
R04	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R05	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R06	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R07	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R08	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R09	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R10	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R11	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R12	3535A37H30	20.0K-OHM 1% .25W M.F.	G01	G02	G03	G04	G05	G06
R13	3535A39H01	100-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R14	3535A38H69	5.11K-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R15	3532A38H93	909K .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R16	3535A37H01	10.0 K-OHM .25W 1% M.F.	G01	G02	G03	G04	G05	G06
R17	3532A38H01	100K-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G06
R18	3535A37H69	51.1K-OHM .25W,1% M.F.	G01	G02	G03	G04	G05	G05
RA	9645A12H05	120.0 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06
RB	9645A12H07	285.0 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06
RC	9645A12H04	100 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06
RD	9645A12H06	176.9 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06
RE	9645A12H02	9.04 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06
RF	9645A12H03	16.7 OHM .75W .2% 35V	G01	G02	G03	G04	G05	G06

TRANSFORMERS

T01	9645A07H01	PE6292	G01	G02	G03	G04	G05	G03
T02	9645A07H01	PE6292	G01	G02	G03	G04	G05	G06
T03	9645A07H01	PE6292	G01	G02	G03	G04	G05	G06
T04	9645A07H01	PE5292	G01	G02	G03	G04	G05	G06
T05	9645A07H01	PE6292	G01	G02	G03	G04	G05	G06
T06	9645A07H01	PE6292	G01	G02	G03	G04	G05	G06
T07	9645A07H01	PE6292	G01	G02		G04	G05	
T08	9645A07H01	PE6292	G01	G02		G04	G05	
T09	9645A07H01	PE6292	G01			G04		
T10	9645A07H01	PE6292	G01			G04		
T11	9645A07H01	PE6292	G01			G04		

TRANSISTOR

Q01	762A672H15	2N2222A, NPN 40V .8A .4W	G01	G02	G03	G04	G05	G06

VARISTORS

V01	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V02	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V03	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V04	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V05	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V06	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V07	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V08	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V09	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V10	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V11	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V12	3509A31H14	V18ZA1	G01	G02	G03	G04	G05	G06
V13	3509A31H14	V18ZA1	G01	G02		G04	G05	
V14	3509A31H14	V18ZA1	G01	G02		G04	G05	
V15	3509A31H14	V18ZA1	G01	G02		G04	G05	
V16	3509A31H14	V18ZA1	G01	G02		G04	G05	
V17	3509A31H14	V18ZA1	G01			G04		
V18	3509A31H14	V18ZA1	G01			G04		
V19	3509A31H14	V18ZA1	G01			G04		
V20	3509A31H14	V18ZA1	G01			G04		
V21	3509A31H14	V18ZA1	G01			G04		
V22	3509A31H14	V18ZA1	G01			G04		

ZENER DIODES

Z01	862A606H16	1N964B 13V 5% 400MW	G01	G02	G03	G04	G05	G06
Z02	862A606H01	1N753A 6.2V 5% 400MW	G01	G02	G03	G04	G05	G06
Z03	862A606H01	1N753A 6.2V 5% 400MW	G01	G02	G03	G04	G05	G06

DRAWING ROUTING CODE A P V F 33 34 35 36 37 38 39 40 41 42 43 44 45 46

PART NAME APPAR. TYPE PART DESCRIPTION SUB 4

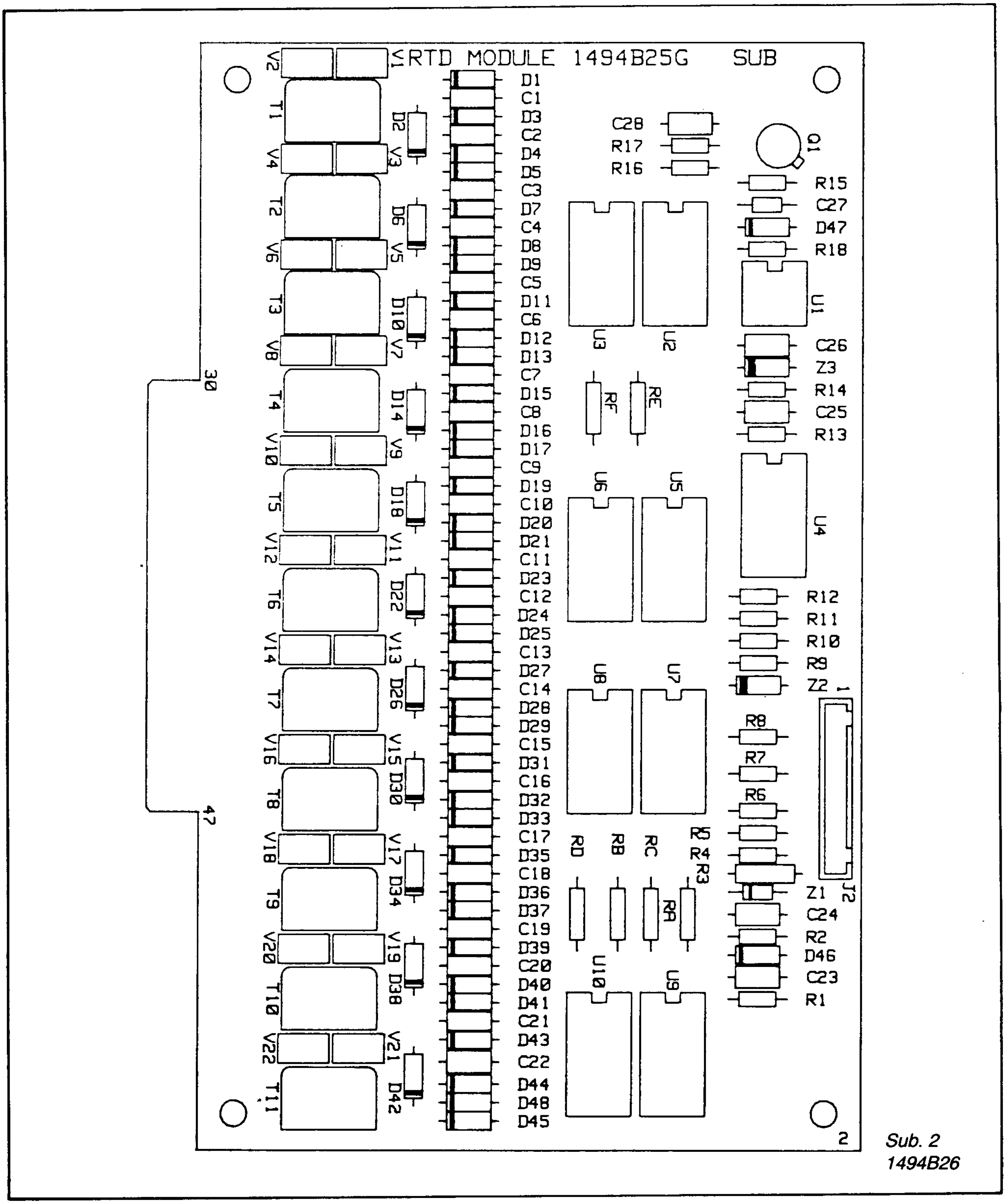
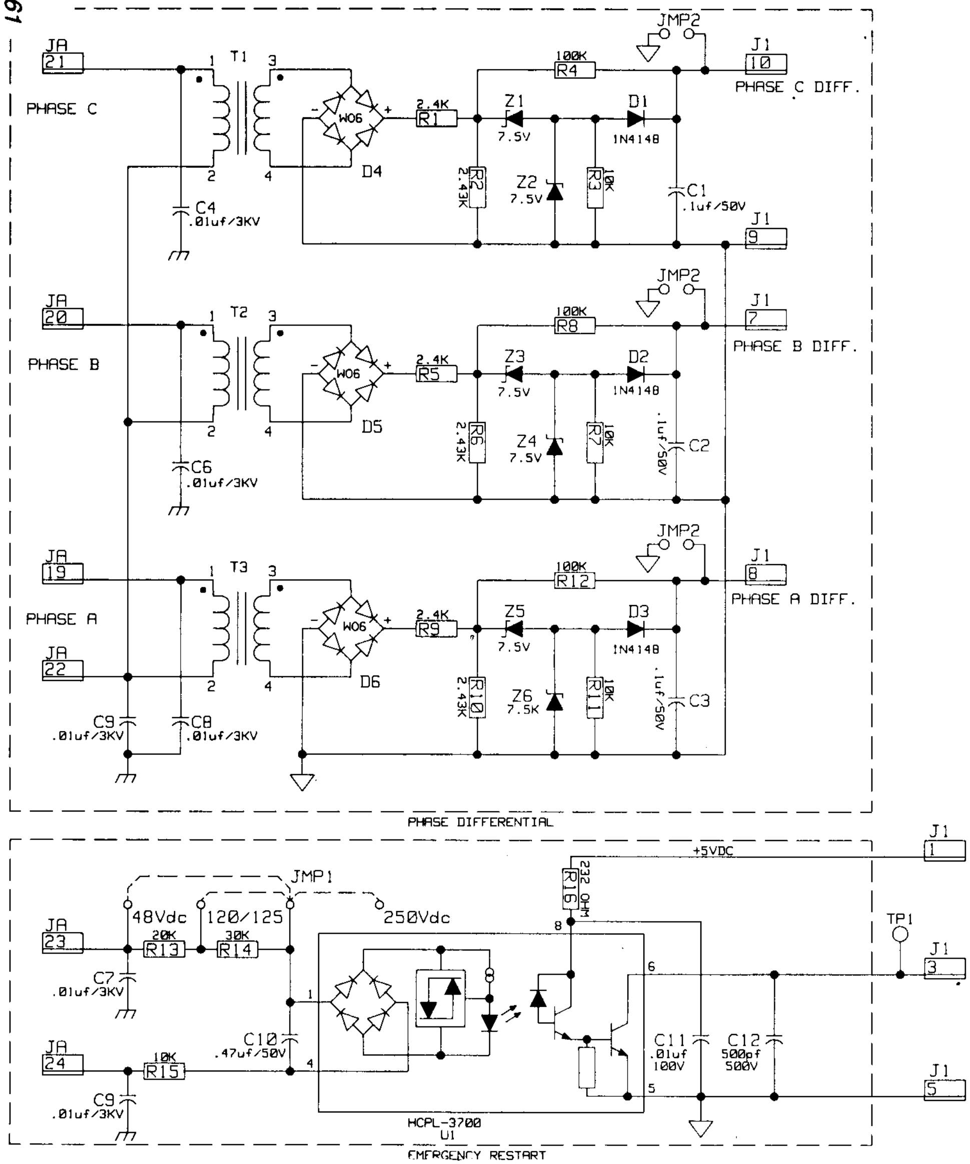


Fig. 5 RTD Module Component Location

Sub. 1
1607C61



CAPACITOR				
C01	9461A00H16	.1 MFD 50V 10% CER		G02
C02	9461A00H16	.1 MFD 50V 10% CER		G02
C03	9461A00H16	.1 MFD 50V 10% CER		G02
C04	3536A32H02	.01 MFD 3KV 20% CER		G02
C05	3536A32H02	.01 MFD 3KV 20% CER		G02
C06	3536A32H02	.01 MFD 3KV 20% CER		G02
C07	3536A32H02	.01 MFD 3KV 20% CER	G01	G02
C08	3536A32H02	.01 MVD 3KV 20% CER		G02
C09	3536A32H02	.01 MVD 3KV 20% CER	G01	G02
C10	762A680H04	.47 MFD 50V 20% CER	G01	G02
C11	184A663H01	.01 MFD 100V 20% CER	G01	G02
C12	184A663H05	500 PF 500V 10% CER	G01	G02
DIODE				
D01	836A928H06	1N4148 75V 10MA		G02
D02	836A928H06	1N4148 75V 10MA		G02
D03	836A928H06	1N4148 75V 10MA		G02
D04	3510A67H01	W06M		G02
D05	3510A67H01	W06M		G02
D06	3510A67H01	W06M		G02
RESISTOR				
R01	862A376H38	2.43K .5W 1% M.F.		G02
R02	3535A38H38	2.43K .25W 1% M.F.		G02
R03	3535A37H01	10.0K .25W 1% M.F..		G02
R04	3532A38H01	100.0K .25W 1% M.F.		G02
R05	862A376H38	2.43K .5W 1% M.F.		G02
R06	3535A38H38	2.43K .25W 1% M.F.		G02
R07	3535A37H01	10.0K .25W 1% M.F.		G02
R08	3532A38H01	100.0K .25W 1% M.F.		G02
R09	862A376H38	2.43K .5W 1% M.F.		G02
R10	3535A38H38	2.43K .25W 1% M.F.		G02
R11	3535A37H01	10.0K .25W 1% M.F.		G02
R12	3532A38H01	100.0K .25W 1% M.F.		G02
R13	185A207H58	20.0K 2.00W 5% CARBON	G01	G02
R14	185A207H62	30.0K 2.00W 5% CARBON	G01	G02
R15	187A643H51	10.0K 1.00W 5% CARBON	G01	G02
R16	848A818H86	232 OHM .25W 1%	G01	G02
TRANSFORMER				
T01	1604C86G03			G02
T02	1604C86G03			G02
T03	1604C86G03			G02
ZENER				
Z01	837A398H18	1N958B 7.5V 5% 400MW		G02
Z02	837A398H18	1N958B 7.5V 5% 400MW		G02
Z03	837A398H18	1N958B 7.5V 5% 400MW		G02
Z04	837A398H18	1N958B 7.5V 5% 400MW		G02
Z05	837A398H18	1N958B 7.5V 5% 400MW		G02
Z06	837A398H18	1N958B 7.5V 5% 400MW		G02
INT CKT				
U01	775B621H02	HCPL-3700	G01	G02

Fig. 6 MPR Differential/Restart Internal Schematic

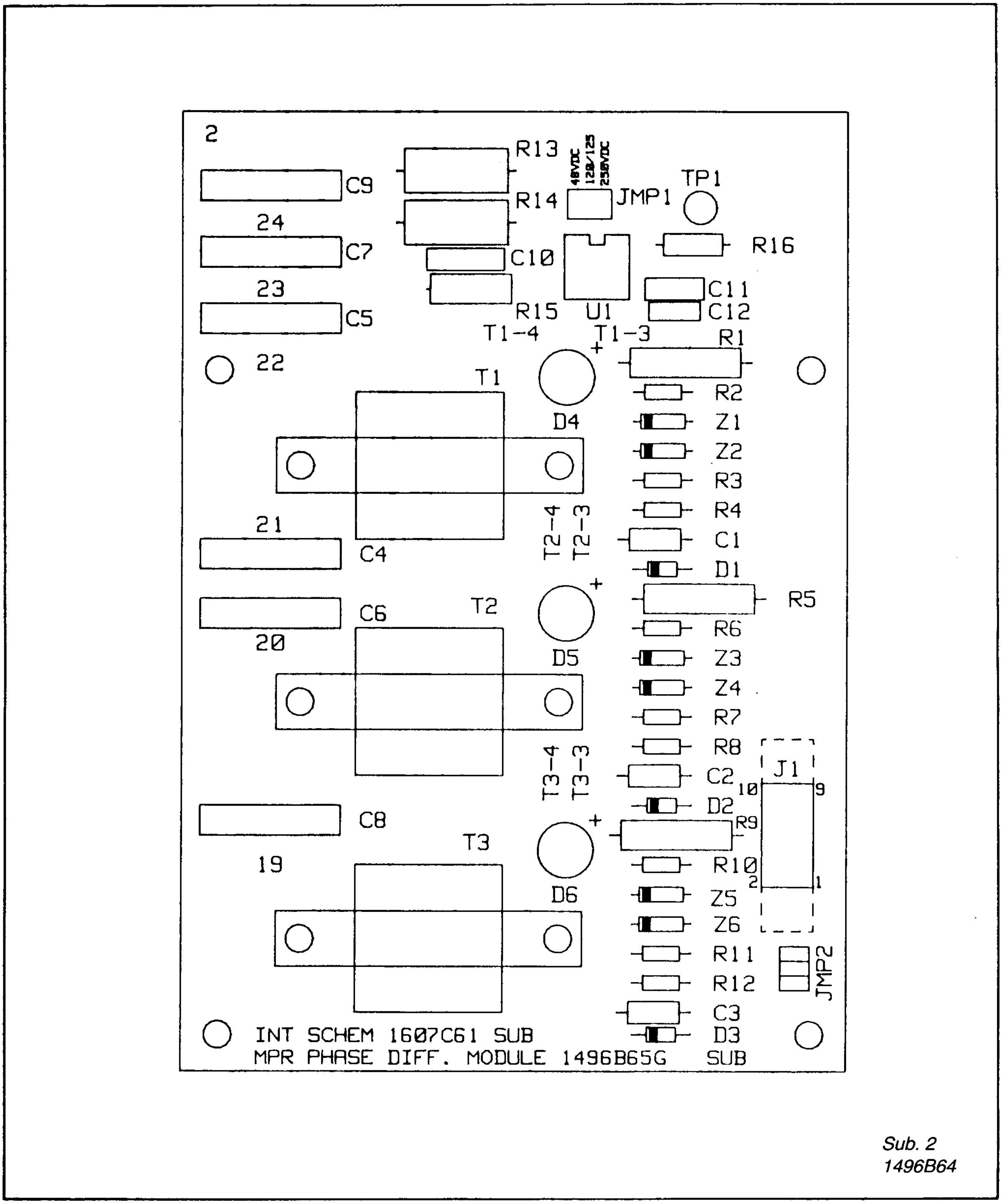
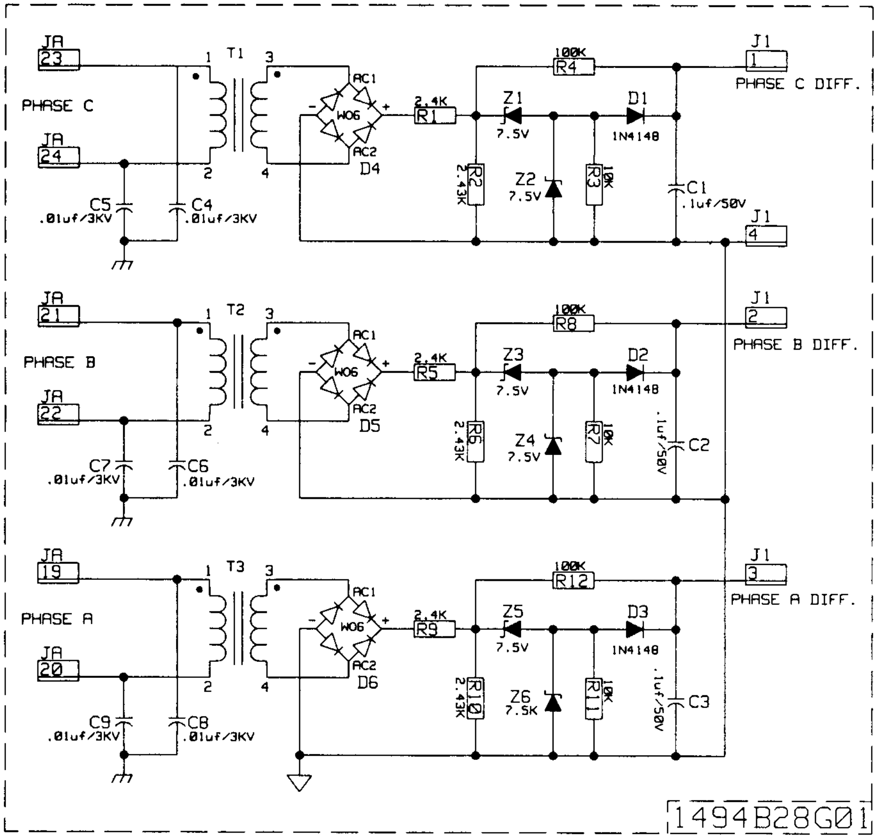


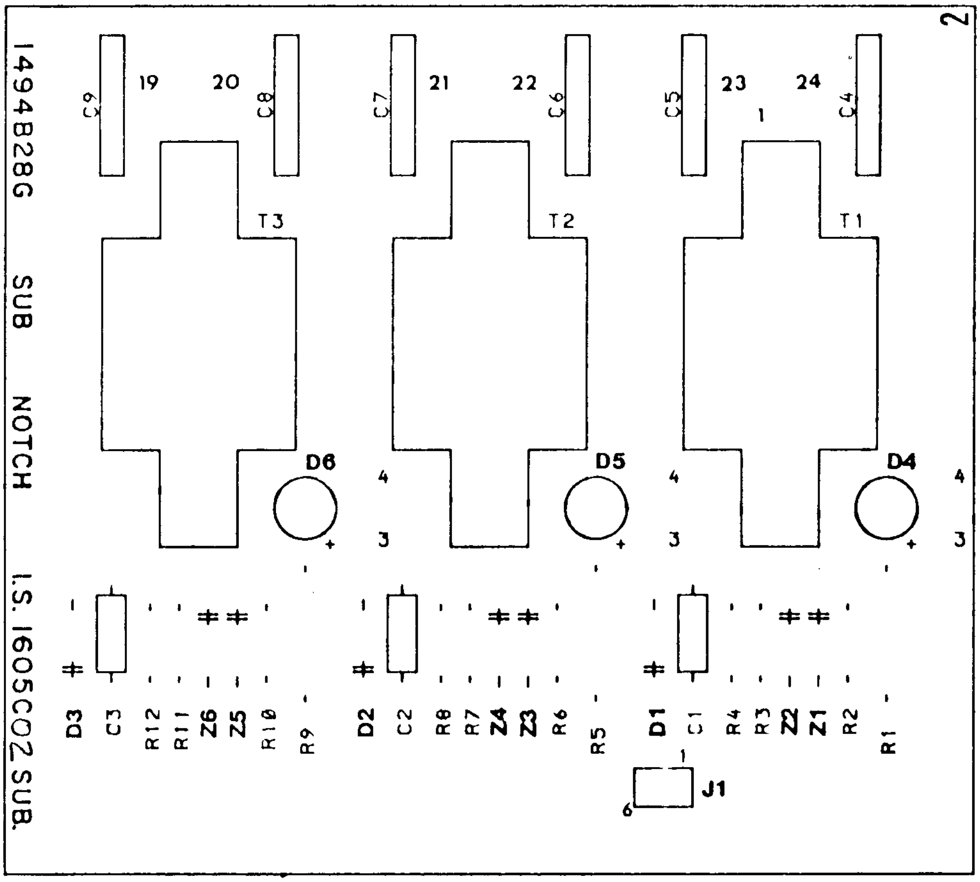
Fig. 7 Differential/Restart Module Component Location



CAPACITOR		
C01	9461A00H16	.1 MFD 50V 10% CER
C02	9461A00H16	.1 MFD 50V 10% CER
C03	9461A00H16	.1 MFD 50V 10% CER
C04	3536A32H02	.01 MFD 3KV 20% CER
C05	3536A32H02	.01 MFD 3KV 20% CER
C06	3536A32H02	.01 MFD 3KV 20% CER
C07	3536A32H02	.01 MFD 3KV 20% CER
C08	3536A32H02	.01 MVD 3KV 20% CER
C09	3536A32H02	.01 MVD 3KV 20% CER
DIODE		
D01	836A928H06	1N4148 75V 10MA
D02	836A928H06	1N4148 75V 10MA
D03	836A928H06	1N4148 75V 10MA
D04	3510A67H01	W06M
D05	3510A67H01	W06M
D06	3510A67H01	W06M
RESISTOR		
R01	862A376H38	2.43K .5W 1% M.F.
R02	3535A38H38	2.43K .25W 1% M.F.
R03	3535A37H01	10.0K .25W 1% M.F.
R04	3532A38H01	100.0K .25W 1% M.F.
R05	862A376H38	2.43K .5W 1% M.F.
R06	3535A38H38	2.43K .25W 1% M.F.
R07	3535A37H01	10.0K .25W 1% M.F.
R08	3532A38H01	100.0K .25W 1% M.F.
R09	862A376H38	2.43K .5W 1% M.F.
R10	3535A38H38	2.43K .25W 1% M.F.
R11	3535A37H01	10.0K .25W 1% M.F.
R12	3532A38H01	100.0K .25W 1% M.F.
TRANSFORMER		
T01	1604C86G03	
T02	1604C86G03	
T03	1604C86G03	
ZENER		
Z01	837A398H18	1N958B 7.5V 5% 400MW
Z02	837A398H18	1N958B 7.5V 5% 400MW
Z03	837A398H18	1N958B 7.5V 5% 400MW
Z04	837A398H18	1N958B 7.5V 5% 400MW
Z05	837A398H18	1N958B 7.5V 5% 400MW
Z06	837A398H18	1N958B 7.5V 5% 400MW

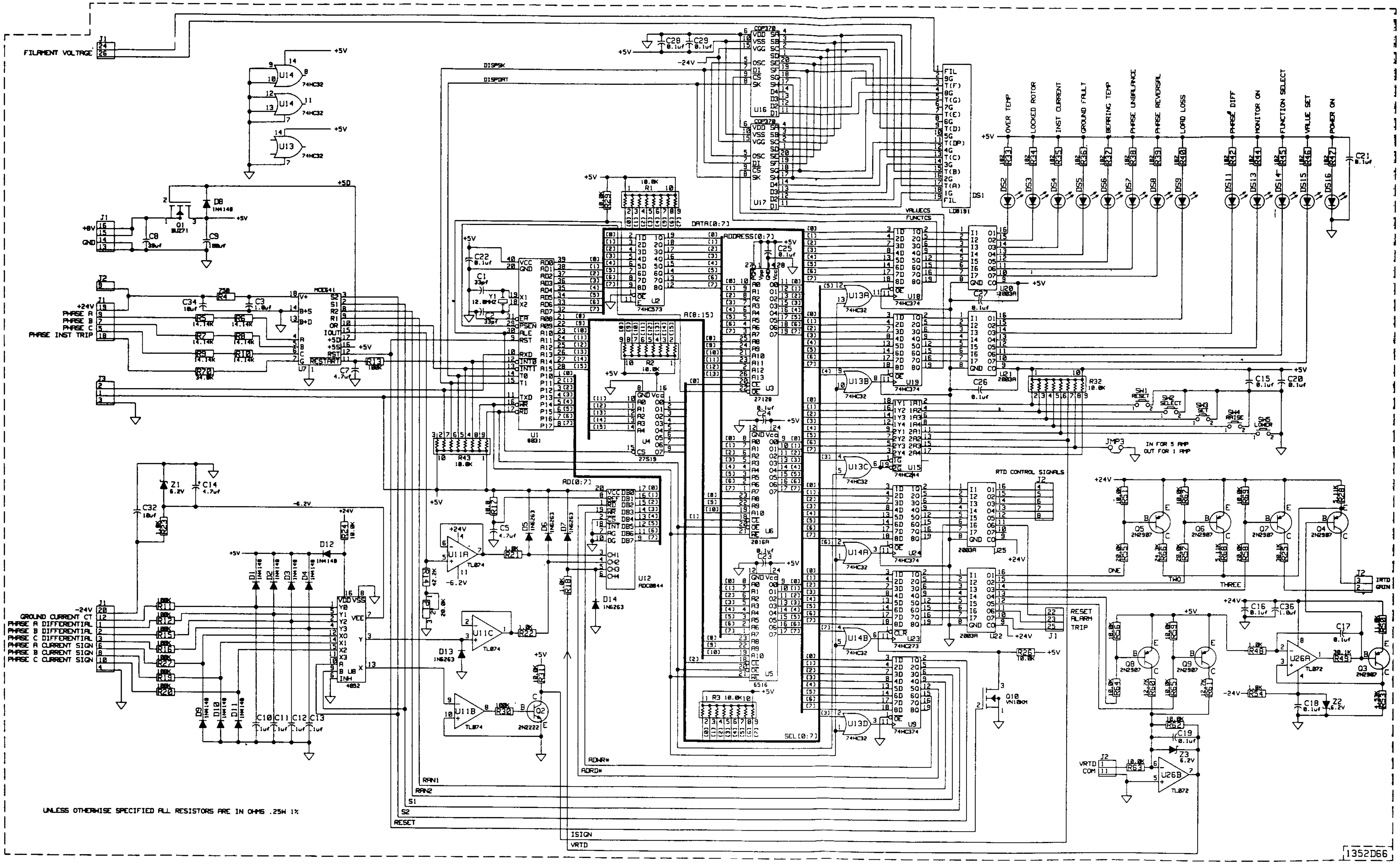
Sub. 1
1605C02

Fig. 8 MPR Phase Differential Module Internal Schematic



Sub. 3
1494B29

Fig. 9 Phase Differential Module Component Location



Sub. 4
2388F31

MICRO-PROCESSOR MODULE 1352D66

CAPACITOR

C01	9645A11H01	33PF 100V 10%
C02	9645A11H01	33PF 100V 10%
C03	9461A43H29	1.0MFD 35V 10% TANT
C05	9461A40H09	4.7MFD 10V 10% TANT
C07	184A661H12	4.7 MFD 35V +10% TANT
C08	9461A40H20	39MFD 10V 10% TANT
C09	862A530H16	100MFD 10V 20% TANT
C10	9461A00H04	.01MFD 50V 10% CER
C11	9461A00H04	.01MFD 50V 10% CER
C12	9461A00H04	.01MFD 50V 10% CER
C13	9461A00H04	.01MFD 50V 10% CER
C14	9461A40H09	4.7MFD 10V 10% TANT
C15	9461A00H16	.1MFD 50V 10% CER
C16	9461A00H16	.1MFD 50V 10% CER
C17	9461A00H16	.1MFD 50V 10% CER
C18	9461A00H16	.1MFD 50V 10% CER
C19	9461A00H16	.1MFD 50V 10% CER
C20	9461A00H16	.1MFD 50V 10% CER
C21	9461A00H16	.1MFD 50V 10% CER
C22	9461A00H16	.1MFD 50V 10% CER
C23	9461A00H16	.1MFD 50V 10% CER
C24	9461A00H16	.1MFD 50V 10% CER
C25	9461A00H16	.1MFD 50V 10% CER
C26	9461A00H16	.1MFD 50V 10% CER
C27	9461A00H16	.1MFD 50V 10% CER
C28	9461A00H16	.1MFD 50V 10% CER
C29	9461A00H16	.1MFD 50V 10% CER
C32	862A530H15	10MFD 35V 10% TANT
C34	862A530H15	10MFD 35V 10% TANT
C36	9461A43H29	1.0MFD 35V 10% TANT

CRYSTAL

Y01	879A920H08	12KHZ .015%

DIODE

D01	836A928H06	1N4148 75V 10MA
D02	836A928H06	1N4148 75V 10MA
D03	836A928H06	1N4148 75V 10MA
D04	836A928H06	1N4148 75V 10MA
D05	9645A04H01	1N6263
D06	9645A04H01	1N6263
D07	9645A04H01	1N6263
D08	836A928H06	1N4148 75V 10MA
D09	836A928H06	1N4148 75V 10MA
D10	836A928H06	1N4148 75V 10MA
D11	836A928H06	1N4148 75V 10MA
D12	836A928H06	1N4148 75V 10MA
D13	9645A04H01	1N6263
D14	9645A04H01	1N6263

DISPLAY

DS01	9645A05H01	LD8191/F1P9J5B

INT CKT

U01	9449A37H53	LD8031AH 8 BIT MICRO COMPUTER
U02	9450A56H52	MC74HC573J OCTAL 3-STATE NONINV LAT
U03	1495B34G01	LD27128 PROG EPROM
U04	9645A56G01	AM27S19DM PROG PROM-BIP
U05	9645A01H01	HM6516B-9 CMOS RAM
U06	1495B33G01	X2816ADI-35 PROG EEPROM
U07	9449A34H51	MCE641
U08	9646A33H02	4052BAL DIGITAL MULTIPLEXER
U09	9450A74H52	MC74HC374J OCTAL 3-STATE NONINV FF
U11	3528A90H01	TL074 IJ QUAD OP AMP
U12	9645A03H01	ADC0844BCJ A/D CONVERTER/MULTIPLEXER
U13	9450A32H52	MC74HC32J QUAD 2-INPUT OR
U14	9450A32H52	MC74HC32J QUAD 2-INPUT OR
U15	9450A44H52	MC74HC244J
U16	9645A02H01	COP370N V.F. DISP. DRIVER
U17	9645A02H01	COP370N V.F. DISP. DRIVER
U18	9450A74H52	MC74HC374J OCTAL 3-STATE NONINV FF
U19	9450A74H52	MC74HC374J OCTAL 3-STATE NONINV FF
U20	9446A96H54	ULS2003R SEPTAL OCTAL DRIVER
U21	9446A96H54	ULS2003R SEPTAL OCTAL DRIVER
U22	9446A96H54	ULS2003R SEPTAL OCTAL DRIVER
U23	9450A65H52	MC74HC273J OCTAL D-TYPE FLIP-FLOP
U24	9450A74H52	MC74HC374J OCTAL 3-STATE NONINV FF
U25	9446A96H54	ULS2003R SEPTAL OCTAL DRIVER
U26	3528A90H02	TL072IJ DUAL J-FET INPUT OP-AMP

LED *

DS02	9644A98H01	HLMP-0301
DS03	9644A98H01	HLMP-0301
DS04	9644A98H01	HLMP-0301
DS05	9644A98H01	HLMP-0301
DS06	9644A98H01	HLMP-0301
DS07	9644A98H01	HLMP-0301
DS08	9644A98H01	HLMP-0301
DS09	9644A98H01	HLMP-0301
DS11	9644A98H01	HLMP-0301
DS13	9644A98H02	HLMP-0401
DS14	9644A98H02	HLMP-0401
DS15	9644A98H02	HLMP-0401
DS16	9644A98H02	HLMP-0401

POTENTIOMETER

P01	880A826H01	20K .75W 10%

RESISTOR

R01	3532A91H03	10K 2% SIP (9x) RES NET
R02	3532A91H03	10K 2% SIP (9x) RES NET
R03	3532A91H03	10K 2% SIP (9x) RES NET
R04	3535A39H85	750 OHM .25W 1% METAL FILM
R05	3535A37H17	14.7K .25W 1% METAL FILM
R06	3535A37H17	14.7K .25W 1% METAL FILM
R07	3535A37H17	14.7K .25W 1% METAL FILM
R08	3535A37H17	14.7K .25W 1% METAL FILM
R09	3535A37H17	14.7K .25W 1% METAL FILM
R10	3535A37H17	14.7K .25W 1% METAL FILM
R11	3532A38H47	301K .25W 1% METAL FILM
R12	3532A38H47	301K .25W 1% METAL FILM
R13	3532A38H01	301K .25W 1% METAL FILM
R14	3535A37H61	42.2K .25W 1% METAL FILM
R15	3532A38H47	301K .25W 1% METAL FILM
R16	3532A38H47	301K .25W 1% METAL FILM
R17	3535A42H01	10.0 OHM .25W 1%
R18	3535A38H01	1.0K .25W 1% METAL FILM
R19	3532A38H01	100K .25W 1% METAL FILM
R20	3532A38H01	100K .25W 1% METAL FILM
R21	3535A38H01	1.0K .25W 1% METAL FILM
R22	3535A38H01	1.0K .25W 1% METAL FILM
R23	184A763H33	1.8K 1/2W 5% FIXED COMP.
R24	3535A37H01	10 0K .25W 1% METAL FILM
R25	3535A37H47	30.1K .25W 1% METAL FILM
R26	3535A37H01	10.0K .25W 1% METAL FILM
R27	3532A38H01	100K .25W 1% METAL FILM
R28	3535A38H69	5.11K .25W 1% METAL FILM
R29	3535A37H01	10.0K .25W 1% METAL FILM
R30	3532A38H01	100K .25W 1% METAL FILM
R31	3535A37H01	10.0K .25W 1% METAL FILM
R32	3532A91H03	10K 2% SIP (9X) RES NET
R33	3535A39H26	182 OHM .25W 1% METAL FILM
R34	3535A39H26	182 OHM .25W 1% METAL FILM
R35	3535A39H26	182 OHM .25W 1% METAL FILM
R36	3535A39H26	182 OHM .25W 1% METAL FILM
R37	3535A39H26	182 OHM .25W 1% METAL FILM
R38	3535A39H26	182 OHM .25W 1% METAL FILM
R39	3535A39H26	182 OHM .25W 1% METAL FILM
R40	3535A39H26	182 OHM .25W 1% METAL FILM
R42	3535A39H26	182 OHM .25W 1% METAL FILM
R43	3532A91H03	10K 2% SIP (9X) RES NET
R44	3535A39H26	182 OHM .25W 1% METAL FILM
R45	3535A39H26	182 OHM .25W 1% METAL FILM
R46	3535A39H26	182 OHM .25W 1% METAL FILM
R47	3535A39H26	182 OHM .25W 1% METAL FILM
R48	3535A38H01	1.0K .25W 1% METAL FILM
R49	3535A37H47	30.1K .25W 1% METAL FILM
R50	3535A37H05	11.0K .25W 1% METAL FILM
R51	3535A37H01	10.0K .25W 1% METAL FILM
R53	3535A38H64	4.53K .25W 1% METAL FILM
R54	184A763H33	1.8K 1/2W 5% FIXED COMP.
R55	3535A37H30	20.0K 1% .25W METAL FILM
R56	3535A37H01	10.0K .25W 1% METAL FILM
R57	3535A37H30	20.0K 1% .25W METAL FILM
R58	3535A37H30	20.0K 1% .25W METAL FILM
R59	3535A37H01	10.0K .25W 1% METAL FILM
R60	3488A04H08	12.4K .25W .2%
R61	3488A04H08	12.4K .25W .2%
R62	3488A04H07	10.0K .25W 1% METAL FILM
R63	3488A04H07	10.0K .25W 1% METAL FILM
R64	3535A37H01	10.0K .25W 1% METAL FILM
R65	3535A37H01	10.0K .25W 1% METAL FILM
R66	3535A37H38	24.3K .25W 1% METAL FILM
R67	3535A37H01	10.0K .25W 1% METAL FILM
R68	3535A38H69	5.11K .25W 1% METAL FILM
R69	3535A37H01	10.0K .25W 1% METAL FILM
R70	3535A37H53	34.8K .25W 1% METAL FILM

SWITCH

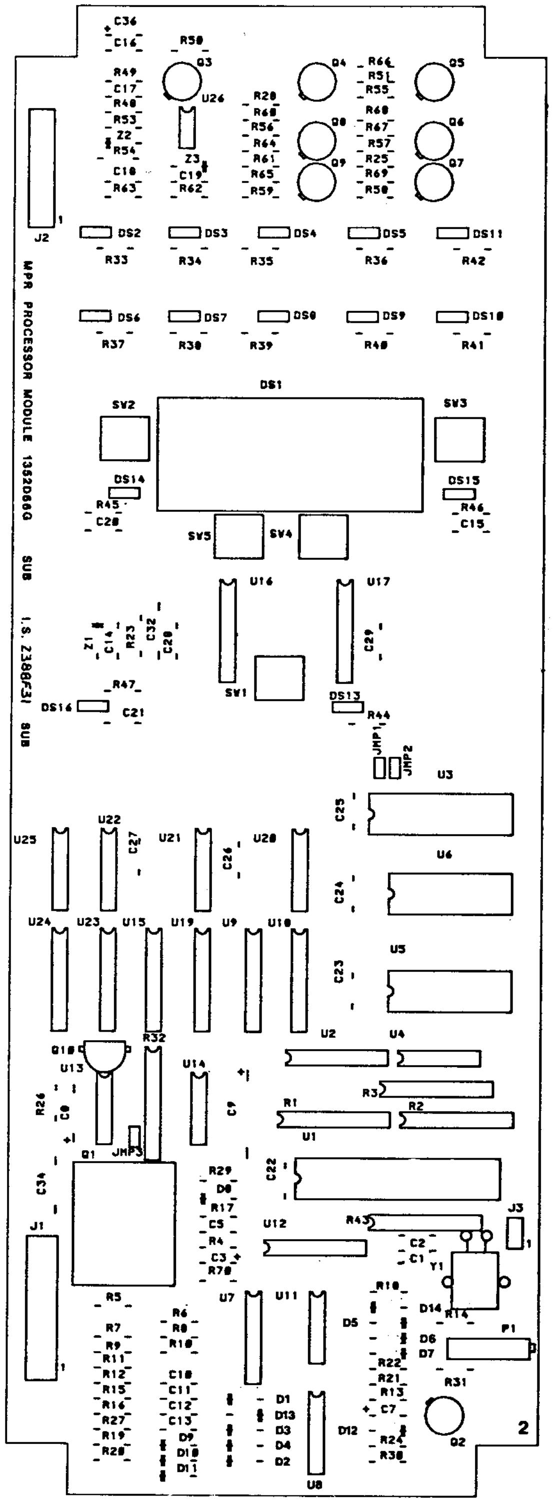
SW01	9645A08H01	DSKA02A
SW02	9645A08H01	DSKA02A
SW03	9645A08H01	DSKA02A
SW04	9645A08H01	DSKA02A
SW05	9645A08H01	DSKA02A

TRANSISTOR

Q01	9645A19H01	BUZ71A N-MOSFET
Q02	762A672H15	2N2222A NPN 40V .8A .4W
Q03	762A672H17	2N2907A PNP 60V .6A .4W
Q04	762A672H17	2N2907A PNP 60V .6A .4W
Q05	762A672H17	2N2907A PNP 60V .6A .4W
Q06	762A672H17	2N2907A PNP 60V .6A .4W
Q07	762A672H17	2N2907A PNP 60V .6A .4W
Q08	762A672H17	2N2907A PNP 60V .6A .4W
Q09	762A672H17	2N2907A PNP 60V .6A .4W
Q10	9448A76H51	VN10KM N-MOSFET

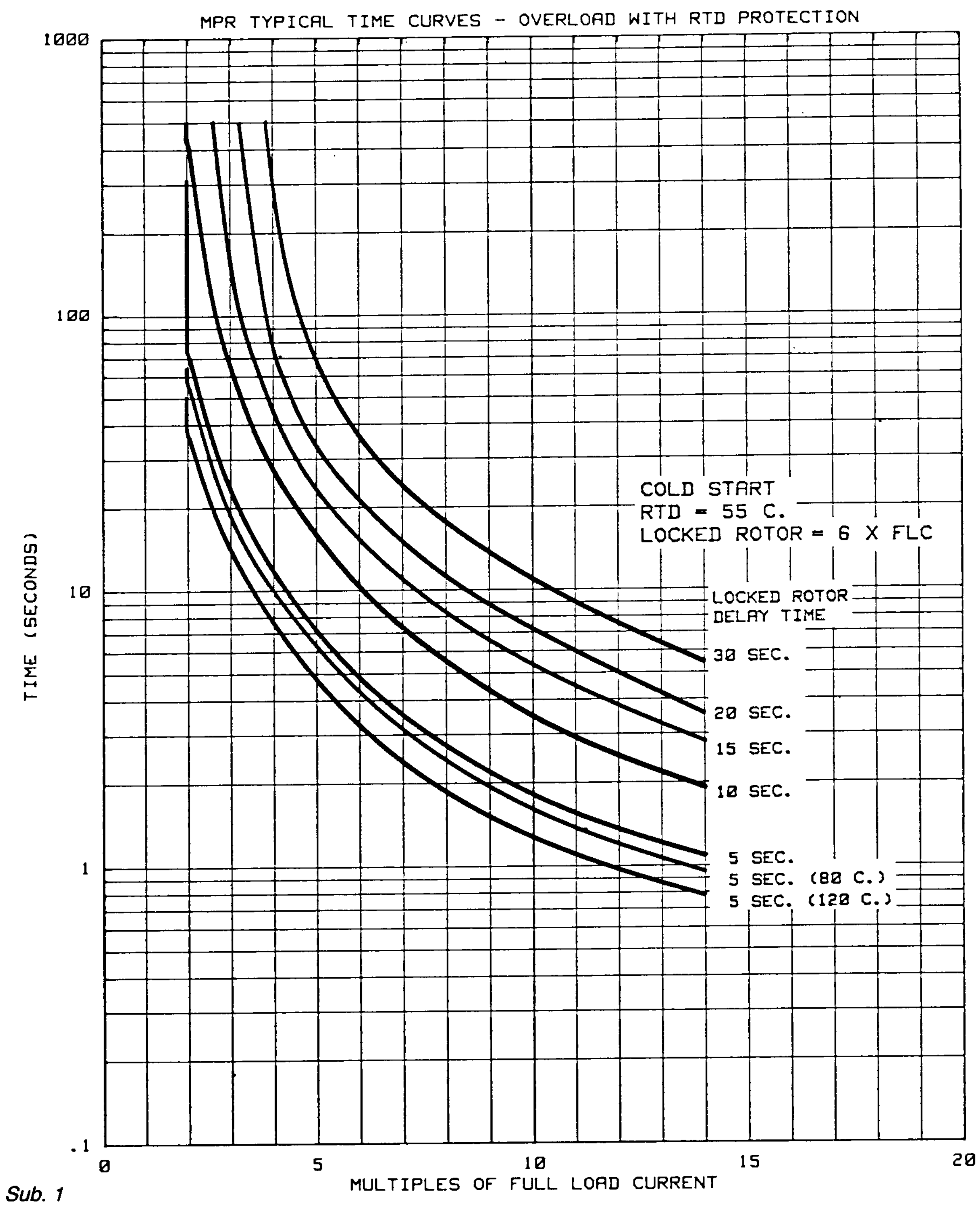
ZENER

Z01	862A606H01	1N753A 6.2V 5% 400MW
Z02	862A606H01	1N753A 6.2V 5% 400MW
Z03	862A606H01	1N753A 6.2V 5% 400MW



Sub. 2
1604C53

Fig. 11 Microprocessor Module Component Location



Sub. 1
619586

Fig. 12 MPR Typical Time Curves-Overload With RTD Protection (Cold Start)

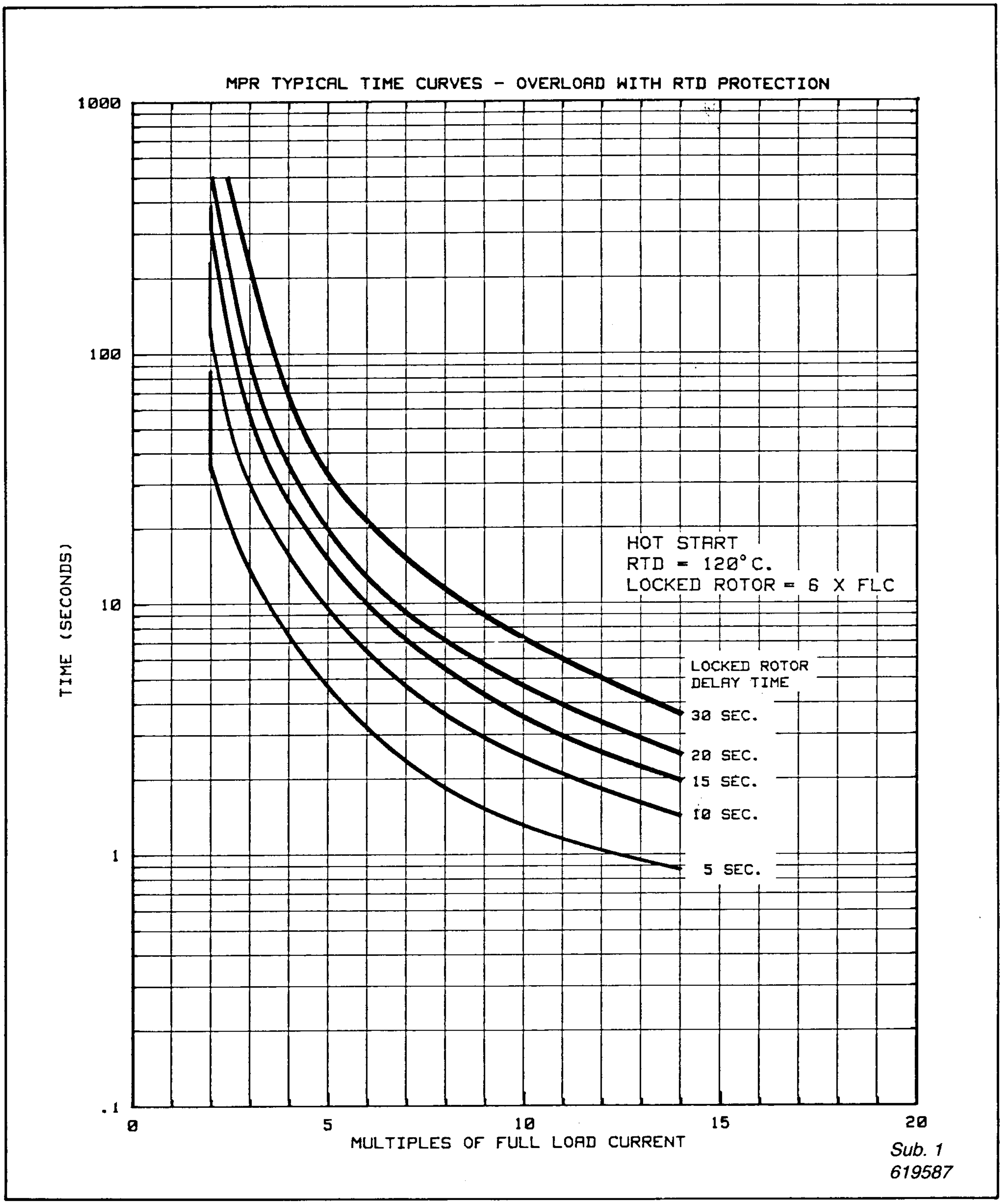


Fig. 13 MPR Typical Time Curves-Overload With RTD Protection (Hot Start)

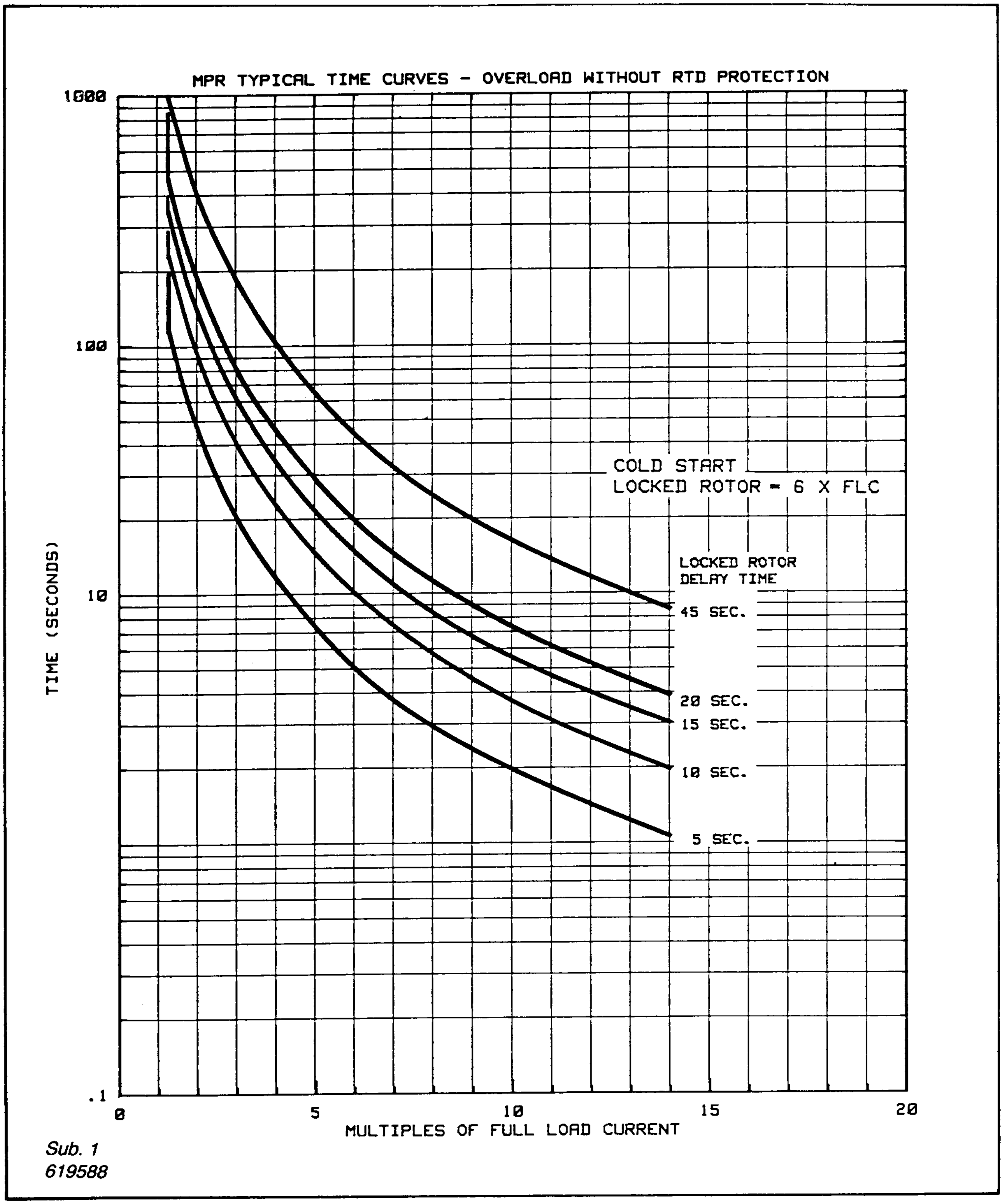


Fig. 14 MPR Typical Time Curves-Overload Without RTD Protection (Cold Start)

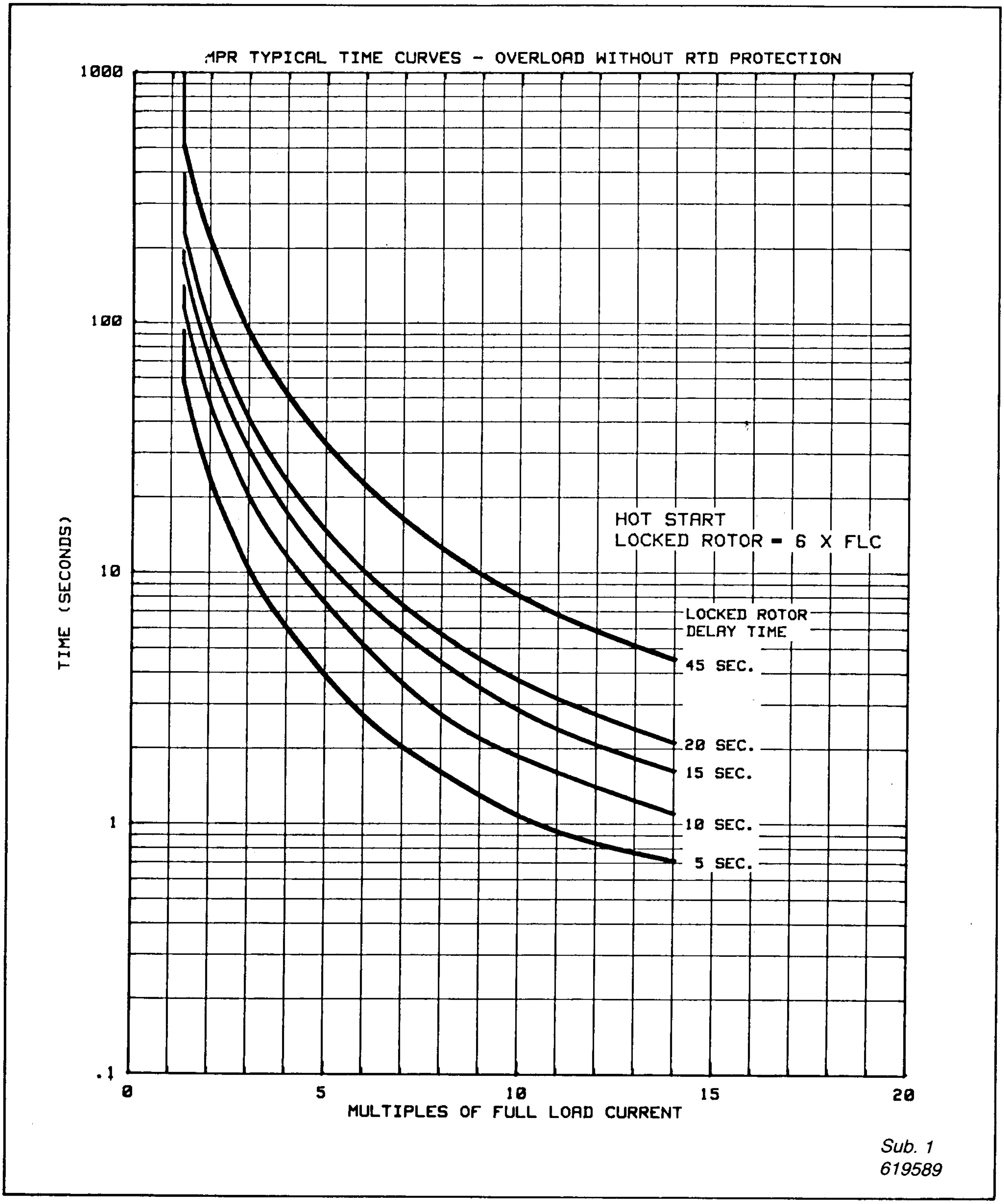


Fig. 15 MPR Typical Time Curves-Overload Without RTD Protection (Hot Start)

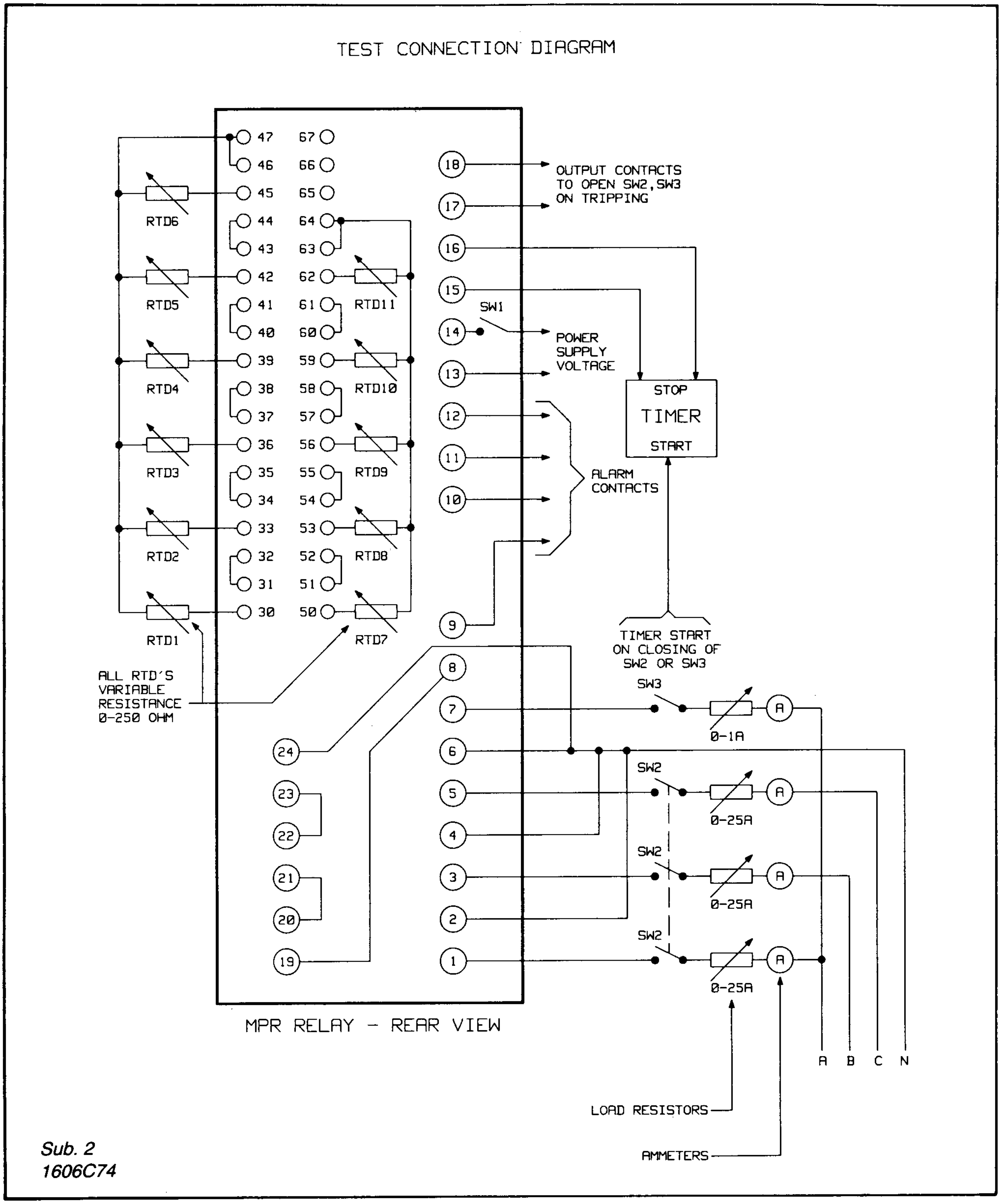


Fig. 16 Test Connection Diagram

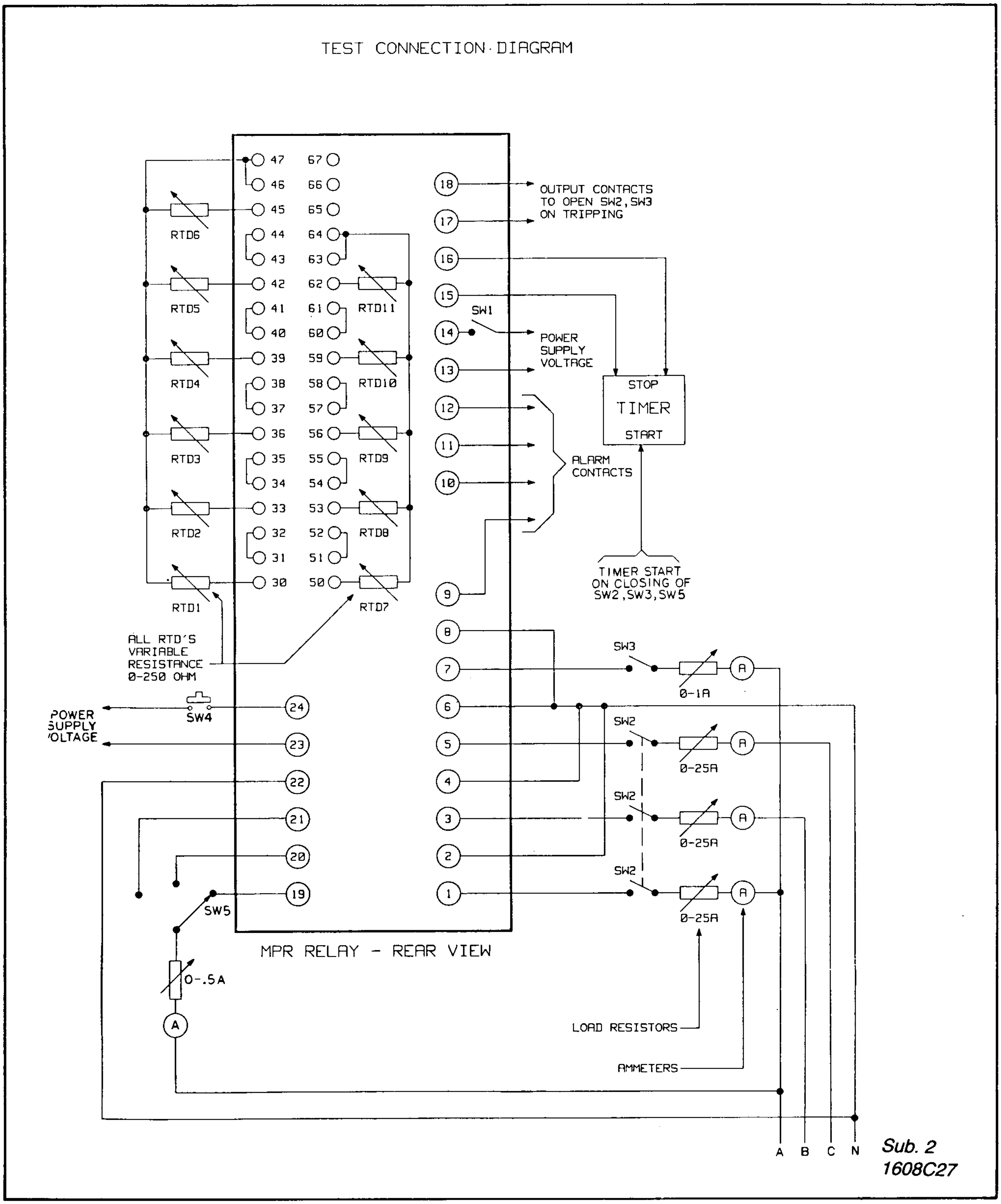
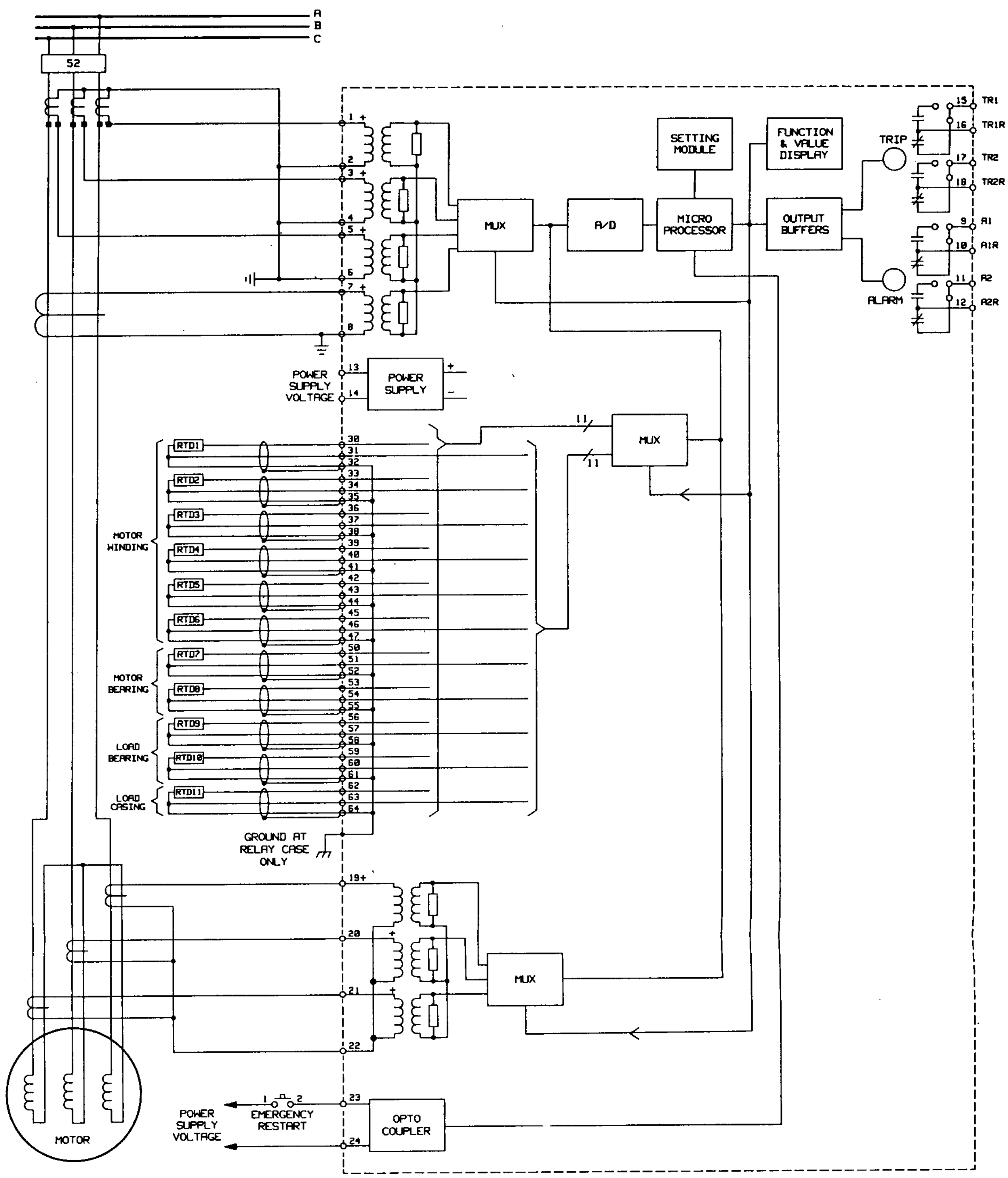
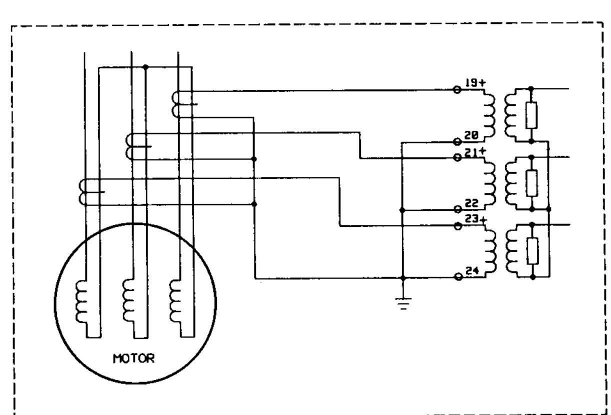


Fig. 17 Test Connection Diagram With Emergency Restart

Sub. 6
1352D50





PHASE DIFFERENTIAL CONNECTION FOR
RELAYS WITHOUT EMERGENCY RESTART

Fig. 18 External Connection Diagram

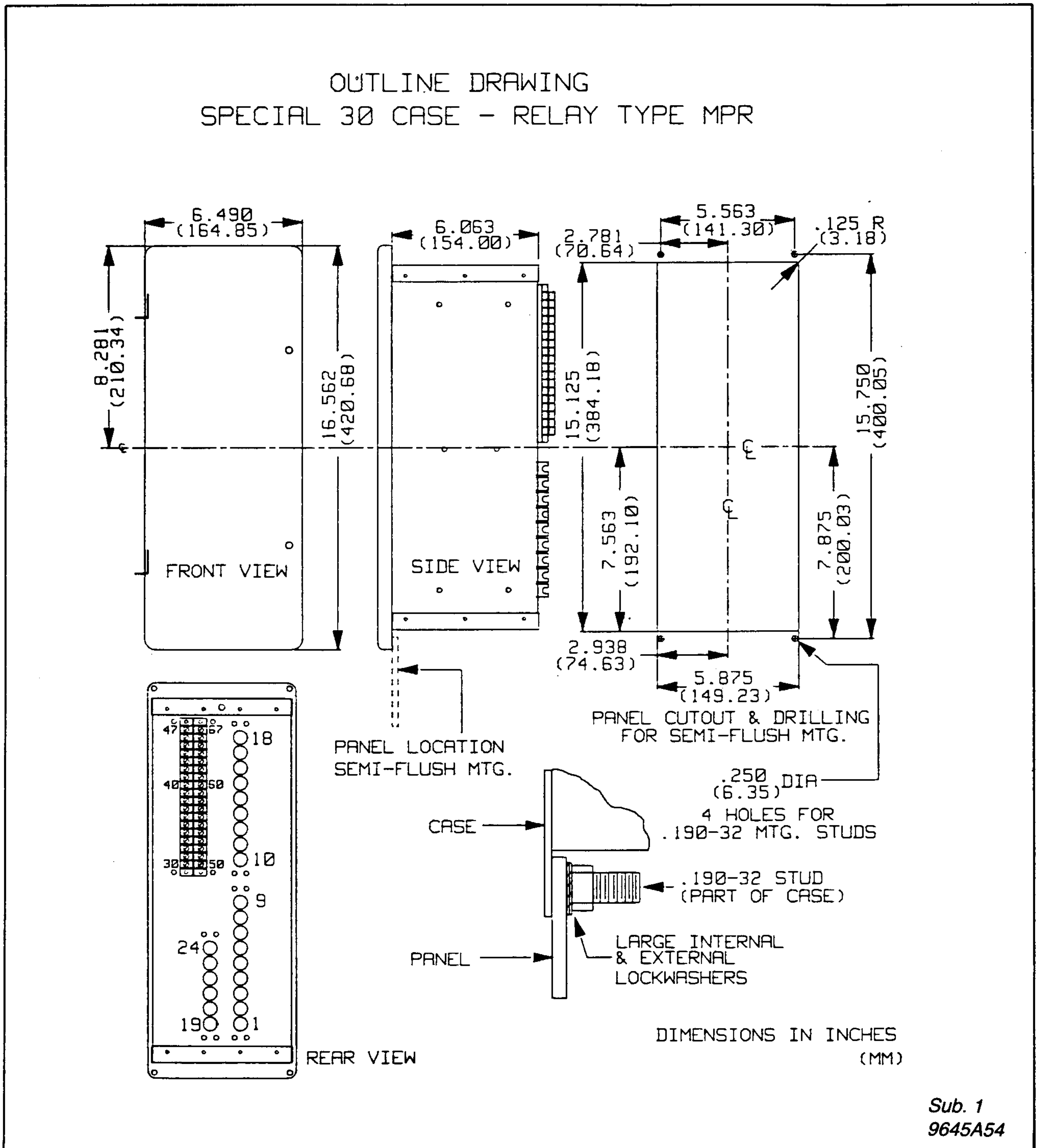


Fig. 19 Outline and Drilling Plan